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Supply Chain Management in Small and Medium-sized Enterprises

A Master's Thesis submitted for the degree of
"Master of Science"

supervised by
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Vienna, 03.11.2011

Affidavit

I, **Thomas Linder**, hereby declare

1. that I am the sole author of the present Master's Thesis, "Supply Chain Management in Small and Medium-sized Enterprises", 84 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted this Master's Thesis as an examination paper in any form in Austria or abroad.

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Signature

ACKNOWLEDGEMENT

I would like to take this opportunity to thank the people who have helped to make this work possible.

First and foremost, I would like to thank my supervisor, Prof. Dr. Peter Kopacek for his guidance through the Engineering Management program and through the writing of this thesis.

I wish to thank Ms. Daniela Mähr for supporting me during the time I took part in this program and my parents for their continuous support in every stage of my life.

And finally, I would also like to thank the lecturers and participants of the Engineering Management course of 2010/2011 for the knowledge exchange during the whole program; it's been a great time.

ABSTRACT

This master's thesis evaluates different methods in Supply Chain Management with a special focus on their use in Small and Medium-sized Enterprises (SMEs).

Whereas there are lots of methods regarding Supply Chain Management which are already implemented in Large Enterprises such as the automobile industry and its suppliers and which are well documented in literature, only some of them are applicable to Small and Medium-sized Enterprises due to various restrictions. This work selects existing methods and evaluates them regarding their potential and their requirements for use in the limited and restricted environments of SMEs. Although a large number of methods exist, only the most promising are selected and analyzed in a more detailed way. These methods include principles based on Lean Supply Chain Management, Agile Supply Chain Management, Kanban, Supply Chain Networks and Sustainable Supply Chain Management.

The second part is dedicated to recent technologies (ERP, RFID) which can be used to support the task of Supply Chain Management. These new trends can be implemented in SMEs without requiring too much personnel and support SMEs in their daily work not only regarding the supply chain.

The reason for this work is to show SMEs how they can improve their supply chain processes to leverage additional potential. This could result in new possibilities for SMEs without having to account for a large increase in staff and system knowledge which in turn reduces costs. The result of this work shows that there are methods which can be used effectively in SMEs, how they can be applied and which limitations exist.

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1 INTRODUCTION

Supply Chain Management is a topic which is usually not taken into account in SMEs although it can change the business environment significantly. When an enterprise comes to life, there are usually more pressing issues at hand which need to be taken care of. These include but are not limited to legal restrictions, economic concerns and also human resource management or project management.

Once a company starts to grow and reaches around ten or more employees the need for a coordinated procurement of goods comes up since no one will be able to track incoming and outgoing goods without a specialized tool anymore. This tool usually comes in the form of an ERP system, not so much in a specialized supply chain application. Yet, since many ERP systems are able to handle the basic requirements of supply chain management, this is a good starting point.

Once such a system is in place, there are requirements which need to be met, such as minimum transport cost and maximum profit gain. Looking at the value chain, no unnecessary work must be added to allow for maximum profit. This thesis explains which tools support this process regarding the supply chain and how their potential can be leveraged in such small enterprises.

Starting from the definition of Supply Chain Management we will explain the difficulties of Small and Medium sized Enterprises. After these problems have been explained, multiple management theories will be shown which could support SMEs in their effort to implement an efficient supply chain. All of these methods are evaluated regarding their potential for SMEs and their area of application.

This thesis is meant as a practical guide for SMEs that need to improve their supply chain. Depending on their specific needs, such an enterprise should be able to select an instrument that matches its business area and requirements. Regarding this thesis, the focus was production oriented enterprises in Europe and North America.

2 FUNDAMENTALS OF SUPPLY CHAIN MANAGEMENT

2.1 Introduction

The term Supply Chain Management (SCM) describes all tasks involved in planning and managing the relationships with suppliers and customers required to design, make, deliver and use a product or service. In the past, it has evolved from a necessary side issue into its own business area. Furthermore, with the possibility of reaching every point on earth within a day, it has evolved from a regional issue and now has to be seen from a global perspective. This does not only hold true for large international enterprises but also for smaller companies. The following chapter will give a short idea of the tasks and goals of Supply Chain Management. Furthermore, we will focus on some problems and concepts which are very common in Supply Chain Management.

2.2 Definition

A formal definition according to the CSCMP (Council of Supply Chain Management Professionals) is:

"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. Supply Chain Management is an integrating function with primary responsibility for linking major business functions and business processes within and across companies into a cohesive and high-performing business model. It includes all of the logistics management activities noted above, as well as manufacturing operations, and it drives coordination of processes and activities with and across marketing, sales, product design, and finance and information technology." (CSCMP, 2010)

In slides from McGraw-Hill / Irvin, a more narrowed, company-specific definition is used (The McGraw-Hill Companies, 2006):

“Supply-chain management is a total system approach to managing the entire flow of information, materials, and services from raw-material suppliers through factories and warehouses to the end customer”

It is important to understand that SCM is not only focusing on a single company with its suppliers and customers but eventually goes further by building partnerships with those involved parties to form a complex network with supplier’s suppliers and customer’s customers (Figure 1). Ideally this will range from the end customer who purchases a final product to the producer of the raw materials which are required in the process.



Figure 1 - Extended Supply Chain Relationships

In such a complex network, not only the material flow will be of interest. This network can also contain information about forecasting, product quality issues and much more, depending on the business values.

2.3 Need for Supply Chain Management

As companies are continuously increasing their efficiency, they are also trying to find new sources and new customer markets. Especially with the effects of globalization, enhancing the supply chain has become an issue for many firms – not only for international enterprises but also Small and Medium Enterprises (SMEs). Other factors for requiring a good supply chain management is general competitive pressure, an increase of importance in e-commerce, inventory reduction, outsourcing and costs for transportation, especially when looking at sustainability.

In (Chopra & Meindl, 2001) the authors identify four main drivers.

- Facilities – these are also labeled Production in (Hugos, 2003): This is the process to make products out of raw materials. According to (Hugos, 2003) there is usually a gap between responsiveness and efficiency in production. This covers both the production of goods as well as storing them (warehousing).
- Inventory: Looking at the supply chain from supplier to customer there are multiple types of inventory. Inventory can be internal such as goods which are waiting for the next production step but can also be external such as finished goods, waiting to be transported to the customer. Inventory is also often categorized as cyclic inventory, buffer inventory or seasonal inventory. The first one is the amount of inventory required between two orders to be able to fulfill the customer's demand. Buffer inventory is seen as safety stock in case of unforeseen problems due to transportation or economic issues. Seasonal inventory is stocked up material which is usually used during a specific season of the year. A company does not necessarily need to employ all three types.
- Transportation: The process of moving goods from one facility to another is another driver. In general, there is always a tradeoff between costs, flexibility, speed and safety. In (Hugos, 2003), six different possibilities for transport are outlined.
 - Ship
 - Rail
 - Pipelines
 - Trucks
 - Airplanes
 - Electronic Transport
- Information: This is the central point. The information flow must not only happen within the other four items but should also flow to suppliers and customers to form a tight network. Yet, it is important to keep in mind, that the more information flows between members of the supply chain network, the more of this information could be used by potential rivals or competitors.

In (Hugos, 2003), a fifth element is given additionally to the drivers mentioned above.

- **Location:** Although closely intertwined with transportation, this factor should be mentioned as well, not only because it can be seen from two sides. On the one side, having a supplier being close to you will yield less transportation cost and will also usually provide higher flexibility. On the other hand, labor costs could be higher or the product price might be higher. All these issues must be taken into account when selecting a new fab location or choosing a new supplier.

2.4 Supply Chain Management vs. Logistics

If you compare Supply Chain Management to Logistics, there are different interpretations of how Logistics is related to SCM. In many books, logistics is considered a part of Supply Chain Management. Others state that the two of them are actually the same. The idea I would like to follow here is that Supply Chain Management spans over multiple involved companies and includes aspects of material and knowledge flow throughout these companies whereas Logistics is related to material and information flow within a single company. This idea is given in (Hugos, 2003) and is a good compromise between the two prevailing ideas.

2.5 Tasks in Supply Chain Management

Supply Chain Management is the integration of activities which can include but are not limited to:

- **Sourcing and Procurement / Purchasing / Forecasting:** We need to have raw materials available when they are actually required and they need to be procured at the best possible cost. It becomes especially important when you can save money by planning ahead and is closely related to finance.
- **Production planning and control:** This is the process of transforming raw materials into finished goods in an efficient manner by planning ahead.
- **Order processing:** This is the process of picking finished goods and deliver them to the next station in the supply chain
- **Inventory management:** This is about specifying the amount of goods on

stock to allow for continuous production and specifying where these goods should be placed to keep the production efficient within the boundaries of the facility.

- Customer Service: This integral part deals with handling customers before, during and after any sales operation. Depending on the business, the requirements for customer service can change heavily. Customers can be either end users or further processing industries.
- Recycling: Especially with today's environmental responsibility efforts, recycling has become a more and more important topic. Also, sustainability of the produced goods has become more and more important in the past years.
- Marketing and Product Development / R&D: This describes the process of bringing a new product into the market with everything that is related from the beginning by evaluation of customer's needs through the product design phase and the launch of the product to providing strategies for sales.
- Finance: This includes dealing with the daily business as well as planning ahead which is essential for inventory and therefore the production.
- Information: Which and how much data should be collected? How can this data be used for any of the other tasks outlined above? Especially regarding performance measurements it is important that data is immediately available so possible problems can be eliminated beforehand. Therefore, the flow of information needs to be taken care of. Yet, by generating and/or receiving too much non-important information this could lead to a decline in efficiency.

These topics pointed out here only refer to tasks related to Supply Chain Management within a company or within direct suppliers or direct customers. Further management tasks when dealing with larger supply chain systems include the management of company relations, thereby improving communication and behavior.

2.6 Goals of Supply Chain Management

The goals of Supply Chain Management are manifold. There is a definition which summarizes these goals very well.

“The goal of supply chain management is to increase sales of goods and services to the final, end use customer while at the same time reducing both inventory and operating expenses.” (Hugos, 2003)

Seen from a different perspective, the main idea behind Supply Chain Management is to achieve a competitive advantage. Mentzer describes this as follows:

“From the foundation of these managerial conclusions (given above), we can begin to discuss SCM as a source of competitive advantage. Our first example illustrates how this all-encompassing approach to a ‘systemic, strategic orientation’ can lead to competitive advantage, especially when we realize that the final consumer can be considered one of the ‘three of more companies directly linked by the supply chain flows’” (Mentzer, 2004)

2.7 Supply chain and business strategy

The supply chain should be designed in a way which supports the business strategy. This means that first and foremost it is the customer who requires a certain level of responsiveness. On the other hand, the processes in the supply chain need to be efficient to allow for reasonable pricing. These two issues are not necessarily mutually exclusive. By designing the supply chain in such a way that the customer’s requirements can be met while still keeping a normal pricing level it is possible to gain a competitive advantage in the market, thus resulting in a higher market share compared to a competitor with similar products but less powerful supply chain instruments.

In (Hugos, 2003) three steps to align supply chain tasks to business strategy are outlined in detail.

1. Understand the requirements of your customers
2. Define competencies / roles your company will have to serve the customers
3. Develop supply chain capabilities to support the roles your company has chosen

Whereas these three points are certainly true and useful, a fourth point should be added to allow for future changes.

4. Continuously monitor, reevaluate and if needed realign your supply chain instruments to support your company's changing business strategy.

Especially in today's fast changing markets and with the current possibilities which globalization introduces, there is a constant change. This change doesn't necessarily affect the business strategy, but it affects the relationships with suppliers and customers. Therefore not monitoring and reevaluation your strategy might not support your goals over time anymore, resulting in poorer performance and therefore less market share.

2.8 Functional View of Supply Chain Management

To get a better understanding of the supply chain, it can be seen from a functional point of view. This view is promoted by the Supply Chain Council (SCC) and is called the Supply Chain Operations Reference (SCOR) model.

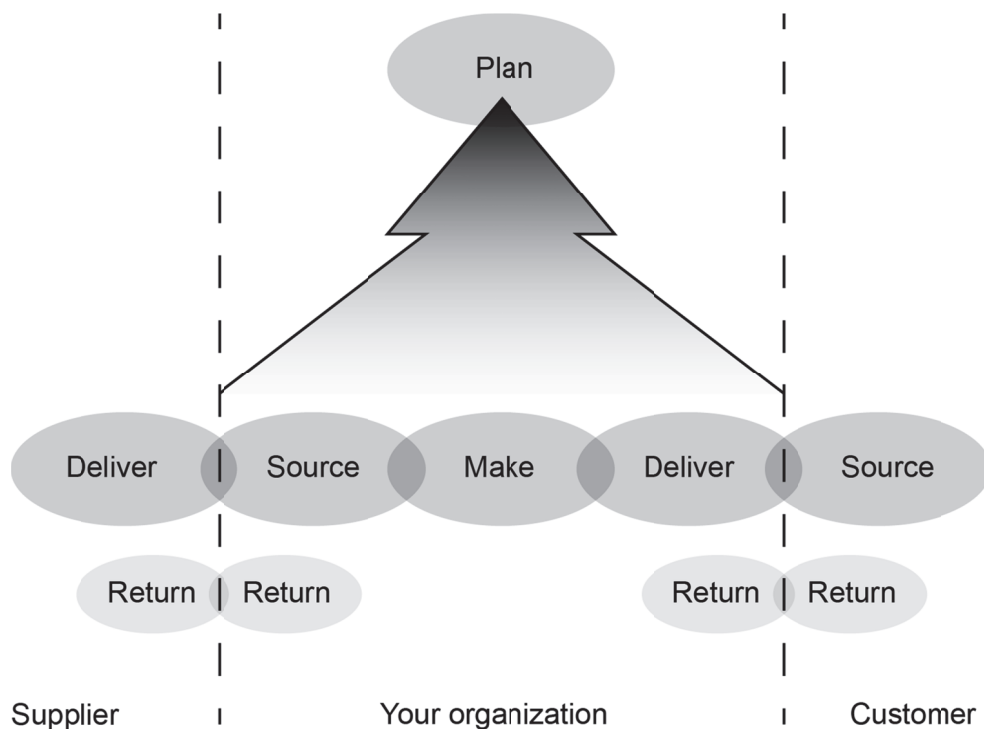


Figure 2 - The SCOR model according to the SCC (Supply Chain Council, 2011)

According to the SCC, the reason for developing such a model is as follows.

“The SCOR model helps refine strategy, define structure (including human capital), manage processes, and measure performance. An organization’s annual strategic priorities are manifested in SCOR’s vertical process integration (management led programs for doing the right things, as defined by the customer) and its horizontal process integration (leadership-led programs for doing the right things well, as defined by capabilities).” (Supply Chain Council, 2011)

Looking at the model (Figure 2), the SCC describes five so called “Level 1” management processes. In (Scott, Lundgren, & Thompson, 2011) and (Hugos, 2003) a more detailed explanation of these processes is given.

- Plan (P): This process describes the planning activities required for operating the supply chain. Main issues are gathering information from supplier, customer and the own company as well as identifying possible problems.
- Source (S): This process describes all tasks associated with the purchase side such as ordering raw materials and scheduling the arrival of goods.
- Make (M): This process describes all tasks involved in transforming items received from the S process which are then output to the D process and may include processing, repair or remanufacturing of items.
- Deliver (D): This process describes the sales side of the business. It does not only include delivery of goods but also related tasks such as invoicing.
- Return (R): This process describes all items related to sending back goods to the supplier or receiving goods from the customer. Reasons can be manifold and range from wrong delivery to not working items.

Of course, the SCOR model shouldn’t only span three companies (your own company, your supplier and your customer) but again should extend over the whole supply chain which is relevant to your business and products.

Additionally, the SCOR model doesn’t only describe the model but also advises on performance by specifying performance attributes. For each of these performance attributes, the SCOR model does also help to measure these by specifying standardized metrics.

- Reliability
- Responsiveness
- Agility
- Costs
- Assets

2.9 Supply Chain Management challenges

When looking at a supply chain there are many potential issues in this complex network of suppliers and customers. A few of these issues should be pointed out because they are important for actual review of methods. These are the issues which can be tackled by implementing an effective supply chain system.

- **Uncertainty:** This is probably one of the hardest issues which needs to be discussed. Possible reasons are changing travel times of materials or unforeseen breakdown of machines. Additional reasons are political issues such as strikes or weather conditions (earthquake, war).
- **Short product life cycle of high-technology products:** Historical data has been used in the past as a good source of data. With ever faster product cycles this historical data becomes less and less available thus eliminating a strategy for forecasting.
- **Just-in-time (JIT) production and long lead times:** The idea behind JIT is to have a minimum of stock. Since long lead times add additional uncertainties, they also reduce the chance of implementing JIT production.
- **Globalization:** With nowadays possibilities of transport, additional aspects need to be taken into consideration. These include cultural issues (national holidays, religious issues or trade embargos), language barriers and also time zone issues (contact is only possible during non-default business hours).
- **“Green” Supply Chain Management:** Looking at the rising interest in sustainability in the past few years, topics such as recycling and pollution become a bigger issue and need to be taken into account. The main issue here is that this strategy has to influence the selection of suppliers as well as your own company environment. Since different countries enforce region-specific environmental issues, a comparison between companies in different countries

is not always easily possible.

- Supply Chain Management not integrated into product design process: Since many new – especially small and medium – enterprises do not put their focus on their supply chain from the very beginning due to other complex problems at hand, they lose part of their competitive advantage. A good advice would be to integrate supply chain management into the product design process as early as possible.

2.10 Supply Chain Management Operations Strategies

In (Scott, Lundgren, & Thompson, 2011), five strategies are given when and how products are being produced. These are very much based on the type of product and the quantities which are being purchased and will result in changes in availability and especially lead time.

- Make and deliver to stock: This usually is the case for commonly used goods such as food. Products are produced and then put to stock. Looking at the supply chain, the stock is usually held very close to the customer (grocery store).
- Make to stock: Usually, a central warehouse is the point where stock is held. It is less regional than in “Make and deliver to stock”.
- Assemble to order: There is no stock of the finished goods but inventory of raw material is held and ready to be engineered into the final product upon receipt of a customer’s order. This has become very popular in the car industry (e.g. BMW) where it is called “mass customization”.
- Make to order: Inventory of raw material is held but not used until a customer’s order. Upon receiving the order, the material is used and the goods are being produced.
- Purchase and make to order: Here, even the supplier doesn’t hold any stock of raw materials required for the finished product. Everything is purely driven by the customer’s order.

Additionally to these strategies, another strategy should be mentioned which evolves more from a service oriented perspective.

- Engineer to order: Products (or services) are not even known until there is a customer's request. Usually these are highly complex products and need to conform specifically to customer's specifications. This type of products is usually tailored to only a single customer. Although this strategy is similar to the "Purchase and make to order" strategy, the difference is that here there is no product displayed to the customer since it is yet unknown.

Looking at these strategies, in summary you can say that the point of stock keeping is moved more and more to the supplier the further you go down the list. This also means that if you go down the list, the lead time will increase.

2.11 Bullwhip effect and supply chain collaboration

The Bullwhip effect is an effect which results from a lack of information flow from customer to the supplier of raw materials and is also called "demand amplification". It is described in detail in (Senge, 2006) and through a hypothetical simulation performed by the Massachusetts Institute of Technology's Sloan School of Management called "The beer game". The Bullwhip effect is the result of a sudden change in demand. This demand is picked up by the supplier who in turn tries to satisfy this demand through his current stock. This results in a bigger demand from the supplier's supplier (producer). The producer is now unable to fulfill the demand and rations the amount of items a supplier will get. The supplier sees that his order couldn't be fulfilled, thereby raising his desired stock level even more, resulting in an even higher demand from the producer. The producer might in turn create new production facilities to satisfy this new high demand.

Now the producer is shipping in larger quantities to the retailer but at the same time the demand drops. Since the demand drops, the supplier is stuck with excess inventory he cannot get rid of. The producer has set up a production chain which could satisfy a higher demand than actually required. Additionally, due to excessive demand, transportation facilities had to be increased, thereby increasing the cost of the product. Since the stock is full at the supplier, he has to drop the price to increase sales for the product. Figure 3 is an example of the Bullwhip effect. This displays how a small change of customer orders (thick, straight line) can trigger a large change in producer orders (thin dotted line).

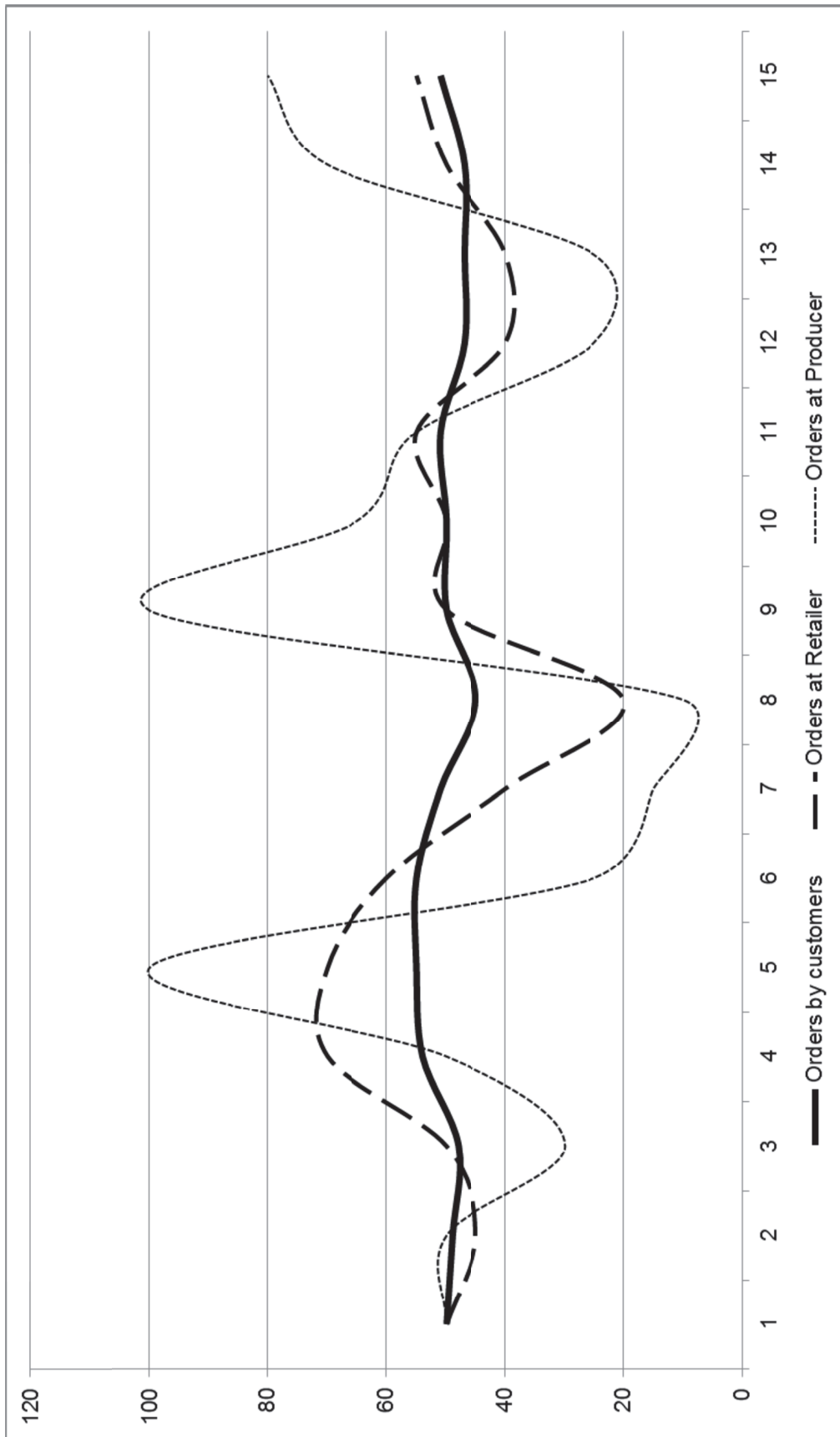


Figure 3 - Example of the Bullwhip Effect

This example outlines why information was outlined as one of the tasks of supply chain management before. To mitigate or even eliminate such issues, different approaches exist.

- Reduce uncertainty in the supply chain: Since the reason for such a behavior can often be found in non-existing communication between companies within the supply chain, a method to eliminate this deficiency has been defined. It is named Collaborative Planning, Forecasting and Replenishment (CPFR). Hereby, data from the point of sale is available directly to the supplier who does not rely on orders anymore.
- Vendor Managed Inventory (VMI): This is another similar technique. By using VMI, the supplier keeps track of the customer's inventory. Even more than that, also supplier's representatives – who are familiar with the product branch – can be on site to take care of product presentation. A method named “shared risk” might also reduce the customers risk by requiring the supplier to take products back in case they are not sold.
- Everyday Low Prices (EDLP) strategy: Often, the reason for large orders can be found in large fluctuations of prices. Therefore keeping prices at a constant level will also keep demand at a constant level. It should be emphasized that also the prices relative to a competitor need to be taken into account.
- Reduction of lead times through methods such as cross-docking or using improved EDI techniques to reduce information lead time.

2.12 The economic ordering quantity in SCM

Closely related to the bullwhip effect is the economic ordering quantity. The goal, especially when ordering a quantity is associated with additional costs, is restocking at the optimum moment. This moment is usually seen as a tradeoff between the cost of ordering and the quantity which is purchased. This can be easily seen in Figure 4 (Hugos, 2003)Figure 4 - Economic Order Quantities .

Line A designates the cost which is involved in ordering a specific number of items. This cost is very high for only small lot sizes. Compared to the total volume of the order this cost will decrease with large lot sizes since large lot sizes can for example reduce production costs.

Line B designates the costs which are involved in keeping a number of items in stock. Keeping items in stock will add costs because the required capacity in the warehouse will grow and it is possible that these goods might lose value over time.

The optimum point is at or around the intersection between line A and line B where the total cost (Line C) is a minimum. This point is named Economic Order Quantity.

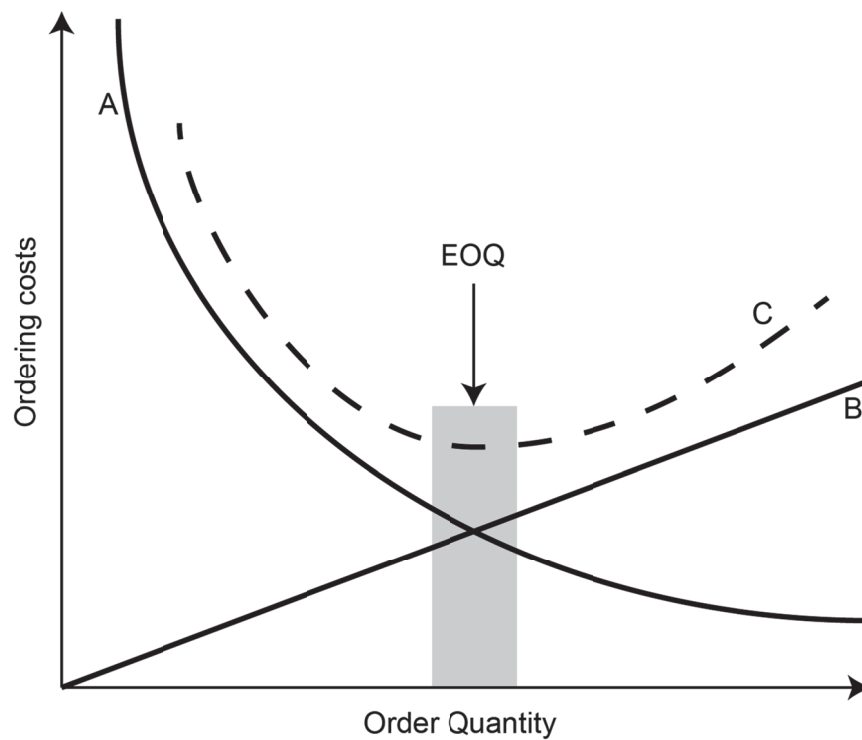


Figure 4 - Economic Order Quantities (Hugos, 2003)

3 SUPPLY CHAIN MANAGEMENT IN SMALL AND MEDIUM ENTERPRISES

3.1 Introduction

The topic Supply Chain Management is a topic which can be found in many industries and enterprises of different scales. Especially large enterprises have established a well-functioning supply chain from their first supplier of raw materials to the final end-customer. For large companies, this can become a fairly complex system. The goal for this thesis is to evaluate how such elaborate and powerful processes can be introduced in Small and Medium Enterprises with as little work as possible. To achieve this, in this chapter we will first define SMEs and then outline specific needs and problems of SMEs when dealing with the supply chain. We will also look at efficient and effective processes and why the supply chain is so important especially for SMEs.

3.2 Small and Medium Enterprises in the European Union

When talking about Small and Medium Enterprises (SMEs), I will follow the definition of the EU commission, especially Article 2 in (Erkki Liikanen, 2003).

“The category of micro, small and medium-sized enterprises (SMEs) is made up of enterprises which employ fewer than 250 persons and which have an annual turnover not exceeding EUR 50 million, and/or an annual balance sheet total not exceeding EUR 43 million.

Within the SME category, a small enterprise is defined as an enterprise which employs fewer than 50 persons and whose annual turnover and/or annual balance sheet total does not exceed EUR 10 million.

Within the SME category, a microenterprise is defined as an enterprise which employs fewer than 10 persons and whose annual turnover and/or annual balance sheet total does not exceed EUR 2 million.”

3.3 Supply Chain Systems in Small and Medium Enterprises

Introducing such a system in an enterprise usually also means a reduction of flexibility. First of all, the processes involved – which usually span the whole enterprise – need to be systematized. Apart from the negative aspect of being not so flexible anymore, this can be seen from two different positive aspects.

On the one hand, this will bring structure into the company. Basically, all purchase requests will have to be routed through the purchase department – or at least through the person who is responsible for purchasing – which will then have to take care of assigning the correct allowances for a department and controlling these. On the other hand, these are tasks which support the quality management by introducing processes which can be measured and evaluated. This will help in introducing a systematic approach to deal with different pricing strategies of suppliers in case more than one supplier is available for a specific product.

Especially when transitioning from a microenterprise – according to the definition of the European Union as stated in (Erkki Liikanen, 2003) around less than ten employees – there aren't any well described processes for purchasing existing already. In the recent past, I have talked to the CEOs of a few small enterprises – all of them located throughout Austria - which went through this transition process.

In three of these cases, there haven't been any written instructions or defined processes on how to purchase goods, neither for internal use, nor for usage in conjunction with a customer. Basically, whoever needed an item went on to purchase it himself and then gave the bills to bookkeeping. Items which were purchased in these cases were never related to customers or projects, which in turn were not reimbursed from the customer. This led to higher expenses for projects than necessary.

In two cases of small enterprises there were ongoing discussions how to introduce defined processes into the company to eliminate such issues. These discussions did not only include the purchasing side, but also many other areas of the company, these being at least one of production, development or sales.

In two other cases of small enterprises, there were already such processes installed,

meaning that the main tasks in the company were described in written form. The CEOs of these two companies pointed out that this was done mainly due to an ongoing ISO9001 certification but has helped them a lot to organize their tasks and responsibilities within the company.

In the last case of a small enterprise the CEO did not see any reason for introducing such a system but wanted to keep flexibility as high as possible.

Unfortunately I was only able to talk to the CEO of one medium sized enterprise. This company already had well established processes and was already also controlling them electronically where possible. According to the CEO of this company, the introduction of an ERP system has actually required this transition. The ERP system was introduced when they had around twenty employees.

According to these findings, the larger a company actually becomes, the more it sees the need for the introduction of defined processes. Of course, this is not universally valid and might change according to the country or the industry type.

Generally, it seems that there is a need to have defined processes which allow for flexibility but still keep the tasks of the business organized.

3.4 Efficient and effective processes

When talking about the supply chain, the main issue is how to get processes which lead to the result you expect them to, without hindering your work force from being unproductive by having to abide to too many, complex regulations. To achieve this, processes which are introduced into the company need to be both efficient and effective.

According to (Becker, 2008) a process describes a sequence of functions which are required for the creation of an object in a defined final condition. It can either be of informational or material type. For every process result, a customer should be available who can describe his specifications and wishes for this product. The inputs of a process will be transformed into the process result (process output).

When talking about supply chains, the input is delivered by a supplier; the process

itself can be a refinement of the input and the output could be given to a customer. When optimizing processes and furthermore when evaluating them, they are usually categorized in being efficient and/or effective. A good visual interpretation about process efficiency and effectiveness is given in (Becker, 2008) which is displayed in Figure 5.

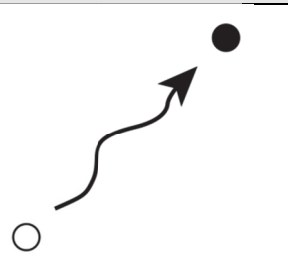
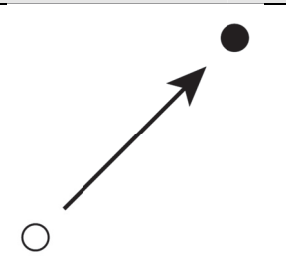
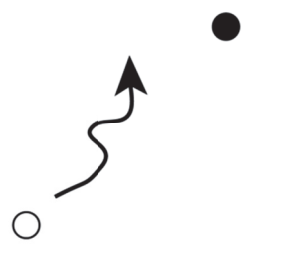
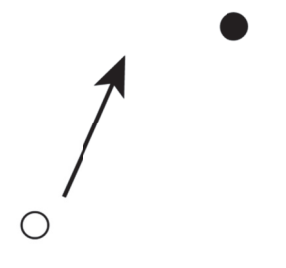
	Not efficient	Efficient
Effective		
Not effective		

Figure 5 - Process Efficiency and Effectiveness (Becker, 2008)

Another definition which is often given is:

- Process efficiency: Doing things right (requiring minimum effort)
- Process effectiveness: Doing the right things (get the right result)

These two items are independent from each other; the optimum process is therefore both efficient and effective.

3.5 Supply Chain Management Challenges in SMEs

The following chapter will focus on problems in the supply chain which mainly appear in SMEs, partly because these companies are small and knowledge is therefore limited or because they cannot utilize some factors large companies can.

- Supply Chain Management literature: When looking at methods for implementing an effective and efficient supply chain, these are usually

targeted at large industries such as the automotive industry in the United States or Germany. The first type of books deals with large production facilities with hundreds of workers, all working on large-scale products, e.g. cars. Topics which are important here are Just-In-Time delivery of components and the idea of having a product where you need it at the very moment. The second type of books deals with production facilities where a few items are being produced in large quantities. Important aspects here are order considerations (lot size, order times) and product availability.

These aspects are perfectly fine when talking about the supply chain and are key performance indicators (KPIs) for a functioning supply chain. Yet, when dealing with Small and Medium enterprises some things cannot be executed as easily in such an environment.

- Frequent updates of the Supply Chain: A supply chain is not a system which is created during a project and then kept for all time. It is more a living structure which has to adapt to ever changing factors and it has to evolve over time. Many large companies continuously update their supply chain due to a variety of factors.

In none of the books I reviewed, I could find information about how much workforce is required to keep a sophisticated supply chain working. A changing environment might change your current supply chain. Who keeps track of business partners going bankrupt or becoming otherwise inaccessible due to political issues (change of political system in a country) or environmental issues (earthquakes, tornados)? For any enterprise, this requires a substantial effort to keep this information up to date and to react to changes before a lack of resources or materials is detected.

Not only environmental or political issues can affect the availability of suppliers or partners. Also the quality of the delivered goods can become an issue. Therefore, suppliers should be evaluated regularly which will also result in requiring a larger workforce which deals with the supply chain.

Such a change – for whatever reason – would require finding a new partner and then also evaluating parts from the new supplier. Any enterprise – no matter if small or large – needs to be able to deliver parts of the same quality to its customers at any point in time. A customer can easily be driven away if

the product quality changes to the worse for whatever reason. Accordingly, improved quality could also yield a positive feedback from the customer, thus resulting in an improved partnership or better opportunities through whatever channels.

- Putting pressure on suppliers: Another big issue, which is independent from the required workforce, regarding the supply chain for SMEs is the potential of large enterprises to put pressure on their suppliers. Large enterprises are – due to their contract volume – able to put much more pressure on their suppliers than small enterprises. This results in an easier scheduling of deliveries since large customers will be favored.

A small company can request delivery times but might not always get the parts when they are actually required due to other products being scheduled differently for a large customer. A company will always try to keep their large customers; even if that means that a small customer will potentially go to a different source. This is an additional difficulty which small enterprises need to tackle.

- Globalization issues in the Supply Chain: The next hurdle, small enterprises need to take, is globalization. Especially when looking to the Far East, language and cultural differences can become a barrier. With many manufacturers located in these countries, it is easier for large companies to have an additional team dealing especially with representatives in these countries, understanding their mentality and taking care of cultural issues. Of course, this issue is not only valid for the Far East but for all countries which are located in different parts of the world. For a small enterprise, it is much more difficult to get an advantage from the possibilities globalization could potentially offer.
- Supply Chain Management in SMEs is localized and limited: In (Asian Productivity Organization, 2002), the following problem description is given: “Because SMEs are small and highly fragmented, they are at a natural disadvantage when dealing with the overall management of the supply chain(s) that concerns them. Unlike MNCs, which have greater geographic reach and more abundant resources, SMEs generally do not have a clear view of the entire supply chain beyond their immediate operations and contacts.

Therefore, these SMEs can only manage the supply chain within their close proximity. Also, by restricting themselves in this manner, they must be subservient to the larger players in the chain, wield little or no management control, and be subject to foreign exchange variations.”

- Supply Chain Management tools require IT knowledge: Especially in today’s automated systems, the introduction of a powerful SCM tool requires a high level of knowledge regarding IT. Many of today’s SCM systems rely on the integration of various technologies, thus requiring a high degree of interdisciplinary knowledge as well, also regarding business processes. People, who have experience in setting up such systems, are hard to find and cost a corresponding amount of money. Especially when a company is in the phase of expansion, these are costs which cannot be covered at that point in time and such elaborate systems are not really needed at that moment. This will result in a delay of the introduction of such a system and then require the work to be done at a later point in time again.

3.6 Importance of the Supply Chain for SMEs

Many companies start with having single contracts with their customers, sometimes for special, custom tailored items, sometimes for common items. Over time, the contract volume increases and leads to more opportunities. With increased demand, also the supply side has to increase. This in turn results in more collaboration with suppliers and customers. As time passes, multiple partnerships on both – the supply and demand side – have been established. Now, questions of the following type arise: “From whom do I want to buy” and “Who is my best customer”.

These are the kind of questions a good supply chain management can answer you. Therefore – although this is not being recognized as a supply chain in the first moment – this company starts to answer such questions and implicitly builds a supply chain from its own point of view. Only later, the now grown company will realize that it could have done that in a more systematic way, using tools which exist already, leveraging their full potential while saving time and money.

When using such a systematic approach, this automatically helps to eliminate potential pitfalls since these tools have been well researched and are used in the

industry at that very moment. Leveraging the power these tools deliver can result in more working capital to allow for growth and a competitive advantage in case there are competitors for that specific product.

The reason for this thesis is exactly this lack of a systematic approach which I was able to observe in two of the companies I have worked for in the past. Both companies went through these steps and basically made the same errors in doing so. Over a few years, they developed a fully working supply chain by basically doing all the things they did at the beginning a second time, this time more systematically and with a larger focus on existing methods which applied to the field they were working in. Of course, their supply chain tools still cannot be compared to fully integrated systems which exist in large production facilities or the automotive industry, but they facilitate their purchase and sales processes and automate processes wherever reasonable and possible. Using these systematic approaches, they were able to gain a competitive advantage.

4 SUPPLY CHAIN MANAGEMENT METHODS

4.1 Introduction

In the following chapters, we will look at various methods and technologies which are used in Supply Chain Management with a special focus on how they can be used in Small and Medium Enterprises. We will also focus on the amount of work required at the point of introduction and during the running phase whenever possible. The topics covered will range from lean principles to agile and Kanban method approaches. We will also focus on Supply Chain Networks and Outsourcing, as well as the Theory of Constraints. The final chapter will then focus on sustainable supply chains which look beyond the economic reasoning of classical supply chain management and include social and ecological viewpoints as well.

4.2 Lean Supply Chain Management

4.2.1 Lean / Six Sigma / TOM

When looking at Lean Supply Chain Management, there are multiple techniques which can be summarized into this one category. If one does not specifically look at Supply Chain Management, one will also find the terms “Six Sigma”, “Lean Sigma” or “Total Quality Management”. This topic mainly focuses on the re-engineering of business processes while taking a close look at them and trying to improve them. The idea is to remove all non-value adding work as shown in Figure 6.

The same holds true when looking specifically at the supply chain. The processes involved in creating and maintaining a supply chain require as much thought as when they are actually performed. Therefore, most of the concepts which can be found in the Six Sigma / Lean area can be very well applied to the area of Supply Chain Management. It is now that these processes can be optimized, therefore eliminating waste which is an essential concept in Lean Supply Chain Management.

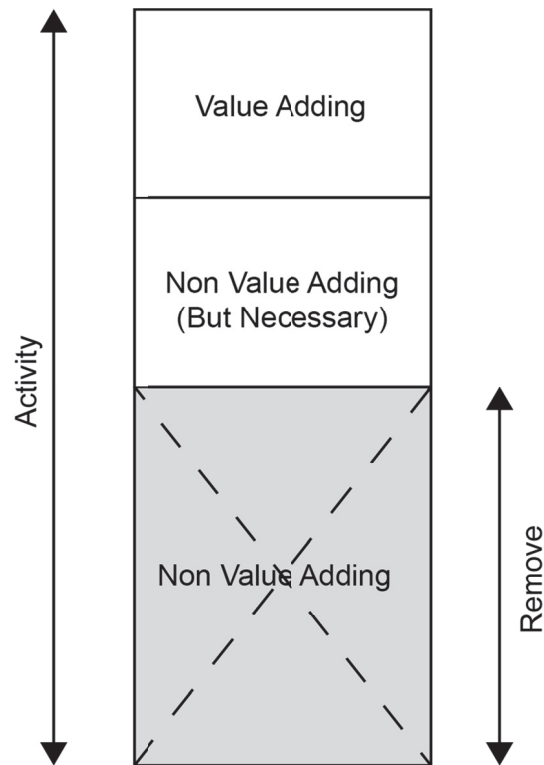


Figure 6 - Value-Adding and Non-Value-Adding Work

4.2.2 Looking at value in Lean SCM

Lean Supply Chain Management deals with the elimination of “muda”, a Japanese word designating “waste” or “everything that does not add value” but consumes resources. The book (Womack & Jones, 2003) describes the following examples for waste:

- Production of items no one wants
- Pile-up of inventories
- Mistakes which require rectification
- Unneeded processing steps
- Unnecessary movement of goods and employees
- Waiting time
- Production of goods which do not meet the needs of customers

A good overview of what is considered as “value” in the language of Lean thinking is given as well.

“The critical starting point for lean thinking is *value*. Value can only be defined by the ultimate customer. And it’s only meaningful when expressed in terms of a specific product (a good or a service, and often both at once) which meets the customer’s needs at a specific price at a specific time.

Value is created by the producer. From the customer’s standpoint, this is why producers exist. Yet for a host of reasons value is very hard for producers to accurately define. [...] What’s been really important for Japanese firms as they have defined value is *where* value is created. Most executives, even at firms like Toyota which pioneered lean thinking, have begun their value definition process by asking how they can design and make their product at home – to satisfy societal expectations about long-term employment and stable supplier relations. Yet most customers across the world like products designed with an eye to local needs, which is hard to do from a distant home office. And they like products made to their precise order to be delivered immediately, which ocean shipping from a Japanese production base makes impossible. They certainly do not define the value of a product primarily in terms of where it was designed or made. [...] Lean thinking therefore must start with a conscious attempt to precisely define value in terms of specific products with specific capabilities offered at specific prices through a dialogue with specific customers. The way to do this is to ignore existing assets and technologies and to rethink firms on a product-line basis with strong dedicated product teams. This also requires redefining the role for a firm’s technical experts [...] and rethinking just where in the world to create value [...] In summary, specifying value accurately is the critical first step in lean thinking. Providing the wrong good or service the right way is *muda*.” (Womack & Jones, 2003)

When transferring this idea to the area of Supply Chain Management, the methods can be directly taken over. Rethink your business processes where possible and try to improve them. When dealing with the complex network of suppliers and customers, see where value is created and try to deliver value to your customers. Eliminate “muda” whenever possible.

4.2.3 Lean SCM in SMEs

When looking at SMEs, this becomes more difficult. Often, there is just one headquarter where all value is created and eliminating unnecessary transport is often just not possible. The term of “rethink just where in the world to create value” is often not a choice because CEOs of such SMEs are often limited by monetary resources.

The above statement also describes the customer’s wish to make a product with an eye on local needs, regulations and requirements. This is an aspect which can be both easy and hard for a company, depending on the location of the customer. For a closely located customer this will be easy, since it will likely be more natural than in a large enterprise with multiple premises around the world and therefore a sum or mixture of regulations. For a more distantly located customer this will be much harder since he is not accustomed to the regulations of the customer’s country or area and therefore has to take extra care of these things.

The next item in Lean Thinking is to identify the value stream. This is very important when looking specifically at the supply chain since there should be no muda at any point in the chain and every section in the chain between the raw material supplier and the end customer can be seen as a single entity or the whole chain can be seen as one combined entity.

The value stream is defined in (Womack & Jones, 2003) as follows:

“The value stream is the set of all the specific actions required to bring a specific product (whether a good, a service, or, increasingly, a combination of the two) through the three critical management tasks of any business: the problem-solving task running from concept through detailed design and engineering to production launch, the information management task running from order-taking through detailed scheduling to delivery, and the physical transformation task proceeding from raw materials to a finished product in the hands of the customer. Identifying the entire value stream for each product (or in some cases for each product family) is the next step in lean thinking, a step which firms have rarely attempted but which almost always exposes enormous, indeed staggering, amounts of muda.”

Also, (Womack & Jones, 2003) explain that a value stream analysis will show three types of actions which occur in the value stream:

- Steps creating value
- Steps which create no value, but cannot be avoided with current technologies or production assets (Type One muda)
- Steps which create no value and could be eliminated immediately (Type Two muda)

Keeping these three types in mind and thinking about supply chain management, one can see optimization potential. Questions one could ask at this point include but are not limited to:

- Does the sequence of my suppliers make sense, could I eliminate unnecessary transports?
- Can I eliminate specific steps in my own value stream, how can I optimize my processes, where can I eliminate muda myself
- Can I support my customers in providing more data or other information which doesn't affect my business but eliminates muda in the upstream chain, thus providing more value to the end customer
- Could I combine some steps in the whole supply chain; do I require every step in the chain or could there be another way, e.g. a partnership with a supplier's supplier.

Now that we have identified where value is generated and where muda can be eliminated and furthermore the stream has been analyzed, the next step in lean thinking is to allow for flow.

(Womack & Jones, 2003) state that we are brought up to think that the optimal way to do things is "batch processing". When looking at lean thinking this is considered to be wrong:

"After World War II, Taiichi Ohno and his technical collaborators, including Shigeo Shingo, concluded that the real challenge was to create continuous flow in small-lot production when dozens or hundreds of copies of a product were needed, not

millions. This is the general case because these humble streams, not the few mighty rivers, account for the great bulk of human needs. Ohno and his associates achieved continuous flow in low volume production, in most cases without assembly lines, by learning to quickly change over tools from one product to the next and by right-sizing machines so that processing steps of different types [...] could be conducted immediately adjacent to each other with the object undergoing manufacture being kept in continuous flow. [...] The most basic problem is that flow thinking is counterintuitive; it seems obvious to most people that work should be organized by departments in batches.” (Womack & Jones, 2003)

Going back to the supply chain and especially SMEs this is an important point. Often in SMEs the lot size is small. Although this is more interesting from a production point of view, it also affects the logistics side. Questions which could arise for a SME here are:

- Should I produce smaller lot sizes and transport them by smaller vehicles to keep up a continuous flow. Will this help my suppliers and customers and lead to more value for the end customer?
- Do I have waiting times inside my company which could be eliminated by being able to use a more continuous stream? In such a case, a partnership with a supplier might be helpful for both parties involved.
- If both, having batches and not having batches does create muda (due to various reasons), where is the optimum point where the least muda is created?

Looking at these questions, (Womack & Jones, 2003) see the following issue:

“The reengineering movement has recognized that departmentalized thinking is suboptimal and has tried to shift the focus from organizational categories – departments – to value-creating processes [...] The lean alternative is to redefine the work of functions, departments and firms so they can make a positive contribution to value creation and to speak to the real needs of employees at every point along the stream so it is actually in their interest to make value flow.”

The next idea in Lean Thinking is the “Pull” principle. According to this theory, by following the ideas above, the result is a drastic improvement in time required for the observed and improved processes. Looking at the supply chain this could mean a reduction of time which the product actually stays inside the own company – thereby creating muda – and an improvement in throughput of the product.

Also, since products are produced in small batches, the supply chain can react much more quickly to a change in demand, thus resulting in fewer inventories and the ability to make exactly what is required at the very moment. (Womack & Jones, 2003) describe this as a “pull” process which originates from the customer. Eliminating the need for inventory, while not running out of products, is the key factor for every SME in providing value to the customer.

The fifth principle of Lean Thinking is called “Perfection”. Since now customers – a customer could also simply be the next member in the supply chain – can simply pull whatever they need at the very moment, there is a continuous improvement of the process to make the time required even shorter and the costs which are induced through storage even lower.

The main idea, why Lean Thinking or the elimination of muda is so important for the supply chain is outlined in (Womack & Jones, 2003):

“Perhaps the most important spur to perfection is transparency, the fact that in a lean system everyone – subcontractors, first-tier suppliers, system integrators (often called assemblers), distributors, customers, and employees – can see everything, and so it’s easy to discover better ways to create value. What’s more, there is nearly instant and highly positive feedback for employees making improvements, a key feature of lean work and a powerful spur to continuing efforts to improve, [...]”

Looking at the theory of Lean Thinking and the concepts involved while comparing them to the needs of SMEs and their supply chain, there are three main issues which can be extracted from this idea:

- Make your internal processes as lean as possible. Do not produce muda where not necessary (eliminate all Type 2 muda).
- Allow for small batches – or even single item production – whenever possible. Especially for an SME this might be an interesting thing to look at.
- Form partnerships with your suppliers and customers so it is possible to form a pull type relationship, eliminating muda from every part of the supply chain, not only your own company.

4.3 Agile Supply Chain Management

4.3.1 Definition of Agile Supply Chain Management

The Oxford Dictionary defines “agile” as “being able to move quickly and easily”. Especially in the area of software development, the agile development process is currently well known. It defines a process which is able to adapt to changes and provides instructions how to manage such changes and how to deal with them if they happen unexpectedly. The very same principle holds true for Agile Supply Chain Management.

In (Christopher, 2000), Martin Christopher defines Agility as follows: “Agility is a business-wide capability that embraces organizational structures, information systems, logistics processes and in particular, mindsets. A key characteristic of an agile organization is flexibility. In that respect, the origins of agility as a business concept lie partially in flexible manufacturing systems (FMS). Initially it was thought that the route to manufacturing flexibility was through automation to enable rapid changeovers (i.e. reduced set-up times) and thus enable a greater responsiveness to changes in product mix or volume. Later this idea of manufacturing flexibility was extended into the wider business context (Nagel and Dove, 1991) and the concept of agility as an organizational orientation was born.”

4.3.2 Flexibility in Agile Supply Chain Management

Mr. Basu and Mr. Wright explain in (Basu & Wright, 2007) that the most important aspect of agility is flexibility. Therefore, standardization procedures are only then put into place when the demand for volume and variety is known. Also, the term mass customization comes into context. This basically describes the late final assembly of pre-processed parts when short lead times are required but still a large variety is needed. This is an approach which is currently used in the car manufacturing industry – especially in Europe - whereas certain components can be ordered and the car is tailored to your needs. This only hides that basically there is a fixed production process which is just changed slightly and provides this “unique” feeling for the customer. Yet, this demands that the full supply chain is involved into the production process.

4.3.3 Functional vs. Innovative Products

Regarding Agile Supply Chain Management, Fisher has a similar approach. In (Fisher, 1997) he describes two different types of products. He distinguishes between functional and innovative products, whereas he assigns the use of an agile supply chain mainly to the products from the innovative category. He furthermore categorizes products by life cycle time:

“Functional products include the staples that people buy in a wide range of retail outlets, such as grocery stores and gas stations. Because such products satisfy basic needs, which don’t change much over time, they have stable, predictable demand and long life cycles. But their stability invites competition, which often leads to low profit margins. [...] With their high profit margins and volatile demand, innovative products require a fundamentally different supply chain than stable, low-margin functional products do. To understand the difference, one should recognize that a supply chain performs two distinct types of functions: a physical function and a market mediation function. A supply chain’s physical function is readily apparent and includes converting raw materials into parts, components, and eventually finished goods, and transporting all of them from one point in the supply chain to the next. Less visible but equally important is market mediation, whose purpose is ensuring that the variety of products reaching the marketplace matches what consumers want

to buy. Each of the two functions incurs distinct costs. Physical costs are the costs of production, transportation, and inventory storage. Market mediation costs arise when supply exceeds demand and a product has to be marked down and sold at a loss or when supply falls short of demand, resulting in lost sales opportunities and dissatisfied customers.” (Fisher, 1997)

According to (Basu & Wright, 2007), an agile supply chain should contain the following key characteristics:

- Flexibility: This is the ability to respond quickly to changes in requirements, usually triggered by the customer. This affects both the volume as well as the variety of products.
- Market sensitivity: This means that the producing company should be able to produce according to the real demand and not some kind of forecast which was done in the past. It is the customer’s demand which has to be satisfied.
- A virtual network: To achieve the two aspects above, it is required to have data at hand when it is needed. Updates should be done in real-time; this means that the current information should always reflect the current demand and supply status throughout the supply chain. To be able to achieve this, the data has to be captured and transferred via means of such a network, at the moment usually the Internet.
- Postponement: This is closely related to mass customization. Nearly finished products are held at stock and are only finalized upon customer’s request.
- Selected lean supply chain principles

4.3.4 Lean SCM vs. Agile SCM

Especially after reading Fisher’s article, it has become obvious that Lean SCM and Agile SCM are in some kind interrelated and it should be able to bring them together. Three approaches how to achieve this are given in (Towill & Christopher, 2001). Two of these approached will be explained here.

The Pareto Approach

The Pareto principle states, that 80% of effects come from 20% of the causes. The

same can be applied to the relationship between Lean and Agile SCM: 80% of the total demand comes from 20% of the products. This is exactly where Lean SCM kicks in. These are products where inventory can be managed centrally, where a rough demand is known and which can be produced to a previously determined forecast. The other 80% of the products are from the “innovative” category and account for the remaining 20% of the demand. For these products, the agile approach can be used. A typical Pareto approach curve is given in Figure 7.

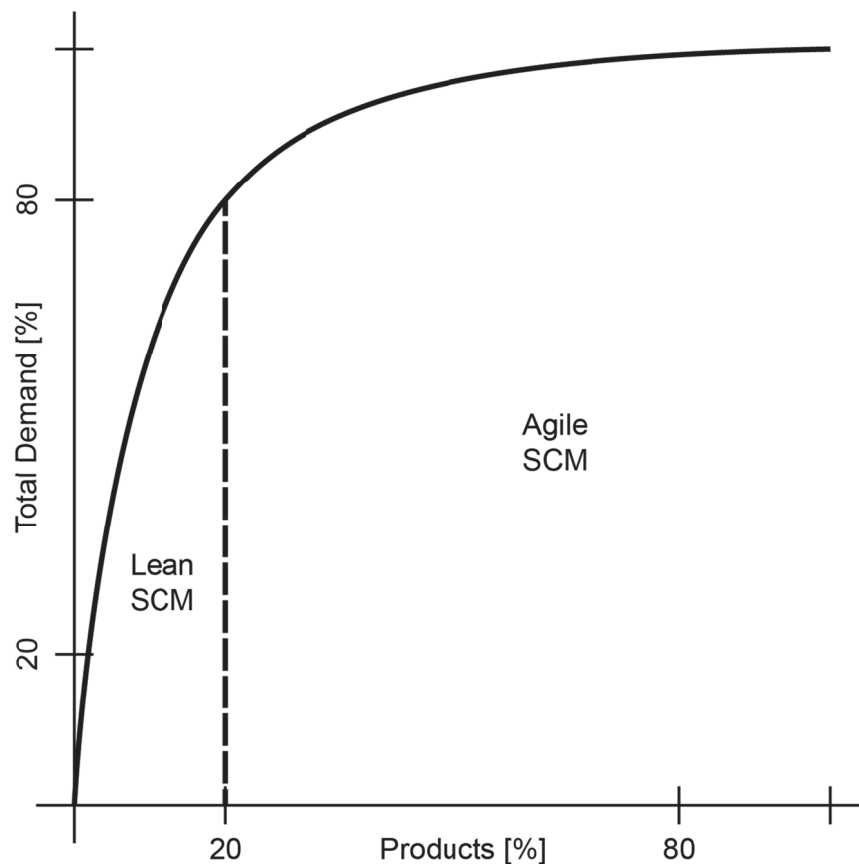


Figure 7 - The Pareto Approach according to (Towill & Christopher, 2001)

The Decoupling Point approach

This approach is outlined in (Towill & Christopher, 2001) and (Basu & Wright, 2007) where it is described as “Postponement”. Basically, the idea behind this approach is to have some point in the supply chain, which is called the decoupling point (Figure 8). Before this point, we are dealing with stocked inventory, with mass produced goods and restocking schedules based on forecasts. This is the area where efficiency is maximized.



Figure 8 - The Decoupling Point Approach

The decoupling point itself is the point where inventory is held. Starting from here, going downward the supply chain in the direction of the customer, mass customization starts. Here, the semi-finished goods are being customized or tailored to the customer’s needs.

As we can see, Agile SCM and Lean SCM are closely coupled and can be used for different purposes in conjunction with each other, either in a timely approach or a quantitative approach. A more detailed comparison in tabular form is given in Table 1, which was compiled from (Basu & Wright, 2007) and (Towill & Christopher, 2001).

	Lean	Agile
Objectives	<ul style="list-style-type: none"> • Low cost • High utilization • Minimum stock 	<ul style="list-style-type: none"> • Fast response • Buffer capacity • Deployed stock
Process characteristics	<ul style="list-style-type: none"> • Elimination of waste • Smooth operation flow • High level of efficiency • Quality assurance • Costs defined by physical assets 	<ul style="list-style-type: none"> • Flexibility • Market sensitivity • Virtual network • Postponement • Costs defined by marketability
Product characteristics	<ul style="list-style-type: none"> • Functional products • Predictable demand • Low variety • Low margin • Long life cycle 	<ul style="list-style-type: none"> • Innovative products • Volatile demand • High variety • High margin • Short life cycle

Table 1 - Comparison between Lean and Agile SCM

4.3.5 *Agile SCM in SMEs*

When looking at SMEs it is often the case that only a few products are produced and that many of them have not yet made it into the phase where they are actually being sold in mass quantities. Therefore, the agile approach would seem to fit to these companies perfectly.

On the other hand, the agile approach requires a lot of tools to be used effectively. It requires that you have exact data about your customers demand and the stock currently available at the distributor. This is information which needs to be collected and managed and thus requires a lot of manpower or appropriate tools which are probably not readily available.

What can be of use is the principle of combining Lean SCM and Agile SCM. Together, these methods can cover many aspects of Supply Chain Management and contain ideas which can be used and should be followed throughout SMEs.

4.4 Kanban in Supply Chain Management

4.4.1 *Definition of Kanban*

The Kanban system is not directly a method of Supply Chain Management but its principles can be used as an input to the supply chain demand. The principle of Kanban is described as follows:

“With kanban scheduling, the operators use visual signals to determine how much they run and when they stop or change over. The kanban rules also tell the operators what to do when they have problems and who to go to when these problems arise. Finally, a well-planned kanban has visual indicators that allow managers and supervisors to see the schedule status of the line at a glance. We define kanban scheduling as demand scheduling. In processes controlled by kanbans, the operators produce products based on actual usage rather than forecasted usage. Therefore, for a scheduling process to be considered a true kanban, the production process it controls must:

- Only produce product to replace the product consumed by its customer(s)
- Only produce product based on signals sent by its customer(s)

Think of kanban scheduling as an execution tool rather than a planning tool. The kanban, which can take many forms, directs the operation of the process on a day-to-day basis. Kanban scheduling does not replace material planning, but rather takes the material planning information and uses it to create the kanban.” (Gross & McInnis, 2003). An example for such a Kanban card can be seen in Figure 9.

Part Number	904-1643-21-1.0
Part Name	SoM-MX53 V1.0
Production Facility	Flexible 4
Internal Container Type	Small Bin
Items / Container	3
Location	SR4 / D3 / 16
Warehouse ID	2019-10000003-187

Figure 9 - An exemplary Kanban card

4.4.2 Kanban in the supply chain

As mentioned, Kanban is not a management tool for the supply chain itself, but it helps operators to monitor and enhance their production processes by visualizing the status of the production line. The information retrieved from this abstracted overview can generate an input to material planning which in turn is relevant for the organization and management of the supply chain.

As stated explicitly in (Gross & McInnis, 2003), a benefit of Kanban scheduling is, that it “increases ability to manage the supply chain”. Typical other improvements which result from the Kanban process are a reduction of inventory and an improved responsiveness if the demand changes. All of these support the enterprise in its intentions to improve and shorten the supply chain.

When looking at Kanban from the Supply Chain side, the customer is the one who is

effectively responsible for the generated demand and therefore the capabilities of the production process. In an environment where a Kanban system is used throughout the whole system, the customer generates the demand and the supply chain is constructed backwards. This approach is shown in Figure 10.

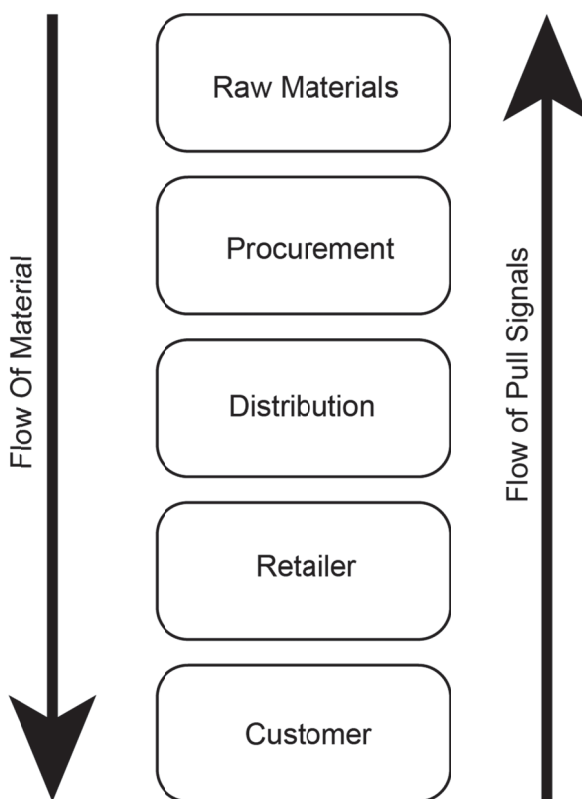


Figure 10 - Reverse-Constructed supply chain by using Kanban

4.4.3 Demand Chain Management

Demand Chain Management is a topic which can be related to Kanban in the supply chain. Basically it links the supply chain to Customer Relationship Management (CRM) and tries to calculate the future demand from the customer side from previous data and CRM data. Additionally, models can be used which also take holidays and other political or religious factors into account. Yet, the main idea is to have a very strong focus on the customer side and not on the supplier's side in the supply chain.

4.4.4 Lean vs. Agile vs. Kanban

To understand where Kanban fits into Supply Chain Strategies, one can setup two dimensions of problems. One dimension is looking at the various methods from the

supply side, where the other is looking at those from the demand side. Taking these into account, it is possible to categorize the methods which have been mentioned by now. This is shown in Table 2 and **Error! Reference source not found.** was originally performed in (Cetinkaya, Cuthbertson, Ewer, Klaas-Wissing, Piotrowicz, & Tyssen, 2011)

		Demand Characteristics	
		Predictable	Unpredictable
Supply Characteristics	Long Lead Times	Lean	Hybrid
	Short Lead Times	Kanban	Agile

Table 2 - Characterization of Kanban, Agile and Lean methods

4.4.5 Kanban in SMEs

The topic of Kanban originates from the producing industry. This is where it is extremely helpful, especially for Small and Medium Enterprises which are starting to develop their scheduling plans. By using this method, it is very easy to keep track of the current demand and process requirements. This data feeds directly into the planning of the supply chain. Since Kanban is being built on visual support for the operator, he doesn't need to calculate the figures by means of an ERP system but is continuously informed about the current status. Especially when processes are created, which is the case at young SMEs, it gives an instant idea where problems might originate from and how they could be handled better because of this visualized approach.

For organizations which are not located in the producing industry, this method is probably not the first such an enterprise would look at. Yet, the idea of maintaining a pull approach might be of use even for non-producing industries. If the idea of Kanban is taken further, one could also see this as creating a need by shortening the demand by intention, yet this is usually a task of marketing or company strategy.

4.5 Supply Chain Networks

4.5.1 Definition of Supply Chain Networks

In the past chapters we dealt with theories for supply chain management. Supply Chain Management basically covers the company, the customer and its suppliers. We extended this to customer's customer and supplier's suppliers. Now, when talking about supply chain networks, this is not a completely different approach. It is more a change in thinking that basically the whole supply chain should be taken into account. This includes direct customers as well as end customers and direct suppliers as well as raw materials producers.

Another good introduction to supply chain networks is stated in (Slack, Chambers, & Johnston, 2010): "A supply network perspective means setting an operation in the context of all the other operations with which it interacts, some of which are its suppliers and its customers. Materials, parts, other information, ideas and sometimes people all flow through the network of customer-supplier relationships formed by all these operations. On its supply side an operation has its suppliers of parts, or information, or services. These suppliers themselves have their own suppliers who in turn could also have suppliers, and so on. On the demand side the operation has customers. These customers might not be the final consumers of the operation's products or services; they might have their own set of customers. On the supply side is a group of operations that directly supply the operation; these are often called first-tier suppliers. They are supplied by second-tier suppliers. However, some second-tier suppliers may also supply an operation directly, thus missing out a link in the network. Similarly, on the demand side of the network, 'first-tier' customers are the main customer group for the operation. These in turn supply 'second-tier' customers, although again the operation may at times supply second-tier customers directly. The suppliers and customers who have direct contact with an operation are called its

immediate supply network, whereas all the operations which form the network of suppliers' suppliers and customers' customers, etc., are called the total supply network.”

Such a structure is displayed in Figure 11.

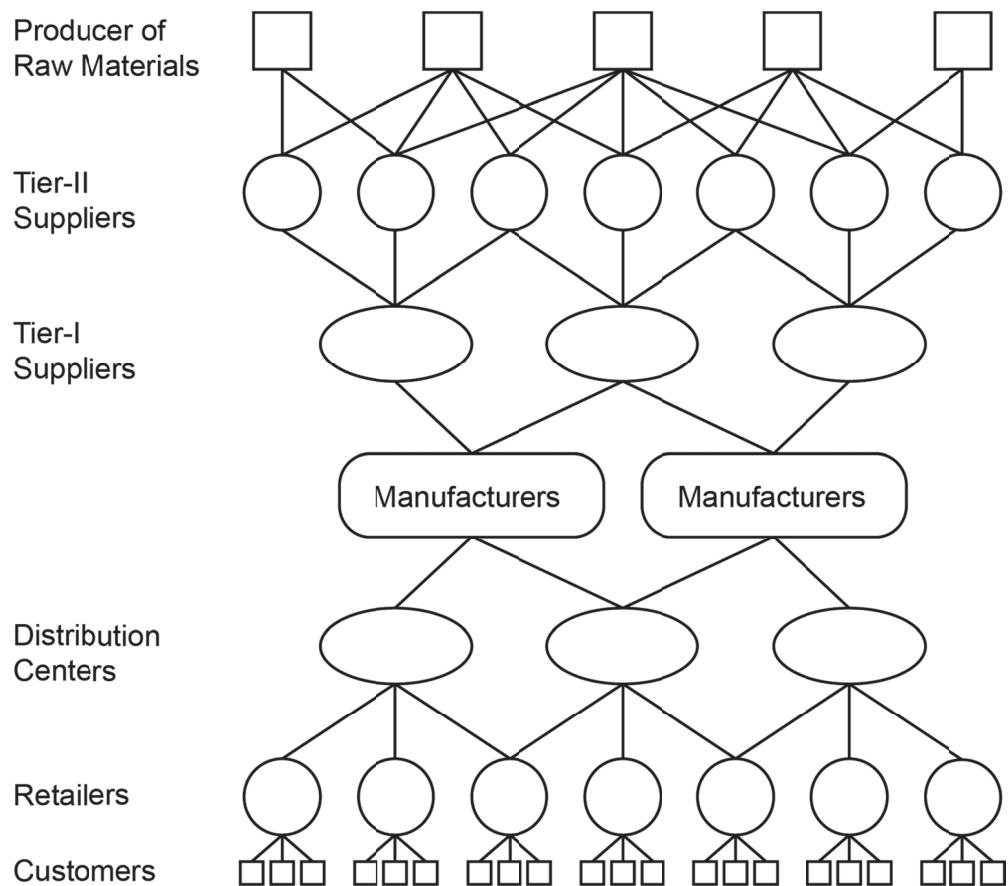


Figure 11 - Supply Chain Network Structure

4.5.2 Issues and Effects

The main issue which should be noted here is, that not only material is involved in such Supply Chain Networks. Also, information is an essential part in the transactions which take place in such a network. This does not only affect sales data such as sales within the last 48 hours but much more. As an example, a vendor could also publish his forecast data to suppliers in order to allow them to better plan ahead and therefore get better prices. Usually, material flow is directed from the raw primary goods to complete goods which are then delivered to the end customer. When looking at the information flow, it is basically the request from the end

customer which sets the relevant information for preceding organizations.

One effect which can result from such networks is the effect of disintermediation. This basically means that the middleman is removed from the supply chain, because all information is known from one step further. A good example for such a case is travel agencies. Not so long ago, a travel was usually booked via a travel agent who then took care of transportation and housing. Nowadays, with the use of the Internet, the customer (in this case we are referring to the end customer) takes over these responsibilities himself by making use of websites which can either originate from the airline or the hotel itself. These can be aggregated by some other website which basically takes over the responsibilities of the travel agent.

Another thing that should be mentioned concerning supply chain networks is that networks can be more complex than simple chains. Whereas a chain describes a sequential order, a network can be cross-linked. Also, multiple different exchanges can occur within such a network. Regarding Supply Chain Networks, it is basically only a matter of trust, which information is available to suppliers or customers.

4.5.3 Collaborative Planning, Forecasting and Replenishment

Even if Collaborative Planning, Forecasting and Replenishment (CPFR) is not limited to Supply Chain Networks, it should be mentioned as well since this can be thought of as some kind of cooperation between companies which could exist within such a network. A good explanation of CPFR is given in (Blanchard, 2010):

“Collaborative planning, forecasting, and replenishment (CPFR) enables supply chain partners to share historical data and develop plans to manufacture and distribute a product. This shared information is used to forecast needs, establish and alter promotion timelines, and determine when stock or supplies need to be replenished.”

The VICS (Voluntary Interindustry Commerce Standards) Association has identified four collaborative activities which allow enterprises to improve their performance:

- Strategy & Planning: Establish the ground rules for the collaborative relationship. Determine product mix and placement, and develop event plans

for the period.

- Demand & Supply Management: Project consumer (point-of-sale) demand, as well as order and shipment requirements over the planning horizon.
- Execution: Place orders, prepare and deliver shipments, receive and stock products on retail shelves, record sales transactions and make payments.
- Analysis: Monitor planning and execution activities for exception conditions. Aggregate results, and calculate key performance metrics. Share insights and adjust plans for continuously improved results.

4.5.4 Supply Chain Networks in SMEs

When looking at SMEs, it has to be clear that such extensive Supply Chain Networks need an appropriate driver. There is a lot of connectivity with different other systems required which can be hard and extensive to setup and maintain. Such a driver could be the automotive industry or other large industries which require a more or less constant volume with slight changes throughout time. A SME will probably never be the driver itself for such an extensive network.

Yet, if a SME decides to take part in such activities, there is a chance for a great performance boost since the SME now needs to align its KPIs with the KPIs of the network. Once the goals and targets are set, there is a clear definition of what has to be reached and what is expected from the SME. Furthermore, the tools and standards regarding technology, information and communication which are used throughout the network will be shared by all partners; therefore there will be a common understanding of potential risks and targets.

It might also be possible that multiple SMEs work together to form a partnership which is e.g. highly specialized and can then be a partner for e.g. the automotive industry. With the possibilities of improved information flow, there certainly are specific possibilities available for SMEs, yet it should be clear that these require a lot of maintenance and work.

4.6 Outsourcing

4.6.1 *Definition of Outsourcing*

When looking at supply chains, there usually are a number of tasks which need to be fulfilled. It is now up to the company to decide which of the tasks it will perform itself because it considers these as core-competencies and which of the tasks it will outsource to some service provider who is able to provide the very same service at a cost which couldn't be reached otherwise.

As an example, transportation is probably an operation of supply chain management which is outsourced frequently. Especially in this area, there are large providers who are able to perform at much better costs than the usual company itself. These are usually known as third party providers. A very good idea of this principle is given in (Blanchard, 2010).

“The increasing sophistication of supply chains—spanning corporate departments and global boundaries—has made it imperative that supply chain professionals think far beyond the four walls of their companies. At a strategic level, this requires a close study of every task, process, and operation within a company's extended enterprise. Because few companies actually have this expertise in-house, and fewer still are willing to invest resources in nonstrategic areas, a new breed of third-party supply chain specialists has emerged to offer their services to companies that are willing to let somebody else do the actual work. Much of the motivation behind this trend is that companies are increasingly being challenged to focus on their core competencies. The question constantly being put to them is: How good are you at what you do, in every aspect of your business? Many companies are best in class at designing products, for instance, but are strictly average in the actual building of them. In previous generations, that might have been a black mark against the company, but today the ability to accurately assess your strengths and weaknesses is itself a best practice.”

4.6.2 *Core competencies and outsourcing*

The key issue here is to find the core competency of the company and concentrate on these competencies which actually you can bring value to. In (Blanchard, 2010) a

case study regarding Moen Inc. can be found where three main questions are used to identify key competencies:

- Is this process or function strategic to our organization?
- Does this process or task provide us with a competitive advantage?
- Do we want to upgrade performance in this area to differentiate us from our competitors?

In an ideal world, an enterprise could simply focus on its core competencies and would not need to worry about any outsourced activities. Of course, this is not what happens in reality. If a company – it doesn't matter if it is a SME or a large enterprise – decides to outsource some of its business, there are certain costs involved and especially at the beginning, there will be a lack of trust. Even if e.g. transport has been outsourced, the company still needs to know where the products are at any point in time. This means that the company cannot simply outsource the ultimate responsibility but will always be responsible for its own actions as well as its outsourcing partner.

Outsourcing must not be confused with offshoring. Although the two can be used in conjunction with each other, they have a different meaning as depicted in Table 3. Offshoring usually refers to the location of operations whereas outsourcing is related to the ownership of operations.

		Location of operation	
		Domestic	International
Ownership of operations	Don't own the assets	Outsourcing Domestic supplier delivers products and/or services	Offshore outsourcing Overseas supplier delivers products and/or services
	Own the assets	Domestic Operations Focal operation performs activities themselves	Offshore operations Focal operation's overseas operation delivers products and/or services

Table 3 - Outsourcing vs. Offshoring (Slack, Chambers, & Johnston, 2010)

4.6.3 Outsourcing in SMEs

Not so long ago, outsourcing was preserved for large enterprises or international organizations. When looking at the supply chain, outsourcing can also be of interest for SMEs. Especially, when non key competencies are being outsourced, this offers the possibility to assign more personnel to key competencies, thereby concentrating on the main business. There are some areas which are required in nearly every enterprise today and which can be outsourced very often, one of those being transportation. Even large logistics providers like UPS or DHL offer services regarding logistics, not transport only.

Another area which can usually be outsourced is the IT business. In this business, there are many competing providers that deliver such a service. If a company does not have the resources it requires to provide a stable IT infrastructure, this can be outsourced easily.

Outsourcing should be one of the main options, a SME needs to realize. Even if initial or running costs may seem to be high at the first glance, you need to take into account what this operation would cost the enterprise itself and how much more value you could generate by focusing on your key competencies.

4.7 Theory of Constraints in SCM

4.7.1 Definition of the Theory of Constraints

The Theory of Constraints is a system which is based on the ideas of Eliyahu M. Goldratts. It takes a complete system and checks this system for the limiting factor. It is a theory which has found many areas of application. It has been used in Marketing, Sales and Financing as well as in the area of Supply Chain Management. Any optimization process which is done, is primarily focused on the bottleneck which has been identified. The system itself consists of the following five pillars.

- Identify the System's Constraints.
Within your system there is exactly one step in the process which limits throughput. This step can be identified by analyzing work time for a specific task or analyzing available materials at one station (this is especially true for the producing industry).
- Decide How to Exploit the System's Constraint.
Since the Constraint has been identified; we now need to fully utilize this section. Basically this means that required material has to be available at any time and no unnecessary work which could be done at another station is blocking the limiting station.
- Subordinate Everything Else to the Above Decision.
This states that all other processes which are being affected by this limiting station only produce as much material or require as much material as can be handled by the station at optimum throughput. Everything needs to be optimized to take care that no unnecessary time is wasted at the limiting station.
- Elevate the System's Constraints.
This basically says that the limiting factor should be eliminated by "reasonable" means.
- If in the Previous Steps a Constraint Has Been Broken, Go Back to Step 1
If the limiting factor has been identified and corrected, the whole process starts from the beginning. The main idea is to have a continuous evolution of the processes involved

This process is displayed in Figure 12.

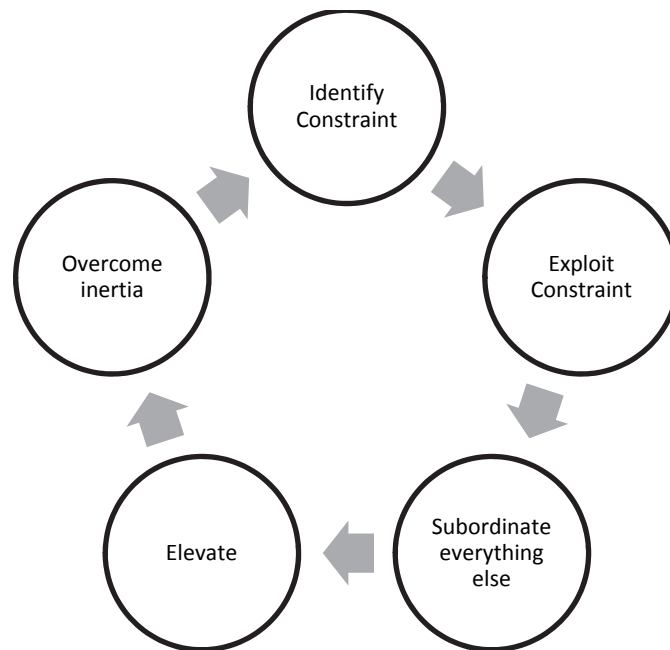


Figure 12 - The idea of the Theory of Constraints

The very same steps can now be applied to the supply chain. Whenever there is a shortage of a product somewhere in the chain or there is another limiting factor within a customer, the main goal is to eliminate these issues. Yet, according to the Theory of Constraints, this has to be done continuously.

The idea of the Theory of Constraints regarding the supply chain basically is to have the right parts in the right location in the right quantity at the right time, ideally with a minimum of work. The availability of any produced good should be 100% and inventories should be reduced wherever possible. This somewhat relates to the Just-In-Time production approach which basically enforces no inventory at all.

4.7.2 The Theory of Constraints in SMEs

The Theory of Constraints can be used in SMEs because it focuses at one problem at a time while still looking at the whole system of processes involved. Especially SMEs which do not feature a fully-fledged supply chain and also do not have the resources to deal with such an extensive supply chain can use this method to focus on the issues which are most important at the moment. It helps them to focus on issues which need to be solved in the near future and not concentrate so much on many other tasks related to the supply chain. This includes finding new suppliers. If for

example a supplier is unable to deliver a required product in time, the Theory of Constraints offers the following approach:

- Identify the blocking source: This has obviously already be done and the supplier which is not able to deliver at the moment needs to be dealt with.
- Utilize all possibilities from this supplier: Make sure that all material which is currently being received from this supplier is transferred to the required station immediately and that it has the highest priority. It must not wait at some point in the supply chain.
- If the minimum material requirements are not met, make sure that no excessive material is being requested from other suppliers which cannot be used at the moment since this would raise your inventory levels, thereby losing money.
- If there is a possibility to have a second supplier supply the same material – maybe even at a higher cost – it could be considered an option.
- Start at the beginning.

As shown, this is a process which could be easily performed in a SME because it is relatively simply but provides a guideline which can be followed without too much interference with other tasks which are not so limited at the moment.

Still, what should be done is to always keep a focus on the whole system, especially in a SME where there it is still possible to have an overview of ongoing processes. Even if the Theory of Constraints is followed, it might prove useful to sometimes concentrate on another task first and always have the full picture of ongoing processes and supplier relationships.

4.8 Sustainable Supply Chain Management

4.8.1 Definition of Sustainability

The concept of sustainability describes the capacity to endure. According to the UN, a sustainable development is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

When thinking about sustainability in any business area, the first thought goes to the

terms “environmentally acceptable” or “green”. Yet, sustainability does not only take care of environmental or ecological issues but also explicitly includes economic and social aspects. This is depicted in Figure 13. For this chapter, we will mainly look at the economic and ecologic aspects.

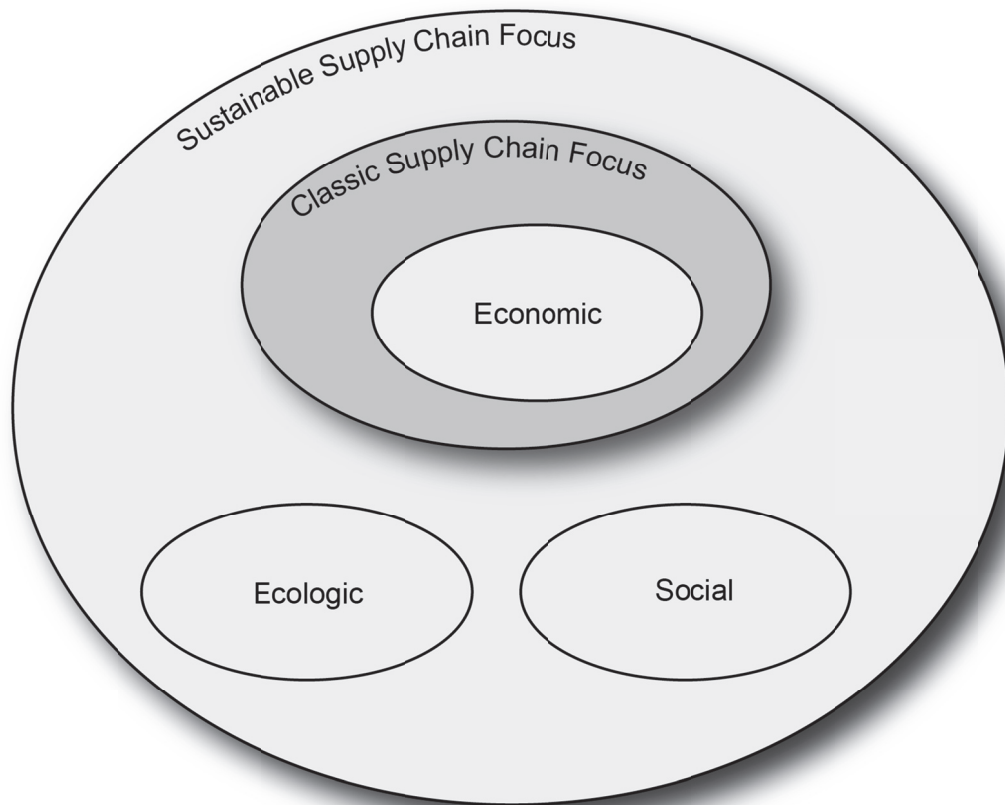


Figure 13 - Sustainable and classic supply chain focus

4.8.2 *Sustainability in the Supply Chain*

When looking at the supply chain, the question arises how a supply chain can be sustainable and which factors are important for a sustainable supply chain. The goals of such a sustainable supply chain are outlined in (Cetinkaya, Cuthbertson, Ewer, Klaas-Wissing, Piotrowicz, & Tyssen, 2011):

“The supply chain, as a key to competitive advantage in many companies, significantly determines the social, economic and environmental impacts of your company, which in turn influence more and more of your stakeholders and shareholders. Hence a sustainable supply chain strategy representing one of the most

important success factors for achieving sustainable development for your company—must exhibit the following characteristics:

- It is aligned to the underlying corporate and competitive strategy
- It considers demand, supply, and in particular other, wider general conditions
- It incorporates environmental, social, and economic perspectives in all proposed actions
- It builds increased shareholder and stakeholder value, especially customer satisfaction

A supply chain strategy exhibiting these characteristics is sustainable and represents the starting point of best practice companies to adapt their enablers for managing internals, managing externals, to adapt their performance measurement system, and to adapt their risk management.”

The most important aspect here is that this supply chain has to be aligned to the underlying corporate strategy. It must be backed by this strategy and fully supported by the management. Additionally, if sustainability is an item which should be introduced in the enterprise, it should be a holistic approach and not only focused on specific business areas.

As with any business process it is important to measure and monitor the process using Key Performance Indicators (KPIs). This is also relevant to the classic supply chain and especially important and equally difficult for sustainable supply chains. As explained, the concept of sustainability does not only take economic but also social and ecological aspects into account. Therefore when measuring the supply chain, also the social and ecological aspects need to be measured. Since such a measurement is hard to make and it is even more difficult to put this into numbers for future comparison, often there will only be a partial assessment of the performance of the supply chain.

In (Cetinkaya, Cuthbertson, Ewer, Klaas-Wissing, Piotrowicz, & Tyssen, 2011), these concepts were evaluated during the BestLog project, a project which was funded by the EU. They found the following guidelines to evaluate the supply chain:

- Social
 - Health and Safety
 - Noise
 - Employees
- Economic
 - Quality
 - Efficiency
 - Responsiveness
- Environmental
 - Emissions
 - Natural resources utilization
 - Waste and recycling

Taking these factors into account, certain principles must be followed and the style of management must match the defined goals. The first item one has to look at is the management within the organization. To build a sustainable supply chain, we need to realign (some) processes so they match the supply chain strategy and to fully integrate them with the sustainability implementation within the supply chain. Another important topic for a sustainable supply chain includes the produced goods. Every produced good has some sort of life cycle which needs to be taken into account. For a sustainable supply chain this does not only cover the transportation to the customer but also includes getting the product back after its lifetime and the disposal or renewal of the product; how can product customization help with this task?

The next important factor for a sustainable supply chain is the management of knowledge. We need to be able to minimize transportation or to allow certain knowledge to transfer into the minds of the employees. This can only be done by making them aware of certain parameters of goods. The easiest moment when one can design for a sustainable product and therefore a sustainable supply chain is during the design or the reengineering process of the product. An idea would be to use the same material as often as possible. One example should be given here:

A company produces product P1 using plastic material A. It also produces a second good, namely P2. This product needs to be more durable and more resistant to

weather. Therefore, they will use material B which is slightly more costly but regarding the product life cycle will be more robust and last longer. During the design phase this is an easy choice to make. For product P1 the designer will most likely choose material A since it meets the requirements of the product and is cheap. For product P2 the designer will use the more expensive material.

Now this has multiple implications, especially on supply chain aspects: The company will have to purchase and manage two different materials, probably from two different vendors, located on two different parts of the world. They would meet the requirements of the management regarding life cycle, durability and cost. With this approach, all sustainable principles are being left out; we will now take the idea of sustainability and include them knowledge-wise into this example.

During the design or reengineering process of both products P1 and P2, the designer checks an internal database containing a list of products and the materials used for these products. He thereby detects that product P2 uses a similar material as P1 which is more durable than the material used until now for P1. He enters this data into the database – simply as a note – and this information is stored. During the reengineering phase for product P1 the designer will now read this info and can check with the designer of P2. Now economic and ecologic aspects will kick in. From an economic side it might be better to only purchase material B. It still is more costly but the amount of material required increases, thereby having a potential effect on the price of material B. From an ecologic view this will have two different impacts. At first, the product will be shipped only from one location to the production facility, thereby reducing the figures “transport cost per unit” and “emissions per unit”. After this has been realized, it might also be possible that in the long run the product life cycle has increased. This might again have negative economic aspects since customers are buying less of the same product since it simply lasts longer but at the same time you are increasing customer satisfaction and maybe customer loyalty since the products produced by this company “seem to last forever”.

For this example, it doesn't matter if the data is stored in an internal database or some other location as long as the knowledge which results from this data can be accessed by every employee. This of course requires that the employees are trained

to look at such complex relationships and are aware of them, so there should be a culture of lifelong learning within the company and information which exists in the company should be shared among the employees.

Another important management topic regarding supply chains is the infrastructure. A sustainable company needs to be aware of its position in the supply chain and needs to plan its location accordingly. From a sustainable point of view there is no use in transporting goods from A to B to A if they could be kept at facility A and produced there. This of course might be different if one looks only at economic aspects. Furthermore, to enable a sustainable supply chain it is important to constantly monitor the demand and supply level and to plan accordingly. This also includes keeping a flexible layout to allow for changing requirements, products or other conditions.

Once these key topics are met, one can look outside the company's boundaries and go to suppliers and customers and maybe include them in the sustainability plan. This could be done by sharing knowledge about required materials in the future or by allowing them to select your future production facilities. Basically this means that regarding sustainability it is important to be collaborative and not only focus on one's own short term business goals. Rewards one can get from this have been explained in earlier chapters; probably one of the most important ones is the elimination or reduction of the bullwhip effect. Anyway, it is important to keep in mind that there are special stakeholders outside the company who might influence your supply chain in one or the other way and while following a sustainable strategy, those should be taken into account and be closely connected to the business strategy. It might also be possible that you have to remove one supplier because the sustainability goals you set for the company cannot be met with this supplier.

4.8.3 A sustainable supply chain in SMEs

A problem which can be seen in SMEs quite frequently is a lack of suppliers to choose from. Therefore, regarding sustainability, one should look at one's own possibilities first. This includes the introduction of knowledge and awareness inside the SME – this is probably also true for larger enterprises. The first step is to make employees aware of sustainability and its importance especially in small and growing

enterprises with structures which allow change to happen frequently and easily. Other topics like relocation of production facilities might not be possible for SMEs due to the large volume of incurred costs.

Another important factor SMEs might need to consider is how they can use the gained potential from developing such a sustainable supply chain and transport it to the outside world via different forms of communication. This is true not only for the supply chain but generally for every undertaking it makes.

Another question is how the sustainability of a corporation is measured if the company wants to transport this picture to the outside world. One way this can be achieved is with the help of Non-Governmental Organizations (NGOs). If a NGO certifies a product or good, the brand can gain hugely and enter new market regions. Yet, there really has to be a real effort and not only lip service as this could cause even more damage which would then need to be repaired.

If the SME has existed for a longer time, it might be a good idea to get someone from the outside to look at business processes and the supply chain. Often, the question “Why do we do it this way?” is answered with a “Just because”. It might be easier for a person from the outside to look behind the curtains and then decide if a specific process or item in the supply chain is acceptable or needs to be reengineered. Also, if this person comes from the outside he or she might be better able to criticize the management and provide alternatives due to prior experience.

Generally speaking, there are two main starting points how an SME might establish a sustainability campaign, both in its internal processes and throughout the whole supply chain. In one case, the momentum will come from the CEO or some other member of the management board. This will always be a strategic decision. The other case is when this awareness comes from within the company. The reason for this can be the awareness of a single person, for example a designer or a group of people working on a project which delivers exceptional results. Such a behavior is probably one the management should be aware of and further.

In no case should a sustainable supply chain be instituted for moral or ethnic reasons alone. The goal is always to be successful not only economically but also socially

and ecologically. There is no use for a perfectly ecological supply chain if the company cannot survive the competition economically. At the same time, if there is a potential for an improved social image, there is no reason why it should not be implemented if the economic situation allows it.

Once all the above conditions are met and the company pursues these goals efficiently and effectively, there might also be the option to get suppliers and customers into the same field to allow the sustainable supply chain to grow further and to allow synergy effects to extend over all involved companies, no matter if small or large enterprises.

5 TECHNOLOGICAL SUPPORT FOR SUPPLY CHAINS IN SMALL AND MEDIUM ENTERPRISES

5.1 Introduction

This chapter will deal with technological advances which have evolved in the past years and which can support even smaller enterprises in their striving to develop a powerful, yet resource-saving supply chain which suits the business area of the enterprise.

Especially with the rise of the Internet in the past twenty years to a network which can be reached at any time of the day in any place in the world and in which a multitude of companies take part, many technologies have evolved which allow communication in a standardized form. This supports doing business on an international scale very easily. Border boundaries are no longer communication boundaries and even complex data can be exchanged electronically within seconds all over the world.

Due to the magnitude of technologies available, we will only focus on those which are relevant today and which could be used even more in the near future. These are also the technologies a SME would probably be most interested to look at.

5.2 Enterprise Resource Planning (ERP)

Enterprise Resource Planning systems can today be found in all large enterprises. For micro-enterprises the implementation of such an ERP system is a task which might not appear necessary at the moment but as soon as it evolves into a typical SME there is hardly no way to survive without a structured system to save business data.

ERP systems usually evolve over time. Usually a SME starts with a simple tool for Material requirements planning (MRP). Over time, this becomes more powerful and will handle the manufacturing resources. With an increase in integration of information and an increasing impact on the supply network this has led to ERP systems. A next step would be a network where multiple partners work together in a collaborative way. When an ERP system is used, controlling usually happens on multiple levels which are typically defined as depicted in Figure 14.

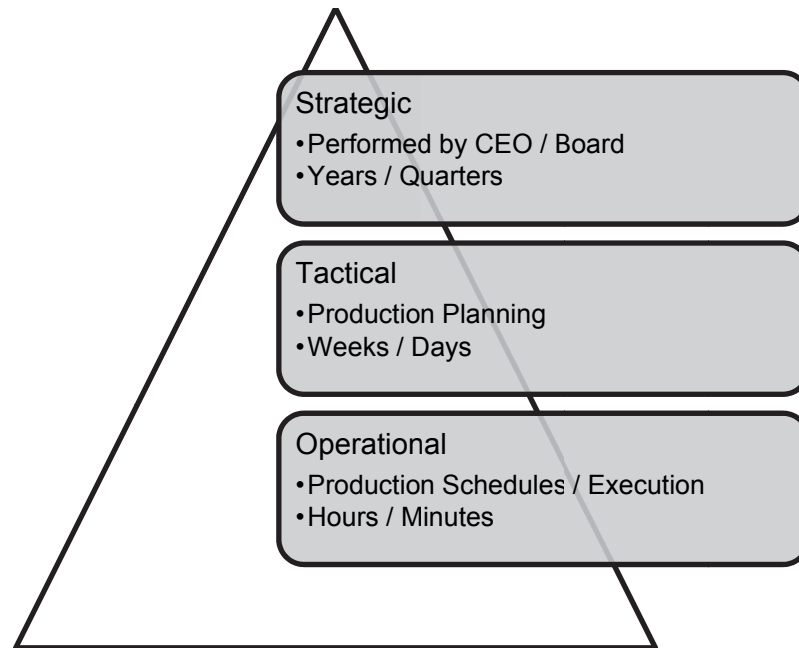


Figure 14 - Controlling horizons in ERP systems

An example of a strategic decision would be the strategic sourcing of required parts in case there might be problems in the future (due to instabilities in the economy or in countries). Not only controlling of the processes involved is performed on multiple levels but also the reporting. The data is usually aggregated and sent to the next higher level with an added layer of abstraction.

Often when a SME is in the process of implementing an ERP system, there will be the need for a CRM system which can be connected to the ERP system so that these two systems will be able to track the daily business tasks. Such a combination of ERP + CRM will usually fulfill at least the following tasks:

- Accounting
- Efficiency calculations / ROI
- Human Resource Management
- Keeping track of business contacts
- Inventory control
- Quality assurance
- Production planning
- Integration of business partners

- Customer information
- Delivery and Logistics
- Service applications
- Strategic reporting

In most of the time an ERP system will not be created from scratch. Usually a functioning system will be purchased and business processes will have to be aligned with the ERP system. This results in a better organization because only specified business processes will be allowed. All others will be blocked by the system, requiring either to change the ERP system according to the needs if they are really required or sticking to the defined business processes.

5.2.1 ERP systems in SMEs

The use of an ERP system in an SME can be a labor intensive task, especially during the initial implementation phase. It usually requires a certain level of rethinking and defining the business processes which are involved. Advantages which result from this are clearly defined business processes which may not exist from the beginning in a SME but have to be defined during the implementation phase.

Disadvantages which may result from the use of an ERP system are that the implementation phase will require a lot of work and a disruption of functionality of the ERP system will also disrupt the business. Therefore, a lot of care has to be taken that the system is in working condition at any time. This can be a problem for a small enterprise with virtually no IT administration staff. Also, Know-How regarding the ERP system needs to be imported into the enterprise.

5.3 Radio Frequency Identification (RFID) Tags

5.3.1 Explanation of an RFID system

The basic functions of RFID are identification, acquisition and positioning. Sometimes such a system is also called a “smart label”. A RFID system consists of two devices. One device is called a “Tag”. This tag can be either active or passive, the technology chosen results in a difference in price, capabilities, distance and storage space or maximum amount of transferrable data. The second device is called

a RFID Reader. This is basically a device which is able to send and receive data over the air (wireless), thereby communicating with the tag. A schematic view is displayed in Figure 15.

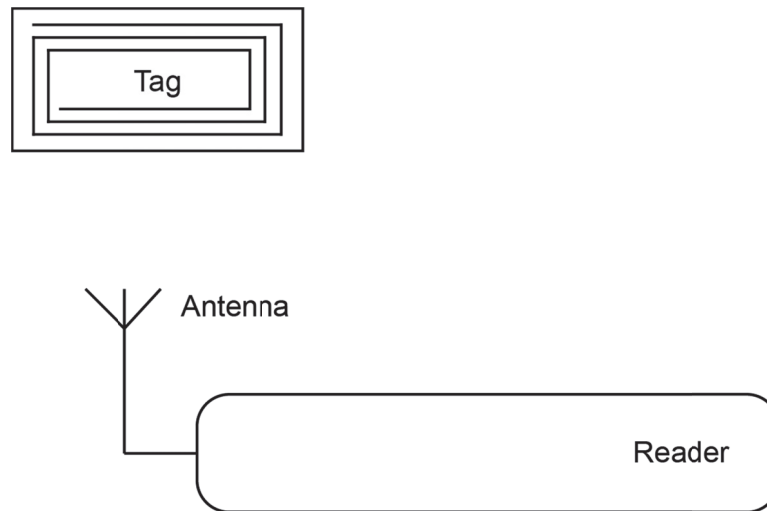


Figure 15 - RFID system overview

Typically an RFID Reader is either stationary or mobile, in the latter case it is usually powered by a battery. In any case, it is considered to be an active device since it will generate an electro-magnetic field which powers the tag.

If the tag is a passive type, it will store the energy it receives from the electromagnetic field and use it to transmit its information to the reader device. This is the cheapest version of tags with just a few cents per piece. Yet, because they have to use an EM field to be powered, the range is very low, usually less than a few meters down to a few centimeters and the data capacity is low as well – usually around 256 bytes to 4096 bytes.

If the tag is an active type, the tag itself contains a battery which keeps the tag alive. This results in the possibility to communicate over a larger distance but will make the tag more expensive. Possible ranges are in the kilometer range and depend only on the technology of the tag and the legal restrictions on radio frequencies.

The system itself can be compared to the barcode system which is deployed nowadays widely – basically a barcode can be found on any product. Yet, the use of barcodes is limited, for example no more than one barcode can be scanned at the

same time and there needs to be a line of sight between the barcode and the barcode reader. This is a limitation which doesn't exist for RFID tags. Another limitation which can be overcome by using RFID tags is the limited space. Basically there is no space limitation for active RFID tags, for passive RFID tags this is usually limited to a few bytes which makes it possible to store e.g. an identification code (similar to a barcode, yet completely unique), lot number, expiration dates, product quality data and an identification of workers who were working on that item. A more detailed comparison is given in tabular format in Table 4.

Feature	Barcode	RFID
Communication	+ Optically	++ Radio
Costs / Tag	++ Can be easily printed on media	- Must be attached to media
Security	-- None	+ Possible, but current security measures are considered deprecated / unsecure
Range	- Centimeters	++ May range from centimeters to whole areas
Visual Identification	++ Easily recognized by users	~ Cannot be seen, special logo might need to be added if required
Wear	~ Could be destroyed	+ If embedded into product practically no wear

Read-Write Capability	-- Write once only	++ Option to rewrite tag, option to write-protect tag
Automation	- Usually user interaction required when scanning	++ All tags inside specified area can be detected
Accuracy	~ Often not read correctly, but usually contains checksum, second scanning required	++ Error detection/correction is performed transparently
Simultaneous scanning	-- Single	++ Multiple
Reusability	--	++
Capacity	-	+
Line of Sight reqd.	--	++

Table 4 - Comparison Barcode / RFID

5.3.2 *RFID systems in enterprises*

Basically there are two main areas where such an RFID system can be of use. One area is the area of inventory monitoring. Using RFID technology, one is – theoretically – able to keep track of every item in stock at any point in time. Basically, every item can be equipped with an active RFID item and could then be tracked by stationary reader devices throughout the enterprise, wherever it might be located at that very moment. Of course, this is a question of costs and will therefore only be implemented for important or large items where the additional cost for such an item is less than what the eventual production of an additional item would cost. Still, the possibility exists.

A very good summary regarding the use of RFID tags in enterprises is given in (Dolgui & Proth, 2010):

“Studies conducted in distribution centers show that bar-code reliability is below 80%, while RFID used by retailers and in airports achieved over 99% reliability. Readers (interrogators) can read multiple tags instantaneously. This reduces drastically item-identification lag, allows the automation of many time-consuming tasks such as scanning inventory inputs and outputs, as well as checking the inventory state: these tasks can be done in real time. Automation of storage activities results in lower inventory levels (and thus buffer reduction) and less out of stock (shortage) occurrences that, in turn, leads to the physical flow speeding up. This aspect is of utmost importance in supply chains. Indeed, inventory and labor costs decrease accordingly. Some other improvements can be mentioned:

- The data provided by the reader portals located at the entrance of the inventories can be matched against the purchase orders, and in the case of a discrepancy action can be taken immediately (rejection of the delivery concerned, launching a new purchase order, etc.).
- A product arriving in a storage facility is identified through RFID and its placement is fixed automatically, thus avoiding misplacement. At the same time, the state of the inventory files in the computer is updated.
- The locations of the products in storage facilities are automatically stored in computer files. As a consequence, scanning bar-code identifiers becomes obsolete when picking up products to continue production or for sale and employees in charge of replenishment will not have to search products that are not at specific locations. Thus, picking operations can be automated.
- Customer billing can be automated using the data provided by a reader portal located at the exit of the system and by a data base dedicated to orders and products.”

Another very detailed explanation including case studies can be found at (Microsoft Corporation, 2005).

5.3.3 *RFID Systems in SMEs*

Since SMEs are usually more flexible than large enterprises, there is a chance for using such a RFID-based system. As mentioned, this is based on the assumption that the goods are expensive and that the loss of a single item results in considerable damage.

Since RFID systems are not deployed throughout the business environment yet, the cost for the implementation and running phase of such a system is probably very high which will hinder many SMEs from implementing this technology. The application of passive or active tags depends on the type of industry and the type of product; so this would have to be decided on a per-company basis.

In case an enterprise is required to track all items which pass through its production facilities for legal or competitive advantage reasons, RFID provides a good implementation choice.

Another reason that might hinder SMEs from implementing fully featured RFID systems is the requirement of having an appropriate software system backing up the enterprise's processes. The data retrieved from the RFID tags must be interwoven with the remaining company data such as sales orders or supplier orders.

6 RESULTS

Results for the supply chain management topics which were outlined in detail are always given at the end of each chapter. This chapter should only give an overview of these findings and outline what possibilities SMEs might add by introducing an effective and efficient supply chain.

This thesis focuses on the needs and requirements of small and medium enterprises and is therefore mainly targeted at these. The topics outlined in detail are very well documented for large enterprises which have the required staff to maintain a well-balanced and working supply chain. For SMEs this is very much different. Usually, especially in small enterprises, there is no real staff that focuses on purchase and sales side and deals with this constantly changing environment.

SMEs need methods which can be implemented with a minimum of incurring costs and within a minimum of time required to perform the constant updating. Therefore, for this thesis some topics have been researched and some have been found as being appropriate for SMEs whereas others are unlikely to be used in SMEs or only used for specific areas.

A method which should be pointed out is the Agile Supply Chain Management method. It allows growing enterprises to dynamically adapt to changing market situations or other business related changes.

Considering the lean principles one can understand that these are fundamental principles which should be introduced into any business because they support basic business goals. As explained in this thesis the theory of lean can be combined with the theory of agile supply chain management. This offers a large range of possibilities since:

- The lean principles only introduce what should be introduced anyway and
- Provide support for large, mass production goods whereas
- The agile method allows for dynamic changes and
- Provides support for rapid development of new products

These two methods work together as it has been explained in the Pareto-Approach example.

The basic principles of sustainability are also principles which can be easily applied without too much additional overhead. What they postulate is the sharing of information to reduce costs, thereby eliminating unnecessary transport or other non-value adding work.

When looking at techniques which have been established in the recent past, the one with the most potential is probably RFID. Of course, this strongly depends on the type of business and the requirements of the produced goods, but it allows a continuous monitoring within (and also outside) business boundaries, thus allowing the supply chain to perform better. Of course, there is some cost involved both in the implementation phase at the beginning and in the operation phase. There has to be some kind of tradeoff between the possibility to track and the cost involved in tagging items and processing them in online computer systems.

From my previous business experience and some talks with CEOs of various SMEs, the introduction of an ERP system should be done as early as possible. There is no need for a specific supply chain management tool at the starting phase of SMEs, since many ERP tools already have a module which can handle the basic requirements such as relationships to customers and suppliers. Most of the times, also a ranking of suppliers is possible and the time it takes to get an item can be added as well. If the enterprise then wants to implement specific procedures or methods, there exist tools that can help in doing so. Yet, the implementation itself has to be done by a person or a team responsible for this task, no tool can eliminate this work.

7 SUMMARY AND OUTLOOK

In the beginning of this thesis we have defined the term Supply Chain Management and discussed the need for the implementation of a supply chain management system or supply chain focused approach. Additionally, the differences between Logistics and Supply Chain Management were explained, especially in the sense that there is no clear border between the two.

In the following chapters we described the tasks which need to be handled by a supply chain management system and what goals should be reached by implementing such a system. We learned how to relate the Supply Chain to the business strategy and by introducing the SCOR model we got an overview of the functions which need to be handled.

The next chapter gave an overview about potential issues which might arise in the supply chain and listed some of the most important ones. Additionally, this thesis provides an insight to production strategies and Supply Chain Management Operations Strategies. The last part of this chapter explained the bullwhip effect and how it could be handled by implementing an effective collaboration plan. Examples for this were given by providing the ideas for Vendor-Managed Inventories and the “Everyday Low Prices” strategy. It was also shown that the Bullwhip effect can be reduced by removing uncertainty from the supply chain which is an essential point.

The next main chapter shows how small and Medium Enterprises are defined in the European Union and what issues may arise with Supply Chain Management Systems in such SMEs. Since I had the opportunity to talk to some CEOs of such SMEs, a short statistic was given to show how such businesses handle their requirements on a day-to-day basis, followed by a short overview about efficient and effective processes and why they are important.

The thesis then focuses on issues with the supply chain especially connected to SMEs. It explains why it can be harder to implement a well-functioning supply chain for a SME than for a large enterprise. This includes the factors that a supply chain has to be continuously updated, SMEs are less able to put pressure on their suppliers and that there are also globalization issues but also chances involved.

This chapter is concluded with an overview why a working supply chain is so important for a SME and why there is no way around it in the long run. The next chapter explains management methods which can be used to implement a supply chain management system in a both efficient and effective way.

Starting with the Lean method approach, there is an overview about the terms Lean and TQM. To understand where the power of the supply chain lies, this thesis explains the meaning of the term value when speaking about a Lean Supply Chain. It then explains how the power of following the lean principles can result in an efficient supply chain and how these principles can be used effectively by a SME.

The following section deals with the topic of agile supply chain management. After defining how an agile supply chain looks like, we discuss how flexibility can be achieved in such a system. To understand the difference between a lean supply chain and an agile supply chain, we explain the functional vs. innovative products example. This section concludes by explaining how SMEs can leverage the power of an agile supply chain.

The next section goes one step past normal supply chains and explains the next step in the evolution of supply chain management. A topic which we will most certainly see even more in the future is the topic of supply chain networks. These of course come with great possibilities but also hard implementation problems. In the course of this chapter we also look at these. To really have all the partners in the supply network work together, this requires a method called collaborative planning forecasting and replenishment in order to reduce inventory and lead time. The final discussion explains how such supply networks can be used in SMEs.

A completely different approach which can also be part of your supply chain is outlined as well. Outsourcing parts of your business is a valid method to enhance your business. Therefore, to understand which parts can be outsourced and which should be kept within business boundaries, this chapter also explains the terms “core competencies” and “competitive advantage”. Finally, there is a short overview of how a SME can outsource parts of its business.

The next method which is explained in detail is the Kanban method. This basically describes a pull system which originates from the customer. Since Kanban is not so well known, there is a short overview how the Kanban system works and what its principles are. How the Kanban system can be effectively implemented for a supply chain is explained in the next section, followed by the term “Demand Chain Management” which follows the same idea. How a Kanban system can be implemented within a SME is explained at the end of the chapter.

One method which follows an approach which seems very much suited to SMEs is the Theory of Constraints method. This method basically says that you should always concentrate on the constraints you can find and that you should do this continuously.

The next chapter does not deal with specific methods for the supply chain anymore but offers technological products which can help to enable an efficient supply chain. Starting with Enterprise Resource Planning systems, this thesis explains how they work and which tasks they fulfill. Also, difficulties when they are implemented in an SME are outlined.

Another technology which is explained in detail is the system of RFID tags and the appropriate reading devices. It is explained in detail how such devices can help in maintaining low inventory by being able to keep track of every part in your inventory. It is explained that since this technology is rather new, it is probably too expensive to be used in SMEs except for a few special cases where it might prove extremely useful.

The results of the thesis which are outlined at the end of every chapter and are focused on the needs of SMEs show that the implementation of an effective and efficient supply chain management is a task which brings a lot of advantages to a typical SME. We have researched a few methods which enable a SME to implement such a management system and which give tools to make this implementation successful. Especially when looking at the great magnitude of methods available, many of the methods selected for this thesis seem to match the needs of a typical SME.

Some of the tools mentioned will very likely become a large topic of interest in the

near future. At the moment, they are not really suited to enterprises of different sizes because they require too much cost overhead or because they require too much personnel to maintain them. The need for extensive supply chain systems needs to be considered in every enterprise, no matter if this enterprise is large or belongs to the group of SMEs. This is also outlined in (Cetinkaya, Cuthbertson, Ewer, Klaas-Wissing, Piotrowicz, & Tyssen, 2011):

“Long-term trends pose challenges for supply chain managers and make increasing requirements on the strategic management expertise of today’s companies. These trends include ongoing globalization and the increasing intensity of competition, the growing demands of security, environmental protection and resource scarcity and, last but not least, the need for reliable, flexible and cost-efficient business systems capable of supporting customer differentiation. More than ever, modern supply chain managers are confronted with dynamic and complex supply chains and therefore with trends and developments that are hard to predict. In years to come, supply chain management will therefore take on additional strategic tasks that extend beyond its current more operational scope of activity. In order to respond to these changes and remain competitive, supply chain managers need to be able to identify and understand new sustainability issues in their company and business environment.”

Considering the changes which happened in the past 15 years, especially regarding the IT infrastructure and the increase in knowledge about management systems, one can deduce that more and more IT systems will exist in every enterprise, no matter if it is a small or large enterprise and that these IT systems will continue to integrate general business processes such as resource planning and supply chain management. Since nowadays even SMEs are able to enhance their business opportunities through globalization, it is not unlikely that also supply chains of geographically separated companies will become interwoven more and more.

Also, the classic supplier-company-customer scheme will change into a more collaborative relationship, thereby enhancing the chance for competitive advantage for companies that know how to take advantage of such systems. This will result in more connected systems and is directly targeted at the topic of supply chain networks which were explained before.

A future goal, especially for SMEs will be to connect their internal systems to the supply chain to make this collaborative approach possible. Of course, this requires a lot of work which has to be performed inside the companies, but the key benefits these companies can gain are (amongst many others):

- Lower inventories while maintaining delivery performance
- Lower costs due to lower inventories and more automatized processes
- More agility and flexibility regarding product change processes
- Enhancing customer satisfaction through an open approach

For the future, especially SMEs will need to make use of ERP systems even more than they do nowadays. These systems are basically the first step towards a fully functioning supply chain. When I supported a company a few years ago in the transition phase between uncoordinated Excel lists with customers, offers and orders and the introduction of an ERP system, it became quickly clear that, although processes existed regarding order tracking, invoicing and basic supply chain operations, only an electronic system could really perform these efficiently. Even more than that, it also helped focusing on these processes and improving them while taking care that these processes are executed in the same way again and again and no exceptions were made. This transition caused a lot of work for all employees in the first place but in the end, the general idea was that this step should have been made much earlier. Since nowadays most SMEs use computer systems already, this is a step which will probably be made in every enterprise. One possibility regarding CRM, ERP and SMEs which has not been mentioned before because it is not a technology itself is to make use of web or cloud based systems. With these systems, even companies which are not able to have their own IT personnel can use easy systems which offer basic functions and connectivity to other systems at a later time, once the enterprise has grown and requires more powerful tools.

When looking into the future even more, the vision is to have completely interconnected systems which perform functions such as order tracking from the final customer to the producer of raw materials whilst keeping track of these items through the whole chain during deliver, use and disposal. Also, the integration of social and ecologic reasoning into the supply chain will be a large topic with many chances.

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10 LIST OF ABBREVIATIONS

CEO	Chief Executive Officer
CPFR	Collaborative Planning, Forecasting and Replenishment
CRM	Customer Relationship Management
CSCMP	Council of Supply Chain Management Professionals
EDI	Electronic Data Interchange
EDLP	Everyday Low Prices
ERP	Enterprise Resource Planning
EU	European Union
FMS	Flexible Manufacturing Systems
ISO	International Organization for Standardization
IT	Information Technology
JIT	Just-In-Time
KPI	Key Performance Indicator
MNC	Multinational Corporation
MRP	Material Requirements Planning
NGO	Non-Governmental Organization
PP	Production Planning
R&D	Research and Development
RFID	Radio Frequency Identification
ROI	Return-On-Investment

SCC	Supply Chain Council
SCM	Supply Chain Management
SCN	Supply Chain Network
SCOR	Supply Chain Operations Reference Model
SME	Small and Medium sized Enterprise
TOC	Theory of Constraints
TQM	Total Quality Management
UN	United Nations
VICS	Voluntary Interindustry Communications Standards
VMI	Vendor Managed Inventory