Department of Industrial Management and Logistics
Engineering Logistics

Application for measuring supply chain performance for Personlig worktops at IKEA of Sweden AB

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Master Thesis in Engineering Logistics

Preface

This Master Thesis was carried out during the autumn 2006 and the spring 2007 as the finishing part of our Master of Science degree in Mechanical Engineering with emphasis on engineering logistics at Lund Institute of Technology. The Master Thesis has been conducted at IKEA of Sweden AB and in collaboration with the Department of Industrial Management & Logistics at Lund University, Faculty of Engineering.

We would like to thank Johan Ström our supervisor and project leader at IKEA of Sweden, BA04 Kitchen and Dining for the opportunity to take part and to carry out this interesting assignment. We would also like to thank Mats Rignell and Henrik Elm for forwarding the contact.

Other people involved in this project that we also would like to dedicate a thank you to are Nils Strand, Supply Planner, and the helpful people at IKSC, Linda Andersson and Anna Svensson, for sharing their knowledge concerning the PERSONLIG business.

Another person that has been very helpful and patient is our supervisor Carina Johnsson at the Department of Industrial Management & Logistics and we would like to thank her for the help and the assistance she has given us.

Finally will we dedicated a thank you to each other for a well done assignment and for a very good cooperation during this thesis.

Lund, 2007-12-29

Emil Claesson Mårten Wennersten

Abstract

Title: Application for measuring supply chain performance for Personlig worktops at IKEA of Sweden AB

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Supervisors: Carina Johnsson, Department of Industrial Management & Logistics, Lund University, Faculty of Engineering, Sweden.

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Purpose: The purpose of this thesis is to present a supply chain performance measurement application for IKEA, which is to be used when assessing the performance of the PERSONLIG supply chain and business.

The outcome of the thesis is meant to present a useful application that will aid in the decision making process for the PERSONLIG business. The aim of this application is to save time, effort and cost for IKEA.

The application will show the performance of the supply chain and running situation for the different sales regions. This will provide an opportunity for IKEA to identify potential areas of improvement in the PERSONLIG supply chain, and also provide a complete picture of how the business is performing.

The application should be able to show deviations in the supply chain for a specific country and where the deviations occur within the supply chain. Furthermore the application should be able to show the total number of customer orders placed in the different countries and how they are divided among the different suppliers.

The thesis will describe the application and the different reports that are generated by using the application. This thesis will also explain the underlying theories concerning the development of a supply chain performance measurement system.

The developed application is analysed from a theoretical point of view to find potential areas of improvement for further development. This is due to the fact that the application was developed in cooperation with IKEA without regards to known theories concerning supply chain measurement systems and performance.

Methodology: For this thesis we concluded that the best methodology approach and perspective would be a case study with a systematic approach. Regarding data collection we found that we needed a certain level of flexibility which could only be acquired using interviews.

Conclusions: One of the problems this thesis has focused upon is how the supply chain was constructed. We think that the supply chain is well constructed to manage the customer requests and the physical flow of products, but not sufficient enough regarding the information flow. The solutions and the possible improvements that we have identified are founded on integrating IKEA with the rest of the actors in the supply chain. Today's and the future global competition will with a high probability become difficult to fully handle without a good structure of the supply chain, with well integrated partners. A well developed supply chain must have clear strategies for how the customer satisfaction is created and developed work procedures for the distribution network and the deviation flow.

When viewing efficiency in the PERSONLIG supply chain, we find that the actors within the chain more or less work as independent companies, with no coordination when it comes to the development of a joint measuring system.

At the moment IKEA measures mostly effectiveness, and this is the natural choice when the customer is focused upon. The metrics IKEA is using all have set goals, which is a requirement if efficiency is to be measured. To be able to control the PERSONLIG supply chain and knowing how far the organization has come in realizing the set goals measuring effectiveness becomes very important. We come to the conclusion that since IKEA is measuring all deviations in an effectiveness way using the new application, they can easily determine how far they have come in realizing their goals. The only better way of measuring effectiveness that we can think of is to ask every PERSONLIG customer to take part in a survey and their by receiving information from more people than just the ones complaining. Presently using the data provided by IKSC gives a more than adequate picture of the current situation.

IKEA has chosen to view the flow of goods from worktop-supplier to end customer. It is this part of the supply chain that directly affects the customer. By doing so the scope of the supply chain only involves key actors which all can affect the customer in a positive or negative way. We find that, by involving this latter part of the supply chain IKEA could with greater precision focus their improvement efforts concerning customer satisfaction by addressing problem areas within the PERSONLIG supply chain. However it is important to consider how the focused efforts affect

the overall performance of the supply chain so that sub optimisation can be avoided.

The application fulfils all the requirements made by IKEA, to allow for decision making and control of the PERSONLIG supply chain and providing insight into the performance of the business. We have come to the conclusion that the next generation measurement system for the PERSONLIG supply chain should incorporate the following functions:

- Completely dynamic
- Fully automated data gathering
- Improved user interface
- Automated information communication
- Allowing for changes to the time frame
- Financial measuring

Keywords: Logistics, Supply Chain Management, Supply Chain Measurement Systems, Supply Chain Performance, Supply Chain Measures, Application Development.

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1 Introduction

This introduction chapter will first provide the reader with a background to the thesis and the problem at hand. After that a purpose and a problem definition will be defined. Then the writers will describe what the focus and delimitations are and who the target group is. In the end of the chapter, a company introduction is also provided followed by an outline of the thesis.

1.1 Background

There is an up going trend among most companies that is having an impact upon the logistics in the supply chain, which is the emphasis on customer satisfaction. To be able to meet the increasing customer requirements, the companies need to know how well the supply chain is performing, and this requires measurements.[1]

The purpose of measurements is to create knowledge which is an essential component for development and improvement. Well developed measurement systems constitute a link between strategy and the day to day activities. For knowledge to be meaningful it requires measuring the correct things in a correct way. To achieve this, the organization must focus on the customer requirements as well as the ambitions and goals of the organization itself.[2]

Understanding the supply chain is fundamental to managing it.[3] One of the major challenges of supply chain management is to maintain the visibility of the entire chain.

Visibility helps supply chain managers in their decision making, enabling better decision making, and faster response for instance when it comes to capacity planning. This is possible when the supply chain and the flow of gods are visualized in real time or near real time.[4]

Having implemented a logistics organization a company must continuously monitor and evaluate its effectiveness. The feedback from this evaluation is essential for organizational changes that will increase the company's likelihood of achieving its desired goals.[5]

IKEA is one of the world's largest home furnishing companies. IKEA´s business concept is to offer a wide range of home furnishings with good design and function at prices so low that as many people as possible will be able to afford them. The range spans from plants, living room furnishings, toys, frying pans to whole kitchens. One can find everything at IKEA that in a functional way helps to furnish the inertia of a home.

[1] Coyle, J. Bardi, E and Langley, J (1996), *The management of business logistics,* p. 21
[2] Ljungberg, A and Larsson, E (2001), *Processbaserad verksamhetsutveckling*, p. 226
[3] Schary, P and Skjøtt-Larsen, T (2002), *Managing the global supply chain*, p. 30
[4] Montgomery, A, Manrodt, K and Collins Holcomb, M (2002), "Visibility, tactical solutions strategic implications", Cap Gamini and Ernest & Young, p. 3
[5] Coyle, J. Bardi, E and Langley, J (1996), *The management of business logistics,* p. 533

IKEA's goal is to become the leading home furnishing company. When it comes to kitchens, this means that they need to offer complete solutions, including a great choice of design/materials and functions of worktops. In 2006 the advertising focus for IKEA was on bedrooms and kitchens. For 2007 the focus lays even more on kitchens with a wide range of everything from complete kitchens to utensils in different styles and price ranges.[6] When it comes to kitchen worktops PERSONLIG is IKEA's high price offer that provides the customer with the possibility to make a customized worktop.

During the past years PERSONLIG sales have increased, and so have the complaints from customers. PERSONLIG is a difficult business since it is a customized option. PERSONLIG is the only truly custom made product in the IKEA range. Any customized products place high demands on the surrounding organisation. IKEA's ordinary administration systems are not adapted to this form of customized product, which leads to problems when deviations occur in the supply chain.

To address this problem with increased complaints, and lack of visibility in the PERSONLIG business, IKEA decided that something had to be done. They came to the conclusion that they needed some kind of measurement application to visualize the supply chain.

The measurement application for PERSONLIG worktops is to be used to gain visibility of the supply chain when it comes to orders, deviations in the chain, and delays. The goal is to have an application that will present simple and useful reports that will help in the planning and decision making for the PERSONLIG business.

1.2 Problem definition

One of the main problems with the PERSONLIG business today is that there is no effective measurement tool regarding supply chain performance. IKEA have identified three areas that are especially important concerning supply chain performance for the PERSONLIG business. The three identified areas are deviations, orders and precision, and are described below:

Deviations
Supply chain deviations can be anything from missing goods to product deviations. Deviations are according to IKEA the most important area in need of visualization for the PERSONLIG business. Presently it is not possible to see how many of the customer orders that are reported to have some sort of deviation, and where these deviations occur. This presents big problems when it comes to running improvement programs.

Orders
IKEA lacks accurate sales figures in terms of actual customer buys. This presents problems for the organisation when it comes to capacity planning and forecasting. The lack of sales figures is due to the IKEA standard control system which operates on an article level, which works for all other products except PERSONLIG.

[6] IKEA internal dokument, *IKEA FACTS & FIGURES THE IKEA GROUP 2006. http://www.IKEA-group.IKEA.com/corporate/PDF/FF2006english.pdf.* 2006-03-13.

Precision
It is important for the customer to receive his or her kitchen on the planned delivery date, e.g. since the customer often has booked a craftsman to install the kitchen. For IKEA it means knowing if a supplier is having problems producing and dispatching worktops in time. IKEA needs to know if the supplier is having problems so that they in turn can notify the customer well before the set delivery date.

One of the problems regarding the performance of these three areas is that IKEA does not have enough supply chain information concerning the business of PERSONLIG worktops. The lack of information and visibility into the supply chain makes it hard to purchase capacity and make accurate forecasts as well as make supply chain improvements.

The task is therefore to provide IKEA with an application that will visualize the supply chain from manufacturer to end customer regarding the three areas deviations, orders and precision.

In order to create the requested application, our study had to be divided into different questions. The questions reflect different step in our study. To gain an understanding for the PERSONLIG business and facilitate the development of a supply chain measurement application, we have divided our research questions the following way:

How is the supply chain of PERSONLIG worktops constructed?

Is the measures provided by IKEA the right measures to be used in the supply chain of PERSONLIG worktops?

How can the developed application be improved to support the PERSONLIG business in the future?

1.3 Purpose

The outcome of the thesis is meant to present a useful application that will aid in the decision making process on a tactical level for the PERSONLIG business. The application is to be used when assessing the performance of the PERSONLIG supply chain. Hopefully, this application will save time, effort, and cost for IKEA.

The application will show the performance of the supply chain and running situation for the different sales regions. This will provide an opportunity for IKEA to identify potential areas of improvement in the PERSONLIG supply chain.

The application is expected to be able to show deviations in the supply chain for a specific country and where the deviations occur in the supply chain. Furthermore the application should be able to show the total number of customer orders for different countries and how they are divided among the different suppliers.

The thesis will describe the application and the different reports that are generated by using the tool. This thesis will also explain the underlying theories concerning the development of a supply chain performance measurement application.

The developed application is analysed from a theoretical point of view to find potential areas of improvement for further development. This is due to the fact that the application was

developed in cooperation with IKEA without regards to known theories concerning supply chain measurement systems and performance.

1.4 Focus and delimitations

The focus of this thesis is to describe the issues that affect the outcome of the measurement application for PERSONLIG worktops.

The only product we focus on in the thesis is the PERSONLIG worktop. Due to the complexity of the PERSONLIG business this will be the only supply chain we study, another reason for this is that this product is the only one of its kind in the IKEA range. The main focus has been on the Swedish supply chain since information concerning the layouts of the other country specific supply chains has been hard to identify.

The physical flow of goods within the PERSONLIG supply chain is viewed from the manufacturer of the worktop to end customer.

1.5 Target group

This thesis is primarily addressed to persons directly involved in the business of PERSONLIG worktops. It is also addressed to the people who will further develop the application.

1.6 Company introduction

IKEA was founded by Ingvar Kamprad in 1943. IKEA is one of the world's leading home furnishing companies and their vision and business idea are[7]:

> The IKEA vision is:
> "*To create a better everyday life for many people*".
>
> The Business idea is:
> "*We shall offer a wide range of well-designed, functional home furnishing products at prices so low as many people as possible will be able to afford them*".

The organization of IKEA can be seen in Figure 1, it stands for long-term independence and security.[8]

[7] IKEA internal dokument, *IKEA FACTS & FIGURES THE IKEA GROUP 2006. http://www.IKEA-group.IKEA.com/corporate/PDF/FF2006english.pdf.* 2006-03-13. p. 4
[8] http://www.IKEA.com/ms/en_GB/about_IKEA/facts_figures/IKEA_is_organized.html 2006-04-16

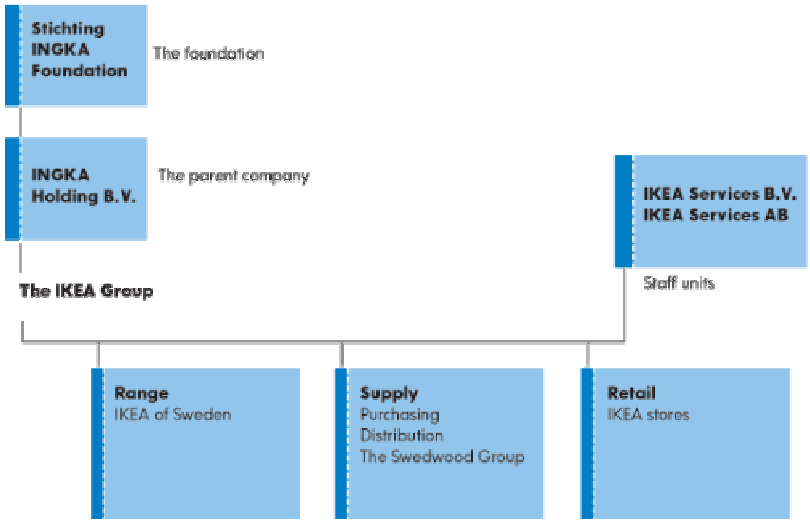

Figure 1: The organization of IKEA.[9]

The part of the organization which a customer sees as "IKEA" is the IKEA Group. The IKEA Group employs about 104 000 persons in 44 countries. The group has 222 stores in 24 countries and additional 29 franchises stores, with a combined area of 5, 5 million square meters (divided by the 222 stores). [10]

The sales in 2006 reached an excess of 17 billion euro. To get a good picture over the growth of the sales for the IKEA group see Figure 2. 2006 was a good year for IKEA with sales up by 17 percent and 16 new IKEA stores worldwide.[11]

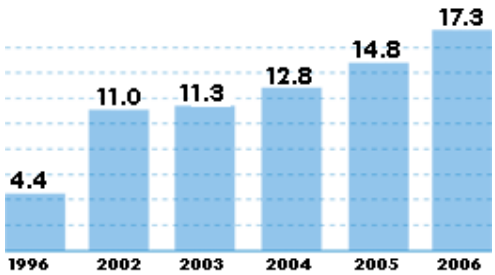

Figure 2 : Sales for the IKEA Group between 1996 and 2006 (billions of euros).[12]

At the moment the IKEA group has roughly 1300 suppliers in 55 countries and 28 distribution centres in 17 countries[13]. The IKEA group is divided into three different areas: range, supply and retail (see Figure 1). The different areas interact with each other to create customer satisfaction. The area *range*, consist of IKEA of Sweden (IoS) and it is this part of the IKEA group that act like an integrator for the organization[14].

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[9] http://www.IKEA.com/ms/sv_SE/about_IKEA/facts_figures/IKEA_is_organized.html , 2007-04-16
[10] http://www.IKEA.com/ms/en_GB/about_IKEA/facts_figures/IKEA_group_stores.html, 2007-04-16
[11] http://www.IKEA.com/ms/en_GB/about_IKEA/facts_figures/figures.html , 2007-04-16
[12] IKEA internal dokument, *IKEA FACTS & FIGURES THE IKEA GROUP 2006. http://www.IKEA-group.IKEA.com/corporate/PDF/FF2006english.pdf.* 2007-03-13.
[13] http://www.IKEA.com/ms/en_GB/about_IKEA/facts_figures/IKEA_in_the_world.html, 2007-03-14
[14] IKEA internal dokument, *IKEA FACTS & FIGURES THE IKEA GROUP 2006. http://www.IKEA-group.IKEA.com/corporate/PDF/FF2006english.pdf.* 2007-03-13.

IoS is responsible for developing the IKEA range and making it available to stores and customers all over the world. IoS is divided in 10 business areas where each drives their business within a specific product segment and creates their part of the home furnishing offer.

1.7 Outline of the thesis

This section presents the different chapters within this thesis.

Chapter 1 - Introduction

The introduction chapter will first provide the reader with a background to the thesis and the problem at hand. After that a purpose and a problem definition will be defined. Then the writers will describe what the focus and delimitations are and who the target group is. In the end of the chapter, a company introduction is also provided followed by an outline of the thesis.

Chapter 2 – Methodology

In this chapter the authors describe how they approached the study at hand, what methodological choices that have been made and the founding reasons why. First the authors describe their methodological approach followed by the different perspectives regarding methodology that has been used for this thesis. The authors conclude this chapter by describing the collection of data, how the case study was conducted and in the end the quality of the data is addressed.

Chapter 3 – Frame of reference

In chapter 3 the authors present the theoretical frame of reference. This chapter will introduce the reader to the supply chain concept, measurements in a supply chain, supply chain performance, what is a measurement system, and how to develop an information system.

Chapter 4 – Empirical studies

In chapter 4 the authors describe the empirical information gathered for this thesis. The reader will be introduced to the PERSONLIG supply chain, the performance of the PERSONLIG supply chain, and the measurement system for PERSONLIG worktops.

Chapter 5 – Development of the application

In this chapter the authors describe the development of the application for supply chain measurements of the PERSONLIG business. The method used to describe the process can be found in chapter three.

Chapter 6 – Analysis

Chapter 6 contains the analysis which the authors have carried out concerning the PERSONLIG supply chain, a measurement system for the PERSONLIG business, and an evaluation of the developed performance measurement application.

Chapter 7 – Conclusions

In this chapter the authors present the conclusions regarding the PERSONLIG business and its supply chain measurement system as well as the conclusions drawn concerning the developed application.

Chapter 8 - Concluding remarks and suggested future research

In the final chapter the authors present important aspects to consider regarding the future, and how this thesis can be applied to other businesses.

1.8 Definitions and abbreviations

Below is a list of the abbreviations that can be found in this thesis.

IKSC	–	IKEA Kund Service Center (IKEA Customer Service Centre)
SAMS	–	Service Action Management System
SAC	–	Service Action Case
IoS	–	IKEA of Sweden
CDC	–	Customer Distribution Centre
DC	–	Distribution Centre
MEMO	–	IKEA email system
YTD	–	Year To Date
4w	–	The average for the past four weeks (on a weekly base)
1w	–	Information concerning the selected week
BO	–	The software Business Objects
Orders	–	The software Orders

2 Methodology

In this chapter the authors describe how they approached the study at hand, what methodological choices that have been made and the founding reasons why. First the authors describe their methodological approach followed by the different perspectives regarding methodology that has been used for this thesis. The authors conclude this chapter by describing the collection of data, how the case study was conducted and in the end the quality of the data is addressed.

2.1 Methodological approach

Different people will have different goals with research depending on that person's fundamental view on knowledge. There are three different approaches of viewing research analytical, systematic and the actors approach.[15]

2.1.1 Analytical approach

A person using the analytic approach will try to give a true picture that is as objective and complete as possible[16]. This person will not use any subjective material. Knowledge is to be independent of the observer. Reality is viewed as a whole, which can be split into pieces where the sum of the pieces is equal to the whole.[17]

2.1.2 Systematic approach

If a person has the systematic approach he tries to describe reality objectively, but he feels that reality is more than the sum of the parts. The systematic approach emphasizes the importance of synergy effect between different parts of reality and that the relation between the parts is as important as the parts themselves. A person using this approach will try to examine the relation between the parts of a system to be able to understand the underlying factors for different kinds of behaviour.[18]

2.1.3 Actors approach

In the actors approach reality is viewed as a social construction that will affect people and people will affect the perception of reality.[19] A person using this approach perceives reality as consisting of multiple pictures of reality, which are shared by larger or smaller groups of people.[20] The picture with is presented by a person using this approach will be dependent upon this persons own experiences.[21]

[15] Björklund, M and Paulsson, U (2003), *Seminarieboken – att skriva, presentera och opponera*, p. 59
[16] Arbnor, I and Bjerke, B (1994), *Företagsekonomisk metodlära,* p. 78
[17] Björklund, M and Paulsson, U (2003), *Seminarieboken – att skriva, presentera och opponera*, p. 59
[18] Björklund, M and Paulsson, U (2003), *Seminarieboken – att skriva, presentera och opponera*, p. 59
[19] Björklund, M and Paulsson, U (2003), *Seminarieboken – att skriva, presentera och opponera*, p. 59
[20] Arbnor, I and Bjerke, B (1994), *Företagsekonomisk metodlära, p. 86*
[21] Björklund, M and Paulsson, U (2003), *Seminarieboken – att skriva, presentera och opponera*, p. 59

2.1.4 The authors own approach

The author's methodological approach corresponds well to the systematic approach which is used when writers wants to explain the reality objectively, but feels that reality is more than the sum of the parts. The systematic approach also puts emphasis on synergy effect, which the authors use by understanding different underlying factors that contribute to different kinds of behaviour.

2.2 Induction, deduction and abduction

During the theoretical and empirical part of a project there are different procedures that can be used[22]. The different procedures are *induction*, *deduction* and *abduction*. Induction means to study a certain subject without first gathering any theoretical material. Deduction means first gathering theoretical material and then conducting empirical studies. Using abduction is to use a combination of induction and deduction.[23] The relation between inductive and deductive approaches can be seen in Figure 3. The three areas are described in more detail below.

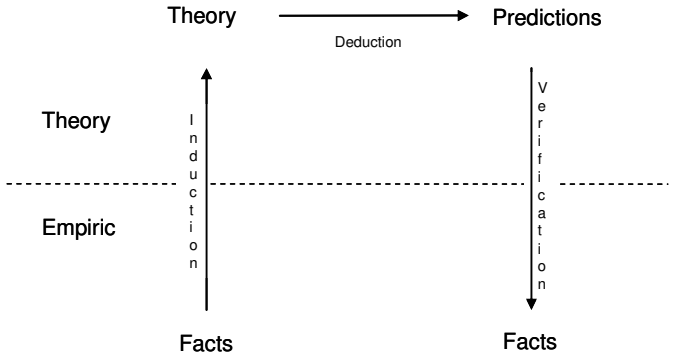

Figure 3 : Illustration of the inductive and the deductive approach. [24]

2.2.1 Induction

Induction means that the researcher starts in the reality and tries to discover patterns that one could connect to models and theory. Induction is furthermore when you approach the subject without first studying the theoretical aspects and instead start with the empiric studies and build your theory around that. One problem with the induction approach is that it could be limited to a special situation and therefore the person how is conducting the study may have an influence over the result since the researcher does not have a frame of reference to lean on.[25, 26]

2.2.2 Deduction

Deduction is the opposite of induction and means that the researcher stats with general principles and existing theories and tries to draw conclusions about single occurrences. From

[22] Arbnor, I and Bjerke, B (1994), *Företagsekonomisk metodlära*, p. 107
[23] Björklund, M and Paulsson, U (2003), *Seminarieboken – att skriva, presentera och opponera*, p. 62
[24] Arbnor, I and Bjerke, B (1994), *Företagsekonomisk metodlära,* p. *107*
[25] Björklund, M and Paulsson, U (2003), *Seminarieboken – att skriva, presentera och opponera*, p. 62
[26] Davidson, B and Patel, R (1994), *Forskningsmetodikens grunder*, p. 21

the existing theories the researcher construe hypothesis that he later tries to verify by the collection of the empirical data.[27,28]

2.2.3 Abduction

If the author is not using a strict inductive approach, nor a strict deductive one, he is using an approach called abduction. Abduction is the interaction between induction and abduction, for instance if one shifts from induction to deduction and back again.[29,30]

2.2.4 The authors own approach

The authors to this thesis have used an inductive approach. The project started out in reality, by conducting interviews with people directly involved in the PERSONLIG business. There was at the beginning no connection to established theories.

The authors had no prior knowledge of Microsoft Access or any Visual Basic programming skills. The start of the project was at the end of October and the finished application was to be put to use the first week of January. The time limit for the project made it impossible for the authors to first gather a theoretical frame of reference and then conduct the empirical studies. This is mostly due to the limited Microsoft Access knowledge of the authors.

2.3 Qualitative or quantitative research

Somewhat simplified you may say that quantitative and qualitative research is how you choose to work on and analyse the information and data that you have collected[31]. An illustration of quantitative and qualitative research is shown in Figure 4. One of the key differences between the approaches is how the study is conducted. The qualitative research is characterized by flexibility, while the quantitative research is more structured.[32] Another difference is that it is more difficult to draw general conclusions from a qualitative study, than from a quantitative[33].

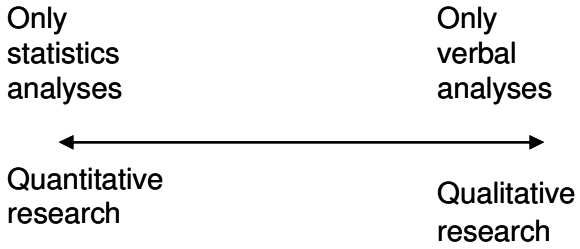

Figure 4 : Illustration of the quantitative and qualitative research.[34]

[27] Davidson, B and Patel, R (1994), *Forskningsmetodikens grunder*, p. 21
[28] Björklund, M and Paulsson, U (2003), *Seminarieboken – att skriva, presentera och opponera*, p. 62
[29] Björklund, M and Paulsson, U (2003), *Seminarieboken – att skriva, presentera och opponera*, p. 62
[30] Wallén, G (1996), *Vetenskapsteori och forskningsmetodik*, p. 47-48
[31] Davidson, B and Patel, R (1994), *Forskningsmetodikens grunder*, p. 12
[32] Holme, I and Krohn Solvang, B. (1997), *Forskningsmetodik Om kvalitativa och kvantitativa metoder*, p. 80
[33] Björklund, M and Paulsson, U (2003), *Seminarieboken – att skriva, presentera och opponera*, p. 63
[34] Davidson, B and Patel, R (1994), *Forskningsmetodikens grunder*, p. 12

2.3.1 Qualitative research

A qualitative research is a method that analyses the data from a verbal perspective. Qualitative research is used if the researcher would like to make a deeper understanding for a special area, special occurrence or situation.[35]

In a qualitative research the flexibility aspect is important, since the layout of the research or study needs to be able to change during the course of the study. This is needed since the authors experience and knowledge is changed during the study. One advantage with this type of approach is that the authors or researcher can change the purpose that they are working towards, since the researcher acquires a better understands for the problem during the course of the research. One example of this can be during the data collection phase, since the researchers have gathered all the information they have a better understanding for the research purpose. One disadvantage regarding this approach is that it is making the information comparison between different stages in the research difficult, since the knowledge of the researchers has changed during each phase of the study.[36]

2.3.2 Quantitative research

Quantitative research is studies that comprise of information that could be measured or valued numerically. Therefore with quantitative research you mean research that use statistics analyses for understanding the information.[37]

The quantitative research tries to find the solution to the problem how information is gathered concerning qualitative research. The information gathering during qualitative research depends upon the researcher knowledge. The quantitative research tries to solves this problem by standardize the gathering of information. To be able to standardize the information gathering, the method divides the approach in two different parts. The first part is to construct the problem definition and purpose of the study. The second is to gather information in a standardized way. The strength of this type of study is that it makes generalisations possible. The weakness is that the researchers do not have any guarantee that the information is relevant to the study.[38]

2.3.3 The authors own approach

To be able to give answers to our problem definitions and to fulfil the purpose of this thesis, the authors had to get a deeper and better understanding of the business regarding PERSONLIG worktops. To do this the authors had to interview a group of people, all involved one way or another in the business of the PERSONLIG worktops. This helped the authors in becoming more "*flexible*", when the researched area grew and became more and more detailed. Without the detailed view it would have been hard to accurately construct a measurement application for the PERSONLIG supply chain and therefore the authors have come to the conclusion that a qualitative research approach would be the best.

[35] Davidson, B and Patel, R (1994), *Forskningsmetodikens grunder*, p. 12
[36] Holme, I and Krohn Solvang, B. (1997), *Forskningsmetodik Om kvalitativa och kvantitativa metoder*, p. 80
[37] Davidson, B and Patel, R (1994), *Forskningsmetodikens grunder*, p. 12
[38] Holme, I and Krohn Solvang, B. (1997), *Forskningsmetodik Om kvalitativa och kvantitativa metoder*, p. 81

2.4 Collection of data

There are different methods to collect data. The choice of method depends on what kind of purpose and problem the study has. There are two types of data that is used during projects, primary and secondary data. Information that is gathered for just this study is considered to be primary data and information that is written in another purpose than for this study is considered secondary data.[39]

2.4.1 Primary data

Interviews

Interviews give access to information that is directly relevant for the study. It is also possible to gain a deeper understanding when one can adjust the questions for each individual informant and the person's previous answers.[40]

According to Björklund and Paulsson, interviews can be conducted in three different ways.[41]

1. **Structured**
   When defining the questions and the order of the questions in detail before the actual interview the interview can be defined as structured.

2. **Semi-structured**
   If the overall subject of the interview is clear and the person conducting the interview defines the questions as the interview goes on the interview can be considered Semi-structured.

3. **Un-structured**
   If the interview takes the form of a conversation or a discussion it can be considered to be un-structured.

The persons we have chosen to interview have all key roles in the PERSONLIG business:

Johan Ström
Johan was the project leader, he was responsible for running an improvement project for the PERSONLIG business. He was also at the time for the project acting as the owner of the PERSONLIG business.

Nils Strand
For the improvement project Nils acted as a "consultant" helping in answering all different kinds of questions regarding PERSONLIG, he has 14 years of experience with the PERSONLIG business.

Linda Svensson
Linda works at the customer call centre in Älmhult. She is responsible for handling customer complaints regarding PERSONLIG worktops. She has been working as a case handler with PERSONLIG for five years.

[39] Björklund, M and Paulsson, U (2003), *Seminarieboken – att skriva, presentera och opponera*, p. 67-68
[40] Björklund, M and Paulsson, U (2003), *Seminarieboken – att skriva, presentera och opponera*, p. 70
[41] Björklund, M and Paulsson, U (2003), *Seminarieboken – att skriva, presentera och opponera*, p. 68

Anna Svensson
Anna has the same position as Linda and has been working with customer complaints concerning PERSONLIG for two years.

The interview material has a central role in the empirical studies in this report. Interviews are a good tool to use when one wants to gain a deeper understanding for a subject and acquire information directly related to the study at hand[42]. The interviews have helped us in acquiring a deeper understanding into the problem areas concerning the PERSONLIG business. The interviews we have conducted have been of an unstructured or semi structured nature.

The interview questioners can be seen in Appendix A.

During the development of the application we visited IKEA of Sweden once or twice every week. During the visits we have primary met with Johan Ström. At most of these visits we have had unstructured interviews in the form of discussions or conversations regarding questions concerning the layout and functions of the application, we also received feedback regarding the work that had been done since the last visit.

Since the purpose of this study have been to gain a deep understanding into the PERSONLIG business and its problems, we feel that interviews have provided the necessary flexibility, since we have been able throughout the project to contact the people involved when questions have arisen which has been important in avoiding abruptions in the development of the application.

Internal documentation
We have gathered internal documentation in the purpose of corroborating the interview material. The documents we have attained have mostly concerned different work processes and routines regarding deviations and deviation classification codes. The information in the routines have helped in attaining information that seems trivial or taken for granted by the informants.

2.4.2 Secondary data
The secondary data has preliminary been articles and literature in the field of supply chain performance and methodology. Especially concerning performance measures in the supply chain.

For the gathering of the necessary articles we have used ELIN which is an electronic article search engine provided for students attending Lund University. ELIN is connected to a multitude of databases and provides good access to full text articles concerning all subjects. This has given us access to a wide range of articles concerning logistics and performance measuring in supply chains.

For literature regarding methodology, the area of logistics, and measuring we have used material made available at Lund Institute of Technology's library "Studiecentrum". The benefits of this have been that a wide range of books are available at all times, which provides good depth into the necessary subjects.

[42] Björklund, M and Paulsson, U (2003), *Seminarieboken – att skriva, presentera och opponera*, p. 70

2.5 Case study

Using a case study is one of several ways of doing scientific research. According to Yin a case study is the preferred strategy when having "how" or "why" questions, when the investigator has little control over events, and when the focus is on modern phenomenon within some real-life context. The case study can also be used when trying to increase our knowledge of an individual, a group or an organization.[43]

In our thesis we find that the case study is a suitable approach since, we aim to answer the questions:

How is the supply chain of PERSONLIG worktops constructed?

Is the measures provided by IKEA the right measures to be used in the supply chain of PERSONLIG worktops?

How can the developed application be improved to support the PERSONLIG business in the future?

We do not control the events in the PERSONLIG supply chain and we only aim to find ways for measuring and visualizing the supply chain at hand, which is also in line with a case study. To be able to answer the questions in this thesis we had to increase our knowledge of the IKEA organization. This is also in line with the case study process according to Yin.

2.6 Case study processes

This chapter explains the way that the study and the development of the application were carried out. Below is Figure 5 that explains how we have structured our work.

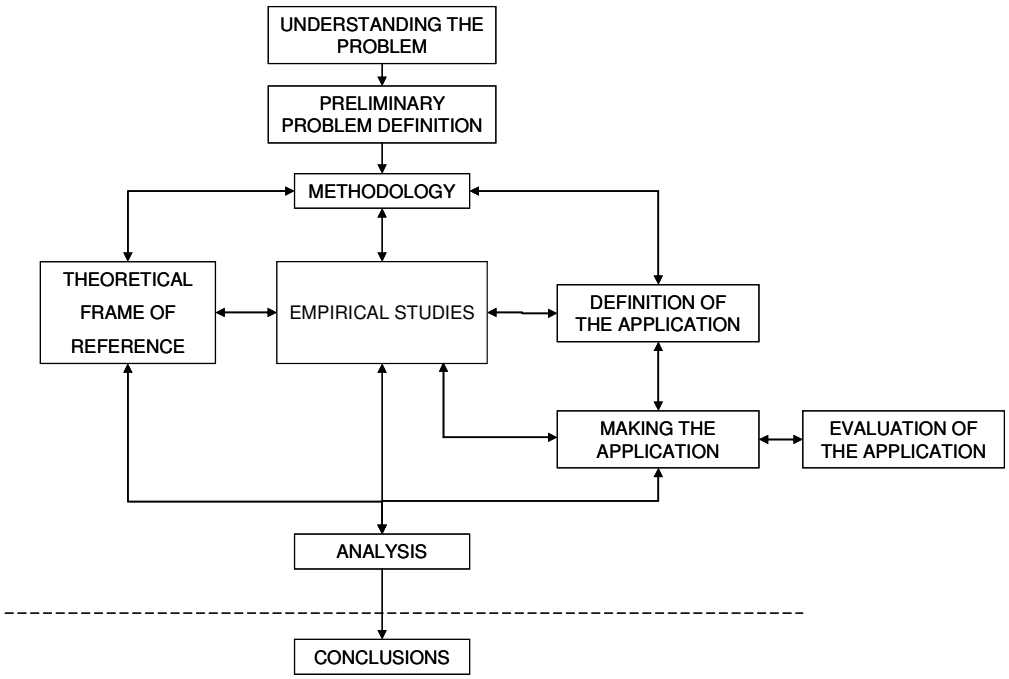

Figure 5 : Explanation over how the work was carried out.

[43] Yin, R (2003), *Case study research, design and methods*, p.1-5

We started out by attaining an understanding for the problem concerning the PERSONLIG business. This was then followed by empirical studies to gain a deeper understanding for the supply chain and the product PERSONLIG. During the empirical studies we started developing the application in close collaboration with the IKEA representatives. The making and evaluation of the application continued for about three months before the application was considered to be finished. This was followed by a literature study, analysis and conclusions.

2.6.1 Understanding the problem

In order to get a more complete picture of the problem at hand, we visited IKEA of Sweden (IoS) in Älmhult. Here we had a general discussion with the people involved in this project. This was done to familiarize ourselves with the PERSONLIG business and its supply chain. We also met with people from the IKEA call center in Älmhult, in order to get a better understanding of their work. This was important since all the deviation data for Sweden originated from this call center. Sometime later we made a second visit to IoS and this time we received additional information regarding general product deviations in the form of internal documents. We then met once more with our contact person at IoS to discuss the problem at hand and to make sure that we all had the same basic understanding of the problem.

2.6.2 Problem definition

When we visited IoS for the second and third time we discussed with our supervisor Johan Ström at IoS the preliminary problem definition and what depth the thesis should have and what limitations the application would have. After the discussions with Johan, he wrote down the preliminary problem definition. This document can be found in Appendix B.

2.6.3 Methodology

For this part of the thesis we started out by reading and studying literature concerning different methodological theories. To be able to decide which theories that would fit our view and the thesis. We discussed what kind of methodology approach and perspective that would be best in this case and we found that a case study with a systematic approach would be best for the problem at hand. Regarding data collection we found that we needed a certain level of flexibility which could only be acquired using interviews.

2.6.4 Empirical studies

In this thesis we have mainly used interviews as a source for the empirical study. The interviews have been used to give us a deeper understanding for the PERSONLIG business itself and the problems IKEA are having regarding the measurement perspective. They have also given us insights in to the day-to-day work at IKEA Customer Service Centre (IKSC).

Another source of primary data we have used is internal IKEA documentation in the form of rules and routines. They have primarily been used to corroborate the interview material. The empirical material has mainly concerned deviations in the supply chain as well as sales data.

2.6.5 Preliminary definition of the application

During our initial meetings with Johan Ström at IoS we sat down and discussed what the primary uses of the application was. We then tried to identify what type of input data we needed and where it could be found.

2.6.6 Making the application

In making the application we had to learn how to use Microsoft Access and SQL programming. We also had to attain a basic knowledge in Microsoft Visual Basic to be able to make the application more user-friendly.

In developing the application we constantly had to see what was possible to construct within the limitations of the input data. When new input data was available new parts to the application was added.

2.6.7 Evaluation of the application

When we were finished with the first version we started to check and evaluate the application with Johan Ström. Time was spent to try and find errors and areas where the application could be improved. This improvement process was then repeated throughout the entire development process and with all the versions of the application.

2.6.8 Frame of reference

We started with an expensive literature study trying to find all relevant theories so that we would have a solid base of knowledge. We started to search for theories regarding supply chain performance and measurements in supply chains. This was done to enforce our knowledge regarding these areas, so that we could analyse the developed application and present areas of improvements. We also studied theories regarding application development, since we wanted to analyse our work concerning the development of the application. The main information source for the frame of reference has been books and articles since we wanted to use both new and established literature regarding the concerned area.

2.6.9 The analysis

In the analysis we analyse the empirical findings from a theoretical standpoint we also analyse the developed application using the frame of reference. When analysing the application we have tried to find what possible areas of improvement we could identify. We then use the analysis as a base for our conclusions.

2.6.10 Conclusions

Our findings in the analysis are used as a foundation for our conclusions. The conclusions are divided into the areas *The PERSONLIG supply chain, The performance of the PERSONLIG supply chain, The measurement system for PERSONLIG, and The application*. Under each title we present the conclusions we have drawn.

2.7 Quality of data

All research tries to produce a good and durable result in an ethic way. In this chapter we will go through questions regarding validation and reliability. Most of the authors that are writing about validity and reliability mean that when writing qualitative research you should have another definition on validity and reliability, since it assumes different assumption of the reality.[44]

2.7.1 Internal validity

Internal validity handles to what extent your results deals with reality. Do the results really capture the reality? The validity has to be judged through interpretations of the researchers experience instead of terms of the reality. [45]

According to Merriam, there are six fundamental strategies that a researcher can use to ensure the internal validity when it comes to practical research and literature concerning qualitative research. [46] To ensure the internal validity in this thesis we have used Merriam's six steps as a guideline, the steps and the actions we have taken are explained below:[47]

1. *Triangulate*
   This means that you use several authors when it comes to literature, more than one interview person and multiply information sources.

   In our literature study we have tried to ensure the information by looking at the same information from more than one author. When it comes to the interviews, we have interviewed two persons with the same type of work with similar and/or identical questions. We have also tried to corroborate the information given by the informants by comparing the interview material with internal IKEA documentation.

2. *Control of participants*
   This means that the persons that provided the information may read the printed information after it has been modified so that the meaning and content is the same after interpretations.

   After the interviews, we and the informant discussed the material gathered during the interview to ensure that we understood everything in the correct way.

3. Observing *for some time* the situation or environment or repeated observations of the same thing. This means that you collect data over a period of time to ensure and increase the validity in the result.

   We have discussed and interacted with people and our supervisor at IKEA during the whole project. We have also conducted discussions on the same topic more than one time to ensure that both we and our supervisor at IKEA understood the problems and the solutions to the problems.

[44] Merriam, S (1994), *Fallstudien som forskningsmetod*, p. 174 and p. 177
[45] Merriam, S (1994), *Fallstudien som forskningsmetod*, p. 177
[46] Merriam, S (1994), *Fallstudien som forskningsmetod*, p. 179
[47] Merriam, S (1994), *Fallstudien som forskningsmetod*, p. 179-180

4. *"Horizontal" evaluation and criticism*
   Means that you ask colleagues to give their point of view and comments on the ongoing work.

   To secure the validity of this point we have had a supervisor at IKEA that have continuously evaluated our work and progress. When it comes to the thesis our supervisor at the department of engineering logistics have continually monitored our ongoing work and evaluated part by part of the thesis.

5. *Procedure in the research*
   This point means that all persons that have been studied should be involved in the project from concept to the design of the final report.

   When it comes to this point we feel that we have tried to inform and involve all concerned people. We have felt that this is a good thing because they have good knowledge and competence in this line of work.

6. *Clarifying of distortions*
   The meaning of this point is that the researcher has a preconceived notion over how the reality works.

   We as researchers of this thesis have reflected on how we view the world and reality so that we have a clear picture of how we perceive the world and reality and how we are thinking.

2.7.2 External validity

External validity implies in what extent the results from a certain study is applicable in other situations than in the one where the study that was conducted. That means to what extent the results of a study can be applied in a generalized way.[48]

We are using a general frame of reference that can be used in any supply chain performance measurement project. We have also tried to provide the reader with an extensive amount of information concerning our case study that can be used as a comparison to other cases.

2.7.3 Reliability

Reliability concerns in what extent you will get the same result if you do the same study once again[49]. Within the case study processes and research that involves people it can become a problem with the measurement of reliability since the human behaviour is not static, it is changeable.[50]

To ensure reliability in this thesis we have used straight forward questions followed by the same but rephrased question to see if we attain the same answer. We have also conducted individual interviews with people that have the same kind of job, to see if we attain the same answers.

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[48] Merriam, S (1994), *Fallstudien som forskningsmetod*, p. 183
[49] Björklund, M and Paulsson, U (2003), *Seminarieboken – att skriva, presentera och opponera*, p. 59
[50] Merriam, S (1994), *Fallstudien som forskningsmetod*, p. 180

3 Frame of reference

In this chapter the authors present the theoretical frame of reference. This chapter will introduce the reader to the supply chain concept, measurements in a supply chain, supply chain performance, what is a measurement system, and how to develop an information system.

3.1 The concept of supply chain

Each company is unique. But in some aspects all companies that either produce or distribute are alike. They all try to sell their products or services on a market. On the market the companies also compete with one another. They are all customers or suppliers and are at least members in one supply chain.[51]

3.1.1 Introduction to the concept

The concept of supply chain underlines the importance of operations as vital to the strategy. The underlying framework for the concept of supply chain is Michael Porters Value Chain.[52] The Value Chain Porter describes is a series of primary processes that add value to the output of the enterprise. The primary processes that create value for the customer are according to Porter *inbound logistics, operations, outbound logistics, sales, and services*.[53] (See Figure 6)

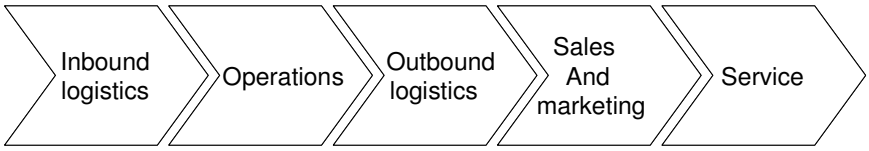

Figure 6 : Porters value chain.[54]

A development of Porters value chain leads to a new framework with three parallel flows that determine the way of a companies business: *Product development*, *Customer relationship* and *Supply chain management*. These three processes or flows are usually treated individually within the organization of the company. But all three processes come together to serve customers. In Figure 7 it is shown how the three processes interact.[55]

[51] Mattson, S (2002), *Logistik i försörjningskedjor,* p. 15
[52] Schary, P and Skjøtt-Larsen, T (2002), *Managing the global supply chain*, p. 23
[53] Quick MBA: Strategic Management, "Porters Value Chain", http://www.quickmba.com/strategy/value-chain/ (2007-03-27)
[54] Egen skapenlse
[55] Schary, P and Skjøtt-Larsen, T (2002), *Managing the global supply chain*, p. 23 and p. 44

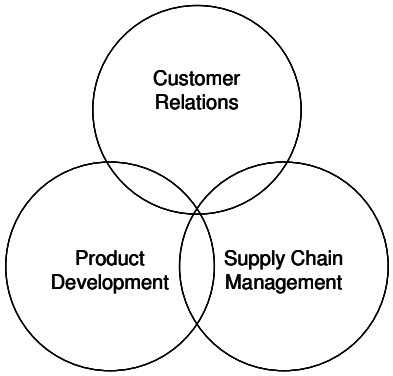

Figure 7 : The three major processes of business.[56]

The product development process is of great importance for the company because this determinates what it produces and how the company choose to compete in the market. It also defines the company's customers and their relationship to the company. The relationship between the product development and customer relations processes determine in which direction the products are developed, how they are distributed and how they meet the customer's requirements. This two processes together, product development and customer relations determine the requirements of the supply chain. They determine the supply requirements for resources, production and the physical links to customers. The supply chain management effects the customer relations through performance and efficiency and also influences product development through capabilities, capacity and distribution.[57]

A supply chain is a chain of companies, which produce raw materials, refines the raw materials and distribute it to the end customers[58]. A simple supply chain is shown in Figure 8. Here you can see the physical flow of products and materials between companies.

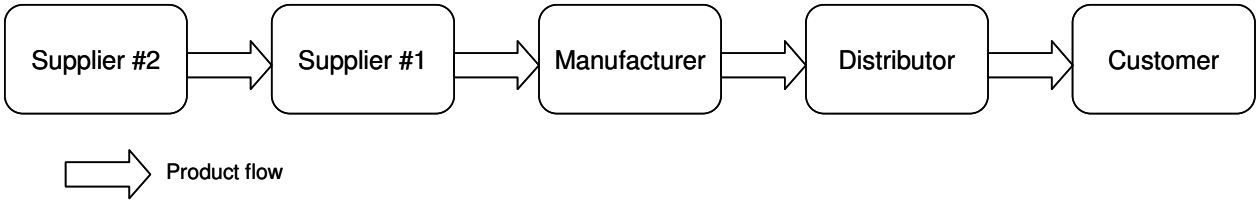

Figure 8 : Illustration of a simple supply chain.[59]

3.1.2 The structure of the supply chain

In the past the organization where defined by their activities. If the organization was manufacturing products the activity could be production or if the organization was distributing products the activities could be such as order-processing and inventory.[60]

However, these roles are shifting. When it comes to supply chains they are a series of activities that defines the process of the product flow. The management of the supply chain

[56] Schary, P and Skjøtt-Larsen, T (2002), *Managing the global supply chain*, p. 24
[57] Schary, P and Skjøtt-Larsen, T (2002), *Managing the global supply chain*, p. 23 and p. 44
[58] Mattson, S (2002), *Logistik i försörjningskedjor,* p. 15
[59] Egen skapelse
[60] Schary, P and Skjøtt-Larsen, T (2002), *Managing the global supply chain*, p. 53

cannot only be concerned with the individual activities but also with the organization of all the different activities. When it comes to supply chain management the physical flow is not the only flow that is interesting. The information flow is also very important since without it the decision making and the management becomes difficult.[61] A general supply chain with both the product flow and the information flow is shown below in Figure 9

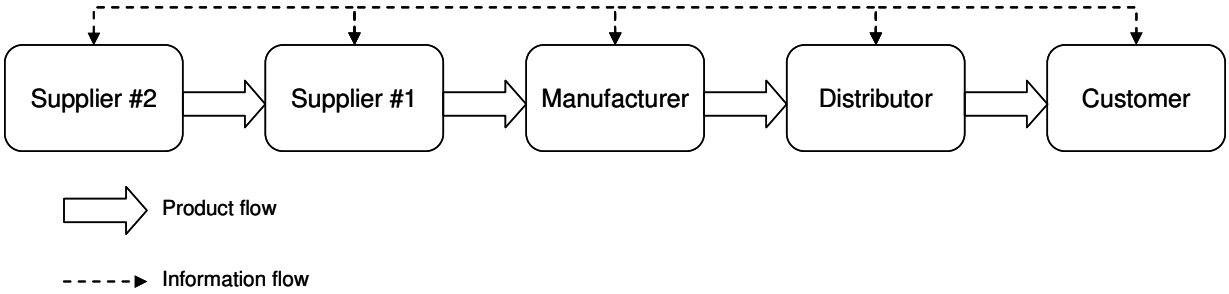

Figure 9 : A general supply chain.[62]

A conventional supply chain includes purchase, inventory and sales activities at each point in the chain. This generally tends to build inventories on forecast demands. This type of inventory system is called a push system.[63]

One objective of supply chain management is to reduce or eliminate unnecessary inventory. The inventory has two purposes for the supply chain. The first is to protect the supply chain against unpredicted demands and the second is to protect the supply chain when delays occur. With a good information flow and good coordination in the chain the unnecessary inventory can be eliminated.[64]

A pull system means that the customer pulls the order through the whole supply chain. This means that you avoid or minimizes inventories though out the whole supply chain and only make exactly the amount the customers want.[65]

Avoiding inventories altogether may be possible in theory if customers are able and willing to wait for delivery. Success for the pull system depends on the speed of production and if the demands are stable.[66]

Another type is customized ordering. This alternative involves the customer in the order-process, the customer chooses options and variations in the product. When it comes to customized ordering there are multiply approaches, and they vary based on how much of the product that is able to customize.[67]

[61] Schary, P and Skjøtt-Larsen, T (2002), *Managing the global supply chain*, p. 53
[62] Egen skapelse.
[63] Schary, P and Skjøtt-Larsen, T (2002), *Managing the global supply chain*, p. 54
[64] Schary, P and Skjøtt-Larsen, T (2002), *Managing the global supply chain*, p. 54
[65] Schary, P and Skjøtt-Larsen, T (2002), *Managing the global supply chain*, p. 55
[66] Schary, P and Skjøtt-Larsen, T (2002), *Managing the global supply chain*, p. 55
[67] Schary, P and Skjøtt-Larsen, T (2002), *Managing the global supply chain*, p. 55-56

According to Lampel and Mintzberg there are five distinct categories regarding customization: pure customization, tailored customization, customized standardization, segmented standardization and pure standardization.[68]

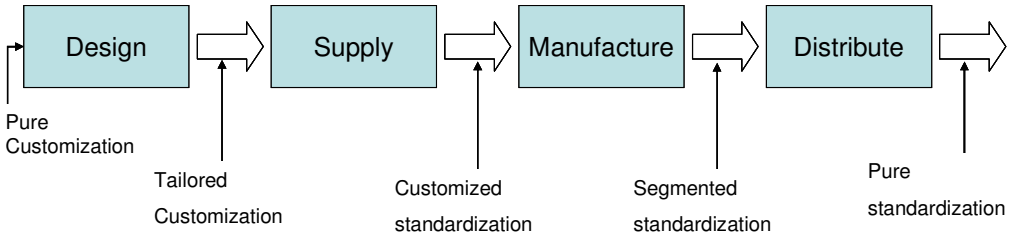

Figure 10: Options in mass customization.[69]

As shown in Figure 10 the five different categories regarding customization are[70]:

Pure Customization
Pure customization is when the customer wishes to design the product in detail themselves. Professions that may be handling pure customization are craftsmen like jeweller or a residential architect who designs to customers requests. Another thing that represent pure customization is so-called "mega projects", such as NASA's Apollo project or the Olympic Games. These type of professions and projects represent pure customization since all the stages – design, fabrication, assembly, and distribution – are mainly customized. When a product is customized in this way the traditional relationship between the buyer and seller is transformed into a partnership in which both sides are involved in each other's decision making.

Tailored Customization
Examples of tailored customization could be a tailored suit or a birthday cake with your name on it. This type of customization is when a company presents a product prototype to a potential buyer and then adapts the product to the buyers wishes and needs. This means that the company develops the design and before the product is manufactured the customer comes into the process and alters the product to his or her requirements.

Customized Standardization
Customized standardization regarding products means that products are made to order from standardized components. This means that the fabrication is not customized but the assembly of the product is. Examples of customized standardizations are modern cars and hamburgers from chains that allow customers to specify their preferences. Modern cars are a good example products regarding customized standardization since automobile companies offers the buyer the option of selecting his or her own set of components into a standard core, such as the automobile body.

[68] Lampel, J and Mintsberg, H (1996), "Customizing Customization", *Sloan Management Review*, Vol. 38, No. 1, p. 21-31
[69] Schary, P and Skjøtt-Larsen, T (2002), *Managing the global supply chain*, p. 327, figure 10.2
[70] Lampel, J and Mintsberg, H (1996), "Customizing Customization", *Sloan Management Review*, Vol. 38, No. 1, p. 21-31

Segmented Standardization
The product within this segment are standardized but with a narrow range of features. This means that a basic design is modified and multiplied to cover various product dimensions but not at the request of the individual buyers. A segmented standardization strategy therefore increases the choices available to customers without increasing their direct influence over the design or production decisions. A good product example is designer lamps since the market offers almost limitless variety of lamps, meanwhile the requests of the customers go unheard.

Pure Standardization
The strategy of Ford Motor Company during the era of the Model T is an excellent example of pure standardization. The strategy was "*any color so long as it was black*". The whole concept objective is that the buyer has to adapt or switch to another product.

3.1.3 Managing the supply chain

The concept supply chain management was established in the 1990: s. The concept was developed since there was a problem area concerning plan, develop, organize, coordinate and control the resource flow in the supply chain.[71]

Supply chain management is unique since it has to visualize a series of activities connected in a pattern, where some of the activities are within the company and some outside. The challenge is that each company within the supply chain has its own unique environment. The members of the supply chain must act as one entity since they compete together against other organizations and supply chains. The supply chain requires trust between organizations, because if the different organizations act individually there is a chance that they only think of their own interests. The result of this could be that the different companies are adding extra buffers in the inventory and extra time in their processes to secure them self against unforeseen incidents. This in turn could impact the supply chain in a negative way since the lead-time to market is prolonged, the inventory level is also increased which in turn would increase the price for the customer.[72]

Most companies are now focusing towards only holding core competencies within the company.
A core competency is a special area where the company or business holds a competitive advantage. The other activities that are not core competencies are outsourced to other businesses. This trend favours the development of the supply chain to unite activities in separate organizations as a unit. This is done to reach efficiency and superior performance in the supply chain. The problem with outsourcing is that it requires negotiation and coordination between the different businesses.[73]

A vital part of the supply chain is the information technology (IT). IT has changed business operations in several ways. IT facilitates an increase in speed and flow of information which leads to a greater control over operations and information exchange across organizational boundaries. The technology has also influenced the future development of the supply chain

[71] Mattson, S (2002), *Logistik i försörjningskedjor,* p. 76-77
[72] Schary, P and Skjøtt-Larsen, T (2002), *Managing the global supply chain*, p. 261-262
[73] Schary, P and Skjøtt-Larsen, T (2002), *Managing the global supply chain*, p. 419-420

since it enables fast and easy connections over the internet. The power of IT regarding transformation of operations and strategy is something that a business cannot ignore.[74]

One important thing is to visualize the supply chain and to bring visibility to the entire chain. For this to be possible the business has to have a good information- and measurement-system. These systems expand the scope of management and permits managers to make well founded decisions, based on information directly available in the systems.[75]

3.2 Measurements in the supply chain

It has been concluded in several studies during recent years that organisations are in need of logistical measures and measurement methods.[76]

3.2.1 Why measure?

The purpose of measurement is to guide and improve performance, providing feedback to individuals, with regard to where they stand concerning the performance metrics.[77]

According to Ljungberg and Larsson there are several reasons for measuring. These are examples which are relevant for this thesis[78]:

- *Measuring gives the answer to where? And where to?* Without measuring it is difficult to know where one presently is, where one is going and how far it is to go. Measuring is a central part in any change or improvement process.

- *Measuring gives the ability to act.* Measuring gives the ability at an early stage to control and adapt.

- *Measuring gives control through focus.* "What is measured will get done" measuring brings attention to what is important.

- *Measuring identifies problems.* Measuring facilitates the identification and understanding of a problem. Measuring does not just reveal problems it also uncovers possibilities. It will also disclose old "truths" regarding what the biggest problem is and who is responsible.

- *Measuring clarifies the relation between effort and result.* The accomplishments for an individual or a team can sometimes be somewhat unclear, and measuring clarifies their efforts. Measuring can also enhance the feeling of importance for an individual.

Measuring is crucial for efficient steering and development of an organisation.[79] A company having implemented a logistics organization must monitor and evaluate its effectiveness. This

[74] Schary, P and Skjøtt-Larsen, T (2002), *Managing the global supply chain*, p. 291
[75] Schary, P and Skjøtt-Larsen, T (2002), *Managing the global supply chain*, p. 291
[76] Bjørnland, D and Persson, G (2003), *Logistik för konkurrenskraft – ett ledaransvar*, p. 72
[77] Pritchard, R, Roth, P, Jones, S and Roth, P (1990), "Implementing Feedback Systems to Enhance Productivity: A Practical Guide", *National Productivity Review*, vol. 10, No. 1, p. 57-68
[78] Ljungberg, A and Larsson, E (2001), *Processbaserad verksamhetsutveckling*, p. 222-226
[79] Ljungberg, A and Larsson, E (2001), *Processbaserad verksamhetsutveckling*, p. 225

feedback is essential for allowing the organisation to change and will increase the likelihood for the organization of achieving its desired goals.[80]

3.2.2 What should be measured in the supply chain?

According to Holmberg, any attempt to design a measurement system should start with a company's strategy. If the company's strategy is not defined it will not matter what you are measuring, since you do not know where you are or where you are heading. Measures can be described as a link between strategic- and operational-objectives. The strategic objectives must be linked to the measures. Examples of measures that are applicable in a supply chain context are customer satisfaction, time, quality, costs and assets. [81]

The characteristics of the measures also influence to some extent what should be measured. The measures should be *Meaningful,* it is important not to measure trivial things. It is also important that the person in the decision-making position understand what is measured and how this affect the effectiveness of the organization. The measures should be kept *Simple,* if the decision-maker has to sit down and try to work out the measures is he not in control. They should also be *Operational*, enabling for the decision-maker to take action. For the measures to be meaningful it is important that they create links between actions and the effect on the organisation.[82]

3.3 Supply chain performance

Neely defines a performance measurement system as *a set of metrics used to quantify both the efficiency and effectiveness of actions*. [83] Another reason for measuring is according to Kaplan, to provide timely and accurate feedback on the efficiency and effectiveness of operations.[84] But what is efficiency and effectiveness?

Gleason and Barnum define efficiency as *the degree to which resources have been used economically* and effectiveness as *the extent to which an objective has been achieved.* [85] In simpler words efficiency is "doing things right" and effectiveness is "doing the right things"[86].

Holmberg uses the illustration below (see Figure 11) to show the consequences of applying the definition of effectiveness and efficiency to a supply chain. [87]

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[80] Coyle, J. Bardi, E and Langley, J (1996), *The management of business logistics,* p. 533
[81] Holmberg, S (1997), *Measurements on any integrated supply chain*, p. 87-89
[82] Holmberg, S (1997), *Measurements on any integrated supply chain*, p. 69
[83] Neely, A, Gregory, M and Platts, K (2005), "Performance measurement system design: A literature review and research agenda", *International Journal of Operations & Production Management*, p. 1229
[84] Kaplan, R (1991), "New Systems for Measurement and Control", *The Engineering Economist,* Vol. 36, No. 3, p. 201-218 (205)
[85] Gleason, J and Barnum, D (1986), "Toward Valid Measures of Public Sector Productivity: Performance Measures in Urban Transit", *Management Science*, Vol. 28, No. 4, April 1986, p. 379-386
[86] Chow, G, Heaver, T and Henriksson, L (1994), "Logistics performance: Definition and measurement", *International Journal of Physical Distribution & Logistics Management*. Bradford: 1994.Vol.24, No. 1, p. 17-29
[87] Holmberg, S (2000), *Supply Chain Integration through Performance Measurement*, p. 114

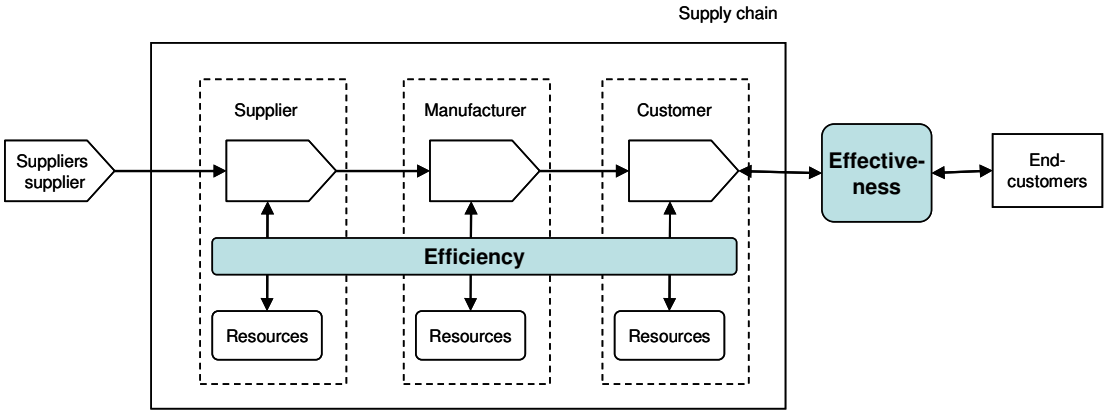

Figure 11: An effectiveness-efficiency framework in supply chains.[88]

3.3.1 Efficiency

All efficiency indicators involve a ratio between some "output" and "input".[89] The overall performance of the supply chain is dependent upon the joint performance of the firms involved. The firms need to find ways of assessing and maintaining the joint consumptions of resources. Measuring the joint supply chain efficiency can be a powerful tool for improving the total supply chain performance. When measuring efficiency in a supply chain each firm conduct internal measuring as part of their management activities. All the firms in the chain measure more or less the same thing. This provides the opportunity to compare data and this information can then be used to improve the overall performance. Comparing and sharing information throughout the supply chain is demanding. In order to compare, the measures need to have the same definition, there are also the problems with lack of data, or insufficient detail of the data from parts of the supply chain.[90]

3.3.2 Effectiveness

Effectiveness indicators should measure the extent to which the goals of the system are accomplished. These measures should generally be "cost free", and should not include ratios involving the use of resources. Before adopting an effectiveness measure it is important that the goals of a business are clear and completely identified. An effectiveness measure is only valid if it truly serves as a measure of goal achievement, it is therefore important to check that an increase in the indicators are directly related to the level of goal achievements.[91]

Effectiveness can be described as the immediate result of a process. The customer can right away decide if the product is up to expectations, specifications and that it has been delivered correctly. [92] The logical choice of measuring effectiveness in a supply chain is at the interface with the end-customer and not between intermediate firms (see Figure 11above).[93]

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[88] Holmberg, S (2000), *Supply Chain Integration through Performance Measurement*, p. 114
[89] Gleason, J and Barnum, D (1986), "Toward Valid Measures of Public Sector Productivity: Performance Measures in Urban Transit", *Management Science*, Vol. 28 No. 4, April 1986, p. 382
[90] Holmberg, S (2000), *Supply Chain Integration through Performance Measurement*, p. 117-118
[91] Gleason, J and Barnum, D (1986), "Toward Valid Measures of Public Sector Productivity: Performance Measures in Urban Transit", *Management Science*, Vol. 28 No. 4, April 1986, p. 381-382
[92] Ljungberg, A and Larsson, E (2001), *Processbaserad verksamhetsutveckling*, p. 244
[93] Holmberg, S (2000), *Supply Chain Integration through Performance Measurement*, p. 116

3.4 A Measurement system

A measuring system is a set of related measures – described by rules and procedures for data capture, compilation, presentation and communication – that in combination reflect key properties and performance of a selected process effectively enough to allow intelligent analysis leading to action if needed.[94]

The purpose of any measurement system is to help management in their decision making, the system must therefore provide information from all parts of the supply chain.[95]

A measurement system consists of three parts, *Metrics, Measurement methods* and a *Performance model*.[96] To get a clear picture of how the different parts of a measurement system interact see Figure 12. A more detailed description of the different parts of a performance measurement system can be found in the following sections.

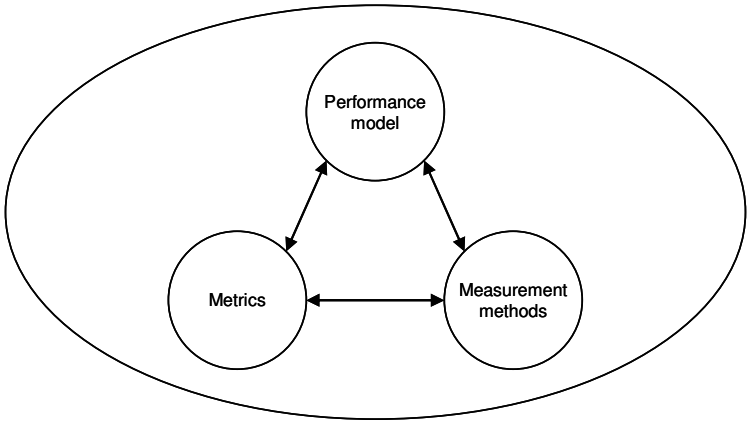

Figure 12: A measurement system.[97]

3.4.1 Performance model

The performance model is intended to be based on an organisations strategy for a particular business and will act as a guide for the selection of metrics and measurement method. It will also provide a description of the business that will give understanding and help in the selection of measures and measurement methods. The description can take many forms, the important thing is that it is informative regarding the business at hand.[98]

It is very important that the choices of metrics and measurement methods reflect critical activities within the supply chain, and that these activities contribute to the value creating for the end-customer. The purpose of the performance model is to support management in the selection and definition of the metrics and measurement methods that are to be used in the supply chain improvement process.[99]

[94] Ljungberg, A and Larsson, E (2001), *Processbaserad verksamhetsutveckling*, p. 231
[95] Holmberg, S (2000), *Supply Chain Integration through Performance Measurement*, p. 112
[96] Holmberg, S (2000), *Supply Chain Integration through Performance Measurement*, p. 109
[97] Holmberg, S (2000), *Supply Chain Integration through Performance Measurement*, p. 109
[98] Holmberg, S (2000), *Supply Chain Integration through Performance Measurement*, p. 109
[99] Holmberg, S (2000), *Supply Chain Integration through Performance Measurement*, p. 120

The process of defining the performance model can be described in four steps[100]:

1. *Uncover the business logic of the supply chain strategy.*

2. *Determine the scope of the integrated supply chain, and thus the part of the supply chain in which the measurement system should operate.*

3. *Determine the structure of the supply chain to provide useful points of measurements, facilitating analysis and restructuring if necessary.*

4. *Determine the proper level of integration between partners in the supply chain, and thus the extent to which conceptual ideas, performance metrics, and measurement methods should be aligned across organisational borders.*

A detailed description of each of the four steps follows below. Holmberg, S (2000), *Supply Chain Integration through Performance Measurement*, p. 268-274 is used as a reference for the following chapters (3.4.1.1 – 3.4.1.4).

3.4.1.1 Uncover the business logic of the supply chain strategy

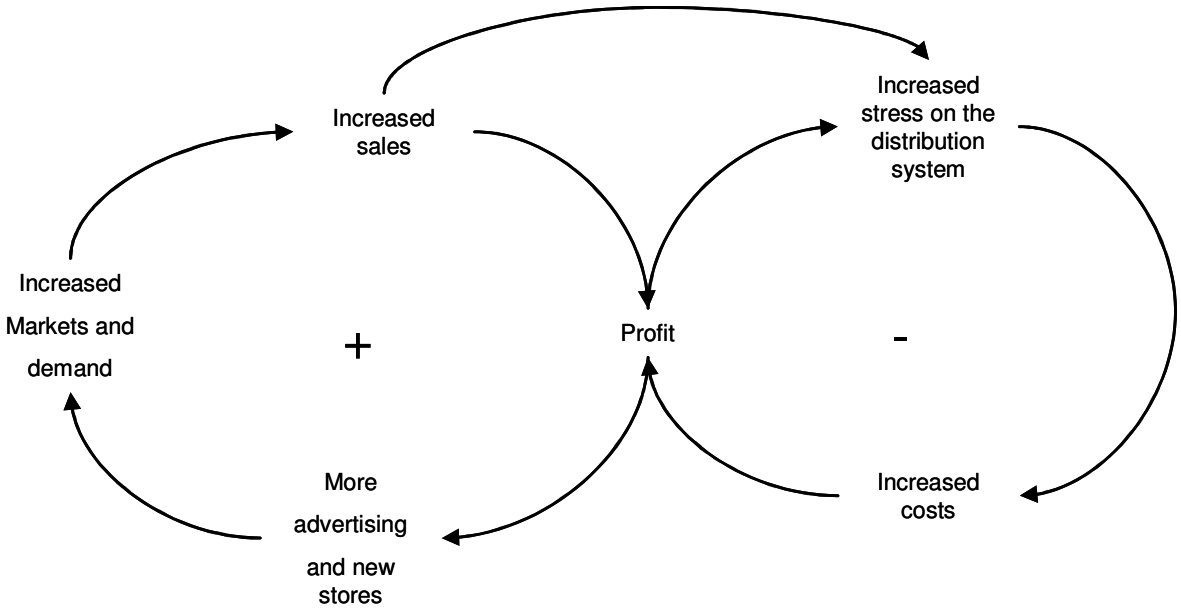

Figure 13: Example of a circular cause-and-effect relationship.[101]

Holmberg describes a strategy as a set of cause-and-effect hypotheses in relation, developed by top management. The cause-and-effect relationship can be described in many ways just as long as they make sense to the user, for an example see Figure 13.

[100] Holmberg, S (2000), *Supply Chain Integration through Performance Measurement*, p. 268-274
[101] Holmberg, S (2000), *Supply Chain Integration through Performance Measurement*, p. 269

3.4.1.2 Determine the scope of the supply chain

By determining the scope of the supply chain one has to decide who is a part of the chain and who is not. Holmberg states that it is not possible to have a close collaboration between all suppliers and customers. It is therefore important to select a number of key participants within the supply chain. An example of the scope can be seen in Figure 14.

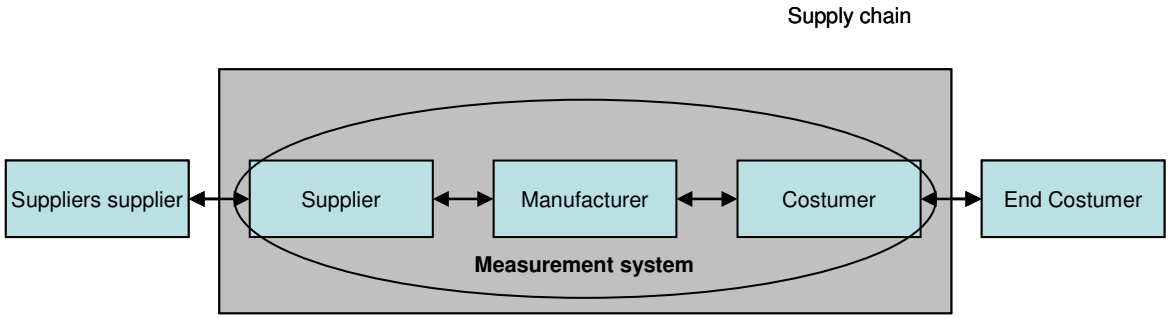

Figure 14: Example of the scope of a measurement system.[102]

3.4.1.3 The supply chain structure

The level of detail needs to be increased even more than in the scope of the supply chain. This is done to provide a sufficient level of detail for the development of a useful measurement system. Holmberg recommends the use of processes when it comes to describing how the product and services are created in the supply chain. The advantage when using processes is that it offers clear measurement points in terms of input, output and transformation. An example of the different processes that can occur in a supply chain can be seen in Figure 15 below.

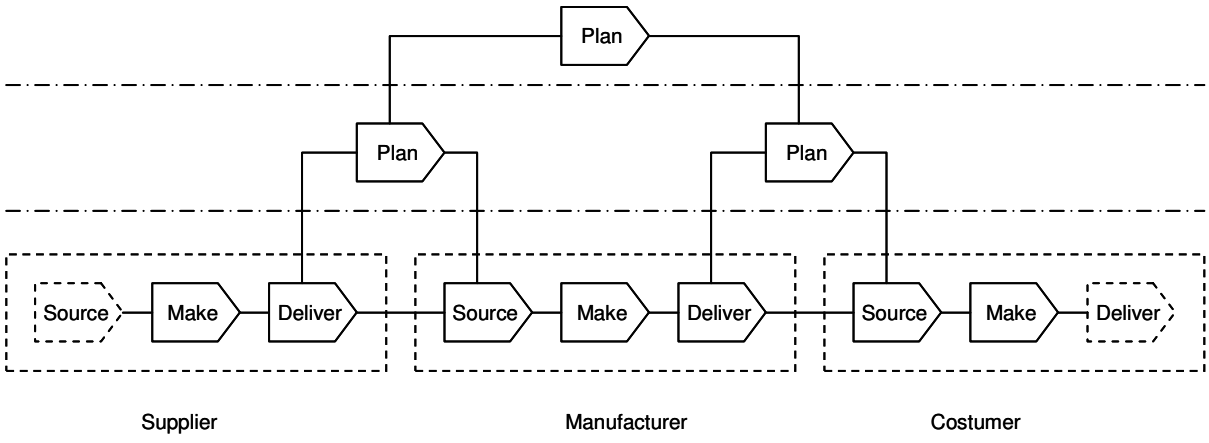

Figure 15: Example of a supply chain processes.[103]

3.4.1.4 The level of integration in the supply chain

The level of integration in the supply chain handles the issue of how many ties that are made upstream and downstream in the supply chain, but also what processes that are included and the level of integration within each process.

[102] Holmberg, S (2000), *Supply Chain Integration through Performance Measurement*, p. 113
[103] Holmberg, S (2000), *Supply Chain Integration through Performance Measurement*, p. 273

There are different levels of integration and according to Holmberg it is important to understand what distinguishes behaviour at one level from that of another.

Holmberg uses a four level model for determining the level of integration in the supply chain, this can be seen in Figure 16 below.

Phase	Performance models	Performance metrics	Measurement methods
I. Aware	Each actor has its own ideas about how business performance is created.	Each actor defines its own metrics in isolation.	Each actor defines its own measurement methods in isolation.
II. Measure	Each party still has its own idea about business performance, but recognises elements of inter- de-pendance. Unbalanced meas-urements used by one actor to exercise power over another.	Metrics focused on internal issues and on intermediate results, but without actively involving the cus-tomers or suppliers.	Each party keeps unique data for themselves, and only universal data are shared. Data structures may not be compatible.
III. Co-ordinate	Regular discussions around functions and responsibility to facilitate co-ordination af activities Both vendor´s and customer´s performance assessed.	Parities converse around metrics and objectives to establish common defini-tions and reach common goals.	Measurement methods are discussed and some unique data are shared. Data structures and tim-ing issues are resolved.
IV. Integrated	Jointly developed definitions of scope and structure expressed in, e.g.a process-based view of the supply chain.	Metrics are based on cross-organisational processes and focus on joint per-formance.	Measurement methods are aligned and based on processes. Each part has easy access to common information.

Figure 16: Level of integration in a supply chain.[104]

3.4.2 Supply chain metrics

When deciding what measures that are to be used in the supply chain, the managers needs to ask themselves why they measure and what they expect of the measured activities.[105]

Traditional measurements are to financially focused[106]. They play an important role in assessing the overall performance of a business. However they are lagging, since they show managers the consequences of their decisions but do little to predict future performance.[107] Eccles captures this in the following quotation[108]:

[104] Holmberg, S (2000), *Supply Chain Integration through Performance Measurement*, p. 275
[105] Holmberg, S (2000), *Supply Chain Integration through Performance Measurement*, p. 277
[106] Ljungberg, A and Larsson, E (2001), *Processbaserad verksamhetsutveckling*, p. 218
[107] Eccles, R and Pyburn, P (1992), "Creating a Comprehensive system to measure performance", *Management Accounting,* October, p. 41
[108] Eccles, R and Pyburn, P (1992), "Creating a Comprehensive system to measure performance", *Management Accounting,* October, p. 41

"Using financial measures to improve performance is like concentrating on the scoreboard in a football game. While the scoreboard tells you whether you are winning or losing, it doesn't provide much guidance about the plays that should be called."

According to Eccles, information about the midway decisions that eventually affect the score is needed. Information like how well the quarterback is passing, how well the defence is stopping the opponents attack, and so on. Measures are needed of the underlying processes and prior outcomes that lead to superior financial results. Many companies recognise the value of broadening their measures to include customer satisfaction, quality, innovation, and similar result. This is done to prevent short-term orientation. [109]

There is no absolute truth when it comes to the choice of supply chain metrics. What metrics to choose depends on the situation, including the strategic objectives of the business.[110] Below in Figure 17 is a general table of metrics that can be applied to any supply chain.

Target group	Lagging metrics	Leading metrics
Customers	Customer satisfaction Customer loyalty	Product availability Visitor conversion rate Responsiveness to costumers demand for new products and services
Shareholders (Financial)	Revenue growth Profitability Return on supply chain assets. Costumer growth & prifitability	Sales (growth) per marketing channel Profit margin per channel and supply chain partner Asset utilisation Structural flexibility
Learning/ growth	Employee satisfaction Employee productivity	Climate for actions Strategic job coverage ratio Cross-organisational collaboration Shared data set ratio
Internal business processes	Supply chain response time Total logistics cost Product/service quality	Product development/phase-out cycle time Product volume per channel Degree of information sharing

Figure 17: A general table of supply chain metrics.[111]

Below is a matrix of supply chain measures (Figure 18) offered by Holmberg. The measures are based upon Holmbergs experiences of IKEA supply chains.

[109] Eccles, R and Pyburn, P (1992), "Creating a Comprehensive system to measure performance", *Management Accounting,* October, p. 41-42
[110] Holmberg, S (2000), *Supply Chain Integration through Performance Measurement*, p. 275-278
[111] Holmberg, S (2000), *Supply Chain Integration through Performance Measurement*, p. 277

Category	Metric
Product Range	- sales figures - gross margin - product range size
Costs	- inventory tied up in stock - weeks of supply
Quality	- customer returns
Goods availability	- availability in warehouse - availability in stores

Figure 18: Supply chain metrics.[112]

3.4.3 Measurement method

The measurement method can be described as the way data is transformed into meaningful actions.[113] Ljungberg and Larsson presents six steps in transforming data into action[114]:

1 Data capture – what data should be registered?
2 Compilation – how will the data be processed for it to become information?
3 Presentation – how will the results be presented?
4 Communication – to who shall the information be communicated?
5 Analysis – who will analyse what and how?
6 Action – which decisions or actions could the information lead to?

The six steps above are described in greater detail below in chapters 3.4.3.1 – 3.4.3.5 and the reference for these chapters is Ljungberg, A and Larsson, E (2001), *Processbaserad verksamhetsutveckling*, p. 227-230.

3.4.3.1 Data capture

Data capture means the registration of a certain variable. Data can be captured manually or automatically, for instance with the help of the company's business system. Even if it is preferable to use automated data capture one should not totally disregard the manual collection. Automated capture should be used when the measure is believed to be interesting for a long period of time.

3.4.3.2 Compilation

Compilation refers to how the captured data is processed. Examples of compilation are calculation or structuring of data, it can also be a matter of classification.

[112] Holmberg, S (2000), *Supply Chain Integration through Performance Measurement*, p. 131-132
[113] Holmberg, S (2000), *Supply Chain Integration through Performance Measurement*, p. 137
[114] Ljungberg, A and Larsson, E (2001), *Processbaserad verksamhetsutveckling*, p. 227-230

The formulas that are used should be as simple and understandable as possible. Different quotients should be presented as a percentage due to the volume independence. This can also prove to be a weakness. Measures that are presented as a percentage can hide real problems compared to absolute numbers. For example 2 % cassation might not sound high but if one translates that into tons or how much money the cassations costs it will be perfectly clear if something has to be done or not.

3.4.3.3 Presentation

The presentation of the compiled data is important since this is the foundation for the analysis. Good graphics in the presentation will usually give a greater commitment for the analysis work. Diagrams and illustrations can interest people who wouldn't study numerical results. A good picture is often easier to interpret than a numerical table.

3.4.3.4 Communication

Even if the information is presented in a good way it does not mean that the information will be available or presented to the right people. The results must be communicated to the right people, the ones that are affected by them or for one reason or another might take an interest in them.

3.4.3.5 Analysis / Action

All measuring must be conducted in a way which will allow for a relevant and intelligent analysis. The purpose of measuring is not to create diagrams but to create a foundation for decision making and control. If one has to question what analysis that can be done with the proposed measures or what action that can be taken as a result of the presented information, one then has to question if the measures are correctly defined or useful at all.

The action that will be taken as a result of the analysis depends on the business-culture and the organisational structure.

3.4.4 Points of measurement

Holmberg defines two different models when it comes to choosing points of measurement depending upon what performance one wishes to measure. There are the single-point-measurements and the multiple-point-measurement.[115]

3.4.4.1 Single-point-measurements

Single-point measurements take place late in the supply chain, close to the customer. Typical single point measurements are sales, service level in store and customer claims. What is characteristic about these measures is that the information often is made available to other members of the supply chain. Since the measurements are conducted only at one point in the supply chain less coordination between the actors is needed, and this makes the measures easier to implement.[116] (See Figure 19)

[115] Holmberg, S (1997), *Measurements on any integrated supply chain*, p. 163-165
[116] Holmberg, S (1997), *Measurements on any integrated supply chain*, p. 164-165

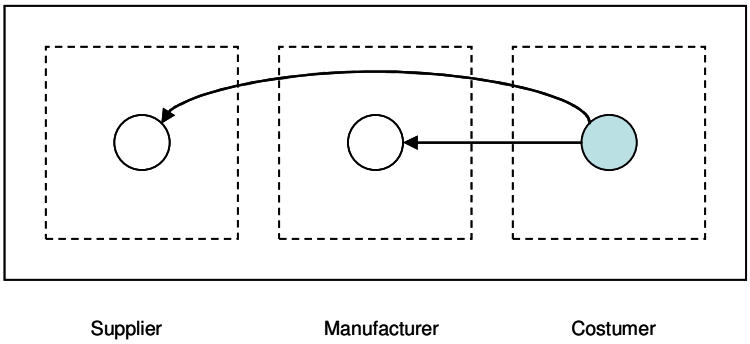

Figure 19 Single point measurements.[117]

Different measures have different characteristics. Customer-claims information is often structured so that an organisation can choose one or several measures and act accordingly. Sales information might not require any action to be taken but can facilitate planning activities.[118]

Single-point measurements primarily influence coordination[119]. For instance, firms can use point-of-sale data and information about customer claims and goods availability upstream in the supply chain to change processes so that they better align with customer needs and expectations.[120] Sales information can also contribute with timely information regarding changing customer buying behaviour which in turn helps when coordinating the necessary activities to meet customer requirements.[121]

3.4.4.2 Multiple-point measurements

Measurements conducted along the supply chain are called multiple-point measurements. Characteristic measures are cost and inventory. In order to provide comparable information from the actors in the supply chain, the data collected must be compatible. This requires an extensive work regarding the coordination of the definitions of the measures and routines for collection and compilation.[122] (See Figure 20)

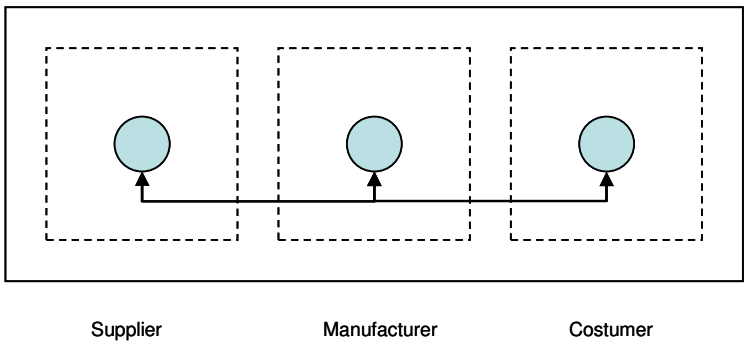

Figure 20: Multiple-point measurement in a supply chain.[123]

[117] Holmberg, S (1997), *Measurements on any integrated supply chain*, p. 163
[118] Holmberg, S (1997), *Measurements on any integrated supply chain*, p. 164-165
[119] Holmberg, S (1997), *Measurements on any integrated supply chain*, p. 165
[120] Holmberg, S (2000), *Supply Chain Integration through Performance Measurement*, p. 177
[121] Holmberg, S (1997), *Measurements on any integrated supply chain*, p. 165
[122] Holmberg, S (1997), *Measurements on any integrated supply chain*, p. 163
[123] Holmberg, S (2000), *Supply Chain Integration through Performance Measurement*, p. 119

Since the data is collected at an organisational level it is possible to compare one part of the supply chain with another. This in turn will help in the decisions regarding shifting tasks between members of the chain. Thanks to measurements it is possible to achieve comparability of the activities in the different organisations. This will facilitate benchmarking, which in turn will help the development of work procedures.[124]

3.4.5 Important characteristics of a measuring system

According to Holmberg the most important characteristics of a measuring system are[125]:

It should be based on and support a company's strategy.
Measures help focus on what is important. A measurement system must thereby be based on the company's strategy.

It should give a good representation of the underlying process.
A measurement must give a balanced view of both long- and short term results. It should also reflect the characteristics of the process so that good decisions can be made.

It should be action oriented and enable improvements by enhancing understanding and learning.
The system must be easy to use and understand. It must also contribute to the understanding of the mechanisms of the business and support learning.

It should be dynamic and adaptable to change.
Since the business environment is in constant change the system must be adaptable to these changes.

3.5 Information system development in theory

The starting point for building or improving an information system is the recognition of a problem or a belief that a better information system could create benefits for the business. The challenge of applying IT and information systems effectively falls as much on business professionals as on IT professionals. This is clear when one looks at the phases in building and maintaining systems. Figure 21 shows the four development phases that a system has to go through. The four different phases are: *initiation*, *development*, *implementation* and *operation and maintenance*.[126]

[124] Holmberg, S (1997), *Measurements on any integrated supply chain*, p. 163
[125] Holmberg, S (1997), *Measurements on any integrated supply chain*, p. 67-68
[126] Alter, S (1999), *Information system*, p. 4 and p. 422

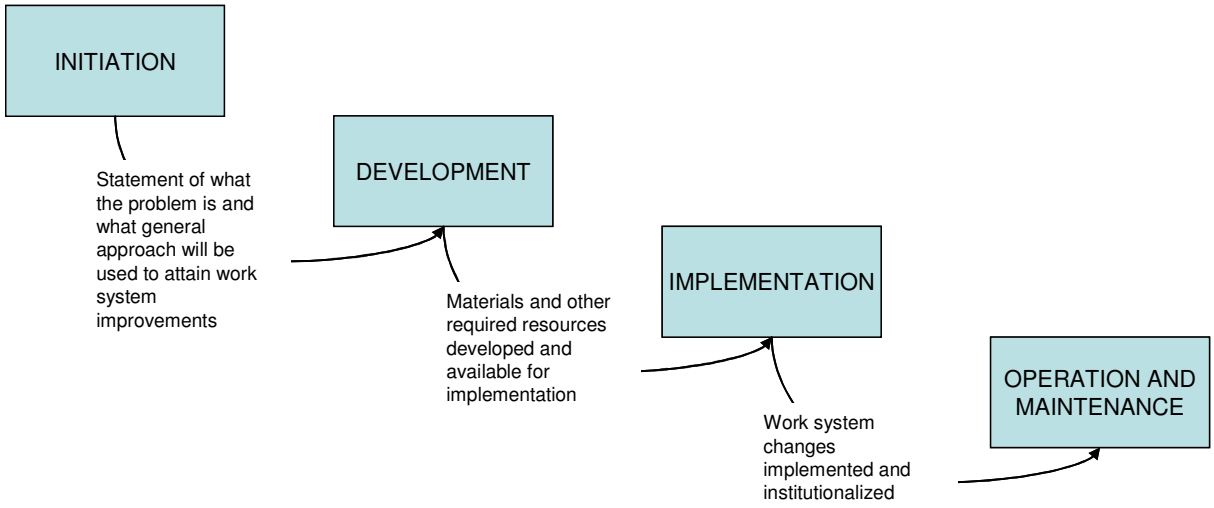

Figure 21: Four phases of a system.[127]

3.5.1 Initiation phase

Initiation is a process that defines the need for a change regarding an existing work system. This process should identify the people that are involved when it comes to decision-making. The process should also describe in general terms how the interaction between the information system and existing business system should work and how the people involved should work. This phase may be initiated when problems are recognised in the existing system. The initiation phase can also be a planning process in which the organization is searching for ways to improve and innovate. Usually when it comes to this phase there is a verbal or written agreement concerning the directions of how the business and information system should change.[128]

3.5.2 Development phase

The development phase is a process of acquiring and configuring hardware, software and other resources that are needed to execute the functions. The phase starts by deciding how the business will operate both regarding how the computerized and manual parts of the system will work. The next step is acquiring the needed resources, if not all the hardware that is needed is in place someone has to buy and install it. When it comes to software there are three options if the company does not have the required software. The different options are: purchasing the software, producing it from scratch or modifying existing software. [129] A more detailed description can be found in section 3.5.2.1 – 3.5.2.3.

3.5.2.1 Purchasing software

When it comes to purchasing standard software, it can be both overwhelming and time-consuming to choose the right software. In an organization purchasing of software can be similar to the process for buying any critical components. To make the purchasing of software

[127] Alter, S (1999), *Information system*, p. 5
[128] Alter, S (1999), *Information system*, p. 4-5 and p. 423-424
[129] Alter, S (1999), *Information system*, p. 5 and p. 424

easier: analyse the business true needs, analyse the market, set a budget, and investigate and test the different products.[130]

3.5.2.2 Producing new information system from scratch

The information system should contain processes and product information and should permit data to be entered into a database. The user should be able to choose to extract data with various search criteria to generate a report. The report should preferably present data in a graphic fashion.[131] The functions of a good information system are shown in Figure 22.

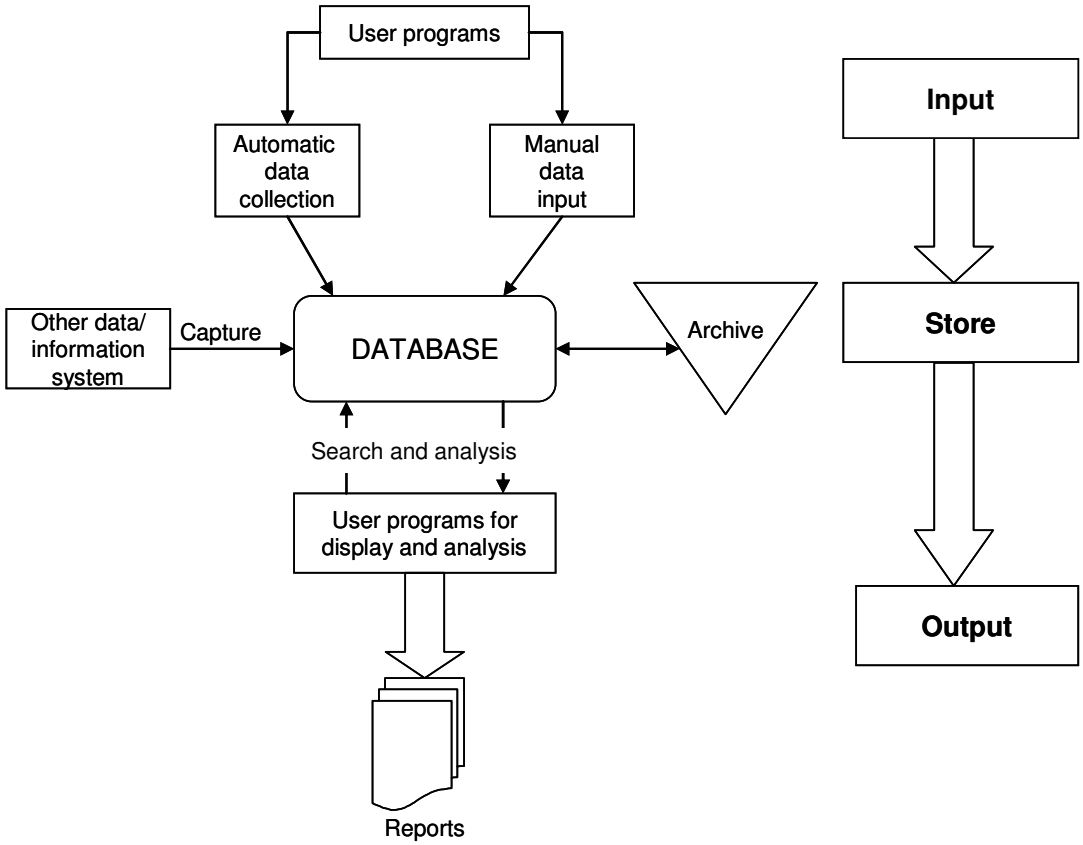

Figure 22: Visualisation of a good information system.[132]

The three major parts of the information system are, data input, the database and the output in forms of reports. A description of the different parts follows below[133]:

Data input

When it comes to the data input it should be possible to input data in two different ways, either automatically or manually. When it comes to the manual inputting of data is it crucial that the data is validated and if it is the wrong type of data an error message should appear. For the application it is important that the terminals or forms where the manual inputs are made are designed specifically for that type of input to minimize errors.

[130] "Basics of the software buy ". *Purchasing*, Boston: Mar 1, 2007. Vol. 136, Iss. 3; p. 40
[131] Oakland, J (1993), *Total Quality Management,* p. 135
[132] Oakland, J (1993), *Total Quality Management,* p. 135
[133] Oakland, J (1993), *Total Quality Management,* p. 135-136

The database
A vital thing is that the structure of the database should be understood by its users. The system should be capable of storing all data and information introduced into the database. The programs used to access the database should not require optimization for different applications and should be easy to use for its users.

The output
The design of the output should be in forms of reports. Normally the output generator consists of two parts. The first part should be a configurator and the second an interpreter. The configurator should provide the user with the means to build or adjust the reports through instructions and choices while the interpreter should generate the reports. The report should contain graphics in form of diagrams, tables figures etc.

3.5.2.3 Modifying an existing software

When a system has been set to use, it is inevitable that changes has to be made for it to remain useful. New requirements emerge and existing requirements change. Business change often generates new requirements for existing software. The process of changing software after delivery is often called maintenance. Changes made to existing software can be in the form of correcting coding errors or more extensive maintenance in the form of adding new functions. Adding new functionality is expensive because a lot of time is spent understanding the system and analyzing the impact of the proposed changes to the system. For a custom made system, the costs of maintaining the software generally exceed the software development costs. [134]

3.5.3 Implementation phase

In this phase, it is important to make the new system operational in the organization. The activities in this process are planning, user training, adaptation to the new system, and follow-up to make sure that the system is working effectively. This phase may involve changes in the way people work or how the organization operates. So the conversion has to be planned and executed carefully to prevent errors or even disorder.[135]

When it comes to the information system the best approach is to use both the new and the old system during a limited period of time. This helps and facilitates identifying problems that might require the information system to be modified before the implementation phase is complete.[136]

3.5.4 Operation and maintenance phase

The operation and maintenance phase is a process that checks the ongoing operations of the system and tries to improve either the system or correct bugs in the system. One important thing in this phase is that someone is in charge of ensuring that the business is operating fine.[137]

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[134] Sommerville, I (2004), *Software Engineering 7*, p. 489-509
[135] Alter, S (1999), *Information system*, p. 5-6 and p. 424-425
[136] Alter, S (1999), *Information system*, p. 5-6 and p. 424-425
[137] Alter, S (1999), *Information system*, p. 6 and p. 425

4 Empirical studies

In the following chapter the authors describe the empirical information gathered for this thesis. The reader will be introduced to the PERSONLIG supply chain, the performance of the PERSONLIG supply chain, and the measurement system for PERSONLIG worktops.

The majority of the empirical information in this chapter is based on interviews with Johan Ström, project leader and Nils Strand, Supply Planner for the PERSONLIG business. The main part of the material in this chapter has been gated using unstructured interviews in the form of discussions, it is therefore difficult to refer the material to a specific date and person, however all the information gathered for this thesis comes from the four people listed in this section. The interviews are to be regarded as the source of information if nothing else is stated. Information concerning the deviating flow in Sweden has been gathered from unstructured interviews with Linda Andersson and Anna Svensson at IKSC in Älmhult.

4.1 The supply chain of PERSONLIG

This chapter will describe and explain how the supply chain of PERSONLIG works and how both the information and the physical flows are constructed. The last part of this chapter will describe what happens when deviations in the supply chain are reported.

4.1.1 The product

The product focused upon is a worktop for the kitchen with the name PERSONLIG. An example set of custom made worktops can be seen Figure 23. One thing that is different with this product compared to the rest of the IKEA range is that this product is a tailored customized product. This means that the customer can customize the product after his or her demands. IKEA is offering this product since they know that a big share of their kitchen customers is in need of longer worktops without any unpractical joints. Other needs that IKEA have identified are that the customer wants to make kitchen islands that are tailored for a specific kitchen or that they would like to have a solution to the problem with a kitchen without perpendicular corners.

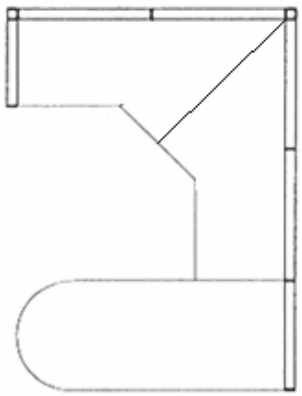

Figure 23: A set of custom made worktops.

IKEA is offering PERSONLIG worktops in four different materials. The different materials are: solid wood, laminate, stone and acrylic. Some of the additional things to choose from except the size of the worktop are: how the edges should look, where the holes and cuts should be, in what kind of materials the edges should be, and want kind of sink the customer would like to have and so on.

The worktop gets home delivered with the rest of the kitchen and in normal cases the lead-time from placed customer order to delivery is five weeks.

4.1.2 The structure of the supply chain

The business for PERSONLIG starts and ends with the customer. The customer initiates the business by making an order in a store. After the order is placed, the store sends the order to the trading agent that is responsible for that country. Then when the supplier gets the order from the trading agent they start to plan their production.

Approximately five weeks later the customer's bell or telephone rings and a delivery truck wants to deliver the worktop with the rest of the kitchen, if the customer has also ordered a kitchen. During these 5 weeks the worktop has been manufactured (at suppliers), transported to a Customer Distribution Centre (CDC), where it has been co-consigned with the rest of the kitchen, and transported to the end customer. The flow of goods and information is shown in Figure 24.

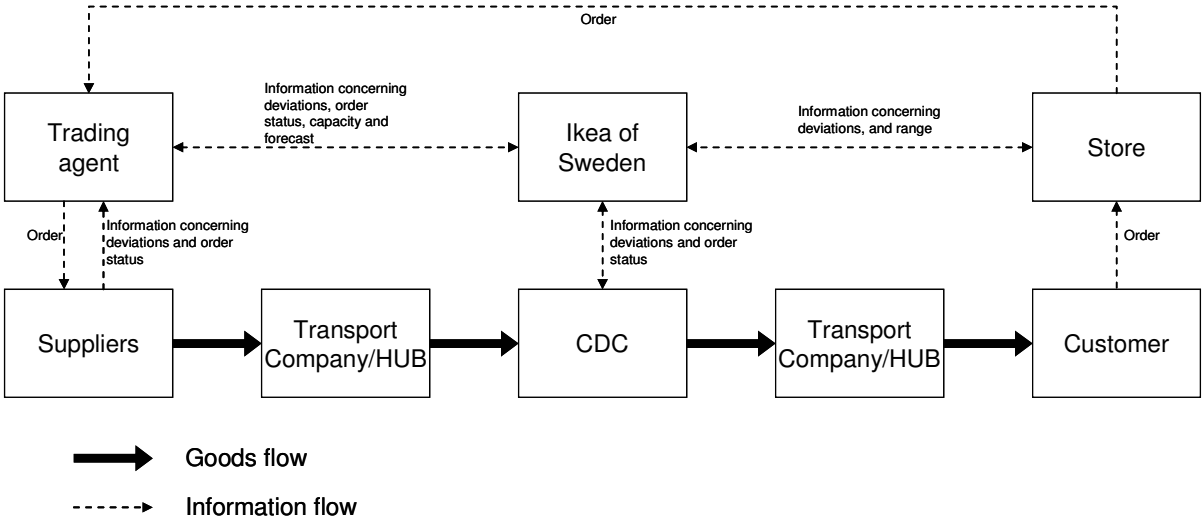

Figure 24 : The PERSONLIG supply chain.

The illustration (Figure 24) above is somewhat simplified since it does not describe all relations of the information flow, that is to keep the illustration simple. For example, IoS acts like the spider in the web, coordination and administers the supply chain. IoS also integrates the different parts of the IKEA organisation.

Below follows a presentation of the different actors involved in the PERSONLIG supply chain.

4.1.2.1 Suppliers

The product PERSONLIG has five suppliers, which are situated throughout Europe. The suppliers are covering certain areas, for example it is not the same supplier that serves France as Sweden regarding solid wood worktops. A predefined matrix states which supplier that supply a certain country or market. Some of the suppliers only supply one kind of worktop material while others suppliers have all the materials. The suppliers vary in size and capacity.

4.1.2.2 Transport companies/HUB

For the Swedish market there are several companies that are responsible for the transportation of the worktops. The transporters are decided in most cases on a country level. One important thing with the transport companies is that they have a good network of HUBs, since the HUBs are used in some cases as distribution centres or points of co-consignment. The transport companies making the transport between supplier and HUB is often a local company without any real connection to the IKEA organisations. The transport company making the customer delivery on the other hand has a contract with IKEA. The transport solutions can vary depending upon which country that is viewed, but the principle is the same for all the countries and can be seen in Figure 24. The HUB is a co consignment solution that is used by the transport companies to achieve a maximum ratio of filling regarding the truck loads.

4.1.2.3 Customer Distribution Centre (CDC)

In Sweden are there two Distribution Centres (DC), one in Älmhult and one in Jönköping. The DC in Jönköping is also working as a CDC. Typical activities at a DC are administration and physical handling of goods for delivery to different stores. The CDC handles all customer orders that are in need of home delivery, co consigning, storing and moving goods.

4.1.2.4 Store

The IKEA stores are a part of the IKEA retail organization. There are 16 stores and one mail order unit in Sweden. The mail order unit is also acting as an on-line shop. The stores are separate business units and each store is responsible for its own financial result.

4.1.2.5 IKEA of Sweden

IoS is located in Älmhult. The traditionally focus of IoS has been on product development, and taking the full responsibility for the efficiency and effectiveness of the product range. They should act as a co-ordinator and facilitate the management of the supply chain. IoS is divided into different business areas with a responsibility for a certain group of articles. For example, a business area can be Kitchen and Dining, another can be Bedroom.

4.1.2.6 IKEA trading agent

Each country, in which IKEA is operating, has a trading organization. Their main task is to match the supplier's capability and capacity to IKEA of Sweden's needs and terms. The trading organization must also communicate the requirements of IKEA to the suppliers and try to develop long-term relationships with them.

4.1.3 Deviation flow in Sweden

This part of the thesis is based on interview with Linda Svensson, deviation case handler, Anna Svensson, deviation case handler, and an internal IKEA rule concerning the deviation flow.

The deviation flow in Sweden starts when a customer calls IKEA customer service centre (IKSC) or visit a store with a complaint. IKSC is a call centre in Älmhult, and their job is to solve customer related problems. They work with receiving complaints and tries to solve the customers problems so that they can be satisfied. When it comes to PERSONLIG, there is a special group of people with knowledge of the PERSONLIG business. This group handles all complains regarding PERSONLIG, since this product is very different compared to the rest of IKEA's range.

If the customer complains in the store, the store sends an e-mail, or in IKEA terms a MEMO (which is the IKEA mail system), to IKSC saying that the store received a complaint. The MEMO that the store sends contains the customers contact information and which order it concerns. When IKSC gets the stores mail, they contact the customer and create a customer complaint case, which IKEA calls a Service Action Case (SAC). An illustration of the flow can be seen in Figure 25.

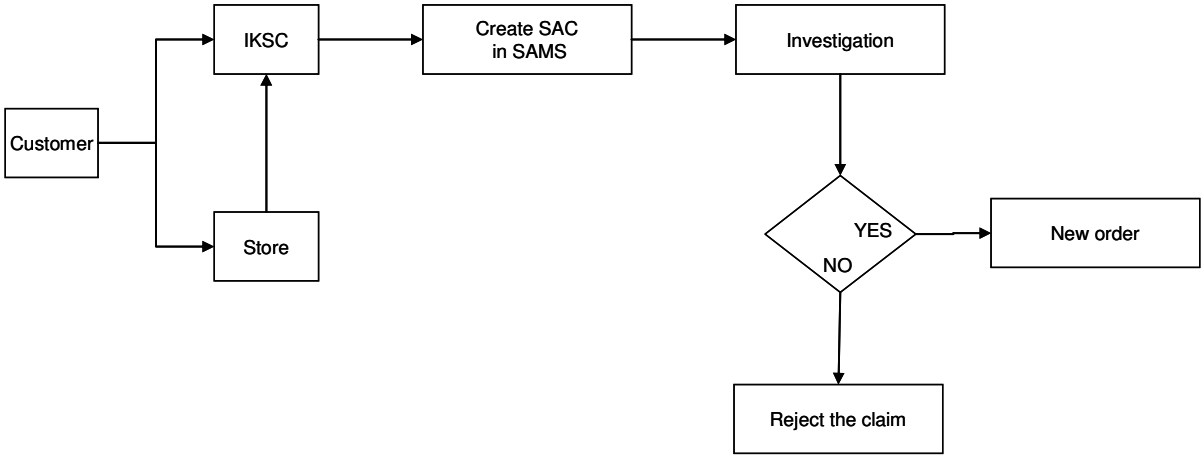

Figure 25: Showing the deviating flow, when the customer reports deviation.

If the customer chooses to call the IKSC directly with a complaint, IKSC takes the customers contact information and order information and logs this as a SAC.

The complaint, SAC, is registered using a system called Service Action Management System (SAMS). SAMS is used to administrate the customer complaints when updating or adding information to the different cases (SAC: s).

After a SAC is created, IKSC proceeds with an investigation. The aim of the investigation is to get to the bottom of the problem so that the customer can get a new worktop. In the beginning of the investigation the case handler at IKSC registers a qualified guess to what the cause of the problem is. This is shown in the SAC as a *reason code* and *causing department*. The reason code states the nature of the problem, for instance product defects or handling defects. The casing department states who are responsible for having caused the problem, for instance which supplier that caused a product defect. During the investigation IKSC ask the customer to provide them with information and photos so that they can determine the actual

cause for the damage. The time for an investigation varies a lot, mainly because the customer does not send photos and information to the IKSC. The time of an investigation should normally not take more than 72 hours, if the customer provides IKSC with pictures and information when they are asked.

When the investigation is completed and IKSC has determined what the problem was, IKSC enters the correct reason code and causing department into the SAC. When this is done there are four different ways to proceed for IKSC. The different ways regarding the customer's complaint are: *order a new worktop*, *pay out compensation*, *reject the claim*, or *a combination of ordering a new worktop and compensation*. Which way IKSC chooses to act depends on the situation and what the cause was and who was responsible for the damage.

There is another type of deviation flow in Sweden and it is when damage arises on a HUB or at the CDC, see Figure 26. If the people at the HUB or the CDC finds a worktop that is damaged, they sends a MEMO to IKSC stating what was wrong with the worktop and sends the damaged worktop to the store where the worktops originally was sold. When IKSC gets the MEMO from the HUB or the CDC, IKSC creates a SAC and sends a new order to the supplier. The new production order which IKSC sends is a prioritized order, so the customer only gets the shortest possible delay. After IKSC orders a new worktop they inform the custom about the delay. A standard replacement worktop is provided for the customer that is to be used while the customized worktop is in production. IKSC also conducts an investigation to be able to determine who is responsible for the damaged worktop.

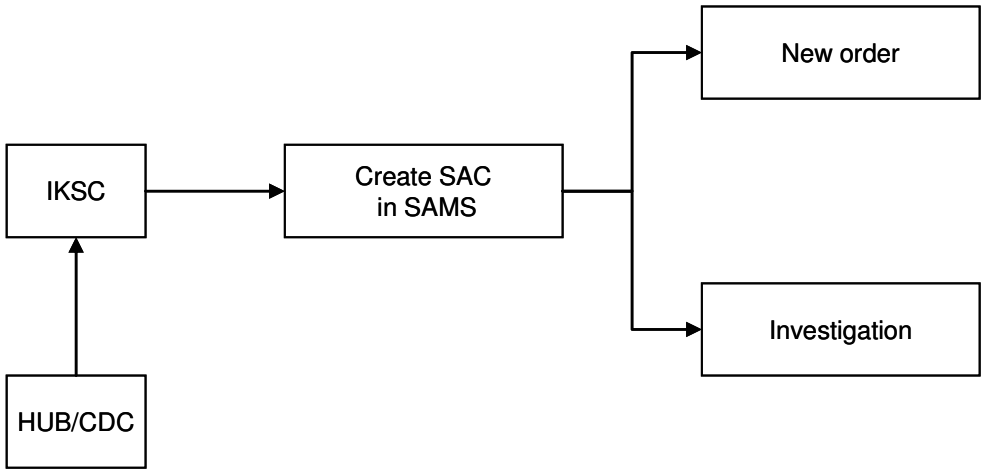

Figure 26: Deviation flow when the HUB reports deviation.

4.2 Performance of the PERSONLIG supply chain

IKEA wants to offer a complete set of solutions, including a great choice of design/material and functions of worktops. IKEA thinks that this would create and maintain a high customer satisfaction regarding the business of the product PERSONLIG. One problem concerning this product is that it is custom made and cannot be kept in stock. In addition it is large and heavy so the probability for transport and handling damages is high.

Another problem regarding the worktops is that they have a tendency to miss the set delivery date. This causes problems since the customer often have installed the rest of the kitchen and cannot use it to its full extent since the replacement worktop is not custom made to the customer's kitchen. This in turn have negative impact on customer satisfaction.

One of the main problems regarding the performance of the supply chain is that there are no effective follow-up regarding this business, IKEA do not know how many customer orders for custom made worktops they have, or how many of them that have sustained some sort of damage in the supply chain. Another thing that is missing is the joint effort concerning developing definitions of metrics that can be used for measuring supply chain performance for different parts of the PERSONLIG supply chain.

4.3 The Measurement system for PERSONLIG

Today there is no effective measurement system when it comes to the PERSONLIG business. The only currently available measurement system is a manual follow-up conducted by IKSC (see section 4.1.3). The standard IKEA systems that are presently used are not equipped to handle this kind of business. The problem with the systems is that they operate on an article level, which works for all IKEA products except PERSONLIG worktops, since the industry standard for custom made worktops is on an order level. Another problem with the standard systems is that they operate on standard off the shelf products, and cannot facilitate the necessary tools for the handling of custom made products. This results in problems with capacity planning and forecasting, since it is hard to attain information regarding actual sales on an order level in the standard systems. When it comes to custom made worktops, the industry standard is on an order level. This means that they do not count individual worktops, they count orders of worktops. For instance one order can consist of multiple worktops.

4.3.1 Performance model

The strategy for the PERSONLIG supply chain is to supply the customers with complete worktops within the right time, right quality, right quantity, and right condition. IKEA has also set goals concerning the overall performance of the supply chain regarding deviations. The only goal set by IKEA is to reduce the deviations to below X[138] %, which means cutting supply quality deviations to X[139] %, sales quality deviations to X[140] %, and product quality deviations to X[141] %. All the goals are put in relation to the number of customer sales.

The strategy for the PERSONLIG supply chain is to deliver worktops according to:

Right Quality
Quality according to IKEA's technical specification.

Right Quantity
According to order quantity, not more not less.

Right Time
According to agreed lead-time.

Right Condition
According to IKEA's requirements regarding: label, packaging, and palletize.

[138] Only available in the non public version
[139] Only available in the non public version
[140] Only available in the non public version
[141] Only available in the non public version

4.3.1.1 The business logic

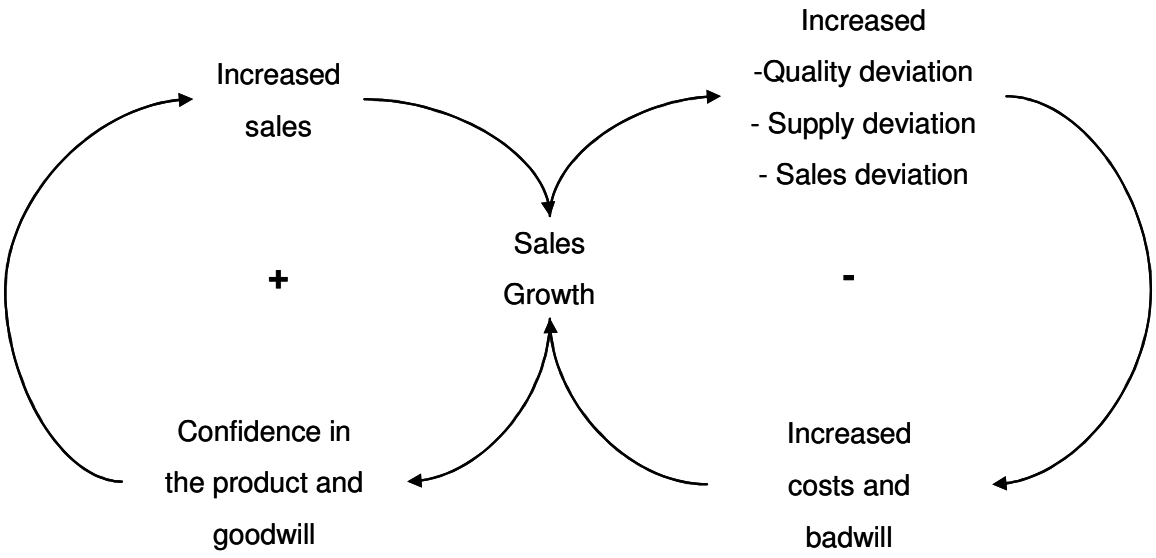

Figure 27: The business logic for the PERSONLIG business

The logic of the PERSONLIG business can according to IKEA be described with a "cause" and "effect" diagram originating from "*sales growth*", see Figure 27.

Sales growth is achieved by increasing the *confidence in the product*. This means having people selling the product which really believe that the PERSONLIG worktop is an excellent product, which can bring customer benefits. By having competent and convincing sales people, *goodwill* is created by the customer, which in turn increases the sales.

Increased sales puts more strain on the supply chain, this causes increased deviations within the chain. By not being able to deliver, or having delivered a damaged worktop the supply chain *costs* are increased and the *bad will* from the customers increase. This will decrease the sales growth completing the circles.

4.3.1.2 The scope of the supply chain

When viewing the supply chain from a measurement perspective, IKEA limits the scope of the supply chain to run from manufacturer to end customer. It is this part of the chain that IKEA feels they can influence when it comes to the PERSONLIG business.

The scope for PERSONLIG supply chain consists of five key manufactures, several CDCs, and several HUBs that are linked by different transport companies. The manufacturers are responsible for all the worktop production. Different countries have different layouts when it comes to delivering the worktops to the customer. An illustration of the scope can be seen in Figure 28. Some countries deliver to a CDC where the worktop gets co-consigned with the rest of the kitchen, others send the worktops directly to a HUB for co-consignment.

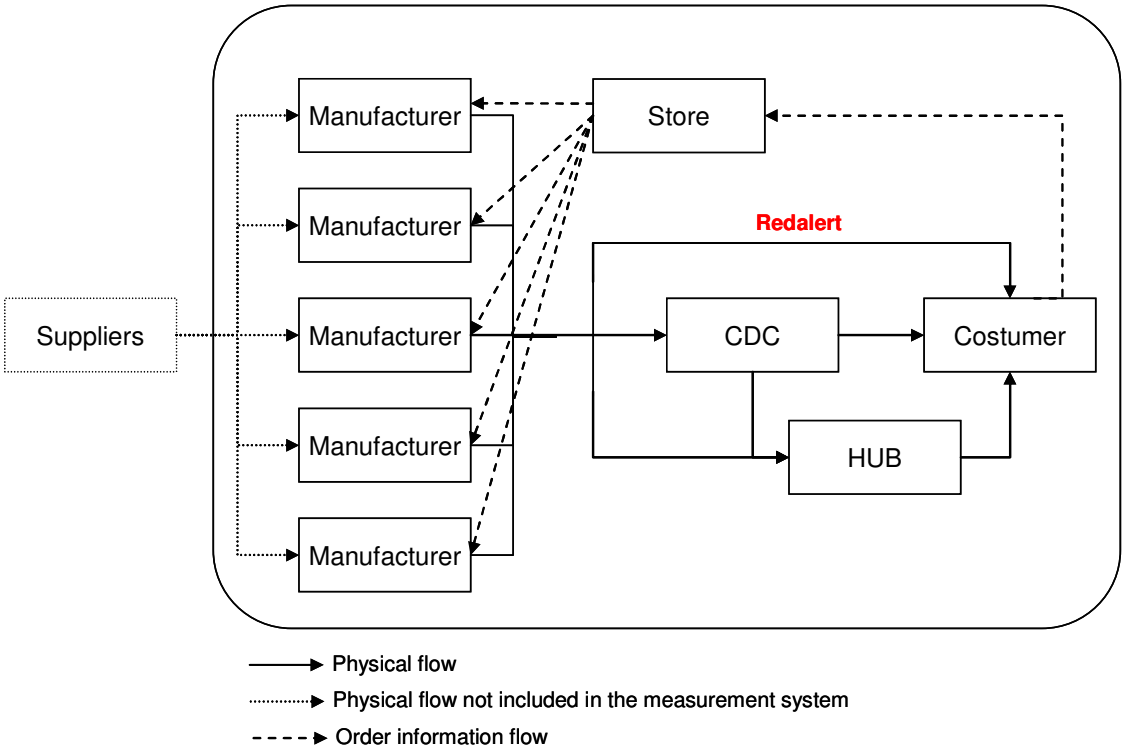

Figure 28: The scope of the supply chain measurement system.

If the worktop for some reason gets really delayed or goes missing it might end up as a red alert, which takes a different route, directly from the manufacturer to the end-customer. Red alerts are uncommon.

4.3.1.3 The supply chain structure

When viewing the supply chain in more detail certain processes emerge (see Figure 29).

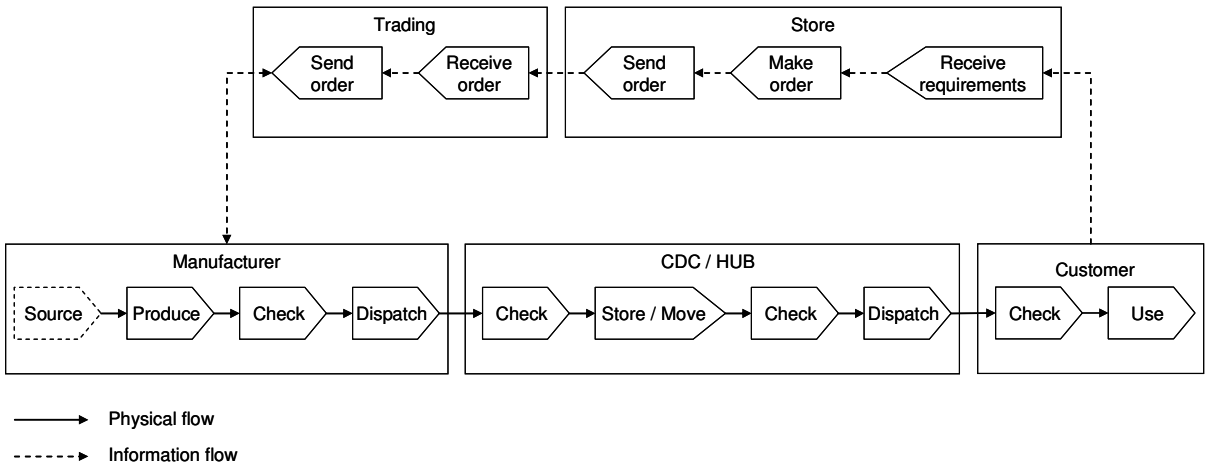

Figure 29: The processes of the supply chain.

Different actors within the supply chain have different internal processes, the actors and processes are described below. The process that activates the production of a worktop has its origin in a store.

Store
When the customer comes to the store he or she is met by a sales person. This person *receives* the customer's requirements regarding material, and other facts concerning the kitchen and the worktops. The sales person then *makes an order* by making the necessary drawings and so on. The order is then *sent* on to a trading office.

Trading
The trading agent *receives* the customer order. They check that everything is in order and *sends* the order to the supplier that serves the region with regard to worktop material.

Manufacturer
The first step in the chain is the *production* of a worktop. The worktop is produced and the finished worktop is *checked* to see that it is up to requirements. If the product deviates from the required quality the product is reproduced. When the product passes the inspection, the product is packaged and ready to be *dispatched* to a HUB or CDC.

CDC / HUB
When the worktop arrives at a CDC or HUB the package is *checked* to see that it hasn't sustained any damage during the transportation. While at the HUB or CDC the worktop-package is *moved and/or stored* within the warehouse until it has been co-consigned with the rest of the kitchen. The package is then *checked* once more to see that it has not been damaged, and after the checkpoint the consignment is ready for delivery to the customer.

If it is discovered at any of the checkpoints that the package is damaged, the HUB or CDC contacts IKSC who will notify the customer of the problem and the delayed delivery, they will also place a replacement order to the supplier. The damaged worktop will not continue in the chain, a standard loan worktop will be provided to the customer as a temporary replacement, until the new undamaged worktop can be delivered. The damaged worktop will get shipped to the store where the customer originally placed the order.

Customer
Upon arrival to the customer, he or she needs to *check* the worktop to see that there are no damages to report. If there are damages the customer takes a photo and reports the damages to IKSC who will place a new order. Once the worktop is checked and is considered to be ok for *use* the customer can fit the desktop into the rest of the kitchen.

4.3.1.4 The level of integration in the supply chain

IKEA trading handles the contacts with the manufactures. They handle the orders and decide the product lead-times. Trading has at the moment no contact with the manufacturers regarding measuring internal performance measuring at the different suppliers. It is the manufacturers themselves that conduct internal measuring, this information is however not shared with IKEA. The only information that is transmitted between the supplier and IKEA is the dispatch information concerning the orders.

The rest of the supply chain, CDC and the companies making the customer deliveries are more integrated by using the same IKEA information systems.

4.3.2 Supply Chain Metrics

When it comes to measuring in the PERSONLIG supply chain there is presently no centralized system. In Sweden IKSC conducts a manual follow-up of the reported customer complaints, which is compiled on a monthly basis and reported to the supply chain manager. The report is based upon IKEA reason codes, *Handling Defects*, *Product Defects*, *Sales Error*, *Change of mind*, *Delivery Problems* and, *Service Problems* (see section 4.3.2.1 Deviations). The report shows how the customer complaints are divided among the different reason codes.

When it comes to metrics for the PERSONLIG supply chain, Johan Ström presented the following areas that are in need of measuring, *Deviations*, *Orders* and, *Precision*. Today these areas are somewhat of a grey-zone in the PERSONLIG business. They need to be crystal clear. The areas are described in more detail below. Presently there is no effort to develop joint definitions of metrics between the different actors in the supply chain.

4.3.2.1 Deviations

Deviation in the supply chain is the most important area when viewing the PERSONLIG business according to Johan Ström. This is the area that lowers customer satisfaction significantly.

The compilation of the manual report is time consuming. IKEA has come to the conclusion that they need an automated application that will assist in the measuring and visualisation of the deviations. They have also found several areas that could increase the usability of the reports in an improvement process for the PERSONLIG supply chain. The frequency of the reports needs to be increased, reports generated on a weekly basis seems more appropriate than once a month according to IKEA. The overall level of detail in the reports also needs to be increased. Presently it is not possible to tell for instance which store is responsible for a *Sales error* or which supplier that has caused a *Product defect*.

For the categorisation of deviations IKEA uses six centralised reason codes, and several sub reason codes that are defined independently by each country. A complete list of the sub reason codes used in Sweden can be found in Appendix C. The main centralised categorise are described below.

Handling defects
In the supply chain the finished worktop-package is loaded, transported, off-loaded, moved and stored several times. If the worktop happens to get damaged during transit the damaged is categorised as a Handling defect. Examples of handling defects are pressure indentations, damaged to edges, and scratches to the surface of the desktop etc.

IKEA wants to know where in the chain the damage is done and how much of the transported goods that sustains damage and consequently who is responsible for the damage (Transport Company, HUB, and CDC etc.). This information is essential for the improvement of the supply chain according to IKEA.

Product defects
If the product has a defect that can be traced back to the production of the worktop the deviation is categorised as a Product defect. Examples of product deviations are missing fittings, bad surface treatment, bad raw materials, and loose edges etc.

IKEA would like to see how well the different suppliers perform. This means in their terms visualizing the share of deviating products that each supplier can be accountable for.

Sales error
Sales errors are mistakes made by personnel at the stores that have resulted in that the customer has purchased the wrong product. This can be wrong measurements on the drawings, ordering the wrong material or simply not supplying the customer with enough information. To be able to categorise the problem as a Sales error the problem must be traceable back to the store.

To effectively focus their educational efforts IKEA needs to know on which stores they need to focus the most resources. They believe that by showing and comparing the different stores in a quantitative way they can get the stores attention for the problems at hand.

Change of mind
If the customer returns an undamaged product the Change of mind reason is used.

The problem measuring change of mind regarding the PERSONLIG business is according to IKEA the lack of information regarding the actual reason for the customer changing his or her mind. The reason can often not directly be connected to the PERSONLIG worktop.

Delivery Problems
If the product is delayed or goes missing somewhere in the supply chain the Delivery problems reason code is used.

When it comes to this area regarding the supply chain IKEA wants to know where in the chain the worktops goes missing, is it before or after the CDC, or is it somewhere when being transported?

Service Problems
If there is a problem with the service regarding ordering via the internet or payments, for instance if a customer places an order over the internet and the article has been taken out of the range the problem is categorised as a Service problem.

The complete list of the Swedish reason codes and sub-reason codes can be seen in Appendix C (Confidential).

4.3.2.2 Orders

IKEA wants to see how many orders that are placed for a PERSONLIG worktop each week. It is not possible today to see the actual number of placed orders. This presents problems when it is time to make forecasts and avoiding reaching the maximum capacity for a specific supplier.

When viewing sales figures, IKEA uses different trends in order to see how the business is performing. The measures that are used are: *orders placed last week*, a *4 week trend*, and a *Year To Date trend* (YTD).

Orders placed last week
The orders placed last week, display how many orders that was placed during the previous week.

Four week trend
The 4 week trend, displays the average weekly number of placed orders for the past 4 weeks

Year to date trend
The YTD-trend displays the average weekly number of placed orders from the start of the fiscal year (FY) up till the present week.

The level of detail when it comes to the sales figures are to be on a country level as well as a supplier level. The two are described below.

Country/forecast
When viewing sales on a country level it is good to know how well the forecast reflects the actual number of placed orders. This is one way of assessing if the forecast is correct or if it needs to be changed. Today the forecast is on a country level, presented by the countries themselves based upon the believed number of placed customer orders. This is one of the areas IKEA wants to gain insight into on a country level, to be able to check if the countries estimates are correct.

Another area that IKEA wants to gain a clear picture of is how many customer orders that are placed in any given country with PERSONLIG sales.

Suppliers/capacity
IKEA would like to know how many orders that are placed to the five different suppliers in relation to their capacity and forecast. When it comes to the forecasts they are made on a country level. Each country is assigned a supplier for each of the different materials (laminate, wood, acrylic, and stone). IKEA would like to get the combined forecast for each of the different suppliers based upon the countries' forecasts and the assigned suppliers for that country.

They would also like to visualize the capacity in relation to the number of placed orders. In the standard systems it is not possible today to see how many orders that are placed to each of the suppliers. This is a big problem that IKEA would like to get rid of. They would like to be able to detect and divert orders from one supplier to another if one is close of reaching its maximum capacity as a preventive measure.

4.3.2.3 Precision

When an order is placed by a customer in a store, the ordering system generates a dispatch day for that particular order. The dispatch date shows when the system thinks that the order is due to be dispatched. The supplier then approves the order and keeps or changes the dispatch date depending upon the situation in their production. This new date is called the confirmed dispatch date. When the order is dispatched by the manufacturer, the date for the dispatch is added to the order as an actual dispatch date. IKEA categories delays in three ways when it comes to the PERSONLIG business.

Delays I
If a supplier updates the dispatch date regularly and dispatches the order on the correct date or before, he will have few orders that are categorized as Delays I. In other words Delays I show how good the supplier is at updating the dispatch date of the orders.

Delays II
The IKEA ordering system will automatically generate a dispatch date for a particular order depending upon the set lead-time or if the customer wants to receive the order a certain date. Delays II shows to what extent the supplier postpones the actual dispatch date in relation to the system generated dispatch date for the orders.

Delays III
Delays III shows how many orders that are actually delayed, when the suppliers confirmed dispatch date has passed and the product still has not been dispatched.

4.3.3 Measurement method

When it comes to the measurement method we are using Ljungberg and Larssons six steps presented in chapter 3.4.3, to describe the current situation at IKEA.

Data capture
IKSC uses a program called SAMS to register customer complaints. Every customer claim is registered into databases. To access these databases there are two ways. The first way is to directly connect to a specific database and retrieve the information. IKEA points out that, different bits of information concerning a certain case can be stored in many separate databases. The second option is to use a program called Business Objects (BO) which function is to combine all the information from the different databases so that one can place a single "query" in BO and retrieve all the specified information concerning a certain case. All the necessary information for generating deviation reports can be accessed by using BO according to IKEA.

For the sales data IKEA uses a program called Orders, where one can specify what articles one wants to retrieve all the orders for and between which dates the orders where placed. It is also possible to limit the search to a certain supplier or country. One of the limitations in the program is that it only produces an output file with 5000 lines, additional information will not be presented. Another limitation is that Order operates on an article level and order line level, so if a customer has ordered three PERSONLIG worktops all three worktops will be listed in the output file under the same order number.

IKEA uses Orders to retrieve data concerning delays. By specifying the status of the orders they can pull orders that have not been dispatched and so on.

Compilation
IKEA have defined the trends and metrics that are to be used in the reports the following way:

Deviations
- One week trend – reported customer complaints having resulted in the order of a new worktop or in compensation during the previous week, divided by orders.
- Four week trend – accumulated deviations for the past four week divided by orders.
- Year to date trend- accumulated deviations from the start of the FY divided by orders.

Orders

- One week trend – orders placed during the previous week.
- Four week trend – the sum of the placed orders for the past four weeks divided by four.
- Year to date trend – the sum of the orders placed from the start of the FY up until the present week divided by the number of weeks.
- Forecasts – on a country level and the combined forecasts split down to the different suppliers.
- Supplier Capacity – in relation to the accumulated sales for each supplier.

Precision

- Delays I – shows how good the suppliers are at updating their orders.
- Delays II – shows to what extent the suppliers postpone the dispatch date in relation to IKEA's automatically generated dispatch date.
- Delays III – shows how many orders that are actually delayed. When an order has passed the dispatch date without being dispatched.

For the compilation of the data IKEA has specified that Microsoft Access is to be used. Access is a database handling system where one can use the data stored in databases to perform calculations, sort and compare data, make user friendly interfaces and generate reports.

Presentation
IKEA wants the information to be presented in an easy and understandable way, preferably with tables or diagrams depending upon what are possible to produce with the in-data. The application should be easy to use and facilitate global usage.

Communication
According to IKEA, the information that is produced by the application is primarily to be used by the business owner of PERSONLIG and the people making the forecasts and capacity planning. The reports are to be published in PDF format and made available on the Kitchen and Dining internal IKEA website.

Analysis/Action
The application will aid in the analysis of the performance of the PERSONLIG supply chain and assist in reducing deviations, more accurate forecasts, and help in capacity planning. The person responsible for making this happen is the owner of the PERSONLIG business. The actions that are to be taken depends upon the situation at hand, but could for example be to move orders from one supplier to another or make changes to the handling routines at a CDC or HUB. It is the business owner that is responsible for the evolvement of the business. In this case Johan Ström was acting as the business owner for PERSONLIG.

4.3.4 Point of measurement

The main areas of measurement are as stated before *Deviations, Sales* and *Delays*. IKEA uses different programs when retrieving and collecting data for these areas. The data that is to be used are generated for other purposes so the outcome or the use is uncertain according to IKEA. The data that is provided, has not to IKEA's knowledge been used for measurement purposes. Since this is the case IKEA does not know if it is possible to use the data provided

from BO or Orders for our measurement purposes. A more detailed description of the three areas, *Deviations, Sales* and *Delays,* follows below.

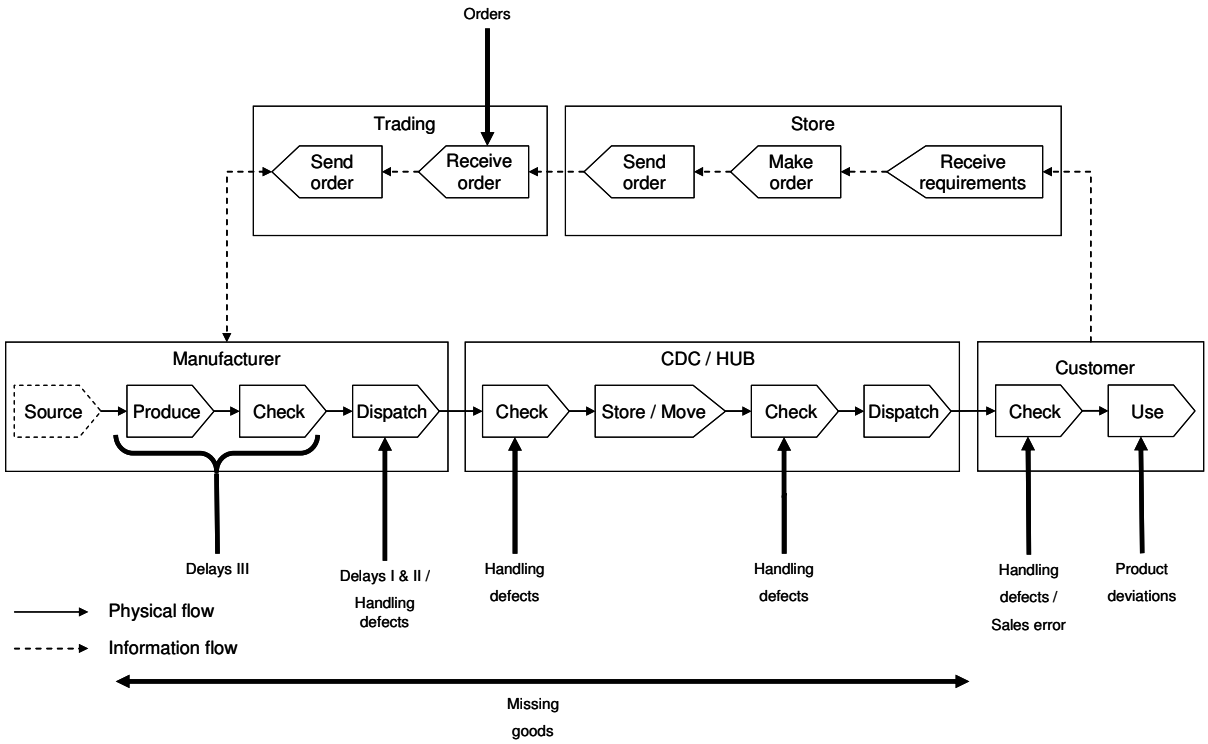

Figure 30: The seven points of measurement in the PERSONLIG supply chain.

All the specified points of measurement can be seen in Figure 30 above. Data for the different points will have different providers, more about this in the following chapters.

4.3.4.1 Deviations

For the deviations in the supply chain IKEA has specified the points that they would like to gain insight into. The areas and the measurement points can be seen in Figure 30.

The data for these measurements will be provided by IKSC when the customer has made a complaint. The data then needs to be retrieved, and this is done using BO. Once the data is retrieved it needs to be processed so that some degree of visibility can be achieved.

4.3.4.2 Orders

The program Orders provides the order data. The output file will consist of all the PERSONLIG orders with the order status, created, ordered, acknowledged, confirmed, consigned, dispatched, delivered, and received. The orders will then be processed and split down on the different suppliers and countries.

The measurement point originates from Trading, which can be seen in Figure 30.

4.3.4.3 Precision

For the measurement of the delays the program Orders will be used. The order statuses that are to be used depend upon which form of delays the user wishes to view. For Delays I-III the statuses are:

I and II: dispatched, delivered and received, using the time span with consideration to order status dispatched, last week (Monday to Sunday).

III: created, ordered, acknowledged, confirmed, and consigned, using the time span with consideration to the order status created , today's date minus the lead-time (5weeks) and as far back as possible.

Delays I and II both uses the suppliers latest updated dispatch date, and they span over the two processes *Produce* and *Check*, while Delays III uses the actual dispatch date (see Figure 30).

5 The development of the application

In this chapter the authors describe the development of the application for supply chain measurements of the PERSONLIG business. The method used to describe the process can be found in chapter three.

5.1 Initiation phase

The PERSONLIG product is not like any other product in the IKEA range. It is, as stated before, the only truly custom made product within the IKEA range. Since this product is nothing like the rest in the range, the standard systems fail in facilitating the necessary tools for allowing this business to grow.

5.1.2 New needs

The number of customer orders of PERSONLIG worktops has increased during recent years. With this increase in sales there has been an increase in customer complaints. IKEA has recognised a need to visualize the PERSONLIG supply chain in order to identify where the problem areas within the supply chain lays. When it comes to capacity and forecasting IKEA is in need of accurate sales figures on an order level to facilitate accurate forecasting and capacity planning. This is presently not possible since there is no system that monitors the PERSONLIG business.

5.1.3 The existing data providers

The underlying problem with the PERSONLIG business is that it operates on an order level instead of an article level. All other IKEA products operate on an article level so naturally the standard systems do the same. The industry standard for custom worktops is according to IKEA on order level and since this is the case the PERSONLIG business is in need of sales figures on an order level, to facilitate comparison of supplier capacity in relation to the number of custom orders. The data originates from two systems, the Service Action Management System (SAMS) and Orders.

5.1.4 How will the system and the data providers interact?

The existing systems will act as information providers for the new application. Different systems will provide different kinds of information. One of the systems is SAMS, which is used by the IKEA call-centre (also known as IKDC) to log received customer complaints. This system is the source that provides information regarding deviations in the supply chain. To retrieve the information from SAMS a program called Business Objects (BO) is used to filter the data so that only the complaints regarding PERSONLIG will be presented. The other system that is used is Orders, which will provide order data and data that is to be used for showing delays in the supply chain.

5.1.5 How will the application be developed?

IKEA has specified that Microsoft Access is to be used for the development of the new application. Since this is the case no changes to existing software is presently to be made. This leaves only the option of developing the application from scratch.

5.2 Development phase

Deciding what to choose concerning software was fairly simple, since IKEA had specified the use of Microsoft Access. Upon the start of the project we immediately started working on the application, trying to compile the different input data, both the manually and the automated input within the application. After succeeding with this we tried to achieve the desired output data. Once we got the desired output, we started working on the output reports. We constantly expanded and changed the application so that it would be more user-friendly and serve its purpose in a better way.

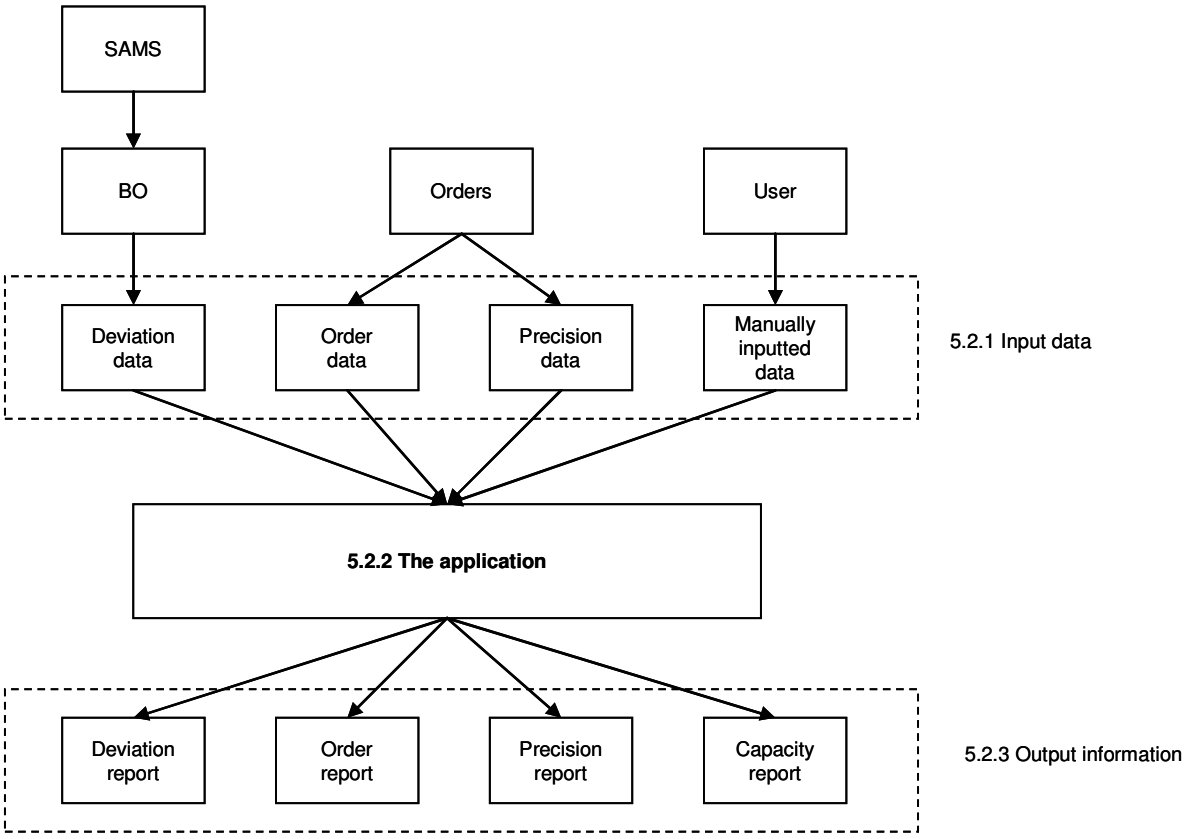

Figure 31: How the different parts of the application interact.

How the different parts of the application interact is described in Figure 31. The different parts of the development phase are described below in section 5.2.1 -5.2.3.

5.2.1 Input data

Our input data is divided into two parts, one manual and one automatic. The automatic data is extracted from two different programs, Orders and Business Objects (BO). These programs "find" data and information in different databases and compile and filter the data so it can be used. Both Orders and BO are programs that work like search engines, the user asks the

program a "query" and the program answers with a report. The reports that BO and Orders compile are in a spreadsheet form similar to the spreadsheets in Excel.

We are using this type of input when it comes to the order-, deviation-, and precision data, since this information is stored in several different databases and these programs helps and facilitates the retrieval of that data. The outputs of these programs are exported as spreadsheets and then imported into the application, which validate the information so that only the right data is imported.

The different types of input data that are automatic inputted are listed below:

Deviation data
The deviation data is extracted using the program BO, in the form of different SAC's. BO retrieves the data from a system called Service Action Management System (SAMS), IKSC uses this system to report complaints and deviations. To get the right information from BO, the user states which article numbers that he or she would like to retrieve information about. Furthermore the user have to state to BO that he or she only would like to have information concerning SAC's that contains a worktop replacement order number and or where there has been an transaction in form of compensation.

Order data
The data concerning sales are extracted using a program called Orders. To get the right order data, the user configures the program so that all orders that were created during a fixed period of time are exported to a spread sheet. In normal cases the timeframe that is to be used, is one week. In Orders the user also decides which product he or she would like to retrieve information about. In this case the search word would be "*perso worktop**".

Precision data
The data that is to be used for the precision report is also retrieved using Orders. But instead of controlling when the order was created the user checks different order statuses to verify if there are any delays in the system. See chapter 4.3.4.3 for the different search criteria.

The manual data inputs are information that is relatively constant, like forecasts, capacity, stores, transport, deviation codes, and a supplier matrix. This data is imported using a manual input, since the information we would like to have does not exist in any regular database. The information must be compiled with human interaction, since the layout and units of the input data can vary, which makes a manual input the best method according to IKEA.

The different types of manually inputted data listed above are described in greater detail in Appendix C (Confidential).

There are also four sets of variables that are fixed. This means that the user can not change or modify any of the information regarding these sets of variables, since the developers have fixed them into the application. The four variables are, the five suppliers, the 21 countries, the lead-time (five weeks) and the worktop materials (acrylic, wood, laminate and stone).

5.2.2 The application

This section describes all aspects of the application, concerning how the data is transformed from unprocessed input data to the output information in the form of reports.

5.2.2.1 Validation input data

The two different types of inputs that are entered into the application are either manual or automatic. The application checks the inputted data to see that it is in the right form. The manually inputted data is validated using input-filters, which means that if one is to enter a four digit number it is only possible to enter four digits and so on. The automatically generated data is validated by checking the names of the columns in the spreadsheets. For example the application could be configured to allow columns: “Orders”, “Name”, and “Company” in the input spreadsheet. If the user tries to enter a spreadsheet with the columns “Orders”, “Name”, and “Quantity” the application would return an error message stating that the input spreadsheet has the wrong column names.

5.2.2.2 Filtering input data

After the data is inputted the application starts to filter the information, so that only the correct and useful data is stored and used in the application. This is done to minimise the size of the application and increase the data processing speed. During the filtering of the automated inputs the application checks and removes any duplicate order numbers and SAC numbers. Once an order number or SAC number is introduced into the application it is not possible to add the same order or SAC number again.

5.2.2.3 Compilation of the input data

When the filtering is completed, the application starts to compile and store the right data into tables with only the right and validated information. During this step the application combines both the manual inputted data and the automatic inputted data. To see an illustration of the compilation of the input data regarding deviations, see Figure 32.

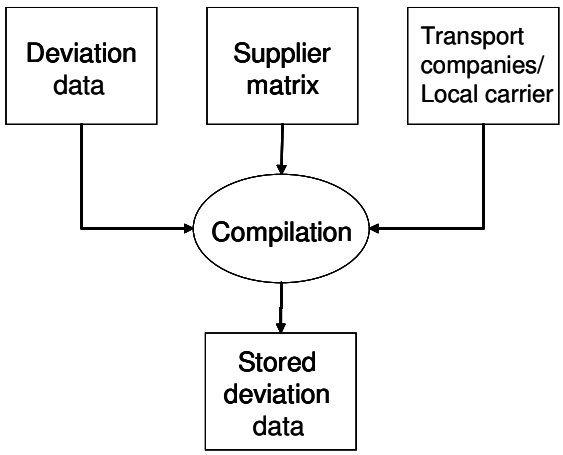

Figure 32 : An illustration of the compilation of the input data.

The application combines the deviation data about with which supplier that manufactured the order and which HUB that handled the order.

Regarding the orders data, no compilation is needed. The application just stores the data. The order data does not need to be compiled with any of the manually inputted data at this point in the compilation process.

For the precision data the process is somewhat different from that of the deviation data. When the data is inputted, the application validates the different orders in the file and adds if they are delayed according to the definitions of Delays I, II, or III. This is done to be able to show different trends. The application adds a Yes or No to the order if it is considered to be delayed according to the definitions of delays. This is done to every order in the precision input file at the time of entry into the application. This is then stored and cannot be removed. Definitions and more information about delays can be found in section 4.3.2.3.

5.2.2.4 User interface

The user interface is constructed to be an easy multi-option tool that will provide the user with different options, for instance updating the data, generate reports or performing a clean-up of the stored data. The layout of the user interface can be seen in Figure 33.

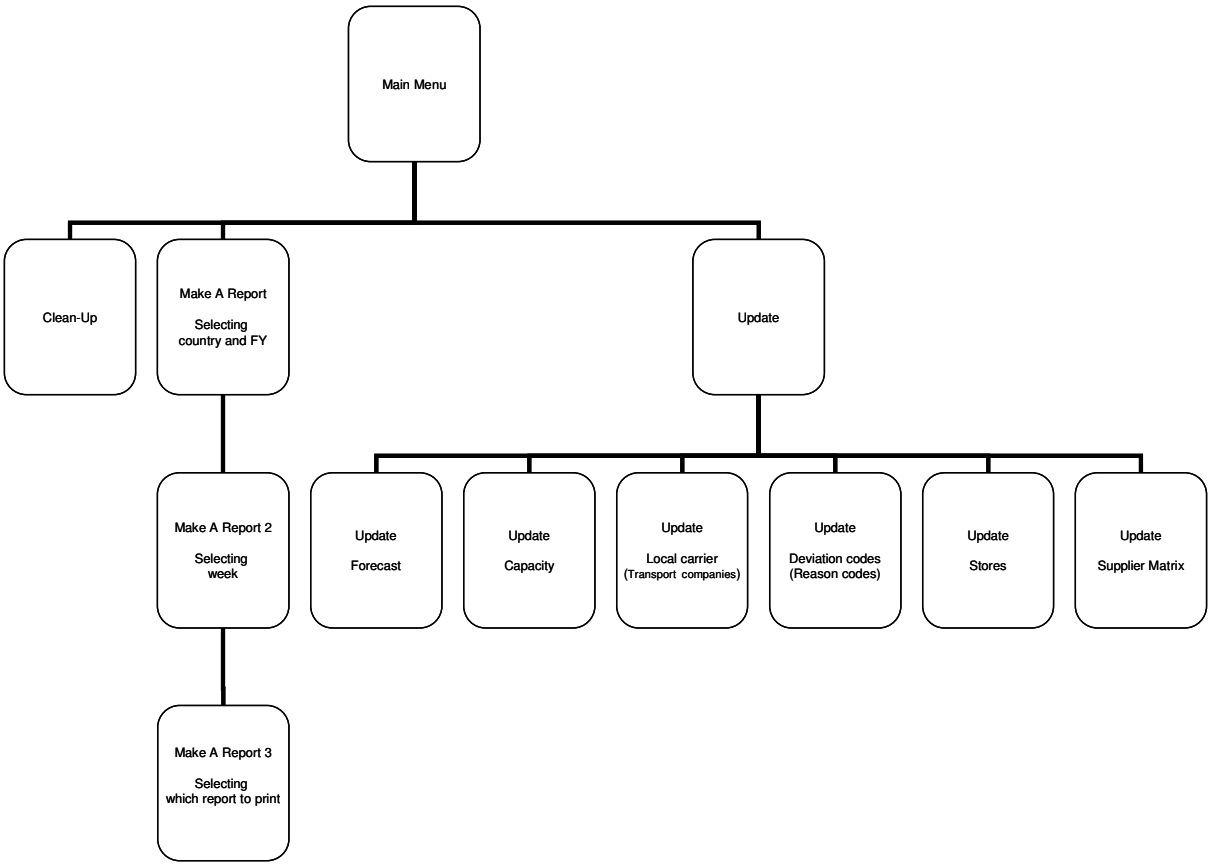

Figure 33 : The layout and the relations between the menus in the application.

The first menu, which the user is introduced to, can be seen below in Figure 34.

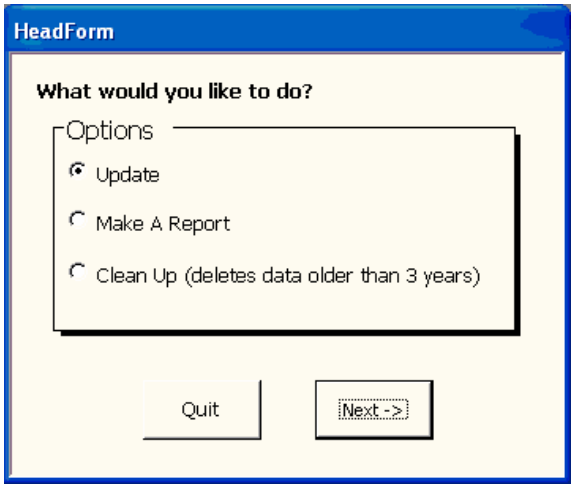

Figure 34 : An illustration over the main menu in the interface.

Update

If the user chooses the first alternative *Update*, he or she will be directed to another menu. The menu that the user will be directed to is the update-menu and it can be seen in Figure 35. The interface regarding updating the data is constructed so the user can see when the latest updates were made, concerning both sales and deviations. This menu also provides the opportunity to update different types of data. The different types of data that can be updated are: deviations, orders, delays, forecasts, capacities, local carrier, stores, deviation codes and a supplier matrix.

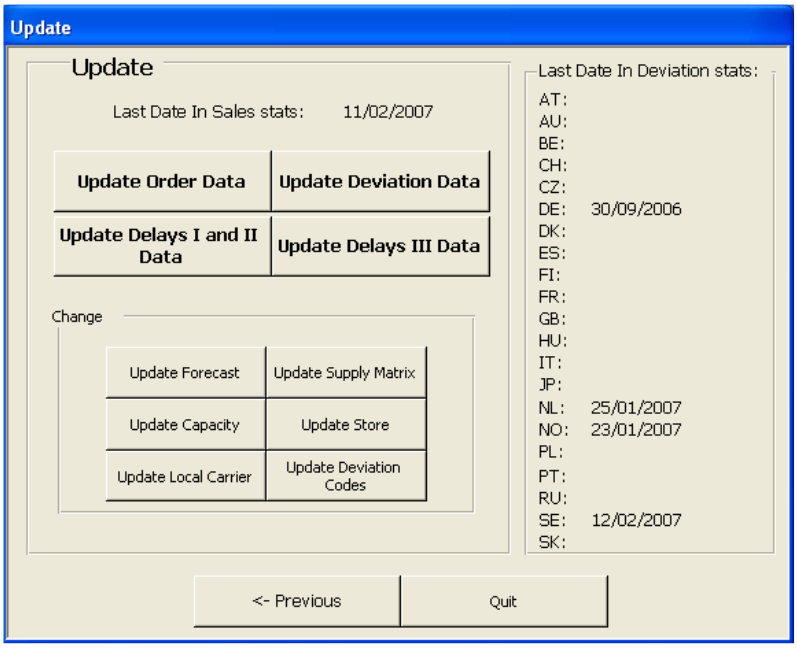

Figure 35 : The menu regarding updating data in the user interface.

All the different types of data inputs are described in Appendix C. When the user has performed the necessary updates, he or she has two options, either to quit the application or go back to the main menu (Figure 34).

Make A Report

If the user chooses to go back to the main menu followed by the alternative *Make A Report*, the user will be directed to a new menu (see Figure 36). In this menu the user will be requested to fill in which country and which fiscal year (FY) he or she would like to generate a report for. The country input concerns only the deviation report. More information concerning the different reports can be found in chapter 5.2.3.

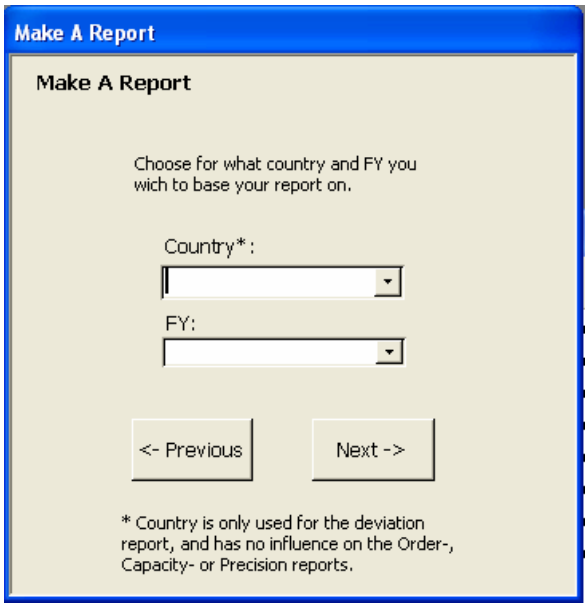

Figure 36 : An illustration over the first menu regarding making a report.

The options on this menu (see Figure 36) are in the form of drop down menus, with different options depending on what information that has been inputted into the application. For instance, choosing a country only concerns the making of a deviation report. Therefore it is only possible to choose countries which have provided deviation data to the application and not a country in general. The choice of country does not influence the making of orders, capacity and precision reports. This has been done to ensure that only the right options are selected. When the user has chosen the preferred alternatives he or she may move on by pressing the “next” button. If the user presses the “previous” button, he or she will be directed back to the main menu.

If the user presses the “next” button, he or she will be directed to a new menu. This menu can be seen in Figure 37.

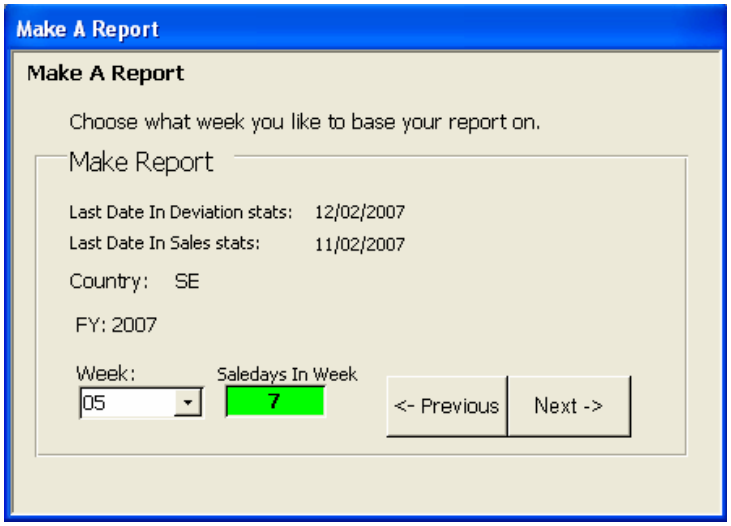

Figure 37 : The second menu regarding making a report.

In this menu the user can see when the deviation- and order-data latest was updated. In the menu there is one drop-down menu, where the user can choose which week that he or she would like to have a report for. When the user has chose a week the window next to the drop-down menu will update and shown how many days of sales there are in the chosen week. This is to show the user if the inputted order data for that week in complete.

When the user press "*next*", the application starts to filter and compile the data for the reports. For more detailed information about this see the chapter below (Chapters 5.2.2.5-5.2.2.6).

After the application has filtered and compiled the report data a new menu appears (Figure 38).

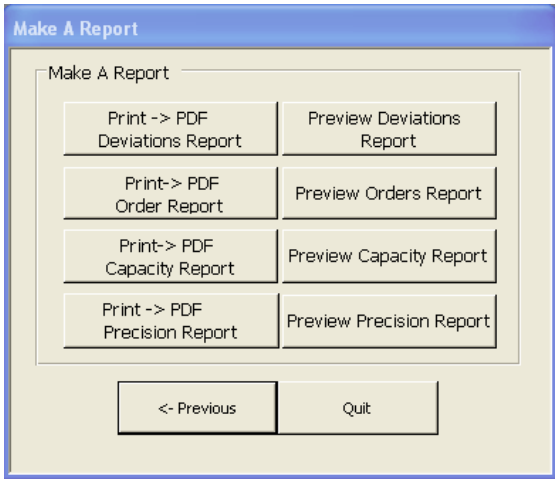

Figure 38: The last menu regarding making a report.

This new menu has eight options. The different options are either to preview or to print the four different reports. When pressing one of the buttons the application will start to generate the asked report. For more information concerning the generating of reports see section 5.2.2.7.

Clean-Up
There is also an available option under the main menu in the application that performance a clean-up. This means that the application removes all data entries regarding the order and deviation data that are older than three years. Once the clean-up is performed it is impossible to restore the deleted data.

5.2.2.5 Filters output data

The filtering of data for the reports depends on three decisions that the user makes, which are fiscal year, week and country. The decisions fiscal year (FY) and week are the bases for the different reports and the selection of country only influence the deviation report.

When the user has chose which FY and week he or she wants have a report for, the application starts to filter all the data in the database within the application. The filtering selects the data concerning the chosen FY so that only this data is used.

5.2.2.6 Compiling output data

This section will give the reader an understanding of the underlying logic of the different reports and how they are compiled. Below follows a description of the four main reports, deviation, orders, capacity and precision.

Deviation Report
The deviation report is compiled using the deviation and order data. This is done since IKEA wanted to know how big part of the total number of customer orders that deviated regarding supply quality, product quality and sales quality.

In the start of the compilation, the deviation and order data is divided into weeks, since the report will show the weekly deviations in relation to the number of weekly orders. After the deviation data has been divided on a weekly basis it is categorized on the different reason codes. This is done to show what kind of deviations that occur in the supply chain. How the data is divided can be seen in Figure 39 (deviations) and Figure 40 (order). To visualize the different trends that IKEA want to view, the deviation data has to be divided on a weekly basis for the last 14 weeks and the order data has to be divided on a weekly basis between 4 weeks and 20 weeks back in time. This since IKEA would like to see the history of the development 14 weeks back in time for the deviations. To connect the order data with the deviation data, the lead-time has to be considered since the purchase of the worktop took place approximately five weeks before the deviation was reported by the customer. The selected week is the week that the user would like to have as an origin for the deviation report, usually the previous calendar week.

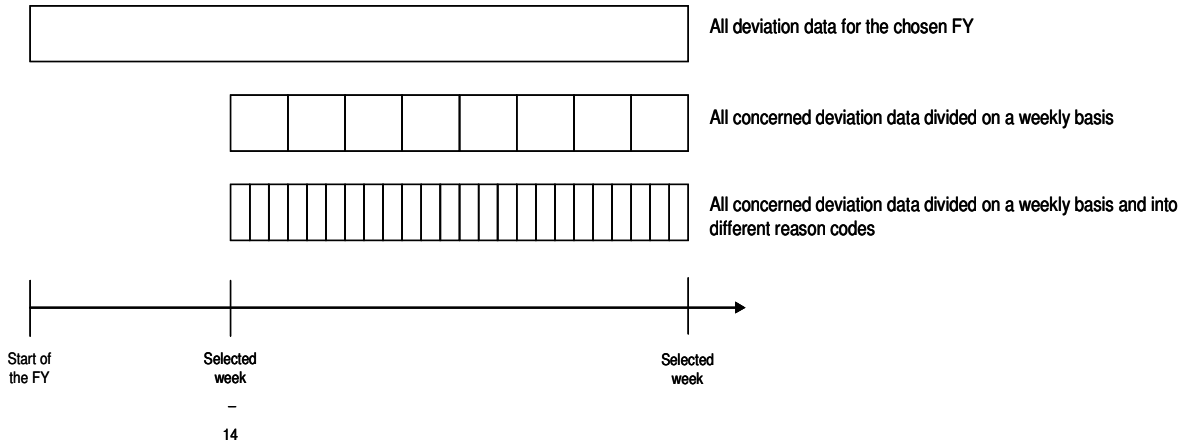

Figure 39 : How the different divisions look regarding the deviation data concerning the deviation report.

After the right parts are acquired, the application compiles the data together with the manual inputted data. The data that is divided on the different reason codes is connected to the responsible causing unit, for example all deviations that are considered to be sales errors are connected with the responsible store. This is since IKEA would like to see how the different stores are acting in regard to sales errors. This is done to be able to take preventive measure, for instance educate personnel. The same thing is done regarding the other reason codes: *product defects*, *handling damages* and *missing goods*. But the *product defects* are connected with the suppliers, *handling damages* is connected to the transport companies, the HUB, or the supplier and *missing goods* are connected to the responsible HUB, or Transport Company, or supplier.

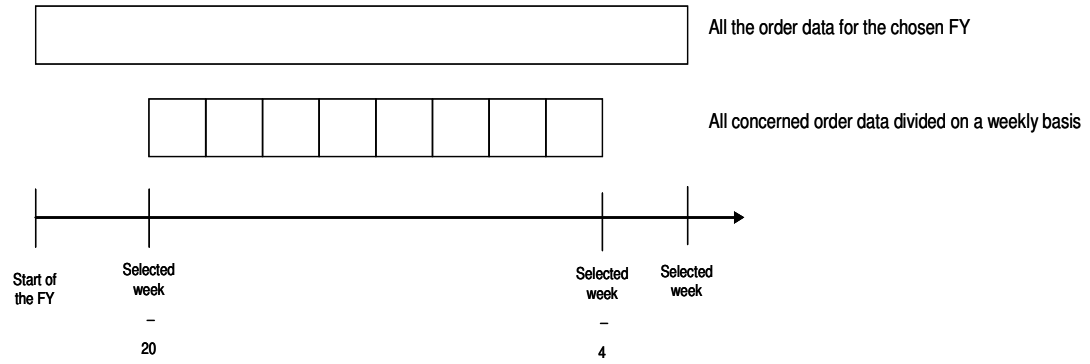

Figure 40 : How the different divisions regarding the order data is processed.

Then the application compiles and saves the compiled data into different segments. The different segments are: 1 week (*1w*), four weeks (*4w*) and year-to-date(*YTD*). A closer description of the different segments follows below:

DEV-1w:
DEV-1w is equal to how much deviation that has occurred during the selected week.

The application calculates *DEV-1w* on the following way:

$DEV-1w = Deviations(ww)$, where *Deviations (ww)* equals the accumulated deviations for the selected week *ww*.

DEV-4w:
Is an average on a weekly basis of how many deviations that has occurred during the last four weeks originating from the selected week.

The application calculates *DEV-4w* in the following way:

$$DEV-4w=\frac{\sum_{ww-3}^{ww} Deviations(ww)}{4}$$, where *Deviations (ww)* equals the accumulated deviations the selected week *ww*.

DEV-YTD:
DEV-YTD is an average on a weekly basis, of the accumulated deviation since the start of the fiscal year (FY) to the end of the selected week.

The application calculates YTD on the following way:

$$DEV-YTD=\frac{\sum_{StartFY}^{ww} Deviations(ww)}{WeekDiff\,(StartFY, ww)}$$, where *Deviations(ww)* equals the accumulated deviation the selected week *ww* and *WeekDiff*(*StartFY,ww*) is a function that calculates the difference in the number of weeks between the start of the FY and the selected week. For example *WeekDiff*(36,1) = 18 weeks.

When the application has connected all the different reason codes with the responsible causing unit and segmented them into "week and reason code parts", the application starts to compile the data with the sales data.

At the beginning of the compilation of the order data, the application starts to compile the order data in the same segments as for the deviation data. During this compilation there is a crucial factor. The factor is the lead-time, which is the time from when the customer places the order until he or she receives the finished worktop. The lead-time is in normal cases 5 weeks. This means that the application have to prepone[142] the reported order date in relation to the deviation date with the lead-time. The lead-time is set to five weeks but this is not an absolute time since it can vary between 4-6 weeks depending upon the suppliers current production situation. To avoid this problem the application calculates an average week based upon order data 4-6 weeks old, in relation to when the deviation was reported.

The application uses the date when the replacement order was created as origin, and an order date which is moved 4-6 weeks in time to before the replacement order was made. For example if the replacement order was created week 15, the application calculates that the original customer order was made approximately between week 9 and week 11.

[142] To bring forward to an earlier time or date. Opposed to postpone. (Oxford English Dictionary)

The segmentation of the order data is almost done in the same way as the deviation data, but with consideration taken to the lead-time factor. A description of the different segments of the order data follows:

ORD-1w:
An average sales week calculated on an average of three weeks, with a time dislocation between 4-6 weeks back in time.

The application calculates ORD-1w in the following way:

$$ORD-1w=\frac{\sum_{ww-6}^{ww-4}Orders(ww)}{3}$$, there *Orders* equals the accumulated sale the selected week *ww*.

ORD-4w:
ORD-4w is an average sales period concerning 6 weeks and this is calculated on an average of the 6 weeks, with a time dislocation between 4-9 weeks back in time.

The application calculates ORD-4w in the following way:

$$ORD-4w=\frac{\sum_{ww-9}^{ww-4}Orders(ww)}{6}$$, where *Orders* equals the accumulated sale the selected week *ww*.

ORD-YTD:
ORD-YTD is the average weekly sales from the start of the FY to 4 weeks before the selected week. This is calculated on an average of the number of weeks that is between the start of the FY and five weeks before the selected week. This is done since IKEA only wanted to see the year-to-date sales.

The application calculates ORD-YTD in the following way:

$$ORD-YTD=\frac{\sum_{StartFY}^{ww-4}Orders(ww)}{WeekDiff\,(StartFY,ww-4)}$$, where *Orders* equals the accumulated sale the selected week *ww* and *WeekDiff*(*StartFY,ww-4*) is a function that calculates the difference of the number of weeks between the start of the FY and the week four weeks before the selected week.

The compilation of the sales and deviation data is divided on one week average and two different trends. The two trends are a four week trend (4w-trend) and a year-to-date trend (YTD-trend). The trends are percentages and they show how bad the situation is. All the trends are calculated using weekly averages. More detailed information concerning the trends follows below:

1w:
This describes how many orders that deviated the selected week. This is calculated by dividing the deviation the selected week (DEV-1w) with the connected average order week (ORD-1w).

Mathematic expression:
$1w = DEV - 1w / ORD - 1w$, there *DEV-1w* and *ORD-1w* is described in more detailed in the sections above.

4w-trend:
This trend shows the tendency regarding deviations for the past four weeks. One can see if the presently selected week is above or below the trend for the past four weeks. The trend is calculated by dividing the weekly average deviations during a four weeks period (DEV-4w) with the belonging average order week (ORD-4w).

Mathematic expression:
$4w - trend = DEV - 4w / ORD - 4w$, where *DEV-4w* and *ORD-4w* is described in more detailed in the sections above.

YTD-trend:
The YTD-trend shows a percentage of how many deviations that has occurred since the start of the FY in relation to the orders during the belonging time period.

Mathematic expression:
$YTD - trend = DEV - YTD / ORD - YTD$, where *DEV-YTD* and *ORD-YTD* is described in more detail in the sections above.

When the application has completed the calculations listed above, the compilation of the deviation report is complete. For more information on how the deviation report is generated see chapter 5.2.2.7 and for a glance of the report see chapter 5.2.3.1.

Orders Report
The orders report shows actual customer orders for all the countries which have PERSONLIG sales. In this report orders are put in relation to the forecast for the different countries. The numbers presented in the reports are actual number of customer orders for the chosen week, four week trend, YTD trend, forecast and the accumulated number of orders since the start of the FY. The metrics are described below:

1w:
This is the actual number of customer order placed for the chosen week.

4w-trend:
This is the sum of customer orders for the past four weeks divided by four.

YTD-trend:
This is the sum of customer orders from the start of the FY divided by the number of weeks since the start of the FY.

Forecast:
This is the manually inputted forecast for a specific country based on a five day work week.

To see an illustration of how the trends are calculated view Figure 41.

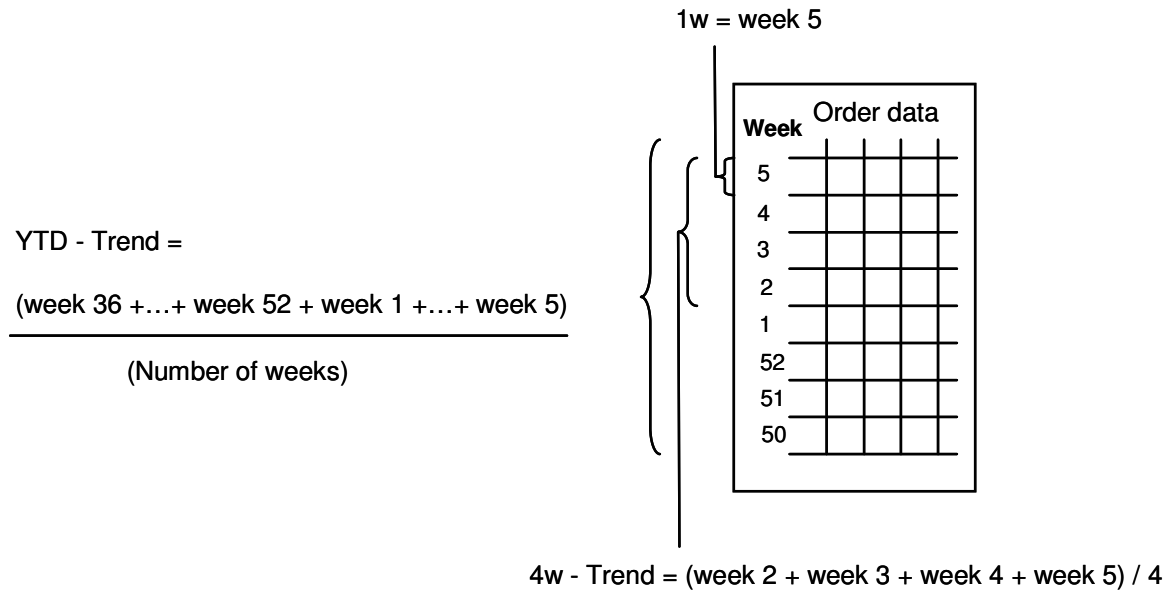

Figure 41: Example of how the trends are calculated for the order report.

The data extracted is divided to a country level to show the trends in relation to forecast, to see an example report view Appendix D (Confidential).

Capacity Report

The capacity report works in the same way as the orders report. But in this report the order data is placed in relation to capacity and divided by supplier. The trends works in the same way as for the order report, for an example see Figure 41. An example report can be seen in Appendix D.

Precision Report

Every customer order has at least two dates present in the order information. The dates are *order date* and *created dispatch date*. The *order date* shows what date the order was created and the *created dispatch date* shows the system generated dispatch date.

Once the order is received by the supplier, the supplier adds a *confirmed dispatch date* to the order. This date represents when the supplier plans to dispatch the order. At the same time an *originally confirmed dispatch date* is added and, this is equal to the first *confirmed dispatch date*. If the supplier for some reason changes the *confirmed dispatch date,* the *originally confirmed dispatch date* remains the same. The supplier is free to change the *confirmed dispatch date*, and this is done so that the delivery information is up to date. Once the order is dispatched a *dispatch date* is added to the order. The flow of the order and which dates that are added at the different actors in the chain, can be seen in Figure 42.

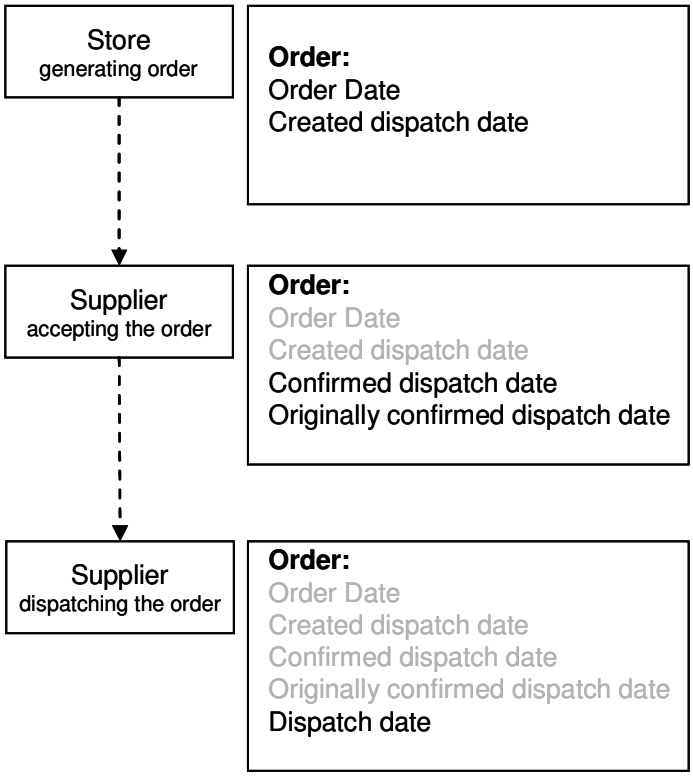

Figure 42: Simplified illustration of the dates added to the order throughout the supply chain.

To keep Figure 42 simple and show the overall picture, some of the steps in the supply chain concerning the flow of orders have been removed.

As described before, IKEA uses three metrics for measuring delays. They are called Delays I, II, and III. In this section we will explain how the application calculates the different delays. This means explaining which dates that are compared and how the different trends are calculated. We will start with describing Delays I followed by Delays II and III.

Delays I
Delays I, show the suppliers *confirmed dispatch date* in relation to the actual *dispatch date*. If the supplier dispatches the order before or on the *confirmed dispatch date* he will have zero delays in this category. To get a percentage, we divide the orders classified as Delays I orders dispatched this week, with the total number of dispatched orders during the week.

For the four week trend, the application takes all the orders which has an added yes according to the Delays I definition, and divides them with the total number of orders dispatched during the four weeks. The same procedure is used for the YTD-trend, but for a greater number of weeks.

Delays II
This category shows to what extent the supplier dispatches the orders later than the system generated dispatch date, *created dispatch date*. This is done by putting the systems *created dispatch date* in relation to the actual *dispatch date*. To get the percentage we use the same method as for Delays I.

The same procedure is used when calculating the trends for Delays II as for Delays I.

Delays III
Delays III shows "actually" delayed orders, which means that the order is not dispatched despite that the *confirmed dispatch date* has past. This is done by putting "today's date" in relation to *confirmed dispatch date*. The application takes all the orders not dispatched, both delayed and orders just put in production, and check which ones that have a *confirmed dispatch date* before today's date and no *dispatch date*. To get a percentage we take the amount of delayed orders and divide them with the total numbers of not dispatched orders present in the input data.

When calculating the trends for Delays III, a different method is used to minimize the size of the application. The application just stores how many delays that was present a specific week and how many that was not. For instance, a given week had 10 delays and 200 not delayed orders, which means that the application would store which week the delays occurred and the amount of delayed and not delayed orders. Another reason for not storing all the precision data for Delays III, is that an order can be delayed for more than one week, and by doing this the delay of the order can be accounted for multiple times. This would have been missed by using the method in Delays I and II, where every individual order is added to the application. When calculating the trends, four week and YTD, the application adds the sum of the delays and divides this with the sum of the not delayed orders for the different time periods.

How the reports are generated is described in section 5.2.2.7 below.

5.2.2.7 Generating reports

All the output reports produced by the application use the same method when being generated. The basic principle is that a single report consists of a series of "small" questions or sorting criteria. These questions are directed to a specific table with a series of predefined criteria, for instance one field in the report will show how many deviations a specific supplier had a specific week. The question in the report specifies in which table the information is supposed to be found and for which supplier it concerns (see Figure 43). If the information is missing in the table a zero is added to the report.

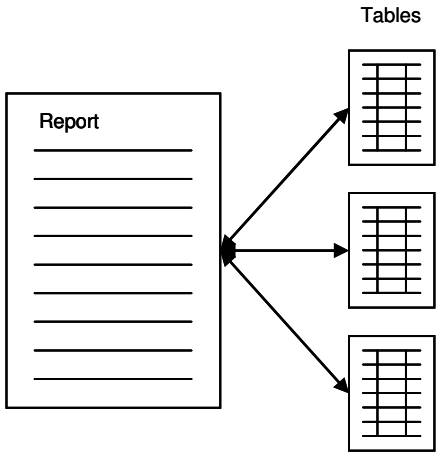

Figure 43 : Illustration of that a report is connected to multiple tables.

A single report can consist of hundreds of questions. Under each number or percentage in the reports lies a unique question. This is illustrated in Figure 44.

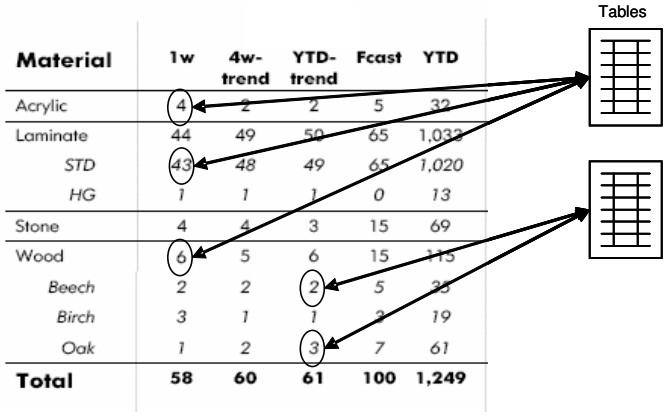

Figure 44: Shows that each number in a single table has a multitude of different questions.

The table in Figure 44 has 50 individually defined questions.

Once the report is generated it is given a name consisting of three parts, what the report contains, if it is in diagram- or table-form, and for what week it concerns. For the deviation reports the country is also added. The six different types of reports are listed below:

dev_SE_w04: Contains the deviation report for Sweden concerning week 4.

cap_tot_w04: Contains the capacity report for week 4.

ord_tot_dia_w04: Contains the order report in diagram form for week 4.

ord_tot_table_w04: Contains the order report in table form for week 4.

ord_vs_fcast_dia_w04: Contains the orders vs. forecast report in diagram form for week 4.

pre_tot_w04: Contains the precision report for week 4.

More information concerning what the reports actually contain is described below in section 5.2.3. All the different types of reports can be seen in Appendix D (Confidential).

5.2.3 Output information

The application generates the output information in the form of reports, concerning four main areas: *Deviations, Orders, Capacity,* and *Precision*. Each area has a number of sub-reports, concerning a limited area within the main area. The areas and the sub reports for each part are described below. A complete set of example reports can be found in Appendix D.

Some of the reports are country specific while others are of a general nature. The reports presented in this section are visualisations of what IKEA has specified and have been developed in close cooperation with them. The reports contain all the trends and figures IKEA has chosen to use as metrics for supply chain performance evaluation.

5.2.3.1 Deviations

Deviations are according to IKEA the main area of concern for the PERSONLIG business. The report is generated on a country level, for example Sweden. Concerning the deviation area, one report is generated (an example report can be seen in Appendix D). The report is divided into four sections, *Total quality deviations, Product quality deviations, Sales quality deviations,* and *Supply quality deviations*.

Total quality deviations

The deviations report begins with a diagram showing the sum of the deviations separated on the three areas, *Product quality deviations, Sales quality deviations,* and *Supply quality deviations,* during a 14 week period (see Figure 45 below).

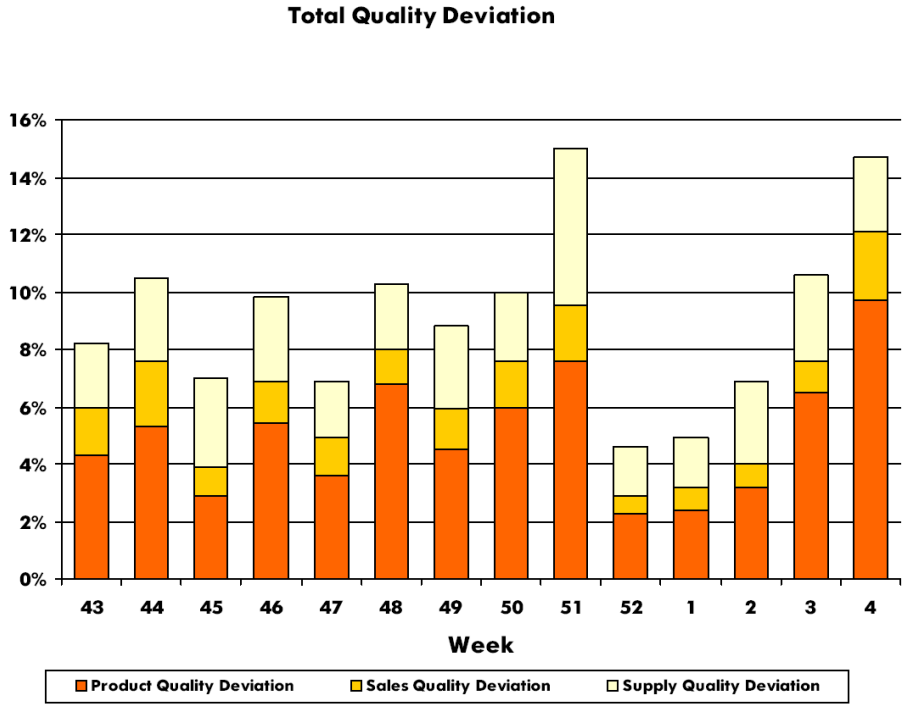

Figure 45: Diagram showing the sum of deviations divided by type.

Showing the diagram in this way presents the viewer with the change of the business concerning deviations. This is followed by a table showing IKEAs different trends and number of the actual deviated orders (shown in Figure 46).

Total Quality Deviation

	1w	1w	4w - trend	YTD	YTD - dev. orders
Sales Quality Deviation	9	2.4%	1.3%	1.6%	167
Product Quality Deviation	37	9.7%	5.4%	6.1%	654
Supply Quality Deviation	10	2.6%	2.7%	3.0%	318
a) Missing Goods	3	0.8%	0.5%	0.4%	42
b) Handling Defects	7	1.8%	2.2%	2.6%	276
Total	**56**	**14.7%**	**9.4%**	**10.7%**	**1,139**

Figure 46: Part of the deviation report showing the total deviations in table form.

The table (Figure 46) shows last week's deviations quantified and as percentages of the total customer orders. It also shows the different trends specified by IKEA. The table gives a more detailed picture of the current situation compared to the diagram. Since the data used reflect real time events, it is important to consider holidays, since this can have an impact on the reported number of deviations as well as orders placed by customers (see for example week 52 in Figure 45). The total figures (diagram and table) are presented on page 1 of the deviation report, and it is followed by a break-down of the different metrics *Sales quality deviations* and so on. A description of the three main deviation areas is presented below.

Sales Quality Deviations
Sales quality deviations are represented by the stores associated with the chosen country. The report shows the actual number of sales errors and the different trends (see Figure 47).

Sales Quality Deviation

		1w	1w	4w-trend	YTD	YTD - rec. orders
010	Handla Hemma	1	4.3%	2.9%	1.7%	577
011	Älmhult	0	0.0%	0.0%	1.4%	647
012	Kungens Kurva (Sthlm)	0	0.0%	0.0%	1.6%	1,006
014	Kållered (Gbg)	0	0.0%	0.7%	1.3%	747
015	Malmö	0	0.0%	0.6%	1.8%	950
016	Västerås	0	0.0%	0.0%	0.7%	591
017	Linköping	0	0.0%	0.8%	1.5%	734
019	Barkaby (Sthlm)	1	4.4%	1.5%	1.1%	848
106	Örebro	0	0.0%	2.2%	1.7%	577
107	Helsingborg	0	0.0%	0.0%	1.5%	672
108	Uppsala	1	6.7%	2.8%	1.0%	381
109	Jönköping	0	0.0%	2.0%	3.0%	806
122	Gävle	3	19.1%	4.7%	2.7%	526
398	Bäckebol (Gbg)	0	0.0%	0.9%	0.5%	571
467	Sundsvall	1	5.6%	3.0%	1.7%	645
469	Kalmar	2	8.8%	2.4%	1.3%	378
470	Haparanda & Tornio	0	0.0%	0.0%	0.0%	63
Total		**9**	**2.4%**	**1.3%**	**1.6%**	**10,719**

Figure 47: Part of the deviation report showing sales quality deviations in detail.

Product Quality Deviations
Product quality deviations are represented on a supplier basis. The percentages represent the reported product deviation in relation to orders delivered to the chosen country (see Figure 48).

Product Quality Deviation

	1w	1w	4w - trend	YTD	YTD - rec. orders
Supplier A	28	9.7%	5.5%	6.1%	8,207
Supplier B	0	0.0%	0.0%	0.0%	0
Supplier C	0	0.0%	0.0%	3.3%	329
Supplier D	9	12.1%	6.0%	6.7%	2,183
Supplier E	0	0.0%	0.0%	0.0%	0
Total	**37**	**9.7%**	**5.4%**	**6.1%**	**10,719**

Figure 48: Part of the deviation report showing product quality deviations in detail.

Supply Quality Deviations

Supply quality consists of handling defects and missing goods. Handling defects can occur at three different places in the PERSONLIG supply chain, at the supplier, between the supplier and the hub (CARRIER/CDC), and between the hub and the customer (local carrier). The visualisation of this can be seen in Figure 49 below.

Supply Quality Deviation (Handling Defects)

SUPPLIER

(At supplier)

	1w	1w	4w - trend	YTD-trend	YTD - rec. orders
Supplier A	1	0.3%	0.1%	0.0%	8,207
Supplier B	0	0.0%	0.0%	0.0%	0
Supplier C	0	0.0%	0.0%	0.0%	329
Supplier D	0	0.0%	0.0%	0.0%	2,183
Supplier E	0	0.0%	0.0%	0.0%	0
Total	**1**	**0.3%**	**0.1%**	**0.0%**	**10,719**

CARRIER/CDC

(between supplier and HUB)

	1w	1w	4w - trend	YTD	YTD - rec. orders
Total	**0**	**0.0%**	**0.0%**	**0.0%**	**10,719**

LOCAL CARRIER

(at HUB or between HUB and customer)

	1w	1w	4w - trend	YTD	YTD - rec. orders
Carrier A	2	0.8%	0.2%	0.0%	7,134
Carrier B	4	3.2%	0.8%	0.1%	3,585
Total	**6**	**1.6%**	**0.4%**	**0.1%**	**10,719**

Figure 49: Part of the deviation report showing supply quality deviations (Handling defects) in detail.

Since the transportation between the supplier and hub often is a local setup, conducted by a company outside IKEA's control, it becomes difficult to present a specific company name under the section *CARRIER/CDC* in the report (see Figure 49). The information presented here is therefore without any causing unit, and only shows the deviation connected to this reason code.

When it comes to missing goods, IKEA has chosen to view two areas, at the CDC and the carrier or at the HUB and local carrier. The local carrier in this case is the company making the customer delivery. The missing goods part of the deviation report can be seen in Figure 50.

Supply Quality Deviation (Missing Goods)

CARRIER/CDC

(Missing goods at HUB excluded)

	1w	1w	4w - trend	YTD	YTD - rec. orders
	2	0.5%	0.2%	0.2%	10,719

LOCAL CARRIER

(Missing goods at HUB included)

	1w	1w	4w - trend	YTD	YTD - rec. orders
Carrier A	0	0.0%	0.0%	0.0%	7134
Carrier B	0	0.0%	0.0%	0.0%	3585
Total	**0**	**0.0%**	**0.0%**	**0.0%**	**10,719**

Figure 50: Part of the deviation report showing supply quality deviations (Missing goods) in detail.

5.2.3.2 Orders

Regarding orders, IKEA has specified that they want three different reports, one general report presenting the total number of placed customer orders, one diagram report showing orders vs. forecast, and one table report showing the trends for individual countries. The reports are described below.

Total Orders

The report produces a single diagram showing the combined number of customer orders divided by the different worktop materials (laminate, acrylic, solid wood and stone). The diagram can be seen in Figure 51.

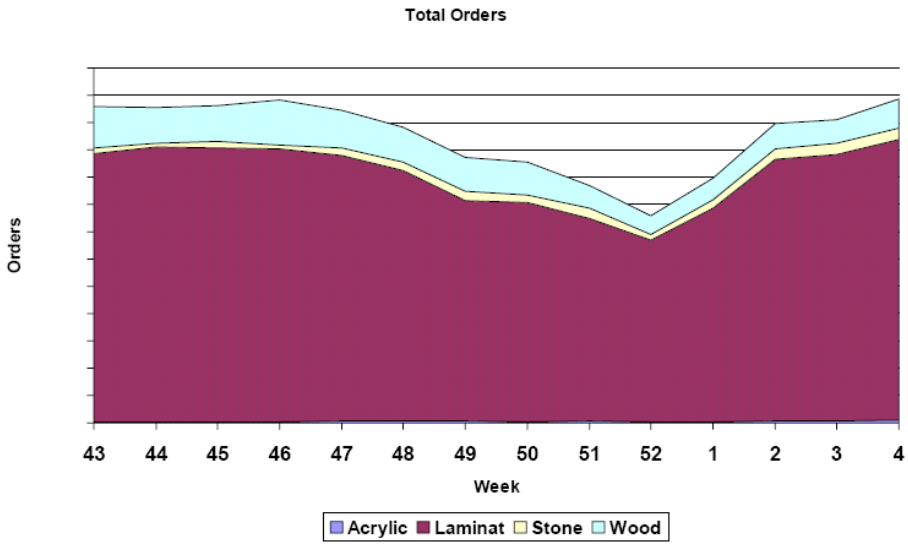

Figure 51: The diagram presented in the total order report.

The diagram is used to see the overall customer order trend. The diagram shows a 14 week period.

Diagram orders vs. forecast

This report presents the orders placed in each country divided upon the different materials and in relation to the forecast for the country. An example for a country is given in Figure 52.

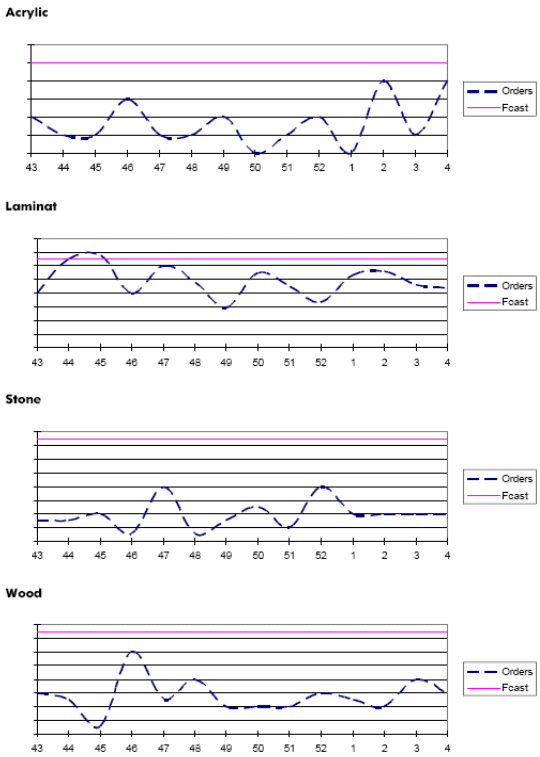

Figure 52: One of the sales countries present in the orders vs. forecast diagram report.

The diagrams (Figure 52) are to be used to see trends for the different countries regarding the choice of materials etc. The report presents diagrams like the one in Figure 52 for all countries that have sales of PERSONLIG worktops.

Table orders vs. forecast

The table is to be used in combination with the diagram report. Within this report the level of detail is greater and the trends specified by IKEA are presented. An example is shown in Figure 53 below.

Material	1w	4w-trend	YTD-trend	Fcast	YTD	1w	4w-trend	YTD-trend	Fcast	YTD	1w	4w-trend	YTD-trend	Fcast	YTD
Acrylic	4	2	2	5	32	0	0	1	20	12	0	0	1	10	13
Laminate	44	49	50	65	1,033	201	166	155	195	3,261	45	47	42	45	873
STD	*43*	*48*	*49*	*65*	*1,020*	*189*	*162*	*153*	*192*	*3,213*	*45*	*47*	*41*	*45*	*860*
HG	*1*	*1*	*1*	*0*	*13*	*12*	*4*	*2*	*3*	*48*	*0*	*0*	*1*	*0*	*13*
Stone	4	4	3	15	69	4	2	1	15	31	0	2	1	20	19
Wood	6	5	6	15	115	46	30	23	20	489	9	9	7	10	136
Beech	*2*	*2*	*2*	*5*	*35*	*16*	*12*	*10*	*9*	*215*	*2*	*2*	*2*	*2*	*35*
Birch	*3*	*1*	*1*	*3*	*19*	*2*	*0*	*1*	*1*	*14*	*1*	*1*	*1*	*3*	*13*
Oak	*1*	*2*	*3*	*7*	*61*	*28*	*18*	*12*	*10*	*260*	*6*	*6*	*4*	*5*	*88*
Total	**58**	**60**	**61**	**100**	**1,249**	**251**	**198**	**180**	**250**	**3,793**	**54**	**58**	**51**	**85**	**1,041**

Figure 53: A segment from the orders vs. forecast table report.

5.2.3.3 Capacity

One capacity report is generated. It contains both diagrams and a table, and shows all orders for PERSONLIG worktops divided upon the different suppliers and materials. The number of orders is put in relation to what capacity IKEA has purchased from the supplier for that particular material. An example of the presented diagrams can be seen in Figure 54.

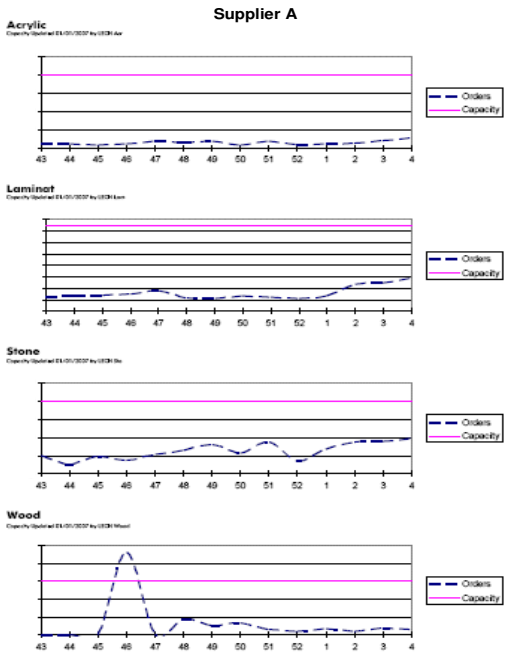

Figure 54: Part of the capacity vs. orders report showing a supplier specific diagram.

The diagrams can be used for identifying if the supplier is in risk of reaching the capacity maximum. It can also be used when planning the capacity for the different suppliers.

The table in the report shows the present situation in detail, concerning capacity and forecast for the different suppliers. An example can be seen in Figure 55 below.

Material	1w	4w-trend	YTD-trend	Cap	Fcast	YTD
Acrylic	26	17	12	200	200	261
Laminate	577	448	276	1,500	100	5,796
Stone	96	86	51	200	365	1,081
Wood	15	14	20	150	0	416
Total	**714**	**565**	**359**	**2,050**	**665**	**7,554**

Figure 55: Part of the table found in the orders vs. capacity report.

The table apart from the trends, and capacity, also show the combined forecast for that particular supplier based upon the supplier-matrix. This can be useful when assessing if the forecasts are in line with the capacity planning for the suppliers.

5.2.3.4 Precision

The precision report is split into three parts, *Delays I, Delays II,* and *Delays III* (Delays I-III are explained in chapter 4.3.2.3). An example report can be found below in Figure 56.

DELAYS I

Actual Dispatch Date vs Confirmed Dispatch Date

	1w	1w	4w-trend	YTD	Total dispatched
	0	0.0%	0.0%	0.0%	136
	20	14.4%	41.0%	34.7%	628
	41	21.1%	25.2%	40.1%	644
	7	13.0%	15.8%	16.2%	167
	29	27.1%	22.4%	14.8%	310
Total	**97**	**18.0%**	**26.9%**	**29.1%**	**1,885**

DELAYS II

Actual Dispatch Date vs Original Created Dispatch Date

	1w	1w	4w-trend	YTD	Total dispatched
	18	40.0%	45.8%	35.3%	136
	17	12.2%	54.9%	40.6%	628
	103	53.1%	65.5%	63.5%	644
	14	25.9%	24.2%	24.0%	167
	43	40.2%	53.1%	40.0%	310
Total	**195**	**36.2%**	**54.7%**	**46.5%**	**1,885**

DELAYS III

Orders still open

	1w	1w	4w - trend	YTD
	0	0.0%	1.2%	5.6%
	7	0.5%	0.7%	0.7%
	13	1.8%	3.0%	7.9%
	0	0.0%	0.0%	0.0%
	58	8.3%	7.0%	2.1%

Figure 56: An example of a Precision report.

The report shows how the suppliers are performing concerning Delays. Both in actual delayed orders and as a percentage of the suppliers total order count. It is important to understand how the different definitions of delays I-III affect the presented results. For instance if the supplier updates the orders on a regular basis, they receive a lower count in Delays I but a higher order count in Delays II.

5.3 Implementation phase

The implementation phase has mostly taken place at IoS and has involved the education of the application users and checking the system compared to the manual reports generated by IKSC. The two areas are described in detail below.

5.3.1 User education

During our visits to Älmhult and IoS, we met mostly with Johan Ström the project leader. The idea was that he was to be the first user of the application since he was acting as the owner of the PERSONLIG business at the time. Ström was providing us with the input data, since he had intimate knowledge of the information providing IKEA system. Since this was the case we showed him how the application worked and what could possibly go wrong with the inputs of both manual and auto generated data. He in turn showed and educated the person who was to succeed him.

5.3.2 Checking the application

Throughout the entire project, IKSC conducted their manual follow-up with the monthly report. The project ran for approximately four months, during this time we compared their manually made report with what the application generated. We found that that the numbers correlated well on a monthly basis. One of the problems we encountered when comparing the numbers was that IKSC changed the reason codes on the SAC when the investigation into the deviation was complete. Since the data already had been entered into the application we were stuck with the old reason code. Fortunately this only concerned a small number of SACs, approximately 5 %. All the versions of the application have been used by IoS, in order to see what could be improved.

5.4 Operation and maintenance phase

The idea was that the system was to be used and tested throughout the course of writing this report. However during this period of time the application has not been put to its full use. This is due to a problem beyond our control. Nils Strand who have been working on the PERSONLIG business have had computer problems and has not been able to test the application to its fullest.

6 Analysis

This chapter contains the analysis which the authors have carried out concerning the PERSONLIG supply chain, a measurement system for the PERSONLIG business, and an evaluation of the developed performance measurement application.

6.1 The supply chain of PERSONLIG

The supply chain for the product PERSONLIG is complex, not only since the product is custom made, but also because it has many handlings points and requires a complex information flow to enable the management of the supply chain.

In this section we will discuss and analyse the different perspectives of the supply chain, regarding the structure and the management, and how the properties of the product influence the two. This will help when evaluating the developed application.

6.1.1 The product

The product is a custom made product, where the customer can choose everything from the shape and material to where the holes are placed, and what kind of extra features in the form of edging or sinks he or she would like to have. Taking the last things into consideration the literature implies that the PERSONLIG product is a tailored customized product. Since the level of customization is relatively high it is hard or almost impossible to keep the products in stock, since one order of PERSONLIG is usually not similar to one another. From a measurement perspective it does not matter what kind of product it is, however it can impact the outcome of the measuring for example if one measures delays in a supply chain. A product that is kept in stock will probably have less delays compared to a custom made product, since a supply chain with stock kept items is less sensitive to breakdowns in the supply chain and the delays can be avoided because the stock is kept closer to the end customer.

6.1.2 The structure of the supply chain

When a customer-order initiates the product-flow within the supply chain, the literature states that the supply system can be perceived as a pull system. An advantage with the pull system is that the actors within the supply chain can avoid or minimises their inventory levels and only produce or transport the amount of products that are ordered by the customers. One problem with pull systems is that it requires collaboration between the actors and a good information flow throughout the entire supply chain. This since the customer both requires fast delivery of their worktops and that the worktops get delivered in right condition.

The present setup of the distribution network leads to that the information flows between IKEA and the different transport companies is not always sufficient. The information flow between IKEA and the contracted distributor is adequate, since they are more or less integrated to the IKEA information and planning systems. The information exchange between IKEA and the distributor that transports the goods from the manufacturer to the CDC is not

sufficient because they are not part of the IKEA transportation network. They are often local solutions provided by the manufacturer and since they are not integrated with IKEA, they do not provide deviation information to the IKEA information systems. One reason for the better information exchange between IKEA and the contracted distributor that distribute between the CDC and customers, is that IKEA has a closer relation to those companies, since they interact regarding greater volumes and more products. For example they interact when it comes to the transportation regarding other home-delivery products. If all the transport companies were contracted by IKEA, this would facilitate measurements and changes in the work procedure. This could be done by comparing the different companies within the supply chain, finding which work procedures that work the best and evaluating if they can be applied to other parts of the chain. Because closer relationships in the supply chain facilitates exchange of information between the different companies this makes the chain act more like one entity and improves the competitiveness of the supply chain.

The lack of information within the chain becomes apparent when the supply chain is viewed. Information concerning deviations and delays is not sufficient from a supply chain management perspective. One of the present problems concerning the lack of information is that the managers, that are to control, monitor, and develop the PERSONLIG business, do not receive adequate information regarding orders, deviations and delays. The information that the managers receives is the monthly deviation report provided by IKSC. The data concerning orders, deviations, and delays exist in databases as unprocessed information. One thing that might make it hard for IKEA in the development of PERSONLIG supply chain is that IKEA is a very big organisation with well working routines for their standard products with high volumes. And since PERSONLIG is the only tailored custom made product in the IKEA range, it becomes difficult to cope with everything a product like this requires concerning the development of the supply chain. Another thing is that the volumes of PERSONLIG are low in relation to IKEA's standard products. This could influence the decision makers in a negative way regarding the PERSONLIG business, since a relatively small and easy improvement to a supply chain for high volume articles can lead to greater profit, in relation to more rigorous and difficult improvements to a supply chain concerning low volume custom-made products.

When developing a supply chain it is important to consider what level of integration between the actors that is necessary for achieving the goals of the supply chain. Since the actors within the supply chain must act as one entity, for the chain to be competitive, it becomes important to know from a management perspective how well the supply chain is performing. At the moment IKEA has some integration between themselves and some of the transports companies and the suppliers since they trade and share some of the information but not in the extent that is necessary to develop the supply chain further. If the needed information regarding deviations, orders and delays is exchanged and the affected people get the right information through a good measurement system, the supply chain could be improved.

Another reason why the supply chain is not developed is that the orders have increased rapidly compared to the development of the infrastructure concerning information exchange. The increased orders might also have had the effect that IKEA has not had the time to manage and cope with all aspects regarding the development of the PERSONLIG business. This may have had the unintended effect that IKEA only could focus on the critical problems regarding the customer satisfaction and solve the urgent problems regarding deviations and that is why the supply chain has not been fully developed yet. If IKEA could have foreseen an increase in orders, they would have had time to take pre-emptive action to improve the information

exchange and develop a suitable measurement system. An important factor regarding keeping the customer satisfaction high is avoiding deviations and having an intimate understanding and control of the supply chain. This can be provided to some extent by having a good and well developed information flow regarding deviations and a good measurement system, which help in the monitoring and development of the supply chain.

A well developed measurement system with appropriate measures can facilitate accurate performance measuring. This in turn enables control and facilitates improvement efforts throughout the supply chain. Today IKEA measures only deviation, which is shown trough a manual deviation report, compiled by the personnel at IKSC and this gives potential for the development of a measurement system. This is not enough, since the interval between the reports is too long and this makes the management of the supply chain, regarding deviations, difficult. When the time between the reports is one month, it is difficult for the decisions makers to make proactive decisions for the supply chain, especially concerning deviations. This since the managers can get the information about the deviations up to a month after they occurred. If this time was shortened the managers could easier make better and more proactive decisions, since the information is presented within a shorter time span of one week. This makes it possible to make changes to the supply chain avoiding further increases of deviations.

6.1.3 The management of the supply chain

The product at hand is a tailored custom made product and gives the management of the supply chain various difficult tasks. The main problem is the lack of information regarding orders, deviations and delays to build a foundation for their decisions. Other tasks are that the product cannot be kept in stock, it has a relative long lead-time, and has many handlings points where damage to the worktops can arise. From a management perspective there are several handlings points in the PERSONLIG supply chain and the risk of having deviations increase at every handling point, since the product is big and heavy.

The literature states that it is difficult to manage a supply chain without an adequate information flow and a custom made product requires a complex information flow to obtain visibility throughout the entire chain. This since a custom made product does not allow inventory levels and therefore when a deviation or delay occurs, it impacts the customer satisfaction directly.

The damage to the worktops makes the management of the supply chain difficult, since it requires the supply chain management team to handle a complex deviation flow with long lead-times between customer-order and delivery of the finished worktop, besides that, the supply chain has to cope with a lot of different customer requests. Some of the request can be different types of materials and shapes of the worktops, making home delivery possible to all addresses in the countries where the PERSONLIG worktops are sold, and personal assistance when problems occur. To provide a solution when problems occur, it is important that IKEA has a good measurement system, which obtains and displays all relevant data regarding the supply chain, so that the personnel at IKEA can make well founded decisions concerning improvements to the supply chain and work proactive in avoiding capacity problems. Since IKEA do not have a measurement system for the PERSONLIG business it becomes difficult to evaluate supply chain performance and work with improvements to the chain.

Information technology (IT) is a vital part in any supply chain, including the PERSONLIG supply chain. The technology is important because it facilitates fast information exchange both within IKEA and to the other organizations within the supply chain. This is needed since the PERSONLIG supply chain requires the ability to swiftly adapt to different circumstances. Two of the circumstances that it has to adapt for are delays and deviations. In the case of the PERSONLIG supply chain it needs this rapid response to keep the customer satisfaction high. This is done by informing the customer if a delay or deviation has occurred. At the moment IKEA do not use IT to its fullest potential, and two reasons for this can be that it is expensive to build the IT-infrastructure and hard and time consuming to integrate themselves with all their sub suppliers.

One of many important aspects to consider regarding development of a measurement system for the management of the supply chain is that the measurement system and the structure of the deviation flows are designed so that they interact with each other. This is important so that no misunderstandings can occur between the measurement system and structure of the deviation flow. Misunderstandings between the measurement system and the information regarding the deviation flow may lead to wrong decisions, which might have a damaging effect to the structure of the supply chain. Misunderstandings can be that the deviation flow considers the damage as a deviation, while the measurement system does not account for the same problem. For example, if a new work process at IKSC where to be implemented with new reason codes and without informing the people using the measurement system, they cannot adapt the system to these changes and the output data would not be reliable. At the moment IKEA does not have any measurement system for PERSONLIG and therefore is it hard to say if it is developed with consideration to the deviation flow.

6.1.4 The deviation flow in Sweden

The different deviation information flows have a complexity regarding how the flows act in different situations. The two different deviation flows uses different work processes. The process regarding when a custom calls IKSC or visits a store with a compliant, the complaint has to be evaluated in close collaboration with the customer, since the customer provides the deviation information. Then the supervisor at IKSC has to investigate and make decisions based on information from the customer, and his or her own experience. This is a disadvantage since information can be twisted and embellished. But these people are specialist and are only working with matters concerning the PERSONLIG business. This gives them good knowledge and gives them the ability to see if the information is twisted in the different cases. One advantage with this flow is that the customer may feel that he or she was treated with kindness and sympathy by the professionals working at IKSC. This leads to that the customers do not feel too disappointed about the damage to the worktop. The other flow, which is the deviation flow when the CDC or HUB reports a deviation to IKSC, is better from a customer satisfaction perspective. This since the customer does not get a damaged worktop home delivered, he or she only get a delayed worktop. Where the delay is considerably reduced since the problem was discovered earlier in the chain.

If the deviation flow would allow for earlier information exchange between IKSC and the different actors within the supply chain, discovery of deviations and delays could be exchanged, at an earlier stage in the supply chain. With an early discovery of the problem and an early information exchange, IKSC could order a new worktop and the delay to the customer could possibly be shortened. This would help to improve the customer satisfaction, since the customer does not receive a damaged worktop and they get the information quicker

concerning the delayed worktop, so that the custom can rearrange the installation-date of the kitchen.

The work procedure concerning the deviation flow could possibly make the measurement easier if the work processes are well developed in relation to the measurement system. Providing an understanding for the measurement system among the people working with the deviation flow, could facilitate that the suitable metrics easier could be incorporated into the work processes. For example, if the personnel at IKSC were involved in the development of a measurement system, their knowledge could facilitate that, suitable areas in need of measuring would be focused upon.

During the work process regarding entering deviations into the deviation system SAMS, the personnel at IKSC use different reason codes and causing units to describe the cause of the deviation and who is responsible for the deviation. Using centralised reason codes and causing units could facilitate global comparison between the different countries regarding deviations. This in turn could help in accessing the performance of both the overall supply chain and which local setup of the supply chain that functions best regarding minimising deviations and improve performance. This could be considered to be a form of benchmarking within the supply chain. This would however require intimate knowledge of all the local setups within the supply chain. Examples of local setups could be that some countries do not use HUBs and or CDCs when distributing the worktops to the customers. A drawback of the benchmarking is that sub-optimisation may occur, since IKEA views the deviations on a country level, possibly missing the holistic view.

6.2 Performance of the PERSONLIG supply chain

IKEA has chosen to focus their measurements on “cost free” metrics which shows the overall performance of the supply chain by measuring to what extent the supply chain goals are achieved. Efficiency and effectiveness are two concepts according to the literature that are used when measuring supply chain performance. In the following sections below, we analyse the supply chain performance through an efficiency and effectiveness perspective.

6.2.1 Efficiency – Doing things right

When it comes to efficiency in the PERSONLIG supply chain, there is little or no exchange of information concerning the consumption of resources in the supply chain. The units in the supply chain act and work like independent units, with little or no cooperation between one and another in the PERSONLIG business. This makes measuring efficiency difficult since this requires close cooperation between the actors within the supply chain. Measuring efficiency would also require a joint measurement system that could link the different actors with IKEA. At the moment there is no system like this for the PERSONLIG supply chain, where the different actors (suppliers, CDC/HUBs, stores or trading) in the supply chain measure the same things in the purpose of comparing efficiency for a better overall performance of the supply chain. Integrating the actors with one another is both time consuming and difficult. It also requires long term cooperation and trust.

Measuring efficiency can be a powerful tool for improving the overall performance of the supply chain. The PERSONLIG supply chain lacks the joint effort concerning developing definitions of metrics for the different parts of the chain. To enable control concerning where to buy capacity, efficiency measures and financial efficiency measures are needed to ensure

that the suppliers use the minimum amount of resources and at the same time produce worktops at a low production cost. By assessing if the suppliers have a low or high number of cassations, IKEA would know which supplier actually could deliver according to the set capacity, since a high number of cassations means that the worktops would need to be re-produced and this lowers the actual number of customer orders produced every day. If the supplier is nearing the maximum capacity the quality of the worktops would, with high probability, be lowered, since the production speed needs to be increased with little or no time to check the finished product. This would have the result that a higher number of deviations would occur and this could lower the overall efficiency of the PERSONLIG supply chain.

By using the same definitions for the measures, and applying them to all the suppliers it would be easy to assess which performs best. The same logic can be applied to the other actors in the chain, for instance looking at the transport companies and comparing how efficiently they are working could give a better negotiations position when buying transports. However measuring efficiency requires integrating the different actors with IKEA in a way that would make IKEA dependent upon the chosen suppliers. Once they are integrated and the infrastructure is in place, it would become difficult to discontinue the cooperation between IKEA and its integrated suppliers.

IKEA´s focus is on the customer, and the customer demands concerning a great choice of materials and functional worktops. This could be one of the reasons for the lack of measurement points in the supply chain concerning efficiency, since efficiency is closely connected to multiply point of measurement with measurements throughout the entire supply chain. Another reason might be that the number of orders has increased, and the focus from IKEA has been to satisfy the customers with limited time for improvement efforts regarding the overall efficiency of the PERSONLIG supply chain. One reason for this is that the worktop is a form of complementary product, for enabling the sales of kitchens. The volume of the product is relatively small compared to any standard IKEA product, and this would make it less prioritized compared to other standard off the shelf products concerning measurements and insight into the supply chain. Measuring efficiency requires multiple points of measuring where the actors within the same category measure the same things, for instance the suppliers would use the same metrics, and the transport companies would use the same. All the actors would be connected to the same measuring system where IKEA could evaluate their performance, and make the necessary adjustments to the supply chain for a better overall performance.

The product is IKEA´s high price offer and this could make the customers less sensitive to higher prices and making efficiency measurements less important. At the moment IKEA is not measuring efficiency in the PERSONLIG supply chain. But in the IKEA vision one can read:

> *"…wide range of home furnishings with good design and function at prices so low that as many people as possible will be able to afford them…"*

This makes the choice not to measure efficiency somewhat confusing. Measuring efficiency ensures that IKEA has an efficient supply chain, which enables offering the lowest price to the end customer.

6.2.2 Effectiveness – Doing the right things

IKEA puts the customer in the centre of attention, since they are trying to meet the customer demands concerning a great choice of materials, shape, and functional worktops. It is difficult to measure pure customer satisfaction, since this would require every customer to give feedback concerning the delivered kitchen and worktop. This would be a time consuming and difficult to carry out and would require a new type of infrastructure concerning information gathering and analysis. Since this is the case, IKEA uses the customer complaints provided by IKSC in Sweden when measuring effectiveness. When measuring effectiveness every part of the supply chain needs to have defined goals to strive towards. Using "cost free" metrics shows how well the supply chain is performing compared to the set goals. The goals set by IKEA concerning the PERSONLIG supply chain is to deliver the worktops within the *right time, right quality, right quantity* and *right condition*. By using effectiveness goals the organisation can assess how far they have come in realising their set goals for the chain. In the case of IKEA they present goals for all the parts of the chain. For the overall performance of the PERSONLIG supply chain they want to reduce the sales quality deviations to X%, supply quality deviations to X% and product quality deviations to X%. Quantifying the goals provides information concerning to where the organisation strives. This can help and encourage the people involved in the different parts of the supply chain to improve the overall performance. Measuring effectiveness helps in determining how far the supply chain has come in achieving the set goals. It is important to have goals for every aspect of the supply chain, which include goals for the number of customer orders placed every year. The forecast can be considered a form of goal, since the forecast should reflect the company's ambitions regarding for instance the number of sold worktops every year.

When viewing the input data that IKEA would like to use, it originates from a customer placing a call to IKSC and making a complaint regarding the PERSONLIG worktop. The data is directly linked to the customer. The data also originates from the interface with the end-user, which is considered the logical measurement point for effectiveness measurements.

Effectiveness is a single point measurement, and provides information concerning how well the supply chain is performing. By using the complaints provided by IKSC, IKEA can determine how well the customer's expectations, specifications and delivery are met. It will also be possible to measure the overall performance since the number of customer complaints are put in relation to the number of placed orders.

6.3 The Measurement system for PERSONLIG

To understand and get a complete picture of the PERSONLIG supply chain, the supply chain management needs to have information from all parts of the supply chain. A well developed measurement system can facilitate control and help in gaining insight into the supply chain and its different actors.

6.3.1 Performance model

IKEA has set the goal to deliver the worktops within the right time, right quality, right quantity and right condition. Quantified this means reducing the total deviations to below 2 % of the customer orders.

When viewing the scope of the supply chain, IKEA have chosen to view the later part of the chain between manufacturer and end customer. This is where the greater part of the refining

of the worktops takes place. It is this part of the supply chain they feel that they can affect in a positive way regarding the overall performance of the supply chain. Choosing who is part of the supply chain and who is not can be difficult. It is important to choose key participants, which can affect the supply chain performance positively. IKEA has chosen the later part of the chain, since it is this part that directly affects the end customer when it comes to the goals of the PERSONLIG supply chain (right time, right quality, right quantity, and right condition). By addressing these goals, and adopting a measurement system accordingly, IKEA could possibly improve the performance of the chain, and by doing so reduce the supply chain cost and lower the price of the worktops.

The structure of the supply chain provides information to where it is suitable to measure, and for the PERSONLIG supply chain we have in collaboration with IKEA identified several points of possible measurement.

- *Handling defects* can be measured at, at least four different points depending upon the setup of the supply chain, one at the supplier, two at the CDC (another two if a HUB is used), and one control when the customer receives the worktop.

- *Sales errors* are discovered when the customer receives and inspects the delivered worktop, the point of measurement must therefore lie at the customer.

- *Product deviations* are discovered when the customer starts to use or unpack the worktop, therefore it will not be possible to measure product deviations anywhere else but at the customer.

- *Delays I & II* are not physical measurement points, the information displays if the supplier has updated the order dispatch information before the actual dispatch took place. The information is retrieved from Orders and refers to the dispatch process at the supplier in the PERSONLIG supply chain.

- *Delays III* is not a physical measurement point, the information is also provided by Orders, and can be referred to the check or production process at the supplier.

- *Order data* is provided by Orders, and the information can be traced back to when Trading receives the order from the stores.

However only two points are used, the measurement points they are currently using are at the trading agent and at the interaction with the end customer. The information provided by IKSC is then processed so that it represents all the measurement points. When the customer calls in and reports a deviation, the personnel at IKSC classifies the complaint using different reason codes. It is these reason codes that is then used by the application to display at what point the deviation took place. Instead of using the information provided by the customer it would be possible to measure at all the points discussed above. This would improve the quality of the data, since the estimation made by IKSC is not always correct concerning the selected reason codes. However trying to implement measurements at all the different points in the chain would require extensive work and closer collaboration between the actors in the PERSONLIG supply chain. It is said that the product is to be inspected and checked at multiple points in the chain, but as long as no measurements are conducted it is difficult to determine to what extent these check actually take place. By introducing measurements to all the checkpoints IKEA could with greater accuracy determine where the deviations actually take place. This could be

done since every handling point would report if a deviation would occur. Measuring at all the checkpoints could facilitate pre-emptive problem solving to reduce deviations and also discover deviations early in the supply chain, so that the damaged worktop would not be transported through the entire chain.

The level of integration within the supply chain only allows IKEA to have insight to certain actors, often the ones totally controlled by IKEA like the CDC. This presents problems concerning improvements of the total supply chain performance, since the actors within the chain act as individual companies. At the moment there is little to no information exchange between the different actors within the PERSONLIG supply chain. The measures used by IKEA mirror the entire supply chain on a holistic level, from supplier to end customer. All internal measuring are kept within each company in the chain and is not shared with the rest of the actors. This presents problems when trying to verify where the problems actually take place, as well as when trying to direct improvement efforts. By getting the actors in the supply chain to share information and conduct measurements, which could be used to compare how the different suppliers are performing, would aid in identifying best practice processes at the different companies. This however is no easy task, and would require a great deal of effort from IKEA, who would be the part responsible for identifying the best processes and trying to transfer them to the different suppliers in the PERSONLIG supply chain.

6.3.2 Supply chain metrics

The supply chain metrics IKEA have chosen to use (supply quality deviation, product quality deviation, sales quality deviations, orders, and precision), gives a good overall view concerning effectiveness, since they are all non financial metrics without any ratio between output and input. No financial measures have been used when viewing the overall performance of the PERSONLIG business. IKEAs focus is on the customer and the metrics they have chosen to use reflect this, since they have chosen to use mostly effectiveness measures. However if one chooses to disregard the efficiency measures, a whole dimension of the supply chain lacks appropriate measurement. If one does not view efficiency it will become difficult to determine if the consumption of resources made in production lay at an appropriate level. This in turn might affect the prices offered to the customer. Since this is a high price offer and a complementary product, price might have a smaller impact on the decision to buy a kitchen at IKEA. By measuring and controlling both efficiency and effectiveness, IKEA could possibly reduce product costs which in turn could provide a greater volume of orders and this could give greater leverage to use in supplier negotiations.

IKEA has chosen to measure three main areas, *Deviations*, *Orders* and *Precision*. Deviations measures customer complaints which can be interpreted as a form of customer satisfaction measure, since the customer expresses his or her unhappiness by complaining. This however does not reflect the customers who is not quite satisfied, but satisfied enough not to complain. IKEA could solve the problem of measuring customer satisfaction, by trying to get as many kitchen customers as possible to fill out a questionnaire, for instance on the internet and then adding a function to the application that could process and visualise the data could be a way of getting information regarding customer satisfaction from more customers. They could also have a third party conducting telephone interviews with the kitchen customers. This would however bring some additional costs.

Measuring customer satisfaction is one appropriate measure according to the theories. Metrics that can be used for this purpose is for instance product availability. When viewing product

availability for the PERSONLIG business it becomes apparent that it is not possible to keep this product in stock, since it is a custom made product and no two worktops of this kind is another alike, concerning where the sink is placed and so on. Availability for this product could be translated into delivering the product according to *right time*, *right quality*, *right quantity* and *right condition*. This is what IKEA is measuring when the deviation report and the precision report is viewed. The Precision report provides information concerning *right time*, this is done by using Delays I-III which shows how the suppliers are performing regarding different delivery time aspects. The Deviation report provides information concerning *right quality*, *right quantity* and *right condition* which is done by presenting the metrics as Supply quality deviation, Sales quality deviations and Product quality deviations. Sales quality deviation shows how well the different aspects of transporting the worktop is working concerning how the worktop is handled and how many that goes missing in the supply chain. This visualisation gives insight into how the different transportation companies are performing, which could help when new distribution contracts are written. However the transportation of PERSONLIG worktops is only a small part of all the customer orders that the transport companies deliver to the customers, so the impact on the contract negotiations with the companies might only be marginal. Sales quality deviation show how many deviations that the stores contribute to, by identifying which stores that are performing poorly and who is performing better, IKEA could try and find the reasons why different stores are better performing than others and transferring the work processes from the better performing to the once in need of lowering their deviation percentage. Product quality deviations shows how the different suppliers are performing, by assessing which ones that are performing better IKEA could encourage those suppliers by giving them greater volume, and decreasing the volume of orders to the once performing poorer. This could help in improving the product quality, since none of the suppliers would like to receive fewer orders and thereby they would try to increase the product quality.

Measuring deviations provides a picture of how the supply chain is performing. IKEA views deviations on a country level, which means that the deviation report generated reflect the country specific supply chain and its performance and not the overall performance of the PERSONLIG supply chain. This could have a negative impact on the total performance of the supply chain with a risk for sub-optimisation, since it would be easy to identify smaller problems with local setups and miss how the improvements on a country level would impact the overall performance of the PERSONLIG supply chain.

Another target group to consider is the *stakeholders*, which means that one can look at metrics like revenue growth, profitability, return on supply chain assets and customer growth and profitability. To facilitate this, IKEA could use metrics such as sales per marketing channel, profit per supply chain, asset utilisation and structural flexibility. The metrics IKEA has chosen to use for this purpose is orders, or more correct the number of customer orders placed. This however only reflects the growth of the business and not the overall profitability of the business. By dividing the number of orders placed on a country level IKEA gains insight into which markets that are performing well and which are not regarding growth. To get a clearer picture, financial measures could be used for instance when viewing asset utilisation. By not using financial measures IKEA will have difficulties in assessing how well the assets are used regarding the PERSONLIG supply chain. It will also be difficult calculating the overall profit for the chain, if no appropriate financial measures are used.

Sales or the number of actual customer orders can be used both as efficiency and effectiveness measures. The number of actual customer orders for PERSONLIG worktops have increased,

which reflects that IKEA has a product that the customers are demanding. This can be interpreted as an effectiveness measure. While measuring orders and putting them in relation to the number of deviations reported by the customers, orders become a metric that show how efficiently the supply chain is operating. It shows how many percent of the placed orders that deviate, which in turn gives the user information on how efficiently the PERSONLIG supply chain is performing. By using orders in this way IKEA can get a clear picture of the supply chain without using multiple points of measurement.

The metrics that are used, gives a good overview of the current situation concerning the PERSONLIG supply chain. By using the metrics IKEA has specified, which contains the different trends, the user can see if the events in the supply chain concerning orders, deviations or precision are temporary or if they are long term. This could help the decision makers, for instance in assessing if more capacity is needed in the long term or if a media campaign is needed to increase the sales if the trends are showing a steady decrease in the number of customer orders.

By not using financial measuring it becomes difficult for IKEA to see the overall performance of the business. It is also difficult to assess where in the supply chain the actual costs of deviations occur, a small percentage of the orders mal-handled at the end of the supply chain could be more costly than a significantly higher percentage of deviations earlier in the chain. This information is lost by only viewing non financial measures and one could easily end up sub-optimising parts of the supply chain or not focusing on the most critical issues. Another thing to consider when using financial metrics is not to lose focus on the supply chain goals. These could easily become shadowed by the costs and the focus on the actual goals could be lost. It is easier to make improvements regarding cost reduction since they are quantified, than improvements regarding customer satisfaction which might be harder to measure.

6.3.3 Measurement method

When it comes to the measurement method, the first thing to view is data capture. IKEA has in the case of the PERSONLIG business chosen to use data collected from other programs. The data have not been developed for the purpose of measurements. An advantage of using this type of data is that it is unfiltered, all the data is unprocessed so no information is lost. A drawback might be that the data gathering is not developed for the specific use of measurement, certain aspects may not be possible to measure. The method is mostly automated which is less time consuming then a manual follow-up. But since the data is not developed for the specific use for the measurement of the PERSONLIG business, certain aspects of the measuring are lost, for instance measuring the costs of having deviations at different stages within the supply chain. It could be that deviations at one stage in the chain, however small, might be more costly than a higher number of deviations at another stage in the chain.

The measures should be simple and easy to understand, so that the user does not have to think twice regarding what the numbers presented means. It is also important to use both percentages and absolute numbers. IKEA uses multiple trends that are put in relation to forecasts and capacity as well percentages and absolute numbers. By doing this the user is provided with enough information to base his or her decisions upon. By both quantifying and using percentages, the measures are presented in a way so that it is possible to determine for instance if a high percentage of deviations actually mean that many customers are effected or not.

For the presentation of the information in the reports, IKEA chose to use diagrams and tables, as well as percentages and absolute numbers. Using a combination of the diagrams and tables, the user themselves can determine the level of detail he or she would like to base their decisions upon. This is important since the measurement system is to be used for accurate analysis and decision making.

Communicating the measurement results to the right people is important. IKEA has chosen to use their internal webpage when communicating the measurement results. Using the internet can be a good way of spreading the information to the concerned people, as long as the information makes its way to the concerned actors in the supply chain. Storing the information on a webpage provides instant access for the information seekers, however finding the wanted information on a given webpage can be demanding and time consuming. This would make the placing of the information in a logical way on the web page important. A drawback regarding the information in the reports is that the person viewing the measurement results must have some connection to the business, since it otherwise might be difficult to interpret the information.

The measuring of the PERSONLIG business presents information that can be directly used in the decision making process. The metrics that IKEA have chosen to use can make the decision making easier, since they use a lot of trends that are put in relation to the forecasts and capacity. The action that could be taken is for instance diverting orders from one supplier to another when a supplier is in risk of hitting its maximum capacity. It could also be used when calculating what capacity is needed as well as producing more accurate forecasts for the PERSONLIG business. The measurements could also be used when focusing on the improvement of the PERSONLIG supply chain, for instance if it is believed that a certain store has a lot of sales errors this can be confirmed or rejected.

6.3.4 Points of measurement

The data which is available originates from either IKSC or from the different trading agents. The deviation data provided by IKSC is split into small parts to reflect the performance of the supply chain. This is consistent with a single point measurement. Since the PERSONLIG supply chain lacks a high degree of interaction between the actors within the supply chain, this is the presently only available solution regarding the number of points of measurement. By integrating a greater number of actors into a centralised measurement system the possibility of having more measurement points is introduced. This however is not an easy task and involves having a long term strategy for the business and the actors involved.

Since a single point is used, transmitting the results of the measuring to other parts of supply chain becomes ever more important, because the other actors might not know how they are performing regarding the measures used by IKEA. A drawback of using single point measurement for the PERSONLIG supply chain is that deviations are discovered too late, since the customer is the one reporting the deviation. The order data is also provided from a single point in the supply chain. Using single points of measurement close to the customer also reflect that the customer is the one in focus. The data provided by IKSC either comes from the customer or from HUB/CDC, where most of the data is provided by the customer.

Using multiple points of measurement requires a great deal of integration between the actors in the supply chain. This however gives another depth to the measuring, allowing for

comparison of different parts of the supply chain. When comparing within the supply chain it is important to use the same definitions of the metrics for all the actors. Applying multiple point measurement to a supply chain requires extensive work. Using this type of measuring correctly facilitates benchmarking between the actors in the supply chain. It might also provide more accurate financial measuring, since all the actors in the supply chain provide their own and accurate information. By applying a multiple point measurement system to the PERSONLIG supply chain, IKEA could get a more comprehensive picture of how the supply chain is performing. Both regarding efficiency and effectiveness, this would facilitate greater control and give the ability to make more founded and better improvement decisions regarding the supply chain and the development of the business. By measuring at every handling point in the chain IKEA could with certainty know where for instance the handling deviations occur as well as identifying who is the responsible party. IKEA could also by getting information regarding production stop times and the consumption of raw materials assess which suppliers that are more reliable and better equipped to handle an increase in orders without having production problems. This requires long term cooperation between IKEA and the suppliers, as well as a higher level of integration between the companies. A drawback of this is that the companies become dependent of one and another which might not be the desired outcome. By measuring at multiple points all the data gathered would become more accurate, since all the checkpoints would be compelled to report any deviation or become accountable for the deviation themselves. This would help in improving all aspects of deviation especially handling deviations and missing goods, since they would be easier to discover at the different handling points.

What is measured will get done, so if the companies measures throughout the supply chain, deviations will get discovered at an earlier stage and the costs of handling and transporting the goods through the chain can be cut. It also creates incentives for the actors to perform well since they will get evaluated using the measurement results. If as stated before the different actors in the supply chain has to check and report every worktop deviation or get accountable for the deviation, every part would improve since no actor would like to be unnecessarily accountable for the deviation. Even if it is said that there are checkpoints throughout the chain, as long as no measures are directly made at these points the checks remain uncertain. When assessing how the actors in the supply chain are performing it might be profitable to shift certain tasks between the actors, for instance shifting the reasonability of controlling and packaging the finished worktop from the supplier to the transport company so that the worktop with certainty was undamaged at the start of the transportation to the end customer.

6.4 The analysis of the application

The application fulfils its purpose and shows what IKEA has specified, but it might be improved in certain aspects. One aspect that can be improved would be making the application more dynamic, regarding customisation of the reports and some aspects regarding the input data. In the application the user cannot change the lead-time, since it is fixed to five weeks. If this option was to be available, the application would become more dynamic but the development and construction would have been considerably prolonged and more difficult. Since this option was discovered at the end of the development phase it would have been impossible to make the change and still have a functional application. Other variables that are fixed in the application are the suppliers, worktop materials, and the 21 countries. Since this is the case it will be difficult, next to impossible, for the user to change or add another country or supplier and preserve the functionality of the application. The same problem would occur if one attempts to change the lead-time. Since these variables were considered to be fixed, the

development of the application was made easier. However using the fixed variables poses problems when changes are made to the supply chain regarding these fixed variables. In our efforts to make the application flexible, we added not just the countries that today have PERSONLIG sales but also the countries that will have sales in near the future. Most of the parts are dynamic, like for instance the stores, transport companies, forecasts, capacity, what articles that are viewed and which reason codes that are used in which country. These areas can easily be changed by the user. One disadvantage with this is that the user needs to understand how the inputs work and what unit the data is supposed to be entered in. For instance, the forecasts are entered on a five workday week. And the stores are mostly open seven days a week. This could be confusing and possibly create misunderstandings, to why the forecasts are not entered on a seven day basis. By improving the user interface the application could become more user-friendly and easier to work with.

The application is dependent upon on the structure of the input data. This is one advantage regarding the manual inputted data, since it is hard to enter the wrong information into the application. The drawback with this type of dependence is if IKEA would change programs for retrieving the automated inputted data regarding orders and deviations. Then the application probably would not accept the new data because it is dependent upon the structure of the old spreadsheets. If the data has the wrong structure the application sends a message to the user that the import has failed. This forces the user to think twice before entering information into the application, which is a good thing since the user has to think and understand what he or she is inputting into the application.

One other thing regarding the application is its outputs, the application provides a multitude of reports, all of which use cost free metrics. The delays report show the actual performance of the country specific supply chain while the order reports show how well all the countries are performing. These reports show both percentages and absolute figures regarding the current situation. The order reports strive to show a holistic view of the ongoing situation for the PERSONLIG business. This can be perceived as a good thing, because the decision makers can make accurate decisions with an emphasis on the holistic view, and by doing so sub-optimisation could be avoided. The reports generated by the application are constructed so that they are to be generated on a weekly basis preferably every Monday morning. The manual follow-up conducted by IKSC is compiled on a monthly basis, according to IKEA this time-span does not allow for quick and responsive actions to take place regarding deviations in the supply chain. Using a narrower time-span, IKEA could take either quicker or pre-emptive action with regard to both deviations and sales, since the application allows only weekly reports to be generated, according to IKEA's specifications. One drawback is that by generating reports on a weekly basis instead of a monthly, the number of reports stored on the user's computer is multiplied fourfold. This could present problems finding the right report, if the user does not delete the old reports continuously. By generating reports on both a monthly and weekly basis, depending upon what information the user is interested in can facilitate a broader time span, which can interest decision makers. Since this provides both depth by viewing the weekly report and a more comprehensive picture of the PERSONLIG business.

IKEA has chosen to communicate the reports on the IKEA intranet. This is a good way of presenting the reports. It is not certain that all the concerned people can access the reports since the suppliers are outside the IKEA organisation. This could be solved by adding functions for emailing the reports to the concerned people. For instance selecting which reports that should be sent to a certain email address. Then all the people that might have an interest in the reports would receive them. A drawback with this is that not all the people

should gain access to the whole reports but just sections of them. The reports generated by the application today, does not allow the user to change the contents of the reports.

The developed application does not incorporate any financial measure. This however could add another dimension to the application, showing the costs of having deviations at different stages in the supply chain. A risk of using financial measuring is that the customer focus is lost and the focus on reducing costs becomes more acute. Having the most costly deviations at one point does not mean that the majority of the worktops are damaged at this point. It is the points with the highest number of deviating worktops that needs to be addressed not the points with the highest cost from a customer satisfaction point.

7 Conclusions

In this chapter the authors present the conclusions regarding the PERSONLIG business and its supply chain measurement system as well as the conclusions drawn concerning the developed application.

IKEA has begun to look at their problems regarding the supply chain for the PERSONLIG worktop business, to see what they can do to visualise and solve the different problems. Like a support for the further development of this business we would like to give IKEA some recommendations on what they can take under consideration for achieving greater insight into the PERSONLIG supply chain.

7.1 The PERSONLIG supply chain

One of the problems that this thesis has focused upon is how the supply chain was constructed. We have come to the conclusion that the supply chain is well constructed to manage the customer requests and the physical flow of products, but not sufficient enough regarding the information flow. This since it fulfils all the customer needs but the communication within the supply chain is not sufficient to handle a complex distribution network, for instance the actors within the supply chain do not share information. The solutions and the possible improvements that we have identified are founded on integrating IKEA with the rest of the actors in the supply chain. Today's and the future global competition will with a high probability become difficult to fully handle without a good structure of the supply chain, with well integrated partners. A well developed supply chain must have clear strategies for how the customer satisfaction is created and developed work procedures for the distribution network and the deviation flow.

Another advantage regarding integrating the different actors is that the information exchange becomes better and the actors know what to do and when to do it. For example, if the transport company know in advance that a worktop is due to be delivered to a certain address, it would become easier for him to plan the delivery, so that no delays occur within his part of the supply chain. Furthermore, by integrating the different actors with IKEA, it would lead to that the entire supply chain can act more like one entity and by doing so, they compete as one supply chain instead of competing as individual companies.

The deviation flow in Sweden is well developed and it functions well in the collaboration to our measurement system, since the measurement system has been developed with consideration to the work procedures at IKSC. A certain group at IKSC are specialists regarding PERSONLIG and are only working with questions regarding this product. This provides the PERSONLIG business with good capabilities to handle deviations. When IKEA wants to alter the deviation flow, they should first discuss the changes with the people working at IKSC, since these people have a lot of experience concerning deviations to the PERSONLIG worktops and are able to give a good picture of the reality concerning the business.

7.2 Performance of the PERSONLIG supply chain

When viewing efficiency in the PERSONLIG supply chain, we find that the actors within the chain more or less work as independent companies, with no coordination when it comes to the development of a joint measuring system.

To develop a measurement system with efficiency measures, close collaboration and integration between the actors is necessary. The purpose of measuring efficiency is to monitor the consumption of resources within the supply chain. This is done to ensure that the supply chain is as competitive as possible, regarding the price offered to the end customer. We find that if IKEA is to be able to offer the lowest possible price to the customer, they have to know how their suppliers are performing concerning the cassations in their production. This could be done by introducing efficiency metrics for all the suppliers in the PERSONLIG supply chain. Since the suppliers do not share their internal measuring with IKEA, it becomes important when negotiating for instance the purchase of capacity and prices to try and persuade the suppliers to share this information. This information is necessary to be able to determine which suppliers has the most potential regarding an efficient production of a PERSONLIG worktop, this evaluation has to be done if the long-term efficiency performance is to be considered as important.

At the moment IKEA measures mostly effectiveness, and this is the natural choice when the customer is focused upon. The metrics IKEA is using all have set goals, which is a requirement if efficiency is to be measured. To be able to control the PERSONLIG supply chain and knowing how far the organization has come in realizing the set goals measuring effectiveness becomes very important. We have come to the conclusion that since IKEA is measuring all deviations in an effectiveness way using the new application, and they can easily determine how far they have come in realizing their goals. The only better way of measuring effectiveness that we can think of is to ask every PERSONLIG customer to take part in a survey and thereby receiving information from more people then just the ones complaining. Presently using the data provided by IKSC gives a more then adequate picture of the current situation.

7.3 The measurement system for PERSONLIG

IKEA has chosen to view the flow of goods from worktop-supplier to end customer. It is this part of the supply chain that directly affects the customer. By doing so the scope of the supply chain only involves key actors which all can affect the customer in a positive or negative way. We find that, by involving this latter part of the supply chain IKEA could with greater precision focus their improvement efforts concerning customer satisfaction by addressing problem areas within the PERSONLIG supply chain. However it is important to consider how the focused efforts affect the overall performance of the supply chain so that sub optimisation can be avoided.

The structure of the supply chain provides information to suitable measuring points. By looking at the different processes within the PERSONLIG supply chain it is theoretically possible to measure at every handling point throughout the chain, between supplier and CDC/HUB, at the CDC or HUB, and between the CDC/HUB and customer. By doing so IKEA could reduce the number of damaged worktops delivered to the end customer, and decrease the costs of the supply chain. By not having to transport a damaged product from where the damage took place all the way to the customer. This improves the profitability of the supply chain and reduces the number of deviations throughout the chain, since nobody

wants to be accountable for having caused a deviation, and thereby taking more care during the handling of the product. The same logic can be applied for the suppliers.

There is little integration between the actors in the PERSONLIG supply chain. This prevents extensive measurements from taking place. By integrating the different actors with IKEA to a greater extent, this facilitates measurements to take place throughout the chain and by doing so the supply chain management team could get a more accurate view of how the supply chain is performing. We also find that this can be accomplished relatively easy with no extensive infrastructural changes just by emailing measurement results to IoS. However this would require some manual work compiling all the received data, as well as implementing the work routines at the different measurement points. The best way would still be using a system for reporting the deviation, but a quick and easy solution like this could be a good start. The metrics that should be used would have to be developed in cooperation between the different actors.

The metrics used in the PERSONLIG supply chain are sales quality deviations, product quality deviations, supply quality deviations and precision. IKEA is also measuring the number of customer orders placed. All the measures used are cost free, they do not show how much resources or money that is lost at different stages within the chain when deviations occur. By having effective financial measures throughout the PERSONLIG supply chain every part of the supply chain could report the actual cost of having a deviation. This would help in quantifying the costs of the supply chain and help in assessing how much money that is lost due to deviations in the chain. We have come to the conclusion that the PERSONLIG supply chain is in need of having financial measures throughout the chain, since this would give a clearer picture of how and where the actual problem areas lay within the supply chain concerning costs of having deviations at different stages in the chain. The areas presently measured (supply quality deviations, sales quality deviations, product quality deviations, sales, and precision) are sufficient metrics to use when assessing the effectiveness and goal achievement of the supply chain. By using all areas of measuring, the supply chain management team could make more accurate decisions and avoiding sub optimizing. And by doing so IKEA could significantly avoid deviations and increase customer satisfaction. A thing to consider if financial measures are introduced to the supply chain is that by doing so, a new dimension is added which might not necessarily affect customer satisfaction and the goals of the supply chain in a positive way. Since addressing where the most money is lost does not necessarily mean that this is the place where the majority of the worktops are damaged.

The results, the averages, and the specific trends that are used (1w, 4w-trend, YTD-trend, and so on) in the reports are easy to understand and provides a good holistic picture of the different areas measured. This is important since the reports are to be used in the day to day work of the owner of the PERSONLIG business. We have come to the conclusion that they provide all the necessary information to facilitate good decisions.

The reports generated by the application contain diagrams, tables, percentages and absolute numbers. By using a combination of diagrams and tables, depth is provided to the reports which help the user in assessing the current situation. We find that by using both absolute numbers and percentages the depth is enhanced even more, enabling for good analysis and decision-making.

By communicating the reports on the IKEA-intranet all the concerned people who have an interest in the information can find it. We have found that this is a good way of communicating the results. However it is very important that the suppliers and other concerned actors in the supply chain also receive the reports, since it is important that they know what is measured and why.

The reports containing the metrics provide a good foundation for analysis and decision making. We draw the conclusion that the information provided in the reports contains all the needed aspects for good control concerning effectiveness.

Presently only single point measurements are available for the PERSONLIG supply chain. This makes assessing the overall performance difficult. Efficiency measurements and multiple point measurements are closely incorporated along with a high level of integration between the actors in the supply chain. We have found that the number of measurement points needs to be increased. By doing this benchmarking between the different actors could be possible as well as assessing which suppliers or transport companies that perform the best regarding efficiency.

7.4 The application

The application fulfils all the requirements made by IKEA, to allow for decision making and control of the PERSONLIG supply chain. We have come to the conclusion that the next generation measurement system for the PERSONLIG supply chain should incorporate the following functions to better support the PERSONLIG business in the future:

- **Completely dynamic**
  The application presently used is not totally dynamic, which could present problems if the supply chain structure is altered, for example, if IKEA chooses to use new suppliers for PERSONLIG worktops or if the lead-time is changed.

  We have come to the conclusion that making the application fully dynamic IKEA could ensure that the application work flawlessly throughout the lifetime of PERSONLIG worktops. One drawback is that trying to make a fully dynamical application would be very time-consuming and expensive.

- **Fully automated data gathering**
  Presently the application uses data gathered by using programs to extract data from different databases. This works fine as long as the programs providing the data are available and the structure of the output files remain the same. One advantage is that by gathering the data directly from the concerned databases, the likelihood of introducing the wrong data to the application is minimised. Another benefit is that the user is not required to have any knowledge of either Orders or BO.

  Considering this, we came to the conclusion that using fully automated data-gathering directly from the concerned databases is the next step for the PERSONLIG measuring system.

- **Improved user interface**
  The current interface is fully adequate for making reports and updating the data. However if professionals had been involved the outcome would probably had been

different. The application can become more user friendly in the aspects of the manual inputs.

Since this is the case we think that a new application should facilitate easy manual inputs and an even more user friendly interface regarding all aspects of the application.

- **Automated information communication**
  The current application can only generate and print the reports. It does not contain functions for communicating and spreading the information to the concerned people. The present setup by communicating the reports on the IKEA-intranet is a fully functional solution.

  We find that by directly sending the reports to the concerned people within the supply chain could help in ensuring that the reports reach the intended people.

- **Allowing for changes to the time frame**
  The application used today only allows for generating reports on a weekly basis. A monthly report could present a more comprehensive picture with a greater time-span.

  We believe that by combining both the weekly and the monthly report could facilitate even greater insight into the PERSONLIG business. Therefore we recommend that this function is to be introduced into any new version of the application.

- **Financial measuring**
  In the application today there is no financial measuring. Adding this would provide another dimension to the supply chain measuring and facilitate even better founded decisions.

  We feel that by adding prices for deviations at different stages in the chain could act as a wakeup call for the person responsible for improving the performance of the supply chain. For instance how much a deviation late in the supply chain costs compared to a deviation early in the supply chain. Having this information could focus the improvement efforts in a better way.

We believe that if all the recommendations made above are realised in the next generation PERSONLIG measurement system, the business would have all the possibilities of realising the supply chain goals, as well as reducing the prices of the product.

8 Concluding remarks and suggested future research

In this final chapter the authors present important aspects to consider regarding the future, and how this thesis can be applied to other businesses.

8.1 Concluding remarks

The road of completing this thesis has been interesting and educational for us as writers. Having been introduced to the complex business PERSONLIG has presented many and interesting challenges concerning understanding the business at hand as well as learning to use Microsoft Access and other related programs and applications. A big part of the assignment has been to develop the performance measurement application for the PERSONLIG business. The developed application contains all the functions specified by IKEA and is a fully functional tool for assessing the effectiveness and running situation of the business. Never the less there are still questions we feel need more attention which we have not had the time to fully comprehend and get a complete picture of, the questions we are referring to can be found below in chapter 8.2.

8.2 Suggested future research

Suggestions for further research are to take a closer look at how the measurements at the different actors within the scope of the supply chain might take place, along with other important factors concerning the PERSONLIG business and supply chain. Below follows a more detailed description of what we have found to be important aspects to consider in the development of a more comprehensive measurement system.

- **How will the measuring take place?**
  With this we mean how the actual measurements will be conducted by the people involved in the production and handling of the PERSONLIG worktops. And what kind of infrastructure is necessary for this to work.

- **Assess why the lead-time between order and delivery is five weeks**
  We believe that the lead-time from order to customer is unnecessarily long. There might be some underlying aspects that we have not realised, but having a lead-time of five weeks for a relatively simple product seems too long. Therefore we suggest that this area is investigated further.

- **Why is the PERSONLIG business on an order level instead of an article level?**
  One of the first things we discovered was the fact that the PERSONLIG business operates on an order-level while all other IKEA products use an article-level. Using an article level is easier to use since all the IKEA information systems use an article level, and it is also strange if the suppliers calculate capacity on an order level, since the machines would have a maximum worktop capacity and not an order capacity. We feel that this subject needs further attention.

8.3 Generalisation

This thesis has been written in order to development a measuring system for the PERSONLIG supply chain. The theories in the frame of reference have been gathered for the purpose of developing a supply chain performance measurement system. The point of origin for the discussions and analysis has had the PERSONLIG business in focus. We believe that any company with the intention of implementing a supply chain measurement system could take interest in reading this thesis. This since many of the problem IKEA is facing is transferable to other supply chains and other custom made products. The conclusions we have given could interest other companies that are in the process of developing a performance measurement system. Considering the different sizes of companies, we know that not every company would have a use for the contents in this thesis, since the size of the company is of importance. We believe that smaller companies will not benefit to the full extent of having a supply chain measurement system since the volumes involved are usually too small. Another thing concerning supply chain measurement applications for smaller businesses is that the development is quite time consuming and expensive.

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Johan Ström
Johan was the project leader, he was responsible for running an improvement project for the PERSONLIG business. He was also at the time for the project acting as the owner of the PERSONLIG business.

Nils Strand
For the improvement project Nils acted as a "consultant" helping in answering all different kinds of questions regarding PERSONLIG, he has 14 years of experience with the PERSONLIG business.

Linda Svensson
Linda works at the customer call centre in Älmhult. She is responsible for handling customer complaints regarding PERSONLIG worktops. She has been working as a case handler with PERSONLIG for five years.

Anna Svensson
Anna has the same job as Linda and has been working with customer complaints concerning PERSONLIG for two years.

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Appendix A Interview

A.1 Frågor till Johan Ström och Nils Strand

A.1.1 Bakgrund:

Vilka bakomliggande fakta gör att ni vill driva projektet nu?

Hur ser dagens uppföljning ut? (innan det nya access verktyget)
Hur ser materialflödet ut?
Olika flöden i olika länder?

Hur ser informationsflödet ut?

Vilka problem finns med dagens uppföljning?

Vilka är målen med projektet/accessverktyget?

Varför är det viktigt för IKEA att visualisera försörjningskedjan?

Var kommer data (fel och försäljning) ifrån? Och hur pålitlig är den?

A.1.2 Problem formulering:

Vilka delar är viktigas att visualisera?

Kunden i centrum påverkar vad som mäts, varför?

A.1.3 Verktyget/empiri:

Vem kommer att använda verktyget primärt?

Vilka rutiner/processer arbetade supply planers med tidigare när det gällde PERSONLIG worktops?

Vilka rutiner/processer arbetade kundtjänst med tidigare när det gällde PERSONLIG worktops?

Hur kommer verktyget att påverka jobbet för supply planers?

Vad ska mätas och varför?

Hur ska data presenteras?

Vilken detaljeringsgrad ska användas dag, vecka, månad osv..

Vilka länder ska primärt ingå och varför?

Vilken detaljeringsgrad ska mätsystemet visa?

Hur kan vi få fram i in-data?

Ska vi alltid titta en tidsenhet tillbaka?

Ska sortering på ske på bänkskivans artikelnummer samt SACnr eller ordernummer samt SACnr?

Har personlig samma artikelnamn i alla länder?

A.2 Frågor till Linda Andersson och Anna Svensson på IKSC

A.2.1 Bakgrund:

Vad tror ni är de bakomliggande faktorerna till detta projekt?

Vilka olika typer av uppföljning har använts när det gäller PERSONLIG?

Hur många kunder ringer in per vecka, och hur många av dessa samtal leder till ny order?

Hur skiljer sig den nya rutinen mot den gamla? Sämre/Bättre

A.2.2 Problem formulering:

Har ni sett en ökning i anlatet klagomål?

A.2.3 Empiri:

Hur långt efter försäljning brukar kunderna höra av sig?

Hur ser processen ut efter det att en kund ringt in?

Hur hade er idealprocess sett ut?

Vad sker i fall där är olika fel på bänkskivorna?

I hur stor utsträckning används digitalbilder?
Fattas beslut direkt på digitalbilder?

Vad händer i fall det blir en ny order? Vad är alternativen till en ny order?

Vem bestämmer om det blir en ny order?

Hur lång tid tar det från dess att en kund ringt tills det leder till ett beslut? Idealfall och snitt.

Är det jobbigt att ha många aktiva sacar öppna? Påverkar det ert arbete?

Vilka rutiner/processer arbetade kundtjänst med tidigare när det gällde PERSONLIG worktops?

Vad är skillnaden mellan reason_code och reason_id?

Vad händer om det uppstår två fel på en bänkskiva, t ex om hålen är felplacerade samt att skivan är skadad i transporten? Genereras det då två sac id till samma skiva?

Vad händer om det är svårt att avgöra vad felet är? Kan det hända att det saknas reason code tills dess att besiktningen är utförd?

Hur många subreason koder, vilka?

Färdiga rutiner?

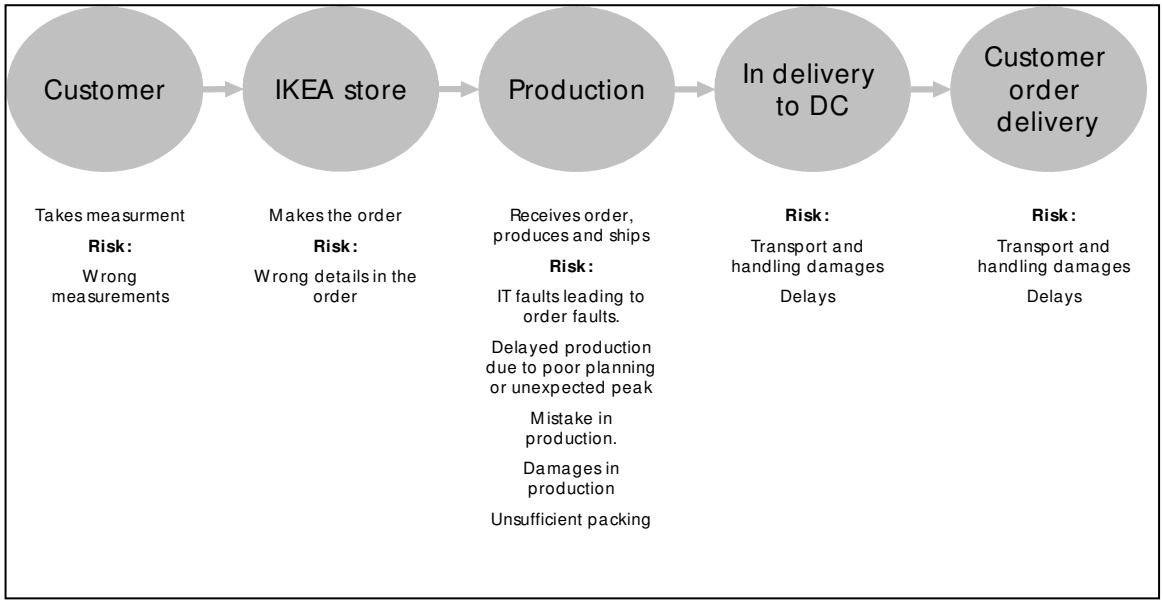
Appendix B Preliminary problem definition

CUSTOM MADE WORKTOPS

Background:
IKEAs goal is to become the leading home furnishing company. In kitchens, this means that IKEA need to offer complete solutions, including a great choice of design/materials and functions of worktops. Our best worktop is NUMERÄR straight work tops. Here IKEA offer a wide range of choices at really competitive prices. But a big share of our customers needs longer worktops without an unpractical joint. In many cases they want to make a kitchen island. Many have kitchens where the room does not provide straight corners.

PERSONLIG is IKEAs high price offer that provides the customer with a possibility to make the work top in the right size. When IKEA does not have it, the customers go to their competitors and spend often the same money on the top as on the entire kitchen at IKEA. IKEA offers PERSONLIG in the same range of choices as NUMERÄR plus more laminates and acrylic stone which offer the best function against heat, scratching and tough wear and tear. The lead time in normal cases is 3 to 4 weeks. The work top gets home delivered with the rest of the kitchen.

PERSONLIG is IKEAs most difficult business. It is custom made which makes it a great challenge to get it right from measurement to ordering and production. Ordering requires special trained competence and the systems are far from fool proof. It's the only IKEA product which is custom made and cannot be kept in stock. On top of that it's large and heavy inviting for transport and handling damages. The result is resource demanding planning, quality defects and often big delays. The delay of a custom made worktop can cause big problems for the customer who already have installed the rest of the kitchen and cannot use it.



Problem description:

One of the main problems with the business PERSONLIG worktops today is that there is no effective follow-up tool regarding supply chain performance, especially concerning the following four areas:

- Right time
- Right quantity
- Right quality
- Right condition

The problem for IKEA is that the don't have any knowledge of how many products that are wrong and how many they are selling

The tool should be able to show deviations in the supply chain for a specific country and where the deviations occur. Furthermore the tool should be able to show the total sales and the sales for different countries and for the different suppliers.

In addition when the tool shows the sales for different countries it should also show the forecast so the user can see if the forecast is in line with the sales. The same thing applies when the tool shows the sales for different suppliers but here is it the capacity in focus instead of the forecast.

Purpose:

The task is to create a tool which will show the performance of the supply chain and running situation for a sales region and shall facilitate where in the supply chain IKEA need to improve.

Appendix C Detailed information about different manual inputs

C.1 Forecast

Only available in the non-public version

C.2 Capacity

Only available in the non-public version

C.3 Stores

Only available in the non-public version

C.4 Distributor

Only available in the non-public version

C.5 Deviation codes

Only available in the non-public version

C.6 Supplier matrix

Only available in the non-public version

Appendix D Example reports

D.1 Example of deviation report (dev_SE_w04)

Only available in the non-public version

D.2 Example of order diagram report (ord_tot_dia_w04)

Only available in the non-public version

D.3 Example of order table report (ord_tot_table_w04)

Only available in the non-public version

D.4 Example of forecast report (ord_vs_fcast_dia_w04)

Only available in the non-public version

D.5 Example of capacity report (cap_tot_w04)

Only available in the non-public version

D.6 Example of precision report (pre_tot_w04)

Only available in the non-public version