Turun yliopisto
University of Turku

# AUTOMATED PURCHASE ORDER – EXPERIMENTS AND EXPECTATIONS IN MID-SIZED MANUFACTURING COMPANIES

Lauri Rantala

TURUN YLIOPISTON JULKAISUJA – ANNALES UNIVERSITATIS TURKUENSIS
Sarja - ser. E osa - tom. 9 | Oeconomica | Turku 2016

## University of Turku

Turku School of Economics
Department of Marketing and International Business
Operations and Supply Chain Management


## Supervised by


Professor Lauri Ojala
University of Turku

Professor Harri Lorentz
University of Turku


## Reviewed by


Professor Harri Haapasalo
University of Oulu

Professor Kari Tanskanen
Aalto University


## Opponent


Professor Kari Tanskanen
Aalto University





ISBN 978-951-29-6637-0 (PRINT)
ISBN 978-951-29-6638-7 (PDF)
ISSN 2343-3159 (Painettu/Print)
ISSN 2343-3167 (Verkkojulkaisu/Online)
Painosalama Oy - Turku, Finland 2016

# ABSTRACT

Automated purchase order – experiments and expectations in mid-sized manufacturing companies

Operational processes were originally designed before of large-scale information technology revolution in industries. Based on this fact, it has been argued that by redesigning business processes with help of information technology, efficiencies in operational processes may be achieved. Process integration and automation should save valuable time and resources at the same time. However, in small and medium sized businesses limited resources reduce possibilities to implement both information technology and changes in business processes. The research in this area concentrates whether on large corporations (in depth or on large samples) or on small and medium sized companies based on statistical information. Longitudinal and deep analysis on business process change in small and medium sized companies is scarce. In depth analysis on small and medium sized companies in the area is scarce.

This research investigates the savings in labour and capital that are achievable through automating and integrating routine purchase process within a supply chain. This study investigated the area of purchasing and especially routine purchasing of direct production materials. Through the use of action research, quantitative and qualitative analysis, a variety of methods are used in order to give a broader view to the data and results.

From the practical point of view, the purchase process of production materials is often repetitive work based on information from diverse information systems and sources. This study investigated the possibility of increasing efficiency through automated routine processes. As an indicator of increased efficiency, change in inventory turns was chosen. Three research questions were set: will purchase order automation have an effect on inventory turns, what are the main contributors to any observed changes in inventory turns and are the observed changes relevant in a larger context of small and medium sized companies?

For the two first questions action research methodology was used with participant observation. Two projects of purchase order automation were conducted and effects on inventory turns were measured. The automation projects were conducted in a medium sized electronics manufacturing company and with two of its suppliers. A controlling sample was collected from the company item transaction database. These results were analysed with quantitative analysis methods. The

data includes three samples of data between years 2000 and 2004. Results showed that automation does not clearly improve inventory turns but the results are mixed. Observed changes result from improved parameter setting and change in business conditions.

The third question was treated separately through semi-structured interviews within purchase professionals in medium sized manufacturing companies. Four interviews were conducted in 2014-2015 to verify results from purchase automation projects. The answers were analysed with qualitative methods. It was found that the process of automation and its results are relevant to medium sized manufacturing companies. Special care, however, should be taken while implementing the system and setting its basic parameters.

From the theoretical perspective, the research emphasizes the assumption that the benefits of business process changes are not always clearly visible but some positive results may be achieved. In regard of human decision-making biases it is clear that they exist and the effects of these biases may be reduced through process automation. The use of several different methods in data collection and analysis opens a larger picture for a deep analysis of the processes and their results. Through action research insights to the actual phenomenon are gained and a longitudinal analysis gives more than a snapshot to it.

From the managerial perspective, process automation is an option to consider but at the same time it should be part of a larger process change initiative to see that it does not result into sub optimisation of processes at the expense of general process optimisation of a company. It is crucial to understand the biases made by individual decision makers in business processes and see, how the negative effects of these biases may be avoided through careful consideration of process automation.

Keywords: action research, business process re-engineering, case study, electronics industry, inventory management, medium sized companies, participant observation, purchasing, supply chain management

# TIIVISTELMÄ

Automatisoitu ostotilaus – kokeiluja ja odotuksia keskisuurissa valmistavissa yrityksissä

Operatiiviset toimintatavat suunniteltiin ennen suurimittaista tietotekniikan vallankumousta eri teollisuuden aloilla. Onkin esitetty, että operatiivisten prosessien tehokkuutta voidaan kasvattaa uudistamalla liiketoimintaprosesseja ja käyttämällä niissä tietoteknisiä sovelluksia. Prosessien integroinnilla ja automatisoinnilla voidaan säästää arvokasta aikaa ja resursseja samanaikaisesti. Pienten ja keskisuurten yritysten kohdalla ongelmana ovat resurssien rajallisuus, mikä vaikeuttaa prosessien uudistamista ja tarvittavien tietoteknisten sovellusten käyttöönottoa. Tutkimus aiheesta rajoittuu joko suuryrityksiin (perusteellinen analyysi tai laajempaan otokseen perustuen) tai pieniin ja keskisuuriin yrityksiin tilastolliseen tietoon perustuen. Perusteellinen analyysi pienissä ja keskisuurissa yrityksissä on tällä alueella harvinaista.

Tällä tutkimuksella selvitettiin, voidaanko rutiininomaisen ostotyön prosessin automatisoinnilla ja integroinnilla toimittajien kanssa saavuttaa säästöjä toimitusketjun työ- ja pääomakustannuksissa. Tutkimus tehtiin siis ostotyön ja erityisesti suorien tuotannollisten materiaaliostojen alueella. Käyttämällä toimintatutkimusmenetelmää, sekä kvantitatiivisia että laadullisia analyysitapoja, saadaan laajempi näkökulma käsiteltyyn tietoon ja tuloksiin.

Käytännöllisestä lähtökohdasta katsoen on tuotannollisten materiaalien ostotoiminta usein toistuvaa, rutiininomaista työtä, joka perustuu tietoon eri järjestelmistä ja lähteistä. Tuottavuuden nostamiseksi oli kiinnostava tutkia saadaanko rutiinityön automatisoinnilla tehostettua kyseistä prosessia. Varaston kierron muutos valittiin tehokkuuden nousun mittariksi. Tutkimuksessa haettiin vastausta kolmeen kysymykseen: onko ostotilauksen automatisoinnilla vaikutusta varaston kiertonopeuteen, mitkä tekijät vaikuttavat havaittuihin muutoksiin varaston kiertonopeudessa ja ovatko tässä tutkimuksessa saadut havainnot merkittäviä suuremmassa joukossa pieniä ja keskisuuria yrityksiä?

Kahden ensimmäisen kysymyksen kohdalla käytettiin toimintatutkimusta ja tutkijan osallistumista toimintaan tutkittavassa kohteessa. Kaksi ostotilauksen automatisointiprojektia toteutettiin ja niiden yhteydessä mitattiin varaston kiertonopeuden muutoksia. Automatisointiprojektit toteutettiin keskisuuressa yrityksessä kahden yrityksen tavarantoimittajan kanssa. Vertaileva otos kerättiin yrityksen nimiketapahtumien tietokannasta. Nämä tulokset analysoitiin kvalitatiivi-

sin menetelmin. Materiaali sisältää kolme otosta vuosien 2000 ja 2004 väliseltä ajalta. Tutkimuksessa todettiin, että automatisointi ei selkeästi parantanut varastojen kiertonopeutta vaan tulokset ovat ristiriitaisia. Havaitut muutokset johtuvat pääsääntöisesti parannetusta järjestelmän parametrien asetuksista sekä muista liiketoimintaympäristön muutoksista.

Kolmas tutkimuskysymys käsiteltiin erikseen käyttäen puolistrukturoitua haastattelurunkoa, jonka avulla haastateltiin ostotoiminnan ammattilaisia keskisuurissa valmistavissa yrityksissä. Vuosina 2014-2015 toteutettiin neljä haastattelua, jotta voitaisiin tarkistaa automatisointiprojektien tuottamat tulokset. Haastattelujen vastaukset analysoitiin laadullisin menetelmin. Tuloksena havaittiin, että automatisointiprosessi ja sen tulokset ovat merkityksellisiä keskisuurissa valmistavissa yrityksissä. Erityinen huomio tulee kuitenkin kiinnittää käyttöönottoprojektiin ja järjestelmän perustietojen määritykseen.

Teoreettisesta näkökulmasta tutkimus vahvistaa näkemystä siitä, että liiketoimintaprosessien muutoksella saadut hyödyt eivät ole aina selvästi näkyvissä, vaikka joitain positiivisia vaikutuksia voidaan havaita. Inhimillisten päätöksentekoprosessien alttius poikkeamille normaalista vaikuttaa myös ostoprosessiin, ja automatisoimalla ostoprosessia sen negatiivisia vaikutuksia varaston kiertonopeuteen voidaan vähentää. Eri menetelmien käyttö tiedon keräämisessä ja tiedon analysoinnissa antaa laajemman kuvan toimintatapoihin ja niiden tuloksiin. Toimintatutkimuksen avulla voidaan päästä lähemmäs asioiden todellisia syitä ja pitkällä tutkimusjänteellä saadaan enemmän kuin yksittäisiä kuvia tilanteesta.

Yrityksen johdon näkökulmasta toimintaprosessien automatisointi on yksi mahdollisuus, mutta sen tulisi aina olla seurausta laajemmasta toiminnan arvioinnista jotta vältytään yksittäisten prosessien optimoinnilta koko yrityksen liiketoimintaprosessin optimoinnin kustannuksella. On myös erittäin tärkeää ymmärtää yksittäisen päätöksentekijän aiheuttamat poikkeamat prosessiin, ja se miten nämä poikkeamat voidaan välttää huolellisella valinnalla siitä, mitä prosesseja automatisoidaan.

Avainsanat: elektroniikkateollisuus, keskisuuret yritykset, liiketoimintaprosessien uudelleenmäärittely, ostotoiminta, tapaustutkimus, toimintatutkimus, toimitusketjujen johtaminen, tutkijan osallistuminen

# ACKNOWLEDGEMENTS

After a long way in life and in research, a goal is now being achieved. Conducting part time research or "research as a hobby" is not the easy way to reach doctoral degree. After almost 15 years of work at the side of family, work and other activities, multitasking has become a new normal. I do not know it yet but probably I will miss the process of investigating and finding new, trying to find correlations and, probably, truth out there.

My journey as a doctoral student started of an apparently light comment from Professor Lauri Ojala that there might be something in my work to prepare a doctoral thesis of. I was ready to take the challenge and started my studies with lots of courage and enthusiasm. I want to thank Lauri who created the positive atmosphere around the research and has always pushed me towards the final goal. In the very beginning, Professor Olli-Pekka Hilmola (currently at Lappeenranta University of Technology) coached me energetically to the world of writing articles to scientific journals. I wish to thank him for supporting my work when everything was fresh and new and sometimes unstructured in my mind. My second supervisor Professor Harri Lorentz joined the team some years later but has been of great support in understanding the purchasing and procurement environment and supporting me in related concepts.

Equally, I would like to thank Professor Harri Haapasalo (University of Oulu) and Professor Kari Tanskanen (Aalto University) to have agreed to act as pre-examiners for my thesis. They have been a perfect choice because of their expertise in the area my thesis. I am also grateful to Professor Tanskanen to have promised to act as my opponent in my thesis defence.

I wish to thank the Foundation for Economic Education and Turku School of Economics Foundation for financially supporting my research process and the publication of my thesis.

A great deal of help and understanding was granted to me in the company that was used as the case of study. Especially, I wish to thank the Director, Procurement to have offered me the opportunity to work on my thesis. Her open-mindedness and understanding of the importance of research in general has been invaluable in supporting my work. All the former colleagues in purchase and IT departments: thank you for supporting me during the process with open mind and eagerness to change things in order to find something new.

Last but not least, my family has been most supportive in all situations. My wife, Laura has only known me as postgraduate student (now 14 years), lately

concentrating to the well being of our little daughters Anni and Elisa. My parents, sisters, niece and nephews, they have always known when not to ask about the progress and when to give advise. This work is for my whole family, there is no better team!

On a crispy cold October morning in Messukylä, Tampere, 7th October 2016

Lauri Rantala

# TABLE OF CONTENTS

## List of figures



## List of tables

# 1 INTRODUCTION

The topic of this research is related to a fragment of supply chain management. The use of the word fragment might appear to downplay the significance of the work, but given the fact that a system is as strong as its weakest link: its importance is not minor. Supply chains have recently become more prominent as firms are increasingly specialising instead of integrating vertically. This creates a need for suppliers and partners to obtain all the services that were previously supplied in-house (Samaranayake, 2005). In order to satisfy the demands of end customers, organisations should focus on managing and promoting the total performance of the supply chain (Cox, 1999). Trust is a prerequisite in this process in terms of facilitating free communication in the pursuit of common goals and success (Potocan, 2009).

Supply chain management, logistics and purchasing are directly linked. They monitor the same flows of material and goods from different perspectives and are connected hierarchically. The Council of Supply Chain Management Professionals defines supply chain management as follows:

*"Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all Logistics Management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, Supply Chain Management integrates supply and demand management within and across companies."* (Mentzer et al., 2008)

This definition shows the importance of supply chain management to companies and business: it incorporates all the planning and management activities affecting the supply of goods and services.

Purchasing makes a major contribution to business performance (Gonzalez-Benito, 2007; Chen et al. 2004). The value of goods and services sourced from outside represents 70 per cent or more of overall company costs, especially in the manufacturing industry (Ellram and Cousins, 2007), and this applies to both strategic and operative purchasing. The role of purchasing is expanding as new processes related to outsourcing, sustainable development and business-to-business relationships emerge (Zheng et al., 2007). In order to enhance performance and gain competitive advantage companies should direct their purchasing resources

to the functions and processes that add most value and promote efficacy (Baier et al., 2008). At the same time, e-business applications facilitate the automation of minor tasks and hence the redirection of resources (Zheng et al., 2007).

Information technology has brought about many improvements in business processes and practices. Various Internet-based business tools are affecting purchasing as well, in the form of e-auctions and the transfer of commercial data. In a wider context, common data-communication languages and interfaces allow data transfer between organisations and systems. Some 20 years ago, electronic data interchange (EDI) systems were introduced as a tool for inter-organisational communication, offering a standard language and interface through which companies could connect with each other. The drawbacks included high costs, difficulties with implementation and the slow development of standards (Chong, 2008). More recently, systems using extended mark-up language (XML) and the RosettaNet standard have been gaining ground due to the lower investment costs, the speedier development of standards and the increased business opportunities (Chong and Ooi, 2008; Fulcher, 2005; Malhotra et al., 2005). Various applications require investments however, and consequently there are differences between larger and smaller companies in adopting these technologies (Zheng et al., 2007).

In order to find out more about the effects of implementing these tools and techniques in small and medium-sized companies, this study investigates the influence of purchase-order automation on inventory turns, and the reasons for any change. It comprises a single-case study involving researcher participation in a system implementation process. Its interest lies not only in the topic, but also in the research method and the availability of detailed purchase and inventory data.

## 1.1 Generic Scope

This research is based on the key concepts of logistics, purchasing and inventory management. All these concepts include the different stages that build up a supply chain. As difference to the operations management area, all of these concepts are serving the movement of “flows” in supply chains (Arlbjorn and Halldorsson, 2001). In this particular research, the flow that is followed is the flow of materials between two companies. As part of managing the flow, purchasing and inventory management play a crucial role. As a tool in managing these flows, information systems are being used.

The aim of this research is to spotlight the effects of purchase order automation to small and medium sized companies. In this research automated purchase order is defined as a process that automates parts of a standard purchase order process at buyer and/or supplier side. Despite the focus on a part of buyer suppli-

er relationships, there is no proper dyadic view but the research concentrates more on the buyer side of the relationship. Further, the scope is on industrial purchasing, that is production related purchasing.

The focus of this research is on the behaviour of inventory levels and turns of electronic components in a medium-sized Finnish electronics manufacturing company. Several criteria were used in selecting the components from the database of the company under investigation. Primarily the selection was based on the purchasing process: it had to have been automated during the investigation period. A secondary group of components purchased by traditional means served as a comparative basis or "normal" set of components. The lifecycle and history of the components also played a role in the selection procedure: only those with at least a three-year history at the time of the investigation were included in the sample. Most of them had a transaction history of four years or more in the company database.

The components under investigation were semiconductors, widely used in the manufacture of all kinds of electronic devices. They were bought for the case company through distributors that purchased them directly from the manufacturers. The focus in this research is on the purchase-order process from the component distributor to the case company, which manufactures electronic devices for its end customers for their service provision. This also limits the scope of the research to industrial electronics manufacturing and the related purchasing processes.

The following table summarises the generic scope of the research.

Table 1 Research scope

| Area | Scope |
|---|---|
| Industry | Industrial electronics manufacturing |
| Objects | Electronic components, semiconductors |
| Organisation | Purchasing, Inventory |
| Number of cases | One |
| Number of companies | One |
| Size of the companies | Medium |

The aspects listed in Table 1 above are further discussed in the various Chapters comprising this thesis. The scope is further defined in the section on limitations (Chapter 1.5). The number of cases is limited to one, and the methodology is further discussed in Chapter 2, The Research Process.

## 1.2 Research questions

This research investigates purchasing and the routine processes involved. The basic premise is that successful purchasing contributes to the overall success of the company, and that there is consequently an interest in developing the methods in order to increase efficiency and corporate performance as a whole. The quantitative data used comprises inventory transactions and the levels after each transaction. The system was developed in order to rationalise and save human labour in routine tasks and free resources for more profitable tasks from the company management's point of view. Following the introduction of the system the apparently natural question arose as to whether it was working as it was meant to. Its effect on inventory development was also questioned. The following research questions were therefore posed:

1. *Will purchase-order automation have an effect on inventory turns?*
2. *What are the main contributors to any observed changes in inventory turns?*
3. *Are the observed changes relevant in a larger context of small and medium sized companies?*

The aim in the first question is to assess the effect of purchase-order automation on inventory turns. Inventory turn, or inventory cost, is recognised as a key general performance indicator in enterprises (e.g., Henfrey et al., 2008; Cai et al., 2009; Dehning et al., 2007), and indicates how many times the current inventory level would be renewed given average historical consumption. It can also be expressed in terms of days, in other words how long the existing inventory will last given average historical consumption.

The second question is more analytical and concerns the reasons for any changes in inventory turns. As such, inventory turns are easily measured and reported as facts, but it is also important to identify the actual, or probable, reasons for any change. The automation of a business process may not be the only reason, given that in any real, uncontrolled situation there are variables that are more or less uncontrolled. In this case, too, some elements were controlled, but others were not.

The third question aims at raising the discussion on a more general level from the narrow case company findings. To answer this question, a small sample of purchase professionals was selected to participate in semi-structured interviews to see their ideas on the topic. Further, the results of the interviews were reflected to relevant literature.

## 1.3 Research objectives

This section continues the above discussion on the research questions and their connection with the current study in further linking them to the research objectives. The automation of business processes is one element of this research, specifically in connection with purchase-order processing.

The main objective is to identify, through one case analysed from different angles, the link between business-process automation and the key performance indicator of the particular process. With regard to the case in question, a further objective is to find relationships between changing from normal manual to automated purchase-order processing, together with changing the parameter setup in the decision-support systems, and the change in KPI that is normally used in evaluating purchasing effectiveness, in other words inventory turn or inventory days of raw materials (Dehning et al., 2007).

To verify at some level the findings from case company, four purchase professionals from different companies are being interviewed to see if the findings could be of more general nature.

## 1.4 Structure of the thesis

This report comprises seven main Chapters. Chapter 2 describes the research process, Chapter 3 the conceptual frame of reference, and Chapter 4 the case study. These chapters inform the reader about the basic research choices and methodology. Chapter 5 summarises the four previously published articles and essays comprising this thesis. The articles and essays are as follows:

Article I: From manual to automated purchasing – Case: middle-sized telecom electronics manufacturing unit
Article II: Analysis of two different automated purchase order systems in telecom electronics manufacturing unit
Article III: Inventory turns changes and sophistication of automation in purchase order systems
Essay I: From total quality management (TQM) through business process reengineering (BPR) to supply chain management (SCM)
Essay II: Perceptions of automated purchase order processing in mid-sized manufacturing companies in South-Western Finland

Chapters 6 and 7 discuss the results and conclusions. In reality, the thesis consists of two parts: the first gives the reader the background information required

to understand the subject and the area, and the second presents the results of the research based on these assumptions.

This first introductory chapter briefly discusses the research questions, objectives and scope. It provides the necessary background information for understanding the choice of research design and methodology and, further on, the results.

The second chapter starts with discussion concerning the theoretical paradigm. Section 2 discusses the choice of case study and how this research represents case-study methodology followed by data collection methods in section 3. The research design and method gives basic information about the technicalities and methodological choices.

Chapter 3 summarises the conceptual discussion in previous literature. Areas of significance to the research include supply-chain, purchasing and inventory management, decision-making, and business-process integration. Given the information-system perspective, a comprehensive view of ERP (Enterprise Resource Planning) systems is included.

The fourth chapter includes an extensive description of the case study, which is enhanced in Chapter 5 in the article and essay summaries. Chapter 6 discusses the results with respect to the research questions and the overall objectives, and assesses the generalizability of the case-study findings. Finally, Chapter 7 summarises the general conclusions and gives suggestions for further research.

## 1.5 Limitations

The limitations of this research derive in part from its generic scope, which is discussed above. The data covers one case company in the electronics industry. This industry has specific characteristics in terms of logistics, and there are certain presuppositions with regard to the realities. The role of specialised distributors is essential (Shunk et al., 2007). The use of only one case company limits the possibilities for generalisation, but on the other hand, the methodology used is not limited by the industry. To open up the results from the case company a controlling round of interviews was conducted within purchase professionals in similar companies in size but from different industries.

With regard to the conceptual frame of reference, the results enhance knowledge of change in business processes and the effects of human decision-making. They are therefore of relevance in the areas of supply chain management, logistics, purchasing, inventory management, enterprise systems, change in business processes, decision-making and the electronics industry. This is quite a wide area and inevitably limits the depth of the investigation in the context of this thesis. There are many other fields of research that could have made a con-

tribution but were excluded: buyer-supplier relationships (e.g., Hansen, 2009; Kannan and Tan, 2006) and partnerships (e.g., Ryu et al., 2009), trust (e.g., Smeltzer, 1997), and supply networks (e.g., Mills et al., 2004). Buyer-supplier relationships and partnerships, and the trust related to them, are briefly discussed in the analysis of the interview results in the second essay. Supply networks, on the other hand, fall beyond the scope of the study in that the focus is not on networks but on single relationships in supply chains in which purchasing and logistics are of more relevance. The scope is also limited to research on buyer-supplier interaction, and what lies around it is not discussed. There is a reason for this.

The investigated case on business-process change in operative buying could apply to all sorts of environments, wholesale or manufacturing, for example. Physical transactions including supply and demand will always take place. It does not really matter where the input comes from or where the output is going. Figure 1 below illustrates this.

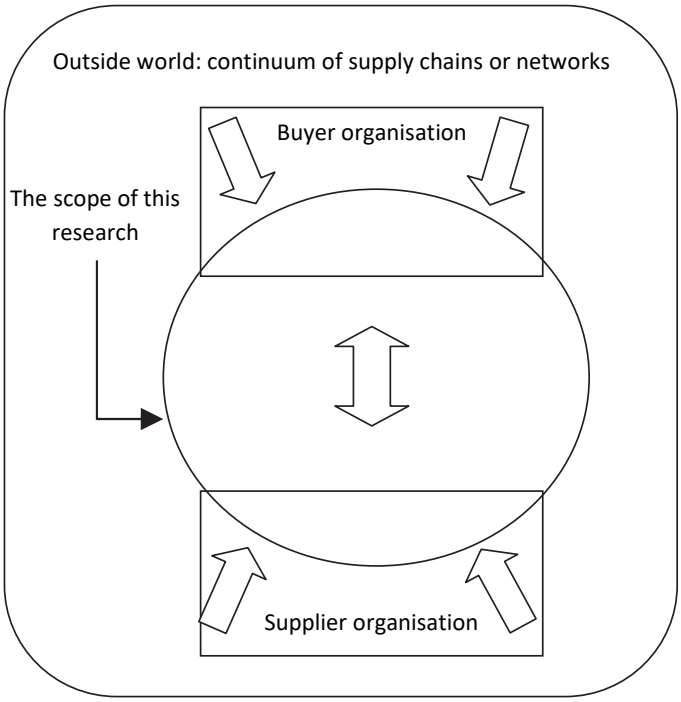


Figure 1 The scope of the research

As Figure 1 shows, this research is limited in that buyer and supplier organisations are involved from their purchasing and sales sides, respectively, and the other areas are excluded. They belong to the world outside that is creating either demand or supply in the area and process under investigation. The focus is on the exchange of information and material between the buying and selling organisations.

The analysis is based mostly on quantitative data and quantitative methods. The collection of qualitative data was limited, consisting mainly of e-mail discussions concerning the implementation of the automated purchase-order process in the case company. Of course, given the nature of the research, involving the participation of the author in the process, personal experience and observation, as well as documented discussion, also serve as material for qualitative analysis. The controlling interviews were analysed with qualitative methods for a deeper understanding of the phenomena.

## 1.6 Understanding the context of electronics industry and SMEs

During the last 30 years the electronics industry has established a presence in all walks of life: at home and at work, in healthcare, transportation and communication, for example. Its origins lie in the semiconductor industry (Kozmetsky and Yue, 1998). Semiconductors are the basic components used in all electronic devices. Given the huge amount of applications, throughout its existence the industry has been in a state of continuous and rapid change that has assumed a cyclical pattern (Shunk et al., 2007). At the same time, product lifecycles are shortening continuously and profitability has suffered as a consequence (Olson and Sharma, 2008; Aizcorbe, 2006).

In order to increase margins, large American, European and Japanese semiconductor manufacturers started to transfer production to low-cost countries as early as in the 1970s (Rasiah, 2009). Malaysia was one of the first countries in which National Semiconductors, one of the major players in the industry, built offshore factories in 1971. Other companies soon followed suit, including Advanced Micro Devices, Intel, Hewlett-Packard, Siemens and Motorola, to name a few. (Salih et al., 1988)

During this time of rapid development in the electronics industry there was also a change in the market for telecommunications equipment (also of major importance), driven by its liberalisation in the US (Olley and Pakes, 1996). By the 1980s US production of electronic equipment was worth over 100 billion USD, Europe accounting for roughly half of that, Japan a quarter and Asia and the rest of the world a fifth (Chiang, 2001). Semiconductors were mainly shipped to the US and Europe for electronic-equipment production because local Asian markets

only started to develop at the beginning of the 1980s, with the exception of Japan. United States and European semiconductor companies had a 62-per-cent market share, measured in net sales, and Japanese companies had the rest (Kozmetsky and Yue, 1998; Chiang, 2001). The situation had changed by the mid-1990s in that that US and European companies together had approximately 45 per cent of the market while Korean and Taiwanese companies had started to make inroads (Kozmetsky and Yue, 1998). At the turn of the millennium the US still held the leading position in the production of electronic equipment, at double the value of that produced in Europe, Japan and the rest of the world (Chiang, 2001).

The electronics industry typically uses intermediaries or distributors between component manufacturers and product manufacturers, their existence depending on the policies of the semiconductor manufacturers (Levine, 1998) and on the industrial economic cycle (Shunk et al., 2007). On the downturn increasing cost awareness strangles distributors and they need to reorganise their operations and also to come up with new service concepts to justify their margins. By the end of the 1990s electronics manufacturing service (EMS) companies were thriving, and this started to change the customer base of component distributors (Levine, 1998). At the same time, the emergence of electronic commerce through the Internet and the appearance of virtual distributors reduced the options of traditional component distributors (Levine, 1998), although it appeared in 2004 that the Internet was not such a big threat (Jorgensen, 2004). It is rather the allocation of larger volumes to EMS providers with high volume/low mix production that is limiting the role of distributors in that business (Shunk et al., 2007). What, then, remains of the business for traditional distributors? It seems that low volume/high mix OEM/ODM companies will require the services of component distributors (ibid.). However, given that the priority for customers of commodities is economic and for buyers of complex parts is time and availability, component distributors must increase the efficiency of their customer operations through introducing new services and attracting self-servicing customers (Shunk et al., 2007; Jorgensen, 2004).

As the stated above, the role of component distributors seems to concentrate on serving low volume/high mix OEM/ODM companies. In many cases those companies also fall to the small and medium sized (SME) category. The definition of SME's itself is not self-evident. Measurement for defining them has been challenging over time because of the often arbitrary measures. Most often, the measures have included number of employees, annual sales and amount of assets, management organisation structure and dominance in its operating industry (Osteryoung and Newman, 1993). Different organisations and countries have made their definitions based on different interpretations and purposes for this group of companies (examples see e.g. Buculescu, 2013). Based on these definitions some

industry specific problems rise. In some industries, in this case electronics industry, companies have grown in to a level where the gap between the large suppliers and smaller OEM/ODM companies has widened to the measure that mid-sized manufacturers no longer belong to the official categories of SME's but are still facing the problems of SME's due to their relative small size inside the industry.

# 2 THE RESEARCH PROCESS

Research is a process. Conducting it and obtaining results requires a systematic approach to the basics. It is also important that the researcher has a clear picture of what needs to be done and understands the process he or she has to follow. These are often not the easiest choices, and sometimes the research takes over and goes its own way. Even then, however, the principles and practices should be clear in the researcher's mind.

The terminology describing research and the related choices may be challenging. Indeed, it seems from a review of the literature on terminology that even senior researchers sometimes have trouble in deciphering the meaning. New concepts and terms are constantly being invented and therefore some of the topics covered are more recent than others.

This research was largely inspired by practical questions and therefore the process does not strictly follow known methods. The aim in the following description is to clarify the process and the choices made for the benefit of the reader. The respective sections cover the theoretical paradigm, the research design and method, the case-study methodology and the data-collection methods used.

## 2.1 Theoretical paradigm

Kuhn (1996) refers to a paradigm as an accepted science incorporating a set of laws, theories, applications and instrumentation. It is a basis for thinking of and building a common understanding of scientific theory and practice. A paradigm is created when a synthesis is produced that attracts most of the next generation's practitioners, and will generally cause the disappearance of older schools of research from the field. However, it is not a stable concept but rather something that is further developed and limited according to the conditions.

Gummesson (1991) defines a paradigm as "the underpinning values and rules that govern the thinking and behaviour of researchers." These two definitions certainly refer to the same issue, but Kuhn seems to be emphasising rigor in using and accepting the given view and methods whereas Gummesson offers a broader perspective and more freedom to researchers to apply their own views.

Paradigms fall into four different categories based on ontology, epistemology and methodological choices: positivism, constructivism, critical theory and real-

ism. Positivism basically means seeing the world as real and objectively measurable, whereas constructivism acknowledges that there are multiple local truths and that objectivity is not necessary. The main difference between these two is that the former concentrates on testing the theories, and the latter aims to construct new views on the world. Critical theory concentrates on the reality that is governed by the social values of different groups, and in this action research is used to change the social reality of the participant groups. In the case of realism, an observable phenomenon is true and real but its nature must be reaffirmed through multiple sources or method triangulation. Qualitative methods are mainly used for this purpose. (Sobh and Perry, 2006; Guba and Lincoln, 1994)

In general, there seems to be a simplified division between quantitative and qualitative paradigms or schools that differ in their views of the world (Berg, 1995; Creswell, 1994). Quantitatively oriented thinking appears to be the more comprehensive with quantitative methods of analysis and positivist thinking. Qualitative methods are mostly used in social sciences, and there has recently been a range of literature explaining qualitative research and different points of view. However, the quantitative approach is still treated with more respect in the social sciences (Berg, 1995). It has even been used to set the quantitative/positivistic/conventional and qualitative/alternative paradigms against each other (Hill and McGowan, 1999).

Perry (1998) argues that realism is the preferred theoretical paradigm for case-study research. This is supported by the fact that such research often investigates "unobservable" phenomena whereas positivism requires all investigated phenomena to be observable (Creswell, 1994). Critical theory and constructivism emphasise transformation and participation and, therefore, are perfect for action research and participant observation (Sobh and Perry, 2006; Huxham and Vangen, 2003).

There has been a move in operations management from traditional positivist/empiricist (Fuller and Mansour, 2003; Hill and McGowan, 1999) to interpretive research (Craighead and Meredith, 2008). This development is evident in this study. The three published articles could be defined as positivist given the use of quantitative methodology if analysed separately. To set the results of the quantitative analysis in a larger picture, the results from them was investigated through a case study among purchase professionals in medium-sized manufacturing companies. The aim in this report is to analyse the phenomena described in the articles and essays. Even though realism suits case research, the thinking is on the constructivist side, which is manifested in the desire to explain the reality behind the different findings reported in the three articles. This brings in unobservable phenomena, which is not characteristic of positivist thinking. Next section describes the research design and explains the choices made.

## 2.2 Case study methodology

Case study research and methodology have their roots in cultural and other social studies (Lukka, 2005). The methodology is applicable to quite a wide variety of evidence and data. It may be either qualitative or quantitative and come from various sources. It is also possible to combine different types of data (Yin, 1981). The benefits of data triangulation are seen to improve accuracy of the information of a phenomenon (Jick, 1979). Quantitative methods have been dominant in many fields of research (e.g. logistics, Halldorsson and Aastrup (2003)) and over time there has been many questions about the applicability of qualitative methods in research and especially together with case study methodology (e.g. Jick, 1979). This does not mean, however, that qualitative methods should be any less accurate in describing the phenomenon and contribute to theory (Ahrens and Chapman, 2006).

Eisenhardt (1989) defined case study as "a research strategy, which focuses on understanding the dynamics present within single setting". However, there has been discussion for and against case studies as appropriate for scientific research (Yin, 1981). It has also been argued that they should not be used in post-graduate research (Perry, 1998). Nevertheless, it is also suggested that case-study research makes a substantial contribution in terms of constructing new theory (Eisenhardt, 1989) and incorporating information from contemporary phenomena into operations management, marketing and management accounting (e.g., Voss et al., 2002; Perry, 1989; Lukka, 2005).

Given the large variety of methodological choices and application areas, there are numerous ways of conducting case research. Lukka (2005) distinguishes between two classes based on the intervention of the researcher: non-interventionist and interventionist. The basic premise is that the (management accounting) researcher adopts one of two positions in his or her empirical intervention. The dominant position is that the researcher should be objective and value-free, whereas the less dominant one allows intervention in order to influence the research object in question.

Non-interventionist modes of research include theory discovery, illustration, refinement and testing. These different modes are discussed briefly below. Theory-discovery case research is typically open-ended, focusing on new theory or theory building, and Grounded Theory is possibly its most structured form. Theory illustration involves using an existing theoretical framework to interpret the empirical findings, whereas theory refinement, as the name suggests, adds more details or makes the theory broader in scope. Finally, the main principle in theory testing is to strengthen existing theory. Basic case-research methods are used in all of these modes and the researcher remains objective and value-free. (Lukka 2005)

Interventionist modes of case research, on the other hand, involve the active participation of the researcher. There are two alternative approaches, action research and constructive research. Action research began to emerge as early as in the 1940s when Lewin (1946) suggested that researcher participation in practical development work automatically and simultaneously produced a theoretical contribution. Such a contribution is not minor in comparison with the non-interventionist modes discussed above. Another type of interventionist research that is especially prevalent in the Swedish action-research tradition is the constructive approach, which emphasises limited intervention. Real-world problem solving is done together and in co-operation with the organisation. (Lukka, 2005)

Case studies may involve different cases in the same company or cases in different companies (Voss, 2002). There may be single or multiple cases. Yin (2008) describes four different types based on the number of cases or the existence of embedded units of analysis. Moreover, both induction and deduction may be used (Perry, 1998) There are nevertheless some problematic areas. A case study, by nature, offers "rich and thick" description (Gummesson, 2007) from a variety of angles and is adaptable to the different conditions and changing policies of organisations. Case-study research in supply chain management should cover several stages of the supply chain in order to produce a better description, but also needs to be well documented in all respects (Seuring, 2008). On the other hand, Peikkari et al. (2009) found in their survey that there were case studies involving single or a limited number of cases and quantitative data from the case-specific environment that were not designated as a "case". In their view these could easily be turned into real case studies.

In terms of case-study methodology this thesis describes a situation in which the researcher participated in the process and therefore produced the results. Of Lukka's (2005) different modes of case research, action research comes closest: unlike traditional positivist approaches it involves both action and research (Coughlan and Coghlan, 2002). It resembles ethnography, but the difference is that the focus in ethnography is on observation, whereas in action research the key is participation (Näslund, 2002). It is not considered as stable and predictable as other research approaches, however (Coughlan and Coghlan, 2002). Nevertheless, it has been found useful in many areas of business research: marketing (Perry and Gummesson, 2004; Kates and Robertson, 2004), operations management (Westbrook, 1995; Coughlan and Coghlan, 2002), information systems (McKay and Marshall, 2001; Avison et al., 2001) and logistics (Näslund, 2002), although there may be problems distinguishing between the practical and theoretical contributions (Zuber-Skerritt and Perry, 2002; Gummesson, 1991). As a research process, Zuber-Skerritt and Perry (2002) define two project areas in academic thesis writing: core action research and thesis action research. This division clarifies the difference between learning experience in the organisation and theory

contributing to knowledge creation. McKay and Marshall (2001) describe the clearly twofold cyclical nature of an action-research project: one cycle of problem identification, context learning, problem-solving planning activity and then act-and-learn rounds, and another cycle of identifying research themes/questions, reviewing the literature, planning and designing the research and finally implementing and evaluating. Westbrook (1995) similarly presents an evolved model of action research in operations management. By way of a synthesis, the following simplified model of action research is suggested

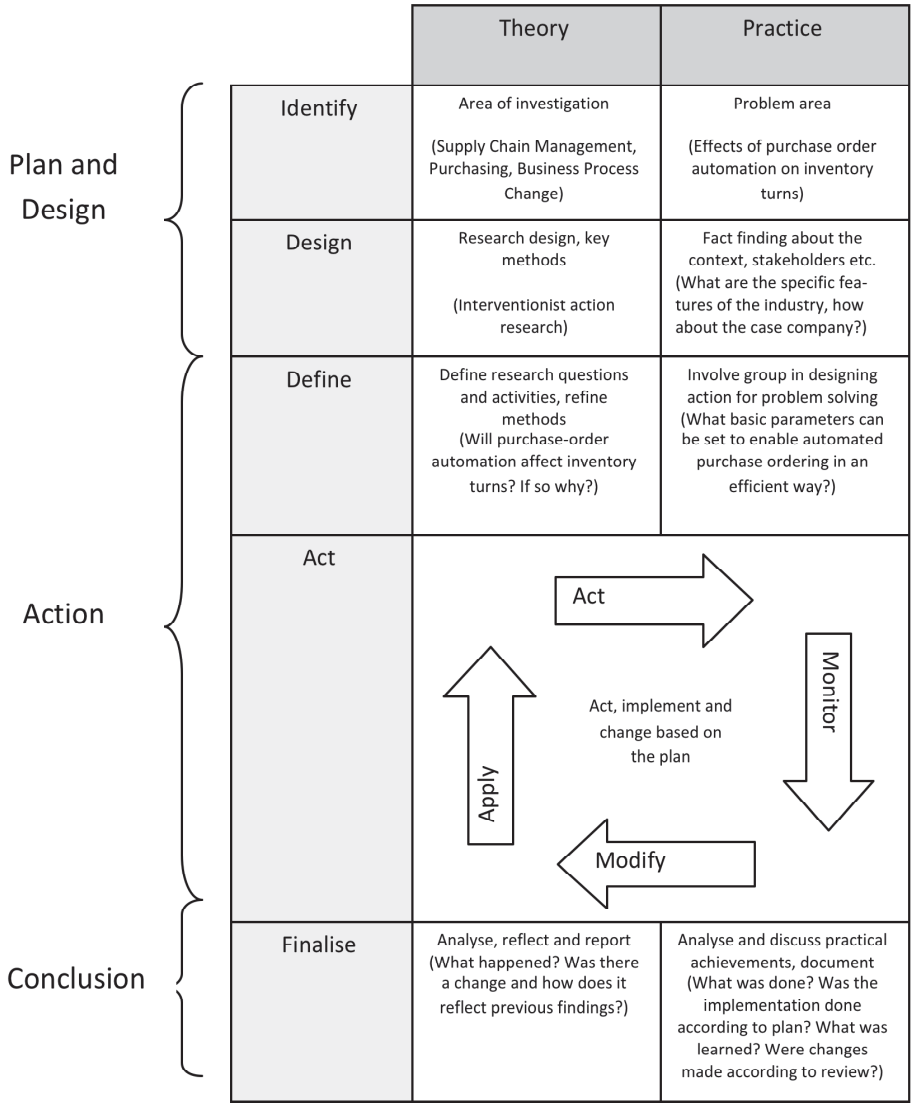


Figure 2 A simplified Action Research model

The model presented in Figure 2 is based on the models of Westbrook (1995), McKay and Marshall (2001) and Zuber-Skerritt and Perry (2002). As mentioned above, the area of investigation is divided into theoretical and practical areas. Basically, the model does not differ radically from normal research design except in the area of action and the fact that the researcher works as a facilitator or participant in the change process.

This research employs case-study methodology in two steps: first involving a single case analysis with multiple units of analysis. Second step is a case analysis collecting qualitative evidence through semi-structured interviews. Given that the researcher participated in the action in first step, it could be classified as a participative type of case study and as applying the basic tenets of action research while the second step includes simple case study with qualitative data analysis.

## 2.3 Data collection

This research uses both quantitative and qualitative data. In first step the data consists of qualitative and quantitative data concerning the case company and the two supplier companies involved in the process under study. In addition to the data of the focal company, the second step uses data collected from a round of interviews held among purchase professionals in manufacturing companies in order to review the results from focal case company.

In case of the first step of the research, quantitative data consists of inventory transaction information and inventory value levels derived from the transactions. It was obtained from the focal case company's database through the same query for all units of analysis, and includes the following information.

Table 2 Basic data for analysis

| Information | Explanation |
|---|---|
| Item ID (ITMIDT) | Item code in the ERP system |
| Registered date (RGSDTE) | Date of the transaction (year, month, day) |
| User (LSTUPDUSD) | System user who made the transaction |
| Transaction quantity (TRSQNT) | The quantity of the transaction in pieces |
| Quantity on hand (STRQNTHND) | Quantity on hand in the inventory after the previous transaction (before the transaction of the current line) |
| Purchase order ID (PRCIDT) | Purchase order number in ERP |
| Final delivery option (FNLDLVOPT) | Marked if the transaction completed the delivery |

Figure 3 below is an example of the data extracted from the ERP database by means of a query tool. It shows earlier data for one component item.

| ITMIDT | RGSDTE | LSTUPDUSD | TRSQNT | STRQNTHND | PRCIDT | FNLDLVOPT |
|---|---|---|---|---|---|---|
| 5196010 | 20010105 | avanttop | 2500 | 0 | 0 | |
| 5196010 | 20010109 | etuhma | 2500 | 2500 | 136283 | X |
| 5196010 | 20010109 | teamsmd | 2500 | 5000 | 0 | |
| 5196010 | 20010123 | suokmi | 2500 | 2500 | 136305 | X |
| 5196010 | 20010208 | teamsmd | 2500 | 5000 | 0 | |
| 5196010 | 20010216 | suokmi | 2500 | 2500 | 136340 | X |
| 5196010 | 20010309 | teamsmd | 2500 | 5000 | 0 | |
| 5196010 | 20010321 | suokmi | 2500 | 2500 | 136369 | X |
| 5196010 | 20010418 | korpjo | 2500 | 5000 | 0 | |

Figure 3 An example of the data extracted from the database

Later the data was aggregated to the monthly level and the monthly average inventory was calculated in order to calculate the inventory turn. The average purchase-order quantity was also calculated on a monthly basis in order to analyse the changes.

Inventory turns were calculated from average monthly inventory levels. Obtaining the 12-month inventory turn involved dividing 12-month consumption by the average inventory level over the 12-month period. This was repeated for the periods with both normal and automated purchase orders. The average turns from both periods were then compared.

Qualitative data in the form of e-mail discussions was also collected and produced in order to complement the quantitative material. These discussions took place before the application of automated purchase ordering and therefore offer insight into the very process. They occurred between different participants in the three companies involved. Given the involvement of the researcher in the process, this data forms part of the discussion in the case study description.

In the second step, to place the results from focal case company to a larger context, interviews were conducted among purchase professionals in medium-sized manufacturing companies. Those interviews were constructed as semi-structured and following some observed phenomenon from the focal case company data. Four interviews were made out of which the answers were analysed in a table.

## 2.4 Research design

The research design is the logic that connects the data to be collected to the initial research questions (Yin, 2003). In this case the interest was in the effects of purchase-order automation. The data collected is directly linked to the research questions concerning the effects of the automation on inventory turns, which is in line with the notion that the design should start with the selection of a topic and a paradigm (Creswell, 1994).

There are also different ways of looking at the research design. It could be described in terms of four basic questions: How will the empirical material interact with the paradigm in question? What is the phenomenon under study? How is the inquiry organised? What are the collection methods? (Denzin and Lincoln, 1994) Another possibility is to draw an analogy with dance: it is present in the four stages of choreography, warming up, exercise and cooling down, in other words in the initial question, the starting of the study, conducting the pilot and ongoing studies and making the decisions (Janesick, 1994).

This research sprung from a practical interest in improving a business process. The improvement initiative was based on the assumption that automating business processes will save resources from manual and routine tasks that could be directed to more productive tasks. In fact, the research started from a conceptual idea that developed into an action in which the researcher was involved as project manager. The implementation took place, and after some results had been achieved the analysis focused on improvements in inventory turns, statistical methods being used in order to highlight the impact of the business-process change. The publication of the articles coincided with the analysis, and thus there

was a constant reviewing of the findings in the light of relevant literature in the field. Figure 4 below illustrates the research design and process.

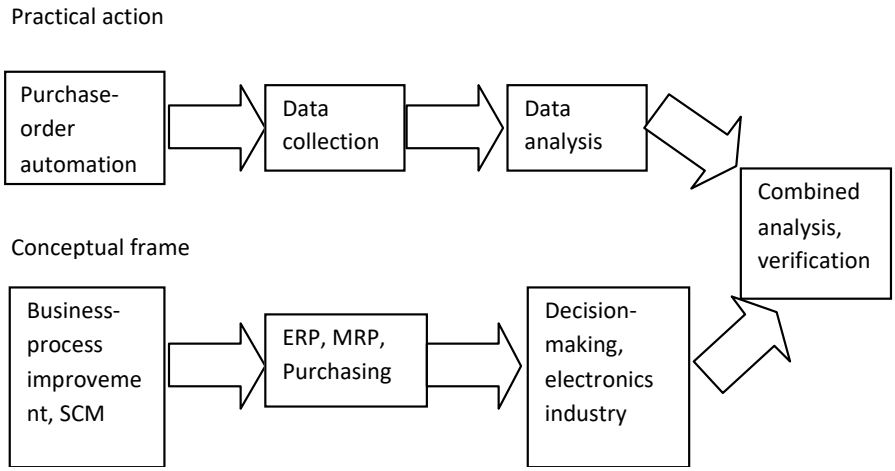


Figure 4 The research design with reference to the conceptual framework

The research design is presented in terms of practical action and the conceptual frame in accordance with the actual facts. The initial aim of the research was to improve part of a business process. The data-collection process started a few years after the automation was implemented in order to allow enough data to accumulate to compare it with the data on manual purchase ordering. This phase corresponds with research on Enterprise Resource Planning (ERP) and Material Resource Planning (MRP), as well as with the purchasing literature. The data analysis reported in articles I-III was derived from the conceptual framework. Finally, the decision-making and special features of the electronics industry are taken into consideration in combining the relevant research results and theoretical issues.

## 2.5 Research method

The starting point of this research was the author's interest in the results of a business-process change. It took some time to consider the various research options in this context and to select methods that would suit this subject. A data search of the ERP system in connection with the author's Master's thesis sparked his interest, and the logical way of investigating the change was to search similar

data and use it for this research within a longer timeframe and focused on components for which the automated purchase-order process had been implemented.

The research started in 2001 with the implementation of a change to part of a business process. In this sense it started as a management consultancy exercise. There is clearly a danger of mixing management consultancy with research. However, action research makes it possible to combine practical change with inductive theory building (Gummesson, 1991). In fact, the data to be analysed in the future was produced through the business-process change. It was first subjected to quantitative analysis in order to assess the results of the process change and to see if the assumptions made at the beginning of the process were valid. In the course of the research questions arose from some of the results of the quantitative analysis, and these were addressed through qualitative analysis of the data produced during the change process.

As stated earlier, the research methodology reflected the participant action that is typical of action research (Gummesson, 1991). It also combined different data types even if quantitative methods prevailed, which is often referred to as triangulation (Jick, 1979). In fact, the research could be called a case study. The technical definition of a case study is twofold: it examines a contemporary phenomenon in its real-life context in which the limits of the phenomenon and the context are not clear, and it uses multiple data sources and existing theory to guide the data collection and analysis (Yin, 2003). Figure 5 illustrates the research process.

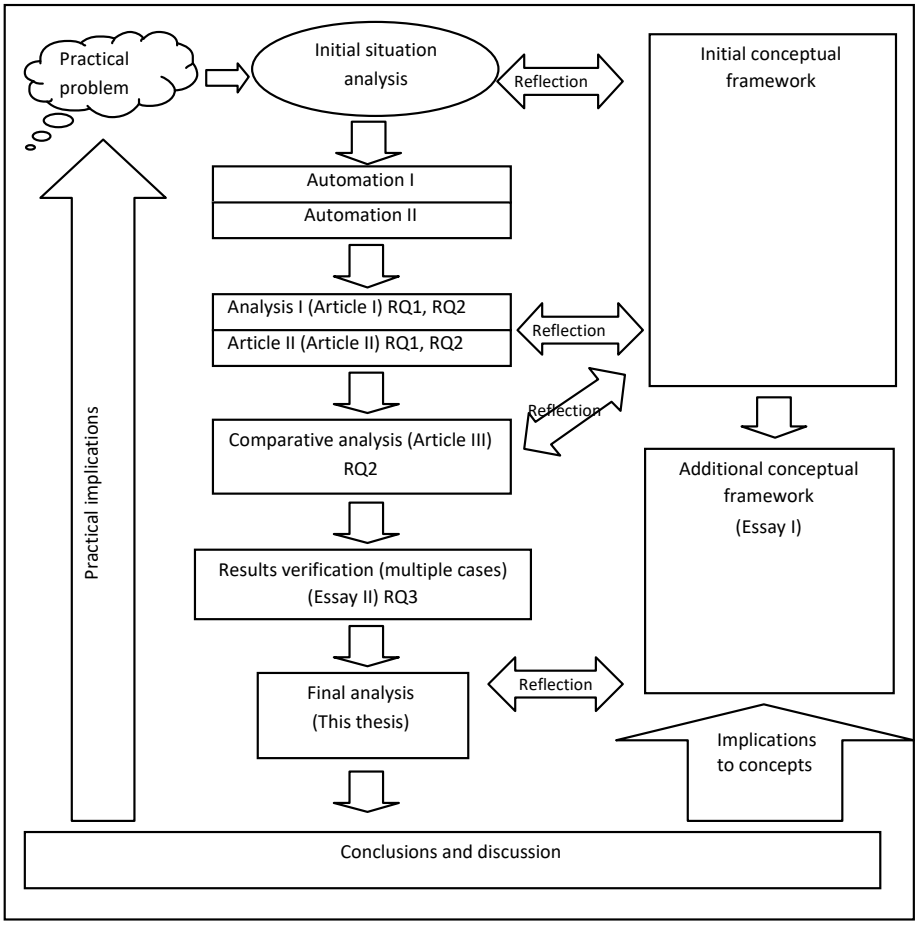


Figure 5 The research process

As Figure 5 shows, the initial analysis of the situation was based on an expressed practical management problem in the case company in mid-2001. At the same time the initial theoretical framework was formed. The practical design and implementation started at the end of 2001, managed by the author of this thesis. Articles I, II and III are referred in Chapters 5.2, 5.3 and 5.4 respectively as the essays I and II are referred in Chapters 5.5 and 5.6. Treatment of the three research questions has been marked with corresponding articles as RQ1, RQ2 and RQ3.

The analysis phase started after the implementation at the end of 2004, in the form of quantitative data analysis conducted by the author. Professor Hilmola, who co-authored the articles, inspired the practical writing process while the author carried out the data analysis. The first article analyses the effects of auto-

mated purchase order implementation to inventory turns. The second article started to take shape at the end of 2005 after publication of the first one and following a similar pattern with analysis of second case of purchase order automation within the same company. In this article, the two cases of automation are compared in terms of changes in inventory turns, order size, inventories and consumption. At this point the author decided to explore the changes with a reference group of component items. The results of previous analyses were compared with the initial framework, and comparative quantitative data was gathered from a process that had not been transformed. This was done in order to set the baseline for comparing the results in the case processes. The results of this analysis were again compared against the initial theoretical framework. This analysis was reported in article III, and was presented at the annual NOFOMA conference in 2007. In this article, the results were also analysed through statistical analysis. Based on the process described above, it was clear that some results had been obtained from a single company, multiple case analyses. It became obvious in the process that supply chain management (SCM), total quality management (TQM) and business process re-engineering (BPR) as concepts needed to be discussed separately in order to further understand their meaning to the cases at hand. The first essay is written to open and develop this framework. Then at the practical side a question was raised: Where the results in concordance with the larger picture of purchase management and in other similar companies? This question was then treated with a multiple case analysis through purchase professional interviews, which was reported in the second essay that was also presented at the NOFOMA 2016 conference as full paper.

The final analysis phase (this thesis) constitutes an additional theoretical framework together with qualitative data analysis from the business-process transformation, the aim being to enhance understanding of the subsequent changes and results. The additional framework is also meant to facilitate understanding of how human decision-making processes influence the results of research. The conclusions and the final discussion are based on all these analyses in a summary of the theoretical and practical implications of the research.

# 3 CONCEPTUAL FRAME OF REFERENCE

This conceptual frame of reference connects the research to the discussion and results of previous research on the same topic. In this case, as no doubt in many others, there were many subjects to choose from and it was a question of taking those that best fitted the case in question and the phenomenon to be investigated.

Purchasing and supply management as approached in this study incorporates a multitude of topics. Current research on supply chain management is clearly relevant but the focus is mostly on logistics, purchasing and inventory management. Because it is question of automating part of a purchasing process, changes in business processes and enterprise systems are also of interest. It also became clear during the research period that human decision-making and its characteristics belong to the area under investigation. It is therefore included in the discussion in this Chapter.

## 3.1 Supply Chain Management

Supply chain management is discussed in a wide range of current textbooks. Most of the ones referred to below have been published in the 21st century. The emergence of the subject could be attributed to the increasing predominance of global trade and manufacturing. The raw material is often excavated in one part of the world, refined in another and finally consumed in a third. Companies are increasingly seeking cost-efficient manufacturing solutions and locations worldwide, and this has increased the need to transfer goods, information and money around the globe.

In describing these transactions there have been many attempts to define the chain of material, information and money supply. A major contributor to these definitions is the concept of the value chain as presented by Michael Porter in his book *Competitive Advantage,* published in 1985. This has inspired several authors to define the supply chain accordingly (e.g., Kotler, 2003; Fill and Fill, 2005; Schary and Skjott-Larsen, 2001; Gourdin, 2001).

For reasons of clarification, Porter brings in the concept of a value system, which combines several value chains one after another. He uses the value system in an attempt to describe the creation of competitive advantage between firms. As mentioned earlier, this is a good start in defining the supply chain, but possibly concentrates too much on the firm's internal functions and does not put enough

emphasis on networks of companies. Fill and Fill (2005) avoid this by linking value chains to supply chains and ignoring Porter's definition of a value system. Kotler (2003) uses the term value-delivery network to describe the value system, but acknowledges the term supply chain in parenthesis.

Fill and Fill (2005) complete the picture in defining the supply chain as a marketing channel (successive value chains) with a physical flow involving the "movement of parts, supplies, and finished products moving from source of raw material to the end customer". Furthermore, they define the supply chain as "the activities that bring the right product, in the right place, for the right customer to access in a timely and convenient way". Schary and Skjott-Larsen (2001) also consider the origin of the supply chain in the concept of the value chain. Interestingly, they add: "The supply chain is also open to different interpretations depending on the management perspective", thereby leaving the definition somewhat open.

There are also definitions that do not directly link the supply chain to the concept developed by Porter. The value system is seen as a clear chain with a focal company and divergent members up- and downstream. Other non-value-system-related definitions also adopt this simple viewpoint. Waters (2003) refers to series of activities and organisations moving goods from initial suppliers to final customers. It has also been described as "a string of organizations" (Barrat and Whitehead, 2004) and a chain of different operators (Chopra and Meindl, 2007). Mentzer et al. (2008) focus on the relationship between supply chain management and logistics, marketing, production and operations management, coming to the conclusion that management of the supply chain involves "applying analytical tools and frameworks to improve business processes that cross organisational boundaries".

Upon closer inspection, descriptions of a supply chain often seem quite simplistic because relationships in modern business are far more complex than just a chain of operators and activities. A network view is evident in some of the definitions. As mentioned above, the notion of the supply chain suggests "a string of organizations", but from a professional perspective it could be considered more of a supply network (Barrat and Whitehead, 2004). This definition gives more scope to the concept and acknowledges that a supply process does not always resemble a straightforward chain but has more complex patterns. It might be that the word "chain" used to be appropriate, but new rules and forms of partnering and the trend towards uniqueness in customer needs is turning chains into more complex networks of relationships (Bowersox et al., 1999) or facilities (Laudon and Laudon, 2002). The chain analogy may leave aside some indirect parties, and therefore networks or clusters would be a more appropriate definition (Michael et al., 2003).

The fundamental discussion went on for a period of 10 years. Michael Porter's definition of the value chain was published in 1985; Bowersox et al. (1999) described the nature of the supply chain more than ten years later, using the expression that it was more complex than just a chain. Nevertheless, many authors came back to the idea of a chain several years after this. It seems that all the definitions are quite similar but differ in the details. The supply chain is not a new concept that appeared some 10 to 20 years ago. It could also be described in more contemporary terms as what is now called logistics but was previously known as physical distribution (Fill and Fill, 2005). This interesting link between these two definitions provides a stepping-stone to the following paragraphs on the concept of logistics.

## 3.2 Logistics

Logistics has its roots in history and military manoeuvres (Gourdin, 2001). War used to involve large-scale transportation and warehousing operations that were crucial to its success, and the interruption of supplies had devastating effects in hostile foreign territories. In modern times the term implies much more. Previously the emphasis might have been more on moving physical goods to meet customers' requirements, but with the increasing importance of service elements in supply it may be more appropriate to refer to the moving of desired benefits to customers in the right conditions, at the right time and to the right place (Gourdin, 2001).

Logistics typically involves physical activities: the flow of materials (Waters, 2003), transportation, inventories and information (Schary and Skjott-Larsen, 2001). From this it would seem to concentrate more on physical activities and distribution than the supply chain. At the same time, the supply chain as a term refers to a chain of activities. Nowadays logistics is focused more on transportation and warehousing, which becomes apparent when one browses published articles in scientific journals. It is also becoming more competitive and cost-aware (Soosay and Chapman, 2006), and logistics management therefore has an important role in enhancing supply-chain performance (Bhatnagar and Teo, 2009). Its role in supply-chain management is also becoming more prominent and the subject of much discussion (Mentzer et al. 2008; van Hoek et al. 2008). In fact, there is lively debate among professionals on how to define SCM. According to the Council of Supply Chain Management Professionals (CSCMP, earlier known as the Council of Logistics Management, CLM), it includes all logistics-management activities. The same council defines logistics management as follows:

*"Logistics management is that part of Supply Chain Management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and point of consumption in order to meet customer requirements." (Mentzer et al., 2008)*

Logistics management thus involves managing the flow of physical goods, and the information flow that is closely related to it.

## 3.3 Purchasing

Purchasing is one part of the supply chain, or according to the ideas of Porter the value chain. In supply-chain terms it is the function that is responsible for procuring the necessary goods and getting them to where they are needed. It has traditionally been of prime importance to manufacturing companies in which a large proportion of the product cost is the material. According to Baily and Farmer (1981), the total cost of materials includes their specification, inventory levels, timing and price. Of course price is traditionally considered the most important factor, but there are benefits to be gained if procurement is taken into account at the very beginning of the product-specification process when the major decisions affecting total materials costs are made. It should be noted that purchasing is a high-priority function in other types of organizations as well. It is vital in the wholesale business, for example (Baily and Farmer, 1981). It is typically considered a functional department, but in fact it is more of a process involving a large number of professionals other than purchasing experts (Zheng et al., 2007).

### *3.3.1 Objectives for purchasing in firms*

Purchasing functions in firms have several objectives. Baily and Farmer (1981) suggest the following five:

- Maintaining a steady relationship with a range of current and potential suppliers so as to ensure a steady flow of materials and services that will meet planned needs
- Efficient buying in order to extract the most value from the money that is spent
- Effective inventory management, given the importance of inventories
- Being a source of information to other departments in the organization and providing insights into the outside world of supply.
- Taking responsibility for developing the staff, policies and procedures, and the whole organization of purchasing and procurement.

In a similar way, Eberhard E. Scheuing (1989) developed a list of objectives he called “The Ten Commandments of Purchasing”. The objectives are similar to those of Baily and Farmer, and also include keeping up with market trends and thereby being involved in developing the organization’s competitiveness. This is an important point: purchasing provides the organization with value-creating opportunities. An identical list is also to be found in Dobler and Burt (1996). Interestingly, Colton and Rohrs (1985) put buying at the lowest possible price at the top of their ten-point list of managerial objectives with regard to purchasing. Previous lists emphasise getting the best value rather than paying the lowest possible price as the ultimate objective. There are two views on this. Of course, getting the best value for money is also paying the lowest price for the defined quality. However, putting the lowest possible price as the first target undermines the importance of acquiring goods and services of the desired quality.

### *3.3.2 Different aspects of purchasing*

In the light of the above definitions and objectives of purchasing, and with reference to Porter and the value chain, two different types emerge: routine purchasing and procurement. What are the different roles? Procurement is seen as creating the purchasing framework and therefore concentrates on sourcing and supplier-management activities. E. Raymond Corey (1978) divides the procurement function into supplier selection, pricing and negotiation. This clearly describes a function that supports the day-to-day purchasing process.

Dobler and Burt (1996) classify materials management on three different levels: purchasing activities, procurement-process activities and supply-management activities. They are mentioned here in terms of their tactical or strategic focus, purchasing activities being the most tactical. Essentially, they include everything from source search and identification to purchase-order issuance and on this level there is quite a strong focus on the tactical. Procurement activities include involvement in material specification and market research, for example. Supply-management activities have the strongest strategic focus, and include corporate strategic planning, material and acquisition planning, and partnering and strategic alliances. This classification lifts purchasing above the day-to-day level on which suppliers are known and purchase orders are based on valid framework agreements. In fact, the basic purchasing process is lifted from the operational to the tactical level.

Interestingly, all the sources quoted above attribute the task of creating physical purchase orders to purchasing managers. Should not purchasing managers have more strategic tasks than routine buying? Bilborough and Dale (1985) discuss this in their paper on the different roles of corporate and factory buying.

They base their argument on the fact that a corporate structure incorporates many layers of purchasing professionals. On the corporate level purchasing is responsible for annual contracts and larger capital investments, whereas on the factory level purchasing professionals are mostly occupied with materials and the measurement of supplier performance on a daily basis. This division reflects Porter's notion that corporate-level purchasing is more of a support function and factory purchasing is one of the operational functions that directly create value. Companies operating worldwide have geographically dispersed sourcing and purchasing operations. Purchased goods and services and their commonality change from company to company and are dependent on the industry. The need for sourcing integration in this kind of company is affected by uncertainty related to category characteristics, supply-environment characteristics and interdependence among the purchasing units. In all of these cases the information-processing-capability requirement increases as the level of uncertainty increases (Trautmann et al., 2009).

On the strategic level the field of purchasing or sourcing is covered in many different theories, including resource dependency, network theory, system theory and transaction cost economics (Shook et al., 2009). This is evidence of the considerable interest in purchasing and supply management in many areas of research. The division of purchasing into strategic and tactical functions is justifiable given the management focus on aligning the purchasing and the corporate strategy in order to enhance the financial performance of the company (Baier et al., 2008). A recent study shows that procurement professionals consider their position to be strategic, but their view is not shared in the organisational context (Tassabehji and Moorhouse, 2008).

## 3.4 Inventory management

Successful inventory management is considered crucial to the success of a company (Gourdin, 2001; Coyle et al., 1996; Sahin and Robinson, 2007). The word successful here means optimal and avoiding excess: the inventory ties up company resources and working capital. Successful inventory management improves the overall financial performance of the firm (Sahin and Robinson, 2007), and is therefore crucial.

There is always good reason to keep an inventory. Gourdin (2001) suggests three: to facilitate economies of scale, balance supply and demand, and guard against uncertain demand. Sahin and Robinson Jr. (2007) give similar reasons. Upon closer inspection, it could be said that the function of the inventory is to make up for any imperfections in the supply chain in terms of timing and scheduling. If there is not the need for quantities that produce economies of scale, in-

ventory holding is obligatory in order to secure some level of discount based on purchased quantities. Secondly, the balancing of supply and demand is especially relevant in the case of seasonal demand patterns. When consumption is in a narrow time period, it may be advantageous to extend the production over a longer period, which would require lower investment in labour and machinery, and thus to suffer some inventory costs. Third, protection from uncertain demand is possibly related less to time and more to the level of customer service: when demand is uncertain, the service level increases through inventory holding.

Coyle et al. (1996) place inventories in two categories, physical supply and physical distribution. Physical-supply inventories support the processing and manufacturing functions of the firm, whereas physical-distribution inventories cover finished goods waiting to be shipped to customers.

Another inventory classification distinguishes between independent and dependent demand (Sahin and Robinson Jr., 2007). Independent demand means that the demand for one item does not affect the demand for others, as with the sale of retail and wholesale merchandise, and repair or maintenance items. Dependent-demand items include the components, parts and subassemblies that are required to manufacture a product.

There are also various types of inventories. Normal inventories (Gourdin, 2001), or cycle stock (Sahin and Robinson Jr., 2007), enable the organisation to supply products based on average demand. This is the main inventory and therefore it is important to manage its value in order to optimise working capital. Safety stock (Gourdin, 2001; Sahin and Robinson Jr., 2007) is created to reduce uncertainty in supply, demand and lead-time, and is normally used to avoid running out of materials and supplies. Other types of inventories include speculative stock and work in progress.

Given that inventories cost money and often account for a significant proportion of the total logistics expenditure (Coyle et al., 1996), efforts have been made over the years to find ways of optimising the costs through the optimisation of one or several of the attributes. One of the most common models is the economic order quantity model, in which the number of units to be ordered is calculated based on the cost of placing an order, annual demand, inventory costs and the unit cost of the item, although new control methods and systems are constantly being developed. Terms such as postponement, quick response (QR), vendor-managed inventories (VMI), just in time (JIT) and material requirements planning (MRP) have gained ground. MRP systems were introduced in the late 1960s and early 1970s, coinciding with the increasing use of computer-aided calculations in inventory management. The focus in the following section is on enterprise systems, the aim being to shed more light on this form of inventory management.

## 3.5 Enterprise systems

Modern firms tend to use company-wide information systems (Samaranayake, 2009), and for some time have been moving beyond company boundaries to include suppliers and customers in the supply network. This development is on going, and it seems that existing enterprise systems (ES) fall short of fully supporting it (Xu, 2009). One reason for this could be that Enterprise Resource Planning (ERP) systems were not intended for this kind of use. Another reason could be that their implementation has suffered from reductionist and fragmented thinking (Wood and Caldas, 2001): they were mainly used in internal company transactions (Davenport and Brooks, 2004). ES traditionally include an ERP system, packaged or customised, accompanied with auxiliary systems to support the activities (Davenport et al., 2004).

Given that many ERP systems are packages with predefined processes the implementation should also include taking a critical look at the company's business processes and possibly re-engineering them (Chen, 2001; Wood and Caldas, 2001). The systems have traditionally been implemented in larger firms, but as more affordable packages become available they are increasingly attracting small and medium-sized businesses. There is still a need for more research on the success of the implementation (Snider et al., 2009). In the MRP context it has been found that management support, the level of functional integration and data accuracy are important in small and medium-sized companies (Petroni, 2002). The impact of the systems on corporate financial performance has been found not to be negative (Hendricks et al., 2007), but there is no uniform positive indication. It has also been found that internal processes and inventory indicators may suffer as a result of ES implementation, but there are improvements in response to external partners and profitability (Hendricks et al., 2007; Dehning et al., 2007).

### *3.5.1 MRP systems*

MRP (Materials Requirements Planning) is a system of parameters and logical rules related to materials management inside the organisation. It covers material net requirements and resource usage depending on the scope, based on the gross requirements in the master plan. These systems have been implemented in conjunction with the computerisation of operations (Colton and Rohrs, 1985). With the increasingly heavy usage of computers in production control, MRP and ERP systems and applications have become more popular. Despite new materials-planning techniques and the problems associated with MRP, it seems that such systems continue to prevail in the manufacturing sector. Oliver W. Wight and Joseph Orlicky developed the basic MRP logic (Kumar and Meade, 2002).

There are three goals related to the use of MRP: securing component availability, maintaining the lowest possible inventory level, and the planning of manufacturing, delivery and purchasing (Coyle et al., 1996). The system is designed to control and time material flows inside the organisation. This internal perspective was prevalent when data communications were still under-developed. The execution was based on information calculated by the system (Colton and Rohrs, 1985). The development of EDI and other inter-company communication tools and integrated ERP and MRP systems has made it possible to automate the implementation process and connect companies to networks. On the tactical level this has not changed the reality of interaction between companies related to negotiations on prices and other matters. On the operational level, however, it has lowered the barriers between companies and has facilitated the simplification and automation of inter-company processes.

### *3.5.2 Material Requirements Planning*

MRP, or Material Requirements Planning, concerns how gross requirements set out in a master plan, and downstream of the supply chain, can be met from optimised inventories especially in manufacturing firms (Rabinovich et al., 2003). The objective is to define the requirements for each inventory item in a time-phased manner. This involves planning how to cover the requirements of the master plan, and generates net requirements and planned actions. The attachment to time is elementary compared to order-point-based materials management (Orlicky, 1975).

The purpose of MRP systems is supposedly to serve manufacturing by holding only a minimum inventory, taking into consideration current changes in demand, anticipating future changes and reacting to them so as always to cover the gross long-term requirements (ibid.). There are several sources from which the MRP system takes the inputs on which the requirement calculations are based: the master production schedule, external orders, forecasts of independent demand, inventory records and the bill of materials (ibid.) Inventory-level information together with safety stocks and scheduled receipts enable the calculation of net requirements from gross requirements (Coyle et al., 1996).

The processing of the inputs through the MRP system creates certain outputs, primarily notices to release, reschedule or cancel an order. They also include backup data with which to analyse item status and planned orders for future release. There are secondary outputs that depend on the system and the programmed options. (Orlicky, 1975)

MRP implementation follows one of two different planning logics: regenerative or net change (Orlicky, 1975). The main difference between them is in the

planning frequency and the reason for starting the process. The regenerative approach involves re-calculating, level by level, the requirements for each item from the end product to the components on the deepest level. The net change method, on the other hand, involves calculating the net requirements only in part at any one time. In other words, every time there is a transaction all the affected items are re-calculated. Thus there is no comprehensive requirement calculation, but partial calculations are done constantly. (ibid.)

According to Orlicky (1975), it is not possible to run a complete regeneration frequently due to the massive amount of data requiring to be processed. Given the developments in data processing and information technology it is more common to implement a regeneration-based system (Coyle et al., 1996).

The basic components of the MRP system - BOM (Bill of Material) information, inventory-level information and the MRP program (Coyle et al. 1996) - are discussed in the following.

### *3.5.3 The basic components of MRP systems*

The Bill of Material (BOM) is a list of all the components comprising a product. It includes the material items catalogued in the MRP system that are linked to form the product, and may have several levels if there are sub-assemblies that make up the end product. It also includes the numbers of items and the lead times of the components, and indicates the order in which the components have to be purchased in order for manufacturing to start (Coyle et al., 1996).

Inventory-level information is needed in order to define the production schedule and purchase requirements. Net requirements are based on this information and on gross requirements. It also incorporates safety-stock information and facilitates inventory optimisation (Coyle et al., 1996).

The MRP program is a calculating tool that is based on end-product demand and uses BOM and inventory-level information to create a master production schedule and a list of purchase requirements based on net requirements (Coyle et al., 1996).

Coyle et al. (1996) also mention the master production schedule and outputs and reports as key elements of MRP. In fact, the schedule and outputs derive from MRP calculations in which all the needs are pooled and scheduled based on the lead times introduced into the system. As can be seen, MRP in this configuration does not take capacity issues into account. Capacity was considered infinite in the initial systems, and was added in the second phase, also called MRPII, together with manufacturing routings and work-centre capacities (Kumar and Meade, 2002). Other primary functions such as marketing and finance were also

included at this point, as well as personnel, engineering and purchasing, although there were minor differences to ERP systems (Chen, 2001).

## 3.6 Decision-making

This section concerns the biases that are typical in decision-making situations. When people make decisions they do so with the best knowledge available, but their information-processing capacity is limited (Hogarth, 1980). This is the typical psychological perspective on human decision-making. In economics it is traditionally considered a rational process (Simon, 1986). However, there are differences in how rationality is defined: in economics it refers to the choices made, whereas in psychology it lies more in the process (Simon, 1986). This is widely discussed in the literature on decision-making and the rationality of human decisions.

Hogarth's (1980) model comprises a simple information-processing scheme leading to judgement: the acquisition of information, its processing, and the output (decision). The acquisition and the processing may be biased in many ways.

In the case of supply management, decisions are bound to be based on available information. Inherent in the MRP system are several parameters that are set in order to achieve the correct planning result. In terms of logistics performance, conditions are related to item characteristics, environmental characteristics and parameter setting, and have an impact on the overall performance. Problems arise when a large amount of information related to these characteristics is available, but the lack of appropriate analysis tools and feedback makes it difficult for humans to make optimal decisions on control parameters (den Boer, 1994). This often leads to the situation that in each case an individual decision-making process is run through even though an adjustment of the system parameters would improve performance. The uncertainty about the results remains because the individual is not aware of all the consequences of his or her decision (Einhorn and Hogarth, 1986). This typically leads to a disregard of system suggestions and decisions, and a case-by-case problem-solving approach (Fransoo and Wiers, 2008). It is also recognised that humans are better at inductive than at deductive reasoning. Inductive reasoning is characterised by the use of patterns in complicated decision-making situations, and the result of using them will then strengthen or weaken our beliefs about them (Arthur, 1994). Humans typically tend to emphasise the positive sides of the selected alternative, and the negative features of the non-chosen alternatives (Janis & Mann, 1977, Einhorn, 1982).

Carter et al. (2007) reviewed the literature on decision-making bias. They identified 76 different biases and created taxonomy of nine. These categories are summarised in Table 3 below.

Table 3 An overview of decision biases and their effects on rationality (Carter et al., 2007)

| ***Category*** | ***Effect on judgement or decision rationality*** | ***Example from supply management*** |
|---|---|---|
| Availability cognition | Over-optimistic/-pessimistic evaluation<br>Disregard of relevant alternatives | The perception or recall of productive collaboration between producer and supplier may lead to over-optimistic evaluations |
| Base rate | Over-optimistic/-pessimistic evaluation<br>Erroneous evaluation of event probabilities of outcomes | Adjustment error concerning the reception of new relevant information about supply-market developments may lead to over-optimistic/-pessimistic evaluations |
| Presentation | Disregard of relevant alternatives<br>Over-optimistic/-pessimistic evaluation<br>Erroneous evaluation of even probabilities or outcomes | Perceived comprehensiveness in the presentation of a set of alternative suppliers may lead to an unjustified disregard of other suppliers |
| Control illusion | Erroneous evaluation of event probabilities or outcomes<br>Over-optimistic/-pessimistic evaluation<br>Disregard of alternatives | A sequence of random events such as previous supplier innovations may be mistaken for the essential characteristic of a process |
| Output evaluation | Over-optimistic/-pessimistic evaluation<br>Erroneous evaluation of event probabilities or outcomes | Disappointing supplier collaboration may be associated with poor luck and satisfaction with the abilities of the supply department |
| Commitment | Over-optimistic/-pessimistic evaluation<br>Disregard of relevant alternatives | A supply-management department may commit to an unsatisfactory course of action (supplier integration) by including sunk costs in its evaluation |
| Confirmatory | Disregard of relevant alternatives<br>Over-optimistic/-pessimistic evaluation<br>Erroneous evaluation of event probabilities or outcomes | Tendency to search for or interpret information in a way that confirms ones preconceptions about a supplier or supplier base |
| Persistence | Disregard of relevant alternatives<br>Over-optimistic/-pessimistic evaluation | As individuals have a strong tendency to maintain the status quo this may be an obstacle in terms of considering other suppliers |
| Reference point | Over-optimistic/-pessimistic evaluation<br>Erroneous evaluation of event probabilities or outcomes | Adjustments from an initial position (anchor) are usually not appropriate for setting target prices |

In terms of the effect on judgment and decision rationality in the above taxonomy, over-optimistic/-pessimistic evaluation occurs in all categories, and other characteristics also appear in several or almost all. This raises the question of why the column exists if there is little difference between the biases on that dimension. There is no clear explanation in the text. The third column, giving ex-

amples from supply management, is more relevant and illustrative. In any case, the taxonomy gives a comprehensive picture of recent developments and findings in the research on decision-making bias.

## 3.7 Business-process change

There are many discussions concerning change in business processes, one of the most well-known being Porter's (1990) value-chain analysis. There are also many different terms in use: process reengineering, process improvement, process innovation, and business process redesign (Kettinger and Grover, 1995). The concept Business Process Reengineering (BPR) emerged at the beginning of the 1990s and was widely adopted as a way of improving business performance (Burgess, 1998). The instigators were Davenport and Short (1990) and Hammer (1990) (Kettering and Grover, 1995), and Hammer and Champy developed it further in 1993 (Drago and Geisler, 1997). It featured heavily in the literature at first, but at least initially it did not seem to produce evidence of great success (Burgess, 1998; Kettering and Grover, 1995, Drage and Geisler, 1997). It also seemed to cause trouble because of its apparently easy implementation and large gains (Al-Mashari et al., 2001). Later the emphasis started to move from radical change to continuous improvement, which was seemingly less productive but worked better in organisations (Davenport, 1993; Kettinger and Grover, 1995).

Davenport and Short (1990) define a business process as: "a set of logically related tasks performed to achieve a defined business outcome". This basically means that tasks are organised so that customers will be satisfied with the ordered good or service. In any case there are several processes that form a business system. Davenport and Short (1990) attribute the need for business process re-engineering to the fact that most business processes were designed at a time when information technology (IT) did not play a prominent role. They argue that the implementation of IT systems heralded an era of sub-optimisation, and the need for BPR. Figure 6 below depicts the five-step process-redesign model:

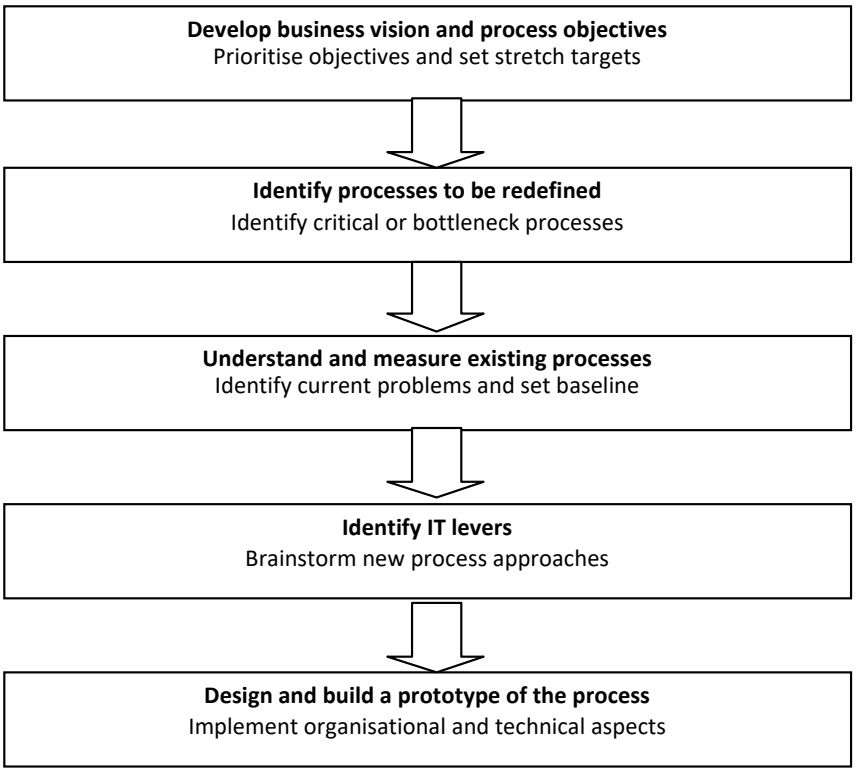


Figure 6 Five steps in process redesign (Davenport and Short, 1990)

Figure 6 clearly shows how the process of redesigning in the model is implemented through corporate-wide analysis. This sets quite high requirements and demands rigor in following the plan.

The fact that large-scale business-process change was found to be less than optimal provoked a discussion about the alternatives. Davenport then developed a classification of operational change, as depicted in Figure 7.

| | Pace of change | | |
|---|---|---|---|
| Degree of change | | Fast | Measured |
| | Tactical | Focused Process Improvement (Quality, Time, Cost) | Continuous Improvement |
| | Strategic | Focused restructure | Business Process Innovation |

Figure 7 Alternative approaches to operational change (Davenport, 1993)

The figure shows four types of operational change along two dimensions, the degree and the pace of change. The options in the former are tactical and strategic change, ranging from limited tactical change to profound strategic change in how the organisation operates. In terms of pace, the change may be fast or measured. Fast change runs rapidly through the organisation whereas measured change concentrates on the longer term. This creates the following four different types of process change (Davenport 1993):

- Tactical and fast change: focused process improvement that is strictly limited in scope to quality, time and cost. The change process may only take a few months. This type of change does not fundamentally change the way of working on the general organisational level.
- Strategic fast change: focused restructuring includes different means of acquiring, consolidating or divesting organisational capabilities to profoundly change ways of working. This does not necessarily mean that the changes remain.
- Tactical measured change: continuous improvement means that incremental improvements are made to processes on an ongoing basis.
- Measured strategic change: business-process innovation means building the processes up from scratch. Existing processes are ignored.

According to this typology, change in business processes should focus on innovation, then continuous improvement. In other words the preference is for measured rather than fast change: a slower pace and a well-organised process often produce better results than fast changes that are not co-ordinated on the corporate level (Al-Mashari et al., 2001).

Even at the end of the 1990s there was a sense of connection between Supply Chain Management (SCM) and BPR (Burgess, 1998). Process re-engineering already recognised the inter-organisational processes and their importance to the

company, as well as the benefits of IT and EDI (electronic data interchange) (Davenport and Short, 1990). Later, when the trend towards inter-organisational relationships and IT-enabled processes gathered pace, the literature on business processes began to focus on SCM and IT or enterprise systems (Bhatt and Troutt, 2005; Davenport and Brooks, 2004; Xu, 2009).

Despite the problems with the concept of business process reengineering, there are benefits to be gained from its implementation. Like any other strategic, large-scale change in corporate structure, it has the potential to foster competitive advantage on condition that it is acknowledged to be relevant to the problem in question and that all parties understand that real change takes time and effort (Burgess, 1998). Successful process change also requires good knowledge-sharing and learning practices, and awareness that organisations do not exist in a vacuum but belong to larger networks. It is also a top-down project, meaning that top management should give the strategic initiative (Kettinger and Grover, 1995).

Information technology has always been a part and an enabler of process reengineering, and is sometimes seen as the most radical change agent in the process (Davenport, 1993). ERP and other enterprise systems have recently become the motor of change in business processes (Samaranayake, 2009; Bhatt and Troutt, 2005; Davenport, 2004; Berente et al., 2009), and most small and medium-sized companies currently run an ERP system. Even though the systems are in place, however, their full potential is not exploited in terms of eliminating waste, and simplifying, integrating and automating business processes (Samaranayake, 2009). Improvements in communication technologies over the years have focused interest not only on intra-organisational processes but also on inter-organisational process integration (Davenport and Brooks, 2004; Bhatt and Troutt, 2005; Xu, 2009). In general, information consistency and availability are critical in IT systems. Keying in known data is the most common problem, in other words manually transferring system data from one area to another (Berente et al., 2009). In order to enable the transfer of inter-organisational data, different standards and processes have been developed that facilitate standard communication between different enterprise systems. This started with EDI standards, but the development has been slow compared to the more recent RosettaNet standard (Chong and Ooi, 2008). The easier connectivity to other companies also provides a broader view of the information transferred, and improves the visibility of the whole supply chain (Malhotra et al., 2005).

## 3.8 Summary

In conclusion, this section summarises the above conceptual discussion. The conceptual frame includes the following areas: supply-chain management, logis-

tics, purchasing, inventory management, business-process change, enterprise systems, decision-making and the electronics industry. It operates on two levels. The first comprises a basic theoretical knowledge of supply-chain management: logistics, purchasing and inventory management serve as a base on which the remaining theoretical issues stand. The second level incorporates business-process change, enterprise systems, decision-making and the electronics industry, which provide additional context to the basic theoretical knowledge. Figure 8 below clarifies this division and shows how the concepts influence each other.

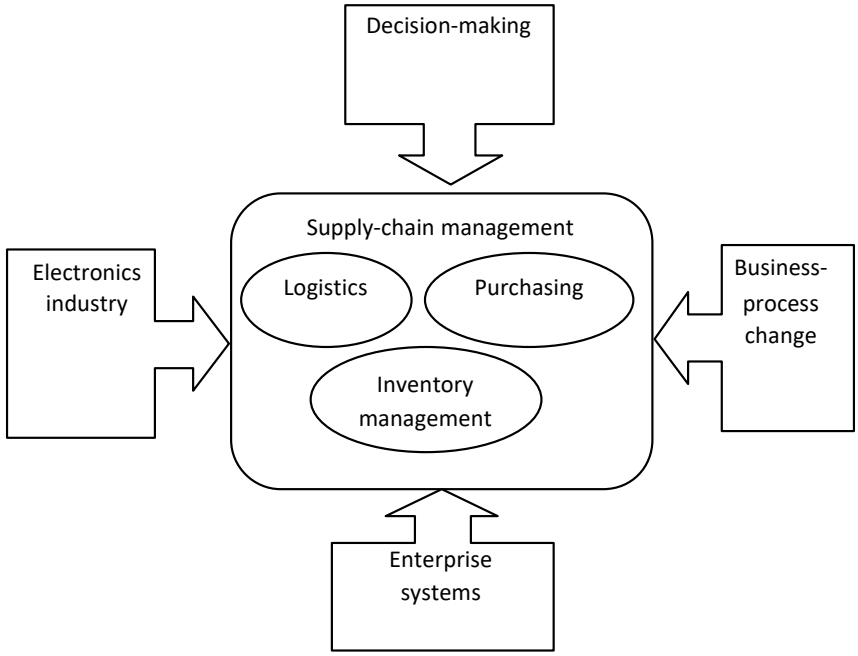


Figure 8 The relationships between the topics incorporating the theoretical frame of this research

As the figure shows, within the concept of supply-chain management the focus of the investigation is on logistics, purchasing and inventory management, which in turn are conditioned by the effects of decision-making, business-process change, the electronics industry and enterprise systems. These effects are now considered in more detail.

As mentioned, the supply chain is a broad concept incorporating the tools and frameworks that affect the process across company boundaries. Purchasing and logistics are, according to this definition, business processes or parts of business processes in the framework of supply chain management. Thus the focus is on

operative purchasing, and on one part of that process. Logistics processes are concerned in that the focus of the discussion is on the effect of purchase-process outcomes on one of these processes: inventory management. The processes are connected in some way through the fact that purchasing supplies goods to inventories and production that are influenced by purchasing decisions. Inventory management is affected by the purchasing decisions and should be monitored and analysed in order to optimise output. The demand side of the discussion is missing here, except for the fact that demand is uncertain and therefore safety stocks are needed. In this case it is production that is geared to operations management. Given the focus in this research on purchasing and inventory management, demand is taken as given and there is no possibility of affecting it. This is also supported by the fact that consumption could also be a sales issue. Therefore, in terms of this research it does not matter where the demand comes from.

Decision-making is one of the major issues in the supply-chain context. Decisions are made daily on strategic, tactical and operational levels. They affect the outcome of the supply chain, but at the same time various inputs from it that are consequences of other decisions affect the decision makers. A set of human decision-making biases is identified that affect day-to-day decision-making in some way or other. With regard to purchase decisions the relevant biases include base-rate thinking, according to which new information about the current situation is compared to the actual level, and the amplitude of the change is not considered large enough to affect the functioning of the system. Secondly, confirmatory bias means that the decision maker tends to search for information that confirms previously established presumptions. A third possibility is reference-point bias. This is similar to base-rate thinking and leads to situations in which decisions do not take into account the magnitude of the change, but rather attenuate it.

Business-process change happens in almost all organisations on a regular basis, although it might not be identified as such a change, or it may not happen organisation-wide as when the concept was developed. Nowadays when IT applications are in use in almost all organisations, IT is a normal and essential part of every business-process change. In the current context the change affects part of the operational business process, and because of the existing interconnection with logistics and supply-chain management it also affects these processes. This example shows how small changes in one operational process may have an extensive impact on processes on different levels.

As mentioned above, IT is part of almost all business processes, and therefore is naturally part of the theoretical framework incorporating the concept of change in business processes. In the case of supply-chain-management processes, special IT tools such as ERP systems have been developed. Together with current communication technologies the development of these tools is an essential part of the reality of supply chains, which is why they are discussed separately. Modern

ERP systems and inter-organisational communication tools and techniques benefit operative purchasing though supply chain management, in new ways. Their calculation capacity facilitates automation, higher accuracy and effective decision-making.

The electronics industry is particularly relevant here because the realities - the historical development and certain facts about the supply chains in the industry - in some cases limit and in some cases enable different processes. The particularity of some inventions and the nature of the electronics business therefore affect the operational purchasing processes in this case.

# 4 CASE STUDY DESCRIPTION

## 4.1 Basic information about the case company

The case company is a medium-sized manufacturer of industrial electronics in the field of telecommunications, and exports 90 per cent of its production to operators worldwide. It has its own sales offices in Europe but operates through partners in other markets. It has developed worldwide market coverage although it has not targeted South America. Despite its extensive network of sales offices it ships most of its orders from its headquarters in Finland, where the central warehouse and major manufacturing facilities are located. The company also has an operating unit in the Far East as well as subcontractors supplying semi-finished assemblies and end products.

At the time of this research the author had just graduated from Turku School of Economics and had signed on as a doctoral student. At the same time he was appointed manager of a project involving a move from defined business to automated purchasing. The subject was fascinating and his interest in the results of automated purchasing was awoken. When the first project ended a second one followed, which gave further insight into the effects of automated purchase ordering on inventories.

The case company was then using a standard ERP (Enterprise Resource Planning) system to run the logistics at its headquarters and factories, and the inventories attached to it. The software covered the functions of manufacturing, inventory management, sourcing, purchasing, customer service and materials requirement planning (MRP). The ERP system was taken into use in 1999 and ran until the beginning of 2005.

In the electronics industry the manufacturing of devices normally starts with the assembly of a circuit board, which is frequently called a module. It is usually a part that completes one of the product's functions. End products frequently contain one or more circuit boards, the elements of which include a printed wired board (PWB) and a number of electronic components (e.g., transistors, resistors, memories and processors) assembled by machine or manually by inserting components into the PWB. The case company has its own module manufacturing facility even though it sub-contracts part of that phase of the production.

The components needed for module manufacturing are supplied either directly by the manufacturers or through distributors. Distributors mainly provide value-adding services in warehousing and logistics, but in the case of small and medi-

um-sized customers the manufacturers also use them to split larger manufacturing lots. In this sense distributors are of interest to both component manufacturers and manufacturing customers, and are able to reduce the number of customers and the number of suppliers, respectively (e.g., Berry et al., 1994).

There are many ways of packing electronic components depending on the size, type and need. The most common practice is to pack the components individually in a tape that is rolled on a reel. This is the most convenient method from the manufacturing customer's point of view because the machines used to assemble the modules use these reels as standard. The reel contains more components in one unit than other packing methods, typically from 200 up to 10,000pcs, and this enables a high usage rate for the assembly machines. Tube packing is also possible, and is used when a whole reel is not needed. It is convenient in the sense that assembly machines may also use tubes to supply components. The capacity of a tube is typically limited to between five and 30pcs depending on the component type. The most labour-intensive packing method is the tray: the components need to be fed manually into the machine or inserted in tubes for assembly. A tray typically contains 10-50pcs, but manual treatment is often required before the assembly machine can use the components.

For this research the investigation focused on the relationship between the case company and two of its distributors through purchasing. The case company was developing a system to automatically transfer demand information on a range of components to these two distributors on a weekly basis. This arrangement was made in an attempt to rationalise the work at the case company and release manpower to work on more complicated sourcing issues faster with the same amount of resources. This could also be called a business-process-improvement initiative. The suppliers probably had the same kind of purpose because the initiative came from the component distributor in the first place.

## 4.2 Purchase order processing concepts

Three different purchasing modes are described in this research, all concerning the practical process from the purchase request to the delivery of the goods. Figure 9 below depicts a typical manual purchasing process.

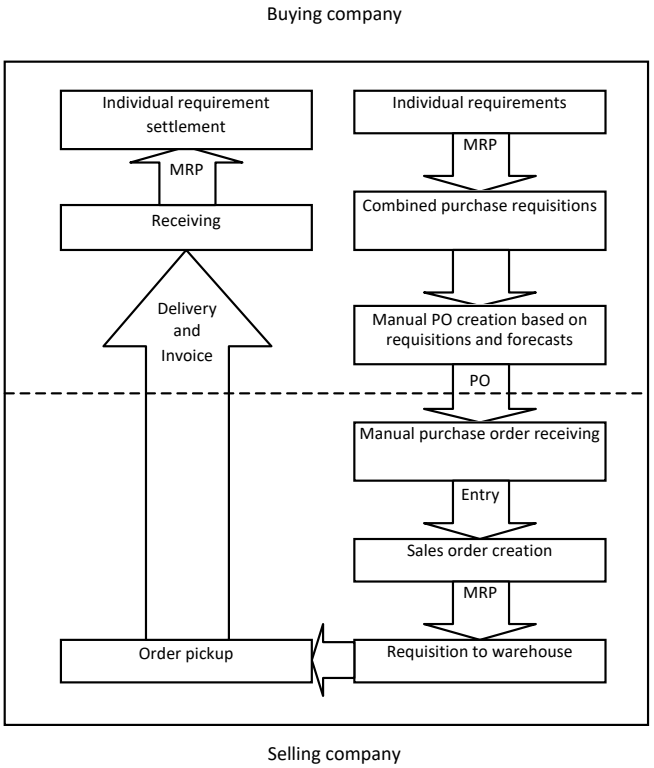


Figure 9 A manual purchase-order process

The purchasing side of this manual purchase-order process is represented in the top half of the figure. The dashed line in the middle represents the boundary between the purchasing and the selling company, and the lower part represents the selling company. The process starts with the individual requirements of the production or another department. If it is a wholesale organisation the requirement comes from direct customer demand. The demand is processed through an MRP system, as described in the theoretical framework. Aggregate demand is transformed into purchase requisitions, which are manually gathered together in a purchase order that is sent on to a supplier. This supplier receives the order and enters it into its system for processing in its inventory or manufacturing system. In the case of wholesale purchasing the order is requested directly from the warehouse. This model does not incorporate the internal process of securing the availability of the materials, the assumption being that they are available. The requests on the supplier side are sorted by the customer and picked up from the warehouse. Delivery and invoicing take place after the pickup. The buying company duly receives the goods and enters the information into its operating system.

The next time MRP is running the increase in inventories is taken into consideration, the purchase order no longer remains open and demand for the goods is satisfied.

The above is an example of a manual purchasing process. It was in use in the case company before the implementation of automated purchase ordering described in the two samples that follow. The automation project discussed in the following sections was meant to simplify the process through the elimination of the manual steps. A crucial element of it was the ERP system and the automation inherent in it. This integration enables the use of entered data throughout the organisation, and reflects business-process re-engineering with its goals of waste elimination, simplification, integration and automation (Samaranayake, 2009). These principles were followed in terms of eliminating manual data entering, simplifying the process, and integrating and automating customer and supplier processes. The purchase-order process was fully automated in the first sample and partially automated in the second. It was adapted as described in the following case descriptions.

## 4.3 Two case samples

This research concerns two case samples representing two different forms of process change. The two samples involve two sets of electronic components purchased through different processes. The Chapter describing the research process outlined some of the basic principles applied. Here the component samples are presented in the context of the ERP system, which is essential in terms of understanding the behaviour of the item samples. Table 4 below gives the samples and their characteristics.

Table 4 Sample characteristics

| Characteristic | Sample 1 | Sample 2 |
|---|---|---|
| Number of items | 18 | 18 |
| Lead time | 5 working days | 5 working days |
| Minimum order quantity | Manufacturer package size | Manufacturer package size |
| Safety-stock-calculation principle | 20 days demand, defined as a 6-month average | 20 days demand, defined as a 6-month average |
| Period of supply | 15 days | 15 days |
| Investigated automation period | 22 months | 16 months |
| Type of process after the change | Fully automated | Semi-automated |

As indicated, the parameters were the same in both samples. The differences were in the period of investigation and the type of process change. The investigation period for sample 2 started approximately 12 months later than for the first one, but continued some six months longer. The number of items and the lead-time expectation were also the same. The minimum order size was set to the minimum manufacturer package size, which is an industry standard and varies from half a dozen components to several hundred depending on the item. Safety stock was set at 20 days consumption in order to keep enough items in stock to meet short-term demand. The period of supply could be defined as the period forward of which the system looks at demand. It could also be called the demand window, which is open for 15 days to come. This basically means that all requirements for the next 15 days are anticipated and combined in the same purchase lot. The total number of different items in this component area was 2,323 that were supplied by 93 different suppliers.

## 4.4 The first sample

The collection of data for the first case sample started at the end of 2001 with a discussion of the MRP (Materials Requirement Planning) results and package sizes in the system. This discussion was on going between the case-company sourcing director (SD), the operative buyer (OB), the IT specialist (ITS) and the project manager (PM). It soon extended to the supplier's sales assistant (SA) and later its IT specialist (SITS). Prior to this the case company had a commercial relationship and a contract with the distributor specifying products, prices and minimum order size. The total number of items included was 76 at the beginning of the investigation period, after which the number of active components was found to be 42. Thus, the investigation included some 40 per cent of the components in the automated purchase ordering from this supplier. The supplier was special in the sense that there was a binding contract covering annual volumes. The case company also had some items that were strictly customer-specific, and the contract was more rigorous with regard to these components.

The order process had been manual and the buying was MRP-based. OB issued orders through ERP and sent them by fax to the counterpart sales assistant (SSA). SD had agreed on the standard order-lot sizes with the supplier, and it varied from a single package to a lot of several. OB and SSA made changes to the standard lot sizes on a daily basis. OB and SD also defined the safety stock information in the ERP component by component, and also freely defined the order frequency.

The first topic of discussion before the implementation of the automated order system was order size. The aim was to set this as one package, which would al-

low the smallest possible order especially when deliveries were supposed to take place weekly. The agreement between the case company and the distributor stated a minimum safety stock to be kept by the distributor, in order to avoid stock-out situations. SD agreed with the distributor SSA that the minimum order quantity (MOQ) would be one package, and OB and SSA went through the components covered in the agreement to enter this information into the ERP systems of both companies. The safety stock of components intended to be included in the automated purchase order with this distributor was based on six-month historical demand and set at two weeks. This calculation was made on a monthly basis. The two-week safety margin was based on the idea that when a purchase order goes through with the demand information there will be one week before the next purchase order is set and those goods would be delivered two weeks from the present. The following figure from Rantala and Hilmola (2010) describes the resulting purchase-order process:

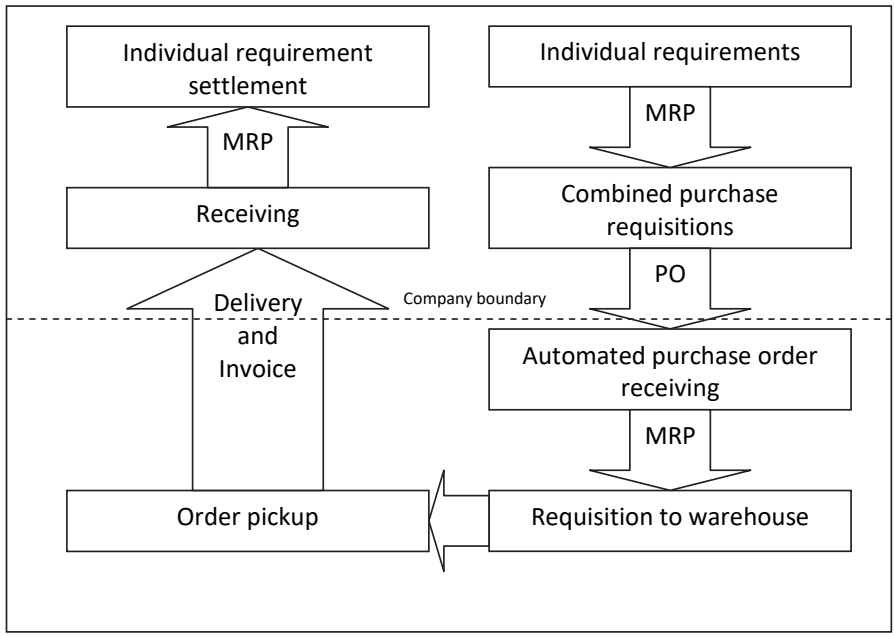


Figure 10 An automated purchase-order process (Rantala and Hilmola, 2010)

Figure 10 above depicts the fully automated process as created in the first automated purchase-order implementation. The dotted line in the middle of the represents the company boundary, the case company being above it and the supplier company below. Individual production requirements are combined in the MRP

calculation to create purchase requisitions for each item if there are not enough in the inventory. Purchase orders are based on the rules explained above. The supplier ERP system receives the order automatically and creates the requirements in its MRP for the warehouse/purchasing to supply. When the items are ready for shipment they are picked up and packed for transportation to the customer. The customer enters the items manually into its ERP system, and the next MRP run is to meet individual requirements.

The system ran from February 2002. A single open purchase order was included in the ERP system to enable the receipt of shipments. At first there were some problems concerning partial shipment and the related reports, as well as pricing issues. OB and SSA discussed these day-to-day matters, which were resolved case by case without upsetting the delivery schedule and therefore did not affect the inventory transaction figures significantly. They mostly concerned the ERP technology and had no commercial importance. Later on, SD and SSA discussed updating the contract and adding new items because the distributor ERP system blocked new items that were not included in the trade agreement.

## 4.5 The second sample

The case company initiated the second sample in September 2002. Discussions started following a seminar in which the supplier presented its electronic commerce solutions. The case company had intended to implement a similar system with this distributor to the one described in the first sample. The supplier (a component distributor) could either operate through a local messaging service in accordance with the RosettaNet standard (see e.g., Fulcher 2005, Malhotra et al. 2005, Choong and Ooi 2008), or communicate through e-mail messaging. The latter was selected because using a service provider would have incurred the additional cost of connecting to the server and a regular maintenance fee. The automated e-mail service was free of additional charges. It was also comparable to the service described in the first case. The initial discussions were between the Project Manager (PM) and the Supplier IT Specialist (SITS), and later on the Sourcing Manager (SM), the Supplier Sales Manager (SSM), the Operative Buyer (OB) and the Supplier Sales Assistant (SSA) joined in. The case company IT Specialist (ITS) was involved in the implementation phase.

Discussion between PM and SITS started at the end of September 2002 and covered general aspects of the e-commerce solution, specifically its extent (purchase orders and/or forecasts), and types of information-transfer files and their contents. It then moved on to practical issues such as order frequency, order size and delivery time. It was concluded that a weekly cycle was suitable in this case, too: the order size and delivery time were the same as in the normal delivery con-

tract with the distributor. There was further discussion about the information to be distributed to the case company concerning the process and delivery status. It was agreed that the customer would receive an order confirmation by e-mail or fax and would be informed in case of deviation from the normal procedure.

The next phase concerned the selection of items for the automated purchase-order system. It was concluded that the fastest-moving items and those with better availability should be included and that slow-moving and customer-specific (by the classification of the distributor) items should be excluded. This was based on SM's and OB's argument that with slow-moving items there were more often situations that required discussion between the case company and the distributor. The total number of items at this supplier was 600 but only 18 were included in the automated purchase-order process according to the inventory-turn and commonality criteria. The necessary definitions and choice of items were agreed by the end of October 2002 and the first test messages were sent from the case company's database.

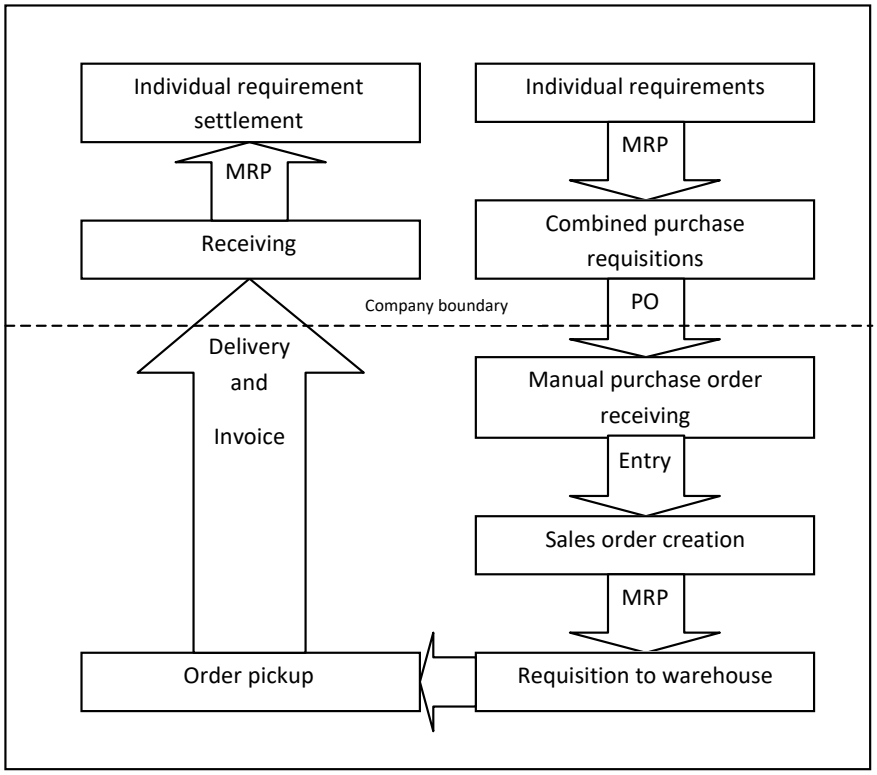


Figure 11 A semi-automated purchase-order process (Rantala and Hilmola, 2010)

During the test phase the distributor asked for price information to be included in the file as well. The final order form covered the following information: item number (case-company database), requested date, quantity, price and contract number. Testing was on going during November 2002 due to problems in the distributor's IT systems. The next delay was due to the fact that from this distributor needed to be shipped to two different delivery addresses. This problem was solved through the use of separate files for each address. Changes in trade agreements and items to be included in the automated system delayed its implementation until the beginning of 2003. By mid-December 2002 the following parameters had been updated in the case company's ERP system for use in automated purchasing with this distributor: two weeks safety stock, a five-day delivery time, and the screening of unsettled requirements in a 30-days-ahead window. This last parameter basically introduced the idea that all item requirements

that were visible 30 days forward would be ordered from the distributor. This second case sample adopted a semi-automated process, as depicted in Figure 11.

The difference in this semi-automated process from the fully automated system is that when the case-company system sent the purchase-order information to the supplier it was electronically received, but entered manually into the supplier's ERP system for MRP processing. The data was reviewed at this point and possible anomalies were communicated to the case company.

The samples were analysed separately and together in the three articles attached to this thesis. The following chapter briefly summarises these articles and essays, and assesses their results in line with the analysis. All of the processes described above were used in the samples.

# 5 SUMMARIES OF THE ATTACHED ARTICLES AND ESSAYS

## 5.1 Introduction

The articles summarised below follow the logic of automated purchase-order implementation, but at the same time the findings offer something new and each article brings novel insights. The first two present two separate sets of data and the results of their analysis, which are compared in the third article with a third set of data that serves as a reference point.

The first article describes automated purchase-order implementation and its results in inventory turns. The theoretical basis lies in net requirements logic and its implications in terms of demand data. The inventory turns of the first case are analysed before and after the implementation of the automated system.

The second article analyses the data from the second case and reviews that from the first case. The differences between the three different kinds of purchase process are explained, and the two cases are compared in terms of changes in inventory turns, order size, inventories and consumption.

In the third article the two automated-purchase-order data sets are compared with a larger set in which the purchasing was processed manually, and which covered the whole investigation period of approximately four years. This set provided a reference point for the automated process. Three hypotheses were posited in order to assess inventory-turn improvement in automated purchase-order systems, the influence of the level of automation, and the impact of the absolute component price. The first essay comprises a discussion about the similarities between supply chain management and two other concepts that are closely related to change processes. In terms of theory it is based on the literature on total quality management (TQM), business process reengineering (BPR) and supply chain management (SCM). It makes a valuable contribution in terms of explaining the context in which processes are automated or reengineered.

Finally, the second essay is a written analysis of the controlling round of interviews on purchase professionals run in order to place the results from case company to a larger context of purchasing.

## 5.2 From manual to automated purchasing – Case: middle-sized telecom electronics manufacturing unit

The starting point of this research was the implementation of an automated purchase-order system involving the case company and one of its suppliers, a large component distributor. The case company wanted to free human resources to concentrate on more productive tasks such as solving day-to-day problems related to sourcing and purchasing. This would add momentum to its sourcing work and so increase its competitiveness.

The focus in the article is on the effects of automation on inventory values and the turnover of raw materials. Changes in order size, average inventory value and average consumption are also analysed in order to give a fuller picture of the situation and of changes in the data. Variance and standard deviation were calculated in order to show the change in the whole set of items before and after automation. The data concerned items that were included in the automated process, which ran from March 2002. With a view to comparing the inventory turns before and after automation the data collection started in 2000 and ended in 2003, thus giving an investigation period of almost four years, covering periods of almost equal length for both purchasing methods.

Analysis of the data revealed that the average inventory turn of all items increased from 7.73 to 10.11, the variance decreased from 27.0 to 5.0, and the standard deviation from 5.0 to 2.0. This suggests that the automated process was successful in terms of inventory turns. It also reduced the differences in component turnover, as the heavily reduced variance and reduced deviation show. With regard to individual components, there was great variation in the changes, which was attributable to the above-mentioned change in variance. During the automated period it appears that one item had a different pattern from the others: the inventory turn for Ftheta dropped from 24.0 to 4.0. This was due to the fact that customer demand for the item suddenly dropped, and was also visible in the 78-per-cent drop in average consumption between the two periods. Other items also showed a negative consumption development but they at least maintained or increased the inventory turn. There was a similar development with Fgamma, but of lower magnitude. In this case the reason was the temporary heavy demand increase that affected the safety stock calculated on the basis of the previous six months' consumption. The safety stock remained high even when consumption dropped heavily. This reduced the inventory turns by 24 per cent between the manual and the automated periods.

Another interesting finding was the extremely high improvement in inventory turns in one group of items. The reasons for this were twofold. First, there was a heavy increase in the consumption of two items during the automation period. Together with the decreases in order size and inventory demand this created a

high inventory turn. Secondly there was a lower demand for two items than in the manual period. However, stock levels and order size showed a similar decrease, and thus there was an increase in inventory turns despite the decreased demand.

Overall, there was item unification in terms of inventory turn. Furthermore, there was a reduction in average order size and average stock despite the reduction in consumption of most of the components between the two periods. In order to implement such a system companies must have a basic data-management process covering stable items and reliable current demand data, as well as a long-term contract base with suppliers. A further prerequisite for companies with several production facilities is to use either combined requirements or "chained" MRP systems. This would avoid increasing the inventories in several manufacturing locations on account of the individual minimum-order-size requirements of each unit.

## 5.3 Analysis of two different automated purchase order systems in telecom electronics manufacturing unit

The outcome of the first case of purchase automation raised the question of whether automation would also work in other cases. The second sample was analysed quantitatively in the same way as the first so as to allow comparison of the results. The results are presented in the second article.

The different purchase-order processes are first described in order to clarify the situation in the two cases. The manual system is then explained in order to provide a point of comparison. They all differed in terms of the process but the flow of goods followed a regular pattern. The major difference between the two automated processes was in the reception of the customer's purchase order on the supplier side: in the fully automated process the supplier received and registered the order automatically whereas in the semi-automated system the known information was entered again into the supplier's system. The parameters of the MRP system are reviewed next.

The analysis of the fully automated system follows the same logic as in the first article, as does that of the semi-automated system, with the same calculated values. The number of items is also the same in both samples. Because the second process only began at the beginning of 2003, the investigation period was extended from the end of 2003 to mid-2004 for that sample.

The analysis of the semi-automated system revealed differences in characteristics compared with the first case analysis. There were practically no changes in average inventory turn between the automated and the manual periods. What appeared to be similar in the two series was the reduction in variance and standard deviation: variance was reduced to one fifth in the fully automated and by a half

in the semi-automated system, having originally been on the same level in both. It was still considerably higher in the semi-automated system at the end of the process. Furthermore, average consumption decreased by almost 20 per cent whereas the change was 69-per-cent positive in the first case. It could be said that in these conditions maintenance of the average inventory turn was a challenge.

There were two groups of exceptions, however. The first case sample revealed a case of MRP nervousness that is present when there are sudden changes in demand, and which creates disturbances in component demand. MRP systems often suffer from this effect. It concerned one item in the fully automated system and two items in the semi-automated system. As mentioned above, there was one high-consumption peak affecting safety-stock calculation in the former, and two items with several high demand peaks (Adelta, Aeta) and one with only periodical demand (Arho) in the latter.

The second group of exceptions concerned contractual issues with suppliers when customer demand suddenly drops. This development was visible only in the Ftheta item, as explained in the first article.

In sum, the semi-automated purchase-order system did not seem to significantly improve the inventory-turn pattern. This was not the case with the fully automated process, which resulted in significant improvement. However, in the former case there was a saving in direct labour and overheads, allowing the allocation of staff to more profitable tasks in the company. It was also observed that purchase-lot sizes decreased, which according to economic-order-quantity thinking (EOQ) should improve inventory turns. It is interesting that in both systems the average annual inventory turn was almost tenfold, the variance decreasing simultaneously on the component level. This was supposedly due to the uniform setting of the item parameters. The failure of the semi-automated system could be attributed to two possible causes: either the period of investigation was not long enough or the system is inherently less effective than the fully automated system. Comparison with a set of components purchased in the normal manner would shed light on the development of these two systems.

## 5.4 Inventory turns changes and sophistication of automation in purchase order systems

This article continues the theme of the two previous ones. It begins with a brief description of the two automated purchase-order systems, and then sets out the three research hypotheses.

Hypothesis 1: Purchasing automation enables inventory turn improvement regarding purchased component inventory.

Hypothesis 2: Level of automation has an effect on inventory turn improvement.

Hypothesis 3: Expensive components have higher inventory turns.

The research environment is briefly reviewed next, the case company and component distributors are introduced, and the basic parameters of automated purchase ordering are explained. The empirical data analysis follows.

This article introduces a new sample of 56 different items purchased normally (manually) from different component distributors, including the two with automated purchase ordering. The same data-analysis principles were applied as with the analysis of the automated samples, and the additional data was further analysed separately with both. The observation period for these manually purchased items was over 50 months. Regression analysis was used in the analysis.

It appeared from the results of the regression analysis that automation was not the primary reason for the improvement in inventory turns: the likelihood of a consequent decrease in the fully automated system almost reached a statistically significant level. The conclusion was that it was not automation that caused the increases but the fact that the basic parameters, and especially order-lot size, were set to a minimum. Thus, the first hypothesis did not seem to be valid.

At first glance the second hypothesis about the level of automation seemed to hold. However, deeper analysis revealed that the success of the safety stock and other parameters, together with demand development, had a greater impact on inventory-turn development. Consequently, the second hypothesis was also rejected.

With regard to the third hypothesis, it turned out that the item price level had an impact on inventory-turn improvement. It was concluded that this was attributable to the fact that more expensive items are often packed in smaller packages, which in turn affects purchase-order quantities.

Process automation, especially in the supply-chain context, is assumed to increase efficiency and improve the use of inventories. However, it seems from the results of this research that automation itself is not a driver of such improvement, and that other parameters, such as demand and stock levels, play a role. Interestingly, order quantities had no significant effect on inventory turns, and in some cases automation might even lower the levels. It thus seems that traditional materials-management parameters are essential and key elements in terms of improving inventory turns. This analysis only covered a small fraction of one supply chain and the inventory holding within it. In future and in order to validate these results, larger-scale research should be carried out in organisations capable of generating similar data. Chain-wide inventory-level analysis would shed light on inventory development in the supply-chain context.

## 5.5 From total quality management (TQM) through business process reengineering (BPR) to supply chain management (SCM)

Total quality management (TQM), business process reengineering (BPR) and supply chain management (SCM) are seemingly separate concepts. However, the literature identifies connections between them that could enhance the success of the changes in business process that commonly occur in companies. SCM as a concept is possibly the oldest of the three. TQM evolved at the beginning of the 1980s in a bid to increase competitiveness in US industry, and BPR developed from this in order to increase the effectiveness of change. These concepts have common features, of which the most important are process orientation, the use of information technology and inter-organisational coverage.

Information technology (IT) is common to all of the concepts but has a somewhat different role in each one. Its role in TQM is to facilitate its development and practices, but it is only a business-development tool. On the other hand, it has a leading role in BPR in terms of redesigning business processes. IT has featured in SCM for a long time in the form of MRP and ERP applications, which currently define many aspects of supply-chain thinking. EDI and other communication-technology tools have extended the use of IT to inter-organisational relationships.

The use of IT in SCM is logical in logistics, which has traditionally focused on flows of materials and information. However, SCM also incorporates process-based thinking so as to better describe these flows. By definition, TQM presents an opportunity to involve suppliers in the process of continuous improvement. In the context of BPR inter-organisational relationships are seen more broadly as inter-organisational processes. A change in focus from the transactional to the holistic would produce greater benefits.

It is obvious from the above discussion that the point of these three concepts is to increase competitiveness, and not only inside company borders but also further afield among other companies working together in a chain or network. Such co-operation could be fostered with the help of modern IT tools through the spreading of strategic processes among organisations on the transactional as well as on more advanced levels. It is crucial to understand that while routine transactions are transformed, the whole picture should be taken into consideration for that obsolete processes are not given too much attention.

## 5.6 Perceptions of automated purchase order processing in mid-sized manufacturing companies in South-Western Finland

Purpose of this essay is to report the findings from a multiple case study. This study was made in order to place the results from above-reported studies to a larger picture in purchase order management. Research was made based on semi-structured interviews made among purchase professionals from four manufacturing middle-sized companies. All of the companies were chosen from a database of participants to a larger research programme in South-Western Finland. Their business areas varied and included electronics manufacturing, automotive and general machinery manufacturing industries. More important than the companies were the respondents and their professional opinions and experiences about the subject.

The covered topics were concentrating on the applicability of automated purchase order. The questions were asked in form of propositions that were testing the results obtained from the focal company case study. Topics varied from technical and economical realisation to practical implications of the applied automated order processing.

It was found that most of the respondents had no personal experience on automated purchase order processing. One of the respondents had recently implemented the automated purchase order processing in his current position. Even though most of the respondents did not have personal experience on the matter, they quite well were able to end up with the same conclusions than the one with more experience. The most time and effort consuming task was found to be the review of item basic data in beforehand of the system implementation. Secondly, the competence and resourcing of the system implementation team was identified as important to success in the process.

On the items in focus, those with long lifecycle in view and stable demand were seen suitable for automation. Vendor Managed Inventory (VMI) was seen as an alternative way of purchasing to those items. This finding is interesting because it stresses the need of long term contractual relationship with suppliers where automated purchase order is a sign of trust and longevity of the relationship. As interesting is that if compared, VMI seems to build even stronger relationship because the supplier is willing to invest in inventory on customer premises. In case of small or medium sized (SME) companies the automated purchase order may be the preferred option from both sides: from suppliers' because no intensive inventory building is necessary in a probably small scale and to the buyer for more simple structure of reporting and data processing.

Experiences of the automated purchase order in one of the companies were interesting. Their driver to automate was increase performance of purchase personnel and related cost savings in fixed costs. As flow of products was optimised,

increase in use of working capital was achieved. What was found negative in the system was “blindness” to the material flow that required additional controls in order to monitor the effects of purchase order to inventory levels. The problems were identified to be related either the malfunction of the system or incorrect item basic data in the system.

In conclusion, automated purchase order was seen to add rigor in item data management, increasing the use of capital and reducing fixed costs. The system was also seen suitable for an SME company both operationally and implementation-wise. The phenomena should be further researched from buyer-supplier relationship point of view as well as from key figure impact analysis point.

# 6 DISCUSSION

The story of this research is a long one. As stated earlier, a supplier made a proposition to the case company to develop an automated purchase-order system. The case-company representative accepted the proposition and the work to establish automated routine purchasing began. The underlying assumption, reflecting the literature on process re-engineering (e.g., Samaranayake, 2009; Kettinger and Grover, 1995), was that automation would save resources and time and improve inventory management. The thinking of the persons starting the process, the decision makers, may not have been related to any of the theories of business-process change or supply chain management, and may have been more practical in terms of following good business practice and saving manpower for something more productive. Nevertheless, the essential thinking was there. As a recent graduate working on different kinds of projects in the case company the author considered this just one assignment among others. Of course it was interesting on the same practical level in that it would potentially save money and resources.

Thus began the practical part of the research. On the theoretical and academic levels the origins are more difficult to define. The emphasis in Chapter 2 on research methodology introduces case-study methodology and action research. Certainly, there are elements of both. The quality of the research compared to the methodological description is another issue. Action research starts from the theoretical consideration of a problem area on a larger scale (Westbrook, 1995; McKay and Marshall, 2001; Zuber-Skerritt and Perry, 2002). It is a type of case research, which would make this a single case study with multiple perspectives on the same phenomenon. Larger-scale theoretical thinking was not conscious at this stage. Conscious thinking started in line with the data analysis. Thus there are flaws in the methodological process. The effect of these flaws on the results of the research may be analysed through the reading of this thesis. Despite this shortcoming the research could be said to have started at the beginning of the implementation process, which conforms to action-research methodology.

The development phase started with the adjustment of the parameters, a time-consuming and difficult task due to number of parameters involved and the need to understand their effect on the functioning of the system. There was a one-year interval between the implementation of the two systems. It could be said that the first implementation served as a prototype of the second on the system-parameter side. The second implementation raised new issues concerning delivery addresses and different IT system configurations on the supplier side, however, and was

therefore not a copy of the first. Furthermore, experience was not the only parameter used in the process changes in that there were environmental conditions that forced the system into a different configuration than in the first automated system. Figure 12 below illustrates these influences.

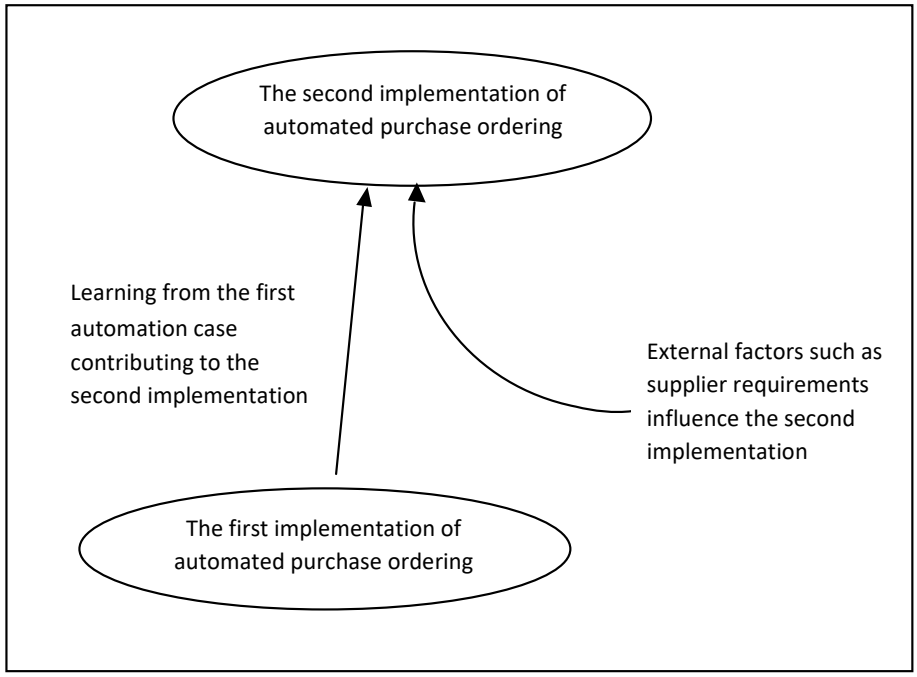


Figure 12 The origin of changes in the second case of purchase-order automation

There was clearly a learning process before the new implementation started. Unfortunately, there was no concrete return to the existing theoretical frame at this point. One reason for this was that there was not enough data available before the second implementation to see a permanent change in the development of inventory value. In fact, compliance with action-research methodology would have required the second implementation to have taken place some two years after the first one so as to enable conclusions to be drawn about inventory development. This was more of an improvement than a change in the business process (Kettinger and Grover, 1995).

IT systems were at the heart of this project. Of specific significance are the enterprise systems that currently account for a major proportion of IT investments in companies (Samaranayake, 2009). However, there are two faces of IT in-

volved in a process like this: technical and business knowledge. Technical knowledge in this case serves as the basic facilitator for setting communication-system parameters for the different systems involved. On the other hand, business knowledge comprises an understanding of the business facts and data in the IT systems that facilitate understanding of the business picture of the case in question. This knowledge allows the setting of parameters based on business facts and an understanding of the various data in the system's history and for the foreseeable future. Knowledge about and the establishment of operative processes are considered critical success factors in ERP implementation (Snider et al., 2009). However, if it is a question of changing the behaviour of the system to better support the business process, then technical IT knowledge is required. The starting point in this project was that the suppliers were able to transfer simple messages concerning purchase-order data into their ERP systems. It was assumed that setting up the automated purchase-order system would not require extensive resources. On the case-company side technical IT knowledge was used in setting up the order communication to suppliers, whereas the discussion on business IT knowledge was more intense, especially with regard to the parameter setting.

Thus there were requirements related to IT, purchasing and business processes. What was not known at this point was how the system would behave nor what the critical outcome would be: the effect on inventories was used as one measure of purchasing performance. There was also a lack of understanding of the fact that a person making purchasing decisions is bound by the limitations that are typical of any human being. The decision-making and assessment of the situation are biased by a number of factors. This appeared to be of fundamental significance in explaining the results of the experiment.

Three research questions were posed at the beginning of this thesis. Two of them concerned the effect on inventory turns of purchase-order automation and the main constituents of the observed change. The third question asks whether the results observed from the case company are relevant in a larger context of SME companies. The published articles address the first question, mainly through the quantitative analysis of inventory turns. The second question is more complex in that it focuses on why the changes took place. The third question is investigated in the second essay in detail.

## 6.1 The first research question

As mentioned, the results on inventory-turn changes are analysed in the published articles. It was found that there was not a uniform change in direction in the case of purchase-order automation. The first sample provided evidence that it improved inventory turns in general, but there were large differences between the

individual items. Analysis of the second automated sample revealed no significant improvement, although the levels remained the same as in the first one. The levels in the first sample were, on average, initially weaker than at the starting point of the second sample. When they reached the same level the average increase was high. The statistical analysis showed signs of a negative effect of automation, but not quite to a significant level. In terms of the first research question it could be said that the results are mixed. There was no clear improvement in inventory turns but there was no clear deterioration either.

The results regarding the first research question are, in fact, in accord with the literature on enterprise systems. It was argued in Chapter 3 that the implementation of supply chain and enterprise systems seems not to have negative effects on a company's financial performance (Hendricks et al., 2007), but in fact it was also found that internal measures (including inventory indicators) seem to suffer, at least immediately after the implementation (Hendricks et al. 2007, Dehning et al., 2007). This confirms the mixed results of this research: it is not a question of implementing a full enterprise or supply-chain system, and allowance should also be made for partial process change. With regard to the results and methods of previous research, statistical analyses have involved large numbers of companies and extensive public data. Care should be taken in comparing the results with those of this study, but all in all the same phenomenon was found and this confirms the findings.

## 6.2 The second research question

The second research question is more complex than the first in that it concerns why the inventory turns were affected as they were. The results of the quantitative analysis give some insights, but the qualitative analysis based on the observations of the participating researcher and deductions from the theoretical frame were also revealing. There were, in fact, two sorts of change: change to the whole sample and changes within the samples.

Changes in the entire samples were identified when they were analysed individually and in comparison. As reported in the published articles, the first analysis covered the single fully automated sample, the second was a comparative analysis of the fully and semi-automated systems, and finally, both automated samples were compared with the "normal" sample of manually purchased items. The first analysis showed a positive average trend in inventory turns, and it was argued that there was a pattern of decreasing order-lot size and unification as a whole. This was interpreted as improvement due to fully automated purchase ordering and parameter setting. It seemed from the second analysis that fully automated purchase ordering gave better results than the semi-automated process.

By the time of the third analysis everything pointed to the probability that purchase-order automation at any level improved inventory turns. However, following comparison with the "normal" data the picture changed. It appeared from the statistical analysis that purchase-order automation brought no improvement. It was thus concluded that the new parameter setting and changed business conditions had been largely responsible for the improvement.

### *6.2.1 The second research question in a decision-making context*

The fundamental change in the process would seem to be the transfer of the purchase decision from a human being to a machine. As discussed earlier, Fransoo and Wiers (2008) found that production planners largely ignore MRP calculations. They tend to change the parameters for the single production order but do not touch the basic parameters guiding the system. This shows a lack of trust in MRP to calculate the right amounts to order. It also indicates a belief that human beings are superior to machines in making purchase decisions. This might be true, but according to the theory, human decision-making is biased by the information received prior to and during the process. There are different ways of dismissing the totality of a change, and even when accepted it is referenced to a base rate and its force is reduced. In fact, moving routine decision-making to a machine should improve the quality, especially when the algorithms and parameters are correctly set to respond to the requirements and changing conditions. This reflects the results of the first analysis of automated purchase orders.

Especially in the first sample, the effect of the decision-making was visible in the sample: there was significant variance in inventory turns before the automation. This may have been due to the fact that the basic parameters were adjusted individually to the items in accordance with the knowledge that was available at the time. Another reason might have been that the parameters had not been updated for a considerable time, and this affected inventory turns in the long run. The demand for some items may have changed but the guiding parameters may not have been adjusted accordingly. Demand is mentioned here as an issue because change in demand was identified as significant in explaining the changes in inventory turns. Even when changes were made they were influenced by the bias inherent in human decision-making. This individual treatment of items probably influenced the change in the first sample. The situation seems to have been better in the second sample because the turns were initially at the level the first sample ended up with. Therefore, no such change was observed in the second sample. It is impossible to say from this analysis why the second sample had better inventory turns at the beginning.

### *6.2.2 The second research question from a business-process-change perspective*

In theoretical terms, a change was made inside the business process. This is far from the notion of re-engineering, which involves the remodelling of complete processes or all the processes of an entire firm. As discussed in Chapter 3, the initiative for change in information technology and processes must be technology driven. Figure 13 below depicts the change process positioned in Davenport's (1993) model.

| | Pace of change | | |
|---|---|---|---|
| Degree of change | | Fast | Measured |
| | Tactical | Focused Process Improvement (Quality, Time, Cost) | Continuous Improvement |
| | Strategic | Focused restructure | Business Process Innovation |

Figure 13 This research in the context of alternative approaches to organisational change (Davenport, 1993)

The positioning of this research in focused process improvement is easy to justify. There was some improvement in one part of a process that was meant to improve the quality, time and cost of carrying out one part of a business process. The approach was both fast (the change took only a few months) and tactical (an operative purchasing-process change in one commodity area).

Thus, what happened in this study was that technology-driven change did occur and human resources were freed for other process-related tasks. In practice the two implementations together saved the contribution of one white-collar worker on a yearly basis. Each implementation, in turn, required three months' work from one white-collar employee. In terms of other costs, there was no need to invest in hardware or software because the system used current ERP functionalities and common office applications. Therefore it could be stated that the implementation payback time for the two systems was half a year in terms of labour, other costs being insignificant given that the organisation had a compliant ERP system and common office applications.

It can be seen from the statistical analysis that the effect of the business-process change on the change in inventory turns was even negative in certain cases. Basically, the process was not initiated as a business-process change and it lacked the necessary systematic approach. This may explain the effect on inventory turns. It could be argued that the effect might have been more positive had the correct process been followed. Given that the implementation was part of the research, this failure could be attributed partly to a failure in the research process.

### *6.2.3 The second research question in the context of the electronics industry*

The electronics industry has many particularities, one of which is the structure of the supply chain. As the level of investment required for the production of electronic components is quite high, the suppliers are often considerably larger than the customers. It is a cyclical industry, partly due to rapid technological development and the economic cycles that affect consumer demand, on which it is strongly dependent. Cyclical demand is also a fact in industrial electronics manufacturing, in which the case company operates, and technological change also plays a role. All these factors have opened the market to component distributors that offer warehousing and technical services. In the era of the Internet this is one way in which distributors can justify their existence in the electronics supply chain (Jorgensen, 2004).

The use of those distributors was a crucial factor in this research. On the one hand they had a positive effect in terms of pooling demand from several small customers and were therefore able to offer inventory-management and safety-stock services at affordable costs. However, because some of the items were customer-specific, certain rules applied in case of drops in demand. Packaging is one item in the electronics industry that may cause problems in the supply chain. There are several options in packing electronic components, but all these packing methods include more than one component. The components are therefore always ordered in bulk, and the package size is often not the optimal for production needs so the leftover quantity remains in the inventory. This is especially true of components with low quantity requirements.

The comprehensive business model enabled the use of automated purchase ordering due to the guaranteed availability of the components from the distributors. Their highly developed IT systems and inventory management made it possible to introduce the system described in this thesis. Therefore the improvement in inventory turn, if any, was due to the advanced inventory-management and business model of the distributors.

However, there were also changes on the individual-component level attributable to the distributor business model that had a negative effect. Such a change

was observed for one component when the inventory turn collapsed during the investigation period. This collapse was attributable to the decrease in demand, but also to the contractual condition that forced the case company to take a certain amount of customer-specific stock at given times even if there was no demand. This kind of obligation easily reduces the inventory turn with regard to items with drastically reduced consumption.

Generally, the specific nature of the electronics industry may affect inventory turns in many ways. Positive factors stem from the use of distributors that allow the timely fragmentation of the sales batch from the manufacturer. The distributors, at least in the cases presented here, had advanced IT systems that supported supply-chain development. Negative features included package-size requirements and contractual restraints that disturbed the pattern regularly and on special occasions when there were disruptions in demand.

### *6.2.4 The second research question from the perspective of the enterprise system*

As far as the enterprise system was concerned, the reason for the change could be attributed to the fact that MRP systems work within given parameters, which are used until they are changed. The basic systems are not so intelligent and not all the information required for purchase decision-making is there. In this particular case the system had item-specific fixed parameters, with the exception of safety stock the level of which was based on the monthly average consumption over a six-month period. On the general level this setting did not appear to influence the inventory turn, but it did have an effect in individual cases. For an item with a high peak in demand the safety stock is affected for six months to come, and in this case it is logical that this will have a direct effect on the inventory turn of that item. There was a single extreme case and some minor cases of this in the sample. It could therefore be argued that this had an effect on the item level, which was attenuated on the aggregate level.

## 6.3 The third research question

Third research question is mostly about generalizability of the research results. Based on the experience and answers of the respondents of the interviews run in the frame of the case study described in the second essay, automated purchase order systems are a valuable tool in streamlining purchase order functions on a larger scale. Both experience and perceptions from the interviewed sample indicate improvements as savings in fixed costs and inventory turns. As was found in

the statistical analysis, the improvement in inventory turns is not a result of automation itself but the streamlining and rationalisation of item basic data affecting MRP calculations. Even though respondents were not asked specific questions related to the item basic data setting principles in case of automated purchase orders, their answers indicated clearly that systematically setting them is key to success in process automation.

As of the experience of the case company compared to attitudes and experiences of the sample respondents, the case company seems to have been quite timid in implementing the system thus probably not achieving all of the benefits when done in larger scale. Case company benefits of fixed costs was not seen as significant driver at the level of automation while in the interview sample the company that had automated purchases had experienced true savings in fixed costs. The difference was due to the scale in automation. In fact, as discussed in section of decision-making effects on second research question, to avoid the harmful effects of human decision-making biases, all of routine purchasing should be done automatically based on calculated parameters. This would improve the use of human resources as well as the results of purchasing at key performance indicators level on inventories.

All in all, this means that in system implementations a multi-focus view is required. Not only item or supplier focus is enough but a holistic view is required to include items, supplier relationships and information systems. Industrial peculiarities are not absent to this review but are of minor importance. The following picture will show the process to consider.

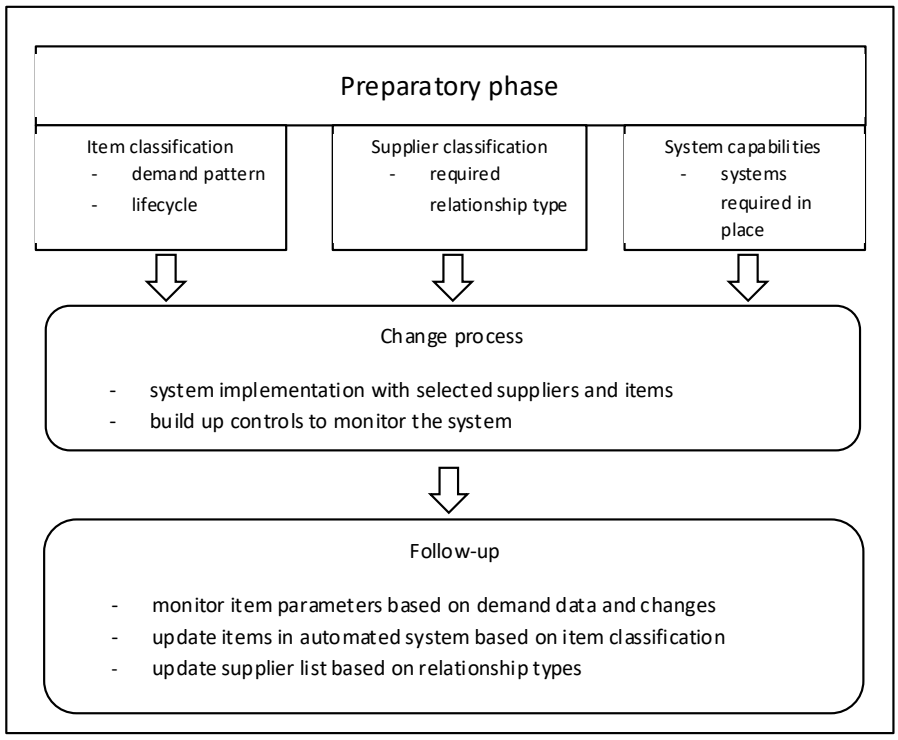


Figure 14 Purchase order automation process

In the figure above, the purchase order automation process is presented. Before automation it is important to make necessary classifications to items and suppliers and verify that systems are capable of working with the automated systems. In this case, item classification means classifying items by demand pattern and foreseeable lifecycle. Only items with stable demand pattern and long lifecycle will be selected. In supplier classification only those suppliers that are seen to be trustworthy on a longer term are selected with adaptable IT solutions. Securing the system capabilities includes the review of ERP and MRP systems so that they enable automated message transfer between external systems.

In the actual change process, the system is implemented with selected suppliers and items. On the items, it is important to review all item basic data and set them to agreed parameters. At the same time controls should be built up to be able to monitor the behaviour of the system and its influence to e.g. inventory levels.

Probably the most important part of the process is the follow-up phase, where the controls established allow monitoring the functioning of the system. At the same time continuous update of the system is required to remove items that no

longer fill in with the stability criterion. Similar process is run continuously with the supplier base. It is utmost important to keep the supplier base updated for that there is no stagnation in price and other conditions for to keep the company competitive.

If comparing these results to the concept of Peter Kraljic (1983) on supply strategy it may be stated that in nature, items are different through their meaning to a company but in case of the automated purchase order, different criteria is used. The application of Kraljic model may be used to follow a supply strategy but in tactical decisions over way of purchasing the goods, all the principles in Kraljic model do not apply. This is best shown in the fact that for an item to be included to the automated routine, it does not matter whether it is of crucial importance or a leverage item. Process-wise these items are all treated equally as long as demand pattern, item life cycle and supplier relationship factors are in the right position. The strategic positioning of the items is more of a question while strategic decisions are being made concerning supplier selection and analysis. For an SME the situation seldom is such that purchase volumes would allow simultaneous use of several sources for same items on an economical manner.

## 6.4 The generalisability of the research results

This research was conducted in one case company and used several samples to analyse the effects of purchase-order automation on inventory turns. The nature of the study is more longitudinal than wide, longitudinal in this case referring to an investigation period of approximately four years. The data was analysed with care and comparative data was used in order to establish base rates.

The industrial context was electronics manufacturing, which set some parameters with regard to basic assumptions concerning the data. A typical feature of the electronics industry is the industrial supply chain. MRP systems are quite common, but other business-planning tools are also in use.

Generalising research results is complex for the reasons described above. Therefore a controlling study was made in form of interviews to see the generalizability at least to other industries. In view of the results from the interviews, results of this research could be applied to medium-sized companies operating in manufacturing industries and using MRP to manage their production and purchase schedules. The findings also stress that industries where there is a relatively low level of stock-outs on the supplier side, IT systems support, automated sending and receiving of demand information, multi-item packaging of items to be purchased, and needs that are defined based on MRP logic will benefit from the system.

# 7 CONCLUSIONS

## 7.1 General conclusions

Processes should always be considered with a critical eye (Samaranayake, 2009; Bhatt and Troutt, 2005). Even if we do not call our activities processes, we should question them from time to time. This will keep things moving and developing, and help us to find sensible ways of doing things and to abandon activities that do not add value, whatever it may be. It has been argued that it is better to adopt a policy of continuous improvement and change rather than changing everything at the same time. In this way the overall context is known and the effects of the changes are visible. This applied to the changes brought about in the case company: one part of the process changed and the results were reviewed in the light of the old and current processes. The current research followed the same path: samples were compared with previous data, against each other, and against data indicating no changes.

In principle, automated purchase-order processing saves resources and frees them for more productive work. The benefits may be calculated in terms of resource savings or additional profit resulting from the more productive use of labour in the supply chain. Naturally, any savings should be greater than the inevitable disadvantages arising from the process change, which always involves inconveniences and resistance, to a greater or lesser degree (Burgess, 1998). Nowadays, with the multitudes of innovations in communications technology, tools are not what are missing. The implementation of SCM IT systems improves financial performance on many levels (Dehning et al., 2007). What seems to cause most problems is extracting accurate information from the systems and endowing them with the adaptability and intelligence that will enable them to respond to sudden changes in the real world.

In the supply-chain context system automation can reduce excess inventories and minimise stock-outs (Dehning et al., 2007). Automated systems are most appropriate in environments that are stable and relatively free from sudden changes. When there are disturbances the parameter setting might not follow the developments, as reported here. In such cases it should also be automated to follow changes in demand patterns.

There are also two levels of success in this kind of project: overall average success and the success of the individual items involved. Overall success is, of course, dependent of the success of the individual parts: analysis of the success

factors and disturbances to the general pattern requires analysis on the individual level. The learning process starts through the disturbances registered with regard to the individual items. What has also been learned is that things may look different when viewed from different angles and based on different measurement points. In the case developed here, as long as the samples were looked at individually and compared to the historical data a positive change was registered, but when they were compared to a "normal" sample it appeared that there was no such uniform development. Therefore on the individual level the samples produced positive results, but at the same time there was a general improvement going on that was revealed only when they were compared to a reference group. Based on these results, it is quite difficult to give an exact answer whether there really was an improvement based on automated purchase order process.

Through the set of interviews there was a confirmation that through right procedures positive results may be obtained. Success may also come as better decision-making. As decisions are made on the right level with right tools, an improvement in general level may also be achieved. In case of this research it means that purchasing professionals define the general guiding parameters for the systems and then leave the system decide on right purchases at the right time. As a result, the work of professionals is directed to complex problem solving issues while disturbances in the general setting happen. This means bill of material changes or technological driven changes in demand as well as disturbances that automated systems cannot handle.

## 7.2 Research objectives and research questions

Two objectives were defined at the beginning of this thesis, one on the theoretical level and one on the practical level. The first, theoretical objective was to:

*Identify any link between business-process automation and the key performance indicator of the particular process.*

The second, more practical objective was to:

*Find relationships between changing from normal manual to automated purchase-order processing, together with changing the parameter set-up in the decision support systems, and the change in KPI that is normally used in evaluating purchasing effectiveness, in other words inventory turn.*

These objectives were pursued in the light of the three research questions addressed in the three attached articles together with two essays and the discussion in Chapter 6 of this thesis.

*The first research question* concerned the effect of business-process automation, in this case of a purchase-order process, on inventory turns. In terms of the first research objective it was verified that there was a link between automation of the process and the key performance indicator.

The identified link was weak, but the process automation was not in itself the reason for the improvement in the key performance indicator. On the practical side the aim was to see whether purchase-order automation would bring about an improvement in inventory turn and reduce the amount of working capital required to run the business. It was found that automation in itself did bring about the improvement.

*The second research question* concerned the relationships leading to the change, if any, observed in the inventory turns after purchase automation. On the theoretical level this explained the reasons for the change and directed further research to areas that could shed light on the phenomenon, namely business processes and information-technology systems. On the practical side, there are several items to be studied before the process automation is started as well in the process itself as in the targets of the process.

It was found that parameter setting in an MRP environment is crucial to the success of purchasing and thereby to inventory turns. This is connected to the decision-making and the biases involved. When parameter setting is logical and rational the system makes better decisions than human beings at times of relatively stable demand. However, there must be rapid reaction to sudden changes in demand patterns, and this is where professionals are needed. Those responsible for day-to-day purchasing should otherwise trust the logical parameter setting and only react to sudden change in demand.

*The third research question* wanted to verify the applicability of the results to a wider context of business, especially small and medium-sized companies. It was verified through a case sample that findings in case company were applicable to a larger context. Especially the fact, that parameter setting really is crucial to the success of the system. At the same time a control factor was raised to picture: in order to properly manage the outcomes of the system, controls need to be established to monitor the automated system.

## 7.3 Recommendations for the case company

For the case company, the practical implications from the research concern the automated purchase-order process and the reasons for the changes as well as its total strategy of application.

Implementation should be viewed as a decision that involves purchasing and the suppliers in question, and also a change in processes that affect business success. The implementation process described took account of direct practical issues but lacked a process perspective. This suggests a need for a sharper focus on the process and on analytical aspects. In general, supply-chain automation and integration should be pursued. If processes are only sub optimised there will be no benefits on a larger scale. This was seen while comparing the situation of the verification sample company with large scale automated purchase order implementation: they had obtained savings on both fixed costs and working capital.

The items involved in the samples were screened prior to the implementation to include only those with regular patterns of demand and consumption. More thorough screening might help in terms of avoiding some individual failures. A regular demand pattern seems to be crucial for the proper functioning of automated processes. Cases of drastic change in demand or higher input than required are especially challenging, and prevent the system from functioning as expected. Hence automation of the purchasing process is not suitable when demand is highly uncertain. However, the case company should also be more ambitious in including items to the automated system to achieve savings in fixed costs as well as improve the use of working capital on a larger scale. The situation where majority of the items is automated and only exceptions are handled manually is to be pursued. This will reduce the biases of human decision making and leave time to tackle with problems on a larger scale.

In terms of information systems there are a few points to be made. Investments are often expensive, and systems with advanced planning capacity are often economically beyond the reach of a small or medium-sized company. Moreover, they might not always produce the expected improvements in overall financial performance (Rabinovich, 2003). Therefore special care should be taken only to implement projects for which there are sufficient resources and system support. Many enterprise-system implementations fail or do not produce the expected results. The most important prerequisite is an MRP system that functions properly and is able to supply calculation results that can be passed on to suppliers. As seen from the results of the controlling case, internal controls should be established to be able to monitor the system. This will also reduce the willingness of operative buyers to manually alter the automated purchase process. Thus, trust needs to be built among buyers that the system is able to perform the tasks while buyers can concentrate on more productive work with suppliers.

In this particular case purchase-order automation required a reliable MRP system and parameters that were adjustable to the changing demand conditions, given that change in demand had the most significant effect on inventory turns. On the other hand, automated parameter-setting calculations are beneficial because people might not make the actual changes to the system appropriately, or may not see the importance of a change in demand pattern. As has been found in previous research, manual reviewing of parameters tends not to be on the level of needs (Jonsson and Mattsson, 2006), or they are ignored in the planning process (Fransoo and Wiers, 2008). It is also important to ensure employee trust of IT systems if the automated system is to function without manual interference. What was found beneficial in the system setting was the unification of the inventory turns among the items, meaning that items behave in more or less the same way when the parameters have clear rules and are regularly set.

As far as future actions on the broader level are concerned, the case company should manage its programme for change in operative processes as illustrated in Figure 15 below.

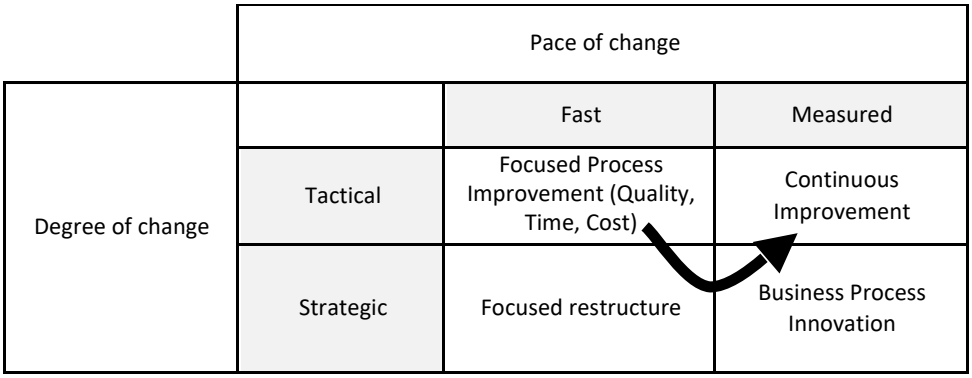


Figure 15 The recommended route for operational-process change in the case company (adapted from Davenport, 2003)

As Figure 15 shows, the case company should move from focused to continuous improvement through business-process innovation. In other words it should take a fresh look at its operational processes in general, which should be redesigned in a controlled manner, and continue the process after the implementation. As the case shows, automating part of a purchase process saves some resources at quite low cost. However, achieving savings through process innovation and continuous improvement would offer higher potential in terms of gaining competitive advantage and making savings. Automating processes that are no longer

valid is not a source of competitive advantage and therefore the automation should take place after their redesign, in the spirit of continuous improvement.

Given that the case company is not working in a vacuum, it should also take into consideration the total supply network in which it is acting. The automated purchase order system was facilitated by the fact that suppliers were holding stocks based on an agreement that enabled it to keep lower inventories than it otherwise could have done. It should be noted that these arrangements should be carefully reviewed, and the functioning of the total supply network and the different possibilities it offers should be fully understood. It is also important to be aware of the total cost of supply. The case company could save money if it allowed suppliers to hold safety stocks, but the cost of acquisition should be carefully analysed with a view to identifying feasible alternatives.

## 7.4 Future research areas

This research has brought new insight to the phenomenon of process automation and its effects on one key performance indicator from the perspective of one case company and two of its suppliers. It has confirmed that the implementation of a new supply-chain system does not necessarily improve the functioning of the supply chain. This opens up several interesting research opportunities that would enhance understanding of supply-chain processes.

The particularity of this research was the very deep focus on a set of items a change of purchase order process. The emphasis was on the process inside the case company. In this the research differs from studies on process change and IT-system implementation from an external perspective, of which there are several examples (e.g., Dehning et al., 2007; Bhatt and Trout, 2005). The results imply that purchase-order automation does not necessarily improve inventory turns to a significant extent. It should be noted that all cases are unique, and thus exact replication of the setting could be challenging. Indeed, it should be enough to find a similar setting or case dealing with the same phenomena.

One interesting avenue for further research would be to test purchase-order automation in different settings and with different basic parameters. The context of this study was the electronics industry and a manufacturing case company. The aspect of manufacturing is not emphasised because the study could have been conducted in many other environments. The focus was on the parameter setting and the effect of demand on inventory turn given the current setting.

This research was limited to one case, and it would be most interesting to see the same methodology applied to other cases in order to confirm or negate the results. There are industry-specific features that may limit the findings, and more instances are needed in order to form a larger picture of the phenomenon. Some

indication of the results was obtained through the interviews between purchase professionals. Previous studies have concentrated on superficial analysis of company performance indicators on the general scale, and more detailed research is called for.

There is also an interesting research opportunity in the area of human decision-making. Fransoo and Wiers (2008) discuss this issue in relation to production planners, and thus it would be useful to gather results from purchasing and sales, for example. The updating of basic information is important in the ERP/MRP environment, and it is recognised that this work is often neglected (Jonsson and Mattsson, 2006). The aspect of human decision-making and change resistance in process automation is an interesting topic, which was briefly touched on in this study. It would also be interesting to study the effects of demand forecasting and its transmission on the chain in terms of comparing automated communication with manual communication and its effects on availability.

Finally, given the focus in this research on one part of the supply chain and one buyer-supplier interface, the impact of process automation on the whole supply chain, or network, remains to be investigated in detail. The current results concern the case company, and the impact on the component distributor's inventories is unknown. The effect on the rest of the supply chain when one operator changes its demand behaviour remains to be seen.

# REFERENCES


Ahrens, T. - Chapman, C.S. (2006) Doing qualitative field research in management accounting: Positioning data to contribute to theory. *Accounting, Organization and Society* Vol.31, No.8, pp.819-841

Aizcorbe, A. (2006) Why did semiconductor price indexes fall so fast in the 1990's? A decomposition. *Economic Inquiry* Vol.44, No.3, pp.485-496

Al-Mashari, M. - Irani, Z. - Zairi, M. (2001) Business process reengineering: a survey of international experience. *Business Process Management Journal,* Vol.7, No.5, pp.437-455.

Arlbjorn, J.S. - Haldorsson, A. (2001) Logistics knowledge creation: reflections on content, context and processes. *International Journal of Physical Distribution & Logistics Management*. Vol.32 Issue 1/2, pp.22-40

Arthur, W.B. (1994) Inductive Reasoning and Bounded Rationality. *American Economic Review*. Vol.84 Issue 2, pp.406-411.

Avison, D. - Baskerville, R. - Myers, M. (2001) Controlling action research projects. *Information Technology & People* Vol.14, No.1, pp.28-45.

Baier, C. - Hartmann, E. - Moser, R. (2008) Strategic alignment and purchasing efficacy: an exploratory analysis of their impact on financial performance. *Journal of Supply Chain Management* Vol.44, No.4, pp.36-52.

Baily, P. - Farmer, D. - Jessop, D. - Jones, D. (2005) *Purchasing principles and management.* 9th edition, Pearson education limited, Harlow

Barrat, C. - Whitehead M. (2004) Buying for business – Insights in purchasing and supply management. John Wiley & Sons, Chichester.

Berg, B.L. (1995) Qualitative research methods for the social sciences, 2nd ed. Allyn & Bacon, A Simon & Schuster Company.

Berente, N. - Vandenbosch, B. - Aubert, B. (2009) Information flows and business process integration. Business Process Management Journal Vol.15, No.1, pp.119-141.

Berry, D. - Towill, D.R. - Wadsley, N. (1994) Supply Chain Management in the Electronics Products Industry. International Journal of Physical Distribution and Logistics Management Vol.24, No.10, pp.20-32.

Bhatnagar, R. - Teo, C-C. (2009) Role of logistics in enhancing competitive advantage – A value chain framework for global supply chains. Inter-

national Journal of Physical Distribution and Logistics Management Vol.39, No.3, pp.202-226.

Bilborough, C.A.M. - Dale, B.G. (1985) The Role and Influence of Factory Level Purchasing within a Corporate Structure. *International Journal of Physical Distribution and Materials Management* , Vol. 15, issue 1, pp. 39-48

Bowersox, D. J. - Closs, D. J. - Stank, T. P. (1999) *21st Century Logistics: making supply chain integration a reality*. Council of Logistics Management.

Buculescu, M-M. (2013) Harmonization process in defining small and medium-sized enterprises. Arguments for a quantitative definition versus a qualitative one. *Theoretical and Applied Economics*. Vol.20, No.9, pp.103-114

Burgess, R. (1998) Avoiding Supply Chain Management Failure: Lessons from Business Process Re-engineering. *The International Journal of Logistics Management.* Vol.9, No.1, pp.15-23.

Cai, J. - Liu, X. - Xiao, Z. - Liu, J.(2009), "Improving supply chain performance management: A systematic approach to analysing iterative KPI accomplishment" *Decision Support Systems* 46, pp. 512-521.

Carter, C.R. - Kaufmann, L. - Michel, A. (2007) Behavioural supply management: a taxonomy of judgement and decision making biases.

Chen, I.J. (2001) Planning for ERP systems: analysis and future trends. *Business Process Management Journal*, Vol.7, No.5, pp.374-386.

Chiang, S. (2001) Asia: the growth engine for the world electronics industry over the next 20 years. *Circuit World*. 27/4, pp.26-30

Chong, A.Y. - Ooi, K. (2008) Adoption of interorganisational system standards in supply chains – An empirical analysis of RosettaNet standards. *Industrial Management & Data Systems* Vol.108, No.4, pp.529-547

Chopra, S. - Meindl, P. (2007) *Supply chain management – strategy, planning and operation.* 3rd edition. Pearson Education Inc. Upper Saddle River, New Jersey

Colton, R. R. - Rohrs, W. F. (1985) *Industrial Purchasing and Effective Materials Management*. Reston Publishing Company Inc. Reston.

Corey, E. R. (1978) *Procurement Management – Strategy, organization, and decision-making* CBI Publishing Company.

Coughlan, P. - Coghlan, D. (2002) Action research for operations management. *International Journal of Operations & Production Management*. Vol.22, No.2, pp.220-240.

Coyle, J. J. - Bardi, E. J. - Langley, C. J. Jr. (1996) *The Management of Business Logistics.* 6th edition, West Publishing Company.

Cox, A. (1999) Power, value and supply chain management. *Supply Chain Management: An International Journal* Vol.4, No.4, pp.167-175.

Craighead, C.W. - Meredith, J. (2008) Operations management research: evolution and alternative future paths. *International Journal of Operations and Production Management* Vol.28, No.8, pp.710-726.

Creswell, J. (1994) Research Design – Qualitative and Quantitative Approaches. Sage Publications.

Davenport, T.H. - Short, J. (1990) The new industrial engineering: information technology and business process redesign. *Sloan Management Review* 31, pp.11-27.

Davenport, T.H. (1993) Need Radical Innovation and Continuous Improvement? Integrate Process Reengineering and TQM. *Planning Review* May/June 1993; Vol.21, No.3, pp. 6-12

Davenport, T.H. - Brooks, J.D. (2004) Enterprise systems and supply chain. *Journal of Enterprise Information Management* Vol.17, No.1, pp.8-19.

Davenport, T.H. - Harris, J.G. - Cantrell, S. Enterprise systems and ongoing process change. *Business Process Management Journal*, Vol.10, No.1, pp.16-26.

Dehning, B. - Richardson, V.J. - Zmud, R.W. (2007) The financial performance effects of IT-based supply chain management systems in manufacturing firms. *Journal of Operations Management* Vol.25, No.4, pp.806-824.

Den Boer, A. A.A. (1994) Decision support for material planners. *Production Planning & Control*, Vol.5, No.3, pp.253-257.

Denzin, N.K. - Lincoln, Y.S. (1994) *Handbook of Qualitative research*. Sage Publications.

Dobler, D. W. - Burt, D. N. (1996) *Purchasing and Supply Management – Text and Cases* 6th edition. McGraw – Hill.

Einhorn, H.J. (1982) Learning from experience and suboptimal rules in decision making. In Kahnemann, D.; Slovic, P. and Tversky, A. (eds.) *Judgment under uncertainty: Heuristics and biases*. Cambridge University Press, Cambridge.

Einhorn, H.J. - Hogarth, R.M. (1986) Decision Making under Ambiguity. *Journal of Business* Vol.59, No.4, pp.225-249.

Eisenhardt, K.M. (1989) Building Theories from Case Study Research. *Academy of Management Review.* Vol.14, No.4, pp.532-550

Ellram, L.M. - Cousins, P. (2007) Supply Management in Mentzer, J.T. - Myers, M.B. - Stank, T.P. (eds.) *Handbook of Global Supply Chain Management*. Sage Publications Inc.

Evered, R. - Louis, M.R. (1981) Alternative Perspectives in the Organisational Sciences: “Inquiry from the Inside” and “Inquiry from the Outside”. *Academy of Management Review* No. 3

Fill, C. - Fill, K. E. (2005) *Business to business Marketing – Relationships, Systems and Communications.* Pearsons Eduction Limited, Harlow

Fulcher, J. (2005) Don’t let confusion over competing standards derail your e-business strategy. *Manufacturing Business Technology* Vol.23 Issue 6, pp.46-47

Fransoo, J. C. - Wiers, V.C.S. (2008) An empirical investigation of the neglect of MRP information by production planners. *Production Planning & Control,* Vol.19, No.8, pp.781-787

Fuller, J.A. - Mansour, A.H. (2003) Operations management and operations research: a historical and relational perspective. *Management Decision* Vol.41, No.4, pp.422-426.

Gonzalez-Benito, J. (2007) A theory of purchasing’s contribution to business performance. *Journal of Operations Management* Vol.25, No.4, pp.901-917.

Gourdin, K. N. (2001) *Global logistics management – a competitive advantage for the new millennium.* Blackwell Publishers Ltd, Oxford.

Guba, E.G. - Lincoln, Y.S. (1994) Competing Paradigms in Qualitative Research in Denzin, N.K. - Lincoln, Y.S. *Handbook of Qualitative Research*. Sage Publications.

Gummesson, E. (1991) *Qualitative methods in management research*. Revised edition, Sage, Thousand Oaks, CA.

Gummesson, E. (2007) Case study research and network theory: birds of a feather. *Qualitative Research in Organisations and Management: An International Journal*. Vol.2 No.3, 2007 pp. 226-248.

Halldorsson, J. - Aastrup, J. (2003) Quality criteria for qualitative inquiries in logistics. *European Journal of Operational Research* Vol.144, No.2, pp.321-332

Hansen, J.M. (2009) The evolution of buyer-supplier relationships: an historical industry approach. *Journal of Business & Industrial Marketing*. Vol.24, No.3/4, pp.227-236.

Hendricks, K.B. - Singhal, V.R. - Stratman, J.K. (2007) The impact of enterprise systems on corporate performance: A study of ERP, SCM, and CRM system implementations. *Journal of Operations Management* Vol.25, No.1, pp.65-82.

Henfrey, N. - Scharff, R.C. - Lee-Warden, C. (2008) Adviser Q+A – The key to peak performance – What are the best key performance indicators (KPIs) for a purchasing and logistics executive? *Supply management* Vol.13, No.9, pg. 19.

Hill, J. - McGowan, P. (1999) Small business and enterprise development: questions about research methodology. *International Journal of Entrepreneurial Behaviour & Research* Vol.5, No.1, pp.5-18.

Hogarth, R.M. (1980) *Judgement and Choice – The Psychology of Decision*. John Wiley & Sons, Ltd.

Huxham, C. - Vangen, S. (2003) Researching Organisational Practice Through Action Research: Case Studies and Design Choices. *Organisational Research Methods* Vol.6, No.3, pp.383-403

Janesick, V.J. (1994) The Dance of Qualitative Research Design – Metaphor, Methodolatry and Meaning in Denzin, N.K. and Lincoln, Y.S. (Eds.) *Handbook of Qualitative Research*. Sage Publications

Janis, I.L. - Mann, L. (1977) *Decision Making – A Psychological Analysis of Conflict, Choice, and Commitment.* The Free Press, New York.

Jick, T.D. (1979) Mixing Qualitative and Quantitative Methods: Triangulation in Action *Administrative Science Quarterly* Vol.24, No.4, pp.602-611

Jorgensen, B. (2004) The state of the industry – Distributors must continue to change to meet market challenges. *Electronic Business* May 2004, 30, 5, pg.44

Kannan, V.R. - Kan, K.C. (2006) Buyer-supplier relationships – The impact of supplier selection and buyer-supplier engagement on relationship and firm performance. *International Journal of Physical Distribution & Logistics Management* Vol.36, No.10, pp.755-775.

Kates, S.M. - Robertson, J. (2004) Adapting action research to marketing – A dialogic argument between theory and practice. *European Journal of Marketing* Vol.38, No.3/4, pp.418-432.

Kettinger, W.J. - Grover, V. (1995) Toward a Theory of Business Process Change Management. *Journal of Management Information Systems* Summer 1995, Vol.12, No.1, pp.9-30.

Kotler, Philip (2003) *Marketing management*. 11th edition, Pearson Education Inc., Upper Saddle River, New Jersey.

Kozmetsky, G. - Yue, P. (1998) Comparative Performance of Global Semiconductor Companies. *Omega, International Journal of Management Science.* Vol.26, No.2, pp.153-175

Kraljic, P. (1983) Purchasing must become supply management *Harward Business Review* (61:5) pp. 109-117.

Kuhn, T.S. (1996) *The Structure of Scientific Revolutions*, 3rd ed. The University of Chicago Press.

Kumar, S. - Meade, D. (2002) Has MRP run its course? A review of contemporary developments in planning systems. *Industrial Management & Data Systems* Vol.102, No.8, pp.453-462.

Laudon, K. C. - Laudon, J. P. (2002) *Management Information systems – managing the digital firm*. 7th edition, Prentice-Hall International Inc., Upper Saddle River, New Jersey

Levine, B. (1998) Distributors face a changing world. *Electronic News* Vol.44, Issue 2217, p.58.

Lewin, K. (1946) Action research and minority problems. Reprinted in Lewin G.W. (ed.) (1948) *Resolving social conflicts: Selected papers on group dynamics by Kurt Lewin.* New York: Harper and Brothers, p. 201-216

Lukka, K. (2005) Approaches to case research in management accounting: The nature of empirical intervention and theory linkage. In Jönsson, S. and Mouritsen, J. (eds) *Accounting in Scandinavia – The Northern Lights*. Liber & Copenhagen Business School Press, 2005, p.375-399.

Malhotra, A. - Gosain, S. - El Savy, O.A. (2005) Absorptive Capacity Configurations in Supply Chains: Gearing for Partner-Enabled Market Knowledge Creation. *MIS Quarterly* Vol.29, No.1, pp.145-187.

McKay, J. - Marshall, P. (2001) The dual imperatives of action research. *Information Technology & People* Vol.14, No.1, pp.46-59.

Mentzer, J.T. - Stank, T.P. - Esper, T.L. (2008) Supply chain management and its relationship to logistics, marketing, production, and operations management. *Journal of Business Logistics* Vol.29, No.1, pp.31-46.

Mills, J. - Schmitz, J. - Frizelle, G. (2004) A strategic review of "supply networks". *International Journal of Operations & Production Management* Vol.24, No.10, pp.1012-1036.

Näslund, D. (2002) Logistics needs qualitative research – especially action research. *International Journal of Physical Distribution & Logistics Management* Vol.32, No.5, pp.321-338.

Olley, G.S. - Pakes, A. (1996) The dynamics of productivity in the telecommunications equipment industry. *Econometrica*. Vol.64, No.6, pp.1263-1297.

Olson, E.G. - Sharma, D. (2008) Beating the commoditization trend: a framework from the electronics industry. *Journal of Business Strategy*. Vol.29, No.4, pp.22-28.

Orlicky, J. (1975) *Material Requirements Planning – The New Way of Life in Production and Inventory Management* McGraw-Hill Inc.

Osteryoung, J.S. - Newman, D. (1993) What is a Small Business? *The Journal of Small Business Finance*. Vol.2, No.3, pp.219-231

Perry, C. (1998) Processes of a case study methodology for postgraduate research in marketing. *European Journal of Marketing* Vol.32, No.9/10, p.785-802.

Perry, C. - Gummesson, E. (2004) Action research in marketing. *European Journal of Marketing* Vol.38, No.3/4, pp.310-320.

Petroni, A. (2002) Critical factors of MRP implementation in small and medium-sized firms. *International Journal of Operations & Production Management* Vol.22, No.3, pp.329-348.

Piekkari, R. - Welch, C. - Paavilainen, E. (2009) The Case Study as Disciplinary Convention – Evidence From International Business Journals. *Organizational Research Methods*. Vol.12 No.3, pp.567-589.

Porter, M. (1990) *The Competitive Advantage of Nations.* The Macmillan Press Ltd., London.

Potocan, V. (2009) Does Trust influence Supply Chain Management? *The Journal of American Academy of Business, Cambridge* Vol.15, No.1, pp.118-124.

Rabinovich, E. - Dresner, M.E. - Evers, P.T. (2003) Assessing the effects of operational processes and information systems on inventory performance. *Journal of Operations Management* Vol.21, No.1, pp.63-80.

Rantala L. - Hilmola, O-P (2010) Analysis of two different automated purchase order systems in telecom electronics manufacturing unit. Accepted for publication in *International Journal of Manufacturing Technology and Management* .

Rasiah, R (2009) Expansion and slowdown in Southeast Asian electronics manufacturing. *Journal of the Asia Pacific Economy* Vol.14, No.2, pp.123-137.

Sahin, F. - Robinson Jr., E.P. (2007) Inventory Management in Mentzer, J.T. - Myers, M.B. - Stank, T.P. (eds.) *Handbook of Global Supply Chain Management*. Sage Publications.

Salih, K. - Young, M.L. - Rasiah, R. (1988) The changing face of the electronics industry in the periphery: the case of Malaysia. *International Journal of Urban & Regional Research*. Vol.12, Issue 3, pp. 375-403.

Samaranayake, P. (2009) Business process integration, automation, and optimisation in ERP – Integrated approach using enhanced process models in *Business Process Management Journal*, Vol.15, No.4, pp.504-526.

Samaranayake, P. (2005) A conceptual framework for supply chain management: a structural integration. *Supply Chain Management: An International Journal* Vol.10, No.1, pp.47-59.

Schary, P. B. - Skjott-Larsen, T. (2001) *Managing the Global Supply Chain* 2nd Ed. Copenhagen Business School Press.

Scheuing, E. E. (1989) *Purchasing management* Prentice-Hall International.

Seuring, S.A. (2008) Assessing the rigor of case study research in supply chain management. *Supply Chain Management: An International Journal*. Vol.13, No.2, pp.128-137

Shook, C.L. - Adams, G.L. - Ketchen, D.J.Jr - Craighead, C.W. (2009) Towards a “theoretical toolbox” for strategic sourcing. *Supply Chain Management: An International Journal* Vol.14, No.1, pp.3-10.

Shunk, D.L. - Carter, J.R. - Hovis, J. - Talwar, A. (2007) Electronics industry drivers of intermediation and disintermediation. *International Journal of Physical Distribution and Logistics Management* Vol.37, No.3, pp.248-261.

Simon, H.A. (1986) Rationality in Psychology and Economics. *Journal of Business* Vol.59, No.4, pp.209-224.

Smeltzer, L.R. (1997) The Meaning and Origin of Trust in Buyer-Supplier Relationships. *International Journal of Purchasing and Materials Management* Winter 1997.

Snider, B. - da Silveira, G.J.C. - Balakrishnan, J. (2009) ERP implementation at SMEs: analysis of five Canadian cases. *International Journal of Operations & Production Management* Vol.29, No.1, pp.4-29.

Sobh, R. - Perry C. (2006) Research design and data analysis in realism research. *European Journal of Marketing* Vol. 40, No.11/12, pp. 1194-1206.

Soosay, C.A. - Chapman, R.L. (2006) An Empirical Investigation of Performance Measurement for Managing Continuous Innovation in Logistics. *Knowledge and Process Management* Vol. 13, No.3, pp.192-205.

Tassabehji, R. - Moorhouse, A. (2008) The changing role of procurement: Developing professional effectiveness. *Journal of Purchasing and Supply Management* Vol.14, No.1, pp.55-68.

Trautmann, G. - Turkulainen, V. - Hartmann, E. - Bals, L. (2009) Integration in the global sourcing organisation – An information processing perspective. *Journal of Supply Chain Management* Vol.45, No.2, pp.57-74.

Van Hoek, R. - Ellinger, A.E. - Johnson, M. (2008) Great divides: internal alignments between logistics and peer functions. *The International Journal of Logistics Management* Vol.19, No.2, pp.110-129.

Voss, C. - Tsikriktsis, N. - Frohlich, M. (2002). Case research in operations management. *International Journal of Operations & Production Management* Vol.22 No.2, pp.195-219.

Waters, D. (2003) *Logistics – An introduction to Supply Chain Management.* Palgrave Macmillan, New York

Westbrook, R. (1995) Action research: a new paradigm for research in production and operations management. *International Journal of Operations & Production Management* Vol.15, No.12, pp.6-20.

Wood, T. - Caldas, M.P. (2001) Reductionism and complex thinking during ERP implementations. *Business Process Management Journa*l, Vol.7, No.5, pp.387-393.

Xu, H. - Koh, L. - Parker, D (2009) Business processes inter-operation for supply network co-ordination. *International Journal of Production Economics*, Vol.122, Issue 1, pp.188-199.

Zheng, J. - Knight, L. - Harland, C. - Humby, S. - James, K. (2007) An analysis of research into the future of purchasing and supply management. *Journal of Purchasing and Supply Management* Vol.13, No.1, pp.69-83.

Yin, R.K. (1981) The Case Study Crisis: Some Answers. *Administrative Science Quarterly.* Volume 26, March 1981.

Yin, R.K. (2003) Case study research – Design and Methods. 3rd Edition, Applied Social Research Methods Series, Vol.5, Sage Publications.

Zuber-Skerritt, O. - Perry, C. (2002) Action research within organisations and university thesis writing. *The Learning Organisation* Vol.9, No.4, pp.171-179.

**Article III** **Rantala, L.; Hilmola, O-P. (2007) Inventory turns changes and sophistication of automation in purchase order systems. Peer-rewieved and accepted for to be presented in annual NOFOMA conference 2007, Reykjavik, Iceland.**

# Inventory Turns Changes and Sophistication of Automation in Purchase Order Systems

**Lauri Rantala***

**Olli-Pekka Hilmola****

*) Logistics, Department of Marketing, Turku School of Economics, Rehtorinpellonkatu 3, 20500, Turku, Finland
E-mail: lauri.rantala@tse.fi, Tel: +358 40 5535 206; Fax: + 358 2 2441 420

**) Department of Industrial Engineering and Management, Lappeenranta University of Technology, Kouvola Research Unit, Prikaatintie 9, FIN-45100 Kouvola, Finland
E-mail: olli-pekka.hilmola@lut.fi; Fax: +358 5 344 409

## ABSTRACT

MRP systems were implemented three decades ago to schedule production and increase efficiency in intra-organizational perspective. But mostly improvements were intended to be gained from purchasing, since net requirement calculations could produce purchase orders automatically for further manual processing. Situation has not dramatically changed, as ERP systems were introduced during 90's; most interfaces between organizations should be integrated in order to achieve 'once typed data' objective (integration). The aim of this has been to integrate inter-company relationships to follow the same logic as intra-company relationships. Anyhow in inter-company relationships there are traditionally stronger needs to sub-optimize the performance of different partners than in intra-company relationships. This work presents an analysis of two automated purchase order systems together with a manual purchase order system data using multiyear observation period from medium-sized telecom electronics manufacturer and compares the performance of these systems. The focus in this research is to investigate, does automation generally have an effect on inventory turns change, and how the level of sophistication in automated systems affect on these results. Our research results indicate that both automated systems perform significantly better than manual counterparts. However, regression analysis argues that automation is not the reason for this, but consumption changes, inventory level changes and in some cases prices of the components that have impact on inventory turn change. Thus, automated systems use standardized procedures for ordering, which in the end enable to take into account these root issues of inventory turn improvement.

*Key Words:* *Purchasing, level of automation, supply chains, inventory levels, MRP.*

## 1. Introduction

Modern logistics and supply chain management requires huge databases; for example, in the end of 90's Walmart had an information exchange capacity of 24 terabytes, being the second largest in the USA (after the government, see Cooper & Tracey 2005). Similarly Korovyakovsky (2006) reports Russian railways to have 10 terabytes storing capacity in their IT system. It is not surprising that global market place with merger and acquisition waves have created so vast need for Enterprise Resource Planning (ERP) and database solutions (e.g. Application Service Providers). For example, huge information technology (IT) companies such as Oracle and SAP were non-existent several decades ago. Increased competition, or even hyper competition, in global markets has enforced companies to automate their administration procedures with 'once typed philosophy' (intra-company IT integration, consisting multiple locations, possibly in different continents; Gulledge 2006). However, further improvements in cost efficiency, inventory reduction and responsiveness are in most of the cases built through inter-organizational IT system integration initiatives and implementations (Tarn et al. 2002; Neubert, Ouzrout & Bouras 2004; Helo & Szekely 2005).

Inter-organisational relationship have been under discussion for a while and it has somewhat changed the view of industrial economics. Especially in industrial marketing, the buyer supplier relationships have been under investigation (e.g. Håkansson 1982), although industrial markets may resemble to the consumer market (Howard 1989). One way of describing the difference in behaviour is the transaction cost approach (Williamson 1985); in industrial settings transaction costs from abandoning supplier and taking new one in might be very costly due to initial cost of learning. Therefore buyer-seller interdependency leads to source loyalty and to stability in industrial marketing exchanges (Howard 1989). So, due to the fact that industrial relations are more stable than consumer relations, there is also the aim for increasing the cost efficiency attained in rationalising the daily routine transactions between the parties. The most common transactions are of course related to buying and selling transactions (Hill 2005), where IT has increasing role. EDI (electronic data interchange) has been one application and source for several studies on its impact on supply chain (e.g. Walton & Gupta 1999; Leonard & Davis 2006; Machuca & Barajas 2003).

Until today, we have not identified case study research reports regarding to comparison of automated, semi-automated and manual purchase order systems, which are vital part of productivity improvement, especially in fast changing and high clock speed industries (e.g. electronics). However, automated purchasing is relevant further avenue in this industry, since responsiveness and time based management strategies have been identified as key factors of profitability (Papadakis 2003 & 2006; Appelqvist & Gubi 2005; Helo 2004). Automation of purchasing orders is important topic in electronics (Rantala & Hilmola 2005), since product variety is vast and volume spikes rapid, and eventually outsourcing is being used in great extent, not only in soldering, placement of components and assembly work, but as well as in wafer fabrication of integrated circuits (Lu, Hung & Yang 2004). Additional dynamics in this sector is being created by price erosion of purchased components; Grimm (1998) estimates that memory chips have yearly lost 20 % from sales price in time period of 1985-1996, while microprocessors have faced more severe yearly decline of 35 %. However, most often it is forgotten that small and medium-sized manufacturers have longer life cycles in their products, and the end of life cycle component purchasing is therefore relatively problematic. Constant yearly declines could change rapidly into hefty increases (price development reminds frequently much like a "bathtub" –type of curve); this gives high requirements for

management to follow price recovery of different products in short intervals of time (e.g. Rao & Miller 2004; Rao 2006).

This research bases its findings on the case study of medium sized telecom electronics manufacturer, which automated its purchasing in the early 2002. We base our research on Yin's (1991 & 1993) case research methodology, since one of the authors of this paper was part of the implementation team, and it therefore fulfils triangulation requirements (using multiple source of evidence, and intuition, e.g. Eisenhard 1989), although it is being reported using quantitative data. Our research is 'explorative' (as suggested by Yin 1991) in the sense that the purchasing method is new; and is forming a single case study using induction (from data to theory, please see Hilmola, Hejazi & Ojala 2005). It basically tries to generate modification and justification for inventory management theories with respect of automated purchase orders. It should be noted that implementation could not be repeated in research laboratory, since the automation did not only consist internal operations, but database interface to distributor was also automated, and eventually ERP net requirement logic triggers orders in some of the selected components. Also availability of components and other issues of operations management affect greatly results. In a case of semi-automated purchase orders also behavioural (e.g. opportunistic or sub-optimization) issues have implications on automation results. As we show in this paper, this change also required significant changes inside of the manufacturer (developing standard algorithms for component purchasing parameter estimation), but also externally from suppliers (using e.g. the buffering services of distributor more widely). Our research is only limited in one case study, but embedded (multiple units of analysis) analysis instead of holistic (single unit of analysis) increases generalization. However, it should be reminded that in operations management single case studies are most frequently used (Hilmola & Häkkinen 2005). We are interested to answer following research questions with our work: (1) Do automated purchasing systems improve inventory turns? (2) Do different levels of automation in supply chain affect inventory turns change? and (3) Does expensive components behave differently in terms of inventory turns during the automated period than less expensive ones?

This paper is structured as follows: In the following Section 2 we will introduce different purchasing processes in ERP environment, and also briefly discuss about integration issues, lot sizing, and other technical matters of ERP/MRP (material requirements planning) based purchasing. In Section 3 is represented research environment, medium sized telecom electronics manufacturer and its two distributors. It is evident that electronics purchasing is demanding issue due to several factors (shortening life-cycles, outsourcing activity as well as increased complexity, used product platforms etc.), and medium sized Original Equipment Manufacturers (OEM) need to use distributors, which have diverse service portfolios for their customers. Empirical data analysis is completed in Section 4, where two different automated systems are analyzed together with manual purchasing, and results of purchasing automation for inventory efficiency are discussed in Section 5. In the final Section 6 we will conclude our research work and provide avenues for further research.

## 2. Purchasing Processes in ERP – Manual, Semi-Automated and Fully Automated Systems

Generally research has agreed that information technology improves purchasing performance (e.g. Hemsworth et al. 2005), but research rarely discusses about inter-organizational issues of purchasing, and mostly interest has been on the lot sizing, quantity discounts, and limited planning horizon (Bergman 1991; Hu & Munson 2002; Yenisey 2006). However, rarely

research has discussed about the information system integration in purchasing, between (OEM) and its suppliers. Based on the literature, integration of (Helo & Szekely 2005; Gulledge 2006) different computer system could be completed, e.g. with hub-and-spoke technique (Enterprise Application Integration) or more traditional database-to-database integration method. The latter mentioned is most often completed in real-life with separate files, which are produced from one system, and sent to another, and structures, items and other technical issues are standardized in this file to enable communication between organizations.

## 2.1. Manual Purchasing Process in MRP/ERP

Manual purchasing process is a typical procedure of inter-organization database utilization, where requirements are gathered from information system through Material Requirements Planning purchasing netting calculations. This requirement creation is one of the basic MRP processes, and is widely reported in the course books of production and operations management (Tersine 1985; Plossol 1994; Vollman et al. 1997; Ptak 2000). When net requirements are created, they are then summarised and combined to purchase orders by using different combination criteria: buyer, supplier, commodity type etc. Basically main drivers in calculations are end-item demand, inventory positions and bill of materials. In normal situation purchase requisitions are used as tools for buyers to make purchase decisions on a daily basis. Individual requisitions may also be combined manually into a different configuration that was initially made by MRP. System parameters are also often set manually and on more or less random way (or with Economic Order Quantity based logic). Adjustment of the parameters might be made on a daily bases to answer the current needs.

When purchase order has been created, it will be communicated to a supplier with such different means as attachment file of e-mail (like PDF file) or fax. Sometimes even ordinary postal services are used. This purchase order is then received by a supplier sales contact (or directly to warehouse) and communicated to the organisation through a mean. If the supplier has an ERP system, purchase order is opened as sales order and, in case of use of an MRP; it will then be processed as a requirement further in the upstream of a supply network. Purchasing information is in this case hand typed from purchase order to another database. This manual process is depending on the speed of the mean transmitting the purchase order and also the workload of sales personnel.

In case of a distributor, the sales order is addressed to the warehouse as picking job. Job is then picked at requested time and then delivered and invoiced manually or automatically. At supplier side the order is received often against the purchase order. This receiving will then settle the original requirement created by MRP.

In manual purchasing process of MRP, number of different people are involved in the order process, and quite often initial order from OEM is not the final one. For example, in case of inventory shortage, supplier might negotiate with OEM that initial order should be decreased, or then some amount from delivery is on the backorder. However, more typical is the situation that supplied tries to “sell” entire inventory from warehouse or larger economic production lot, and therefore discounts for OEM are given in the hope of larger order. It is not uncommon to find out that OEMs own purchasing department does not see the value of smaller orders, and they manually double or triple net requirements to save their working time.

## 2.2. Semi-Automated Purchasing Process in MRP/ERP

Semi-automated purchasing is a mode of supply-delivery chain including some automated components of the same purchase order process described earlier. As in the manual process,

individual requirements are created and possibly combined in MRP, if combination setup is used. Based on those requirements created by MRP, the system is creating a purchase order with preset parameters that include the purchase order form, supplier, order frequency etc. This order is then sent through (directly after net requirement calculations) an electronic mean to supplier (no human intervention). Normally, sales order is then created in ERP as in the case of manual purchase order and transmitted to the supplier by MRP requirements. So, name of semi-automated purchasing becomes in this case from non-automated side of the supplier organization. This enables similar order negotiation culture between OEM and supplier, which is the case in the manual purchase orders of MRP. Occasionally automated purchase order is completed several times, since every now and then supplier makes a counter offer, which OEM can't refuse to utilize.

### 2.3. Fully Automated Purchasing Process in MRP/ERP

In fully automated purchase order process, MRP is creating purchase requisitions via net requirements calculations as in the previous cases. Requirements are then combined automatically to purchase orders and transferred by an electronic mean to supplier, usually with separate file. Supplier treats this file with own information system, converting order information into its database, or in some cases special middleware programs complete this task. After data transfer, supplier's ERP system converts completed purchase order as a sales order. Requirements of that sales order are communicated as picking requisitions to the warehouse. Order is shipped together with the invoice to the customer, and received against the automatically created purchase order.

Fully automated order enables the full use of "economic order quantities" and its derivatives, since supplier does no longer have negotiation power against OEM. In some cases, warehousing operations are in these cases often automated, since orders could be given directly into automated warehouse systems. Only downside in this system is the inventory availability; sometimes supplier's automated system is not capable to deliver needed amounts, and these are discovered as parcels reach OEM warehouse/manufacturing unit. There exist some research works, which are reporting results entirely against of automated purchasing, e.g. Leonard & Cronan (2005) argued, based on the large empirical data analysis from company level, that electronic supply chain solutions do not yield better price or availability.

### 2.4. Research Hypotheses

Based on the understanding presented in the above subsections, as well as inventory theory (models of economic order quantity, Harris 1913) we have developed following research hypotheses:

**Hypothesis 1**: Purchasing automation enables inventory turn improvement regarding purchased component inventory.

**Hypothesis 2**: Level of automation has an effect on inventory turn improvement.

**Hypothesis 3**: Expensive components have higher inventory turns.

These hypotheses have as key component inventory turn improvement that is one of the key performance indicators in inventory management (e.g. Scheuing 1999).

## 3. Research Environment

### 3.1. Techco

Techco is a medium sized company focusing on product development and manufacturing of communications network equipment. Most of the main competitors are larger than Techco, and business is in general geographically shared in equal parts among different companies (e.g. U.S companies dominate in Americas, while European market is shared among far smaller local companies).

Techco has two different business areas, which are partly using the same technology, but targeting to different customer segments. Product development plays very important part, but lately logistics/supply chain functions have increased their importance, mostly through sourcing and procurement functions. Techco has an integrated ERP system used in most parts of the operative functions. Thus, the high rate of configurability of the products has increased the need for accurate information and requirements set. The item library of ERP database contains thousands of items, including approximately 6000 active material items (purchased components), 300 modules (semi-finished items) and 2000 active end-product items. To the active product range should also be added customized products, which are being built through the use of modular product platforms and software; this practice offers millions of different possible product alternatives. In the recent years the competition has intensified, and therefore new product development has been used to generate new products for existing customers, and also reaching new market segments. However, this development has made the life of purchasing more complex, since the amount of active items has increased significantly. Techco has tried to manage this undesired situation with the use of modularity and platforms, but this has only been partial solution for the arising problem.

### 3.2. Component Distributors – Distri I and Distri II

Electronics distributors Distri I and II have emphasis to offer services all around the world, and represent wide range of electronic component manufacturers. In many cases both of the two distributors offer components from same manufacturers. As the most of global distributors, like Techco's Distri I and II, offer technical support, warehousing and other logistics solutions. Those are the main competitive advantages they own. Normally the margins in distribution business itself are quite low and profits are needed to be created from other value added services (e.g. component buffering for number of different customers using same item, resulting on lower supply chain inventories due to demand pooling; theoretical justification please see Zin et al. 1989, Das & Tyagi 1999). Distributors have centralised distribution warehouses serving their respective areas in the world.

Both Distri I and II are specialised in offering a wide range of components to a large customer base in differing order volumes. Their IT systems have generally been designed to support multiple customer-manufacturer item libraries. Quite often central question in OEM-distributor relationship is the used part numbering system; OEMs frequently use own coding system, while distributor favours the codes used by component manufacturer. Both Distri I and II have an ERP-system made in-house for the needs of the company. For the customer the system is shown as integrating sales, operations and finance. The most important feature for a customer is automated processes and ability to receive simple forms of information through electronic means. These include reception of order with confirmation of reception, order confirmation, automated warehouse functions with order pick-up and delivery notice with freight forwarder's tracking number. However, it should be reminded that level of sophistication and automation is different between these two distributors: Distri I has an integrated ERP with fully automated process. Thus, Distri II has resolved the purchase order

reception and confirmation with a manual process. Automatically released and sent purchase orders are sent to supplier as in fully automated process. The difference is that purchase order is received manually and transformed to a sales order in the ERP system (semi-automated). At this same moment, some adjustments might be made concerning minimum order quantities.

### 3.3. Determining Parameters for Automated Purchase Order (APO) Processing

Automated order processing was established between Techco and Distri I in spring 2002. The two partners have contracted buffer stocks at Distri I's warehouse for Techco's needs. Techco is issuing forecasted information to adjust buffer stocks at Distri I's site. This has been seen a way to improve availability of supplied items (Kaipia et al. 2006). Before year 2002 orders were made manually to Techco's ERP system and sent over to national sales representative, who entered the order into Distri I's system to be delivered from regional warehouse by express airfreight. The orders were passed over to supplier in a random matter depending on the urgency of the lines needed. Each component was having individually defined safety stocks and minimum order quantities.

In the case of Distri II, automated purchase orders were initiated in the beginning of 2003, almost a year after automation of Distri I orders. This was due to two reasons: there were doubts in Techco organisation about the functionalities and security of automated purchase orders. Also Techco was willing to see the function of all parameters set to Distri I automated purchase order. Distri II had a similar gateway to offer than Distri I for purchase orders to enter but they did not authorise the purchase orders to be automatically converted into sales orders and added to the sales order stock. Therefore purchase orders were received by the system and then transmitted in a special view to sales assistants' attention. Then purchase orders were manually converted to sales orders by sales assistants. For forecasts the situation is the same with Distri II. Forecasts are transferred electronically to Distri II, but they are then analysed and released to the ERP manually.

The relationship between Techco and Distri II was also a bit different compared to the relationship between Techco and Distri I. Distri I requested Techco to sign contracts over buffered quantities and Techco was requested to clear all excess at the end of each contract period that was normally set to one calendar year. With Distri II the situation was somewhat different. They were much more flexible in buffer setting and allowed greater liberty in keeping extra inventory to their customers. This is also why in data of Distri II no such peaks were registered than at Distri I that was related to buffer stock clearance.

When designing automated purchase orders, the following decisions were made on item parameters:

- Lead time for components is set to be 5 working days
- Minimum order quantity (MOQ) is the manufacturer package size and its coefficients
- Safety stock for parts is 20 days demand, estimated based on 6 months' historical demand
- Period of supply (POS) for needs is 15 work days (ERP 'batches' future 15 days needs into one purchase requisition)

The lead-time for components has been set to five workdays for the reason that deliveries from suppliers are made once a week and the delivery time is more or less from 24 hours to 5 working days. Maximum delivery lead-time is used in the system due to reason that deviations in order fulfilment could in this way be hedged. The standardisation was important not only

for requisitions of the system, but also to gather information on automated purchase orders in general.

## 4. Empirical Data Analysis

Empirical data was gathered from Techco's ERP-system consisting four years time period. The time period was slightly different to every component. The investigation period starts from year 2000 and ends at mid 2004. Automated purchase order system was implemented in March 2002 for Distri I and in January 2003 for Distri II.

Most of the purchased items for Distri I have nearly equal amount of observation points before and after system implementation. However, in some of the cases before implementation data was incomplete, and observation period therefore begins from some other early months of the year 2000. So, it could be concluded that for all Distri I items automated purchase order observation period is 22 months, while manual period varies from 19 to 26 months.

For Distri II the situation is somewhat different. Manual observation period is approximately 30 months. The absolute number of months depends on item and the period starts either from the beginning of January 2000 or from January 2001. For all items it ends when purchasing was automated in January 2003. The automated period is then shorter than manual period. Automated period is 16 months for all items. For some items there were no transactions on the 16th month that is affecting the results on three items out of eighteen.

In addition to automated purchase order data, some manual purchase order data on component level was collected. This manual sample consists of 56 similar items that were used in automated samples. They are sourced from different component distributors including Distri I and Distri II. This data has been analysed with same parameters than automated samples. Two sets of indicators were calculated to conform to the periods in two automated cases. In this paper both automated samples are analysed together with their respective manual data set. Manual data includes as mentioned previously 56 items with similar time frame as automated items. The period for items in average is 50 months with minimum value of 39 months and maximum of 53 months. To better determine the data set, median was calculated over the individual periods with result of 52 months as median. This shows us that most of the items are having a period of 50 months or over.

Data contains information about received orders and used items. Received order information contains data about received quantity and date of reception. With this information it is possible to calculate average orders size and amount of received components per month. Consumption information is represented by the amount of used components by production. Because some items are used by packages, consumption information is on a rough level. Item consumption is therefore measured only on monthly level.

Based on this information we have compared the inventory turns for different items on a basis of a moving average. This means that for each component, a moving average was calculated so that the first value was calculated 12 months after the first observation for manual and for automated period. This means that the total number of observations was: number of observation months – 22 (11 for both periods).

### 4.1. Analysing Regression Model of Distri I – Full-Scale APO System Use with Comparative Data from Manual Purchasing

In full-scale APO implementation, our research results indicate (as is shown in Table 1) that among 74 purchased items (of which 18 were fully automated purchased items, while 56 were order with manual and more traditional purchasing methods), automated systems are nearly significant in explaining inventory turn change among items. Thus, oppositely as expected, coefficient of automation has negative impact on inventory turns! However, stock change and consumption change are, of course, significant factors in inventory turn change, and their coefficients are as expected (as stocks increase, these will negatively affect on inventory turns, while consumption increase will improve it). However, it should be noted that overall three variable regression models is able to predict inventory turn change by 51.4 %, and therefore still another half from the change is explained by other factors.

It is rather complicated to understand the negative relationship of full-scale automation in purchasing on inventory turns change. As Figure 1 shows, automation could be with a first glance argued to have superior effect on inventory turns change. However, as regression model earlier suggested that most important issues regarding to improvement are related to stock and consumption changes. As full APO implementation is observed in item level, we identify that nearly in half of the cases; demand for these components has been increasing considerably (even three digit percentage improvements). However, another half of the items experience considerable demand decrease. Thus, the positive demand change in firstly mentioned items was so huge that group of components altogether showed considerable inventory improvement. Another issue in full APO system to have much better average and median values was developed detailed algorithm to estimate needed safety stock level. This formula proved to be good for demand growth items; as demand improved in these components, stock levels did not increase that much and this was clearly a route for improved performance. However, in one component out of 18 we identified that MRP nervousness created inventory performance deterioration, and in another one relatively large once happened quantity buy back during APO use period due to failed aggregate forecast (buffering service contract).

*Table 1 Regression model to estimate inventory turn change in full scale automated purchasing system and manual ordered items during the same period.*

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.7169 |
| R Square | 0.5139 |
| Adjusted R Square | 0.4930 |
| Standard Error | 0.7456 |
| Observations | 74 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 3 | 41.1329 | 13.7110 | 24.6653 | 0.0000 |
| Residual | 70 | 38.9116 | 0.5559 | | |
| Total | 73 | 80.0445 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 0.221 | 0.106 | 2.083 | 0.041 | 0.009 | 0.433 | 0.009 | 0.433 |
| Average stock change | -1.686 | 0.225 | -7.487 | 0.000 | -2.135 | -1.237 | -2.135 | -1.237 |
| Average consumption change | 1.275 | 0.160 | 7.979 | 0.000 | 0.957 | 1.594 | 0.957 | 1.594 |
| Automation | -0.426 | 0.238 | -1.788 | 0.078 | -0.901 | 0.049 | -0.901 | 0.049 |

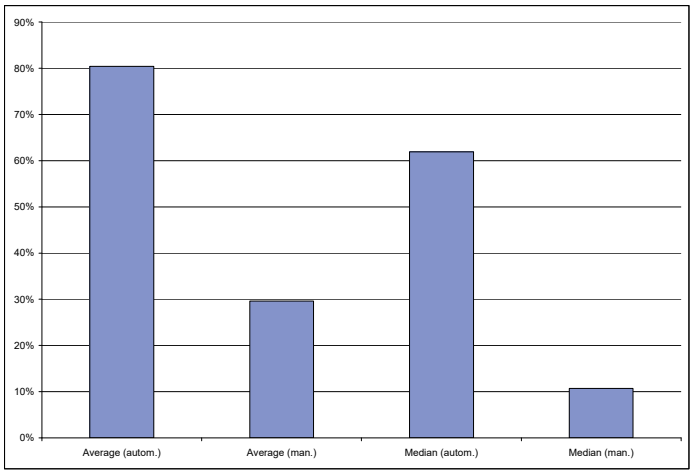


*Figure 1 Inventory turns change (%) in fully automated system and manual purchasing*

As price of single component is important factor in appropriate management actions regarding to different items (higher value items will gain more interest, since larger and sometimes unnecessary inventory holdings will gain management interest due to higher amount of needed working capital in operations), we enlarged our regression model with price considerations. Based on the experience gained from daily purchasing, we divided different items in two groups, where 10 euros per component was dividing factor (high value items were 10 euros or above, while low value items had value of under 10 euros). In larger multifactor regression model this resulted on situation (where average order size was also one explaining factor, but having low probability to explain inventory turns change), where price was having 9.5 % probability that it will not affect purchasing performance, but in smaller model (

below) it is considered as statistically significant in explaining inventory turns change during period. Interestingly in smaller regression model automation had much lower probability since in this model we forced regression model to start from zero position in y and x-axis, as larger model had probability for its significance 14.6 %. Thus, coefficient of possible price change effect on inventory turn change is as could be a priori assumed – higher price improved roughly 46 % inventory turn change. It is also interesting to note that smaller amount of variables in here is able to explain inventory turns change a bit better (58.5 %) than what is the case in previous model.

*Table 2 Regression model to estimate inventory turn change in full scale automated purchasing system and manual ordered items during the same period, model extended with component price information*

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.765 |
| R Square | 0.585 |
| Adjusted R Square | 0.553 |
| Standard Error | 0.743 |
| Observations | 74 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 54.438 | 13.610 | 24.650 | 0.000 |
| Residual | 70 | 38.648 | 0.552 | | |
| Total | 74 | 93.086 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Average stock change | -1.693 | 0.223 | -7.578 | 0.000 | -2.138 | -1.247 | -2.138 | -1.247 |
| Average consumption change | 1.285 | 0.159 | 8.063 | 0.000 | 0.967 | 1.603 | 0.967 | 1.603 |
| Automation | -0.315 | 0.219 | -1.434 | 0.156 | -0.752 | 0.123 | -0.752 | 0.123 |
| Price | 0.464 | 0.211 | 2.202 | 0.031 | 0.044 | 0.884 | 0.044 | 0.884 |

## 4.2. Analysing Data of Distri II – Semi-APO System Use with Comparative Data from Manual Purchasing

Regression analysis results regarding to semi-automated purchasing system do not show any further support for the effect of automation on inventory turn change (74 observations, from where 18 were included in semi-automated system). As Table 3 reveals, probability that automation has not affected on inventory turns is 58.4 %, and this performance is explained mostly with average changes in stock levels and consumption. Overall, these two factors (among intercept) explain above 60 % from total change, which is slightly better than in firstly analyzed automated system. All the significant factors have similar coefficients as was earlier recognized.

Further analysis of our research data reveals the reason, why automated system does have connection to inventory turns; on the average (**Error! Reference source not found.**Figure 2) automated system is clearly better, and in the median level as well. However, situation is the same as in the full scale APO system; there exist several items, which have improved their inventory turns impressively, but performance deterioration was identified in several components (in two of those, due to MRP nervousness).

*Table 3 Regression model to estimate inventory turn change in semi -automated purchasing system and manual ordered items during the same period.*

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.7788 |
| R Square | 0.6065 |
| Adjusted R Square | 0.5954 |
| Standard Error | 0.4729 |
| Observations | 74 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 2 | 24.4750 | 12.2375 | 54.7170 | 0.0000 |
| Residual | 71 | 15.8792 | 0.2237 | | |
| Total | 73 | 40.3543 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 0.1829 | 0.0689 | 2.6532 | 0.0098 | 0.0454 | 0.3203 | 0.0454 | 0.3203 |
| Average stock change | -1.2821 | 0.1411 | -9.0867 | 0.0000 | -1.5635 | -1.0008 | -1.5635 | -1.0008 |
| Average consumption change | 1.2841 | 0.1483 | 8.6600 | 0.0000 | 0.9884 | 1.5797 | 0.9884 | 1.5797 |

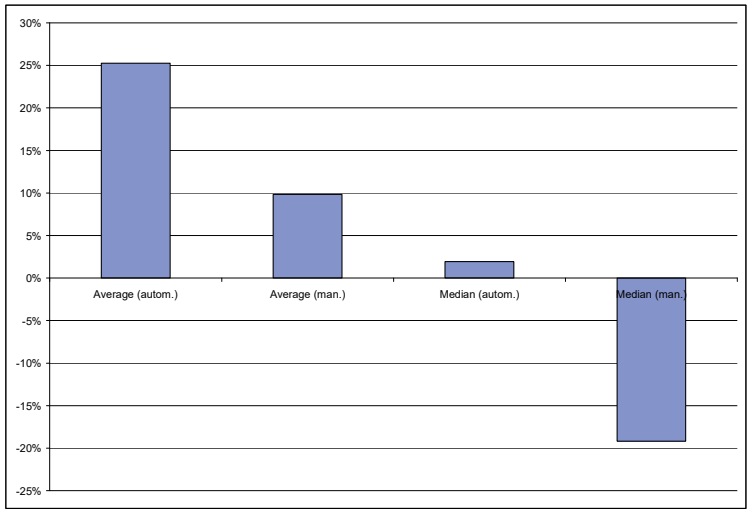


*Figure 2 Inventory turns change (%) in semi-automated system and manual purchasing*

As automation did not have any affect on inventory turn change, interestingly prices did not explain it either (Table 3). We used in here same dividing criteria as in previous case (10 euros). In larger model (inc. also consumption change and automation) probability that price has not an effect on inventory turns change is 15.7 %, and its significance decreases considerably in smaller model (65.8 % probability that it will not have any effect). In the larger model, we could identify that, if prices have an effect on inventory turns, dearer components will improve turns change with approx. 20 %. Explanation power of larger model in here has similar performance with previous one. However, in smaller price based model, regression curves without intercept looses much of its ability to predict this behaviour.

*Table 4 Regression model to estimate inventory turn change in semi-automated purchasing system and manual ordered items during the same period, model extended with component price information.*

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.4806 |
| R Square | 0.2310 |
| Adjusted R Square | 0.1952 |
| Standard Error | 0.6722 |
| Observations | 74 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 3 | 9.6358 | 3.2119 | 7.1074 | 0.0003 |
| Residual | 71 | 32.0861 | 0.4519 | | |
| Total | 74 | 41.7219 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Average order size change | 0.2344 | 0.1947 | 1.2035 | 0.2328 | -0.1539 | 0.6226 | -0.1539 | 0.6226 |
| Average stock change | -0.8218 | 0.2048 | -4.0133 | 0.0001 | -1.2301 | -0.4135 | -1.2301 | -0.4135 |
| Price | 0.0955 | 0.2150 | 0.4440 | 0.6584 | -0.3333 | 0.5242 | -0.3333 | 0.5242 |

## 5. Discussion

Based on our research, we identified that automation alone is not primarily the reason for inventory turn improvement, and interestingly in the first model, it was nearly statistical significant that automation will decrease inventory turns. After further investigation and

research especially thanks to the regression analysis, we realized that automation itself was not the primary reason for improved inventory turns. It appeared to us that the standardization of item parameters in MRP calculation is the reason among demand increase (in some of the items) for improving inventory turns. One interesting point is that items are bought in after MOQ. When starting the APO order quantities were reviewed and set to lowest possible level. Regression analysis did not show any significance of purchase order size to inventory turns. This is not that surprising result, since currently used MRP systems (periodic demand) do not lead on inventory investment based on order quantities as what was the case in traditional EOQ (Economic Order Quantity) models. As case company is mid-sized telecom electronics manufacturer, high variety among moderate demand creates often situation where one standard package is enough to satisfy production needs. Package sizes are often driven eventually by production needs, and reels save labour time in production and therefore these are favoured in purchasing. So, taking these factors into account, it is rather easy to understand the insignificant role of order quantities.

So, our first hypothesis appeared not to be valid, and our initial assumption based on literature. Surprisingly, the second hypothesis stating that the level of automation has an effect on inventory turn improvement might at first sight reveal to be true. But after a more detailed view on the development it seems that the reason for differences among APO systems is in the successfulness and fit of algorithms developed to safety stock estimation, and customer demand development. Therefore, we reject second hypothesis, and argue that different APO systems do not have an effect on inventory turns. This was further supported by correlation analysis between different factors of this research work and automation – as Table 5 shows in Semi-APO case automation tends to be utilized with cheaper items, while in full scale APO consumption change and automation have positive correlation relationship (maybe high demand expectation items were eventually automated – this was first implementation case).

*Table 5 Correlation (Pearson) analysis concerning semi-APO implementation items and comparative items from manual purchasing (denotations: OSC = Order Size Change, SC = Stock Change, CC = Consumption Change and InvC = Inventory Change).*

| | | Automation Semi-APO | Price Semi-APO | Automation Full-APO | Price Full-APO |
|---|---|---|---|---|---|
| OSC | Pearson Correlation | -0,114 | -0,227 | -0,196 | -,288(*) |
| | Sig. (2-tailed) | 0,331 | 0,052 | 0,094 | 0,013 |
| | N | 74 | 74 | 74 | 74 |
| SC | Pearson Correlation | -0,016 | -0,163 | 0,127 | -,236(*) |
| | Sig. (2-tailed) | 0,893 | 0,166 | 0,283 | 0,043 |
| | N | 74 | 74 | 74 | 74 |
| CC | Pearson Correlation | 0,148 | -0,073 | ,434(**) | -0,173 |
| | Sig. (2-tailed) | 0,209 | 0,534 | 0,000 | 0,140 |
| | N | 74 | 74 | 74 | 74 |
| Automation | Pearson Correlation | 1 | -,237(*) | 1 | 0,028 |
| | Sig. (2-tailed) | | 0,042 | | 0,816 |
| | N | 74 | 74 | 74 | 74 |
| Price | Pearson Correlation | -,237(*) | 1 | 0,028 | 1 |
| | Sig. (2-tailed) | 0,042 | | 0,816 | |
| | N | 74 | 74 | 74 | 74 |
| InvC | Pearson Correlation | 0,090 | 0,123 | 0,209 | 0,160 |
| | Sig. (2-tailed) | 0,448 | 0,295 | 0,073 | 0,174 |
| | N | 74 | 74 | 74 | 74 |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Our research indicated that the price level of a component has an impact on inventory turns change. However, this is not statistically significant in every case. In literature it is often explained that organization itself develops methods to improve inventory efficiency of higher priced items. Thus, we have found in case company that exogenous factors also have an affect to inventory turns. In dearer items suppliers favour extremely low supply quantities for these items. Also in some of the cases dearer items are have larger size (more sophisticated and integrated chips), so this also favours lower delivery quantities (as it is needed). This argumentation holds some possible ground with full scale APO system in Table 5 – price leads into lower purchase order quantities and lower inventory holding levels.

## 6. Conclusions

It has generally been assumed that automated IT-systems improve efficiency of manufacturing, and lowers the transaction costs considerably. This effect is further enhanced; as suppliers or customers are integrated into transactions with commonly agreed database structures or even use EAI (Enterprise Application Integration) systems between different parties. However, it is still unknown, whether these automated systems truly improve performance of logistics, and especially amount of inventories. Based on the earlier supply chain research, inventory holdings should decrease in a whole chain context due to shorter delays in a process, and enhanced information availability and visibility. However, our research did not verify these assumptions; automation and more efficient purchasing system is not the driver of inventory turn change, but actually in every case change in stock levels, and demand play most important part. Interestingly, if automation has an affect on inventory turns, it is most probably negative one. In some of the items automated systems truly improve the performance, and observing automated system through aggregate numbers (like average and median) at first glance it seems to be case that these system really have positive impact on inventory efficiency. However, regression analysis treats and fits linear curve into data through all purchased items, and therefore this resulted in our case to the situation, where automated systems do not improve performance at all. Based on this research we argue that traditional materials management variables play important role in explaining inventory turns changes. It should be reminded that due to several different factors (MRP systems, moderate volumes and high variety), order lot sizes do not seem to have any connection to inventory turns change.

In the future this research should be followed with similar type of data and same analysis method in different environment and greater sample of automated items. Current cases of automated purchase orders include 18 items and regression analysis of these quantities is not reliable enough to make larger generalizations. Therefore we suggest that this research should be repeated with greater sample (e.g. 35 items ordered via APO-system) and analysed accordingly. Through this research, the nature of automated purchase order and the impact of other factors to inventory turns could be tested. This research has been treating a very narrow concept of automated purchase orders that is only one fragment of all supply chain processes. In addition, the meaning of automated purchase order and its applications should be presented in a wider context and investigate all the related processes. This might offer more ideas and a total view for process automation to improve the effectiveness of supply chain processes. Also in a chain context, amount of total inventories should be analyzed, by including distributor inventory holdings in figures as well. However, distribution inventory holding is not that simple issue to be further researched, since inventories could be dedicated for the customer, or inventory holdings are general, and serve the purpose of number of different customers.

References

Appelqvist, Patrik & Ebbe Gubi (2005). Postponed variety creation: case study in consumer electronics retail. *International Journal of Retail & Distribution Management*, 33:10, pp. 734-748.

Bergman, Robert L. (1991). Selecting among MRP lot-sizing methods for purchased components when the planning horizon is limited. *Production and Inventory Management Journal*, 32:2, pp. 32-39.

Cooper, Darren P. & Michael Tracey (2005). Supply chain integration via information technology: strategic implications and future trends. *International Journal of Integrated Supply Management*, 1:3, pp. 237-257.

Das, Chandrasekhar & Rajesh Tyagi (1999). Effect of correlated demands on safety stock centralization: patterns of correlation versus degree of centralization. *Journal of Business Logistics*, 20:1, pp. 205-213.

Eisenhardt, K. (1989) 'Building theories from case study research'. *Academy of Management Review*, Vol. 14, No. 4, pp.532–550.

Gulledge, Thomas (2006). What is integration? *Industrial Management & Data Systems*, 106:1, pp. 5-20.

Grimm, Bruce T. (1998). Price indexes for selected semiconductors. *Survey of Current Business*, 78:2, pp. 8-25.

Helo, Petri (2004). Managing agility and productivity in the electronics industry. *Industrial Management and Data Systems*, 104:7, pp. 567-577.

Helo, Petri & Szekely Bulcsu (2005). Logistics information systems: an analysis of software solutions for supply chain co-ordination. *Industrial Management and Data Systems*, 105:1, pp. 5-18.

Hemsworth, David, Cristobal Sanchez-Rodriguez & Bruce Bidgood (2005). Determining the impact of quality management practices and purchasing-related information systems on purchasing performance – A structural model. *The Journal of Enterprise Information Management*, 18:2, pp. 169-194.

Hill, Terry (2005) *Operations management* Second edition, New York, Palgrave Macmillan

Hilmola, Olli-Pekka, Annukka Hejazi and Lauri Ojala (2005). Supply chain management research using case studies - A literature analysis. *International Journal of Integrated Supply Management*, Vol. 1, Iss. 3, pp. 294-311.

Howard, John A. (1989) *Consumer behaviour in marketing strategy* Englewood Cliffs NJ, Prentice-Hall

Hu, J. & CL Munson (2002). Dynamic demand lot-sizing rules for incremental quantity discounts. *Journal of the Operational Research Society*, 53:8, pp. 855-863.

Häkkinen, Lotta & Olli-Pekka Hilmola (2005). Methodological pluralism in case study research: an analysis of contemporary operations management and logistics research. *International Journal of Services Operations Management*, 1:3, pp. 239-256.

Ed. Håkansson, H. (ed.) (1982) *International marketing and purchasing of industrial goods. An interaction approach* Chichester, John Wiley & Sons.

Kaipia, Riikka, Hille Korhonen and Hartiala Helena (2006). Planning nervousness in a demand supply network: an empirical study. *The International Journal of Logistics Management*, 17:1, pp.95-113.

Korovyakovsky, Eugene (2006). A research note: Russian railways' information technologies. In

Harris, Ford W. (1913). How many parts to make at once? *The magazine of Management*, 10:2, pp. 135-136, 152. Reprinted in *Operations Research*, 38:6, pp. 947-950.

Hilmola, Olli-Pekka (ed.): *Second Research Meeting Held at Moscow - Strategic Role of Logistics and Supply Chain Management*. Lappeenranta University of Technology, Department of Industrial Engineering and Management. Research Report 177.

Leonard, Lori N.K. & Clemons Davis, Chrisine (2006). Supply chain replenishment: before-and-after EDI implementation. *Supply Chain Management: An International Journal*, 11:3; pp. 225-232.

Leonard, Lori N.K. & Timothy Paul Cronan (2005). Electronic supply chain management: does consumer benefit? *International Journal of Integrated Supply Management*, 1:3, pp. 335-343.

Lu, Louis Y.Y., Shiu-Wan Hung and Chyan Yang (2004). Successful factors of the fabless IC industry in Taiwan. *International Journal of Manufacturing Technology and Management*, Vol. 6, No.1/2, pp. 98-111.

Machuca, José A.D. and Barajas, Rafael P. (2004) The impact of electronic data interchange on reducing bullwhip effect and supply chain inventory costs *Transportation Research* Part E 40

Neubert, Gilles, Yacine Ouzrout & Abdelaziz Bouras (2004). Collaboration and integration through information technologies in supply chains. *International Journal of Technology Management*, 28:2, pp. 259-273.

Papakadis, Ioannis S. (2003). On the sensitivity of configure-to-order supply chains for personal computers after component market disruptions. *International Journal of Physical Distribution and Logistics Management*, 33:10, pp. 934-950.

Papadakis, Ioannis S. (2006). Financial performance of supply chains after disruptions: an event study. *Supply Chain Management: An International Journal*, 11:1, pp. 25-33.

Ptak, Carol (2000*). ERP – Tools, Techniques, and Applications for Integrating the Supply Chain*. St. Lucie Press: USA.

Plossol, George W. (1994). *Orlicky's Material Requirements Planning*. McGraw-Hill: USA. 2nd edition.

Rao, Mohan P. & David M. Miller (2004). Expert system applications for productivity analysis. *Industrial Management and Data Systems*, 104:9, pp. 776-785.

Rao, Mohan P. (2006). A performance measurement system using a profit-linked multi-factor measurement model. *Industrial Management & Data Systems*, 106:3, pp. 362-379.

Rantala, Lauri & Olli-Pekka Hilmola (2005). From manual to automated purchasing, case: middle-sized telecom electronics manufacturing unit. *Industrial Management and Data Systems*, Vol. 105, No. 8, pp. 1053-1069.

Scheuing, Eberhard E. (1989) *Purchasing Management* Englewood Cliffs, Prentice-Hall

Tarn, Michael J., David C. Yen & Marcus Beaumont (2002). Exploring the rationales for ERP and SCM integration. *Industrial Management and Data Systems*, 102:1, pp. 26-34.

Tersine, Richard J. (1985). *Production / Operations Management: Concepts, Structure, and Analysis*. Second Edition. North Holland.

Vollmann, Thomas E., William L. Berry & D. Clay Whybark (1997). *Manufacturing Planning and Control Systems*. Irwin/McGraw-Hill: USA. 4th edition.

Walton, Steve V. and Gupta, Jatinder N.D. (1999) Electronic data interchange for process change in an integrated supply chain *International Journal of Operations &Production Management* Vol. 19 No. 4

Williamson, Oliver E (1985) *Economic institutions of capitalism: firms, markets, relational contracting* New York, Free Press

Yenisey, Mehmet Mutlu (2006). A flow-network approach for equilibrium of material requirements planning*. International Journal of Production Economics*, 102:2, pp. 317-332.

Yin, R. (1991). *Case Study Research*. Newbury Park, CA: Sage Publications.

Yin, R. (1993). *Applications of Case Study Research*. Newbury Park, CA: Sage Publications.

Zinn, Walter, Michael Levy, Donald J. Bowersox (1989). Measuring the effect of inventory centralization / decentralization on aggregate safety stock: The "square root law" revised. *Journal of Business Logistics*, 10:1, pp. 1-14.

**Essay I** **Rantala, L. (unpublished) From total quality management (TQM) through business process reengineering (BPR) to supply chain management (SCM)**

# 1 FROM TOTAL QUALITY MANAGEMENT (TQM) THROUGH BUSINESS PROCESS RE-ENGINEERING (BPR) TO SUPPLY CHAIN MANAGEMENT (SCM)

Abbreviations of concepts or theories often comprise three letters. Practitioners are ready to adopt them, and if they reflect the concept they will be easy to implement in practical life. Some concepts derive from an urge to change things, which obviously applied to one of the proponents of TQM, W. Edwards Deming (see Deming, 1985). In other cases there is need for something new that will bring sizable benefits within a short time period, which seems to have been the driving force behind BPR (see Davenport, 1993). SCM has been developing more or less smoothly over time. Several authors trace its origin to Michael Porter's (1985) seminal work *Competitive Advantage* (1985), in which he presented his view of the value chain (e.g., Kotler, 2003; Fill and Fill, 2005; Schary and Skjott-Larsen, 2001; Gourdin, 2001).

All three concepts have achieved prominence, some more recently than others. They are connected by the fact that the aim is to change management practices and improve organisational quality and profitability, elements that, according to the literature, are intertwined and have common characteristics. The purpose of this essay is to show how the three theories or concepts are linked.

## 1.1 The emergence of the concepts

The three concepts, TQM, BPR and SCM, emerged for different reasons. TQM thinking grew from the need to strengthen the competitiveness of US industry against Japanese companies in the early 1980s. W. Edwards Deming (1985) voiced this cry for higher quality and competitiveness in the 14 points he made for improving the Western style of management. These points fall into the following categories: constant improvement, transformation, constant quality work, teaming, total costing, and professional support of the personnel on all levels. Moreover, they correspond to typical Japanese management philosophies. The emergence of the concept in the US certainly contributed to

its booming start there. According to Easton and Jarrell (1998), it achieved fame through a national quality award and the participation of major US companies in it.

The arrival of BPR was probably less related to national urgency. It was conceived of through the work of Hammer and Champy (1993) and Davenport (1993), the driving force being to complement TQM thinking with something that would offer managers a less costly and faster change process that produced results more quickly. This view was dismissed later as short-sighted thinking (Al-Mashari et al. 2001). It soon became evident that drastic change was not appropriate to practical life, however. Davenport and Short published an article in 1990 in which they were already suggesting combining information technology (IT) and business-process redesign. It is interesting that at this stage it was still a question of redesign rather than re-engineering. The authors also claimed that the power of IT as a tool for change was comparable to Frederick Taylor's industrial engineering. From the beginning IT has been a driver of BPR, and in this sense process development became a necessity because information systems (IS) tend to change the way work is done. Hammer and Champy (1993) differentiate between BPR and TQM, suggesting that the aim in the latter is to improve existing processes, and in the former to match them better with current needs. IT is also considered important, but it is clearly not useful to automate obsolete processes. Davenport (1993) sees two roles for IT in facilitating re-engineering: producing better designs and implementing new ones.

SCM gradually emerged as a concept through the work of different authors and the definitions they put forward. Supply chain management developed from materials management, physical distribution and logistics (Coyle et al. 1996). Its first use can be traced to the early 1980s when it was described in Oliver and Webber: *Supply Chain Management: Logistics catching up with strategy* (1982) (Jüttner et al. 2007), and various definitions have been put forward over the years. Later, Michael Porter (1985) presented his idea of the value chain, which has been an inspiration to many. There has always been a somewhat holistic view of the complete chain of activities involving purchasing, production and logistics management. Information systems are also a natural part of the supply chain in that different enterprise systems (ES), such as ERP (Enterprise Resource Planning), are used in companies of all sizes and types.

Thus, these concepts have very different starting points, but they all represent a process view of the company. They also emerged for different reasons. TQM was a response to the national outcry to be more competitive, and BPR offered faster and easier access to organisational change and quick results. Supply chain management has different origins even if the term

emerged in the same decade as TQM: its roots go back centuries to the development of logistics.

## 1.2 The development of the concepts

SCM and TQM evolved in parallel, whereas BPR only came to light in the early 1990s. The three development paths are described in more detail in the following.

### 1.2.1 TQM

Easton and Jarrell (1998) first revealed evidence of improvements in accounting variables and stock returns from an investigation they conducted in 1998. This development was certainly facilitated by the strong support from US organisations with an interest in improving the competitiveness of the national economy. However, the basic TQM principles Deming listed in 1985 were already pointing in this direction in that they incorporated some of the principles that were typical of Japanese management philosophies that had proved successful. Later, Easton and Jarrell (1998) listed the key characteristics as follows:

**Table 1: The key characteristics of TQM (Easton and Jarrell, 1998)**

| Characteristic | Description |
|---|---|
| Process focus | The process concept is a fundamental building block of the organisation |
| Systematic improvement | Prevention -based orientation, focus on quality improvement, cycle-time reduction, waste or cost reduction |
| Companywide emphasis | Process and improvement goals implemented throughout the company |
| Customer focus | Customer focus in terms of customer satisfaction, service, information and integration |
| Management-by-fact | Objective data and information-based decision-making with established metrics |
| Employment involvement and development | Decision-making close to the employees and to the actual process, involvement in improvement |
| Cross-functional management | Cross-functional view on improvement and on the process |
| Supplier performance and supplier relationship | Holistic view of suppliers in process and quality improvement |
| Recognition of TQM as a critical competitive strategy | Senior management should provide leadership in the development and deployment of quality management |

As the above table shows, there is a holistic view to the company in terms of processes. Different functions are involved in their continuous development, as are customers and suppliers. The primary focus is still on customer satisfaction with the whole product, which applies to the company and the suppliers, the aim being to gain competitive advantage through operational excellence.

### 1.2.2 BPR

The adjectives fundamental, radical and dramatic characterise the BPR process (Hammer and Champy, 1993). Davenport (1993) suggested integrating BPR with TQM in order to match radical innovation with continuous improvement, and just three years later he announced the demise of BPR (Davenport, 1996). The greatest reason for this "sudden death" was the radical thinking behind the concept. The application of radical change did not take into consideration of realities in corporate world and factors of human resistance to change. Sudden change of all processes in a company often means interruption in supply to customers. This is difficult to accept in the world where short term profit follow-up is current practice. Several authors have discussed the failure of BPR. Burgess (1998), Drago and Geisler (1997) and Al-Mashari et al. (2001) all see the concept problematic.

Drago and Geisler (1997) see five different problem areas in BPR implementations: lack of sufficient preparation, problems associated with implementation, organisational weaknesses, weaknesses inherent in BPR and problems developed in the aftermath of BPR. To overcome these challenges, they propose a seven point list. They also argue that constant improvement is essential and the concept itself is viable. Al-Mashari et al. (2001) also found that implementing the BPR requires careful planning and implementation to succeed. They also found that if the organisation had previous experience of TQM the chances of success were greater. This appeared to be one reason why US companies performed somewhat better than others.

### 1.2.3 SCM

The SCM concept has been developing freely since its creation, and there are several definitions. It is worth noting that it has replaced logistics as a term in many cases, being considered wider in scope and more appropriate for processes describing material and information flows. Divergent views have evolved and SCM has been connected with the network view (supply-network

management) and marketing (demand-chain management or demand-supply-chain management).

IT tools are essential to SCM, having supported its further development in terms of process integration. An example of this is the real-time view of the supply chain to the different players involved, which enables demand information to move along the chain without constraints. This works through data communication and specially designed software packages (Davenport and Brooks, 2004). ERP systems are at the core of SCM, and the question has been raised whether they support its development or vice versa. It has also been noted that even if electronic data interchange (EDI) programs have been available and in use in larger companies for decades (Davenport and Brooks, 2004), current software solutions still cannot support the co-ordination of an entire network (Xu et al., 2009).

## 1.3 Common features and links between the concepts

The three separate concepts described above have some commonalities and some differences, which with regard to TQM and BPR are discussed above. The link between these two and SCM is less obvious, however, although like BPR SCM is nowadays heavily dependent on IS in many respects. One thing that is common to all three is the process-oriented view of organisations.

Different companies have different ERP systems, and the focus on inter-organisational relationships is increasing the need for IS-enabled linkage. Increased networking requires opening the door to more and more partners, including subcontractors and suppliers. The use of information systems in this is transforming working practices and, though the need for re-engineering, creating more work. On the inter-organisational relationships level, changing practices in communicating with suppliers, customers and other partners requires changes in internal practices as well. This connects SCM with TQM and BPR.

In terms of principles, both TQM and BPR rely on changing processes. Deming (1985) does not mention the word process, but he clearly sees a connection between the work of different company functions, and a link to supplier and customer companies. This is quite well aligned with the notion of a process as: “a set of logically related tasks performed to achieve a defined business outcome” (Davenport and Short, 1990).

However, the concepts have different perspectives on change: in TQM it is a slow and time-consuming process that transforms the organisation over a longer time period, whereas BPR aims at fast change and revolutionary approaches. Davenport (1993) pointed out at the very beginning that both

revolutionary thinking (BPR) and continuous improvement (TQM) were required in order to increase profitability through change. He also noted that IS provided the fundamental support for and facilitated the change process. In his view, BPR came first in terms of updating processes radically in response to organisational change. This radical change made room for continuous improvement promoted by TQM thinking.

| | | Pace of change | |
|---|---|---|---|
| | | Fast | Measured |
| Degree of change | Tactical | Focused Process Improvement (Quality, Time, Cost) | Continuous Improvement |
| | Strategic | Focused restructuring | Business Process Innovation |

**Figure 1: Alternative approaches to operational change (Davenport, 1993)**

Figure 1 illustrates the different change processes along the dimensions of degree and pace of change. The degree of change may be tactical or strategic, and the pace may be fast or measured. When the pace is fast it is possible to make focused process improvements (tactical change) or to effect focused restructuring (strategic change). When the change is measured, on the strategic level it is possible to achieve business process innovation whereas tactical change brings continuous improvement. This seems to be one way of adopting elements of TQM (continuous improvement) in BPR and thus integrating the two in order to effect more strategic development and less drastic patterns of change.

According to Kettinger and Grover (1995), all business-process-related change has a common goal, and different terms are used to describe what used to be business process re-engineering: process improvement, process innovation and business-process redesign could all be combined to describe change in business processes. They also note the accommodation with TQM that brings a broader perspective to BPR.

On the other hand, Burgess (1998) found certain similarities between SCM and BPR: a fundamental rethinking, a process-based approach, strategic consideration and the use of information technology as a catalyst. In terms of fundamental rethinking, inherent in both concepts is the assumption that companies have to adapt to a larger spectrum of customer requirements. It is a question not only of making existing products efficiently but also of designing

new products effectively. Furthermore, companies do not operate in isolation but work in co-operation. Process-based thinking is evident in both concepts, in other words a function-based structure is outdated and the entire process should be followed from one end to the other, from supplier to customer. On the strategic level, companies need to reformulate their strategies in order to fit in with such thinking. Time is also of the essence: there is a tendency to minimise time and effort that do not add value, and thus to compress process lead time. The elimination of waste is another key common goal, in the achievement of which IT has a crucial role.

Customer orientation is a driving force behind all of the concepts. In the case of TQM, the loss of markets and customers to competing foreign companies triggers the drive for a better internal organisation and a process orientation. A customer focus is possibly a little less obvious in BPR, but the drive for competitive advantage fuels the wish for radical change. A customer orientation is visible in SCM in the focus on the competitive advantage of the complete supply chain.

## 1.4 The role of IT in TQM, BPR and SCM

IT has a role in each of these three philosophies or concepts. For the most part it facilitates the development and implementation of processes aimed at ensuring higher quality, reducing costs and increasing the speed of delivery.

Its role in TQM is evident (Sanchez-Rodriguez et al. 2006), but it is not an essential element of TQM thinking. It facilitates its development and practices, but it is only a tool in terms of business development. This is not the case with BPR and SCM. IT has had a clear role in BPR from the very beginning, and according to Davenport and Short (1990) the following capabilities reflect its contribution potential: Transactional, Geographical, Automatical, Analytical, Informational, Sequential, Knowledge Management, Tracking and Disintermediation. Later, Hammer and Champy (1993) emphasised the role of IT as an essential lever, but at the same time warned that its misuse could reinforce old working ways and habits and jeopardise re-engineering. It is clear that it can support change and create new ways of working. Similarly, just as it is recognised that IT is changing ways of working, it is also assumed that electronic commerce as one type of application will also change business processes, and this calls for the application of BPR. IT tools have been used exclusively in automating business processes and thus lowering transaction costs and eliminating intermediaries. Today, widespread enterprise systems offer possibilities for integration and process optimisation (Davenport et al., 2004).

IT has gradually assumed a major role in SCM, particularly if materials requirements planning (MRP) and ERP software are included. Later, EDI applications steered SCM towards inter-organisational processes, and new tools that are easier and more cost-effective are currently gaining ground. Various applications that facilitate intra-organisational work are also being implemented, including intelligent automated transportation systems and radio frequency identification (RFID).

## 1.5 Inter-organisational relationships

Inter-organisational relationships are relevant to the three concepts in various ways. TQM, as Deming defines it, incorporates inter-organisational aspects with regard to co-operation and a focus on the total cost of acquisition. Suppliers should be taken into account in design, manufacturing and sales in order to bring competitive and high-quality products to the market. In other words, it is the total cost that matters, not only the cost of the product from the supplier (Deming, 1985). The role of suppliers is also clearly important in product design and sales. This is a significant change to the traditional arm's-length principle according to which the supplier only supplies the necessary goods at the lowest possible price, and can be changed easily if the attributes are not satisfactory. Basically, the change process still only concerns the internal processes of the company. Suppliers are involved through their participation in tasks that have traditionally been regarded as belonging to the company's internal processes, and their processes are not considered in this definition.

In BPR inter-organisational relationships are considered inter-organisational processes (Davenport and Short, 1990), which in many organisations take the form of simple transactions automated through the use of EDI or a similar tool. However, a true inter-organisational business process involves the parties on a much broader level. As mentioned above, the aim is still to involve suppliers in a very wide range of functions, such as manufacturing and design. The role of IT as discussed above is also important in process optimisation and integration in the context of inter-organisational relationships.

SCM by its very nature is inter-organisational. As the name implies, it concerns the management of a chain of suppliers, and if it is to work properly it requires inter-organisational co-ordination. The partner relationships are of strategic importance (Sheth and Sharma, 2007), and in the case of SCM the focus should shift from the transaction to the relationship. This effectively describes the SCM perspective on inter-organisational relationships: given its

different offshoots such as supply network management and demand chain management, the emphasis on the relationship aspect only increases.

## 1.6 Discussion

As demonstrated above, all three concepts discussed in this essay are interrelated, the common denominator being the use of IT as a facilitator. Information technology has been developing over the years, at an increased pace since the 1980s. ERP systems have arrived, communication systems have evolved and more recently mobile communications have transformed not only voice but also data communication. Systems are updated through hand-held devices by means of radio frequency identification (RFID): data is automatically fed into the IT system based on distance reading. IT systems development is aimed at increasing efficiency and shortening cycle times in business processes, and IS processes have to be remodelled to fit the organisational realities.

The three concepts have certain common features. As stated above, information technology is one, and a process-based view is another. Inter-organisational relations are a third common aspect, and are particularly significant in that they increase the competitiveness of the total chain or network. They are thus the key to the overall success of process change. Fourthly, both customers and suppliers are key resources in the development of competitive advantage. There are also differences of course. TQM is probably closest to organisational philosophy given its intensive development in the 1980s and 1990s, whereas BPR is mostly classified as a tool for consultants and there is not so much theoretical discussion behind it (Kettinger and Grover, 1995). SCM has developed slowly from materials management, physical distribution and logistics to embrace a more holistic view on the flow of material and goods from raw materials to end customers (Coyle et al. 1996). Both TQM and BPR focus on the internal organisation of the firm in focus, although the importance of involving customers and suppliers is recognised. SCM differs from the other two in its broader perspective on the supply chain. The focus extends from raw-material suppliers to end customers, and the aim is to optimise processes in between so as to offer the most value to the end customer and thereby gain competitive advantage and market share.

Figure 2 below illustrates the similarities and differences described above.

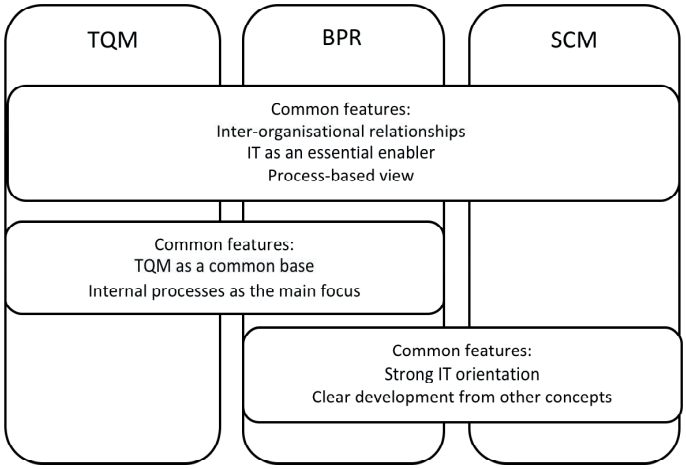


**Figure 2: The commonalities of the concepts**

The figure shows the common features rather than the differences because they are clearly identifiable. It also illustrates the relationships between the concepts: TQM is further away from SCM than BPR, and vice versa. The development of a common framework combining them is rather more difficult. However, TQM and BPR could be seen as tools driving SCM processes to a higher level of efficiency and competitiveness.

Figure 1 above represents an attempt to combine TQM and BPR. In such circumstances, it would be more fruitful for companies undergoing fast change on a tactical level to move to a more strategic level. Figure 3 below illustrates this development.

| | | Pace of change | |
|---|---|---|---|
| | | Fast | Measured |
| Degree of change | Tactical | Focused Process Improvement (Quality, Time, Cost) | Continuous Improvement |
| | Strategic | Focused restructuring | Business Process Innovation |

**Figure 3: Alternative approaches to operational change (Davenport 1993)**

The focus should move from tactical and fast development through strategic and measured development to tactical and measured development. This is how the change process should be planned on the strategic level in order to take in the chain as a whole: in order to avoid continuous improvement of obsolete

processes, business-process innovation should aim at redesigning them. When they correspond to the current situation, the continuous improvement can start again.

From the relationship perspective, given that all of the process-change models lay emphasis on inter-organisational relationships, they should also be in focus when the processes change. Given the increasing involvement of customers nowadays, perhaps the focus should be on supplier relationships. The word relationship is important. Co-operation is often based on transactions, and the most common ones are routine. In order to fully benefit from the advantage created through inter-organisational processes, other than transactional relationships should be developed. EDI solutions or similar tools often prevail when it is a question of deciding the role of IT in buyer-supplier processes. These are typical examples of transactional process optimisation. Of course, transactional processes are often easier to change and automate than processes involving several organisations. Even so, consideration should also be given to how other process types will fit in with them. Inter-organisational relationships as such are an interesting area of research, and it would be interesting to explore them in combination with the concepts discussed here. This would enhance understanding of quality, business processes and supply chains, and of the role these relationships play.

References:

Al-Mashari, M.; Irani, Z. and Zairi, M. (2001) Business process reengineering: a survey of international experience. *Business Process Management Journal* Vol.7, No.5, pp.437-455.

Burgess, R. (1998) Avoiding Supply Chain Management Failure: Lessons from Business Process Re-engineering. *The International Journal of Logistics Management* Vol.9, No.1, pp.15-23.

Coyle, J.J.; Bardi, E.J. and Langley, C.J.Jr. (1996) The Management of Business Logistics, 6th ed. West Publishing Company.

Davenport, T.H. and Short, J.E. (1990) The New Industrial Engineering: Information Technology and Business Process Redesign. *Sloan Management Review* Vol.31, No.4, pp.11-27.

Davenport, T.H. (1993) Need Radical Innovation and Continuous Improvement? Integrate Process Reengineering and TQM. *Planning Review* May/June 1993, 21,3, pp.6-12.

Davenport, T.H. and Brooks, J.D. (2004) Enterprise systems and the supply chain. *Journal of Enterprise Information Management* Vol.17, No.1, pp.8-19.

Davenport, T.H.; Harris, J.G.; Cantrell, S. (2004) Enterprise sustems and ongoing process change. *Business Process Management Journal* Vol.10, No.1, pp.16-26.

Deming, W. E. (1985) Transformation of Western Style of Management. *Interfaces* 15:3 May-June, pp.6-11.

Drago, W. and Geisler, E. (1997) Business process re-engineering: lessons from the past. *Industrial Management & Data Systems* Vol.97, Issue 8, pp.297-303.

Easton, G.S. and Jarrell, S.L. (1998) The Effects of Total Quality Management on Corporate Performance: An Empirical Investigation. *Journal of Business* vol.71, no.2, pp.253-307.

Gourdin, K. N. (2001) *Global logistics management – a competitive advantage for the new millennium*. Blackwell Publishers Ltd, Oxford.

Hammer, M. and Champy, J. (1993) Reengineering the Corporation: a Manifesto for Business Revolutions. HarperCollins Publishers, Inc.

Kettinger, W.J. and Grover, V. (1995) Special Section: Toward a Theory of Business Process Change Management. *Journal of Management Information Systems* Vol.12, No.1, pp.9-30.

Jüttner, U.; Christopher, M.; Baker, S. (2007) Demand chain management – integrating marketing and supply chain management. *Industrial Marketing Management* Vol.36, pp.377-392.

Kotler, Philip (2003) *Marketing management*. 11th edition, Pearson Education Inc., Upper Saddle River, New Jersey.

Fill, C.; Fill, K. E. (2005) *Business to business Marketing – Relationships, Systems and Communications.* Pearsons Eduction Limited, Harlow

Schary, P. B.; Skjott-Larsen, T. (2001) *Managing the Global Supply Chain* 2nd Ed. Copenhagen Business School Press.

Sánchez-Rodríguez, C.; Dewhurst, F.W.; Martínez-Lorente, A.R. (2006) IT use in supporting TQM initiatives: an empirical investigation. *International Journal of Operations & Production Management* Vol.26, No.5, pp.486-504.

Sheth, J.N. and Sharma, A. (2007) Relationship Management in *Handbook of Global Supply Chain Management* Mentzer, J.T., Myers, M.B. and Stank T.P. (eds.). Sage Publications Inc.

**Essay II** **Rantala, L. (2016) Perceptions of automated purchase order processing in mid-sized manufacturing companies in South-Western Finland. Peer-reviewed and accepted for to be presented in annual NOFOMA conference 2016, Turku, Finland**

# PERCEPTIONS OF AUTOMATED PURCHASE ORDER PROCESSING IN MID-SIZED MANUFACTURING COMPANIES IN SOUTH-WESTERN FINLAND

Lauri Rantala*

*) Turku School of Economics, Operations and Supply Chain Management, FI-20014 University of Turku, Finland, E-mail: lauri.rantala@utu.fi

## ABSTRACT

**Purpose**
Purpose of this research is to find out whether operational efficiencies could be achieved through purchase order automation in mid-sized manufacturing companies.

**Design/methodology/approach**
To answer the research question, a set of companies was chosen in South-Western Finland in connection to another research project. Case study methodology is used with semi-structured interviews analysed with qualitative methods. The approach to the subject is through application of supply chain and purchasing concepts with lean thinking. Kraljic (1983) model on item classification is reviewed. The development of business-to-business e-commerce and small and medium sized enterprise context are taken into consideration as well.

**Findings**
While automating parts of a process, the whole process should be considered in terms of information systems as well in order to achieve sustainable change.

**Research limitations/implications**
The limited sample of companies is limiting the generalizability of this research. Therefore a larger sample with wider geographical spread would open up the phenomena. As well the constant development of information systems is increasing the possibilities of process automation.

**Practical implications**
Purchase order automation seems to decrease fixed costs and also improve efficiency. It should also be kept in mind that purchase order automation should be accompanied with a larger process improvement and information systems development in supply chain considering supplier processes as well.

**Original/value**
In this paper, the effects of purchase order automation and the linkages on other business processes are researched through professional experience. The results open interesting avenues for further research in small and medium sized companies.

*Keywords: Purchasing, Process automation, Supply Chain Management, Small and medium sized enterprises*

## 1. INTRODUCTION

In 1983 Peter Kraljic titled his largely cited article "Purchasing must become supply management". In this article Kraljic created an item based classification of supply management strategy. Later on, supply management has become supply chain management that The Council of Supply Chain Management Professionals defined as *"...In essence, Supply Chain Management integrates supply and demand management within and across companies"* (Mentzer et al. 2008). Purchasing, though, has not disappeared from the field of business. It needs to be performed in order to receive the necessary physical items from upstream of the supply chain. Lean thinking and supply chain management stress that there is a continuous flow where unnecessary stockholding is minimised (Krafcik 1988, Lamming 1996). In purchasing this is translated to supplier partnership and streamlining the relationship with suppliers (Krafcik 1988, Ansari and Modarress 1988). In day-to-day purchasing activities this translates to automation of all routine tasks in order to increase efficiency.

This article investigates the views on automated purchase order with its pros and cons through analysis of interviews made within purchase professionals in manufacturing industries. It is based on the results of previous research presented in Rantala and Hilmola (2010). Purchase order automation serves as part in integrating supply chain through the means offered by information systems and supports the ideas of lean thinking. Objective of this research is to find out whether operational efficiencies could be achieved through purchase order automation. The research is done through analysis of answer of four semi-structured interviews to purchasing professionals in Finnish small and medium-sized manufacturing companies.

This paper continues with discussion on the theoretical frame related to supply chain management, lean thinking, purchasing and business-to-business e-commerce. Finally, the context of small and medium-sized enterprises is discussed. Based on the theoretical discussion, a simplistic model of automated purchase order process is presented followed by data collection and operationalization methods. The results of the interviews are concluded with a discussion and suggestions for further research.

## 2. METHODOLOGICAL CONSIDERATIONS

Purpose of this research is to investigate on purchase order process automation concept from the practical side. Previous research (Rantala and Hilmola, 2010) has shown that purchase order automation leaves open questions on the benefits of its application. This research attempts to verify, how purchase professionals see the pros and cons of automated purchase order. In order to achieve this goal it is important to define research strategy, type of evidence collected and the data collection method. It is important to clearly define these as there is often confusion around these concepts but their definition is critical in defining case studies (Yin, 1981). In this research, case study is used as a research strategy. The evidence is in form of qualitative data collected with semi-structured interviews.

Yin (2003) defines case studies as examining a contemporary phenomenon in its real-life context in which the limits and the context are not clear, and it uses multiple data sources and existing theory to guide the data collection and analysis. Barrat et al. (2011) see several data sources in qualitative methodology: structured or semi structured interviews, observations and archival sources. In this research purchase professionals are being interviewed with semi-structured interviews. The choice of semi-structured interviews has been made because it allows updating the tool while data is collected. This way emerging, interesting data related to the

phenomena under investigation may be collected even if it is not included in the original plan of data collection.

Selection of case companies was made based on a database collected during a larger research project among manufacturing companies in South-Western Finland. Selected companies were representing the larger side of the participating companies and were found willing to participate to this study. The main criterion for selection was that they were manufacturing companies using typical material planning methods (MRP). The previous experience in automated purchase order was not asked in beforehand. This choice was made because the purpose of the research was to find out perceptions of the purchase professionals in the company, not especially their experience at current employer.

# 3. CONCEPTUAL FRAME OF REFERENCE

## 3.1. Supply chain management

Supply chain management can be defined as integrating supply and demand management within and across companies (Mentzer et al. 2008). The discipline itself is quite new and might not be yet called as a discipline in scientific sense. It appeared at first through articles in trade journals written by consultants. (Ellram and Cooper 2014)

Supply chain integration has been discussed several years. One definition of supply chain management integration was developed by Näslund and Hulthen (2012) as follows: *"Supply chain management integration is the co-ordination and management of the upstream and downstream product, service, financial and information flows of the core business processes between a focal company and its key supplier and its key customer."* In 1996 after a large survey conducted in United States, integration seemed more supported than implemented (Neuman and Samuels 1996) and that there still is little empirical evidence of supply chain management integration (Näslund and Hulthen 2102)

Integrating the supply chain within different partners requires the use of information technology (IT) (Gunasekaran and Ngai 2004). Information technology and information systems (IS) are not only vital inside each company in the supply chain but also in between different organisations of a supply chain (Williamson et al. 2004). Based on these arguments information systems have become an integral part of supply chain management.

In relation to IT, it is important to align the IS in order to manage the supply of goods from upstream of the supply chain (Qrunfleh et al. 2012). Contractual relationship with suppliers that enable information sharing has proven to lower risks and costs (Durugbo 2014) and IT-based sharing capability seems to affect positively firms supply chain flexibilities (Jin et al. 2014). At the same time, integrating the supply chain through transaction automation requires trust between partners (Paiva et al. 2013). In order to achieve the required level of trust, and thus integration, in supply chain, building long-term relationships is vital (Prajogo and Olhager 2012). Supply chain management and integration play an important role when streamlining the relationship between partners in supply chain. Lean thinking as described in next paragraph will complement each other.

The above discussion may be concluded that supply chain integration is a vital part of developing supply chain core business processes. As a tool in improving information exchange as part of supply chain integration, information systems play a crucial role.

## 3.2. Lean thinking

The roots of lean thinking are in the automotive manufacturing and what was called Fordism with high level of vertical integration but later was adopted by Toyota as Just-In-Time (JIT) with focus on supplier partnerships (Krafcik 1988). The basic idea is that production is a continuous flow where the time elapsed between the start and completing production is minimised. Krafcik (1988) illustrates the idea through opposite concepts of buffered and lean concepts where buffered means buffer stocks all along the production chain and lean the situation where stocks are kept at minimum level at all stages. The supply chain management is naturally involved in lean production thinking because in automotive manufacturing, suppliers and part assemblers have had a large role in added value (Lamming 1996). Womack and Jones (1984) stressed that companies must unite their efforts to build a lean enterprise that forms a value stream to offer superior products and services at lower costs. Ansari and Modarress (1988) ranked major improvement activities of JIT purchasing to include smaller lot sizes, reduction of number of suppliers and forming partnership relations with them. To achieve this, MRP tools are essential in providing a master schedule and requirement picture (Aghazadeh 2003). Through the optimisation of purchase order processing, one stage at implementing lean thinking may be achieved.

## 3.3. Purchasing

Purchasing in a manufacturing company is, at its very basic, a manual work lead by calculations on material sufficiency in the warehouse. Depending on the size of the company and its manufacturing operations different systems may be used to calculate material requirements. Increased complexity in manufacturing operations often requires advanced enterprise resource planning (ERP) and material requirement planning (MRP) systems in order to form material requirements for purchasing. MRP systems have at least three advantages: it provides the calculations on dependent demand, with basic parameters the calculation is more accurate than with earlier systems and changes in production plan are taken into consideration (Aghazadeh 2003) In large companies purchasing is often divided into operational buying and strategic buying: operational buying performing the daily procurement activities at the same time as strategic buying is concentrating on tasks that have longer effect on general procurement pattern. Dobler and Burt (1996) classify materials management on three different levels: purchasing activities, procurement-process activities and supply management activities. Bilborough and Dale (1985) divide purchasing to corporate and factory buying. These different classifications clearly show the different aspects that purchasing needs to work with. Purchasing activities (Dobler and Burt, 1996) and factory buying (Bilborough and Dale, 1985) by definition are responsible for the day-to-day activities of acquiring required materials to warehouse.

Purchasing is related to items and suppliers. Items are different in nature as well as the suppliers of them. Over time, there have been several classifications of items and suppliers in different categories. In item classification Kraljic (1983) has been probably the most cited author but after, other classifications have followed, namely Olsen and Ellram (1997). Lately, Terpend et al. (2011) have attempted to verify the strategy creation based on the classifications used among professionals in large US companies without any predetermined number of purchase types. They identified similar patterns than Kraljic, Olsen and Ellram but also some new dimension on item-supplier classification. As the original Kraljic classification, the idea is based on the power situation on the market and the strategic meaning of the purchased item to the buyer.

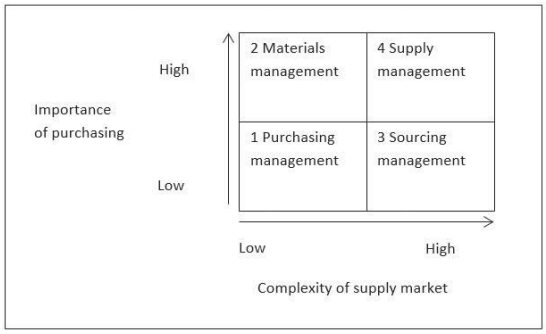


*Figure 3.1 Kraljic (1983) stages of purchasing sophistication*

In the Kraljic model in the figure above, there are four different stages that classify the purchasing sophistication in two dimensions: importance of purchasing and complexity of supply market. Purchasing management may be used when there is abundant supply of non-critical items (commodities) from local sources. Both importance of purchasing and complexity are low. The move to materials management is characterised by increasing importance of the purchasing to the company in terms of cost of material compared to total cost of the product. Sourcing management stage is characterised by increasing complexity of supply market while importance of purchasing to the company remains low. Items belonging to this category are typically bottleneck items. Not necessary representing important cost factor but posing availability issues and thus threatening the production process of the company. Supply management stage means high market complexity and high importance to profitability of the company. At this stage the importance of the materials require long term contracts on supply with central control inside the company. To shape the supply strategy, Kraljic has four phases: classification, market analysis, strategic positioning and action plans. Through this classification for the strategic items, there are three alternative strategies depending on company strength and supplier strength: where the company strength is highest, it should exploit the relationship. In the opposite, where the supplier strength is highest, the company should diversify sourcing and seek for a balance. Caniëls and Gelderman (2007) pointed out the importance of power and interdependence underlying in the Kraljic model thinking. The results of their survey indicate that a supplier dominated relationship may be found satisfactory from buyer's perspective. Terpend et al. (2011) also discuss the fact that product based classification might not always be the right one when relationships and performance characteristics are dominant. Clearly, each purchased items have their characteristics. They may be defined by their physical or relational characteristics but it is important to consider their origins and attributes related to those origins. Thus, a buyer needs to consider not only the physical attributes of the purchased items to the company but also the relationship that is created through the business relationship to the supplier of an item.

## 3.4. Business-to-business e-commerce

Based on previous sections on supply chain management, lean thinking and purchasing the context is finalised with discussion on business-to-business (B2B) e-commerce (EC).

Reason to use EC in B2B relationships is driven from changing traditional business processes to use the possibilities offered by IT. Kettinger and Grover (1993) list in their principles of business process change as fourth principle *that "Business process change should leverage*

*information technology's process, storage and communication abilities to facilitate knowledge sharing capability".* There are two important concepts of knowledge sharing and IT leveragability that are related to B2B EC. Based on the idea of Kettinger and Grover, efficient sharing of knowledge through IT tools generates performance improvements in the supply chain. To ensure the usability of IT in this knowledge sharing, both tools and standards have been created. At the same time it has to be accepted that B2B EC is only a mean to support supply chain strategies (Cassivi et al. 2005)

MRP and ERP systems are commonly in use in today's business companies (Aghazadeh 2003). Automation and process integration has often been justified by improvement in general corporate performance. This generation of superior performance has led to the fact that more and more companies and supply chains adopt these solutions. Thus adoption of MRP and ERP is also influenced by pressure from competition (Sila 2013). It has been shown that SCM IT implementations (Dehning et al. 2007) and especially ERP implementations (Bendoly and Schoenherr 2005) improve effectiveness and impact to B2B e-procurement and enhanced time-based delivery performance (Iyer et al 2008).

Implementing B2B EC offer certain advantages as discussed above. EC in B2B relationship often strengthens general business relationships because of the strategic and monetary investments required by collaborative practices (Cassivi et al. 2005; Standifer and Wall Jr 2010). But strengthening of the relationship requires trust in trading partners (Paiva et al. 2013; Sila 2013). Companies with less trust in their trading partners seem to adopt B2B EC less than others (Sila and Dobni 2012). Top management support is essential to the implementation (Sila and Dobni 2012; Sila 2013).

For SME's system (Fu et al. 2014) and data security and complexity (Sila 2013) are issues while implementing B2B EC systems and SME's have more difficulties in adopting B2B EC practices. While the information exchange itself seems rather simple matter, apparently the complexity in information exchange technology and different interfaces is not diminishing (Schubert and Legner 2011).

## 3.5. Small and medium-sized enterprise context

Small and medium-sized enterprises (SME) have been investigated largely on national contexts. Examples of these are lean procurement in New Zealand (Wilson and Roy 2009) and in Sweden (Karlsson and Åhlström 1997), ERP implementation in Norway (Zach et al. 2014) or in the Netherlands (De Loo et al. 2012) and in Portugal (Ruivo et al. 2014). In these examples one source of discussion is the restraining fact of limited resources of the SME's in relation to larger companies when implementing enterprise systems and philosophies. On purchasing and SME's the research has been scarce (Ramsay 2008). Through research in UK SME's it was found that in many companies purchasing was not a separate function and its importance was ranked very low (Quayle 2002), there was great variations in purchase activities, purchasing was not used strategically and there was little evidence of supplier evaluation (Pressey et al. 2009). A research in Swedish SME's showed that managers are reluctant to source abroad and entries to the market are often more reactive than proactive (Agndal 2006). All previously mentioned give a quite depressing view to the development of SME's in terms of processes and new technologies. On the contrary, Karlsson and Åhlström (1997) found that most of the lean principles are applicable to SME's while adaptations must be made in order to fit them into the setting where resources are scarcer than in large corporations.

## 3.6. Summary of the reviewed concepts

Based on the discussion above, as part of the supply chain management integration, purchasing should select proper strategies in order to fit different item categories and their supply patterns to fit in supply chain management integration strategies with proper information systems. Lean thinking should be applied so that all unnecessary stock holding is minimised and processes run continuously. In routine purchasing of commodities of low added value to the company, the most cost efficient way of acquiring those materials should be introduced. IT tools to apply B2B EC should be analysed to achieve this goal. When small and medium-sized companies are in case, the information systems should be simple and cost efficient to implement for not to waste limited resources of the company.

# 4. CASE DESCRIPTION

## 4.1. Definition of the automated purchase order

Cullen and Webster (2007) have created a model of B2B e-commerce that relies on connectivity and purpose. The model includes nine different scenarios for business transactions that are presented in table below

*Table 4.1 B2B e-commerce scenarios model (Cullen and Webster 2007)*

| **Scenario** | **Purpose** | **Connectivity** | **Involve an intermediary?** |
|---|---|---|---|
| Individual trading | Selling | 1 supplier – many buyers | No |
| Collaboration | Selling | Few suppliers – many buyers | Yes |
| Marketplace | Selling / buying | Many suppliers – many buyers | Yes |
| Proprietary sales | Selling / integrated | 1 supplier – few buyers | No |
| Private trading exchange | Integrated | Few suppliers – few buyers | Yes |
| Aggregation | Buying | Many suppliers – few buyers | Yes |
| Intranet / EDI | Integrated | 1 supplier – 1 buyer | No |
| Restricted bid, RFQ | Buying | Few suppliers – 1 buyer | No |
| Reverse auction | Buying | Many suppliers – 1 buyer | No |

First column of the table is the description of the scenario; the second describes the primary purpose of the user who initiates the transaction. On connectivity column is the typical structure of parties involved in the transaction and the fourth column informs if there is typically an intermediary involved in the design of the solution. This research is describing a scenario of the type Intranet / EDI that is integrated one-to-one interaction model and is efficient in dealing with large number of repeated orders (Cullen and Webster 2007). This model clearly calls for established, contractual buyer-supplier relationships and requires investments and trust from both parties.

Schubert and Legner (2011) developed five different scenarios on technical integration of B2B in global supply chains. Their model is based on a dyadic structure that is well described by previously presented as Internet / EDI in Cullen and Webster scenarios. The following table presents these five scenarios.

*Table 4.2 B2B technical integration scenarios by Schubert and Legner (2011)*

| Scenario | Main information system | System access | Use of intermediaries |
|---|---|---|---|
| 1 | Separate / different | Manual | No |
| 2 | Separate / different | Data interchange | No |
| 3 | Separate / different | Data interchange | Yes |
| 4 | Same / central | Joint use | No |
| 5 | Same / central | Joint use | Yes |

In Table 4.2, the scenarios are presented with their characteristics in system description, system access and use of intermediaries. Based on the inquiry of Schubert and Legner (2011) in their sample the most common scenario (42% of cases) was scenario 2, where parties were using their own operating system (ERP) with direct data interchange connections between buyers and suppliers. Based on these definitions, an automated purchase order scenario is defined in the following.

A prerequisite to use an automated purchase order is that contractual relationships exist with suppliers. For the items under automated purchase orders, it requires that common rules are agreed on item codes, package size, delivery times and possible safety stocks. This defines the setting to an established relationship between the two parties. To define automated purchase order, a simple definition was made. The following figure illustrates the principle of it. The figure was first presented by Rantala and Hilmola (2010) and is used here as a basis for to illustrate one possible scenario of automated purchase order.

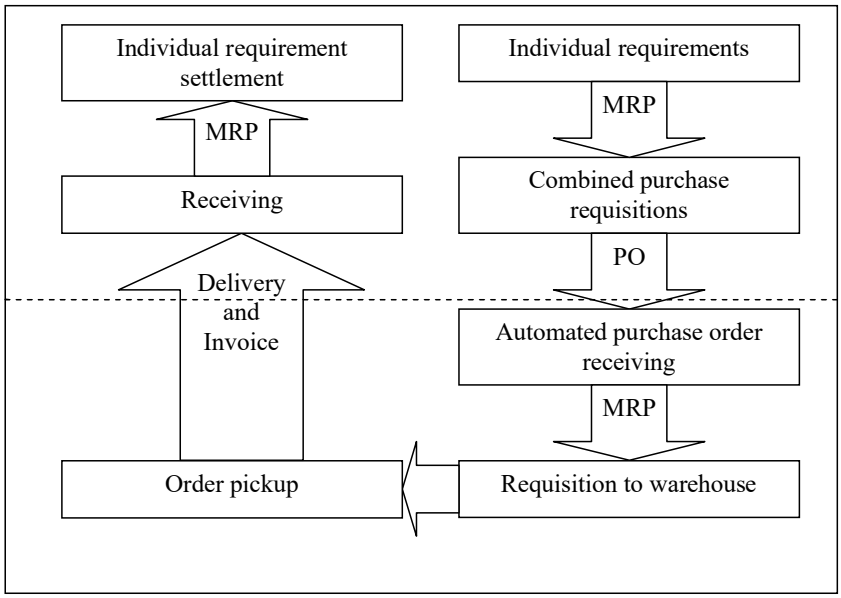


*Figure 4.1 automated purchase order process (Rantala and Hilmola 2010)*

It consists of ERP system with included MRP system at both ends of the buyer-supplier dyad. As part of the ERP system or as separate software, a system that automatically, with a set of parameters, collects purchase order proposals from ERP system and transfers them to predefined supplier in ERP system. Items have defined package sizes and orders are always made on complete packages. This order is received into the ERP system of the supplier, handled automatically and delivered without manipulation from the personnel of the selling company. The ideal situation is to work on a regular (weekly or more frequent) order pattern.

## 4.2. Data collection / operationalization

The data was collected using semi-structured interviews in 2014-2015. This method was chosen to collect not just answers to the specific questions but also to the logic behind them. The questions were designed to investigate on presumptions of the respondents on implementation of automated purchase order and its effects on inventory turns. A five-step grading was used to answer structured questions and was as follows: very likely, likely, probably, unlikely, very unlikely. After each specific question the respondents were asked to justify their answer. Open questions were asked for to find other possible benefits and pitfalls of the purchase order automation. The questionnaire was mostly directed to the persons interviewed to open their individual ideas as purchase professionals. Information on their current employer was asked in order to reveal some of their current professional background.

As in many IT system implementations, maintaining schedules and budgets are often criticised. Often their complex nature is denied which leads to unsuccessful implementation processes (Wood and Caldas 2001). It seems that the key to success even in smaller companies is to invest in proper planning and staffing of high quality (Petroni 2002). As research on Portuguese

SME:s show, ERP systems take on average 70% of the firms IT investments (Ruivo et al. 2014) and therefore are crucially important to the company's success, questions were ask in order to review respondents ideas about the cost effects of the implementation process.

There are several means to measure supply chain performance. Gunasekaran et al. (2001) classified supply chain performance measures and metrics. Based on their research, performance metrics may be classified to strategic, tactical and operational metrics. Further, these metrics are divided into financial and non-financial metrics. In financial operational metrics, inventory-carrying cost is the most cited metric in the reviewed metrics. Dehning et al. (2007) found that IT-based SCM systems improved inbound and outbound processes with first improvement in inventory turnover. Based on this information, a question of effects on inventory turns was included to the questionnaire to reflect the impact of process automation to a key financial measure.

Based on the Kraljic (1983) it is important to optimise the cost of acquisition of commodities and items of low value added to the company. In relation to this, questions about the applicability of automated purchase order to items were asked.

## 4.3. Case companies described

Interviews were made within four manufacturing companies in different industries in order to see ideas of professionals of purchase order automation and possible experiences on the related projects. The companies were divided in the following way: one in electronics industry (company A), one in automotive industry (company B) and two in general machine building industry (companies C and D). The characteristics of the companies are described in Table 4.3. The selection of companies was made with the principle that they had to be manufacturing companies.

Company A in electronics industry is working on contract manufacturing business. Company B in automotive industry is a supplier to automotive manufacturers and the companies C and D in general machine building industry are original equipment manufacturers. Number of purchased items varied between 3 000 and 8 000 items and the number of suppliers of those items was from 40 to 200 different suppliers. The companies were also asked to tell, how many suppliers supply 80% of the purchases in monetary terms. The answers varied between 10 and 30 suppliers. As of monetary volume, the amount of annual purchases varied between 6 and 10 million euros.

The amount of so-called passive items out of monetary value of the inventory was asked. These passive items were defined as items with inventory to be sufficient for a year or more with current demand. Company A had only 6% of inventory of this kind of items. This is easily explained by the fact that items are bought mostly after the orders from OEM companies. This helps in controlling the inventory turns compared to OEM manufacturers. Company D had only 5% of the slow moving inventory. This is due to fact that most of the purchased items are made to measure due to the high customisation of end products. Companies B and C with own product development and their slow moving inventory were 20-30% of the total inventory value. The reasons for high slow moving items were due to discontinued products and safety stocks of discontinued components.

*Table 4.3 Characteristics of interviewed companies*

| **Company** | **A** | **B** | **C** | **D** |
|---|---|---|---|---|
| Industry | Electronics manufacturing | Automotive | General machinery | General machinery |
| Purchase type | Components | Components, parts and products | Components, parts and products | Components and parts |
| Number of items | 7 000 – 8 000 | 6 000 | 3 000 | 4 000 |
| Number of suppliers | 200 | 150 | 150 | 40 |
| No. of suppliers delivering 80% of purchases | 30 | 15 | 15 | 10 |
| Yearly purchase volume (millions EUR) | 6-7 | 10 | 10 | 7-8 |
| Share of slow moving items | 6% | 30% | 20% | 5% |
| Seasonal demand peaks | No | No | No | Yes |
| Number of yearly peaks | 0 | 0 | 0 | 1 |
| Share of demand during peaks | 0 | 0 | 0 | 75-80% |

There were also questions concerning seasonal peaks in demand. This question was formulated in order to identify the seasonality patterns of the demand. The definition of peaks was left rather open and only characterised by situation where large changes in demand were observed on a seasonal manner. Only company D identified peaks in the demand and in their case the peak was rather large compared to the annual volume: the company estimated that one peak represented 75-80% of annual demand.

Persons interviewed were of different functions in the companies. The main criterion for selecting persons interviewed was the experience in purchase activities. Their current position was also purchase related. In companies B and D the persons interviewed were mostly in managerial positions; in companies A and C the persons were in clerk or expert positions in their respective organisation. The experience in purchase functions for the interviewed persons in companies A, C and D was over 10 years, for the person in company B the experience was only a few years.

For the IT systems used, all companies had ERP and MRP systems in place to support purchasing. In companies A, B and D a regular forecasting pattern towards suppliers was in use. In company B an automated purchase order system was used. All companies purchased the items directly from suppliers but in company B there were also centralised purchases on the corporate level that the company was using in part of the material supplies. Company B thus has a corporate purchase department in addition to purchase departments in regional companies with company B being one of the regional companies. The use of corporate pooling was limited because of the corporate negotiated lot sizes were too large for the subsidiary. Purchase orders in the companies are done one by one. Companies A, C and D use also scheduled orders based on yearly contracts. This means that yearly purchase volume has been agreed with supplier

having certain inventory level reserved. For the company B, an automated purchase order system was in use that was based on a weekly scheduling instead of single purchase orders.

## 4.4. Perceptions on automated purchase order system

Perceptions on the automated purchase order were quite unanimous in the interviewed group. The technical implementation was estimated to take time by the companies A, B and C. They argued that cleaning up the item basic data was the main obstacle for fast implementation. Some concern was also directed to the technical readiness of the existing systems. Company C pointed out that if there is no reliable sales forecast, the implementation is not possible at all. Companies A and D argued that project management and increased investments were drivers to speed up technical implementation.

The costs of implementation were estimated to remain probably in the budget. When asked for reasons for this answer, the respondents were quite confident that if the plan and current state ERP analysis was made thoroughly, the only risk on cost side was the possible system supplier and the competence of their consultants. Respondents A and D emphasized the importance of the preparatory work and resourcing of the assisting persons inside the company.

The respondents were asked whether all of the company's purchased items were suitable to be purchased based on the automated purchase order. The answer from all respondents was that it is not possible. There were several reasons mentioned including short life cycles, uncertain forecast, large seasonal variations in demand, project based demand. The obvious result was that only items with stable demand pattern were eligible to automated purchase order. A controlling question was asked whether items with stable demand pattern could be automated. The answers were all very likely. In reasoning the automation was seen only a technical issue.

On question about the influence on automated purchase order on inventory values, the respondents considered the inventory turns to improve moderately due to the purchase order automation. There were many aspects to support this. Firstly, it was seen that the increased control over items in inventory was improving the turns. As well, the impact of human error was mentioned in three out of four answers meaning that when system calculates and regulates the flow of incoming goods, the speculation of the future needs is reduced or eliminated from the order processing.

For the general benefits of the system the most important was the release of human resources to more productive work and reduction in human resource costs. It seemed the benefits depended on the size of the company. More the company had operative buyers, more cost benefits were seen. In smaller companies a shift to more productive work was emphasised.

The cons of the automated purchase order were related to the blindness and loss of control to the order process. When the order processing no longer is under a person's control, it raises fears of a system that is no longer under control. So it was seen that in case of purchase order automation, some systems should be created in order to monitor the system performance and actions. Threats were also seen in the occurrence of false item basic data that more easily translates into unwanted inventory or problems in supply depending on the failure in setting up basic data.

## 4.5. Purchase order process and automation experiences of company B

The interviewed company B had been running an automated purchase order system for 18 months and the overall results are positive. The company uses three different purchase order

methods: single purchase orders, vendor managed inventory (VMI) and automated purchase orders. Single purchase orders are applied to items that are rarely needed. The reasoning for this was that then they are not ordered over the actual need. The automated purchase order system was described as follows.

In the automated system, the company does not make any separate orders but updates a delivery schedule. On Fridays, a new requirement plan is run to the system. On Sundays, new supply plan is distributed to suppliers including frozen supply window that will no longer change in the forthcoming plans. This window is from one to four weeks depending on the item type and agreement reached with the supplier. The company B always wishes to freeze the fixed window to a week but suppliers often request a longer period up to four weeks. Items are supplied from the suppliers based on the plan. Only deviations to actual supply are communicated from supplier to company B. If there is no reaction from supplier side, the items will be delivered based on the plan on the frozen periods. The supplier always receives demand information on 12 months but can limit the view for example to three months independently. Company B normally has knowledge of 60% of the demand up to six months in beforehand.

The implementation took some 6 months. Most of the work was related on cleaning the ERP system basic data and correcting purchased item information. Soon after the implementation it became clear that additional reporting is needed on items in the warehouse. Several causes of disturbances were identified: batch arriving to inventory with no future needs, arriving batch was far too large for the current demand pattern. To find answers to these occurrences, the company B needed to improve warehouse reporting. The respondent estimated the item basic data clean-up to take yet more time while the system is in use.

The cost of implementing the system was estimated to have remained in the budget, but this was not completely proved because of the difficulties in following and costing own work in the project. In this case there was support from corporate headquarters to the subsidiary. The system had been implemented previously in other subsidiaries meaning that an internal process had been defined to the implementation process.

The benefits of the purchase order automation were estimated substantial. There was a certain increase in inventory turns but that was mostly attributed to the line-up and cleaning of item basic data. The most important benefit was the reduction of personnel in purchase order management from five to three persons meaning a 40% reduction of costs on that area. There was a change in tasks of the remaining purchase personnel from individual order follow-up to supplier negotiation tasks (eg. prices, lot sizes, quality issues etc.). The current status is that 80% of the items are moved to automated order processing.

A change was also observed at supplier side. Some suppliers realised the benefits of order and lot size reduction to their own processes. Previously, when lot sizes were higher or not controlled, orders created a peak in demand. Through the lot size reduction and increased delivery frequency, there have been improvements in responsiveness and scheduling in suppliers' internal processes improving also the cash flow in both supplier and buyer. As well, increased visibility was found beneficial as company B was willing to share their demand data for several weeks to come.

Negative experiences relate to the blindness of the situation that creates uncertainty without proper reporting on the inventory. Item basic data must be followed and updated continuously in cases of changes in demand due to end-of-life, product mix change, etc.

## 5. DISCUSSION

Based on the results of the interviews, the respondents seem to agree on several ideas. Implementing automated purchase order system takes time and effort, notably in reviewing item basic data. The cost seems not to be an issue as long as the implementation process has been well defined. Implementation team has a most important role in the implementation. Crucially important is the commitment of qualified personnel from the consulting company. These same ideas were identified in a study on Canadian SME:s for ERP implementations (Snider et al. 2009) As the example of company B shows, a well-defined implementation process helps the success of the process.

On items to be automated, critical success factor was quite clear to the respondents: it is not possible to automate purchasing of all items but those with stable demand and long life cycle. Based on the interviews a demand pattern based classification appeared: items with unstable demand with classic manual purchase orders, items with more stable demand to be purchased with automated purchase order or through vendor managed inventory (VMI) as was found in case of company B. The underlying idea or even requirement for the purchase order automation is the existence of contractual relationship with a supplier that includes terms in relation to safety stocks and lead times. Safety stocks are not mandatory if supplier is able to produce with a constant volume to ensure availability. Therefore it seems not to be important which items are moved to automated purchase order as long as the buyer supplier relationship and items with it are stable enough in demand and life cycle. This supports the idea of Terpend et al. (2011) that product based classification might not always answer to the question, which strategy to use but also the relationship built in between the parties.

The discussion between automated purchase order and VMI is interesting due to some similarities: both require contractual relationship and some security of demand over a certain time. What is separating VMI from automated purchase order is the fact that supplier is willing to invest in inventory holding in customers premises. This means that in VMI there is an inventory but with automated purchase order inventory holding is not necessary in case the supplier's production process is able to follow customer demand pattern. Schubert and Legner (2011) concluded that in fact VMI requires stronger information processing needs than order-based relationship. This reveals also something about automated purchase order systems. A system where single purchase orders are sent periodically to suppliers might not be as intensive relationship wise than the example of company B where the customer sent a long term forecast with frozen order period. Even that case might not be as binding between parties because in VMI also the supplier reveals more to customer in terms of inventory holding levels.

This relationship building does not necessary tell about power but certainly of interdependence as well as trust. In case of power, Caniëls and Gelderman (2007) found that suppliers are perceived to dominate satisfactory relationships. This would mean that formation of successful automated purchase order setting would involve a stronger, trusted partner that an SME can rely on in the supply of needed items. Somehow this is in conflict of the model presented by Kraljic (1983): he sees increasing power of suppliers a reason for the company to diversify sourcing. In case of SME's that would no longer be the case but the most successful strategy would be to build a strong relationship to this dominant supplier. The Kraljic model seems also more suitable to a frame with large organisations and large supply volumes. In case of company B, head office was supporting the subsidiary through supply contracts and system support. This means that the head office has most probably done the tasks of analysing item and supply base, possibly through an application of Kraljic model or similar.

What then comes to the application of corporate policy to the subsidiaries, a decision to transfer an item to automated purchasing may as well fit to a strategic item with stable demand and long life cycle as well as to a commodity with similar attributes. The key is that supply is stable whether it is realised through warehousing of the items or a flexible manufacturing solution (lean, JIT, etc.) and has adapted information systems.

On the other hand, strong relationships with suppliers include the risk of stagnation of the purchasing dynamics. This means that when relationships are built, there might be the possibility that price levels are fixed with less interest to search for alternative sources of supply. Partly, this is probably a result of purchase professionals' preference of supply security over cheapest price.

From SME's viewpoint, automated purchase order is a desirable way of following a supply chain integration strategy. It should not be forgotten that purchase order automation is a small part of IT strategy inside supply chain integration. The economic restraints are best seen in reliance on software consultant use. While company B as small subsidiary of a large corporation received guidelines and ready software tools to implement purchase order automation, independent companies need to run towards ready solutions and seek for experienced consultants to find best solutions. As pointed out by Zach et al. (2014) many SME's do have the IT knowledge to implement complex systems. In view of resources the investments are often quite large for small companies (Ruivo et al. 2014)

The experiences of company B are relevant to the results of the other respondents. Experienced benefits were including reduction of labour in routine purchasing tasks. Persons previously charged with daily purchasing were able to move to more productive and proactive tasks and create value through e.g. price negotiations. This was identified as the root cause of moving to the automated purchase order system. Increase in sharing information and continuous flow of products benefitted both supplier and buyer. The following picture summarizes the perceived benefits of automated purchase orders in company B.

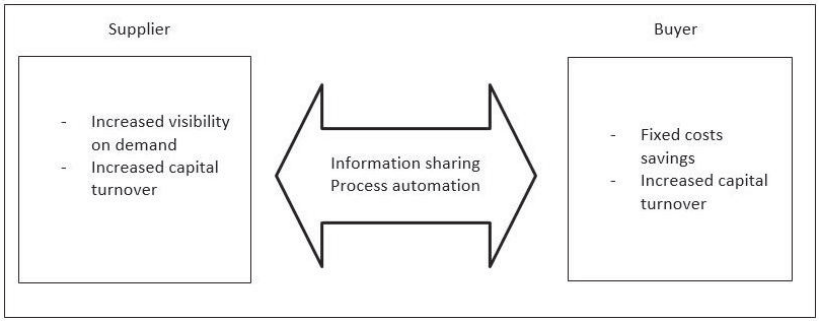


*Figure 5.1 perceived benefits of automated purchased order*

As may be seen, the perceived benefits are in concordance with lean purchasing and their goals (Ansari and Modarress 1988). Through reduction of lot sizes, increased delivery frequencies and trusted partnership with suppliers, both parties can enjoy fixed cost savings and increased capital turnover with more stable production processes.

From the negative effects of purchase order automation the company B identified the blindness of buyers to the real materials flow. This meant that controls needed to be built up to secure

correct function of the system. In other case companies the answers were not so precise but they all identified a sort of "blindness" that was related either to the malfunctioning of the system or to the incorrect basic data. This derives the danger that if the system is uncontrolled and incorrect basic data is influencing purchase orders, the situation may cause either shortages or unnecessary stocks of materials.

As stated by van Hoek (2001) it should be secured that supply chain management and the use of IT in it does not remain on fragmented parts of a supply chain but that higher goals are set in order to achieve strategic and integral view of the e-supply chain. Therefore, in enhancing the supply chain performance will require that supplier management practices are aligned with IS strategy (Qrunfleh 2012). Also the examined phenomenon is a dyadic integration of information between a buyer and a supplier which is still far of real supply chain management integration (Näslund and Hulthen 2012).

## 6. CONCLUSIONS AND FUTURE RESEARCH

Based on this research, purchase order automation is an important topic in streamlining daily routines in purchase-related tasks. Purchase order automation has potential and some proven track in reducing fixed costs and adding value to the work of purchase professionals. Purchase order automation seems to add rigour to the item basic data update. That finally is the way of improving the use of working capital. Implementation of automated purchase order gives way of increasing the importance of key supplier relationships. Implementation process itself needs focus and rigour to achieve a reliable and cost efficient system. Implementation should also follow and complement the overall IT strategy. For SME's economic realities may restrain the application of the solution but it is also possible to implement it without large IT investments.

There are also some problem areas. While automated purchase order increases the importance of selected suppliers, it also stiffens the supplier network structure and possibly blurs the price level knowledge of the market. Inside the company "blindness" to the material flows and system total influence to the inventory level requires additional controls to monitor warehouse levels of components and their key performance indicators.

The discussion raises questions about several interesting areas of research. Firstly, automated purchase order processing or B2B EC is a topic that is interesting to professionals. Tools on this area are developing constantly and their applications may be done in many different ways. There are clearly many ways of implementing it and larger samples should be collected to investigate the phenomena. Purchase order processing and use of different ordering methods (purchase orders, VMI etc.) is an interesting topic also on a relationship view as well as their impact on key financial metrics.

Buyer-supplier relationships and their impact on supply strategy is a widely discussed issue. Development for models based on relationships would be interesting viewpoint in addition to current item or product based taxonomies. It seems that a trusting relationship with a supplier does not necessarily limit the spectrum of goods purchased from the supplier.

## REFERENCES

Aghazadeh, S-M (2003) MRP contributes to a company's profitability. *Assembly Automation*, 23, 3, 257-265

Agndal, H. (2006) The purchasing market entry process – A study of 10 Swedish industrial small and medium-sized enterprises *J. of Purchasing and Supply Management* ,12, 182-196

Ansari, A.; Modarress, B. (1988) JIT purchasing as a quality and productivity centre *Int. J. of Production Research* ,26, 1, 19-26

Barrat, M.; Choi, T.Y.; Li, M. (2011) Qualitative case studies in operations management: Trend, research outcomes, and future research implications *J. of Operations Management* , 29, 329-342

Bendoly, E.; Schoenherr, T. (2005) ERP system and implementation-process benefits *J. of Operations & Production Management* ,25, 4, 304-319

Bilborough, C.A.M; Dale B.G. (1985) The Role and Influence of Factory Level Purchasing within a corporate structure *Int. J. of Physical Distribution and Materials Management*,15,1,39-48

Caniëls, M.C.J; Gelderman, C.J. (2007) Power and interdependence in buyer supplier relationships: A purchasing portfolio approach *Industrial Marketing Management*, 36, 219-229

Cassivi, L.; Léger, P.-M.; Hadaya, P. (2005) Electronic commerce and supply chain integration: the case of the telecommunication equipment industry, *Business Process Management J.*,11,5,559-572

Christopher Durugbo (2014) Managing information for collaborative networks *Industrial Management &Data Systems*,114,8,1207-8

Croson, R.; Donohue, K.; Katok, E.; Sterman, J. (2014) Order Stability in Supply Chains: Coordination Risk and the Role of Coordination Stock *Production and Operations Management* , 23, 2 176-196

Cullen, A.J.; Webster, M. (2007) A model of B2B e-commerce, based on connectivity and purpose *Int. J. of Operations & Production Management* ,27, 2, 205-225

Dehning, B.; Richardson, V.J.; Zmud, R.W. (2007) The financial performance effects of IT-based supply chain management systems in manufacturing firms *J. of Operations Management* , 25, 806-824

De Loo, I.; Bots, J.; Louwrink, E.; Meeuwsen, D.; van Moorsel, P.; Rozel, C. (2013) The effects of ERP-implementations on the non-financial performance of small and medium-sized enterprises in the Netherlands *Electronic J. of Information System Evaluation* ,16, 2, 101-113

Dobler, D. W.; Burt, D. N. (1996) Purchasing and Supply Management –Text and Cases 6th ed. McGraw–Hill

Ellram, L.M.; Cooper, M.C. (2014) Supply chain management: it's all about the journey, not the destination *J. of Supply Chain Management* ,50, 1, 8-20

Fu, H.-P.; Chang, T.-H.; Ku, C.-Y.; Chang, T.-S.; Huang, C.-H. (2014) The critical success factors affecting the adoption of inter-organization systems by SMEs *J. of Business and Industrial Marketing* ,29, 5, 400-416

Gunasekaran, A; Ngai, E.W.T. (2004) Information systems in supply chain integration and management *European J. of Operational Research* ,159, 269-295

Gunasekaran, A; Patel, C.; Tirtiroglu, E. (2001) Performance measures and metrics in a supply chain environment *Int. J. of Operations & Production Management* ,21, 1/2, 71-87

Iyer, K.N.S.; Germain, R.; Claycomb, C. (2009) B2B e-commerce supply chain integration and performance: A contingency fit perspective on the role of environment *Information&Management*,46,313-22

Jin, Y.; Vonderembse, M.; Ragu-Nathan, T.S.; Turnheim Smith, J. (2014) Exploring relationships among IT-enabled sharing capability, supply chain flexibility, and competitive performance *Int. J. of Production Economics* ,153, 24-34

Karlsson, C.; Åhlström, P. (1997) A lean and global smaller firm? *Int. J. of Operations & Production Management* ,17, 10, 940-952

Kettinger, W.J.; Grover, V. (1993) Toward a Theory of Business Process Change Management *J. of Management Information Systems* ,12, 1, 9-30

Krafcik, J.F. (1988) Triumph of the Lean Production System *Sloan Management Review* ,30, 1, 41-52

Kraljic, P. (1983) Purchasing must become supply management *Harward Business Review* (61:5) 109-117.

Lamming, R. (1996) Squaring lean supply with supply chain management *Int. J. of Operations & Production Mgmt*,16, 2, 183-196

Leger, P-M; Riedl, R; vom Brocke, J. (2014) Emotions and ERP information sourcing: the moderating role of expertise *Industrial Management & Data Systems* , 114 , 3 456 – 471

Mentzer, J.T.; Stank, T.P.; Esper, T.L. (2008) Supply chain management and its relationship to logistics, marketing, production, and operations management *J. of Business Logistics*,29,1,31-46.

Neuman, J.; Samuels, C.(1996) Supply chain integration: vision or reality? *Supply Chain Management:An Int.J.*,1,2,7-10

Näslund, D.; Hulthen, H. (2012) Supply chain management integration: a critical analysis *Benchmarking: An Int. J.* ,19, 4/5, 481-501

Olsen, R.F. and Ellram, L.M. (1997) A portfolio approach to supplier relationships, *Industrial Marketing Management* (26:2) 101-113

Paiva, E.L.; Marques Vieira, R.T.L.; Beheregaray Finger, A. (2014) Supply chain planning and trust: two sides of the same coin, *Industrial Management & Data Systems*, , 114 ,3 405 – 420

Petroni, A. (2002) Critical factors of MRP implementation in small and medium-sized firms *Int. J. of Operations & Production Management* ,22, No3. 329-348

Prajogo, D.; Olhager, J. (2012) Supply chain integration and performance:The effects of long term relationships, information technology and sharing, and logistics integration *Int. J. of Production Economics*,135,514-522

Pressey, A.D.; Winklhofer, H.M.; Tzokas, N.X. (2009) Purchasing practices in small- to medium-sized enterprises: An examination of strategic purchasing adoption, supplier evaluation and supplier capabilities *J. of Purchasing & Supply Management* ,15, 214-226

Qrunfleh, S.; Tarafdar, M.; Ragu-Nathan, T.S. (2012) Examining alignment between supplier management practices and information systems strategy *Benchmarking, An Int. J.*,19,4/5, 604-617

Quayle, M. (2002) Purchasing in small firms *European J. of Purchasing & Supply Management*, 8, 151-159

Ramsay, J (2008) Purchasing theory and practice: an agenda for change, *European Business Rev.*,20,6,567-69

Rantala, L.; Hilmola, O-P (2010) Analysis of two different automated purchase order systems in telecom electronics manufacturing unit. *Int. J. of Manufacturing Technology & Management* ,19, 1/2, 140-164

Ruivo, P.; Oliveira, T.; Neto, M. (2014) Examine ERP post-implementation stages of use and value: Empirical evidence from Portuguese SMEs *Int. J. of Accounting Information Systems*,15,2,166-184

Schubert, P.; Legner, C. (2011) B2B integration in global supply chains: An identification of technical integration scenarios *J. of Strategic Information Systems*,20, 250-267

Sila, I. (2013) Factors affecting the adoption of B2B e-commerce technologies *Electronic Commerce Research*,13,199-236

Sila, I.; Dobni, D. (2012) Patterns of B2B e-commerce usage in SMEs *Industrial Management & Data Systems* ,112, 8, 1255-1271

Snider, B.; da Silveira, G.J.C.; Balakrishnan, J. (2009) ERP implementation at SME:s: analysis of five Canadian cases. *Int. J. of Operations & Production Management*, 29, 1, 4-29

Standifer, R.L.; Wall Jr., J.A. (2010) Conflict in Business-to-Business e-Commerce (B2B): A Study of B2B Relational Structure and Perceptions of Conflict, Power, and Relationship Success *Negotiation and Conflict Management Res.,* ,3,3, 205-231

Terpend, R.; Krause, D and Dooley, K.J. (2011) Managing Buyer-Supplier Relationships: Empirical Patterns of Strategy Formulation in Industrial Purchasing *J. of Supply Chain Management*,47,1, 73-94

van Hoek, R.I. (2001) E-supply chains – virtually non-existing *Supply Chain Management: An Int. J.* ,6, 1, 21-28

Williamson, E.A.; Harrison, D.K.; Jordan, M. (2004) Information systems development within supply chain management *Int. J. of Information Management* , 24, 375-385

Wood, T.; Caldas, M.P. (2001) Reductionism and complex thinking during ERP implementations *Business Process Management J.* , 7, 5, 387-393.

Womack, J.P.; Jones, D.T. (1994) From Lean Production to the Lean Enterprise *Harvard Business Review* ,72, 2, 93-103

Yin, R.K. (1981) The Case Study Crisis: Some Answers *Administrative Science Quarterly* ,26, 1, 58-65

Yin, R.K. (2003) Case Study Research – Design and Methods. 3rd Ed., Applied Social Research Methods Series, 5. Sage Publications

Zach, O.; Munkvold, B.E.; Olsen, D.H. (2014) ERP system implementation in SMEs: exploring the influences of the SME context. *Enterprise Information Systems*, 8, 2, 309-335