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# **OFFSHORING AND OUTSOURCING UNDER DEMAND UNCERTAINTY -A SUPPLY CHAIN MANAGEMENT ANALYSIS**

Master's Thesis  
In Logistics

Author:  
Aarni Nordqvist

Supervisors:  
Prof. Lauri Ojala  
M. Sc. Sini Laari

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Turun kauppakorkeakoulu • Turku School of Economics

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## 1 INTRODUCTION

Within the increasing competition and new possibilities in the globalizing world, rethinking the supply chain strategy does not only involve the coordination of different activities in the supply chain. It also includes deciding what to make internally, what to offshore and what to outsource or offshore outsource. (Simchi-Levi et al. 2008, 14.)

Outsourcing and offshoring or any combinations of these have not just become a popular phenomenon, but are viewed as one of the most important management strategies of modern time due to the new possibilities from globalization. In academic literature there have been calls to elevate the process of outsourcing-insourcing, i.e. deciding which activities to do within the company and which to move beyond the company's geographical or organizational boundary, to the status of a new management function that can replace entire departments within the firms' operations. However, offshoring and offshore outsourcing include a broad variety of different risks and questions that need to be identified and discussed; history has proved that nearly half of the outsourcing-insourcing operations have ended in failure. (Schniederjans 2005, xix.)

Offshoring and offshore outsourcing have been practiced because they have given companies the possibility to develop their business and save especially in labor costs. Many managers have however forgotten or have not noticed that both of them present numerous additional cost factors in the firm's operations. From the supply chain management point of view one of these is for ex. the need to address more carefully the customer demand because often offshoring or offshore outsourcing lengthens the lead time and makes it harder to react to changing customer demand. At its worst, the consequence of poor demand management might be uncontrolled fluctuation of inventory levels and great inefficiencies also known as the bullwhip effect. (Ferreira & Prokopets 2009, 23-24.)

A more international supply chain can increase the overall costs of operations due to extended material pipelines, longer lead times and the decrease in control. The total cost concept can help managers to evaluate the financial effects of offshoring and offshore outsourcing more thoroughly. The basic idea and benefit of the concept is to use cost components that are normally left aside from the basic cost accounting which can have a critical impact in the decision-making. By this way the managers can evaluate the possibilities of offshoring and offshore outsourcing with a long-term perspective, not a short-term, initial-cost perspective. (Trent & Monckza 2003, 609; Kumar & Kopitzke 2008, 107-108; Ferrin & Plank 2002, 18.)

## 1.1 Aim of the study

The case company of this Master's Thesis is an international rubber product manufacturing company. It mainly operates as a first tier or second tier supplier for heavy automotive industry. As the automotive industry operates with the just-in-time concept, the products of the supplier must be at production site strictly on time. Besides timing, the other major challenge within the company's business is increased price competition due to the high bargaining power of the customers and new cheaper manufacturers in the developing world. To overtake these challenges, the concepts of offshoring and offshore outsourcing within the production have already been used to decrease costs, but their role in the company's general strategy has not yet been rationalized since the lack of information concerning the effects to operations in general.

Within the supply chain management the company's aim is to optimize its supply chain to meet the two challenges of decreasing prices and sustaining or increasing the customer service level. The effect of non-competitive pricing and errors in product delivery can be crucial.

The aim of this Thesis is to describe and analyze the cost drivers of the supply chain and the effects of offshoring and offshore outsourcing. The most important task of this Thesis is to compare the calculable supply chain total costs of potential offshoring and offshore outsourcing alternatives. This will be done by:

1. Constructing a total cost model to assess the relevant cost in this context.
2. Analyzing available cost data with the model.
3. Providing a cost assessment of the given alternatives.

The introduction Chapter of the Thesis will give an overview of the supply chain and the challenge in linking it with demand uncertainty and demand forecasting.

The second Chapter concentrates on explaining offshoring and offshore outsourcing as a part of the supply chain strategy. The benefits and risks of both of these concepts are discussed.

In Chapter three the concepts to analyze the cost effects of offshoring and offshore outsourcing are presented. In Chapter four the methodology and the analyzing model for the case company are explained. The supply chain, the offshoring and offshore outsourcing plan and the operations of the case company itself will also be presented.

The results of the model will be presented in Chapter five as well as the recommendations for decision-making. In the final Chapter six the conclusion of the case and the potential further usability of the offshoring and offshore outsourcing analyzing model will be given.

## **1.2 Limitations**

Supply chain strategy and development are large and complex entities. As the focus of this study is in evaluating offshoring and offshore outsourcing production as a part of supply chain development, some limitations are needed. The offshoring and offshore outsourcing of other logistics flows such as information, capital, or recycling flows are present but not in detail in this study.

This Thesis is aimed at evaluating the possibilities in situating the upstream activities of the supply chain in different geographical locations. Thus, the framework of comparing trade-offs between offshored, offshore outsourced and insourced production is applied. The alternative locations for production are given. Therefore, the evaluation of offshoring and offshore outsourcing site selection is not included in the study. This case study offers a basis for the further investigation for optimal offshore or offshore outsourcing site selection.

This study considers mainly quantitative factors related to the evaluation of production offshore or offshore outsourcing possibilities. The qualitative factors, which cannot be left out from decision-making are not studied in such detail.

## **1.3 Definitions of outsourcing, offshoring and offshore outsourcing**

In the manufacturing and service sectors new sourcing patterns have emerged due to the growth in international trade and global competition. In the manufacturing sector international networks of production are being established. Within this scenario the development of supply chain networks by adapting offshoring and offshore outsourcing is a critical issue for multinational enterprises or companies that are starting to globalize their upstream activities. (Mangan et al. 2008, 79.)

Globalization and offshoring or offshoring outsourcing presents various benefits to different business but bring new problems concerning especially supply chain issues. In the following Chapter, the terms offshoring, outsourcing and offshore outsourcing are defined. Then it is answered why companies have started to offshore or offshore outsource production. Finally, the possibilities and risks of offshoring and offshore outsourcing are presented.

To define outsourcing, offshoring and offshore outsourcing it is useful to first look at them from a wider outsource-insource perspective. In this perspective the basic question within the company's management is where to allocate the resources of the company between organizational and geographical boundaries. There are many varieties to execute this. Schniederjans (2005) has created the following list to present the options:

Table 1 Common types of outsourcing (Schiederjans 2008, 8)

Type of outsourcing	Description
Offshore Outsourcing	Outsourcing to a provider located in a different country from the client firm. In a variant of this a client firm offshores their operations to another country by starting up their own business in the foreign country. This type of <i>offshoring operations</i> is not considered outsourcing, but is a form of insourcing.
Nearshore outsourcing	The same as international outsourcing but in this case the countries are neighbors.
Transitional outsourcing	Outsourcing an older business system so the firm can concentrate on making a new system work.
Co-sourcing	Outsourcing where the provider's payment is based on achieving a particular goal such as improving the client's business performance.
Spin-offs	Outsourced business activities of one company being brought together into a completely and separate firm.
Backsourcing	A kind of insourcing where a client firm, having experienced less than desirable outsourcing, moves the outsourced business back to the client firm.
Business process outsourcing	Outsourcing of an entire process or department within a firm.
Business transformation outsourcing	Business transformation outsourcing typically focuses on helping the client firm create a new infrastructure or business model.
Value-added outsourcing	Client and provider strengths are combined to market products or services.
Netsourcing	Renting computer applications, services, and infrastructure over Web networks.
Shared outsourcing	When one outsource provider works for more than one client firm at the same time.
Multisourcing outsourcing	When multiple outsource providers are used simultaneously to ensure, for example, competitive bidding in the outsourcing arrangements.

There are numerous different variations of the definitions concerning outsourcing, offshoring and offshore outsourcing in academic literature. In this Thesis the terms are referred from manufacturing and supply chain management point of view. There, offshoring and outsourcing are considered two different terms that do not refer to each other directly. However in many situations the characteristics of both of them are combined as what is called offshore outsourcing or foreign outsourcing. Each of the terms is defined in the following.

Outsourcing is defined as sourcing goods and services previously produced internally within the sourcing organization from external suppliers. The term outsourcing can cover different business operations such as manufacturing and services. Usually the term is used when the supply of a product or service activities are switched to external suppliers.

(McIvor 2005, 7; Liu et al. 2008, 435.) Offshoring is moving production or service activities that are earlier executed locally to a destination in another country (McIvor 2005:12).

Offshoring is not the same as outsourcing because outsourcing involves giving ownership to another organization, whereas with offshoring the company can still own and control the process itself which is executed usually in a lower cost location. (Mangan et al. 2008:79.) Offshore outsourcing is outsourcing business operations to outside the domestic market served by the company. Offshore outsourcing is literally offshoring and outsourcing at the same time. (Tate & Ellram 2009, 256; Liu et al. 2008, 435.)

A term also used to define the moving of activities and business processes from one country to another is called nearshoring. The meaning of it is basically the same as offshoring but it is used when the target location is close. As an example a US company would nearshore its production to Mexico. (Robinson & Kalakota 2004, 31.)

It is important to differentiate offshoring from business process outsourcing, which involves the migration of services to an external provider. A common misconception is that all offshoring includes outsourcing. While outsourced processes are handed off to third-party vendors, offshored processes can be handed off to third party vendors or remain in-house. The definition of offshoring includes organizations that build captive centers of their own in remote, usually lower-cost locations.

#### **1.4 Demand uncertainty in the supply chain**

Demand uncertainty is one of the great challenges a company meets in its operations and it can have an effect in offshoring or offshore outsourcing decisions. Demand is uncertain in most situations. Recognizing it and predicting it as truthfully as possible is vital for a company to successfully meet customer demand and service requirements. Especially in modern days, demand uncertainty has increased due to rising complexity of the product portfolio and more intense competition. (Simchi-Levi et al. 2008, 31-32.)

The context, where the demand uncertainty forecasting is made is the supply chain. Thus, the supply chain should be defined. In many scientific publications, supply chain is a network of value adding organizations for an output. Mangan et al. (2008) define it as:

*“the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate customer.”*

Simchi-Levi et al. (2008) also remarks the importance of the development chain as the context of factors not linked directly to physical product flow but the infrastructure and decisions behind it, such as strategic partnering and supply contracts. Both are important

and related to demand uncertainty. The term mostly used in this Thesis will be supply chain since it's renowned position in scientific and every-day situations.

There are two types of demand that should be distinguished for the later analysis of demand uncertainty. The first is independent demand which means the demand from a single end customer. The second one is derived or dependent demand in which the demand is derived from the production requirement schedule. When identifying demand uncertainty itself, one should also consider that demand uncertainty can be implied, where the demand uncertainty is measured by only that part of customer needs the supply chain aims to satisfy. For example if the service level requirements are heightened, the actual demand uncertainty does not increase but the implied demand uncertainty does. (Ballou 1992, 111; Chopra & Meindl 2007, 27.)

Demand uncertainty varies sometimes strongly depending on customer needs. The customer needs are reflected from the product type that is offered. The logistics requirements for product types may differentiate strongly in terms of f. ex. lead time, service level and variety. According to these indicators, the customers can be segmented into categories because many customers have the same preferences. The manufacturer should then be aware of these customer categories and understand the role of logistics requirements affecting the demand uncertainty as presented in Table 2. (Chopra & Meindl 2007, 26-27.)

Table 2 Impact of customer needs on implied demand uncertainty (Chopra & Meindl 2007, 27)

<b>Customer need</b>	<b>Causes implied demand uncertainty to...</b>
Range of quantity required increases	Increase because a wider range of the quantity required implies greater variance in demand
Lead time decreases	Increase because there is less time in which to react to orders
Variety of products required increases	Increase because demand per product becomes more disaggregate
Number of channels through which product may be acquired increases	Increase because demand per product becomes more disaggregate
Rate of innovation increases	Increase because new products tend to have uncertain demand
Required service level increases	Increase because the manufacturer now has to handle unusual surges in demand

For example if the customer demands shorter lead times, it affects the uncertainty by increasing it since the manufacturer has less time to react to orders. In addition, if the service level is high, the implied demand uncertainty is also high because the company has to react without any buffer to possible stronger than normal changes in demand.

Fisher (1997) has pointed out other correlations with implied demand uncertainty and product characteristics. These are product margin, forecast error, stockout rate and markdown of products. Products with low profit margin tend to be more mature with steady competition having a low implied demand uncertainty. Forecast error for products with high uncertainty is higher and it is then easy to see that there are also more matching problems with these products in terms of supply and demand and markdowns. (Fisher 1997, 105-106.)

An essential part of the success in forecasting is the free flow of material and information. Therefore they need to be observed in the company. Demand forecasting and the supply chain are often seen as two separate functions within the firm. However, in reality forecasting is an important part of the supply chain network design. Likewise, the supply chain gives the feedback whether the forecast has been executed well or not. (Klatch 2007, 23.)

## 1.5 Demand uncertainty forecasting

Demand forecasting is difficult and probably one of the most inexact functions in management. Many even consider it more as an art than science. However its importance is obvious as it forms the basis of all supply chain planning by generating the basic inputs for the planning and control of all functional areas not only in long-term but also on a day-to-day basis. These are logistics, marketing, production and financial areas of the firms operations. For example, estimation of demand is essential in deciding capacity levels for manufacturing resources, subcontractor requirements and transportation requirements. In general level, the forecasts guide in solving financial needs and general business structure of the company, all of which have their own forecasting problems. (Ballou 1992, 108-109; Waller 2003, 261.)

There are several matters that the user of demand forecasting must address. Chopra and Meindl (2007) offer a six-step approach to perform effective forecasting (Chopra & Meindl 2007, 191-193):

1. Understand the objective of forecasting
2. Integrate demand planning and forecasting throughout the supply chain
3. Understand and identify customer segments
4. Identify the major factors that influence the demand forecast
5. Determine the appropriate forecasting technique
6. Establish performance and error measures for the forecast.

In contrast, Chambers et al. (1971) present three questions that should be answered when making a forecast (Chambers et al. 1971, 2-5):

- What is the purpose of the forecast – how is it to be used?
- What are the dynamics and components of the system for which the forecast will be made?
- How important is the past estimating the future?

As it was explained previously, demand forecasting affects nearly all functions of a company from marketing to purchasing activities. Especially in marketing, demand forecasting is considered one of its main operations. However it has become clear, that demand forecasting plays a key part in planning logistics operations in a company as well and should be given importance (Ballou 2003, 108).

### *1.5.1 Issues affecting demand uncertainty forecasting*

When forecasting demand, the output of the analysis should preferably be simple and easily understandable. The nature behind this simplicity though can be greatly confusing and complex as preparing a creditable forecast demands a deep consideration of both intra-company and outside the company factors. These include the markets and the economy, the users of the forecast and the nature of company strategy and customer's preferences. In brief, as detailed data as possible should give as simple and clear information as possible.

The nature of the product should be recognized when forecasting the demand uncertainty. Chambers et al. (1971) emphasize the necessity to identify the position in the products lifecycle based on the sales of the product. The start of the rapid growth phase and its intensity as well as the steady state phase should be predicted as these require different approach in forecasting (Chambers et al. 1971, 55). Another issue is the products which are in the beginning or end of their product life cycle since the most popular forecasting techniques are difficult to apply for phasing products. These products might have lumpy or irregular demand and, depending on the nature of the company itself, represent as much as 50 percent of the firm's turnover. (Ballou 2003,109.)

The time horizon of the forecast has an effect in the forecasting accuracy. Basically the longer the forecast horizon is, the worse is the forecast. However, sometimes it is needed to make forecasts for longer period, for example, 12 to 18 months. (Simchi-Levi et al. 2008, 35.)

When analyzing the demand from the long-time sales perspective, three typical patterns can be and should be recognized. If the demand is random or level, the line of the average sales in a chart would be straight. Another pattern is an increasing or decreasing line when the demand has a trend. The third pattern is seasonality where the demand is systematically below and above the average. Demand with different trends should be handled differently than demand with seasonality in terms of forecasting. Neglecting this could come up as serious forecasting errors. (Ballou 2003, 109-110; Chambers et al. 1971, 65.)

When forecasting, not only the time aspect i.e. temporal should be considered but also, where the demand occurs i.e. spatial demand analysis. This is important when planning warehouse network, balancing the inventory levels across the logistics network and allocating transportation resources. The forecast should be allocated to regional levels as accurately as possible. The question for the forecast maker is whether to aggregate information based on the general situation since aggregated forecasts tend to be more accurate or to forecast each area separately in order to achieve greater benefit from the forecast to the actual business decisions despite the accuracy risk. (Ballou 2003, 109, 133-134.)

Knowing the basic business situation is also critical. This includes analysis from both inside and outside the company and from both macro- and microeconomic factors. In

addition to sales information from historical data, the general state of the economy as well as the actions taken by the competitors should be considered. If these change, the behavior of the customer changes as well. Samples of macroeconomic factors include interest rates, exchange rates of currencies, unemployment level, demographic trends, government regulations, political climate and labor unrest. In addition, market changes in raw materials requirements that might affect the sales of refined products. When speaking of competition, knowing the competitors and their actions, the price and quality level of their products and the developing technology compared to the analyzing company and potential market saturation ought to be distinguished. (Waller 2003, 264-266; Chopra & Meindl 2007, 189.)

A factor coming inside the forecasting company itself would be the planned advertising or marketing efforts such as promotion, pricing discounts, rebates, new product introduction and product withdrawals. These actions can also be called as demand shaping. (Simchi-Levi et al. 2008, 197).

It is important to notice that from quite many factors affecting the business environment it is hard to find quantitative data. A company should consider the advertising and marketing efforts the company itself has made and also the actions the competitors have taken. This means that there has to be qualitative human input in the forecast and, if not, high criticism towards forecasts based purely on past demand data. (Chopra & Meindl 2007, 189-191).

A critical and problematic part of forecasting is clearly the selection of the most appropriate forecasting technique. Chambers et al. (1971) present three questions that may help to decide the methodology (Chambers et al. 1971, 46-48):

- What is the purpose of the forecast – how it should be used? If simple gross sales estimates are sufficient, a less complex technique is probably appropriate. The desired richness of details in the estimates give the basis of selecting more advanced techniques
- What are the dynamics of the system for which the forecast will be made? Are there for example reasons in the data to concentrate on causal relationships or seasonality
- How important is the past in estimating the future? If the past is very important, time-series method might make sense. If there however have been radical changes in the environment that decrease the importance of historical data, then judgement or market research methods may be indicated.

The form of the forecast depends not just by the methodology but the people who make it. Inside a company, there are different groups with different preferences when designing a demand forecasting model. These groups can be the management of the company, the sales people or other people in not managerial position. Based on this, there are two approaches to forecasting which are top-down and bottom-up. In the top-down mode, the executives

give the forecast to the use of the rest of the organization. In the bottom-up approach, the lowest levels of the organization forecast their anticipated demand, such as sales, which is aggregated to the higher levels of the organization forming the forecast (Long 2004, 86).

The basic difference between the management and other groups is that management would try to emphasize the factors from the general business environment and point out all the risks that might affect their most important reference group, the investors and the value of the company. On the other hand for example the sales people gather the information more likely from direct sales statistics and can be motivated by potential sales bonuses distorting the risks based on general business situation. (Waller 2003, 267-268.)

The users of forecasting methods should pay attention to the fact that forecasts are always wrong to some degree. As understanding it, the forecasts should be based on aggregated information that has more flexibility to handle appropriately the possible changes in the demand situation. (Chopra & Meindl 2007, 233-234).

The forecast error itself or respectively the accuracy of the forecast is also an important output in the demand-forecast and demand-shaping process. This information provides insight into the likelihood that the demand or components in the demand data might be different than expected. High demand forecast error can decrease the supply chain performance. Therefore, minimizing the potential forecast error and understanding the actual error are important issues. (Simchi-Levi et al 2008, 197.)

### ***1.5.2 Forecasting methods***

Often demand forecasting methods are categorized into three main groups: qualitative, time series analysis and historical projection, and causal methods. Each group differs in relative accuracy in forecasting over the time horizon used, the level of quantification used and the logic base in using historical data, expert opinion or surveys. (Ballou 1992, 112; Chambers et al. 1971, 48.)

It can be difficult for a company to decide, which is the most appropriate method for executing forecasting. In fact, several studies have indicated that it is more effective to use multiple methods than only one method. (Chopra & Meindl 2007, 190.)

#### ***1.5.2.1 Qualitative methods***

Qualitative methods are based on judgment, intuition, surveys or comparative techniques to produce quantitative estimates about the future (Ballou 1992, 112). The objective is to bring together all information and judgments which relate to the estimated factors in a logical, systematic and unbiased way. The accuracy in this method depends on the good

judgment, honesty and philosophy of the individuals concerned. (Chambers et al. 1971, 49; Waller 2003, 267.)

The qualitative techniques are usually adapted when the source data is scarce for example in a situation where the product is first introduced to the market. It might also be the only option to analyze government policy changes or the impact of new technology. (Ballou 1992, 112.)

Qualitative methods can be divided into judgment methods and market research methods. Two general judgment techniques are panels of experts and the Delphi method. In both cases the individuals involved are experts from outside or inside the company with various functional areas in the company. The difference between them is that in the Delphi method the experts are not gathered together like in the panel but interviewed separately. (Simchi-Levi et al. 2008, 57-58.)

### ***1.5.2.2 Time series analysis***

Time series methods use past variety of historical data to estimate future data. It can be used when adequate amount of data is available and the trend and seasonal variations are stable and well defined. The quantitative nature of the time series requires mathematical and statistical models to be used as the primary forecasting tools. Normally it is considered that the shorter the time horizon in the analysis is, the more accurate the forecast is. (Ballou 1992, 116; Waller 2003, 262.)

A time series analysis is usually presented in a graphical form, for example a xy-table. They are the simplest method to implement and considered a good starting point for a demand forecast. Commonly used techniques are moving average, exponential smoothing, methods for data with trends and methods for data with seasonality. (Simchi-Levi et al. 2008, 58.)

### ***1.5.2.3 Causal methods***

The basic approach of the causal method is that the demand forecast is highly correlated with certain factors in the environment which can be the state of the economy interest rates or other macroeconomic factors mentioned previously but not the actual sales. The key is to find the predicting variables and the variables to be forecasted based upon them. In many cases these are hard to find and have low association with each other. (Chopra & Meindl 2007, 190; Ballou 1992, 116.)

A causal method is the most sophisticated type of forecasting tool. It expresses quantitatively the relevant causal relationships and can directly incorporate the results of a

time series analysis. Usually because of the more complex technique, the model might lack some kind of data related to it. In this case, assumptions need to be made and through continuous revision corrected when the data is available. (Chambers et al. 1971, 55.)

## **2 IMPLEMENTING OFFSHORING AND OFFSHORE OUTSOURCING INTO SUPPLY CHAIN NETWORK DESIGN/OPERATIONS**

The supply chain network is a complex network of partners and networks. Today there is increasing pressure to globalize the supply network. Even smaller firms are following the example of large multinational companies to disperse their supply chain. Together with conflicting objectives between different channel members, supply chain management is challenging. In addition, the uncertainties in demand and the evolving structure of the supply chain causes problems (Karrus 1998, 132-133). The increasing competition in global market has set new challenges for companies in many industries. In order to survive the companies have seen it important to focus on their core competencies and finding the distinctive value-adding services from their supply chain (Byrne, Markham 1991, 63-66).

The purpose in logistics revolves around efficient integration of suppliers, manufacturers, warehouses and stores. The materials in the supply chain should be in the right place at the right time with minimum costs. The term supply chain management is defined based on these fundamentals. Simchi-Levi define it as follows:

*“Supply chain management is a set of approaches utilize to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize systemwide costs while satisfying service level requirements”.* (Simchi-Levi et al. 2008, 1.)

### **2.1 Supply chain strategies for different products**

The supply chain strategy consists of two aspects. The first explains how the material flow occurs in the company and to or from the company. The second aspect explains the role of each supply chain member in the process. (Chopra & Meindl 1997, 23.)

The design of the supply chain and the supply chain strategy starts with the considerations of what kind of a demand the product will have. The products should be categorized to innovative products or functional products which is the basis for a supply chain strategy design. (Fisher 1997, 107.)

The two product types, innovative and functional, demand a different supply chain design and strategy. This can be seen from the demand pattern. For example, the innovative products typically have a more fluctuating and uncertain demand than the functional products which usually are products used in everyday life having so a stable demand. They also have a higher profit margin. Two different supply chain profiles should

then be made: a responsive supply chain, that is more reactive and transformational and an efficient supply chain based on cost-efficiency. The following characteristics should be used when determining the product type: demand predictability, product life-cycle, service level requirements and product variety and lead time. (Fisher 1997, 106-109.)

For functional products, the most important focus in the supply chain is to minimize physical costs by making the flow of goods in the supply chain as functional and flawless as possible since there basically is no demand uncertainty that might interrupt the solid flow of goods. In design, the flow of information and the process structure are given attention. As there is demand uncertainty in innovative products, that increase the risk of excessive warehousing, market mediation costs should have the greatest focus. (Fisher 1997, 107.)

### ***2.1.1 Supply chain decision and adjustments to fit product nature***

Having determined the nature of their products and the priorities in the supply chain design, a two-dimension matrix can be formed the help formulating the supply chain strategy. The four cells of the matrix present the four possible combinations of the product types and the supply chain priorities. (Fisher 1997, 109.)

By using the matrix, the company can measure whether their processes fit the product nature. Companies that have innovative products with efficient supply chains or functional products with responsive supply chains usually have problems.

	Functional Products	Innovative Products
Efficient Supply Chain	match	mismatch
Responsive Supply Chain	mismatch	match

Figure 1. Matching supply chains with products (Fisher 1997, 109)

It is rare that the companies find themselves from the lower left-hand cell since according to Fisher (1997) most companies understand the importance of having an efficient supply chains for functional products. More often were companies found in the upper right-hand cell having innovative products with efficient supply chains. The reason

for this is that the cost of investing in more responsiveness in the supply chain is far greater than investing in effectiveness so that it is financially challenging for companies to be motivated to invest in responsiveness leaving them with unsuitable supply chain for their product. (Fisher 1997, 109-110.)

There are two options to move away from the upper right-hand cell. The first one is to start treating the product as a functional product which is done by changing the product offering and reducing the innovativeness of the product. The second option is to implement a responsive supply chain. As mentioned earlier, this requires costs and is difficult to implement. Flexible capacity is needed and data from customer demand must be captured. For some components, safety inventory is a necessity if lead times cannot be reduced. In automobile industry, this is a challenge especially for the contract manufacturer since the vehicles are mainly produced by just-in-time –method.

The Fisher's model has been widely re-evaluated in contrast to for example quantitative methods and bullwhip effect. These researches have sometimes given different results than assumed by the model. Using quantitative methods, Li and O'Brien (2001) compared the adaptability of three different supply strategies: make-to-order (MTO), make-from-stock (MFS) and make-to-stock (MTS) using value adding capacity, demand uncertainty of materials and demand uncertainty of finished products as indicators. They concluded that when demand uncertainty is high and value adding capacity low, the make-to-order strategy is most effective differing from Fisher's results. One research was made based on the situation that the Fisher's model does not give tools to differentiating the supply chain strategy between multiple product groups. Kaipia & Holmström (2007) noticed, that especially original equipment manufacturers operate in a complex and fast-changing environment where there can be a constant need to change the supply chain strategy. This need is even higher if the company has a large product portfolio.

Kaipia & Holmström (2007) developed a procedure model to plan supply chain strategy differentiation in an original equipment manufacturing company (OEM). The criteria used for the selection of planning approaches were ability to support variable demand and changing product features, ability to utilize customer demand information and ability to manage long lead times in supply chain upstream. The chosen planning approaches were vendor managed inventory VMI, streamlined supply chain planning using demand visibility, sales-based planning and expert driven supply chain planning. (Kaipia, Holmström 2007, 9.)

To ability for a company to change or differentiate the supply chain depends on the position the company has referred to its supply chain partners. For example Selldin & Olhager (2007) notice that a manufacturing company might be dominated by a focal company in the supply chain so that it does not experience the opportunity nor resources the adjust their supply chains. It rather concentrates on managing with the existing supply chain. (Selldin, Olhager 2007, 49.)

### ***2.1.2 Offshoring and offshore outsourcing decisions in supply chain strategy configuration***

As Fisher's model concentrates on the general structure of the supply chain from the OEM point of view in the downstream, it is valuable to focus also on the decision variables met in the upstream of the supply chain. These problems consider outsourcing, purchasing and procurement.

As discussed in introduction, the importance of offshoring, outsourcing and offshore outsourcing is undeniable in today's supply chain management. This has also meant the importance of supply and/or purchasing management. Whenever a company has to procure critical items competitively under complex conditions, supply management is relevant. Kraljic (1983) has presented that a company's need for a supply strategy depends on two factors: (1) the strategic importance of purchasing measured by the value adding effect, (2) the complexity of the supply market gauged by supply scarcity, pace of technology and substitutive materials, entry barriers, logistics costs or complexity and competition circumstances. (Kraljic 1983, 110.)

Based on these two dimensions, Kraljic (1983) created a supply matrix to differentiate products to four different categories and help managers deciding the best supply strategy. The top right quadrant represents strategic items where supply risk and impact on profits are high. This can be for example car engines or transmission systems. These items have to highest impact on customer experience and they represent a major part of total production costs. The most appropriate supply strategy for these items is strategic partnership. The bottom right section represents a high risk but low profit products. These are also called bottleneck items and the best supply strategy is to ensure continuous supply even with high costs. The items on the left side of the matrix which are noncritical items should have a simplified and automated procurement policy.

Simchi-Levi et al. (2007) questioned what should be the sourcing strategy for components. As Kraljic's (1983) and Fisher's (1997) model might consider OEM's that have outsourced all manufacturing processes, Simchi-Levi et al. built a framework that is component sourcing centered by using both Fisher's and Kraljic's frameworks.

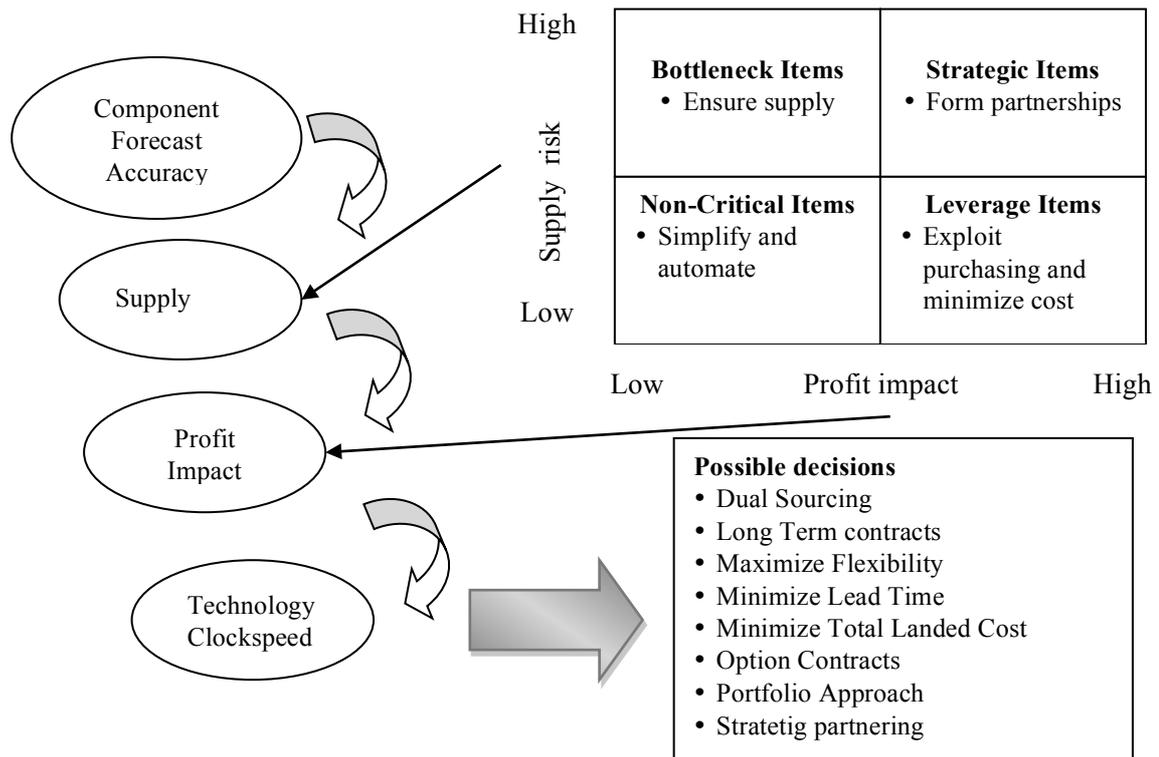


Figure 2. A qualitative approach for evaluating component sourcing strategy (Simchi-Levi 2008, 289-290)

Depending on the criteria presented in the matrix, the company may decide to focus on minimizing total landed costs (costs of purchasing and delivering the product to its destination such as unit cost, transportation cost, inventory holding cost, handling cost, duties and taxation, cost of financing), lead time reduction or increasing flexibility. If for example forecast accuracy is high, supply risk is low, financial impact is high and clockspeed is slow, a cost-based sourcing strategy is appropriate. (Simchi-Levi et al. 2008, 289-290.)

## 2.2 Offshoring and offshore outsourcing in strategic decision-making

Outsourcing has had a strong position in business and it is also considered not just a functional, but a component in decision-making. The drive for better efficiencies and cost reductions has given pressure to the organizations to specialize in a limited number of key areas and redesign the boundary of the organization. The outsourcing practice will most likely continue and potentially increase as firms look to consolidate and focus on their core

business activities while outsourcing support or non-core functions to firms that have the appropriate expertise. (Liu et al. 2008, 435-436; McIvor 2005, 1.)

The main reasons for companies to start to offshore were that companies noted that in some emerging economies there were fewer regulatory controls and significantly lower wages. This has happened due to globalization. In today's world it has made it possible to search for new opportunities to improve old or develop new business processes outside the firm's local area. Some reasons for this are the improvement in materials logistics with better and faster transportation vehicles and more efficient logistics control, lower transportation costs, or improvement in telecommunications infrastructure and digitization of paper-based business processes. On the other hand, increasing competition, continuing trade liberalization and introduction of new technologies have increased the pressure to globalize and outsource operations. (Mangan et al. 2008, 28-30.)

Robinson and Kalakota (2004) present a wider view with six themes that form the cornerstone of the offshore outsourcing. As globalization is the first theme the second theme is evolution where offshore outsourcing is seen as an evolution rather than revolution. The deflation as mounting customer demands concerning faster cheaper and better operations is the third theme. The fourth theme is demographics as the growth and workforce potential is moving increasingly towards developing countries. The fifth theme is competition and sixth theme politics as offshore outsourcing is an unstoppable megatrend. (Robinson & Kalakota 2004, 9-15.)

Mangan et al. (2008) present the following list of reasons why especially manufacturing companies offshore and/or offshore outsource operations (Mangan 2008, 80):

- Reduce direct and indirect costs
- Reduce capital costs
- Reduce taxes
- Reduce logistics costs
- Overcome tariff barriers
- Provide better customer service
- Spread foreign exchange risks
- Share risk
- Build alternative supply sources
- Pre-empt potential competitors
- Learn from local suppliers, foreign customers or competitors
- Gain access to world-class capabilities or attract talent globally.

Although taking advantage of globalization by offshoring or offshore outsourcing production is usually seen as a solution to reduce costs it should also be seen as means to create new revenues as well. (Farrell 2004, 84; Liu et al. 2008, 436.) The decision to outsource or offshore should not be viewed as a single project or job to find independent

cost savings in a certain area of the firms processes. According to Trent & Monckza (2003) in their literature review, international sourcing has usually been a means to find the lowest cost suppliers. It's also been discussed, that managers have seen international sourcing as only a short term rather than long-term competitive advantage. Offshoring as part of globalization, which represent great potentials in finding a competitive edge in today's business should be seen as strategic component such as outsourcing. (Trent & Monckza 2003, 609-611.)

The number, size, and diversity of organizations offshoring and offshore outsourcing businesses are large. Robinson and Kalakota (2004) have presented a two-dimensional model to better understand the business and revenue models in offshoring and offshore outsourcing.

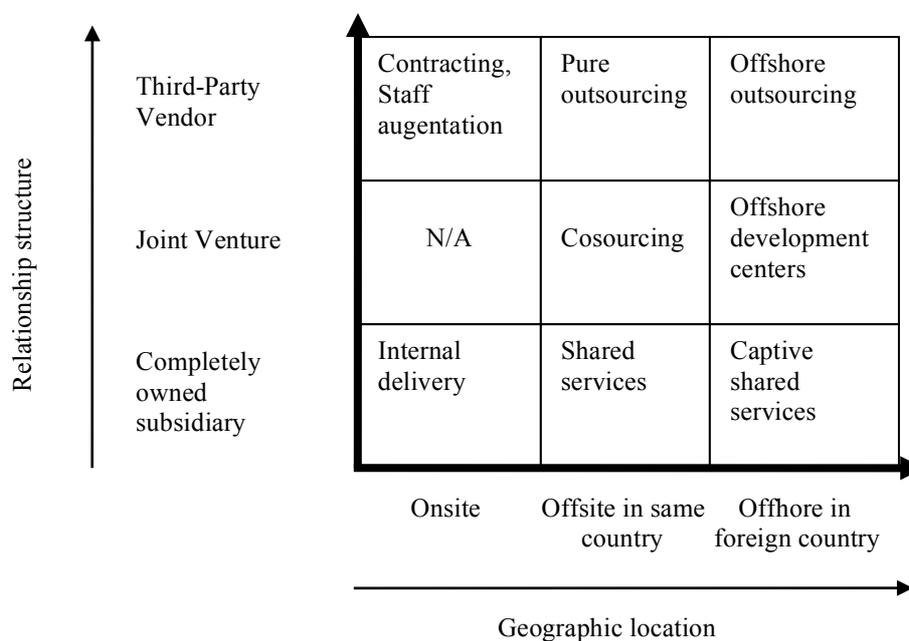


Figure 3 The two dimensions of offshoring business models 33 (Robinson & Kalakota 2004, 33)

The many combinations and ownership structures that exist give rise to numerous distinct business models. While in the model they are called business models it can be noticed that many of them are more like delivery models. As a business model typically illustrates how a company makes money, the idea of the delivery models is to support the firms overall strategy. This is the case for example with captive shared services where the company decides to build their own subsidiary to an offshore location. Within these models there are particular advantages and disadvantages for each both in terms of ownership structure and geographic location. Generally the different models are appropriate at different levels of organizational maturity and complexity. (Robinson & Kalakota 2004, 28-35.)

As offshoring and offshore outsourcing is often seen as a trend, managers should have carefulness in deciding whether and how intensively the possibility of offshoring and outsourcing should be used as they both are extremely complex issues. When organizational structures are planned to be reshaped, a company must carefully analyze the changes in business processes and potential problems designing a whole new business plan. Especially outsourcing operations have failed when there hasn't been a full discussion and analysis of the consequences in operations and costs. (McIvor 2005, 1-2, Liu et al. 2008, 436.)

There are many different lists of criteria to which the suitability of offshoring or offshore outsourcing could be based concerning a firm or a company. They can be put under Farrells (2004) simple list of three main factors. These are production, regulatory and organizational. In production the relocation sensitivity to relocate parts of the business processes and location-specific advantages are key elements. The relocation sensitivity considers the capability to ensure production quality remotely, the uncertainty in demand and any sunk costs and the difficulty of transportation. To judge the location-specific advantages, the important variables are labor intensity, skill requirements and economies of scale and scope. Regulatory factors are tariffs, limitations concerning import and export or other governmental regulations that interfere offshoring possibilities. The third, organizational factor consists of internal management structures, incentive systems and unionization. The internal organizational factor is especially important in outsourcing as in the outsourcing process the determination of the organizational boundary, analysis of key activities and capabilities give the basis for the outsourcing process. (Farrell 2004, 85-86; McIvor 2005, 70-72.)

To indicate the industrial potential to offshore, Farrell (2004) presents a method where the ratio between the annual value of global trade of the supplied components with final goods and annual sales is calculated. If the ratio is over 100% so that the trade is larger than sales, the industry is considered very global.

If a company decides to offshore, the company can use a five step approach depending on the intensiveness of the globalization. The first step is to enter new markets by establishing production presence in the chosen area. Usually it is easier to choose a similar production model abroad as it is used in home markets. The second step is to specialize the production of chosen products into low-cost locations. In the next two stages the value chain is first disaggregated, so that the manufacturing part of the production would be made in different locations and then assembled into final product elsewhere, and then reengineered to suit local market conditions. The last step is to create new markets. These steps can be combined if the situation fits to that better. (Farrell 2004, 87-88.)

If offshoring includes outsourcing as well, the best possible candidate for outsourcing should be chosen. Companies may have different criteria depending on the product and

service how to analyze the qualifications of potential suppliers. Mangan et al. (2008) present the following list of indicators (Mangan 2008, 83):

- Reliability of delivery on time
- Quality certifications
- Conformance to agreed specifications
- Delivery lead time
- Financial capability
- Performance track record
- Price or cost reduction
- Senior managements attitude
- Responsiveness to demand uncertainty
- Record of corporate social responsibility.

After choosing the outsourcee, the relationship type between the sourcing partner must be confirmed. The good management of outsourcer-outsourcee relationship also includes continuous evaluation.

To evaluate the type of supplier relationship needed, the importance of the outsourced activity and supply market risk should be analyzed. The supply risk determines how much effort should be used to keep the supplier. The more important the outsourced activity, the more collaborative should be the outsourcer-supplier relationship. (McIvor 2005, 79-80.)

According to Aron & Singh (2005) there are three fundamental mistakes that managers do when offshoring or outsourcing production. The first mistake is, that not enough consideration is put into which operations to offshore and which not. This results in offshoring or outsourcing wrong processes which actually are strategic core competencies to the company forcing the companies to draw these processes back in-house resulting in additional costs. The second mistake is that the companies do not address all the potential risks adequately enough. The third mistake is to think that offshoring or offshore outsourcing is an all or nothing decision. The process is a continuum with multiple options for executing it and the consideration of different possibilities should be analyzed continuously. (Aron-Singh 2005, 136.)

### ***2.2.1 Benefits and risks in offshoring***

The main benefit of offshoring for companies are cost savings. Most of these savings come from labour costs as they can be extremely lower in undeveloped or developing countries. The low wages gives possibilities for other cost savings as well. These are reengineering the production process so that high cost capital involved in manufacturing equipment such

as robots can be substituted to low-cost workforce without decreasing manufacturing efficiency. Low salaries also enable the use longer production times despite the extra costs of off-hours. Farrell (2007) calculates that offshoring can cut production costs by as much as 70 %. The other benefit of offshoring is the possibility to utilize new market opportunities. Many of the popular offshoring countries are developing markets themselves and gain a great market potential of the arising middle class. The revenues of using new business opportunities can even exceed the cost savings of offshoring. (Farrell 2007, 88-89.)

Offshoring production can create a more complex supply network with heightened risks especially concerning the supply chain. These risks must be recognized and traded off against the advantages of moving operations overseas. To assess the supply chain risks, Schoenherr et al. (2008) have built a framework where the risks are divided under the main objects of product, partner and environment and their sub objectives.

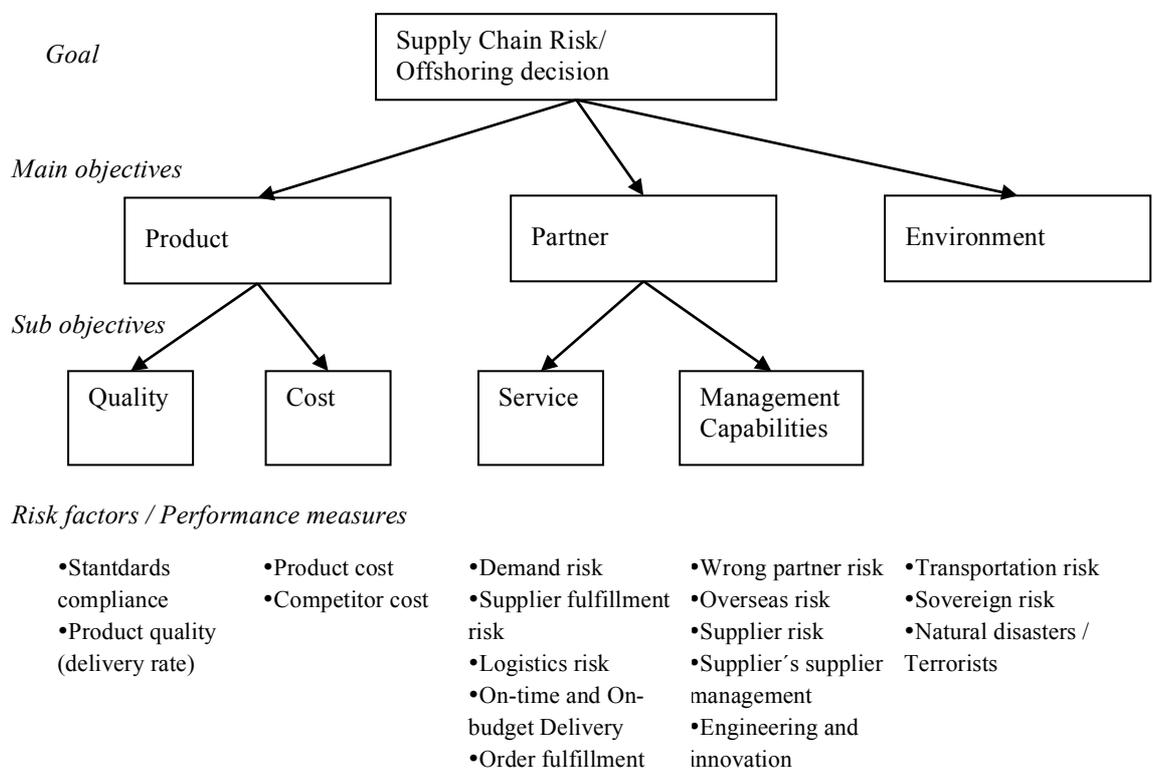


Figure 4. Framework for assessing supply chain risks (Schoenherr 2008, 105)

The Schoenherr model (2008) found 17 different risk factors. Other risks that are difficult to point out but important include the lost visibility into lengthened supply chains due to offshoring that reduce capability of the manufacturer to react to customer demand changes. Offshoring also increases the risk of not being able to use the supply chain as a competitive advantage with better customization and flexible ordering patterns as offshoring usually requires container size minimum orders and long cycle times to gain

cost advantage. When asked from managers of manufacturing companies, they considered cycle and delivery time, supply chain flexibility, supply chain visibility, coordination and control and bottlenecks in logistics networks most concerning. (Ferreira & Prokopetz 2009, 22.)

Recently there has been discussion especially of the risks concerning labour and transportation. As the labour costs in for example China have increased rapidly and the price of oil has been very unsteady resulting in very little if any at all cost savings, many companies have instead of planning offshoring started to think about using local suppliers. (Ferreira & Prokopetz 2009, 20-22.)

### ***2.2.2 Benefits and risks in offshore outsourcing***

The benefits of a well-executed offshore outsourcing can be significant appearing in different ways. First of all it maximizes the returns of internal resources as investments and abilities of the organization are concentrated based on core competencies. The company can also use more resources to specialize more in depth with their strengths. Secondly, well-developed core competencies protect the company from competitors that aim to expand into the company's area of interest. Third and probably the most significant benefit is the full utilization of the external supplier's investments, innovations and skills that would be extremely expensive to execute internally. In addition, the external suppliers usually have better performance within the area of their core competence. In many activities, clusters have been formed to different parts of the world with a very competitive cost-quality ratio. (Mangan et al. 2008, 28.)

The fixed costs are converted into variable costs in the company when operations are outsourced. The special benefit in offshore outsourcing compared to them both separately is that organizations can access highly skilled labor at a fraction of the cost compared to local workforce. This does not consider only contract manufacturing but also tasks that require high education. For example India and China have improved their education system aggressively in recent years. Fourth, if market and technological situation is volatile, offshore outsourcing decreases the company's direct risks, shortens life cycles, lowers investment costs and creates better customer responsiveness and flexibility. (Quinn 1995, 48-49; McIvor 2005, 21-23, 272-274.)

The risks of offshore outsourcing are great as well as the benefits. As presented earlier, cost savings are potential but in certain situations total costs may actually increase. In some situations for example, outsourcing might require supplemental invests in management to control the relationship between the outsourcer and the outsourcee. This need is even higher when the physical and cultural distance is longer. Ignoring this could lead up to excessive management costs in order to gain control of the outsourcing. The second risk

considers the loss of critical skills or development of wrong skills. If an organization has outsourced numerous critical activities it may lose its ability to innovations and strategic flexibility. The capability to innovations consist of slack resources, organic and fluid organizational processes and experimental competencies, all of which an outsourced supplier cannot guarantee. The risk of negative impacts of losing skills is higher if the outsourcing company and supplier are conflicting or if the supplier decides to become a competitor. The third risk considers losing cross-functional skills within the company as interaction of people with different competencies weakening the organization structure. One major difficulty in outsourcing has been managing the change process inside the organization and between organizations. The attitude and commitment has not supported the process because of weak transparency between the parties. (Quinn 1995, 48-49; McIvor 2005, 23-26.)

### **3 ANALYSING OFFSHORING AND OFFSHORE OUTSOURCING COSTS IN SUPPLY CHAIN NETWORK**

To understand the trade-offs and to be able to make rational decisions, the trade-off effects of offshoring and offshore outsourcing must be measured. Basically, what a firm does not measure, it cannot offshore or outsource well. Constructing metrics that take objectively into account the performance of the offshored or offshore outsourced activities and set tolerance limits for errors give a stable basis to do offshoring or offshore outsourcing. (Aron & Singh 2005, 138-139.)

In literature, both quantitative and qualitative methods have been used to analyze the rationality of both offshoring and offshore outsourcing decisions. The academic literature has concerned the subject from both the intra-company resource analysis point of view and from the product point of view.

Analyzing procurement and sourcing decisions quantitatively has been practiced for quite some time as calculating inter-functional total costs has been a key issue in logistics. The concept of total cost evaluation and logistics have evolved from the 1940s as they both were basically concentrated on transportation and warehousing. Today, since the formation of the supply chain concept as an extended concept of logistics, the scope of total cost concept has also broadened to consider the actively managed channels of procurement and distribution inter-organizationally. (Cavinato 1992, 285.)

Besides broadening the scope, the other development has been the change of perspective. As the focus in calculating total costs has come from the financial or accounting perspective, it can be seen from the newer cost models, that they tend to emphasize the supply chain management effect of sourcing decisions (Ellram & Siferd 1998, 56; Kumar & Kopitzke 2008, 109). The motivation for this comes from the importance of thoroughly finding the indicators that are not always presented in basic accounting but which represent the occurring costs as truthfully as possible. The traditional cost models have focused on operational or most easily available cost components. The data has been collected from for example basic accounting systems, which have been formed according to the individual functions and groups in which they are formed. In this procedure the cost information does not follow the horizontal flow of materials into, through, and out of the company that would provide a single total cost measure of past and current flows and give managers decision-making information for future flows. It would make it difficult or impossible to perceive the actual benefits or losses which might occur from strategic sourcing decisions. (Cavinato 1992, 292; Ferreira & Prokopets 2009, 23.)

The latest change in total cost concept in relationship with sourcing decisions links to the strategic usability and foundation. Firms have earlier acted reactively to total cost calculations concentrating on the immediate cost advantages and short term benefits. The cost information has based upon single operations and the means have been to minimize

these costs. The emphases has later changed to consider the supply chain as a whole where all the operations and single cost items have to be considered as a part of a value adding systems that aims to create as much value as possible to the customer. Not just the activities inside the supply chain, but all the factors that affect the customer experience must be noticed forming the actual total cost of operations. (Cavinato 1992: 287-290.)

### 3.1 Supply chain costs

The supply chain cost components can vary from company to another widely. This can be concluded if we review the supply chain activities in general. The organizational structure of a company varies depending on the nature of the company's business. However a thorough list of supply chain operations can be presented of likely logistics functions. Ballou (1997) has constructed the scope of business logistics functions as following (Ballou 1997, 7):

- |  |   |
|--|---|
| <p>Physical supply:</p> <ul style="list-style-type: none"> <li>• transportation</li> <li>• inventory maintenance</li> <li>• order processing</li> <li>• acquisition</li> <li>• protective packaging</li> <li>• warehousing</li> <li>• materials handling</li> <li>• information maintenance</li> </ul> | <p>Physical distribution:</p> <ul style="list-style-type: none"> <li>• transportation</li> <li>• inventory maintenance</li> <li>• order processing</li> <li>• product scheduling</li> <li>• protective packaging</li> <li>• warehousing</li> <li>• materials handling</li> <li>• information maintenance</li> </ul> |
|--|---|

Solakivi et al. (2009) divide logistics costs into direct and indirect logistic costs. Direct logistics costs consider the costs that are related to physical material flow such as transportation and warehousing including the capital tied in inventory. The indirect costs are for example administration costs and IT-related costs. The costs related to physical material costs can be easily allocated as indirect costs are often much more difficult to allocate. Both direct and indirect costs can additionally be divided to functional costs and general business costs or trade-off –costs. (Solakivi et al. 2009, 21.)

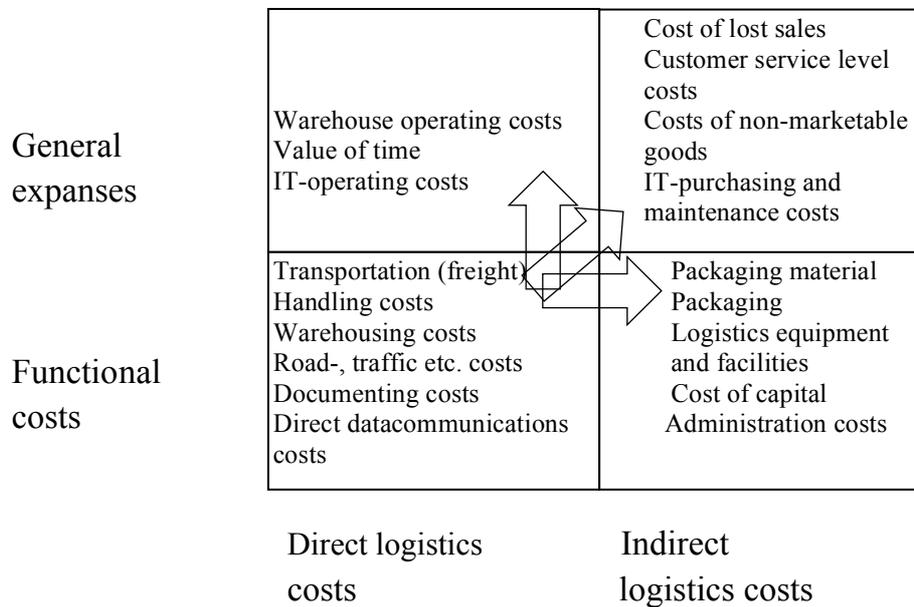


Figure 5. The breakdown of logistics costs (Solakivi et al. 2009, 21)

The balance of the logistics costs vary by industry. In raw material production, transportation costs are often the most significant cost item whereas in highly refined production the warehousing costs can be many times larger. In addition, the operational structure of the firm or production strategy affects the proportion of the logistics costs. (Solakivi et al. 2009, 21.)

### 3.2 Trade-offs in managing offshoring and offshore outsourcing

The supply chain is a collection of different members with different objectives usually from different geographical parts of the planet. Therefore, supply chain management is not just coordinating the activities that occur within the supply chain but also balancing between the conflicts between the members of different stages of the supply chain. In a global environment, this integration of supply chain parts aims to replace the local sequential planning process for an optimized supply chain structure. (Simchi-Levi et al. 2008, 166.)

According to Simchi-Levi et al. (2008), there are four different groups that have conflicting objectives. The first group is raw material suppliers, who's preferences are a large and stable demand and material variation but a flexible delivery time. The second group is manufacturing management that prefers few changeovers in the production and

little demand variation. The third group, which is involved in materials, warehousing and outbound logistics management is oriented in minimizing transportation costs and inventory levels. Finally the customers demand in-stock items, enormous varieties and low prices. In the following chapters, typical trade-offs in supply chain network management are introduced.

The possible internationality of the supply chain can furthermore complicate issues. International logistics is complex, and different from localized supply chains. The main differences that need to be taken into consideration are the extended lead time of supply, extended and unreliable transit times, multiple consolidation and break points and multiple freight modes and cost concepts (Harrison, Hoek 2002, 95).

### ***3.2.1 Safety stock***

Safety stock is the amount of inventory that the distributor needs to keep at the warehouse and in the pipeline to protect against deviations from average demand during lead time. (Karrus 1998, 34-36). Additionally safety stock is used to cover uncertain situations such as supply failure, production shortfall, transport failure, information distortion and any other disruption in service. Safety stock then ensures that customer demand can be fulfilled despite of possible order backlog. The amount of safety stock held in an organization depends upon the variability of demand, the reliability of supply and the dependability of transport. (Wild 1997, 88; Vollmann et al. 2005, 135-136.)

The safety stock is also in relation to service level. Therefore decreasing the safety stock could result on lower service level. On the other hand, having higher availability of products that needed can be expensive as there are then unnecessary items in the inventory. (Simchi-Levi et al. 2008, 47.)

Manufacturing costs have decreased especially when lot sizes have become larger: per unit setup costs are reduced, manufacturing expertise for a certain product has increased and processes have become easier to control. Therefore manufacturers prefer manufacturing large lot sizes. However, demand rarely comes in large lot sizes, which means that large production volumes lead to high inventory. (Simchi-Levi et al. 2008, 167.)

Reducing lead time and enabling fluent and transparent flow of information have been the aims when creating systems to reduce inventory and improving system responsiveness. Setup time reduction and production scheduling systems are examples of modern manufacturing practices that have strengthen the confidence of distributors and retailers to

reduce inventory based on expected problems in manufacturing. (Simchi-Levi et al. 2008, 167-168.)

Having a large product variety creates many problems in supply chain management. With a large product portfolio, the general complexity of the supply chain and manufacturing costs increases and the general manufacturing efficiency decreases. Large product variety usually forces companies to manufacture and transport smaller lot sizes so that both manufacturing and transportation costs are higher. In addition, as it is hard to forecast demand accurately for each product, the total safety stock required has to be large so that the warehousing costs are large as well. (Simchi-Levi et al. 2008, 169.)

The main issue for a company with a large product variety to indicate is how to match supply and demand effectively. An effective method used is *delayed differentiation* where manufacturing is based in generic products and the differentiation to final products is made as late as possible to lessen both manufacturing and warehousing costs. This is also one form of risk pooling where demand variation is handled by aggregating demand across locations. (Simchi-Levi et al. 2008, 48, 169.)

### 3.2.2 *Lead time*

Lead time is the time needed for a supplier to fulfill customer orders. Lead time is affected by the motivations of the supplier and customer. Powerful suppliers are able to use long lead times. On the other hand, if the customer has the bargaining power, the lead times should be expected to be as short as possible. Both of these issues increase costs because they represent the extreme utilization of lead time. Usually the lead time is the compromise between supplier and customer. (Wild 1997, 104-108.)

The offshoring or offshore outsourcing production nearly always has the effect of lengthening the lead time. Longer customer lead times make forecasting more difficult and might decrease the reliability of the supplier. If the forecast is correct and errors are smaller, it has a decreasing effect on lead time. (Wild 1997, 107-108.)

The overall lead time can be divided into order review time, order processing time, supplier lead time, transport time and receiving time. Order review time means the intervals at which the low stock situation is reviewed. Respectively, the order processing time consists of tasks such as (Wild 1997, 105):

- Reviewing the order
- Buying decision
- Transmitting the order to the ordering system
- Raising an order

- Gaining appropriate authority
- Informing the supplier

Supplier lead time is the time needed for the manufacturing of product. Transport time means transfer of product from supplier to customer. Finally, receiving time is needed for receiving products and updating stores records. (Wild 1997, 104-108.)

It is worth noticing that the developments of information technology such as electronic data interchange (EDI) have enabled new innovative concepts in management of lead time in recent years. Information systems can be used for combining transportations and the customer demand at the supplier can be monitored in real time enabling a more efficient transportation. (Sakki 1994, 123-124.)

### 3.2.3 *Service level*

Service level is a typical measure to quantify the company's ability to satisfy the customer order and execute the perfect order sometimes known as *on time in full*. In practice the definition of service level varies depending on the company. The key components of the perfect order are usually the complete and correct quantity and the correct time and date or period of the delivery (Rushton, Crouche, Baker 2006, 50-51).

The service level can be defined in terms of order cycle time, case fill rate, line fill rate, order fill rate, or any combination of above. The order cycle time is the elapsed time between the release of purchase order by a customer and the receipt of the corresponding shipment. A case fill rate defines the percentage of cases or units that can be shipped as requested. As an example, a 95% case fill rate indicated that 95 cases out of 100 could be filled from available stock. The line fill rate is the percentage of order lines that could be filled completely as order fill rate is the percentage of customer orders that could be filled completely. (Bowersox & Closs 1996, 250.)

Service level is also in direct relationship to the cost and performance of supply chain. For instance, the demand variability and the lead times of manufacturing, information and the size of stock keeping units (SKUs) determinate the amount of inventory needed in supply chain. (Simchi-Levi et al. 2008, 47.) Therefore, the service level in relation to the cost of inventory, transportation, and information systems are important factors in the supply chain.

The decision of where to set the service level goal is challenging. On the other hand higher service level improves customer satisfaction and may able more revenues. But at the same time it might raise supply chain costs even more. The service level is naturally

dependent of the business context. However in a certain service dimension, a service level between 92 and 95 percent may have no influence over customer buying decisions. If the service level is below 92 percent, it may prompt customers to seek another provider whereas a service level over 95 may bring in more customers. (Byrne & Markham 1991, 93.)

The trade-offs presented before can be aggregated under one main trade-off between the cost and customer service. Customer service has been defined in many different ways and companies may also have their own definition for it in their operations. However, usually customer service level is defined as the ability to meet demand from stock. It can also mean the ability to meet customer demand quickly and post-transaction capabilities. Customer service is considered an important factor as in many industries customers value it more than product quality and price. It is also showed that changes in customer service level have immediate affects in sales. (Ballou 1997, 81-85.)

Reducing manufacturing, transportation and warehousing costs typically decreases customer service level. However, efficient use of information and appropriate supply chain design, have enabled lowering the costs mentioned without affecting customer service level negatively. Actually these improvements have increased the customer level since customers experience them as value adding operations. (Simchi-Levi et al. 2008, 168.)

#### **3.2.4 *Transportation costs***

Transportation costs are influenced by seven factors. These are distance, volume, density, stowability, handling, liability, and markets. The above sequence reflects the relevant importance of these factors. Distance has a major influence in transportation costs since it directly contributes to variable costs, such as labor, fuel and maintenance. The costs related to distance do not usually increase in a stable manner since longer movements have more intercity than urban transportation. (Bowersox & Closs 1996, 365.)

In terms of volume effect to transportation costs, scale economies exist for most movements. Generally the transport cost per unit of weight decreases as load volume increases. The fixed costs can be spread over additional volume, limited to the maximum size of the vehicle. Therefore, consolidation of small loads into larger loads to take advantage of scale economies is highly recommended. (Bowersox & Closs 1996, 365-366.)

Transportation cost allocation is primarily the carrier's concern. However, because the cost structure influences negotiating ability, the carrier's perspective is important as well. Usually the transportation costs are variable costs, fixed costs, joint costs and common

costs. Variable costs change in relation to activity, such as movement of a load. Fixed costs do not change in the short run. For transportation firms these are for instance the costs of terminals, rights-of-way, vehicles, and information. Joint costs are expenses, such as back-haul costs, that are unavoidably created by the decision to provide a particular service. Common costs are typically overhead costs such as management expenses of a terminal. (Bowersox & Closs 1996, 368-369.)

The share of transportation costs of total logistics costs varies case by case. According to 2011 information, the average share of transportation costs in Finland is nearly 40 % of total logistics costs. The average share of transportation costs is 4,6% of turnover in Finland, being approximately the same between domestic and international companies. (Solakivi et al. 2012, 42-43, 46-47.)

Total lead time comprises of time devoted to processing orders, procuring and manufacturing items and transporting items between various stages of the supply chain. As mentioned earlier, transportation costs are lowest when full truck loads can be used. To this however, shorter lead times are enabled with transporting the items immediately after manufacturing to the customer, without the possibility to accumulating items for full truck loads.

Lead time considering the transportation time can be reduced by using faster modes of transportation. In terms of transportation costs, it is nearly always more expensive to use for example air than sea transportation. However, improved forecasting techniques and information systems can reduce the lead time of other components so that it may not be necessary to reduce the transportation component. (Simchi-Levi et al. 2008, 168.)

### **3.2.5 *Manufacturing costs***

The identification of manufacturing costs varies depending on the company calculating the costs. Generally, manufacturing costs can be divided into the following categories especially in the case of evaluating manufacturing offshoring or offshore outsourcing possibilities (Bhimani et al. 2008, 49-50):

- Material costs
- Cost of labour
- Overhead costs

Material costs are linked to the materials that are used directly to the production. Labour costs relate to the labour used directly to the manufacturing. The overhead costs are other cost objects that cannot be directly traced to the cost object but which undoubtedly are

needed to operate manufacturing such as administration and electricity. (Bhimani et al. 2008, 49-50.)

As mentioned, offshoring or offshore outsourcing can present high savings in labor costs. However, the movement of production of less developed countries can affect the quality of the production. Firstly, the workers in undeveloped countries still have a reputation as being less productive than in the developed countries. Secondly, as operations in less developed countries are often based on less automated systems, it might lead to a less consistent product and inherently lower quality. The moral of the workers and the efficiency of management can also affect the performance of manufacturing. Therefore, even if qualitative measures can give a straightforward calculation of the cost effects, the qualitative factors could have decisive effects in the overall measurement. (Kumar & Kopitzke 2008, 112; Bhimani et al. 2008, 312-313.)

### ***3.2.6 Other trade-offs***

To determine the cost of offshoring or offshore outsourcing involves evaluating factors that from it is difficult to collect quantitative data. From the logistics operating point of view the measurement of sourcing decisions should go beyond cost and time to the delivery of the goods. The predictability and reliability of the supply chains is increasingly important especially as just-in-time production sharing has become common. Costs related to hedging uncertainty are significant. As well as the cost and quality of supply chain operations are determined by the infrastructure and the performance of public agencies, the availability of quality and competitive private services play an important role as well. In many developing countries, problems of adverse geography are compounded by a weak modern services sector because of poor institutions and over-regulation. (Arvis et al. 2007, 13-17.)

Information on time and costs associated with some important logistics processes such as the lead time components provide a good starting point to analyze the potentials in the offshoring and offshore outsourcing countries but they do not represent sufficient information to make reasonable strategic decision. The critical elements of infrastructure quality, competence of private and public logistics service providers, corruption and transparency and reliability of trading system and supply chains are essential in evaluating the critical factor of predictability in the supply chain. These however cannot be measured from the information available on time and costs. (Arvis et al. 2007, 13-17.)

The logistics performance index (LPI) by the World Bank (2015) and its indicators are constructed to evaluate these important, less quantitative factors in the supply chain

decision-making process. They have a direct impact on the choice of shipping routes and gateways and they influence the firms' decisions about the location of production, choice of suppliers and selection of target markets. (Arvis et al. 2007, 8.) Therefore the LPI is an effective tool to be used additionally with the quantitative supply chain cost indicators to evaluate the production offshoring and offshore outsourcing decisions.

The LPI indicators summarize the performance of countries in seven areas that capture the present logistics environment. It is based on a worldwide survey that gathered information from companies responsible for moving goods and facilitating trade around the world – the multinational freight forwarders and the main express carriers. There are seven indicators in the LPI which are:

- Efficiency of the clearance process by customs and other border agencies
- Quality of transport and information technology infrastructure for logistics
- Ease and affordability of arranging international shipments
- Competence of the local logistics industry
- Ability to track and trace international shipments
- Domestic logistics costs
- Timeliness of shipments in reaching destination.

Table 3 An example of the Logistics Performance Index scores and rankings by LPI dimension out of 160 countries (Logistics performance index 2014)

Country	Year	LPI Rank	LPI Score (min .1, max. 5)	Customs ranking	Infra- structure ranking	International shipments ranking	Logistics compe- tence ranking	Tracking & tracing ranking	Timeliness ranking
<b>Finland</b>	2014	24	3.62	8	28	20	19	39	38
<b>Finland</b>	2012	3	4.05	2	6	4	1	1	15
<b>Finland</b>	2010	12	3.89	7	8	19	10	11	25
<b>Finland</b>	2007	15	3.82	14	17	30	13	2	14

The performance of these indicators are evaluated using 5-point scale, where 1 is the lowest and 5 the highest score. In 2014 the LPI consisted of 160 different countries which are ranked based on total score and the scores for each indicator. An example of LPI scores is presented in Table 3.

### 3.3 Total cost concept

Total cost concept (TCC) calculates the costs of multiple activities in a company to a single cost. The total cost concept can be referred to the trade-off analysis of the company. The cost trade-off is the recognition that cost patterns of various activities of the firm frequently display characteristics that put them into conflict with one another. The total cost concept can be used here to calculate the benefits in total context of the company. (Ballou 1997, 40; Cavinato 1992, 290.)

A TCC is an important tool in strategic cost management. It is a complex approach that requires the company to determine which costs it considers most relevant or significant in the event of offshoring or offshore outsourcing. It is important to understand total costs throughout the supply chain in order to provide direct support for strategic cost management efforts. Lack of understanding a total cost concept can be expensive to the firm as poor decisions will likely hurt the firm's overall competitiveness, profitability, pricing decisions and product mix strategies. (Ellram & Siferd 1998, 56.)

To help analyzing customer satisfaction all costs and values that affect costs and create value should be captured in a total cost/value model. A generic model that captures elements of cost to the firm, supply and distribution channel members, and ultimate customers as well is presented in Figure 6. The model provides a hierarchy of costs and other factors that build upward from raw materials through manufacturing and distribution to final marketing and usage by the ultimate customer. The model consists of twenty basic cost and value elements that combine into ten key strategic and management areas.

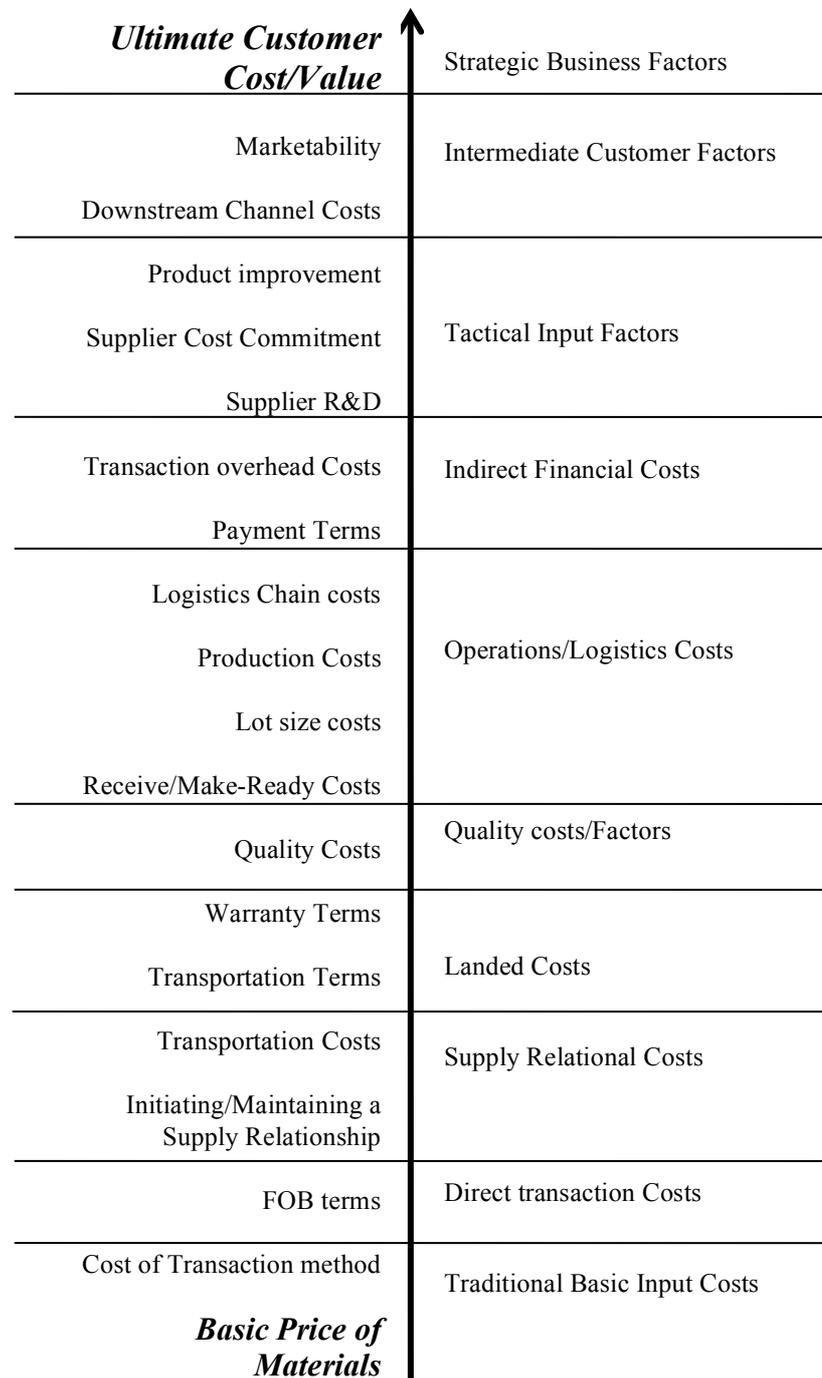


Figure 6 Supply chain total cost/value hierarchy model (Cavinato 1992, 294)

At times, decisions made by a firm in a channel of distribution affect the logistics costs of another firm. For example, inventory policies of a buyer affect both the inventory costs of the shipper and operating costs of the carrier. In these cases it is necessary to extend the boundaries of the system beyond the logistics function or the firm, including several firms. Thus the total cost equation would extend beyond the legal limits of the firm. Total cost

concepts do not usually have clear boundaries and it cannot be proved unarguably that all activities in the economy are directly linked to the logistics problems of the company. It is left to the judgment of management to decide which factors should be considered relevant and to include them in the analysis. This defines whether the total cost analysis will include only factors within the logistics function or whether the analysis should be extended to include other factors under the control of the firm or even outside the immediate control of the firm. (Ballou 1997, 43.) These costs are considered intangible such as political and economic risks, management and control costs and the loss of ability to implement optimum lean manufacturing processes throughout the supply chain (Kumar & Kopitzke 2008, 107).

### ***3.3.1 Total cost of ownership (TCO)***

One of the key issues of using total cost concepts is to understand the relevant costs concerning offshore outsourcing production as a consequence of buying a particular good or service from another supplier. Total cost of ownership is a process of analyzing supply chain activities and their associated costs with a particular supplier for a particular cost or service. The idea is that how much the operation or service would cost if it would be bought from a supplier. (Ellram & Siferd 1998, 56; Kumar & Kopitzke 2008, 109.)

TCO is relevant not only for the firm that wants to reduce its cost of doing business, but also for the firm that aims to design products or services that provide the lowest total cost of ownership to end customers. TCO is an important tool to support strategic cost management. It requires the firm to determine which costs it considers most relevant or significant in sourcing, possession, use, and subsequent disposition of goods throughout the supply chain. (Ellram & Siferd 1998, 56.)

According to Kumar & Kopitzke (2008), the TCO analysis should include the study of factors such as (Kumar & Kopitzke 2008, 110):

- The manufacturability of the product (value analysis)
- The manufacturing infrastructure requirements (the basic facilities, and installations needed for the functioning of the manufacturing operation)
- The structure of foreign and domestic tariffs/duties/taxes
- The costs of transportation and the timeliness of delivery
- Foreign business/labor/environmental regulations
- Foreign political/economic stability
- Foreign currency exchange risk
- Language/communications requirements

- Demand uncertainty of the end-customer and the responsiveness of the network to changes in that demand
- Inventory carrying costs (investments versus service levels)
- Inventory risk (relocation, damage, obsolescence, shrinkage)
- Quality costs.

Even though much of this analysis is able to make quantitatively, some elements require a qualitative evaluation offering less certainty.

TCO is an approach that is mostly used to analyze the total cost of outsourcing production. The models that have been used are modified versions of the cost-ratio method. Using the method, an organization usually identifies several key factors or activities that increase costs. Factors such as those resulting from poor quality and late delivery are added to the total purchase price. Dividing these total costs by the total purchase price yields an index. While TCO analysis can be applied to the analysis before the make-or-buy decision, it should also be applied after it. Transaction costs can vary significantly among suppliers and can be an important decision factor. (Ellram & Siferd 1998, 56-58.)

### ***3.3.2 Total cost model for purely offshoring decisions***

Calculating total costs for offshoring decisions is not as complicated issue as calculating outsourcing decision for example with TCO model. However, the same fundamental problem with total cost calculations apply to it as in outsourcing. In many cases, the models used are too simple and not enough thorough to analyze more truthfully the effects of offshoring. The soft costs that should be considered are the lost ability to sense the market and customer demand potential, the necessity to focus more on customer demand variability since the need for large lot sizes increase, the lost flexibility with distribution options, the cost of reverse logistics and the need for more warehousing. (Ferreira & Prokopetz 2009, 23-24.)

The total cost model for offshoring should comprise of at least these elements (Ferreira & Prokopetz 2009, 23-24):

- supplier unit price and terms
- delivery costs, including logistics, country-specific costs and cost of quality
- customer-centric supply capabilities
- other costs, such as risk and local taxes, broker fees and infrastructure technology and facilities.

### 3.4 Statistical calculations for analyzing inventory levels

In this Chapter the statistical calculations for analyzing the trade-offs between offshoring or offshore outsourcing and insourcing production concerning inventory levels are presented based on Chapter 3.2. One key issue in analyzing the total costs of offshoring and offshore outsourcing is analyzing the inventory level needed in these options under demand uncertainty as inventory management presents costs. For that, statistical calculations that are used in quantifying the demand faced by the warehouse are presented. Additionally, the inventory level calculations that are based on the quantification of demand are presented.

#### 3.4.1 Statistical calculations for quantification of demand

It is common to have variation in customer demand of products. Demand modeling is the basis of strategic decisions including the configuration of production and distribution network. The demand forecasts are also needed in the short-term scheduling and operations planning. (Vollmann et. al 2005, 29.)

The inventory calculations are based on two main variables. Mean (or arithmetic average) and standard deviation. Mean is the average of the observations. When the individual observations are denoted by  $x_n$ . (Oakland 2003, 84.) Hence,

$$\bar{x}(x_1 + \dots + x_n)/n = \frac{1}{N} \sum_{j=1}^N \bar{x}_j . \quad (1)$$

The standard deviation takes all the data into account and is a measure of the deviation of the values from the mean  $\bar{x}$  (Oakland 2003, 86). To counter the calculations from negative values, the deviation should be multiplied by itself resulting in always a positive value. The average of squared deviations is known as variance (Oakland 2003, 87). Thus, the variance or mean squared variation is

$$\sigma^2 = \frac{1}{N} \sum_{i=1}^N (y_i - \bar{y})^2 . \quad (2)$$

Variance is also known as coefficient of variation (Simchi-Levi et al. 2008, 48):

$$\text{Coefficient of variation} = \frac{\text{Standard deviation}}{\text{Average demand}} . \quad (3)$$

Respectively, standard deviation (STD) is the square root of the variance (Oakland 2003, 87):

$$\sigma = \sqrt{\frac{\sum(y - \bar{y})^2}{n}} . \quad (4)$$

Usually, if a sample is being used to estimate the spread of the process, then the sample standard deviation tend to underestimate the standard deviation of whole process. To correct for the bias, the sum of squared deviations is divided by the sample size minus one (Oakland 2003, 87):

$$\sigma = \sqrt{\frac{\sum(y - \bar{y})^2}{n - 1}} . \quad (5)$$

### ***3.4.2 The impact of demand uncertainty on inventory levels***

Normally a supply chain consists of suppliers and manufacturers that convert raw material into finished products. Whether in a domestic or international network, distribution centers and warehouses are an essential part of the supply chain from which finished products are distributed to customers. Therefore, the inventory appears in the supply chain in several forms, such as raw material inventory, work-in-process inventory and finished product inventory. (Simchi-Levi et al. 2008, 30-31.)

Each of these inventory forms needs its own control mechanism and approach. To determine these mechanisms, the effect of efficient production, distribution and inventory control strategies that aim to reduce systemwide costs and improve service levels must be taken into account with interactions between the different levels in the supply chain. (Simchi-Levi et al. 2008, 30-31.)

As holding an inventory seems a difficult and expensive activity, it is a very important part of the supply chain. Inventory is held because of the following reasons (Simchi-Levi et al 2008, 31):

- Unexpected changes in customer demand
- The presence in many situations of a significant uncertainty
- Lead times
- Economies of scale offered by transportation companies.

To manage the inventory with the problems mentioned, different inventory policies are used to help management. Simchi-Levi et al. (2003) distinguish between the following to policies:

- **Continuous review policy**, in which inventory is reviewed continuously on a daily basis concerning the decision of whether and how much to order
- **Periodic review policy**, in which the inventory is reviewed at regular intervals and an appropriate quantity is ordered after each review.

Typically in real life situations, the inventory level is reviewed periodically, more prudently in the beginning of each month or each week. After each review an appropriate quantity is ordered. (Simchi-Levi et al. 2008, 45.)

The periodic review policy is characterized by one single parameter, the base-stock level. That is the pre-determined target inventory. Every new order after the re-order point aims to raise the inventory level to this level. The effective base stock level is determined by the length of the inventory review period ( $r$ ), the delivery lead time ( $L$ ) and the average of daily product demand ( $D$ ) calculated as follows: (Simchi-Levi et al. 2008, 46.)

$$(r + L) \times \bar{D}_{weekly}. \quad (6)$$

Additionally, as the inventory position should be protected against deviations of demand ( $\sigma$ ) during the review period and delivery lead time, the base-stock should include the safety stock, which is calculated as follows (Simchi-Levi et al. 2008, 46):

$$z \times \sigma_{D,weekly} \times \sqrt{r + L}. \quad (7)$$

The safety factor  $z$  is selected from statistical tables in order to ensure that the probability of stockouts during lead time is  $1-\alpha$  ( $\alpha$ ). A list of  $z$  values for different service level percentages are presented in Table 4.

Table 4 Service level and the safety factor  $z$  (Simchi-Levi et al. 2008, 43)

Service level	90%	91%	92%	93%	94%	95%	96%	97%	98%	99%	99,9%
$z$	1.29	1.34	1.41	1.48	1.56	1.65	1.75	1.88	2.05	2.33	3.08

Thus, the base stock level, which is the inventory after receiving the order is the following (Simchi-Levi et al. 2008, 46):

$$r \times \bar{D}_{weekly} + z \times \sigma_{D,weekly} \times \sqrt{r + L}. \quad (8)$$

Respectively, the average inventory level is (Simchi-Levi et al. 2008, 46):

$$\frac{r \times \bar{D}_{weekly}}{2} + z \times \sigma_{D,weekly} \times \sqrt{r + L}. \quad (9)$$

The average inventory level is the average of the inventory level before receiving the order and after receiving the order.

## 4 QUANTITATIVE ANALYSIS OF OFFSHORE OUTSOURCING PRODUCTION

Calculating the costs of offshoring and offshore outsourcing manufacturing has been a popular topic in supply chain management. There are many papers available on this topic. Papers are mainly related to finding out the total costs of offshoring and offshore outsourcing in decision-making and applying thorough cost models to address this issue.

In this Master's Thesis offshoring and offshore outsourcing manufacturing is studied quantitatively as a single case study. Quantitative analysis of offshoring and offshore outsourcing are based on the key factors that are used in estimating the trade-offs of supply chain management by using the applied costs elements of total costs concepts theories. The evaluation of offshoring and offshore outsourcing from the total cost point of view is executed in Chapter 5. Thus, in this Chapter the quantitative formulas applied to this case study are presented. These are created in relation to the source data available in the supply chain of the case company. Also the qualitative factors affecting the analysis are presented.

Since total cost concepts comprise of very large entities with multiple phases of calculation, the model used in this case study is a cut-down model of the total cost concepts focusing on logistics and operational costs and supply related costs. The aim of the method is to analyze the specific characteristics of company's business in case study. These characteristics are:

- Lots of sales data (products groups, products, countries, value, production costs, volume)
- Lots of inventory items
- Lots of products
- Lots of customers
- A number of production facilities in supply chain network

Even though this total cost method is created specifically for the circumstances of a case company, the method can be applied in other companies that have similar characteristics in their supply chain. However this model gives a logistics specific point of view for offshoring and offshore outsourcing decisions. Further research of other total cost related issues is required to give a more thorough base for decision-making.

## 4.1 The case company

The case company produces rubber parts for mainly heavy automotive industry. Thus, the company has to make sure that its products are produced strictly in time to make it in to the production line. The consequence of being late can be very costly and the company is willing to pay great amounts of transportation costs in case of delayed production to make sure the product is delivered in time. The customers are also not ready to hold inventory at the place of production moving the responsibility to the case company.

In the past few years the management and the board of the company has had discussions of the efficiency of their supply chain. A major factor in this discussion has been the decision to move production from Finland to foreign countries including Poland, Thailand and India because of major savings in production costs. With this situation the company now has three different business models according to Robinson and Kalakota (2004) as seen in Figure 3: internal delivery, captive shared services or offshoring and offshore outsourcing. In this case study, internal delivery is considered as insourcing because in the option of producing in Finland it is done by the parent company. The need to offshore and offshore outsource production concerns especially products with low production costs and high volume. The lack of time, resources, and special skills in the management of supply chain have hindered the company to develop its distribution network to fit the development of increasing offshore and offshore outsource production. The situation and future plans present following challenges:

- Offshoring and/or offshore outsourcing production means longer lead times making it hard to produce the correct amount in time
- Because of offshoring and offshore outsourcing production the company needs to have larger safety stock involving more capital especially in current warehouse locations
- Longer distances between production and customer means higher transportation costs.

In Spring 2009 company took contact with the author about the possibility to offer a topic for a Master's thesis in Logistics. At that time the original topic was related to centralize warehousing to Southern Finland as a result of new free space given by offshoring the production of both the final products and raw material. After some meetings with company's management it was agreed that the most beneficial topic would be evaluating the supply chain management possibilities in offshoring and offshore

outsourcing more production from a certain product group to especially Asia (Thailand and India).

The comparison in this study is based on the actual data related to the value and volume of company sales from year 2005 to the beginning of year 2010.

By improving the supply chain network the company should be able to offer improved and more tailored deliveries with competitive prices for customers and save costs. Thus, the company would also be able to get better revenue for its services and products provided to customers.

Company provides customers high quality rubber products with a turnover of about 20M€ in 2008 and 2009. Company's main markets according to sales (€) in 2008 are presented in Table 1.

Table 5 Sales by country of the case company in 2008

<b>Country</b>	<b>Market Share</b>
Finland	41.00 %
Sweden	26.9 %
Germany	9.7 %
Belgium	5.4 %
France	3.5 %
Great Britain	3.4 %
Estonia	2.3 %
The Netherlands	2.3 %
Austria	2.2 %
Italy	1.4 %
Poland	0.9 %
United States	0.8 %
Norway	0.6 %
Denmark	0.5 %
Spain	0.3 %

Company's main markets areas are Nordic countries (69 %) and Central Europe (23%). Company's main markets are Finland (41 %) and Sweden (27 %). Company has 7 main product groups with a large product portfolio. The sales of products in the product groups are distributed generally according to the pareto rule where 20% of the most sold products form 80% of the total sales. However, because of the influence of major customers, it is necessary to keep the less sold products in the portfolio.

The company has two factories, one in Finland and one in Poland. In the beginning of 2010, the factory in Finland manufactured 57 % and the factory in Poland 39 % of the products. The rest 4 % of the production was outsourced to Asia. Since 43 % of the Finland's factory customers are in Finland, nearly 75 % of all sales are exported.

#### ***4.1.1 Production of the company's products***

The company is a make-to-order and make-to-stock company depending on the nature of the products. The production of those item groups that have large variability in design requirements and very short lead time expectancy begins only after the customer order. For those items, warehouses are considered more as terminals.

On the other hand products that have large volume and continuous demand and low variability recommendation in demand are made to stock. For many of these items the customers give forecasts to the case company to ease the production planning. However, the moment of the locked order quantity, "freeze-time" can be as late as a week before product-at-customer date. Therefore, make-to-stock production and warehousing is required. This Thesis will concentrate on these products since the make-to-order products do not have financial nor operational motivation to be offshored or offshore outsourced.

The company has produced its products from raw material until approximately 2009. After that the company has outsourced its raw material production and component production of semi-finished products. This will have a lead time increasing effect on products that are insourced.

#### ***4.1.2 Warehouses in distribution network***

In the current distribution network, regional terminal warehouses are used to cover the main market areas for final products. There are two warehouses that are located in Finland and in Poland. The company has its own inventory space for semi-finished products in Finland and Poland.

Company supplies its final products to customers with three different methods. About 55 % of the production is delivered straight to the customer. The remaining 45 % is distributed via a terminal warehouse in Finland or Poland.

Both warehouses are situated in the same building with the factory. There are two weekly shipments between Finland and Poland. From Asia to Finland there are usually one to two shipments every month.

### **4.1.3 Distribution of products**

The distribution of company's products consist of primary and secondary transportation. Primary transportation between the factory and the warehouse is carried out with trailers between Poland and Southern Finland and by sea transportation followed by trailer transportation in case of Asia production import. Secondary transport between warehouse and customers are usually paid by customer (Ex Works). The small vans or trucks of local logistics operators are used for this. In case of late delivery, the company pays the delivery using fast delivery services or even taxis. In Asia, air transportation services are used in quick delivery situations.

Stock keeping units (SKU) are mostly cardboard boxes. Most of the products are normally packed in cardboard boxes. Some customers demand their own package material to be used. In those cases the products are always shipped to Southern Finland first for re-packaging because Southern Finland is the only site with the correct packaging material. The cardboard boxes are loaded on pallets that are used in warehousing and distribution. The products are self-assembly products, which are assembled by consumer.

## **4.2 Research methods**

The aim of this Thesis is to find out what are the total costs of offshoring and offshore outsourcing production compared to insourcing.

Source data in analyzing the supply chain network are based on sales and production cost statistics. They also set limits for the usability of different cost components for the total cost comparison of offshoring and offshore outsourcing. Both of these statistics components include a large number of data, for instance

- Number of product groups
- Months
- Countries
- Analysis of value and volume
- Production cost components
- Transportation calculation (freight, lead time).

The complete analysis of nearly 200.000 sales and inventory actions would be very challenging and laborious task. Besides the data provided above would comprise a very

large number of variables, it would be difficult to apply them to the potential total cost components. Therefore, a qualification of relevant data was needed.

To pick the relevant data, all six different product groups were analyzed according to their supply chain strategy by interviewing top level management of the company. The product items groups that were picked to the analysis were those, that belonged to those product groups that according to company management were already offshored or offshore outsourced or were seen as potential product groups to be offshored or offshore outsourced due to their nature of little customization requirements and make-to-stock production. After this a total of 798 product items of two products groups were picked for the analysis.

The case is carried out with the help of the following quantitative total cost model. The theoretical framework for this model is presented in Chapter 3.

The suitable metrics for the total cost calculation of offshoring and offshore outsourcing production are mainly selected with the help of the theory of total cost concepts and statistical calculations for analyzing supply chain network presented in Chapters 3.2. and 3.4. These theories are applied here to fit the chosen statistics of a case study.

#### 4.2.1 *Safety Stock and average inventory*

The difference in safety stock presents the possibilities to reduce inventories by positioning the production closer to the customer. The average inventory as well as the base stock, the maximum stock, is also easy to estimate with the inventory policy in question. By using the periodic review policy with a time series method, safety stock and the average inventory levels and costs can be calculated as presented in the following pages.

For the inventory level calculations the average monthly demand (1) is transferred to average weekly demand as follows (Simchi-Levi et al. 2008, 44):

$$\bar{D}_{weekly} = \frac{\bar{D}_{monthly}}{\left(\frac{52}{12}\right)}. \quad (10)$$

Respectively, the monthly sample standard deviation (5) is transferred to weekly sample standard deviation as follows:

$$\sigma_{weekly} = \frac{\sigma_{monthly}}{\sqrt{\frac{52}{12}}}. \quad (11)$$

The inventory level calculations are based on the service level as presented in Table 4. The safety stock is calculated according to (7) and the average inventory level according to (9).

#### **4.2.2 Manufacturing costs**

The identification of manufacturing costs varies depending on the company calculating the costs. In this case study the manufacturing costs are based on material costs and cost of labor.

In the case study the manufacturing cost information is gained from the manufacturing company's production data and management interviews. The case company does not produce the raw material itself. In addition the market price for rubber is considered equal to all manufacturing position options.

The labour cost in this case study is calculated based on production cost calculus and management interviews.

#### **4.2.3 Lead Time**

Lead time for a supplier is the estimated time to fulfill the order placed by the customer. Typically lead times are needed to estimate both customer and replenishment orders. Usually lead times are as well divided into parts to see the time consumption of different processes of a supply chain.

In a case study the lead time comprises order handling time, production and transportation to the final warehouse destination due to Ex Works term. The given lead time is based on interviews with the company management.

#### 4.2.4 *Transportation costs*

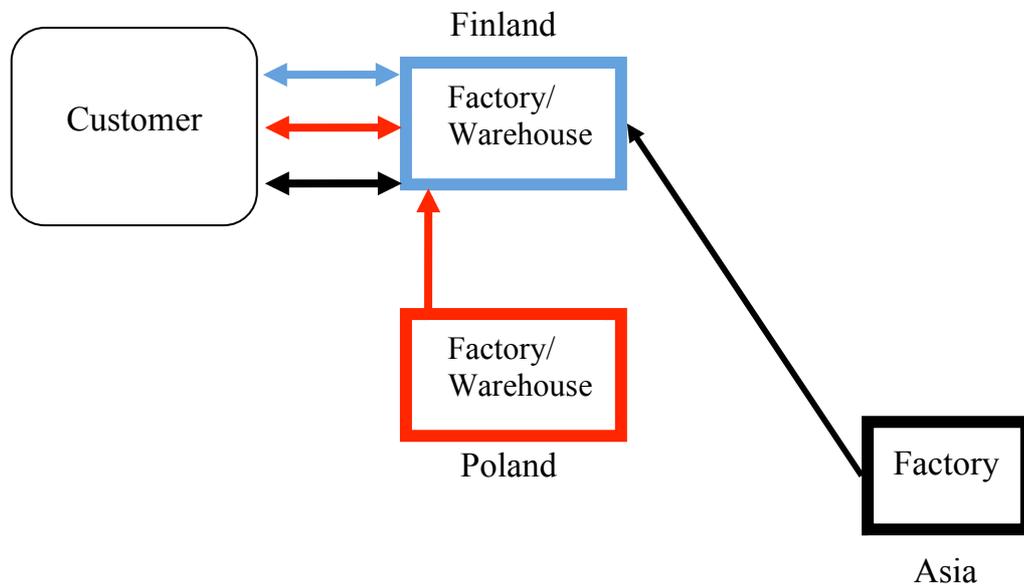


Figure 7. An illustration of the final product flow of the case company. The color of the arrow shows the original production site

Transportation costs in distribution network consist of transportation from the manufacturing site to the factory warehouse in Finland. There is some customer demand in continental Europe which requires transportation to the factory warehouse in Poland. However, as this demand is relatively small and the major part of demand comes from Sweden and Finland (see Table 5) and the aim of this Thesis is not concentrated on alternative warehousing options, but to assess offshoring and offshore outsourcing effects on total costs, the transportation cost calculations are based on having all the products transported to factory warehouse in Finland to be retrieved by the customer (see Figure 7). The calculation of transportation costs are based on production cost calculus data and management interviews.

#### 4.2.5 *Inventory holding cost and cost of capital*

In a case study the overhead costs are the inventory holding cost that comprise of administrative costs relating to inventory management. The cost is calculated by comparing cost accounting data. The ratio from this calculation and the average inventory level according to (9) are then used to calculate the inventory holding cost.

The cost of capital is also a total cost component in calculating offshoring and offshore outsourcing total costs. The capital tied in inventory cannot be used for potential earnings creating capital costs. The cost is calculated by using average inventory level according to (9) multiplying it with a chosen capital cost percentage.

#### **4.2.6 Service level**

The service level is a critical item in calculating the safety stock and average inventory levels. It has a direct effect in logistics costs mentioned in this case study: transportation costs and warehousing costs. A critical decision for the company to make is to choose a service level that satisfies customers but keeps the logistics costs rational.

The case company standard is to produce a service level of 95%. However as the company is a first tier/second tier supplier for mainly automotive industry, the actual service level especially with large customers has to be nearly 100%. To achieve this service level the company mainly has to use express freight which is very expensive.

In this case study the average inventory values are calculated by using the service level from 95% to 99.9% and comparing situations where the standard deviation of demand has increased or decreased 20%.

#### **4.2.7 Total cost**

The total cost analysis gives the management a strategic view to decision-making when evaluating the benefits of different sourcing options. The total costs comprise different cost patterns that have to be analyzed individually.

In a case study the total costs comprise of the most relevant quantitative costs concerning sourcing which are manufacturing costs comprising material costs and cost of labour and logistics costs comprising of inventory holding cost, cost of capital and transportation costs.

#### **4.2.8 Qualitative factors in offshoring and offshore outsourcing**

In analyzing the total costs of offshoring and offshore outsourcing there are many factors that are either difficult or impossible to calculate quantitatively. These factors can relate to the benefits and risks associated in offshoring and offshore outsourcing.

In this case study the logistics performance index (LPI) by the World Bank and its seven indicators are used to analyze the qualitative factors in supply chain decision-making. The indicators concentrate on the logistics environment of Finland, Poland and Asia (Thailand and India), which are the sourcing alternatives in this study. The LPI data used is based on information of 2007, 2010, 2012 and 2014.

#### ***4.2.9 Recommendations for decision-making***

In the final part of the analysis recommendations for decision-making are given to answer the question which is the most beneficial way for the company the organize they're supply chain for potential offshore and/or offshore outsource production. The recommendations are mainly based on results of the quantitative total cost analysis. However, the qualitative factors will be taken into account as an additional notice to the quantitative analysis.

### **4.3 Reliability and validity of the research**

Yin (2009) has recorded criteria for assessing the quality of the research design: construct validity, internal validity, external validity and reliability of the research. The test of *construct validity* involves the identification of correct operational measures for the concepts being measured. *Internal validity* is tested to see has any causal relationships of certain conditions, that are believed to lead to another condition, been developed. *External validity*, on the other hand, refers to the possibility to generalize the findings. Finally, *the reliability* of the study concerns has the operations within the study, such as data collection, being executed so that if repeated they would give the same result. (Yin 2009, 40-45.)

The evidence for the case study can be collected from six different sources. These are documentation, archival records, interviews, direct observations, participant observations and physical artifacts. To benefit most of these sources of evidence, Yin (2009) presents three principles: using multiple sources of the evidence, organizing and documenting the case data i.e. creating a case study database and maintaining a chain of evidence. The last one means that for example the reader of the study should be able to follow the derivation of any evidence ranging from initial research questions to ultimate case study conclusions.

To benefit optimally from the six sources of evidence in order to increase the validity and reliability of the research it is useful to use multiple sources of evidence and create a case study data base. (Yin 2009, 114-122.)

The case company provided documents, archival records for the research concerning manufacturing and sales. In addition, open-ended interviews were conducted with numerous top and lower management people. Site visits for two geographical areas were also enabled to make further observations of the manufacturing and warehouse operations. The recorded sales data from the company was taken from their enterprise resource planning (ERP) system. Therefore there is recorded data available for potential other researchers to examine the offshoring or offshore outsourcing problems within the company.

The time period of this study spans from midyear 2006 until the beginning of year 2010. It should be noticed during this time period the financial situation and demand had a major decrease due to the global financial crisis following a strong growth phase in 2008. This can somewhat weaken the reliability of the study. In addition, as this study is finished in 2015, the results do not give an insight to the current situation, but to past situation which also weakens the reliability.

## **5 OFFSHORING AND OFFSHORE OUTSOURCING TOTAL COST ANALYSIS RESULTS**

In this Chapter the total costs of three different manufacturing sourcing decisions are compared. The framework of the trade-offs are used as a basis of this comparison. The theoretical part of these trade-offs are presented in Chapter 3. The application of theory with the specific circumstances of case company is presented in Chapter 4.

The results are compared against each other at the end of this Chapter where also the recommendations for decision-making are given. The quantitative results in this Chapter are rounded to the nearest hundred.

### **5.1 Comparison of offshoring and offshore outsourcing in production placement**

The aim of this Chapter is to quantify the trade-off between total costs in cases of three different production decisions: insourcing, offshoring and offshore outsourcing. The framework comprises the cost components that are used to form the annual total cost of operations. Additionally, qualitative factors are taken into account to give a broader view for decision-making.

#### ***5.1.1 Safety stock and average inventory***

The effect of the sourcing decision for the safety stock and average inventory is estimated by using aggregated demand. To treat all the product items individually or by stock keeping units would be too complicated a task with the given objects of the study. They are to evaluate the different production network alternatives in general level.

The inventory level calculations are based on periodic review policy. Safety stock presents the amount of inventory needed to cover the standard deviation of demand. The safety stock levels according to 95% service level with standard deviation levels of demand 20% higher or lower of the original is presented in Figure 8.

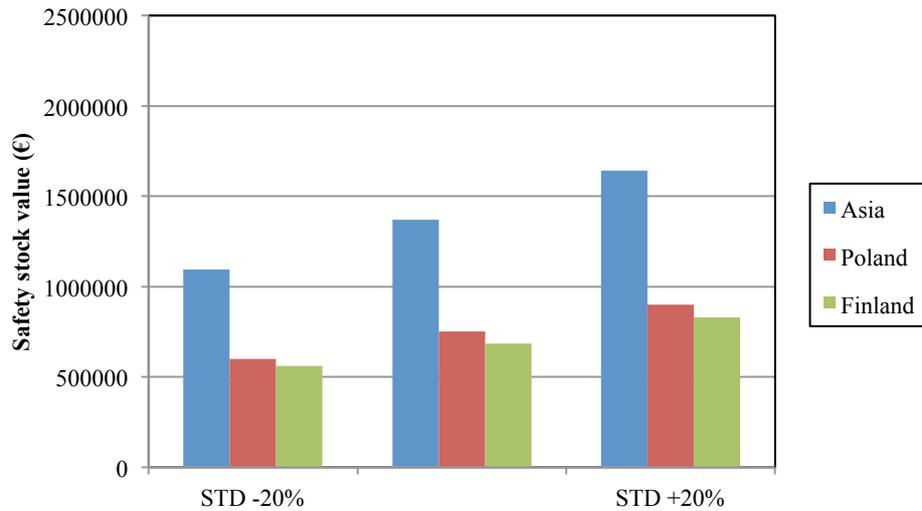


Figure 8. Safety stock levels with increased or decreased standard deviation of demand

The average inventory levels according to service level 95% with standard deviation levels of demand 20% higher or lower of the original is presented in Figure 9.

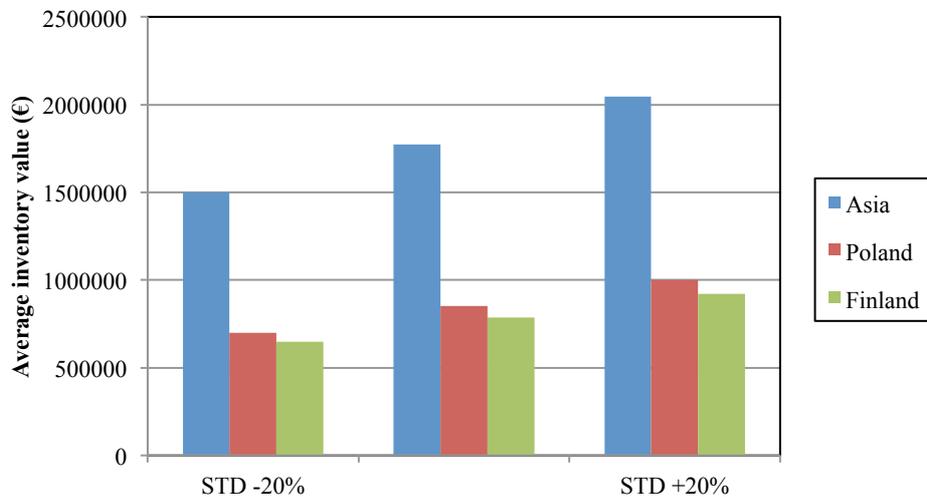


Figure 9. Average inventory levels with increased or decreased standard deviation of demand

The safety stock and average inventory variables have a clear difference between the options. As to offshore outsource production to Asia presents a major increase in lead time which is the main reason for the differences in results. Offshoring production to Poland would only have a small increase in safety stock and inventory variables. Moving

production from Finland to Asia with original standard deviation would increase the safety stock value by 100% from approximately 684,600€ to 1369,100€ and average inventory value by 126% from approximately 785,200€ to 1772,000€. Respectively, moving production to Poland would have a 10 % increase in safety stock from 684,600€ to 750,000€ value and 8% increase in average inventory value from 785,300€ to 850,600€.

When comparing the safety stock average inventory level with the simulation of 20 % increase and decrease in standard deviation the changes in inventory values have a similar increase or decrease. The results tell that demand uncertainty has a clear effect in inventory levels. The effect is more powerful the longer the lead time and inventory review period. Therefore in the case study the option to offshore outsource production to Asia presents most changes in costs and inventory levels based on changes in demand uncertainty.

### ***5.1.2 Manufacturing costs***

The manufacturing costs in this case study comprise of production material costs and cost of labour. According to the production cost calculus and management interviews the material costs are estimated to be half of the product selling price in all products and sourcing options. The material costs then are 5.3 million € in all sourcing options. The cost of labour is dependent on the manufacturing site option. According to the information gathered from production cost calculus and manager level interviews the labour cost of production in Poland is 1 million €, which is 25% of labour costs in Finland. The labour cost in Asia is less than 0.48 million €, which is 12% of the 4 million € labour cost for production in Finland.

By combining the material cost and the cost of labour, the total manufacturing costs in Poland are 6.3 million €, which is 32% lower than in Finland. The total manufacturing costs in Asia are 5.8 million €, which is 38% lower than the 9.3 million € in Finland.

The differences in manufacturing costs, which are based on cost of labour, are significant when comparing the costs of Finland against those in Poland and Asia. However it should be noticed that there can be other labour costs involved in offshoring and offshore outsourcing that are related to the administration and management of offshore and offshore outsourcing matters. Those ought to be studied and analyzed separately as part of the decision-making.

### 5.1.3 *Lead time*

In a case study the lead time comprises order handling time, production and transportation to the final warehouse destination in Finland due to Ex Works term.

The lead time information was gathered by interviewing the company management. According to the interviews, the total lead time for manufacturing in Finland is 4 weeks. For manufacturing in Poland the lead time is 5 weeks and for Asia 16 weeks.

Table 6 The lead times in weeks between the different manufacturing options

Manufacturing site	Asia	Poland	Finland
Order handling time	3	2	2
Production time	3	2	2
Transportation time	10	1	0
Total lead time	16	5	4

The lead times includes order handling and production procedures as well as standard transportation procedures. Transportation in the case company is operated by road freight from Poland and sea-road freight from Asia. The reduced freight times enabled by air freight and express freight were not taken into account due to their rareness.

Between the total lead time, the differences between Asia and the other options Poland and Finland are quite significant affecting the inventory levels. It should be also noticed that for urgent situations where agility is needed, the company does not need to negotiate with another party in case of insourcing or offshoring as is the case with offshore outsourcing.

### 5.1.4 *Transportation costs*

In this case study the transportation cost comprises of transportation from the manufacturing site options of Poland and Asia to the factory warehouse in Finland. The transportation cost for manufacturing in Finland is therefore zero.

The transportation cost information is collected from production cost calculus and company management interviews. According to this information and based on the transportation modes presented in Chapter 5.1.3., the transportation cost for manufacturing

in Poland is 5% of the total manufacturing costs in Poland. For manufacturing in Asia the transportation costs are 10% of the total manufacturing cost in Asia.

The total annual transportation costs for manufacturing in Poland are 316.000€ and for manufacturing in Asia 578.800€.

### 5.1.5 Inventory holding cost and cost of capital

The inventory holding cost according to company management interviews and data from the accounting is evaluated to be 8% of the inventory value in this case study.

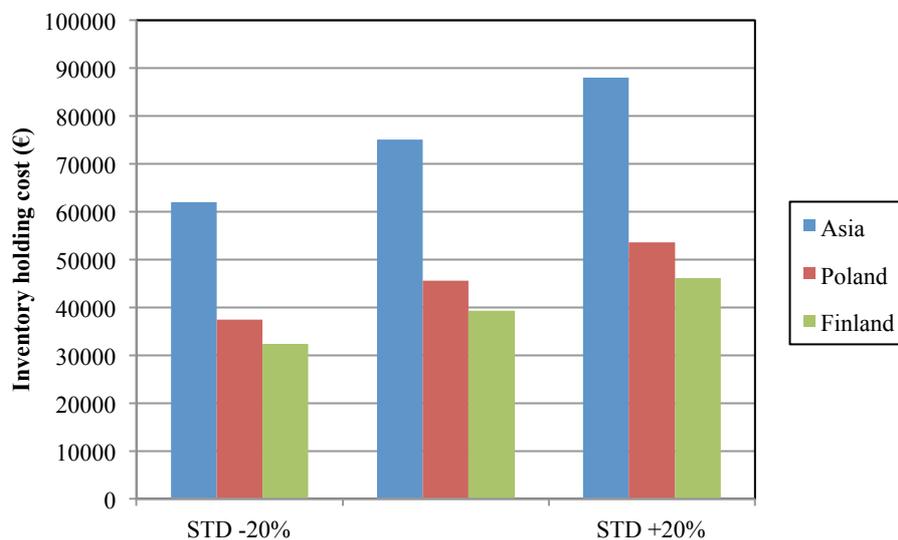


Figure 10. Inventory holding cost with increased or decreased standard deviation of demand

The inventory holding cost for production with original standard deviation of demand is 62,800€ in Finland, 68,100€ in Poland and 141,800€ in Asia. As with the average inventory level, the differences concerning the inventory holding cost is large especially with manufacturing in Asia against Poland or Finland. When the standard deviation is higher, these differences are emphasized. With a 20% increase in standard deviation of demand the inventory holding cost is 73,800€ in Finland, 80,000€ in Poland and 163,700€ in Asia.

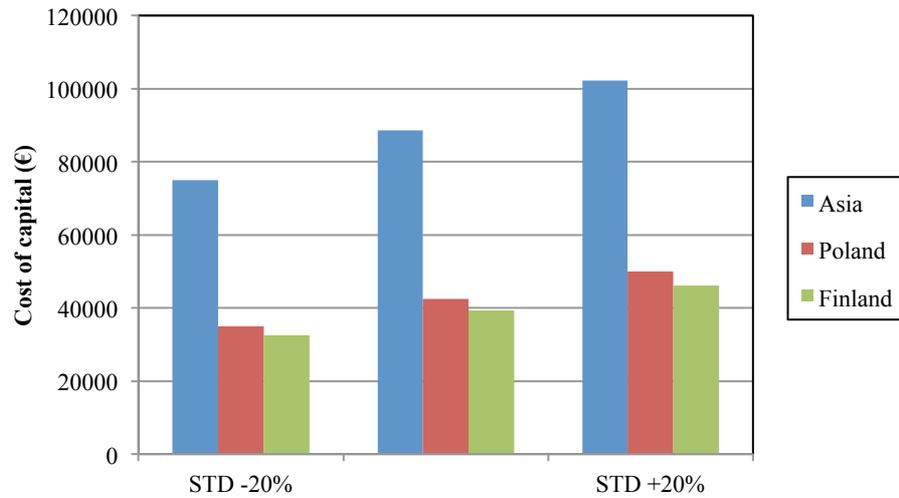


Figure 11. Cost of capital with increased and decreased standard deviation of demand

The cost of capital was calculated with a 5% annual interest rate. The differences between results are similar to those expressed in the inventory holding cost and average inventory levels. The cost of capital with original standard deviation of demand is 39,300€ in Finland, 42,500€ in Poland and 88,600€ in Asia. With 20% higher standard deviation the results are respectively 46,100€ in Finland, 50,000€ in Poland and 102,300€ in Asia.

### 5.1.6 Service level

The relation of service level to inventory value is evaluated in this case study by using statistical calculations comparing the options of insourcing in Finland, offshoring in Poland and offshore outsourcing to Asia.

In Figure 12 the inventory values are calculated with using the standard service level of 95% and also higher service levels up to 99.9% since the costs of delivering on time in full could be very high. According to the results, when the service level increases from 95% to 99.9%, the average inventory value in Finland increases from 785,300€ to 1378,600€. In Poland the average inventory value increases from 850,600€ to 1500,500€ and in Asia from 1772,000€ to 2958,600€.

It can be seen from the results that if the service level increases, it will have a slightly more increasing effect in inventory value in Poland than in Finland. In Asia however, the increasing effect in inventory value is even higher.

In Figure 13 the effects of standard deviation of demand and service level into inventory value are combined to emphasize the effects of sourcing decisions in inventory values. According to calculations when the service level is 95% and the standard deviation is 20%

lower than original, the inventory value is 648,400€ in Finland, 700,600€ in Poland and 1498,200€ in Asia. The difference between Finland and Asia is 849,800€ and 52,300€ between Finland and Poland. Respectively the difference between Poland and Asia is 797,500€.

When the service level is 99.9% and the standard deviation 20% higher than original, the inventory value is 1634,200€ in Finland, 1780,500€ in Poland and 3469,700€ in Asia. Compared to the situation of 95% service level and 20% lower standard deviation, the difference between Finland and Asia increased from 849,800€ to 2835,600€ and between Finland and Poland from 52,300€ to 146,400€. Respectively the difference between Asia and Poland increased from 797,500€ to 1689,200€.

The results show that the differences in inventory value between the options of insourcing in Finland and offshoring to Poland are not that significant. However in the case of offshore outsourcing to Asia there is a major increase in inventory value which is even stronger in the case of increased service level requirements and higher standard deviation of demand. As illustrated in Chapter 5.1.5., these will increase the inventory holding cost and cost of capital.

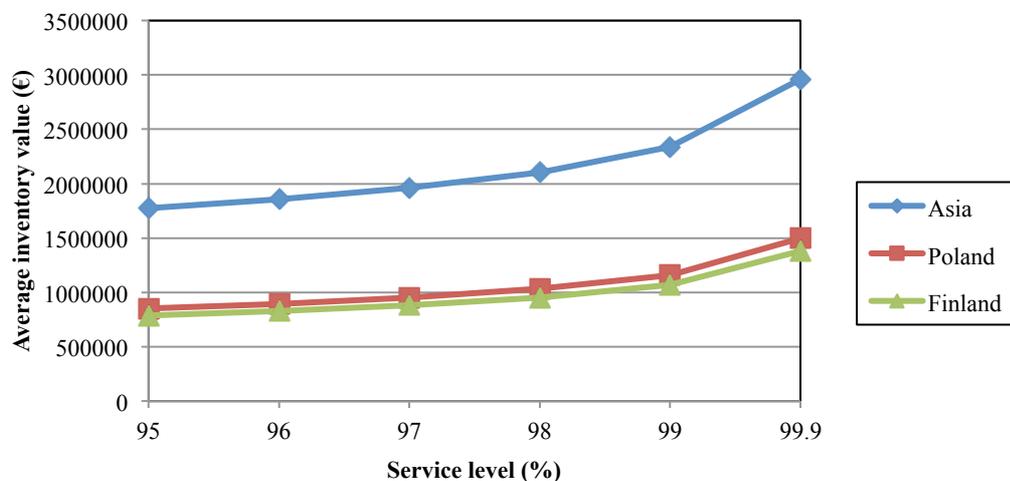


Figure 12. Service level with relation to average inventory in case of sourcing alternatives

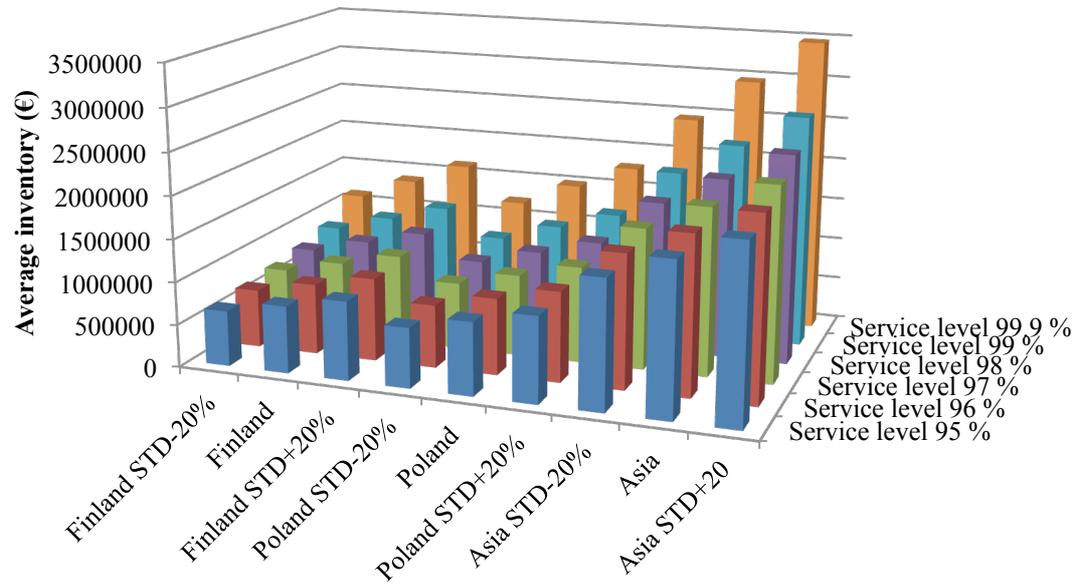


Figure 13. Illustration of the value of average inventory in relation to service level and standard deviation of demand of sourcing alternatives

### 5.1.7 Total costs

The annual total costs of sourcing alternatives comprise two main cost components: manufacturing costs and logistics costs. The manufacturing costs comprise cost of material and labour cost. The logistics costs comprise inventory holding cost, cost of capital and transportation costs. The results are presented in Figure 14. In addition, the results of total logistics costs are presented in Figure 15.

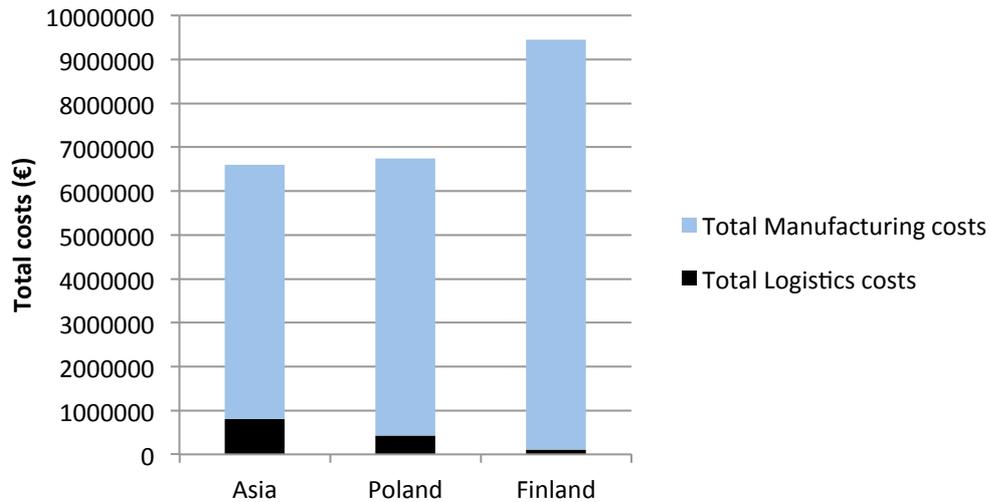


Figure 14. Annual total costs of sourcing alternatives

The total costs of offshore outsourcing production to Asia is 659,700€ which is 2.2% (148,400€) lower than the total cost of offshoring production to Poland and 30% (285,700€) lower than the total cost of insourcing production in Finland. The main factors of cost reduction between offshore outsourcing in Asia and offshoring in Poland against insourcing in Finland are manufacturing costs, more specifically labour costs as the cost of material is considered equal. Between offshore outsourcing in Asia and offshoring in Poland the cost reduction on manufacturing costs in Asia are slightly higher than the cost reduction on logistics cost in Poland.

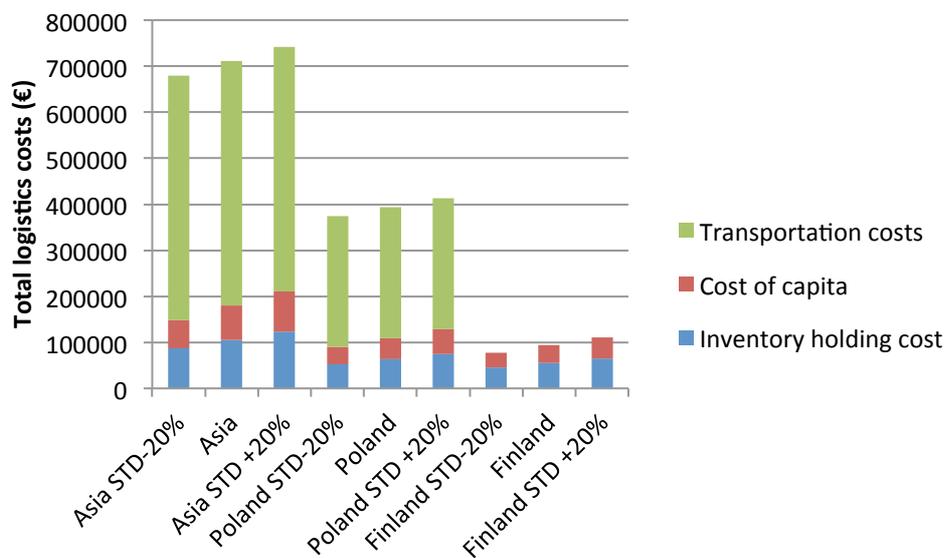


Figure 15. Annual total logistics costs of sourcing alternatives

The manufacturing costs dominate the total costs in this case study. However, if those are left aside concentrating on the total logistics costs, the results between the options are different. With original standard deviation of demand the total logistics costs of production in Finland are 76% (324,400€) lower than offshoring production to Poland. Respectively the total logistics costs are 87% (707,100€) lower in Finland than offshore outsourcing production to Asia.

### 5.1.8 Qualitative factors in outsourcing and offshore outsourcing

In analyzing the total costs of offshoring and offshore outsourcing there can be factors that relate to the benefits and risks associated in offshoring and offshore outsourcing, but are difficult or impossible to examine quantitatively.

The results of the Logistics performance index for the sourcing option countries, Finland (insourcing), Poland (offshoring) and India and Thailand presenting Asia (offshore outsourcing) are presented in Table 7.

Table 7 Logistics performance index scores and rankings by LPI dimension out of 160 countries for sourcing option countries (Logistics performance index 2014)

Country	Year	LPI Rank	LPI Score (min. 1, max. 5)	Customs ranking	Infra-structure ranking	International shipments ranking	Logistics competence ranking	Tracking & tracing ranking	Timeliness ranking
Finland	2014	24	3.62	8	28	20	19	39	38
Finland	2012	3	4.05	2	6	4	1	1	15
Finland	2010	12	3.89	7	8	19	10	11	25
Finland	2007	15	3.82	14	17	30	13	2	14
Poland	2014	31	3.49	32	46	24	33	27	15
Poland	2012	30	3.43	28	42	22	32	37	19
Poland	2010	30	3.44	34	43	35	36	33	2
Poland	2007	40	3.04	38	51	52	38	40	40
Thailand	2014	35	3.43	36	30	39	38	33	29
Thailand	2012	38	3.18	42	44	35	49	45	39
Thailand	2010	35	3.29	39	36	30	39	37	48
Thailand	2007	31	3.31	32	31	32	29	36	28
India	2014	54	3.08	65	58	44	52	57	51
India	2012	46	3.08	52	56	54	38	54	44
India	2010	47	3.12	52	47	46	40	52	56
India	2007	39	3.07	47	42	40	31	42	47

Based on the results, Finland has the best logistics performance. However its overall LPI ranking has dropped from 3rd in 2012 to 24th mainly because lower scores in tracking and tracing and timeliness. Poland is the second best performing country in the group in terms of logistics. Its performance has improved from the first ranking in 2007 from 40th to 32nd in 2014. Thailand's LPI ranking has moved from 32nd in 2007 to 36th in 2014 also representing stability in its performance. India however has dropped from 39th place to 52nd because its logistics performance has not improved as it has with other countries including Poland and Thailand.

The results indicate that based on the recent development Finland is slightly better with its logistics environment compared to Poland and Thailand. Compared to India there is a clear superiority.

## **5.2 Recommendations for decision-making**

The main result of this study can be found in Figure 14. Both offshoring in Poland and offshore outsourcing in Asia are highly potential sourcing options that offer lower total costs compared to insourcing in Finland. Between offshoring in Poland and offshore outsourcing in Asia the latter one has the least total costs (2.2% compared to Poland and 30% compared to Finland). However it would affect logistics costs the most in offshore outsourcing in case of increased demand uncertainty as the inventory levels would be increased much of what in Poland or in Finland. In addition the costs for possible rapid deliveries depend would be the highest in Asia due to longest distance between production and customer. It should also be noticed that the qualitative factors are not included in the calculations mentioned above. The logistics performance is weaker in Asia than in Poland and Finland. Also the risks of outsourcing should be taken into account. The possible extra effort in controlling the relationship between the outsourcer and the outsourcee can have a cost increasing effect.

Offshoring operations to Poland seem to offer the best development if also the qualitative factors are taken into account. The total costs are almost equal to Asia being 29% lower than in Finland. In addition the logistics performance of Poland is competitive compared to Finland and better than in Asia. Offshoring also does not present the risks that incur in outsourcing.

As sourcing decisions have a large effect on business operations, more information and data concerning all possible trade-offs should be collected and analyzed before decision-making. For example the cost of labour should be analyzed more thoroughly with a higher

quality data. Also the company management should have a thorough look into the qualitative issues. These are besides the logistics performance the long-term prospects of the political situation and the economic development of the alternative countries as these can have a significant effect in labour costs, which are the single most prominent cost factor in this case study. If the labour costs between the options would even out, the logistics costs would have a stronger effect. In that case insourcing production in Finland would be a more considerable alternative.

## 6 CONCLUSION

The aim of this research was to analyze the possibilities of offshoring and offshore outsourcing production in a supply chain total cost context. Offshoring and offshore outsourcing have been widely discussed in academic literature. In the globalizing world they have been seen not just operational, but strategic ways to save costs and enhance customer relationships.

Executing offshoring and offshore outsourcing successfully can be more complex than initially expected. Moving production further from the customer weakens the company's ability to react to demand uncertainty. Potential benefits of offshoring and offshore outsourcing from cost savings that are often based on lower manufacturing costs are conflicted by a more complex supply chain. Therefore, offshoring and offshore outsourcing can increase costs and the risk of been unable to maintain customer service level.

The conflicting objects of the supply chain, trade-offs, are presented in the theoretical frame of reference as well as in case of comparison between insourcing, offshoring and offshore outsourcing production decisions.

The case study evaluates the sourcing options of a supply chain network in a manufacturing company. The alternatives are insourcing in Finland, offshoring in Poland and offshore outsourcing in Asia.

For the comparison between different sourcing alternatives a framework is used to assess total costs affected by the trade-offs of the supply chain. These trade-offs are defined between inventory holding cost, cost of capital, transportation costs and manufacturing costs, which are analyzed quantitatively. This is done by using a time series method of past sales data with periodic review inventory policy. In addition the qualitative issues related to sourcing decisions are addressed. Theories of supply chain management concerning the benefits and risks of sourcing options and supply chain costs are presented. As the supply chains are different, the quantitative theories are applied to adapt the circumstances of a case company.

According to the results of this research both alternatives of offshoring and offshore outsourcing production offer possibilities for supply chain development. The results confirm the theories that offshoring and offshore outsourcing would reduce total costs as offshoring in Poland and offshore outsourcing in Asia would result in the lowest total annual costs. The total costs of offshore outsourcing in Asia are 2,2% lower than in offshoring in Poland and 30% lower than in insourcing in Finland. However, increased demand uncertainty would make the alternative of offshore outsourcing in Asia risky and difficult to manage. If offshoring in Poland or insourcing in Finland the risk level is lower.

As the main cost savings in offshore outsourcing come from manufacturing costs, more specifically labour costs, the logistics costs do not have an essential effect in total costs. Thus, the development in labour costs should be well known. In the case of increased labour costs in Asia, the results show that the option of offshoring in Poland would be the most beneficial. This is supported by the results of the qualitative factors that address Asia as the worst logistics environment between the options.

For possible future research of offshoring and offshore outsourcing production the possibility to utilize more detailed data concerning supply chain operations together with additional cost components would offer a more thorough and precise analysis for the assessment. For this study the task was too complex and time consuming for product level analysis and beyond the given cost components. The systematic management of supply chain data with proper information systems would give more value to decision-making information.

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