Warehouse Layout Optimization

- A Commissioned Thesis for Fiskars Garden Tools Oy

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Abstract:

The purpose of this thesis was to find ways on how to optimize the layout of Fiskars's Garden Tools Distribution Center (D.C.) located in Billnäs, Finland. This was done by answering three questions: 1) Which products generate the most sales revenue? 2) Which products have a high picking frequency? 3) Which products are commonly sold together? 4) Where should these High Revenue/Frequently picked products be placed within the warehouse? To find the answer to these questions, an ABC Analysis was used. The ABC Analysis is based on Pareto's 80/20 rule, which states that 20% of your products generate 80% of your profits. An ABC analysis works by dividing all the products into three classifications: A, B, and C products, ranked from most important to least important. Since there were two criteria: 1) Sales Revenue, and 2) Picking Frequency, it was then necessary to do an ABC Analysis on each and then combine them which created a Double ABC Analysis. This meant that instead of having three classifications from one ABC Analysis, there is now nine categories from a Double ABC Analysis. Products were then classified as "AA, AB, and AC" products. Finally, another ABC analysis was done based on the results from the Double ABC analysis. This revealed where these: "AA, AB, etc.." products should be placed in the warehouse for optimum ease of picking. This report is based on primary research on data concerning products, quantities, cost of goods sold, and delivery orders, which all aided in finding of the results for this thesis. Based on the sales revenue and picking frequency, out of the 514 products that were in the database, the analysis identified 51 products that have been identified as "AA" products. This means that these products are of high sales revenue and, picked frequently. It was recommended in this thesis that the management of the Billnäs D.C. should devote more of their resources towards these "AA" products as they are the most important products for the company and place these high revenue and frequently picked products be placed in areas that are closest to the packing station making these products easily accessible to the warehouse workers.

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1 INTRODUCTION

The year 2015 revealed a very slow year for Finland's economy. 4,751 or 18.5% of all retail shops closed their doors because of the current economic situation. Recent statistics show that more stores in the retail industries have been closing compared to the ones that have been opening (Statistics Finland, 2016). Unfortunately, no company or their assets are immune to a downward trending economy. A warehouse can feel the effects of a downward trending economy by the lack of orders that are sent from retailers. If the retailers, who are selling a company's products, become bankrupt and must close their doors, this can affect a warehouse to some extent.

Logistics is a service that links the point of origin to the point of consumption. The purpose of logistics is meeting the needs of the customer. Warehouses are one of many physical things within the scope of logistics. Warehousing plays a vital role in a company's ability to offer customers something extra when it comes to service and value. Companies both large and small, from a small-town retail store to a large global business, can benefit from the many advantages of having a warehouse. As the demands of the market change and grow, so too the demands of having an efficient and lean warehouse. Never has there been a time before now where the pressure has been so high for companies to constantly enhance productivity and at the same time keep costs low. Therefore, it is important for a warehouse to, every now and then, evaluate the many different processes that take place daily, to make sure they are optimized to be as efficient as possible. Especially, in times of bad economic seasons, where economies fluctuate over time, the demands of higher efficiency in a warehouse become the standard (Shape Cut, 2016).

There are many ways for a company to be more efficient. An ABC analysis is one way that companies can better identify what factors are the most important within their company. By determining this, companies can focus the majority of their resources on those important factors (Nikolakopoulos, 2017). With the help of an ABC Analysis tool with multiple criteria, a company can create efficient warehouse practices that would allow their distribution centers to increase productivity and cut waste.

This thesis will focus on Fiskars Oy, more specifically, their Garden Tools warehouse located in Billnäs, Finland. Founded in 1649, Fiskars Oy is a global company with assets valued at 540 million euros and net sales of over one million annually. It is one of Finland's largest, oldest and most profitable companies. Fiskars Billnäs manufactures axes, scissors and various other quality garden tools (Fiskars A.R., 2016).

1.1 Problems

To increase efficiency in a company, it is important to pinpoint possible problems that may occur. Looking at Fiskars, and the many departments that work together, the chart below points out many different problems that can arise and that must be dealt with to ensure a well optimized company:

Figure 1. Departmental Problems within a Company (SPC International et al., n.d.)

Notice from the chart above, one of the problems this thesis aims to answer has to do with the profitability of the products. This is typically an accounting/finance issue, and specifically has do with the sales revenue that the company's products generate,

nonetheless, since it has been requested from the D.C. supervisor, this thesis will aim to answer it from a warehousing perspective.

Adding to the problems listed above, if there is no oversight of analyzing existing data, this can lead to problems that can encompass the various departments mentioned above. Each department represented has its own data associated with them and their day to day departmental actives. This data that already exists, if not analyzed thoroughly, can leave out a lot of unknown benefits, that if found, could aid the company in various cost saving ways. If these problems are not met with a solution early on, then it can mean even bigger problems down the road for the business.

1.2 Purpose

The purpose of this thesis is to ultimately determine the most products the generate the most sales revenue, frequently picked the most, and how to make them more accessible to the warehouse workers. This thesis will focus on some of the problems that are associated with the warehousing and financial accounting side of a business. Of the previously mentioned problems that can take place in a warehouse, this thesis will focus on the following 4:

- Unknown sales revenue of products.
- Need for optimization of picking routes.
- No current tool to analyze the existing data.
- Warehouse layout/Micro-location problems.

From the 4 above listed problems, it is possible to formulate an associated question to each of these problems. These questions form the foundation and the main purpose for which this thesis has been commissioned:

- Which products generate the most sales revenue?
- Which products have a high picking frequency?
- Which products are commonly sold together?
- Where should these high sales revenue/frequently picked, products be placed?

To find the answers to these questions, this thesis will be using already existing data (Secondary Data) located within the company's database. Combined with a ABC Analysis on Fiskars Garden Tools' High sales revenue generating products and their picking frequency, will help develop a proven strategy to increase the efficiency of the warehouse layout. By finding solutions to these four questions, Fiskars Garden Tools will be able to help create a more efficient warehouse, saving both time and money in their day to day activities.

In a nutshell, Figure 2 listed below demonstrates clearly the aim of this study and what it seeks to accomplish. In picture 1, the red line is a typical route of a warehouse worker as

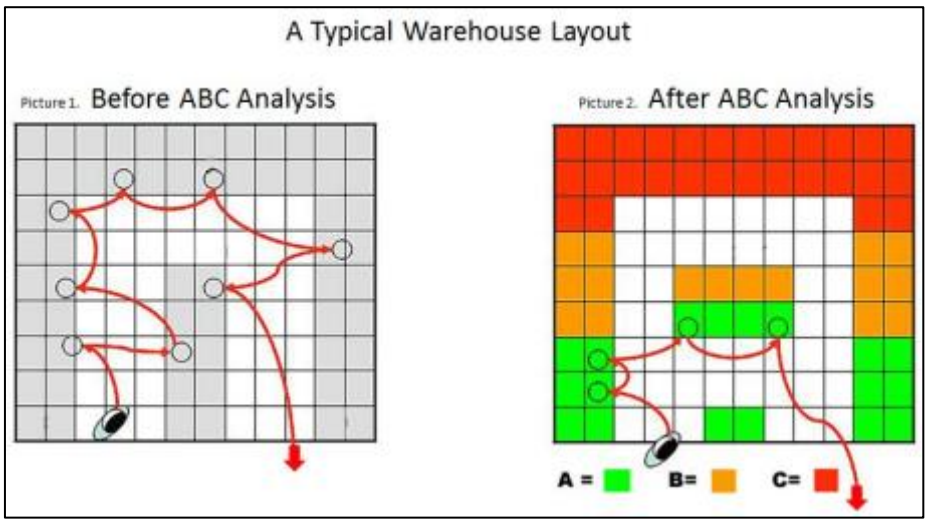

Figure 2. Warehouse Layout before and after an ABC Analysis (Hohmann, 2014)

he/she picks an order. This shows the placement of an inventory that does not have its inventory categorized based on sales revenue and picking frequency. Basically, the warehouse workers must travel long distances and run all over the building trying to find the products for the order. Picture 2, shows how the same picking layout could be optimized if an ABC Analysis was applied to the inventory by dividing the products into A, B, and C categories. Notice how the workers journey is almost cut in half based on this new warehouse layout. The red line shows the warehouse worker traveling a shorter distance and only focusing time on the products that are being sold and picked the most.

The D.C. (Distribution Center) Manager of Fiskars, Billnäs is also interested in determining which products are being sold together the most. This research has not been

done before and will therefore prove to be valuable information for them to structure their inventory and better see the buying habits of their clients.

1.3 Demarcation & Potential Future Research

Fiskars is a large company with many warehouses throughout the world. With six branches in Finland and two of them being warehouses, this thesis will only be focusing only upon the products within the D.C. in Billnäs, Finland.

Figure 3. The different Fiskars branches within Finland (Fiskars, 2017)

This thesis will gather the necessary data from only the year 2016. The scope of this research includes sales revenue and picking frequency. Focusing on these two topics will aid in answering the questions of this study. Other questions that the D.C. Manager would like to get answers to are:

1. Forecasting the long-term trends of the data obtained in this report.
2. What are the lifecycles of the products?
3. Doing an ABC analysis from other categories within the warehouse.

Unfortunately, due to the timeframe and scope of this study, these questions will have to remain unanswered. With relevant data and more time, it would be possible to answer the other questions, if and when Fiskars decides it would be beneficial to commission a separate research project to investigate them.

2 THEORY

This chapter deals with the theory that led to the recommendations and the results within this study. This chapter is broken down into three main sections:

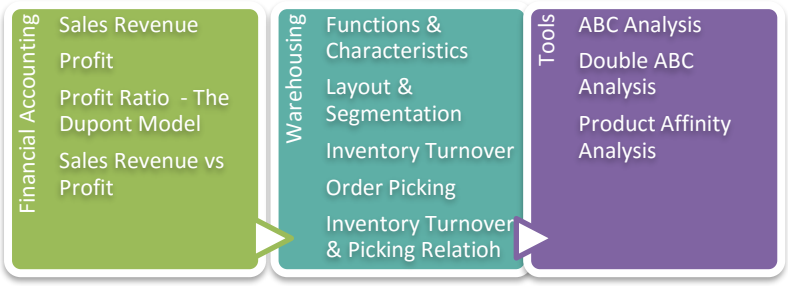

Figure 4. Contents of Chapter 2

2.1 Financial Accounting

Financial Accounting can be defined as: *"the process of recording, summarizing and reporting the myriad of transactions resulting from business operations over a period of time."* Typically, this information is summarized in what are called financial statements that are used to prepare: income statements, balance sheets, amongst others, that deal with the operating performance of any given period (Investopedia A, 2017).

One of the aims of this thesis is to answer:

Which products generate the most sales revenue?

To answer this question, it is beneficial to look at the theory definitions behind sales revenue and profit since these two terms have been known to become confused with one another.

2.1.1 Sales Revenue

Sales revenue can be defined as: *"Every time a company sells a product or service for cash or credit it earns revenue. Revenue is the total amount brought in from goods and services sold."* (Kokemuller, 2017). No matter the company, sales is the department that is responsible for generating revenue. A company can have clever marketing, the best technology for manufacturing, the leanest supply chain practices in place, but if the sales element is not properly functioning, everything else could be rendered useless. Therefore,

it is important to for a company to have the knowledge about the products that give the most revenue (McClintock, 2017). Sales Revenue can be calculated by the following formula (Schofield, 2017):

Sales Revenue = Units Sold x Sales Price

Figure 5. Formula on how to calculate sales revenue (Schofield, 2017).

Since the sales in a company can be dynamic, it is therefore prone to decrease or increase based on many factors. If sales revenue decreases, it can affect many different areas of a company. Businesses would have to make cuts through various departments in order to account for this decline in sales. On the other hand, if sales increase, this means that more money is coming through the business through sales and this means that there could be an extra cash flow to pay off things like debt, and perks to the employees such as pay raises (Schofield, 2017).

This increase which is something most companies historically aim to achieve is called Marginal revenue. Marginal revenue can be defined as: "*the increase in revenue from the sale of one additional unit."* To calculate marginal revenue, one would divide the change in total revenue by the change in output quantity (Boundless, 2017).

The best way to understand the growth of company is to watch it's Sales Revenue. Sales Revenue is usually observed more closely than profit because it shows in detail how the company is fairing. Investors want to know the business whom they have investments in, is able to constantly generate more sales over time. If the sales growth of a company is flat of declining, this typically shows that a company has currently stalled and does not offer any indication of continued growth (Kokemuller A, 2017).

2.1.2 Profit

In economics, the term "Profit" can have several meanings and therefore it needs to be defined what is meant when this word is used. At its most basic form, according to "Economiconline.co.uk", *"profit is the reward gained by risk taking entrepreneurs when the revenue earned from selling a given amount of output exceeds the total costs of producing that output"*. One can express this with this statement below (Economicsonline.co.uk, 2017):

Total profits = total revenue (TR) – total costs (TC)

Figure 6. Formula for Determining Profit (Economicsonline.co.uk, 2017)

There are many different profitability ratios that are used to measure the financial health of a company. One of the more popular tools that are used to do this is called the "DuPont Model". Created by the DuPont corporation in the 1920's, the DuPont Model, also known as the DuPont Analysis, is a method of breaking and assessing a company's return on equity (ROE) into three different parts. This enables a company to view its own overall financial health. To find the R.O.E., one would multiply 3 of the 4 mentioned above main components together (Investopedia B, 2017):

- Profit Margin
- Asset Turnover
- Total Assets
- Equity Multiplier (Financial Leverage)

The formula for calculating R.O.E. is shown below in Figure 7:

Return on Equity = (Net Profit Margin) (Asset Turnover) (Equity Multiplier).

Figure 7. Return on Equity Formula (Kenon, 2017)

Once calculated a company can measure the performance of each one of these components and therefore see which of these components is the most responsible for the changes in the R.O.E. (Investopedia B, 2017). Shown in the appendix section, one is able to see a chart of the components and their relationship to one another.

2.1.3 Profit & Sales Revenue Summary

Profit and Sales revenue can sometimes be discussed as being the same thing but they both have their distinctions in their terminology. Profit it is the net income of a business or in other words, the earnings on sales after all the costs of doing business has been subtracted. Companies typically calculate more than one measure on an income statement. For example, gross profit shows the total revenue and subtracting the variable costs of the goods sold One way to look at this both clearly is that sales revenue is a short-term focus, while profit is more of a long-term focus (Kokemuller B, 2017). Based on the

above section on financial accounting theory, it appears sales revenue would be the most accurate of the two in obtaining the results for this thesis.

2.2 Warehousing

This section can be divided into 3 sub-sections that concern warehousing:

- Physical Attributes – Concerns the actual physical warehouse.
- Inventory Attributes – Concerns the inventory inside the warehouse.
- Picking Routes – Concerns how the inventory is picked.

Figure 8. The 3 main attributes of a warehouse (Relander, 2017).

By researching the theory behind these 3 sections one can have a better understanding how these areas work together and form a properly functioning warehouse (Relander, 2017). Mr. Chand from yourarticlelibrary.com defines warehousing as:

"A place that's used for storing or collecting goods."

Even though modern day warehouses have many other functions, this simple definition sums up well the core function of warehouses. Warehouses are a vital part of a company's logistics system. A warehouse can have many different areas to properly receive and send out products.

Warehouses are used by entities such as: importers, exporters, manufacturers, transport businesses, wholesalers, customs, etc. Most commonly, they are used for storing or acting as a buffer for products. These can be things such as: finished products, raw materials, or goods-in-process. In the below figure, one is able to understand the various arees are are

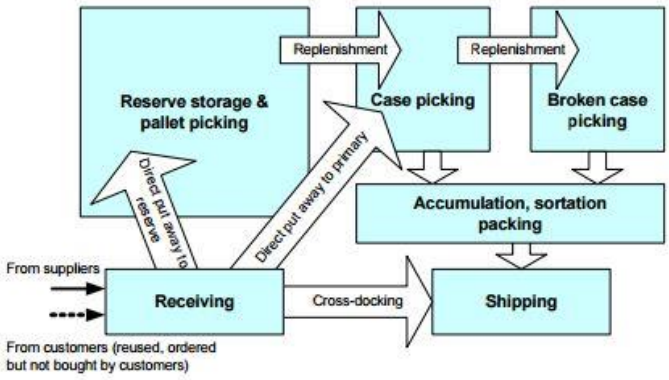

Figure 9. Common warehouse flows and functions (Tompkins, 2003)

typically within a modern day warehouseas. Warehouses often act as "in between points" from the place where they were manufactured to the point of consumption. The above-mentioned quote stated warehouses' main function is the storage of goods, however, if additional distribution is needed and becomes a main function, then the term "D.C.", or "Distribution Center" is used. This is the case when storage plays more of a minor role, and when terms such as the following are used: *trans-shipment, platform, or cross dock center* (Koster, Le-Duc and Jan Roodbergen, 2007).

A Distribution Center or "D.C." is a type of warehouse with the storage of goods as one of its functions. They are also "customer-centric" meaning the D.C.'s main function is not only storing goods, but more importantly, to efficiently meet the needs of the customers. D.C.'s also typically store products for lesser periods of time than normal warehouses. This means the velocity at which products move in and out of the D.C. is much greater than that of a normal warehouse (Baidhurya, 2016). This also happens to be the type of warehouse the Billnäs location is.

2.2.1 Functions & Characteristics

There are plenty of functions that a warehouse satisfies and overall can create a lot of benefits for companies. Listed below are some of the functions and benefits of warehousing (Chand, 2017):

- Storage – Keeping products safe from weather, theft, and other potential risks. Another benefit of storage is the convenience of fulfilling an order when they are needed to fulfill an order.

- Grading and Packing – The ability to sort goods based on quality specifications.
- Regular production - ensures the continual flow of goods. This can be seen in things such as raw materials that must be stored to ensure that mass production can carry on without interruptions.
- Store of surplus goods - Excess goods need to be preserved until the demand of the customers has started.

To continue the trend of warehouse optimization, it is said that an ideal warehouse consists should also consist of the following characteristics listed below (Montgomery, 2009):

- Space – Spacious enough in for the workers to move around and sort products.
- Location – Near highways, railway stations, airports, harbor etc.
- Machinery – Forklifts and other devices should be present.
- Security - 24/7 on site security presence to guard the inventory.
- Fire Prevention - A Sufficient fire prevention system should be installed.
- Sufficient Parking Area - A large area for trucks to park as well as load and unload.

2.2.2 Layout & Segmentation

Warehouse layout design is a highly important factor in creating an effective and efficient operation. If the layout of a warehouse is designed poorly and lacks efficiency, two of the areas that are likely to suffer the most would have to be the (Sykes, 2017):

- Fulfillment area
- Dispatch area

These are areas that require efficiency, and if not properly designed could ultimately cost time of the workers causing the overall labor costs to increase. Other issues that can lead to negative factors of a poorly designed warehouse are (Zeninventory, 2017):

- Inventory control issues
- Decreased productivity

- Shipping errors
- Potential safety risks

One method of preventing these factors from becoming a reality, is using what is called warehouse segmentation. Implementing a segmentation strategy can help a company achieve better efficiency for the day-to-day warehouse activities. Jason Tindly of Logistics Planning Consultants listed different ways this can be done:

- Handling and Storage Requirements

  This type of segmentation is based on how the goods care needs, size, and weight. Keeping products that are alike in these areas simplify the layout of the warehouse. This allows the warehouse workers to know for example where the heavy, cold, perishable, wide or tall products are located.

- Turnaround Speed

  Typically, it works that the demand for the products reveal to the warehouse team where the inventory should be stored within the warehouse. Products that have a fast turnaround speed should be kept in areas that are easily accessible to the warehouse workers. This can be shelves that are low to mid-level or in areas that are close to the packing station or shipping docks.

- Updated Information

  Nowadays more and more activities are being updated in real time. Having updated to the minute information would allow the warehouse to pivot and make a change based on new information. A warehouse worker could update information of product in the packaging is damaged or there was a change in the seasonal demand of a product. Therefore, it would be good for a warehouse to have an area for these unique products or goods that have been damaged.

2.2.3 Inventory Turnover

It is important for warehouses to know exactly how they fair within their own industry. Inventory turnover is one way of accomplishing that by measuring how many times a

business sells its inventory in any given period. Companies use inventory turnover to understand several things, such as:

- How well they are doing within their industry?
- Gauge competitiveness.
- Project their future profits.

Achieving an inventory turnover that is high can translate into high sales, which is a positive thing. However, it could also mean that the company is not keeping enough inventory in the warehouse to meet the demands of the market. If a company has a low inventory turnover, it can mean that the inventory is sitting around and not going anywhere fast. The products in the warehouse inventory are not being sold, which means that there is a lot of money that is being wasted by not moving the products out of the warehouse To find out the inventory turnover for a warehouse, one simply needs to follow this formula (Wood, 2016).:

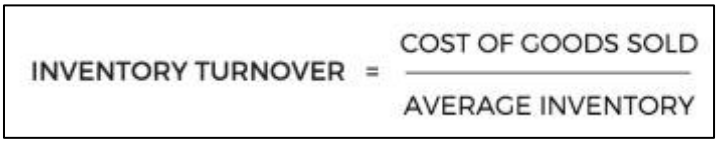

Figure 10. Inventory Turnover Formula (Wood, 2016)

Cost of Goods Sold or (COGS) represent any of the direct costs that incur when producing products that are sold to a customer. For manufactures, included costs would be the costs of the materials, labor time that is required to produce the product, amongst others. This calculation changes depending on whether the business manufactures its own products or buys them from a wholesaler (Wood, 2016).

Looking at this chart we can see what it may look like in a typical warehouse regarding inventory turnover. This shows how a warehouse would function once they have a way

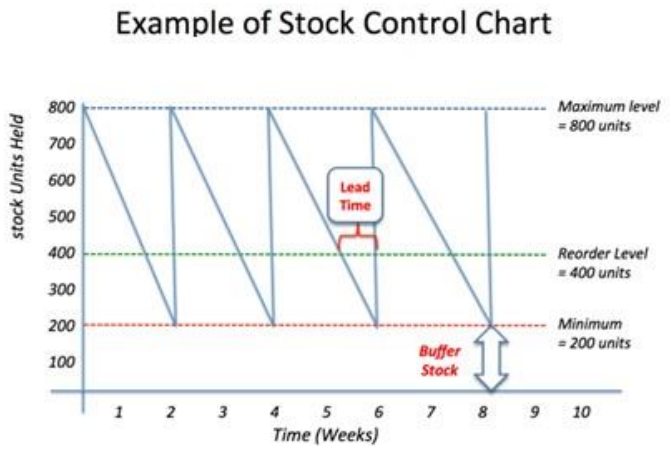

Figure 11. Example of a Stock Control Chart (Riley, 2015)

of filling the warehouse as products are being picked to meet the demand of the market. This chart assumes that the inventory is being consumed at a constant rate within the given period of time. Notice, as time goes forward, the number of units in inventory decreases. Starting at the maximum level of 800 units, the stock decreases as time goes forward. Once it hits 400 units the reordering level is then triggered, which means that the company should place an order to the supplier informing them they need more product, raw materials, etc. By properly calculating lead time, a company can make sure that during the time it takes to replenish their stock, the company still has a minimum amount of product and even a safety stock until their warehouse is completely restocked. Once both the average inventory and the cost of goods sold are found, one would simply divide these two to determine their inventory turnover (Riley, 2015).

2.2.4 Order Picking

Picking can be defined as: *"The activity by which a small number of goods are extracted from a warehousing system, to satisfy a number of independent customer orders."* (Molnar and Lipovski, 2005) These processes have become more complex and more and more important over time. It is not only seen as a costly activity but a labor intensive one as well. Picking for an order is said to be about 50% of the total warehouse operating costs. If the picking of orders shows any signs of underperformance, the results could lead to several problems for a warehouse such as high operational costs, unsatisfactory service, amongst many others (Murray, 2017).

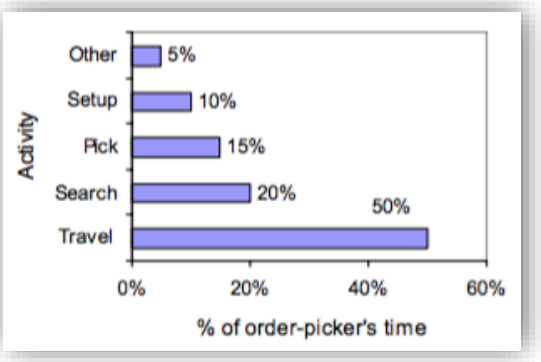

Figure 12. A typical description of a pickers activities (Tompkins et al.

As one can see from data in the above chart travel time plays a large role in the overall time it takes to pick an item. Therefore, this should be decreased in order to cut down on labor costs. On top of traveling the other areas in the day-to-day routines of a warehouse worker such as: setting up and getting ready for the day's work, searching for the item, and picking the item. However, these processes though they do take time doesn't come close to the time it takes traveling from item to item and then back to the packing station (Tompkins et al. 2010).

Choosing the right picking strategy is one way to cut down on costs, this depends on a plethora of requirements that differ from company to company. For examples these requirements could be dependent on things such as: the complexity of an order, its size, how many items are in an order, etc. Finding the best fit picking method is essential for companies who want to ensure an efficient order (Murray, 2017).

There are different ways about going picking an order in a warehouse. Supply chain academics G.P. Sharp and Edward Frazzle have identified 3 ways of picking listed below to efficiently pick an order (Murray, 2017:

- Picker to Part - The warehouse worker reviews the order and using a loader such as a forklift travels throughout the warehouse picking products to fulfill the customer's order.

- Part to Picker - The products are sent from the warehouse to the picking bays. Each bay then receives the products of one or more orders. The warehouse picker then collects the products and fulfills the order.

- Pick to Box - Multiple picking areas are connected by a conveyor belt system. Upon the conveyor built a box moves along to the various picking areas where a warehouse worker fills the shipping box with the products the customer has ordered and the box moves to the various picking zones until the order is complete.

2.2.5 Inventory Turnover & Picking Relationship

There is a distinct correlation here between inventory turnover and picking frequency. If the demand increases but the pace of picking hasn't, problems both internally and externally can occur. In their book: *"The Warehouse Management Handbook"* by Smith and Tompkins, they mention some different problems happen in this scenario:

- Backed Up Orders
    - The increased demand of the products has caused orders to overwhelm the workers and therefore multiple orders remain in the picking queue waiting to be completed.
- Inaccurate Picking
    - The fast pace of the picking can cause warehouse workers to be less accurate in their picking strategies. They may pick to much or too little or even can be picking for a completely wrong order.
- Long Load times
    - Trucks will be sitting outside the warehouse waiting for long periods of time before they receive their order. This causes the time that it takes to ship an order to be that much longer as well as a traffic jam of semi-trucks blocking your loading area.
- Customer Dissatisfaction
    - No company wants customer's dissatisfaction to grow, and since shipping's focus is customer service, if customers aren't getting the product in the timely estimated arrival, customers may choose to do business with a different company.

There are many problems that can take place if the inventory turnover and the picking processes aren't in sync. This shows a direct connection between the two when one

doesn't function properly, the other then fails and causes more problems throughout the process of getting the product to the customer (Smith and Tompkins, 1998).

2.2.6 Warehousing Summary

This section demonstrated my knowledge on the various theories concerning warehousing. They were the: physical attributes, inventory turnover, and picking routes. It was important to cover these areas as they all dealt with warehousing. It was my hope that the reader would take note of the bigger picture of all the aspects that make up a warehouse.

2.3 Tools

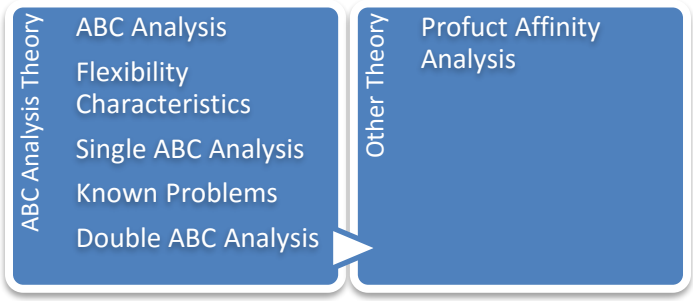

Figure 13. A chart showing the tools that were used in this thesis

Shown in the charts above, one is able to see tools that were used and the theory behind these tools. By researching these theories one is able to get a better understanding for how they are used in order to obtain the desired results.

2.3.1 ABC Analysis

It's unwise for a company to spend that same amount of resources on all the products they sell. To do so would not be worthwhile for the company and in the long run very expensive (Mandhotra, 2014. The truth is, the products in your inventory are quite

"Pay attention to the vital few and ignore the trivial many"
- John Paul Dejoria,

different,

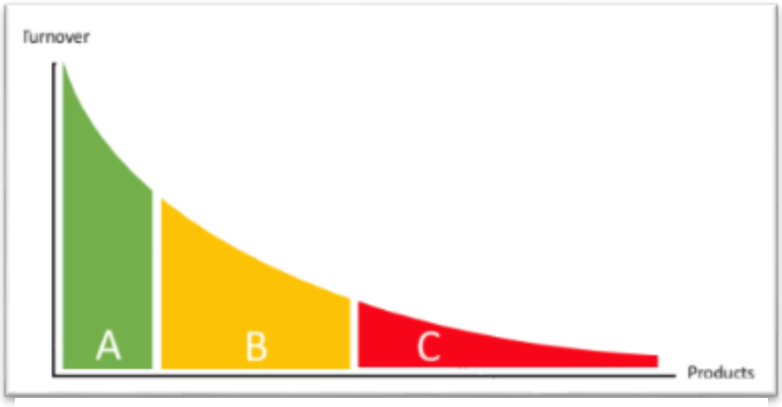

Figure 14. A simple illustration of an ABC analysis (Frandsen, 2014)

it would be highly irresponsible of a company to treat a 10€ product in the same manner as a 100€ product. Not only would it be an expensive mistake, but also a time consuming as well. An ABC analysis can help with managing the various products in one's inventory more efficiently. (Merritt, 2017) The whole purpose behind using an ABC Analysis is to improve one's ability to handle large and complex sets of data. This is done by breaking them down into 3 easily digestible categories:

Category A items are the most important products that are in the warehouse. These are the products that contribute quite heavily to the sales revenue of a business. These products don't require a large amount of resources and are the smallest category in your stock but they generate the most money for your company. These products generally make up 10% of the company's inventory and contribute to about 80% sales revenue (Luenendonk, 2016).

Category B items represent the middle of your products. These products represent 20% of your inventory and 15% of your sales revenue. Often these products tend to be overlooked by management, but these B category items have a lot of potential. With a little investment and care these B products can be developed into money making A products (Luenendonk, 2016).

Category C items are products that don't make a whole lot of revenue by themselves. These products move quickly making little money for the company. This account for about 70% of a company's inventory and only bringing about 10% of the sales revenue. These items need the least amount of control (Luenendonk, 2016).

Once the large amount of data has been broken down into A, B, and C categories it is a lot manageable to focus on the data. This is beneficial as companies can use the information to implement into something practical and help create strategies that are tailor made for each category of product.

For a company like Fiskars to organize them in A, B, and C, categories, we can determine the level of appropriate care that each category needs. Some examples of what that practically means are listed in the table below:

Table 1. Chart of different ABC Analysis Uses (Bassiouny, 2008)

	"A" The few but important	"B" Intermediate	"C" The many but less important
Control	Tight	Moderate	Ordinary
Safety Stock	Low	Moderate	High
Management	Top Level	Middle	Lower
Turnover	High	Moderate	Low
Warehouse Movement	Fast	Moderate	Slow

2.3.2 Flexibility of an ABC Analysis

Flexibility is a prized attribute of the ABC Analysis. As a tool, it allows an individual to prioritize tasks or items according to their greatest importance and return. A consultant by the name of Ahmed Bassiouny mentions in brief the many different topics one can run an ABC Analysis upon areas such as (Bassiouny, 2008):

- Customers - Breaking down clients into different categories based on sales.
- Problems with Quality - Categorization of parts of products that fail the most.
- Waste - Which products are not being sold and taking up valuable spaces?

And other topics such as:

- Errands - Which day to day errands are more important to accomplish first?
- Homework - What homework should be prioritized to be accomplished first?
- Friends - Which friends give you the most joy and satisfaction?

- Household Chores – Prioritization of most important household chores.
- Shopping - Which shopping stores carry the products I purchase the most?
- And many more…

2.3.3 Single ABC Analysis

It is not difficult to perform an ABC analysis, one simply needs to follow the necessary steps and one will have the results. The use of spreadsheets helps simplify the process for example Excel for example is one of the spreadsheet programs that can be utilized to find this information (Valuestreamguru.com, 2017).

Steps Include:

1. Collection of Data.
    a. Material Numbers of the products.
    b. Cost of each product.
    c. Obtaining its consumption value over a specific period.
    d. Calculating the consumption value of each product.
2. Calculating the Consumption Value.
    a. This is done by following this formula:
        i. Item Cost * Quantity used in the period.
3. Grouping your Product Categories
    a. Products are grouped by the amount of revenue they generate from highest to lowest in A, B, and C categories.

2.3.4 Problems with an ABC Analysis

Some of the known problems associated with an ABC Analysis are for example:

- Conflict with Other Cost Systems

    The ABC Analysis doesn't meet the requirements of the Generally Accepted Accounting Principles (GAAP) and therefore conflicts traditional styles of costing systems. If a company would like to use an ABC analysis on sales revenue, the company must operate 2 different types of costing systems. One

that is accepted by GAAP and the other an ABC Analysis (Nikolakopoulos, 2017).

- Requires a lot of resources

  An ABC analysis needs to be frequently done on the inventory to check if the inventory still contains "A" category items. If the demand changes all the sudden that means the products that were once "A" category items have now been moved to "B" category items. This is especially needed with seasonal items as snow shovels for example might be a "A" products in the winter months but then a "C" product in the summer months. Therefore, this fluctuation of demand requires a company's resources constantly checking their inventory (Nikolakopulos, 2017).

- Risk of Loss

  Since "A" items are the money makers, a company must not neglect the "B" or "C" items. These items are still important and an ABC analysis runs the risk of management paying too little attention on the lower value items and therefore causing the risk of loss to rise (Merrit, 2007).

2.3.5 Double ABC Analysis

Once the first ABC Analysis has been done, it is beneficial to do another analysis to get a bigger picture of which products are the most frequently picked. Having already done an ABC analysis on Sales Revenue, the next step is to do another ABC analysis on picking frequency (Frandsen, 2014). The picking frequency would be categorized in the ways in the list below.

- A-products account for 80 % of the picking frequency.
- B-products account for 15 % of the picking frequency.
- C-products account for 5 % of the picking frequency.

Since a single ABC Analysis contains 3 classifications, a Double ABC Analysis would then contain 9 different product classifications, 3 for the sales revenue criteria and 3 for the picking frequency which would give 9 different areas classification. Below is a table that describes what the characteristics of each of these 9 groups (Frandsen, 2014):

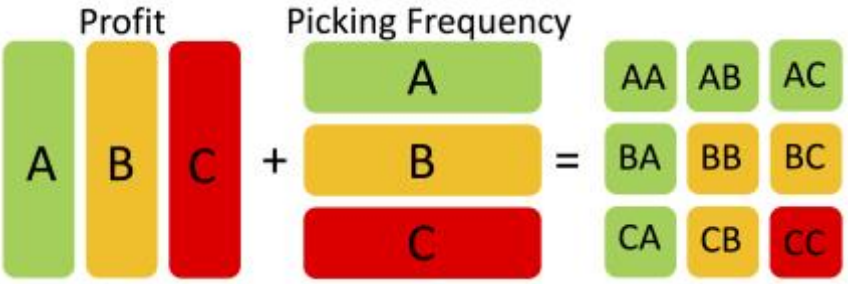

Figure 15. Example of a Double ABC Analysis (Frandsen, 2014).

Implementing the Double ABC Analysis on these two criteria will give us products that are "AA" "AB" or "AC", etc. This will reveal which products have the most sales revenue and the highest picking frequency.

2.3.6 Product Affinity Analysis

It can happen that customers buy products together sometimes not even realizing it. Why did that customer go to the store for one thing and ended up buying other items? While the customers often don't realize the products, they are buying together, the stores they buy the products from certainly do. One way companies know products that are being bought together is by using a Product Affinity Analysis (Whiting, 2017).

This analysis studies the patterns of products and the behavior of the customers to determine links in the purchases. This information would greatly improve the companies cross selling techniques as well as many others. This is a way for a company to sell more based on previous purchasing behavior (Whiting, 2017). Using a statistical program such as SPSS, one would be able to determine which products are have been purchased together. This information would benefit the company to better design a layout of products that are most bought together and therefore aid in creating a leaner warehouse.

SPSS is a statistical program created by IBM and used for many different types of research. SPSS is an acronym that stands for: "Statistical Package for the Social Science". According to the user guide we can find out more of what this program is used for: *"SPSS is a comprehensive system for analyzing data. SPSS can take data from almost any type of file and use them to generate tabulated reports, charts, and plots of distributions and trends, descriptive statistics, and complex statistical analysis"* (IBM, 2011).

3 METHOD

This chapter explains the various methods that were used during investigation of this report. It goes into detail showing the differences of Qualitative and Quantitative methods, and which of them is best suited for the report's findings. This section also deals with the concepts of primary and secondary data.

3.1 Qualitative or Quantitative?

Qualitative research is mainly what is called exploratory research. This type of research is used to obtain knowledge of the reasoning behind motivations and opinions. It brings insights to the problems and helps deal with developing ideas for potential quantitative research. This type of research has also been used to reveal trends in thought and opinions. One can use various structured or unstructured techniques. Some of these methods used can be (Wyse, 2011):

- Observation
- Interpretation
- Participation in Observations
- Focus Groups
- Group Discussion
- Individual Interviews.

On the other hand, quantitative research in a nutshell is used to quantify a problem by the way of creating numerical data that can be implemented into usable statistics. This method can be used to quantify things such as:

- Opinions
- Behaviors
- Attitudes
- Other defined variables

Once this data has been found, it then can be generalized into a large sample size. This method of research uses data that's measurable to create facts and uncover patterns in research. In comparison to qualitative research methods, this type of research is far more structured. The data collections methods of quantitative research methods include different types of surveys such as ones that are conducts though Kiosks, mobile phones, paper, landlines interviews, online, polls and systematic observations. (Wyse, 2011)

3.1.1 The Steps of Qualitative Research

The research in this study is done using the qualitative method for 2 reasons:

- The scope of this study only focuses on the Distribution Center in Billnäs, Finland and nowhere else.
- Since the focus is only on one of the many warehouses that Fiskars owns there is no other warehouse to compare the results to and therefore this research will maintain the focus of interpreting the primary data which purely a qualitative methodology.

To undertake qualitative research there are 6 steps to follow (Bryman and Bell, 2015):

1. General Research Questions.
   This is the first step in determining what the problems are that the researcher is faced with. From that point the researcher can then create questions that the research will answer.

2. Selecting relevant sites and subjects.
   With this step, one should choose the subject that is relevant to the aim of the study.

3. Collection of Relevant Data.
   For this step one would apply the appropriate method of of research in order to collect the data that is relevant. This would be most beneficial by using various sources of data like interviews, observation, etc.

4. Interpretation of Data.
   At this step one would analyze the data find relevant patterns.

5. Conceptual and Theoretical Work.
   At this point the researcher would bring together the theory along with the collected data

5A. Tighter Specifications of the research questions & 5B Collection of Further Data.
At this point in the research process its beneficial to analyze the collected data and from there create tighter more finely tuned research questions. Once that is accomplished, one can collect further data from refined questions and repeat Step 4.

6. Writing up findings and Conclusions.
The last step includes the researcher to write up the all the finding in a report.

3.1.2 Primary & Secondary Data

Primary Research is original research that is carried out by the individual who is conducting the research. This individual gathers data that is going to be used for the goal of obtaining the results of the project. These can be methods such as: surveys, interviews, focus groups, doing an experiment, or simply observing the behavior of the object of your data (My Market Research Methods, 2011).

Secondary Research, unlike Primary Research, has to do with searching through information that already exists. This data was created by someone else at some point of time and can be found in sources such as:

- Online Sources
- Libraries
- Journals

Once one has found the relevant data for the research, one would then apply the found data to the research problems. One needs to keep in mind that the data that one finds is not originally done by you, the researcher. This at times have been referred to as "desk research" as its research that's done by you at your own desk (My Market Research Methods, 2011). Here is a chart that easily explains the differences of Primary and Secondary Data:

	Primary Research	Secondary Research
Original Data was Collected…	By YOU (or a company you hire)	By SOMEONE ELSE
Examples	Surveys Focus Groups Interviews Observation Experiments	N/A...the act of looking for existing data IS secondary research.
Qualitative or Quantitative?	Can be either	Can be either
Key Benefits	Specific to your needs & you control the quality	Usually cheap and quick
Key Disadvantages	Usually costs more and takes longer	Data can be too old and/or not specific enough for your needs

Figure 16. Differences of Primary and Secondary Research (My Market Research Methods, 2011)

3.2 Procedures

This section deals with the various procedures that were done that lead to the results of this thesis. Below is a chart that shows the flow of this sub-section.

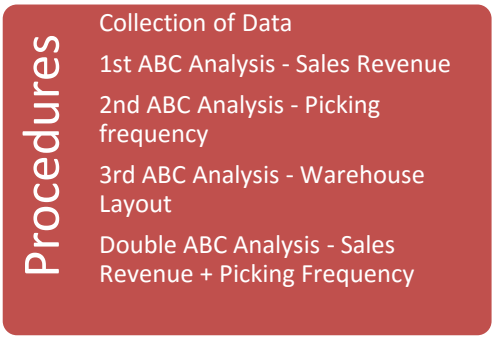

Figure 17. A summary of the contents in this sub-section

3.2.1 Collection of Data

Research was done to determine what appropriate data was needed to carry out the ABC analysis on. sales revenue, picking frequency. This would be same data that would lay the foundation for a Double ABC analysis which is the combination of sales revenue and picking frequency. The results from these analyses would then give the information to perform an ABC analysis on placement within the warehouse of the highly picked, high sales revenue products.

Through conversations with the D.C. Supervisor it was determined in order to carry out the first ABC analysis on sales revenue we would need to first find some vital pieces of data:

- The product I.D. number or material number for each product.
- Sales revenue information.
- Annual usage or demand.

The next step was to determine what data is needed for the 2nd ABC analysis on picking frequency? Therefore, it was vital to know:

- The material number and quantity for each product.
- Determine the picking frequency for each product.
- Discover their annual usage, or in other words how many times they were ordered in one year.

Much of this information was not directly accessible to a thesis worker therefore it proved necessary to contact an employee with access and know how to find the relevant sets of data.

3.2.2 1st ABC Analysis – Sales Revenue

The data was given from an employee in the form of an excel file. The next step was to find a way to sort the many different lines of information into something more easily to work with. This was relevant to since 1 product could have 45 lines delivery and sales data. Therefore, it was necessary to contact the same employee that originally sent the data and determine a way to shorten the size of the data.

Once the data were in manageable sizes, it would then be possible to run the first ABC analysis. The steps for carrying out the ABC analysis on sales revenue are:

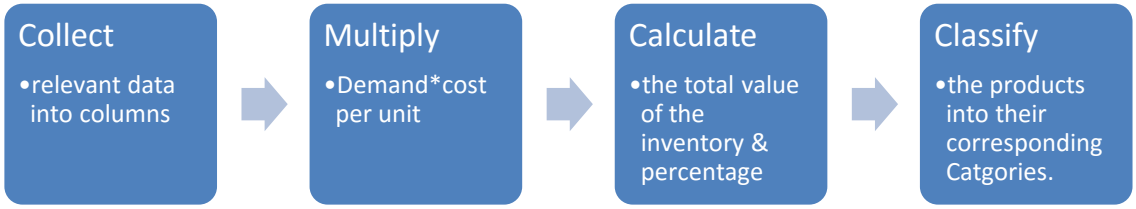

Figure 18. ABC Analysis Steps on Sales Revenue (Luenendonk, 2016)

1. Collect relevant data into columns.
    a. The Data of the product number, the annual demand and the cost of the product need to be placed in the columns.
2. Multiply Demand*cost per unit.
    a. By doing this step the analysis reveals what the total value of each item.
3. Calculate the total value of the inventory .
    a. Once the total value is determined it is important to find the total sum of the inventory. This was done be adding up each product's total value that was found in step 2.
4. Calculate percentage.
    a. It is needed to find out what percentage value does each item represent in your total value. One needs to remember to absolute the column by pressing "F4" on the computer's keyboard so that it remains constant when you copy the formula down to the other rows of product.
    b. Once this is done excel showed the results in decimal placement form. It was then needed to format the numbers in percentages.
5. Classifying the products.
    a. Following the classification guide of: A-products account for 80 % of all sales revenue, B-products account for 15 % and C-products account for 5 %.

Once all these steps were accomplished, the first question:

Which products generate the most sales revenue?

was finally answered.

3.2.3 2nd ABC Analysis – Picking Frequency

To find the picking frequency of a product, one needs to simply repeat the process of the first ABC Analysis with some minor adjustments. The steps that were taken we as follows:

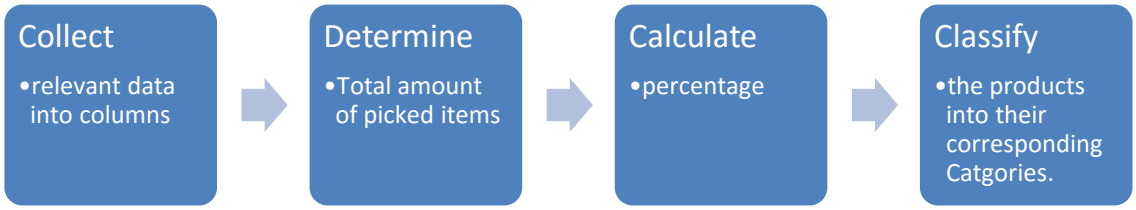

Figure 19. ABC Analysis Steps on Sales Revenue (Luenendonk, 2016)

1. Collect relevant data into columns
    a. The Data of the product number and the quantity formed the criteria to find the solution to this analysis.
2. Find the total amount of picked items
    a. The quantity of the items sold were equivalent to the items picked. This means that if 100 of Product "X" were sold in 2016 then that means in 2016, product "X" was picked 100 times. Therefore, the next step was to add all the quantity of the picked products together to determine the percentage.
3. Calculate percentage
    a. Using a percentage calculator, the first step was to input the total products picked and then using a calculator find: What percentage of total products picked = 80% of total picked items?
    b. The same step done it determining the 15% for B products and the 5 percent for C products.
    c. Once this was done, it was simply a matter of placing the products in ascending order and label which products made up the percentage of A, B and C products.
4. Classifying the products.
    a. Following the classification guide of: A-products account for 80 % of all picked products, B-products account for 15 % and C-products account for 5 %.

b. At this point we have two columns side by side, one with the “A”, “B”, and “C” categories for the sales revenue criteria and a 2nd column the for Picking frequency products.

Once all these steps were accomplished, the question:

Which products have a high picking frequency?

was finally answered.

3.2.4 3rd ABC Analysis – Warehouse Layout/Segmentation

The methods that are used in this section are based upon the results of the ABC analysis on picking frequency and the sales revenue of the products. Based on that information, and we then create aisles that are in the closest proximity to the packing station and label them as

Figure 20. A chart showing the methodology behind warehouse layout

“Hot Spots”. Following the methodology in the above chart shows how the placement was determined. Looking at a blue print of the Billnäs D.C., one is able to get a bird’s eye view of the layout:

Figure 21. A chart showing Billnas D.C. before ABC segmentation

First glance of the blueprint in figure 21, one is able to quickly determine the which aisles in relation to the "Packing Station" are the "Hot Spot" aisles. These aisles shown with the red arrows would be the optimal place to store these "AA" products. This is important since it was discussed in the theory section of order picking that travel time accounts for 50% of the workers time, 20% accounts for search for the item, and 15% accounts for picking the products. This means that by reducing the travel, searching, and picking time, once can drastically improve the amount of time it takes to fulfil an order.

Once all these steps were accomplished, the question:

Where should these high sales revenue/frequently picked, products be placed?

was finally answered.

3.2.5 Double ABC Analysis – Sales Revenue + Picking Frequency

The methodology behind the Double ABC analysis consisted of the methods of sales revenue and picking frequency, and sorting the "A" products of both criteria to form the 9 classifications that were mentioned in the theoretical section. Listed below is a table that shows the 9 classifications and their definition.

Table 2. Description of the 9 Double ABC Categories (Frandsen, 2014).

AA Products	High Revenue, Frequently Picked
AB Products	High Revenue, Moderately Picked
AC Products	High Revenue, Least Picked
BA Products	Moderate Revenue, Frequently Picked
CA Products	Low Revenue, Frequently Picked
BC Products	Moderate Revenue, Least Picked
BB Products	Moderate Revenue, Moderately Picked
CB Products	Low Revenue, Moderately Picked
CC Products	Low Revenue, Least Picked

Once all these steps were accomplished and the products were in the 9 classifications, the Double ABC analysis on sales revenue and picking frequency aided in answering the following questions:

- Which products generate the most sales revenue?
- Which products have a high picking frequency?

3.2.6 Methods Summary

The above methods that were used in this study can all be seen through the scope of the 6 steps of the qualitative research method. First the topic was chosen for this report of doing an ABC Analysis. Secondly, determining this subject of whom to apply an ABC Analysis to, in this case it was the company Fiskars.

The next step was to find the theoretical data before collecting and interpreting the relevant data. Once the relevant data was found the next was to interpret the raw data using software programs such as Excel. The next step would be to combine the theory with the work that has been down and then finally once this has been accomplished we would then move on to the next and final step of witting up the findings and giving recommendation. A Gant chart showing the amount of time that was invested in each section of this report is listed in the appendix section.

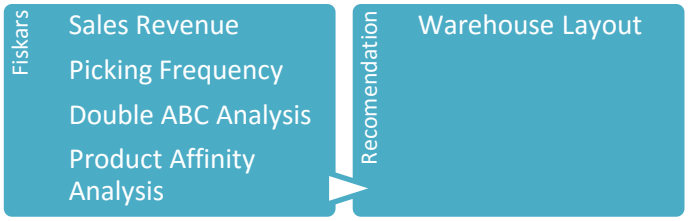

Figure 22. A summary of the results section

4 RESULTS

The section deals with the results that were obtained from the previously mentioned methodology. In the figure below one can see the flow of this section:

The results of this thesis came from performing an ABC analysis on:

- Sales Revenue - Which products generate the most sales revenue?
- Picking Frequency – Which products have a high picking frequency?

Once the results from these 2 ABC analysis were found, it was possible to create the Double ABC analysis and use those results to perform a 3rd ABC Analysis on:

- Warehouse Layout – Where should these high sales revenue/frequently picked products be placed?

This 3rd layout concerning the layout of the warehouse was not a mathematical analysis because the information was already present in database and thus made this 3rd analysis a recommendation.

4.1 Fiskars

Since being established in 1649, Fiskars group has grown to be a leading company in functional and living products. Headquartered in Helsinki, Fiskars group has about 8,600 employees in over 30 different countries, owning over a dozen of quality named brands. Having grown to be the world's #1 Scissor brand with sales of over 1 billion EUR, Fiskars continues innovation of different tools to make gardening, cooking and other activities' more intuitive and enjoyable (Business Wire, 2017).

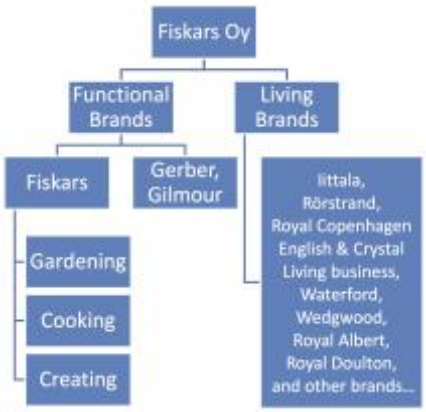

Figure 23. Branches of Fiskars Oy (Fiskars, 2017)

According to Fiskars' 2016 annual report, their net sales reached over 1.2 billion EUR. The year 2016 has also seen increases in cash flow statements, operating profit, and net sales from the prior 5 years. The pie chart figure to the right shows which branch of the Fiskars brands contributed to the net sales of 2016. The functional products accounted for 43% of the total net sales for 2016. It is safe to say the Billnäs factory, being part of the functional living branch, contributed to a large portion of that percentage. Last year alone the garden tools D.C. shipped over 4 million products (Fiskars, 2017).

The Fiskars factory in Billnäs, Finland is partly responsible for all the manufacturing and shipping of their garden tools products. This includes products such as shovels, axes, scissors, and many others.

Figure 24. Fiskars garden tool business structure and garden tool product line.

From the above figure starting from the right you can see the business structure for the garden tools branch in Finland. The factory in Billnäs is divided into two main sections, manufacturing and distribution. Also, pictured above are all the Fiskars products that have been manufactured and distributed by the Billnäs factory. The D.C. also handles some distribution from other garden tool brands they own, however those are typically exports and not available for sale in Finland. Recently, due to various economic reasons, Fiskars had made the decision to centralize most of the manufacturing of garden tools to Poland leaving scissors, axes, and snow shovels to be continued to be manufactured is Fiskars, Billnäs (Fiskars Corp, 2017).

The Billnäs D.C. currently operates 2 + 1 shifts a day with 2 workers per shift. The 1st shift goes from 6.00-14.00, the 2nd from 14.00 – 22.00. There is also a third overlapping shift from 8.00 -16.00 with 4 workers. During the off seasons this changes to usually 1 shift as demand is not as high as the spring/summer months (Mollgren, 2017).

4.1.1 Sales Revenue

One of the questions this thesis aimed to answer was:

Which products generate the most sales revenue?

This analysis focused on the products that generated the most sales revenue for the warehouse. The table below shows the top 15 products based on sales revenue. a product was being picked from the shelves of the warehouse.

Table 3. Excel spreadsheet showing obtained results on sales revenue

Product I.D.#	Demand	Cost/Unit	Value	% of Value	Category
1	103437	0	0	5.14%	A
2	122931	0	0	3.95%	A
3	96271	0	0	3.83%	A
4	88972	0	0	3.08%	A
5	50391	0	0	2.62%	A
6	68647	0	0	2.43%	A
7	53790	0	0	2.29%	A
8	28664	0	0	2.17%	A
9	40783	0	0	2.04%	A
10	233241	0	0	2.01%	A
11	90602	0	0	1.98%	A
12	39192	0	0	1.92%	A
13	24925	0	0	1.76%	A
14	47291	0	0	1.65%	A
15	69416	0	0	1.51%	A

This above table shows the top 15 products that generate the most sales revenue for the company. These products make up part of the "A" category which means, 80% of the sales revenue comes from these "A" Products. This was done by following the steps listed in the 3rd chapter about methodology by: data collection, multiplying them by the cost of the unit, calculating their percentage, and classifying the products. After performing these steps, it was then possible to place them in 3 different categories based on their sales revenue. This being sensative information that actual product i.d., cost of unit, and its value in the above table have been masked. In the chart below, one is able to see what exactly are these high revenue "A" products are:

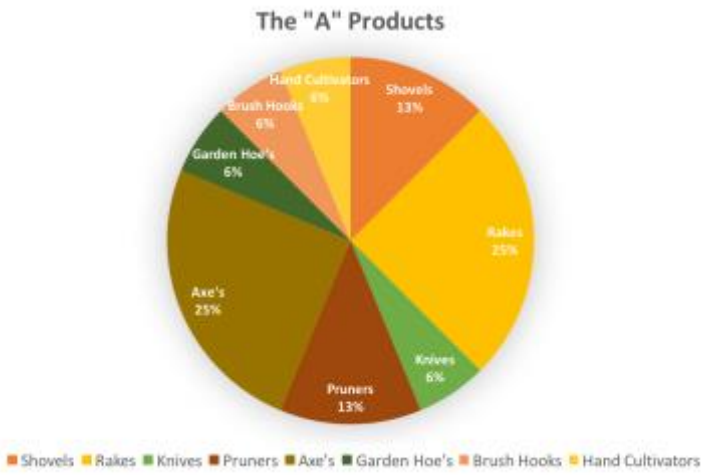

Figure 25. A pie chart revealing the high revenue "A" Products

The above chart represents the top 15 "A" products currently bringing in the most revenue from sales for Fiskars Billnäs. These are products, such as axe's, rakes and shovels. Also listed are their percentages that show how much of the total sales revenue each product is responsible for. These products listed in the above figure are large, heavy, challenging to store in warehouse because of various sizes and can be difficult to pick and pack for the customer. Currently, these are all packed starting from the heaviest items first to the smallest, once the worker has fulfilled an order, it then goes to the packing where it is then packed using various types of boxes and techniques to make sure the products remain protected through the journey.

To understand better the meaning of terms such as a "High Sales Revenue" The chart below shows in more detail:

A = High Sales Revenue – About 5% of inventory makes up at 80% of Sales Revenue
B = Moderate Sales Revenue – About 15% inventory makes - up 15% of Sales Revenue
C = Low Sales Revenue – About 80% inventory makes up 5% of Sales Revenue

Figure 26. A chart defining the A, B, and C, classifications

The chart below is here to better illustrate how much revenue these "High Sales Revenue" products generate.

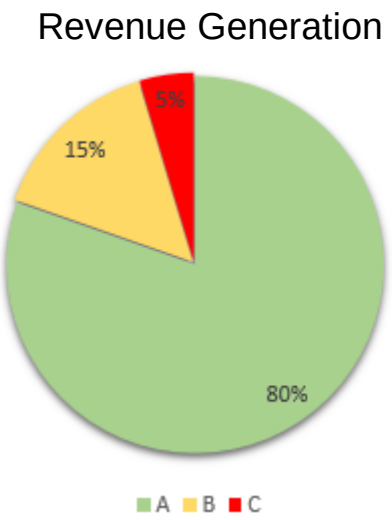

Figure 27. Pie chart of the different classification's revenue generation

Now that the categorizes have been defined, the next step was determining how many of those products are in each category? Based on sales revenue, the 514 products in the database were divided into the following categories shown in the figure below:

Table 4. Results of the ABC Analysis on sales revenue

A	B	C
63	55	396

As expected, based on Pareto's theory we find this ABC analysis has successfully divided the *"…vital few from the trivial many*". The results of this tool reveal the expected few highly revenue generating "A" products, moderately revenue generating "B" products and many not so revenue generating "C" products.

4.1.2 Picking Frequency

Another question this thesis aimed to answer was:

Which products have a high picking frequency?

This analysis focused on how frequently a product was being picked from the shelves of the warehouse. Below is a table showing the top took into consideration how often an item was being picked from the shelves.

Table 5. A table showing the ABC work on picking frequency

Product I.D.#	Demand	% of Picked items	Category
1	233241	5.57%	A
2	122931	2.93%	A
3	103437	2.47%	A
4	96271	2.30%	A
5	90602	2.16%	A
6	88972	2.12%	A
7	69416	1.65%	A
8	68647	1.64%	A
9	53790	1.28%	A
10	50391	1.20%	A
11	47291	1.13%	A
12	40783	1.0%	A
13	39192	0.9%	A
14	28664	0.7%	A
15	24925	0.6%	A

This above table shows 15 of the Highly Picked products that make up part of the "A" category. Following the steps listed in the 3rd chapter about methodology by: data collection, determining total amount of picked items, calculating their percentage, and classifying the products. After accomplishing these steps, it was then possible to place them in 3 different categories based on their picking speed:

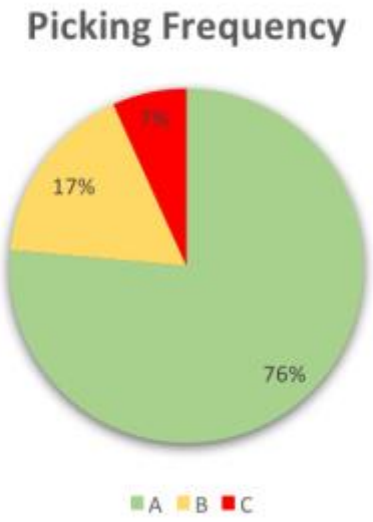

Figure 28. A pie chart on picking frequency

This pie chart shows the classification of A, B, and C products along with their overall frequency of being picked in the warehouse. There categories are further defined as:

A = Frequently Picked – Picked daily

B = Moderately Picked - Picked weekly

C = Least Picked - Picked monthly

Now that the categorizes have been defined, the next step was determining how many of those products are in each category? Of the 514 products that were in the database based on the ABC analysis on picking frequency the results were divided into the categories shown in the figure below:

Table 6. Results of the ABC analysis on picking frequency

A	B	C
81	111	322

Once again, by using Pareto's theory it is determined that this ABC analysis on picking frequency has successfully given the sought-after results.

4.1.3 Double ABC Analysis

This Double ABC analysis is the combination of the questions

Which products generate the most sales revenue?

Which products have a high picking frequency?

This analysis took into consideration how often the products was being picked from the shelves + sales revenue from the products.

Table 7. Excel work showing the results of the Double ABC analysis

Product I.D.#	Demand	Cost/Unit	Value	% of Value	% of Picked items	Profit	Pick
1	233241	0	0	5.14%	2.01%	A	A
2	122931	0	0	3.95%	3.95%	A	A
3	103437	0	0	3.83%	5.14%	A	A
4	96271	0	0	3.08%	3.83%	A	A
5	90602	0	0	2.62%	1.98%	A	A
6	88972	0	0	2.43%	3.08%	A	A
7	69416	0	0	2.29%	1.51%	A	A
8	68647	0	0	2.17%	2.43%	A	A
9	53790	0	0	2.04%	2.29%	A	A
10	50391	0	0	2.01%	2.62%	A	A
11	47291	0	0	1.98%	1.65%	A	A
12	40783	0	0	1.92%	2.04%	A	A
13	39192	0	0	1.76%	1.92%	A	A
14	28664	0	0	1.65%	2.17%	A	A
15	24925	0	0	1.51%	1.76%	A	A

Table 8 shows 15 of the Highly Picked and high revenue generating products that make up part of the "AA" category. Again, the financial information and the actual product I.D. number have been hidden since it is sensitive information. These results were accomplished by following the steps listed in the 3rd chapter about methodology. They were: data collection, determining total amount of picked items, calculating their percentage, calculations used for sales revenue, and finally, classifying the products into the "AA" categories.

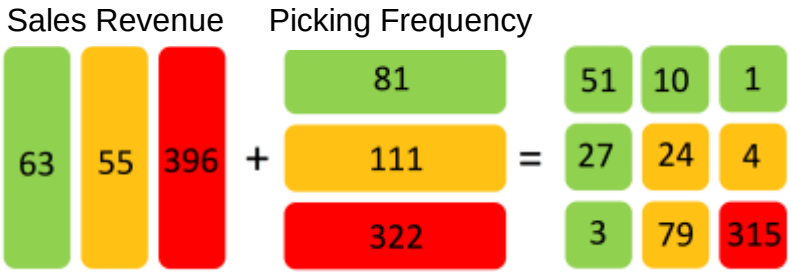

Figure 29. The results of a Double ABC Analysis

Figure 29 illustrates the combination of the ABC analysis on sales revenue and picking frequency. Once combined, it is then possible to determine how many of these products should be categorized in the 9 classifications.

Table 8. Definition of the 9 double ABC clasifications

AA	**51**	High Revenue, Frequently Picked
AB	**10**	High Revenue, Moderately Picked
AC	**1**	High Revenue, Least Picked
BA	**27**	Moderate Revenue, Frequently Picked
CA	**3**	Low Revenue, Frequently Picked
BC	**4**	Moderate Revenue, Least Picked
BB	**24**	Moderate Revenue, Moderately Picked
CB	**79**	Low Revenue, Moderately Picked
CC	**315**	Low Revenue, Least Picked

Table 9 shows the 9 classifications to the right followed by the number of products within the corresponding classification, finally followed by a short explanation of the definition

of the classifications. Once this information was obtained, it was then possible to apply the results of this tool to the layout of the warehouse.

4.1.4 Product Affinity Analysis

One of the questions this thesis aimed to answer was:

Which products are commonly sold together?

The original aim was to find out which products are most commonly bought together. It was determined that the program called SPSS was best suited for the job. After almost a 2-hour long meeting with a knowledgeable teacher, many attempts were made using SPSS to find the correct results from the data, however, through much trial and error it was determined that this could not be done for one main reason:

- The SPSS program available at my university has limited functions.
- Insufficient amount of time to obtain the results.

Since the data was extremely large, the trial version that the school had only allowed data files of no more than 1,000 cells. The data from Fiskars had around 100,000 different cells. One of the solutions were to buy the program and then carry out the analysis on a full license. This became another problem as a full license of SPSS retails for 1,200 USD. Because of the listed above problems results for this question will have to go unanswered within this thesis.

4.2 Recommendation

As previously stated in the chapter 1, the problems that thesis endeavored to answer were:

- Unknown sales revenue of products.
- Need for optimization of picking routes.
- No current tool to analyze the existing data.
- Warehouse layout/Micro-location problems.

By answering these warehouse problems this thesis will be able to fulfill its aim of this thesis of determining these high sales revenue/frequently picked products in the warehouse as well how to make them more accessible to the warehouse workers.

4.2.1 Warehousing Recommendation

The purpose of creating a Double ABC Analysis was to determine which products have a high sales revenue and have the highest picking frequency at Fiskars Billnäs. There are many ways to place "A", "B", and "C" products in a warehouse. One of the recommended methods is to create what Jarvis and McDowell (1991) call "within-aisle" storage. This simply means in the context of this report to place the products with a "AA" in picking frequency and sales revenue in one aisle to create a more efficient warehouse layout.

Listed in the Figure below is the current layout of a D.C. in Bilnäs. Colored in green is a suggestion where "AA" products could be located if the warehouse management were to apply the finding of this study to the current layout.

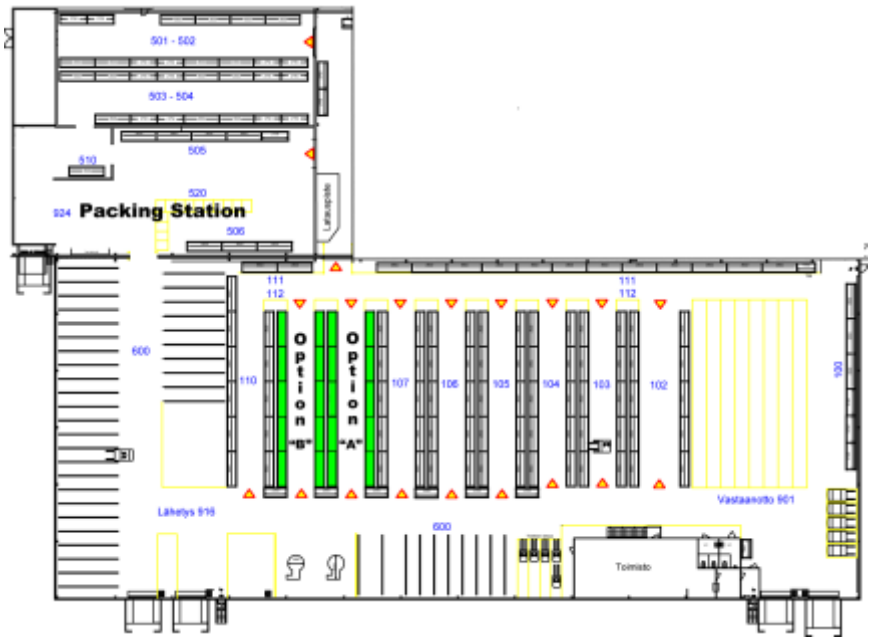

Figure 30. Layout of Fiskars D.C. Billnäs

As you can see from the above Figure, the aisles highlighted in green would be reserved for the 51 "AA" products. First, the most optimal place for "AA" products could be the aisle listed as "Option A" then if this aisle were not enough, the use of the "Option B" aisle could be utilized. It is also the opinion of the author that one doesn't need to change

the entire layout of the warehouse, but instead create a “Hot Spot” aisle that would include all the “AA” products.

It is the opinion of the author that products that are in the “AA” category. Should be have a designated aisle since they are picked the most and worth the most to the warehouse. It should also be placed in an area that is closest to the packing stations. By doing this it will eliminate the amount of travel and the overall time that is required to pick a product.

If there was a scenario where there were not enough “AA” products to fill the shelves, then I would recommend to use “AB” or “BA” as these would still be highly revenue generating and frequently picked products that are next in line to be placed in an area that that is easily accessible by the warehouse workers.

5 CONCLUSION

The aim of this report was to arrive at a recommendation that would prove useful for the development of a warehouse layout that would be more efficient than the current one that’s in place. The main problems that lead to the creation of the questions were:

- Unknown sales revenue of products.
- Need for optimization of picking routes
- No current tool to analyze the existing data
- Warehouse layout/Micro-location problems

Especially since the warehouse has recently changed the layout and has expanded to accommodate taking on the inventory of another warehouse located on the same property. This was done by answering the following questions:

- Which products generate the most sales revenue?
- Which products have a high picking frequency?
- Which products are commonly sold together?
- Where should these high revenue/picked frequently products be placed?

The D.C. in Fiskars Billnäs had some problems associated with the layout of the warehouse. By performing the sales revenue ABC analysis, Picking Frequency analysis, Double ABC Analysis, and the Warehouse Layout ABC Analysis the problem of having an uncategorized warehouse has now been solved. This is something that has not been done by using the perspective of sales revenue to increase the layout of a warehouse. The need of creating a highly efficient warehouse layout is important considering the dire economic times in Finland.

Picture 1.

Picture 2.

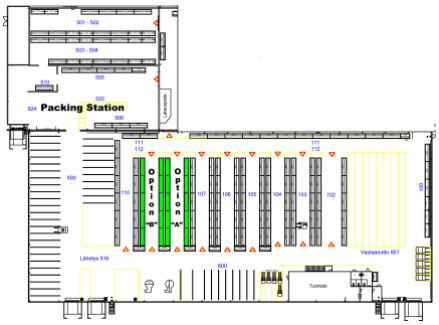

Figure 31. The before and after layout of the Billnäs, D.C.

As one can see from the above chart. Picture 1 shows the warehouse before this thesis was commissioned. This layout did not have an efficient layout based on picking frequency or sales revenue and therefore was an inefficient layout. Picture 2 shows what occurred when the ABC analysis tool combined with the already existing data was applied to the same layout. I was able to optimize the layout by creating two aisles that are able to store the 51 "AA" products. This layout of the Billnäs D.C. has not been optimized in the last decade and through this research I was able to find a way to create an optimized warehouse layout that proved valuable for improving the overall flow of warehouse traffic and also cutting costs.

5.1 Finishing Thoughts

It is my opinion that the criteria that were chosen for the double ABC analysis was a good choice to get the desired results. This was confirmed through the conversation with both the D.C. Manager and the D.C. Supervisor.

Originally, the idea was to do only one ABC analysis on sales revenue along with the product affinity analysis. After seeing the data is was apparent to be me that more could be done to get more accurate results in my findings. I realized adding another ABC on picking frequency would be highly beneficial information for the warehouse management to know, I then thought combining them creating a Double ABC analysis would even be better. Finally, since this report concerned layout, another ABC analysis was performed on the layout of the warehouse do find the best possible locations for the "AA" products. It was my opinion that these analyses would be plenty to obtain accurate information. Especially since it has been determined by prior studies that too many ABC analysis can tend that are more complex can tend to give false readings of what criteria are the most essential.

In the beginning, the work was challenging for the author, there was much to be researched since conducting an analysis on this scale required much learning, research and trial and error. One of the hardest parts of writing this report would have to be finding the picking frequency of the products. Normally, this is not a hard task but when one has over 100,000 different orders with varying amounts, the sheer size of the data can be daunting than simply having an inventory of 10 or 50.

A weak point for the author was the limited time in carrying out this study. Even though the study was started back in September of 2016, it wasn't till February where a lot of the methodology was carried out on top of further research. More could have been done, however it would have required more time. Had the time been there it would probably have been sufficient to answer some of the research questions that the author had to leave behind.

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APPENDIX

Profit Margin Calculation - *Net Income ÷ Revenue*

Asset Turnover Calculation - ***Asset Turnover = Total Revenue / Total Assets***

Owner's Equity Calculation (The Equity Multiplier)

Equity Multiplier = Assets ÷ Shareholders' Equity.

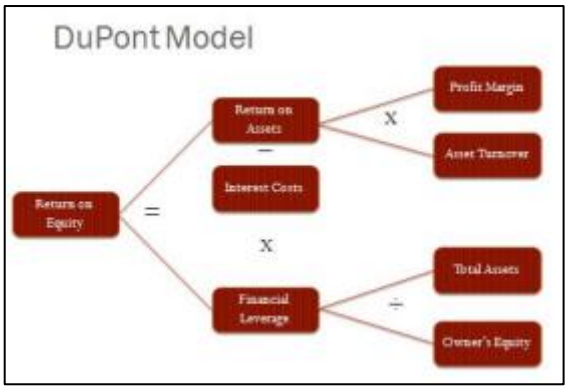

Figure 32. Dupont Model's Component Linkage (Roucan-Kane et al., 2013)

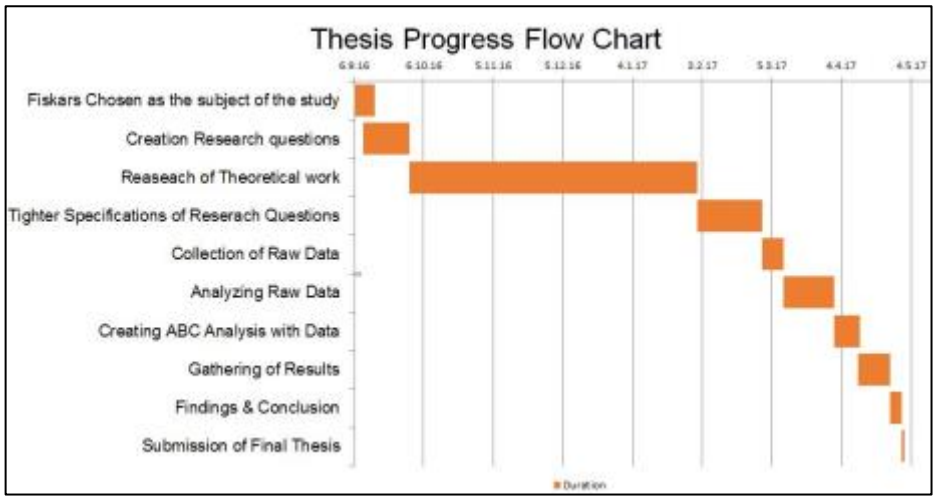

Figure 33. A Gant Chart Showing the Timetable of the Authors Work flow