



Optimizing the location of a fulfilment center

A case study

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Abstract:

E-commerce is a rapidly growing industry, and the customers' expectations of fast deliveries put pressure on companies' delivery services. The lead times of the case company's deliveries to their key markets are longer than ideally preferred, which impacts negatively on customer satisfaction. The aim of this study was to define the optimal location for an e-commerce fulfilment center, and how it would impact the lead times as well as costs. The research questions were: "Where would the most optimal location for the e-commerce fulfilment center be?", "How does the relocation impact the lead time to the key markets?" and "How does the relocation affect the inbound and outbound costs?".

Comparisons were made comparing the current warehouse and a new potential e-commerce fulfilment center. The method chosen for the research was quantitative research with a case study approach. The data was gathered from the case company's ERP system, their 3PL partners, and from the potential new fulfilment center. The data was worked on in Microsoft Excel, where calculations were made for cost comparisons. The optimal fulfilment center location was calculated by using a Center of Gravity-calculation. The results showed that the most optimal e-commerce fulfilment center location would be by the new potential fulfilment center, lead times would hence decrease by an average of 2.5 days to 4/5 key markets, and the total costs would decrease by 23.77% if the fulfilment center was to be relocated.

Keywords:

e-commerce, logistics, delivery service, lead time, fulfilment center, costs

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1 INTRODUCTION

E-commerce is a rapidly growing industry, and more and more people order goods they need online. By ordering online, they save time and effort compared to when they go into a traditional store. In this fast-paced world right now, companies must reach their customers as fast as possible and on time, but of course, also keep the costs under control. However, it is important to recognize that when aiming for a higher service level, costs usually are higher as well (Inkiläinen, 2011).

People ordering online however usually order smaller and more diverse quantities per order than wholesale customers. In addition, they have several options to choose from in regard to delivery speed and location which makes the picking and packing of the orders very dependent on manual labour or automatized operations. Manual labour easily adds to the variable costs, when automatized operations demand capital investment. (Ellinger et al., 2016)

Therefore, the location of the company's warehouse makes a big difference and should be carefully reviewed. Many factors impact the most optimal location for a warehouse, like road, sea, and air connections, especially to the most important markets for the company. Having only one central warehouse can hinder the customer-oriented approach, where again centralizing warehouses can lower the distribution costs and improve the service quality. Having a central warehouse with a few distribution centers as support can again improve the balance between having a customer-oriented approach and costs (Inkiläinen, 2011).

Faster deliveries improve the customer service but often require higher stock levels and warehousing costs. It is essential to identify the requirements of the customers, knowing your customers as well as your goods. This way, the company can improve and build the best delivery system that serves the customer and company. (Inkiläinen, 2011)

Smooth operations are the building blocks of good customer service, but it may be hard to recognize the core values, when the supply chain becomes a complicated network of operations. It is important to be able to give the customer a reliable delivery promise and

commit to it. Information flow between all parties should be smooth and an up-to-date information system is essential for coordinating the flows. (Inkiläinen, 2011)

1.1 Problem statement

The main problem of the company is that the e-commerce orders' delivery service to the key markets takes too long. This impacts customer behaviour since in today's world consumers need and want to receive their goods as fast as possible. Hence, it is relevant for the company to research and optimize the location of the warehouse, and how it would make an impact on the lead time and costs.

The research questions for this thesis are:

Question 1 – Where would the most optimal location for the e-commerce fulfilment center be?

Question 2 - How does the relocation impact the lead time to the key markets?

Question 3 – How does the relocation affect the inbound and outbound costs?

1.2 Aim of the study

The aim of this study is to get a comprehensive idea about what the impacts would be on the lead time and costs if the e-commerce stock were moved to a more optimal place, compared to if it stayed in the place where it is right now. Comparisons between the existing warehouse and a new fulfilment center are calculated. An essential part of the calculations is based on the fact that the existing warehouse will fulfil the new warehouse, and those costs are calculated as inbound costs.

At the end of the study, the company should be able to make an informed decision of whether or not they should consider moving the e-commerce stock or not, and what the consequences of each decision would be.

1.3 Demarcation

This study will not focus on moving or changing any other stock or supplier locations other than the e-commerce stock.

1.4 Definitions

These are the most important definitions used in this study:

Supply Chain – A network of organizations that improve and lead the material and service flows together with information and money flows. The network is reliant on the company's products, customers and industry, and all organizations within the supply chain has their own role. (*Logistics and Supply Chain – Logistiikan Maailma*, n.d.)

Key market or target market – A group of people that are the most likely to be customers for the products a company is selling thanks to shared demographics. A key aspect when making decisions in the company. (Investopedia, 2023)

Lead time – The time passed from the start of a process to its end (Kenton, 2023). In this study, the time it takes for the goods to be delivered from the time an order is made to when it has been delivered to the end customer.

Inbound – Inbound logistics is when the goods are received, checked, unloaded and placed in the warehouse. (Logistiikan Maailma, n.d.)

Outbound – Picking, packing and the delivery of goods from the fulfilment center to the customer as well as returns handling. (Logistiikan Maailma, n.d.)

B2C – Business-to-Consumer (Morana, 2018)

OFC - Online Fulfilment Center (Ferne & Grant, 2019)

3PL – Third-party logistics. A logistics provider that is used when a company outsources their logistics processes. These processes typically include warehousing, transportation, order fulfilment and inventory management. (Dopson & Lockhart, 2023)

1.5 Presentation of the company

The case company is a company selling apparels all over Europe with the most important markets in the Nordics, but also central Europe. The business is seasonal, with the high peaks being in autumn and winter.

2 THEORY

In this chapter theoretical frameworks are presented that are relevant to the study and understanding the different concepts discussed. First the supply chain is presented in general, followed by outbound logistics and its process development. After this the e-commerce processes and customer service are presented, as well as inventory management. Lastly, locational techniques are discussed and how a company could determine the best location for a new fulfilment center.

2.1 Supply chain

There are four cycles in logistics handling the supply chain: customer order cycle, replenishment cycle, manufacturing cycle and the procurement cycle. Logistics management includes several different parts, like managing orders, forecasting demand, packaging, labelling and the documentation flow. This typically is related to the outbound flow of logistics. All the logistic activities that are done in the company are a part of the bigger supply chain and should therefore be planned and executed together and take into consideration the functions of the whole supply chain. (Wood et al., 2002)

The less the supply chain has middle steps, the more streamlined it is. Especially in large supply chains, it is common to have several warehouses and distribution centers, logistics partners and wholesales. Each step naturally increases the costs of the supply chain, and it ties up time as well. This is why it is necessary to review the different operations in the supply chain and the necessity of them. These operations can be for example the

purchasing, warehousing and deliveries. In the retail business, costs for manufacturing, distribution and store costs are traditionally a big part of the cost of the goods. It is possible to lower costs by having electronic ordering software and centralizing and combining the distribution. (Ritvanen, 2011)

Quality customer service is the building block for a customer-oriented supply chain. In order to increase the value for the customer, there are certain areas that contribute to it. First and foremost, one has to start with the demands and needs of the customer. It is important to learn to know the customer and the company's items so that the most optimal delivery system can be built. This way, it serves both the customer and the sold goods. (Inkiläinen, 2011)

Secondly, it is essential to plan the costs correctly. Having the best service tolerates the higher price tag, but it is important to be aware of the costs as well. Sometimes the company has to accept higher costs in order to keep the higher level of customer service that the customer requires. (Inkiläinen, 2011) Being agile is something the company should aim for since agility in business and logistics gives a higher chance of being successful. Coordinating all the different functions to be seamless to be able to give the customer a reliable delivery promise is essential. This becomes more difficult the more complex the supply chain becomes, which is why good communication between the operators and an up-to-date ERP are the cornerstones for good coordination. (Inkiläinen, 2011)

2.2 Outbound logistics

Outbound or downstream logistics is the part that is the most visible for the customer and is thus considered to be the most important. It is the part of the logistics chain that has to deliver the goods to the end customer quickly when the demand comes (Morana, 2018).

Essential parts of outbound logistics are picking and packing of the goods in the warehouse, as well as delivery of the goods. Value-added services and the reverse flow of the goods are also a part of outbound logistics. Value-added services are usually composed of organization, packing, maintenance or recycling of the goods. (Ritvanen, 2011)

The outbound logistics process ensures that the customer receives their order according to their requirements with no disruptions, though this process may not work at several companies. There can be multiple problems within different functions, like errors in picking and packing of the orders, late deliveries or delivery to the wrong address. Damage in orders is as well a common problem. When fixing these problems in the logistics processes, the solutions should be made with customer satisfaction and expectations in mind. (Rushton et al., 2022)

2.2.1 Logistics process development

Developing the logistics process of the company is needed for seamless operations. As presented in Figure 1, the process starts with the *identifying of the key processes* that are in the need of a redesign. Here it is important to recognize and have a clear overview of the requirements of the customer. Second, the processes that are to be redesigned are *mapped* out so that the company gets a clear understanding of the main elements in these processes. This includes what the aim of the certain processes are and what is achieved, main problems and what improvements could be made. (Rushton et al., 2022)

When the first mapping is complete, it is time for a more *detailed flow mapping*, where the processes are gone through in detail by each respective department responsible for the certain process. This stage can take some time, since for example, order fulfilment is a complicated process. That is why all problems are recognized and noted. (Rushton et al., 2022)

After this stage, the process continues with *identifying opportunities for improvement*. Here the improvement points are identified and with this, these opportunities are *measured*, and the *key points* identified when arisen. With this, *feasible solutions* are identified, and potential changes are agreed upon. As the agreement is done, *implementations* for the new processes are made. Here, testing and piloting first is a good idea in order to test whether or not the solution is effective. The new processes are subsequently monitored and followed in the future, so that the development can continue. The development process is described in Figure 1. (Rushton et al., 2022)

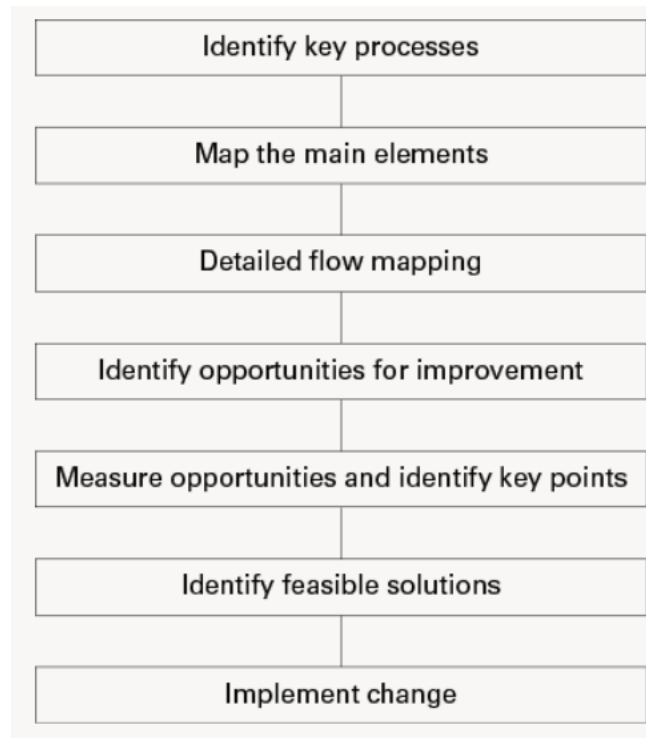


Figure 1. Process design approach (Rushton et al., 2022)

2.3 E-commerce

E-commerce is usually defined as a Business-to-Consumer relationship where the customer places their orders via an electronic device (Morana, 2018). It has grown drastically since the middle of 1990s, and there has been a lot of discussion whether e-commerce will replace the traditional physical stores, and the retailing business will move completely to online. One of the biggest factors that has led to this growth is the increasing access and connection to internet, and the total e-commerce sales in 2018 were about USD 2.8 trillion and is growing every year. (Fernie & Grant, 2019)

Even though e-commerce is growing, it is unlikely that the retail stores will disappear as many customers still want to touch and feel the products. This is why it is suggested that the businesses will move even more towards a model where physical retail and e-commerce are integrated, which impacts the logistics of the company. (Fernie & Grant, 2019)

In order to succeed, the company has to choose the most optimal distribution channel in order to successfully fulfil their online orders, whether it is from a retail store or an online fulfilment center (OFC), provided by a third-party logistics partner. The different options

have differing cost structures, which are important to understand in order to make an informed decision. (Fernie & Grant, 2019)

2.3.1 Delivery service in e-commerce

When the customer places their orders online, they tend to want their items as fast as possible, which adds pressure on the company and their potential 3PL-partners in making sure that this is fulfilled. The four main most important expectations that the customers have for a good e-commerce experience are availability, timeliness, condition and return. (Fernie & Grant, 2019)

Availability in this context refers to having enough inventory to fulfil the customer orders, and a key question in this is that is the inventory available at the fulfilment center immediately or does it need to be ordered? If it needs to be ordered to the OFC, how long is it going to take for it to be available again, or is there possibly some kind of replacement available? If the items are out of stock, it is likely that the customer will turn to another website to order what they need, since it is so easy to order online. Another important aspect in availability, is how the customer is going to be able to track and trace their order, which gives a sense of control over their order since they know when to expect it. (Fernie & Grant, 2019)

Timeliness is the concept that measures the performance of the order delivery, and for the customer it is the time that has gone from when the order has placed their order to when they receive their order. For the customer, this also includes the choices they have on the time window and delivery date, how quickly they receive it and whether or not the company actually can keep their delivery promise. Reliable deliveries that are fast and on time holds a lot of significance, since late and slow deliveries are more likely to be returned. This impacts also the chances of repeat purchases from the customer, and this combined with large amounts of returns impact the company profitability. (Fernie & Grant, 2019)

Condition refers to the condition of the order, and its quality and accuracy. Damaged and faulty items most often result in returns and cancellations, and straightforwardly affects the customer's perceived service quality of the delivery.(Fernie & Grant, 2019)

Returns are the processes that are available for the customer to return products either for reselling, repairing, recycling or otherwise just returning or replacing. Here important aspects are how fast the goods can be returned or replaced, and how faulty, unwanted or damaged products are dealt with. Easy and convenient returns are an essential part of good customer service in e-commerce. (Ferne & Grant, 2019)

This said, it is essential that the company and their potential 3PL partner pay extra attention to the last mile in order to ensure a good fulfilment experience for the customer (Ferne & Grant, 2019). The happier and more satisfied the customers are with the service receive, the more successful the e-commerce is (Wang & Pettit, 2021).

2.3.2 Fulfilment

As the e-commerce business is constantly growing, there are some challenges that it poses on the warehouses. E-commerce is typically impacted by seasonality, which impacts the warehouse planning with staff and space demand, as winter items are significantly larger than summer items. The fulfilment centers have to process efficiently all orders, regardless of order size and value, since every order requires the same amount of equipment and labour. The deliveries being accurate and on time is essential, since otherwise the company risks losing the loyalty of the customers. One of the main concerns in e-commerce fulfilment is the inventory management. If there is an increase of a certain product being picked for orders, it will increase the pressure on those pick locations. Slow-moving goods again may take up a lot of space that would be needed, and that is why it is important to release the space and manage the stock turnover well. (Richards, 2021)

Returns are a big part in e-commerce and can be as much as 30-40 % of the outbound volume. Most returns are goods that can be put into stock again and sold after a quality check, and that is why it is important for the fulfilment center to be able to provide it. This enables a more efficient process that lowers the costs and goods are back in stock faster. (Richards, 2021)

2.3.3 Last mile

In e-commerce, the last mile is the most complex and expensive part, meaning the delivery from the fulfilment center to the customer. The location should be convenient for the customer to pick up their order or be delivered home to them. In home deliveries though, the customers do not generally want to wait the whole day for their delivery, but to be able to choose a narrow timeframe when the order will be delivered. (Wang & Pettit, 2021)

This has brought new logistics challenges to the logistic operators, and the last mile, or final mile describes these certain problems in the final delivery to the customer. Some of the common consequences are that the customer is not available to receive the goods, there is not a safe place to leave the parcel, tight delivery windows, setting up new distribution systems and high return rates. Some more positive consequences are that the already existing delivery systems get increased opportunities for development and in some cases traditional retail stores act more as a showroom, where stock does not need to be replenished as much. (Rushton et al., 2022)

In order for a company to ensure smooth last mile operations, there are solutions that have been introduced to tackle these problems. The fulfilment center locations near to cities, called urban warehouses, makes the fast deliveries possible. Instead of delivering goods home, the customer can choose to pick up their delivery in pick up points near their home when it is convenient for them, as well as return the goods there. The logistics service in e-commerce has become an essential part of the customer service strategy, and should thus recognize the different requirements listed for successful e-commerce fulfilment. (Rushton et al., 2022)

2.4 Warehouse and inventory management

When developing a company's functions, it is important to think about the warehouse management since it affects the whole logistics chain. Generally, in the supply chain, companies aim to keep the inventory levels at the warehouse as low as possible. This is because a lot of capital is tied up in inventory that could be freed up to some other needs. Ideally, inventory levels can be lowered if the delivery times from the supplier to the end customer can be optimized so, that the raw-material can be delivered straight from the

supplier to the manufacturer, and from the manufacturer straight to the end-customer without warehousing. (Ritvanen, 2011)

Large item selections and customers' needs can cause warehousing pressure, which is why it is important to carefully review the need for the item selection. (Ritvanen, 2011) Choosing the type of warehousing a company will use is extremely important. The warehousing methods depend on the goods, warehousing height, aisle width, automatization levels as well as the industry. When choosing the warehouse management system, it is important to take into consideration the most common logistic service factors (Ritvanen, 2011):

- Delivery density, -time, and -reliability
- Reliability of the deliveries
- Delivery flexibility
- Communication in problem situations
- Effectiveness, easiness and flexibility in making the orders
- Impeccable condition of the goods (no damage in delivery)
- Packing
- Packing size and its different variations
- Information on the packaging, i.e., dates and barcodes

2.4.1 Cycle stock

There are different kinds of warehousing types for different needs. Cycle stock and lot-sized inventory warehousing is when the stock changes according to utilization and replenishment cycles. Cycle stock is usually used because of different costs, like delivery costs and the chance for volume discounts. This demonstrates the kind of warehouse, where the average demand for a certain time period is fulfilled. (Ritvanen, 2011)

2.4.2 Safety stock

Having a safety stock is when a company does not want to end up with shortages of goods. By having safety stock, the company ensures that they can still deliver even though there would be fluctuations in demand, delivery times and -amounts. This means that there is always a certain amount of stock in inventory, to ensure the service level when the

demand varies. Safety stocks can be minimized by improving forecasts, limiting variables and improving the cooperation with the supplier. (Ritvanen, 2011)

2.4.3 Seasonal stock

Seasonal stock is when the demand changes seasonally. The aim in seasonal stock is to keep the production at stable level all the time, so that there won't be a situation where the production has a really quiet time resulting in layoffs, or on the other hand being very busy at other times resulting in a lot of overtime. (Ritvanen, 2011)

2.4.4 ABC-analysis

The e-commerce fulfilment center will be fulfilled from the company's main warehouse, and thus it is relevant for the company to calculate and review which products should always be in stock and prioritized when planning the fulfilment.

A company can review and develop its services by using the ABC-analysis, also known as the Pareto principle. The Pareto principle is named after Vilfred Pareto, who was an Italian economist and sociologist. (Ritvanen, 2011) The ABC classification is a variant of the Pareto principle, and they are often used intertwined. The ABC classification was developed by Joseph Juran in 1954. (Morana, 2018)

The Pareto rule is often also referred to as the 20/80-rule. According to this rule, 20 % of the customers bring 80 % of the company revenue, gross profit and customer complaints. These 20 % is classed as the type A. On the contrary, the vast majority i.e., the remaining 80 % bring only 20 % of the business volume. These are categorized as types B and C. (Ritvanen, 2011) Even though this classification is divided into the three categories, the company may add more categories if it is beneficial for them, but it is encouraged to keep the type A class as fixed. (Morana, 2018)

In practice, this means that the company could assume to get the best results when developing the capacity and customer service towards the key customers and markets. In reality though, it can be hard to implement since the customers are all important, even though they would be a part of the types B or C. This does not mean that the customer service levels need to be a 100% for all types, but for example 98% for type A, 90% for type B and 85% for type C. (Ritvanen, 2011)

In the ABC analysis, items are taken into consideration according to their value, and not the quantities i.e., 1 item at EUR 100 is measured as more critical than 100 items at EUR 1 (Morana, 2018).

Improving the customer service levels usually mean that the cost is higher as well, while a lower customer service level can result in reclamations, correcting mistakes and doing double work. This is why it is crucial to find the optimal level, where the customer service is good enough with cost being as low as possible.(Ritvanen, 2011)

2.5 Locational Techniques

The warehouse location is one of the most important decisions a company makes, since it has many impacts and is strategically important. A fulfilment center that is in a strategic location and is the most cost-effective in terms of geographic location has several criteria that have to be taken into account. Fulfilment centers, for example, usually need to be located near big motorway networks in order to reach parcel hubs in time. (Richards, 2021)

Deciding on the warehouse location is a long-term decision that is difficult to reverse and should hence be made with care. Deciding on a location also comes with a lot of different costs that are both fixed and variable. These costs are rent, personnel costs and fixed overhead costs. Some variable costs are handling costs, inventory costs and transportation costs. The location of the warehouse greatly affects the costs, and the main objective for the company is to maximize the benefits of the location and costs. (Verma, 2012)

Both qualitative and quantitative data need to be assessed when choosing the warehouse location. Usually, the largest number of customers and their locations are assessed by many companies in this phase. Some other key factors that affect the decision are the vicinity of transport and economic centers, infrastructure that is both efficient and modern, as well as land costs. Some other factors that are taken into consideration are the availability of skilled labour, transportation costs and costs of operation. Some specific factors for e-commerce are the following (Richards, 2021):

- Rent cost

- Affordable labour availability
- Parcel hub proximity
- Highway network proximity
- Close to consumers
- Space availability, especially for expansion
- Location centrally

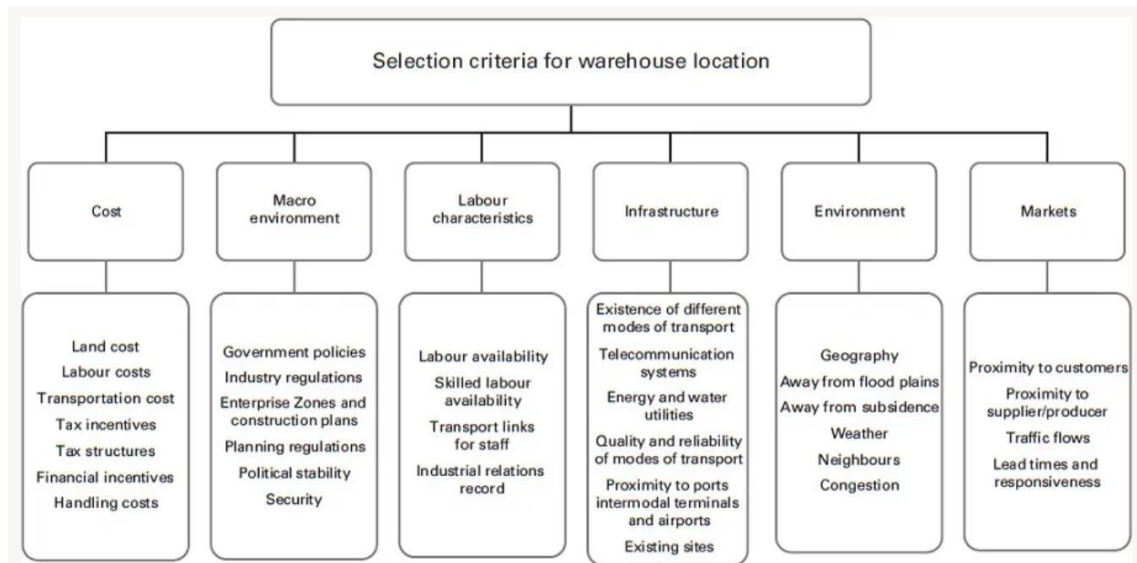


Figure 2. Warehouse location criteria. (Richards, 2021)

The decision of the warehouse location can be made with the help of software programs that are available, and they will take into account the majority of the key criteria and provide several alternatives that are usable. For the most part, these systems use the volume center of gravity calculations, where the location is chosen by minimizing the distance to the customers and suppliers. The other calculation method is the cost center of gravity method, and in this calculation the warehouse is located so that the transport costs to customers and from suppliers are minimized. (Richards, 2021)

2.5.1 Center of Gravity

Center of Gravity is a quantitative method for calculating the most optimal location for a fulfilment center while minimizing costs. The main elements that are taken into consideration in this method are the markets, volume of shipped goods and transportation costs. This method is good to use since it is easy to navigate, takes into consideration

existing facilities and minimizes the costs. In the calculation, the pre-existing fulfilment centers are placed on a gridded map with determined coordinates.

(OpEx Learning, 2011)

2.5.2 Break-Even Analysis

The Break-Even Analysis is also a good method to use when the costs of a fulfilment center are known and can therefore be used to determine the fulfilment center location. This method is also a quantitative method, that takes into consideration total costs. There are four steps in this method, and the first one is to identify both fixed and variable costs in all the locations. Then, the fixed and variable costs are stated in a calculation for total costs to determine the break-even point. After this, the points are put into a graph together with all the location alternatives. With this, one can identify visually the most optimal location that has the lowest cost in regard to the total result out. (Dominguez, 2018)

2.5.3 Factor rating method

The factor rating method is a qualitative method with some quantitative aspects to determine the best alternative in a certain alternative (Lumen Learning, n.d.). It can be used to determine locations based on the different factors that are assigned different weighted scores. The location with the highest weighted score is considered as the best location to choose. There are six steps to this method:

1. Listing the factors that are relevant
2. Giving all factors an importance weight, all totalling 1.0
3. Determine a scale of points for the factors, usually 0-100
4. Give each location with factors a score
5. Multiply the weights with each factor and count the totals for each location
6. Finally choose the location with the highest total score

(Wordpress, n.d.)

3 METHOD

In this chapter the research methods generally are presented as well as the chosen research method for this study. The research approach and the analysis of the data are presented

after that, followed by the reliability and validity of the study. Lastly, research ethics are be discussed.

3.1 Research methods

Science is built on research methods, since they are how we build our systematic knowledge. Gaining knowledge comes from several different sources, like own experience, through parents, teachers, books, social media and news. Own experiences are often detailed and deep, but it is easy to draw misleading conclusions and overgeneralize the conclusions you come to. The second-hand knowledge from other people, books and news includes a lot of different sources, and are often several steps removed from the original source. Learning from others is much more effective and simpler than discovering everything on your own, but it is important to remember that all of the information is not passed down is of equal value, even though it may seem relevant. We may learn things that are based on scientific research, but there is a lot of information out there that are based on someone's own opinions, and interpretations. (Patten & Newhart, 2017)

Learning about scientific research and how to practice it, an individual is able to expand their way of thinking through knowledge and its acquisition in ways that are new. As one gains knowledge about the rules of research, they are able to practice science and produce knowledge. (Patten & Newhart, 2017)

Research methods are meant to be systematic and minimize biases, regardless of the method selected. The idea with them is to present the results and findings to represent reality as accurately as possible, since if one is not systematic in the research, hidden biases may influence the conclusions. This is why it is of utmost importance to document all decisions made and the results of them, as well as being careful when making decisions. These decisions help the researcher to gather information and evidence for the study, and with the help of the rules mitigate the possibilities for bias sources. By learning about research methods, one can learn how to see these decisions and make them. (Patten & Newhart, 2017)

3.2 Quantitative research

The method chosen to use in this study is quantitative research, since the focus in this study is on statistical data and numbers. Using the quantitative method means that the data is being collected and analysed in numbers (Patten & Newhart, 2017).

Quantitative data has many benefits, as it is easier to collect and analyse, and data can be collected from a larger sample and therefore draw conclusions that relate to a larger group. Statistical analysis may be done and enables the researcher to present the findings as their own. Since the quantitative research method is based on numbers and statistics, many people may find it more credible. (Cameron & Price, 2009)

3.3 Case study as the research approach

A case study as a research approach is the research of trying to understand a certain case. There is usually a key theme to this case, and data is accessed from different sources. The several perspectives that come from the different sources are seen as an essential feature of a case study. Case studies are often referred to as research methods, when in reality it is a research strategy to approach the study you are going to conduct. (Cameron & Price, 2009)

When conducting a case study, there is usually multiple investigations being done so that one can get a detailed overview on the research question. In these investigations, multiple or single methods may be used for enriching the picture of the research. Another typical feature of the case study is that the process is not detached from the context where the research is being done. This is especially good when the research area is an essential part of the organization. (Cameron & Price, 2009)

The approach in the case study is to understand a specific issue, and the chosen method to investigate the case is not defined in the case study approach. In some cases, it is needed to use a *multi-method research strategy* in order to understand the case, which is one of the distinctive qualities of the case study approach. This way, the researcher may get multiple different aspects to the problem. (Cameron & Price, 2009) Even though multiple methods could be chosen, there will be only the quantitative method used in this case

study, since it supports the collection, analysing and presenting of data and results from multiple different sources.

As in all research approaches, there are strengths and limitations when conducting a case study. Some of the strengths are that the researcher is able to investigate the case within the organization and the circumstance where the problem exists. It supports to access a wide range of information to gain depth to the study, by using many sources of data and ways of collecting the data. Potentially, it also can meet the need of more stakeholders since the research is conducted by taking into consideration multiple sources. Limitations to the case study are that it can be hard to demarcate what is included in the study, since the data collection is so wide. Gathering data from multiple sources can be very time-consuming, and if one is using several methods, broader analytical skills are required. Lastly, the researcher has to be able to present the conclusions so, that they are intelligible. (Cameron & Price, 2009)

The reason this research approach is used in this study is that there is a clear case that is needed to be analysed from several perspectives. The data is gathered from several sources, and the research case operations are essential to the company.

3.4 Data collection

Data collection depends on the research nature and what its objectives are. Large amounts of quantitative data, like that that has been used in this study, can be accessed through electronic databases or surveys, for example. The standard method of data collection in these days are through digital technology.(Hair et al., 2019)

The data collected for this case study came from the company's own ERP system, and from the company partners. Data such as prices and other numerical data came from a 3PL-provider in the area where the fulfilment center could move. The data was transferred into Microsoft Excel, where it was then edited and worked on.

3.5 Analysis of the data

An important part after the data has been collected is to transform the data into knowledge, and to do this it has to first be edited, coded and perhaps even transformed. This way a quantitative analysis can be made properly. All data analysis starts with the preparation of the data into a form where it can be worked on. The preparation means that the data is being examined so that it actually is valid and complete. If there is data missing, it needs to be dealt with so that it is in a form where it can be worked on, by eliminating those numbers or substituting the missing values with an appropriate number or the mean. (Hair et al., 2019)

In this study, all of the data was imported to Excel, where it was worked on. First it was ensured that the data is valid and usable in the research. After this the data was edited so, that it was uniform formats since it came from different sources. Lastly, the data was analysed with calculations and by forming tables of it so that it was easier to interpret and read.

3.6 Validity and reliability

Validity in quantitative research is when what is measured is performing like it should. This means that validity is relative to the subject that is measured, which is why it is important to define clearly what is measured. Validity is measured as a degree, not whether it is valid or not, and one could say that there is no valid research as such. (Patten & Newhart, 2017)

Consistent results in research and tests are indicators on reliable results. Reliability in research can be determined for example by measuring twice and then comparing the measurements. If they are consistent with each other, one could say that the results are reliable. It is important for research to be both reliable and valid, though validity can be seen as more important of the two. For a research measure, it has to be *reasonably valid and reasonably reliable*. (Patten & Newhart, 2017)

This study can be considered and valid and reliable, since the data collected and used is based on actual data that has been realized. The data used from 3PL-providers are also

based on actual figures and offers, that could be realized and thus are considered as valid. No data in the study is based on imaginary numbers, and all possible data was collected so that the data is comparable.

3.7 Ethics

Research ethics are something all researchers have to take into consideration and are faced with. It has to do with how the research is conducted related to the researcher, respondents, management, and the researchers own professional integrity. In the beginning of a research, it is important for the researcher to communicate what is deliverable, and that both client and researcher are on the same page on deliverables. The results of the study have to be interpreted honestly and fully, even though the result may not be what the client hopes. It is important to maintain the research participant's privacy, and the information is not to be given or sold forward. All data about the company, both financial and employee data, are confidential. Therefore, it should be made sure that the data is safeguarded properly. (Hair et al., 2019)

In this study, all data was stored behind firewalls and on the researcher's work computer so that the data would not leak from their own computer. The data was handled with confidentiality and not disclosed to anyone outside of the organization. The company was all the time aware of the use of the data, and there was open communication about it. The data was analysed fully, and it was not manipulated so that it would be beneficial for the company no matter what.

4 RESULTS

In this chapter, the results are presented. First, the various research areas are presented and their results, and lastly the results are summarized. The comparison is made between two warehouses, the current one (warehouse A), and one closer to key markets (warehouse B). Distribution costs and lead time results to the key markets are as well presented.

The research questions in this study were:

Question 1 – Where would the most optimal location for the e-commerce fulfilment center be?

Question 2 - How does the move impact the lead time to the key markets?

Question 3 – How does the move to this location affect the inbound and outbound costs?

4.1 E-commerce fulfilment center location

The first research question in this study was: Where would the most optimal location for the e-commerce fulfilment center be? To determine this, a Center of Gravity calculation was done. The calculation used the key market locations, as well as the existing warehouse and the new potential fulfilment center location. The locations were named in the following way:

Warehouse A: The current warehouse

Warehouse B: The potential new fulfilment center location

Key markets 1-5: Each key market was given a number from 1-5

Key markets 1-3 are in close proximity to warehouse B, while key markets 4 and 5 are close to the current warehouse A.

All these locations were placed on a gridded map, and the optimal location was calculated by first summing up the X-locations of all key markets together, and then dividing by the number of key markets, in this case 5. The same was done with the Y-locations. This gave the result of the most optimal X and Y-locations for a fulfilment center, which was between key markets 1, 2 and 5.

Since in this first case the amount of delivered goods was not taken into consideration, a weighted calculation was done next. Each key market was calculated a weighted number by dividing the amount of goods delivered to the market with the total of delivered goods to all key markets.

The X and Y-locations were calculated with the following formula:

$X = (\text{weighted number 1} * \text{key market 1 x-location}) + (\text{weighted number 2} * \text{key market 2 x-location}) \dots \text{until key market 5.}$ This gave the new X-location. The same was done with the Y-location.

As a result, the most optimal location with weighted calculation is almost the same as in the first calculation, between key markets 1, 2 and 5, but this time a little closer to 1 and 2.

As a conclusion of the calculation result with the Center of Gravity method, warehouse B would be the most optimal location for the e-commerce fulfilment center.

4.2 Lead time

The second question in the study was: How does the relocation impact the lead time to the key markets?

The current lead times to the key markets are as follows in Table 1 presented here:

Table 1. Key markets and lead times from warehouse A

Key market	Lead time, days	Average lead time, days
1	4-6	5
2	3-4	3.5
3	4-7	5.5
4	3-4	3.5
5	1-2	1.5

For this calculation, the average lead times were calculated as the mean of the lead time in days.

If the fulfilment center moves to warehouse B, which is closer to all key markets except 5, the lead times would change to the following presented in Table 2.

Table 2. Key markets and lead times from warehouse B.

Key market	Lead time, days	Average lead time, days
1	2-3	2.5
2	1-2	1.5
3	2-3	2.5
4	1-2	1.5
5	2-4	3

As a result, the lead times would decrease on average by 2.5 days to key markets 1-4 and increase by 1.5 days to key market 5.

4.3 Impacts on costs

The third research question in this study was: How does the relocation affect the inbound and outbound costs?

The costs were calculated based on the known costs of warehouse A, and costs of warehouse B that were obtained from an offer. Warehousing, handling, linehaul and distribution costs were calculated and then compared. In order to get comparable data, all prices and units were converted to euros and pieces. The currency rate for conversions was taken on November 1st, 2023, and this was used for all calculations in the study to get accurate and comparable data. Personnel costs are all included in the handling costs, so those did not need to be considered separately.

The comparisons are always made by comparing warehouse B to A, since warehouse B is a fulfilment center that the company is interested in moving the e-commerce operations to.

4.3.1 Warehousing costs

Warehouse A in this study is the one that the company is using at the moment for its e-commerce fulfilment. It is a traditional warehouse, where the goods are picked and packed manually. It is closest to key market 5 but has good networks to key market 4 and 2 as well.

Warehouse B is a fulfilment center with automatized warehousing using an AutoStore. It is in close proximity to the key markets 1-4 and has good distribution networks to key market 5 as well.

An AutoStore is a robotized storage and order processing system that enables the storage of large quantities of small items while increasing the storage density by using bins and robots in the order processing. In an AutoStore, the bins are stacked on top of each other, which optimizes the storage space used. As the orders are processed, the AutoStore learns over time which items rotate faster and which slower, and naturally optimizes the location of those items to ensure even better picking efficiency. (Swisslog, n.d.)

Calculating the warehousing costs was done by first converting the costs to the same units in both warehouses and this way the data was comparable. The used base data was the same for both warehouses. The calculation was made as cost per piece since the items sold are sold individually. The costs were calculated with the warehouse rent divided by the inventory amount for each month. After this, the mean for stockkeeping cost was calculated based on the whole year's data. This was done because the inventory levels fluctuate throughout the year, while the rent stays the same. As a result, the warehousing costs in warehouse B are 28.6% higher than in warehouse A.

4.3.2 Inbound

The inbound costs were as well calculated per piece in both warehouses. Initial results showed that there would be a 55.79% decrease in inbound costs if changing to warehouse B. Warehouse A would fulfil warehouse B if the e-commerce stock were to be moved, which is why fulfilment costs from warehouse A to B should be taken into account in inbound.

Calculating the fulfilment inbound to warehouse B, there is a 326% increase in costs, compared to when the goods are only fulfilled to warehouse A. In this model though, warehouse B would not need to keep very high stock levels, since it would be fulfilled according to need. This will be discussed in the discussion part of this study.

4.3.3 Outbound

Outbound costs were calculated in two ways, per piece and per average order size. The outbound calculation includes work, material, and other related costs. Material costs are invoiced differently in the warehouses, which may cause some fluctuation, and it may not give a completely accurate answer. In this calculation, the material costs were calculated with the average material cost using cost data from a whole year. The calculation gave the following result presented in Table 3 for the outbound cost.

Table 3. Outbound cost comparison.

Warehouse	Per piece	Per average order
B vs A	-26.7%	2.6%

This means that when calculated per piece there is a decrease in cost if e-commerce stock would be moved to warehouse B, while warehouse A would be cheaper when calculating with average order sizes.

4.3.4 Distribution

Distribution prices to all five key markets were calculated by using shipment data gathered from distribution invoices from warehouse A. The same shipment data was used when calculating the average distribution prices from warehouse B. Calculations started with calculating the mean distribution price for each month in a year for each key market from warehouse A. After this, the whole year mean distribution prices were calculated.

This was followed by calculating the new mean distribution prices from warehouse B using the same logic. The results are presented in Table 4 down below. Results are presented by comparing warehouse B to warehouse A.

Table 4. Distribution cost comparison

Key market	Cost difference per average order in %
1	-28%
2	-59%
3	-29%
4	-30%
5	109%
Total decrease	-39%

As the results present, the distribution costs to key markets 1-4 would significantly decrease and increase by 109% to key market 5. Calculating all of these together, the decrease in distribution costs is 39%. The market share of key markets 1-4 together is 72%, and key market 5's market share is 28%.

4.3.5 Impacts on total costs

Relocating a fulfilment center is a big entity with a lot of different costs that are impacted, which is why it is important to consider the impacts on total costs. The total costs were calculated with an average order from inbound and outbound costs at the warehouse to the final delivery to the customer at all key markets. Calculating the cost for warehouse B includes also the fulfilment cost from warehouse A, as it is an extra but compulsory cost if the stock was moved to warehouse B. The cost comparison is presented in Table 5, where warehouse B was compared to warehouse A

Table 5. Total cost comparison

Key market	Per average order
1	-17.40%
2	-39.47%
3	-19.80%
4	-18.68%
5	71.58%
Total decrease	-23.77%

The results indicate that the total costs to all key markets except key market 5 would decrease if the fulfilment center was to be moved to warehouse B. Calculating all these together, the total impact is that the cost would decrease by 23.77% in warehouse B compared to warehouse A.

4.3.6 Summary

The impacts on costs were calculated from several angles to get an as comprehensive view as possible, and finally the impacts on total costs. A summary of the total impact of all costs are presented in Table 6.

Table 6. Cost comparison summary

Type of cost	Change %
Warehousing cost	28.6%
Inbound	326%
Outbound	-26.27%
Distribution	-39%
Total costs	-23.77%

The costs vary depending on the cost type, and they should be analysed in their entirety. Some costs would decrease and some increase. A careful analysis of them should be made to be able to make an informed decision, since an increase in costs in one area may mean that the company would benefit in another area. The analysis of the results is discussed in the next chapter.

5 DISCUSSION

In this chapter, the results are discussed and analysed supported by the theoretical framework and research questions of the study. The discussion chapter starts with the analysis of the most optimal location of the fulfilment center, followed by an analysis of the impact on lead times. Lastly, the impacts on costs are analysed.

5.1 Optimal e-commerce fulfilment center location

The most optimal e-commerce fulfilment center location was determined by making a Center of Gravity-calculation. As a result, the most optimal location is near the location of warehouse B, which makes it the best choice from this point of view. As Richards (2021) also states, this calculation provides an optimal warehouse location that minimizes the distance to customers as well as transport costs. The location of the fulfilment center is an important decision a company makes, and since the location affects greatly the costs, it should be made with care in order to maximize the benefits (Verma, 2012).

The location will greatly also affect the delivery service of the company, which is considered the most important part for the customer (Morana, 2018). Strictly from this point of view and based on the calculations, the company should choose warehouse B for their new fulfilment center. To get an even better comprehensive overview, a Break-Even Analysis or a Factor Rating calculation could be made.

Since the costs are affected by the move, these are discussed later in this chapter.

5.1.1 Impacts on lead time

The lead times would according to the results decrease by an average of 2.5 to key markets 1-4 and increase by 1.5 days to key market 5 if warehouse B was chosen to be the new fulfilment center. Key markets 1-4 make up 72% of the market share, which is significantly more than key market 5 with 28%. The lead time to key market 5 has already been quite short, and an increase of 1.5 days could be considered as reasonable from the consumer point of view. As Fernie and Grant (2019) wrote, the most important expectations of a customer for a good e-commerce experience are item availability, timeliness, condition of the goods and the return process. Due to the impact that the move would have on the lead times to key markets 1-4, customer satisfaction could increase with faster deliveries. This in return would i(Wang & Pettit, 2021)e success (Wang & Pettit, 2021).

5.2 Impacts on costs

The impact on costs by moving the fulfilment center are perhaps the most important ones to consider, since it affects the profitability of the company. There were several phases to calculating the impacts on costs, starting with the warehousing cost, which is discussed next.

5.2.1 Warehousing costs

The warehousing costs would increase by 28.6% in the new fulfilment center, i.e., warehouse B. However, the space and picking locations would be more optimized in warehouse B since the AutoStore automatically organizes and optimizes the location of the goods. This decreases the risk of the slow-moving goods taking up space from the fast-moving goods. Here, it could be said that an ABC-analysis, described by Morana (2018), is made automatically since the most important products (A) are in the best picking location for faster picking and delivery, while the least important (C) are moved where it takes a little bit longer to pick. Also, the fulfilment from warehouse A to warehouse B could be planned with the help of this ABC-analysis. In warehouse A, an ABC-analysis has to be made and moved manually which again requires more handling, and therefore increases costs. From this point of view, it is important to consider where the company wants to take the cost and what kind of service level they want to offer the customer. As Inkiläinen (2011) states, the best service often has higher costs, but that is something a company may have to accept and tolerate.

5.2.2 Inbound costs

The inbound costs were calculated in two ways, and since the whole picture has to be considered when calculating costs, the result for inbound was that the cost would increase by 326%. Like earlier stated, the inventory levels would not need to be as high as they would normally be, since the fulfilment center would be fulfilled according to need. Hence, the role of inventory management is very important. Especially in e-commerce, it is important to have enough stock in order to keep the customers instead of them turning to another seller (Fernie & Grant, 2019). Therefore, having a safety stock is ideal since it minimizes the chances of having shortages of goods (Ritvanen, 2011).

5.2.3 Outbound costs

The outbound cost impacts were different depending on if it was calculated per piece or per average order. The cost would decrease by 26.7% per piece and increase by 2.6% per average order. Like earlier stated, this number may not give a completely accurate picture, since material costs are invoiced differently. To get a more comprehensive idea, it would be beneficial to further calculate the outbound costs with different scenarios. An essential part of outbound are the distribution costs since they are often higher than handling costs overall.

In this case, the distribution costs to all key markets except market 5 would decrease significantly, resulting in a 39% decrease overall. Combining this with the faster lead times, which improves customer satisfaction, makes it worth considering as the current lead time is one of the challenges of the company.

However, when calculating costs, it is important to calculate the total cost of an order if the fulfilment center is to be relocated, since it is one of the main factors to consider when selecting the warehouse location (Richards, 2021). This calculation resulted in a total cost decrease of 23.77% with warehouse B. Here, it was the cheaper distribution costs that made a big impact on the total costs since the monetary value in distribution is bigger. Total costs however can still fluctuate depending on some variables, and it would be beneficial to calculate different scenarios according to them to get an even better overview of what the total costs could be.

5.3 Discussion of method

The method for this study was quantitative research since the main focus was on calculations and numbers. The research approach was a case study, and the data was gathered from several different sources. Data from the company side was easily accessible, though it had to be carefully considered what data would be needed to get as accurate calculations as possible. To be able to compare the costs reliably, the study was dependent on getting prices and data from the potential new fulfilment center, and it was almost so that all data did not make it in time. Luckily, all the needed numbers were obtained which made it possible to carry out quantitative research.

The method was very fitting for this case since calculations were the main method of working and analyzing the data. A qualitative method would not have suited this study, since there was no need for interviews. The validity and reliability of the study could be considered as good since the results are based on actual numbers and offers, and hence they have not been modified to suit the case better. To increase the validity and reliability, several cost calculations could be made with different scenarios. This way, one could make sure to have as reliable data as possible.

6 CONCLUSIONS

The study had three research questions:

Question 1 – Where would the most optimal location for the e-commerce fulfilment center be?

Question 2 - How does the relocation impact the lead time to the key markets?

Question 3 – How does the relocation affect the inbound and outbound costs?

The aim of the study was to answer these questions while getting a comprehensive overview of the impacts that the potential move of the e-commerce stock would have. As a result, the company should have enough information to be able to make an informed decision regarding the location of the e-commerce stock.

The research question 1 was answered by calculating the most optimal location with a weighted Gravity of Center-calculation. As a result, the company should move to warehouse B.

Research question 2 calculated the impacts on lead times to the key markets, and the calculations resulted in the overall lead times decreasing by an average of 2.5 days to key markets 1-4 and increasing by 1.5 days to key market 5. As a conclusion, the move to warehouse B would be the best from the lead time point of view.

In the third research question, all the inbound and outbound costs were calculated and compared, resulting in the total costs decreasing by 23.77%. This is a big decrease, which supports the relocation of e-commerce stock to warehouse B.

As a conclusion, all three research questions were answered, and the results of the questions support the relocation of the e-commerce stock to warehouse B. This would increase customer satisfaction with faster delivery times since the fulfilment center is in a better geographical location. Additionally, the reduction of costs is beneficial for the company while at the same time being able to provide better service to the customers in the most important market.

6.1 Limitations of the study

There are limitations to all studies, as well as in this one. The data the study is based on is reliable and accurate, but since the two 3PL providers invoice their services in different ways, all the data has to be converted to the same units to be comparable. It is possible that some costs have been overlooked because of this, even though the study was done as thoroughly as possible. Also, return costs were not compared due to missing data.

The study also only compares one potential fulfilment center to the current one, and to get even more reliable data, more fulfilment centers could be compared.

6.2 Suggestions for further studies

This study compared one potential new fulfilment center to the current set-up. To further study the case, more offers could be gathered and compared to get a comprehensive idea on what the cost level is, and what could be done. The calculations could also be further deepened by calculating different scenarios, including return rates and considering also the not-so-optimal cases, and what the results would be then.

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