# Kitting type evaluation tool: Inbound or Outbound?

Company study case

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Abstract:
Inventory kitting, which is the procedure of grouping, packaging, and selling usually separate items together, has grown popular as its combined characteristics from make-to-stock and make-to-order. In the context of company study case, two types of kitting are studied - inbound kitting (process of creating a new stock keeping unit (SKU) from a group of materials) and outbound kitting (process of grouping different separate materials together when sales for the kit is generated). The aim of the study is to create an evaluation tool on current type of kitting (outbound or inbound) and decide if some kits shall be changed from one type of setting to the other. The research questions are: "What are the factors that affect the decision whether inbound or outbound kitting to be used?" and "How to make a decision to switch to the more cost-effective kitting type?" in which the second being the main one. The main theories are inventory management, cost reduction as a driver, delivery performance, kitting, and economic order quantity. The research method chosen was action research which the data collection method was qualitative interview, and the method of analyzing data was thematic analysis. The results show that the factors which affect kitting decision can be categorized into two groups: planning factors (demand, cost of creation of kit, obsolescence risk, criticality) which bring a different result on annual cost depending on what kind of kitting is used, and design factors (technical changes, numbers of components, dimensions of components, variability of a family of kits) which do not bring a different result on annual cost regardless of what kind of kitting is used. An Excel sheet was created which gave the decision if the kitting type had to be change from one to another. The tool calculated annual cost for the current kitting type and estimation annual cost for the other kitting type. With the tool's suggestion, a decrease of 8.5% of total number of outbound kits sales order lines was witnessed, which would considerably improve the delivery performance. The tool forecasted to make a saving impact of 8% total costs for both types of kitting in the first year. The research was limited to the definitions of inbound and outbound kitting in the company case as they are not universal terms.

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# 1 INTRODUCTION

With the continuous developing competitiveness in the supply chain world, delivering goods to customers that meet their demands has become key identifier to success. There are two popular strategies in delivering product: make-to-stock and make-to-order. Make-to-stock is when materials are purchased into the stock for immediate delivery when sales happened. On the other hand, make-to-order allows customers to purchase configurable products, usually in small volume. In other words, process of buying/producing is only done after sales order is placed. (Krajewski, Ritzman and Malhotra 2010)

Besides two main popular concepts above, inventory kitting (kit) has grown popular in the last decades. Inventory kitting is the procedure of grouping, packaging, and selling usually separate items together. In other words, when kit is purchased, sales order will be generated for sub-component items. (Intuit Inc 2021) When comparing the definition of kitting to conventional make-to-stock and make-to-order, kitting is a hybrid between make-to-order and make-to-stock that utilize advantages from both strategies. In other words, kitting brings numerous benefits, for example: raising average order values and providing greater flexibility to customers. These benefits are discussed later in this paper.

Kitting is a strategy other than two popular strategies – make to stock and make to order. There are certain advantages observed by kitting process. By studying its application and benefits, business could make better decisions based on the characteristics of its.

In the context of the specific study case business, two types of kitting are studied in detail - inbound kitting and outbound kitting. Inbound kitting is the process of creating a new stock keeping unit (SKU) from a group of materials which might include assembly activities and technical changes. The new SKU can be created from one single material (when some technical changes are done to it) or more materials. All materials are packed and stored together in distribution center until sales order for the whole kit is generated. Outbound kitting is the process of grouping different separate materials together when sales order for the kit is generated. In other words, sub-components are kept separately until a sales order is created. There are different advantages for each type of kitting which are later discussed in this paper.

The company being studied in this paper is a leading company in the industrial field. They provide technical products and services. Their spares part business will be the main study object in this research.

## 1.1 Problem statement

The company in research currently has a variety of kits in the operation including both inbound kits and outbound kits. Generally, outbound kitting has the advantage of more flexibility, less capital tied up, less possibility to become obsolete. However, as the work of grouping materials happens in outbound area together with normal sales order, it demands considerable man force in picking and packing parts order by order. On the other hands, inbound kitting solves the issue of demanding labor work but requires more stocking space, more capital tied up, less flexibility. Outbound kitting is in favor when it comes to more flexibility. However, in the year or 2022, due to high rate of sick leaves from COVID-19, the outbound area has been overloaded with the number of traditional orders and outbound kit orders, which consequently turns to bad delivery performance. Therefore, there is a huge need to evaluate current setting for the kits whether outbound or inbound should be used to reach better delivery performance and economic performance in which reducing annual cost is a driver.

This study provides more complete understanding of kitting process in specific spares part business to the general readers and the company's employees. In other words, the employees shall understand what kind of kitting is needed in each case, how beneficial it is, and what shall be focused on in next development projects.

## 1.2 Aim of the study

The aim of the study is to create an evaluation tool on current type of kitting (outbound or inbound) and decide if some kits shall be changed from one type of setting to the other.

The research is designed to study research questions below, in which research question 2 being the main one:

Research question 1: What are the factors that affect the decision whether inbound or outbound kitting to be used?
Research question 2: How to make a decision to switch to the more cost-effective kitting type?

## 1.3 Demarcation

Due to the scope of this bachelor thesis, only outbound/inbound kitting in inventory management are researched. Make-to-stock and make-to-order are not subjects to be studied in this thesis; however, they are mentioned as a reference of other types of production strategy.

This text only considers outbound/inbound in the context of spares business in the company case study as there is limitation for discussing their characteristics and performance in a different environment.

## 1.4 Definitions

Inventory kitting: is the procedure of grouping, packaging, and selling usually separate items together. (Intuit Inc 2021)

Make-to-stock: is the procedure when items are held in stock aiming at immediate delivery when sales happen. (Krajewski, Ritzman and Malhotra 2010)

Make-to-order: is the procedure when items are produced according to customer specifications in low volumes when sales happen. (Krajewski, Ritzman and Malhotra 2010)

Stock keeping unit (SKU): is “a specific numeric or alpha-numeric identifier for a specific item.” (Muller, 2019)

Inbound kitting (in the context of studied business): is the process of creating a new stock keeping unit (SKU) from a group of materials which might include assembly activities

and technical changes. All materials are packed and stored together in distribution center until sales order for the whole kit is generated.

Outbound kitting (in the context of studied business): is the process of grouping different separate materials together when sales for the kit is generated. Sub-components are kept separately until a sales order is created.

Bill of materials (BOM): is a record of all components of an item, the relationship with the parent item, and needed quantities from process designs. (Krajewski, Ritzman and Malhotra 2010)

# 2 THEORY

The theory chapter includes theories and research related to the topic of this thesis. To begin with, a general introduction of inventory management is presented. Secondly, the chapter continues with the flows in the logistics. Cost reduction as a driver and delivery performance are then presented. Afterwards, theories about kitting are illustrated including its benefits, kitting and manual work at warehouse. The chapter finishes with theories of economic order quantity (EOQ) and calculations around it.

## 2.1 Inventory management

All organizations keep at least some inventory. Inventory refers to not only finished products that would be sold to customers but also raw materials, work-in-process, supplies needed for operation activities. Since inventories always associate with cost, managing inventory is important. The relevant costs incurred when carrying inventory are, but not limited to, below: (Muller 2018)

- Price: can include both the purchasing price paid for the material and other costs to have the materials delivered to warehouse such as freight, insurance, custom, inspection, testing, certification.
- Holding costs: are also called carrying costs which are costs incurred when carrying inventory. The calculation of this cost is discussed in more details in chapter 2.4.1.

- Ordering costs: are also called replenishment costs which are incurred when procuring material from a supplier.
- Shortage costs: are costs generated when extra activities are needed when customer needs a material which the company does not have on hand. In this case, backorder is created, and extra monitor is required. If the customer does not agree to wait, the company loses their revenues, which also decreases the customers' satisfaction.
- Other costs: inventory control work, analysis of discrepancies, etc.

Inventory management is a term refers to activities to manage how much inventory to keep on hand and how often to reorder. It is usually the case that the pattern, time point, demand quantity rarely is the same as the amount of inventory existing at the company. Most companies do not wish to have too much inventory on hands when sales are low either. On the other hand, companies would end up with sales-loss if they do not have enough inventory when sales orders are generated. Therefore, generally, inventory is kept to cover the uncertainties of demand. (Mercado 2007)

The objective of inventory management is to ensure demands are met and, at the same time, keep inventory costs at a reasonable level to optimize profit for the business. Meeting customer demand and reducing cost cannot go solely but connect closely with each other even though they are opposite to each other considering themselves. (Mercado 2007)

## 2.2 The flows in the logistics

In logistics, two flows that are mainly concerned are information flow and material flow across the supply chain to ensure customers need are met. (Harrison 2019) Figure 1 below shows the material flow (supply) and information flow in regard to time, from raw material to the end-customer. The relationship with suppliers which provide raw materials is referred as upstream, and the relationship with end-customers is referred as downstream.

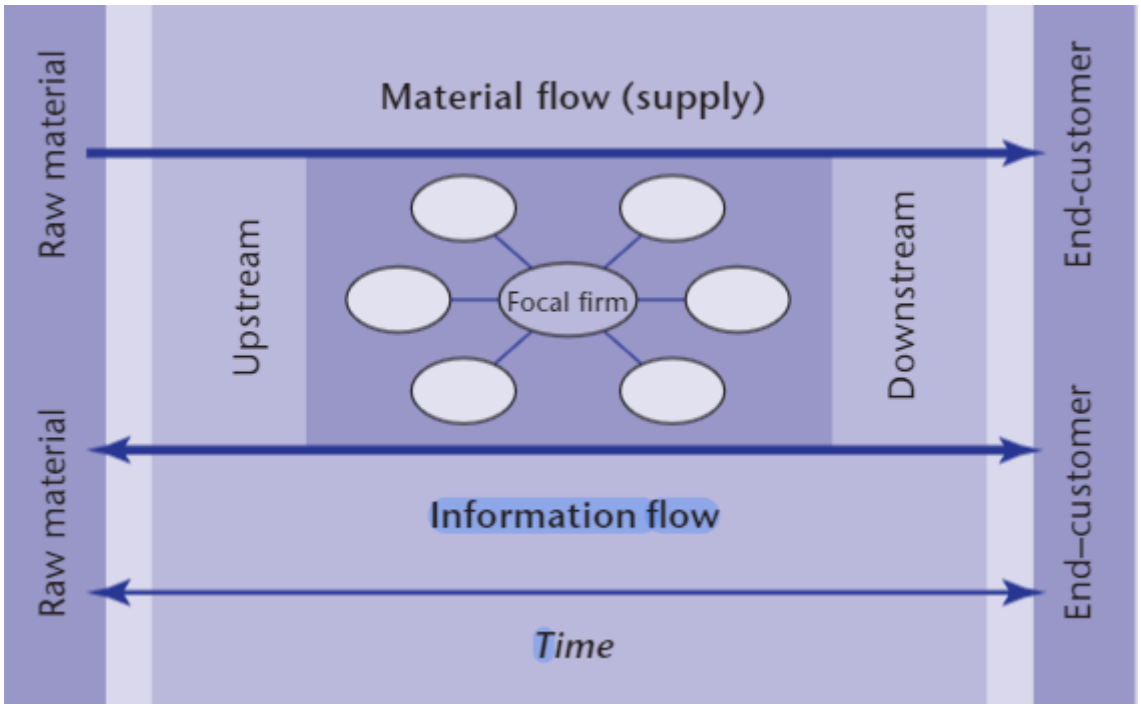


*Figure 1 Material and information flow in logistics (Harrison 2019)*

Within a supply chain, the purpose is maintained as keeping the material flow from supplier to the end customers. Products are expected to move along the supply chain as fast as possible, targeting at eliminating inventory build-up at any point in the supply chain. (Harrison 2019)

According to Knill (1992 p.54), "the goal is continuous, synchronous flow. Continuous means no interruptions, no dropping the ball, no unnecessary accumulations of inventory. And synchronous means that it all runs like a ballet. Parts and components are delivered on time, in the proper sequence, exactly to the point they’re needed."

To ensure material flow, information has to be shared upstream starting from end-customer across the supply chain. Demand chain is created after sharing the end need with the help of information technology in increasing detail and sophistication level. Demand and supply information have to be integrated so that a clear picture can be observed. Figure 2 below shows the connection between demand and supply chains, which are glued together by information flow. (Harrison 2019)

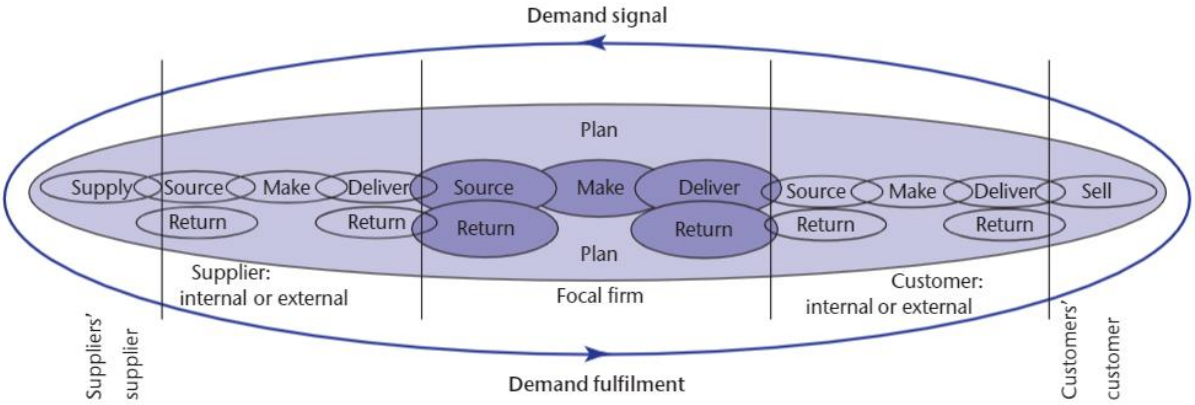


*Figure 2. Integrating demand and supply chains (Harrison 2019)*

### 2.2.1 Cost reduction as a driver

Most businesses and organizations try to improve the productivity of capital – return on investment (ROI). ROI is calculated with the ratio between net profit and capital employed (Christopher 2011):

$$ROI = \frac{Profit}{Capital\ employed}$$

Figure 3 below illustrates the major factors which determine ROI and potential improvement in logistics management to achieve better ROI, one of which is costs with logistics efficiency as potential development:

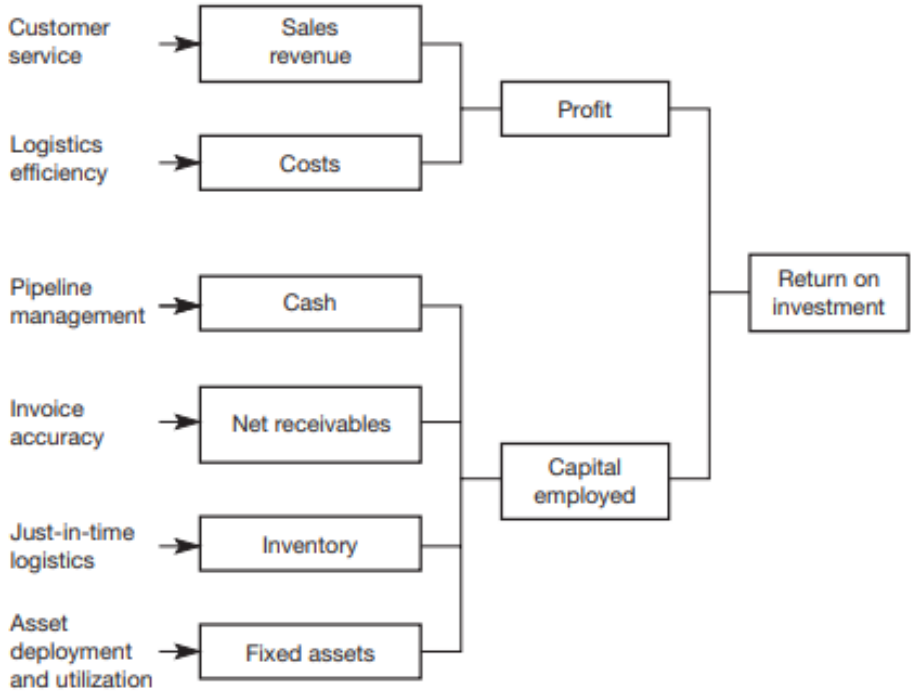


*Figure 3. Logistics impact on ROI (Christopher 2011)*

Reducing cost through logistics and supply chain management is significant since there are considerable proportion of costs which are the results from logistics decisions and the quality of supply chain management. It is popular that companies are investing into enhancing their margins by taking closer look at their supply chain management. The costs that a company has to pay include not only transportation, storage, handling, order processing, but also upstream logistics costs. (Christopher 2011)

### 2.2.2 Delivery performance

The direct impacts by the supply chain on the customers is delivery. Customer satisfaction is thereby determined by the delivery performance; measuring and improving delivery is positively affecting competitiveness. (Gunasekaran et al. 2004)

According to Stewart (1995), it is possible to improve delivery performance by reducing lead-time associated. Second character of delivery performance is on-time delivery. In other words, on-time delivery means if customer order is delivered perfectly, which is also a measurement for customer service level. As a similar idea described by Christopher

(1992), on time order fill is demonstrated as a sum of delivery reliability and order completeness. There are many factors which impact delivery effectiveness, for examples vehicle speed, delivery reliability, frequency of delivery, location of depots. Inventory levels can decrease if a higher efficiency is achieved (Novich 1990).

The table 1 below shows the order of importance of delivery performance measures. The three most important metrics are quality of delivered goods, on time delivery of goods, flexibility of service systems to meet customer needs.

*Table 1. Importance of delivery performance measures (Gunasekaran et al. 2004)*

| Assessment | Delivery performance metrics | Percentage rating |
|---|---|---|
| Highly important | Quality of delivered goods | 12.34 |
| | On time delivery of goods | 12.20 |
| | Flexibility of service systems to meet customer needs | 11.43 |
| Moderately important | Effectiveness of enterprise distribution planning schedule | 10.31 |
| | Effectiveness of delivery invoice methods | 10.23 |
| | Number of faultless delivery notes invoiced | 10.05 |
| | Percentage of urgent deliveries | 9.32 |
| | Information richness in carrying out delivery | 8.76 |
| Less important | Percentage of finished goods in transit | 7.76 |
| | Delivery reliability performance | 7.70 |

## 2.3 Kitting

According to Piroozfar and Piller, kitting is "A New Kind of Ready-to Assemble Service". Already from the sixties, an understanding of design and technology is not enough has been established, service is key successful factor and greatly invested in by big companies in the market. It is certain that manufacturers and deliverers have to offer variety of combinations of products and services to survive in the rising competitive markets. (Piroozfar and Piller 2013). In this chapter, kitting refers to the definition of inbound kitting in the context of the business case study.

### 2.3.1 Benefits of kitting

According to Carlsson and Hensvold (2008), kitting has been found with many benefits recognized by several authors such as saving manufacturing or assembly space, increasing the flexibility of the workstation, better floor control due to less work with individual components, enhancing product quality due to early quality control stage in the assembly line, less education needed for new staff, possibility to implement robotic handling at site, balancing the line. However, it is pointed out at the same time by Carlsson and Hensvold the considerable limitations: time and effort consuming with no direct added value, high possibility of increasing storage space, shortage of components causing abruption in availability of kits, possible defective component causing problems, the work of picking part being monotonous and possibly demotivated.

When company considers implementing kitting solution, these factors below should be considered (Fansuri, Rose, Nik Mohamed and Ahmad 2017):

- Products quality and assembly support: kitting might better the product quality since kitted material is grouped in a way that eases the assembly activities.
- Man-hour consumption: kitted material is accessible for next assembly procedure or picking up activity.
- Flexibility in product changeover: kitting provides the possibility to flexibly modify one product to another.
- Inventory volumes and space requirement: kitted product with complex bill-of-material will require less stocking location then components being stocked separately.

### 2.3.2 Kitting and manual work at warehouse

The preparation of kits associates closely with man-hour consumption and cost. Research done by Hanson and Medbo (2016) studies critical design aspects of kit preparation process and how they affect labor consumption. To research the factors, group of authors conduct a list of aspects related to designs and contexts potentially affecting labor consumption as table 2 and table 3 below:

*Table 2. The aspects of design (Hanson and Medbo 2016)*

| Aspects |
|---|
| Batch size |
| Customization of kit container |
| Distance between kit container and component racks |
| Information system |
| Layout of picking area |
| Location of picking system |
| Moving or stationary kit container |
| No. of pickers working simultaneously |
| Picker – who prepares the kits? |
| Size of picking area (m2) |
| Tasks included in picking cycle |
| Type and size of storage packages |
| Type and design of rack for storage packages |
| Type, size and configuration of kit packaging/carrier |

*Table 3. The aspects of context aspects (Hanson and Medbo 2016)*

| Aspects |
|---|
| Amount of part numbers in kit preparation area |
| Demand on positioning of part in kit packaging/carrier |
| Demand on traceability |
| Extensive packaging handling? |
| Height of operators |

| |
|---|
| Kit production volumes |
| Lifting aid required |
| Number of parts per kit |
| Number of picks per hour |
| Part “pickability”: ease of grasp and handling |
| Part commonality (within kit or batch) |
| Part sensitivity |
| Part size |
| Part weight |
| Standard kits or not |
| Type of product |

After the analysis, the authors come to the conclusion that most important aspects affecting kit preparation process are: information system, type and size of storage packages, type, size and configuration of kit packaging, type and design of rack for storage packages, batch size, layout of picking area, moving or stationary kit container, size of picking area as of design aspects; number of parts per kit, part size, amount of part numbers in kit preparation area as of context aspects. (Hanson and Medbo 2016)

## 2.4 Economic order quantity

According to Mercado (2007), economic order quantity (EOQ) is “the order quantity for an item that is most economical with due consideration of the cost of ordering and the cost of holding inventory.” Holding costs (carrying costs) are costs which are created when a firm carries inventory. Usually, the more inventories are carried, the higher holding costs are. Ordering costs (replenishment costs) are incurred when purchasing stock from a supplier. Therefore, for a known yearly demand, the larger quantity is ordered at a time, the fewer total times order must be placed. However, ordering with big amount will result in high level of average inventory. On the other hand, to maintain low level of inventory, orders with lower quantity can be placed but more frequently. Consequently, ordering cost will increase. (Mercado, 2007)

Therefore, EOQ concept aims at finding the key point which is a balance that holding cost and ordering cost sum up the least. This point is named EOQ which stands for Economic order quantity. The formulas related to the EOQ calculation are: (Mercado, 2007)

Holding cost = order quantity/2 × (cost of item × annual holding cost)

Ordering cost = (annual usage/order quantity) × unit ordering cost

Total cost = holding cost + ordering cost

Economic Order Quantity = Square root ((2 x annual usage) x unit ordering cost)/(cost of item x annual holding cost))

The model comes with assumptions: (Mercado, 2007)

- Item taken into model is analyzed individually, independent of other items
- The annual demand is defined, accurate, and has stable demand during the year
- Each order is complete
- Lead time is constant
- Quantity discount is not possible

Figure 4 below shows visually ordering cost, inventory holding cost, and total costs relatively to Order quantity. The total costs reach the lowest value when order quantity is economic order quantity.

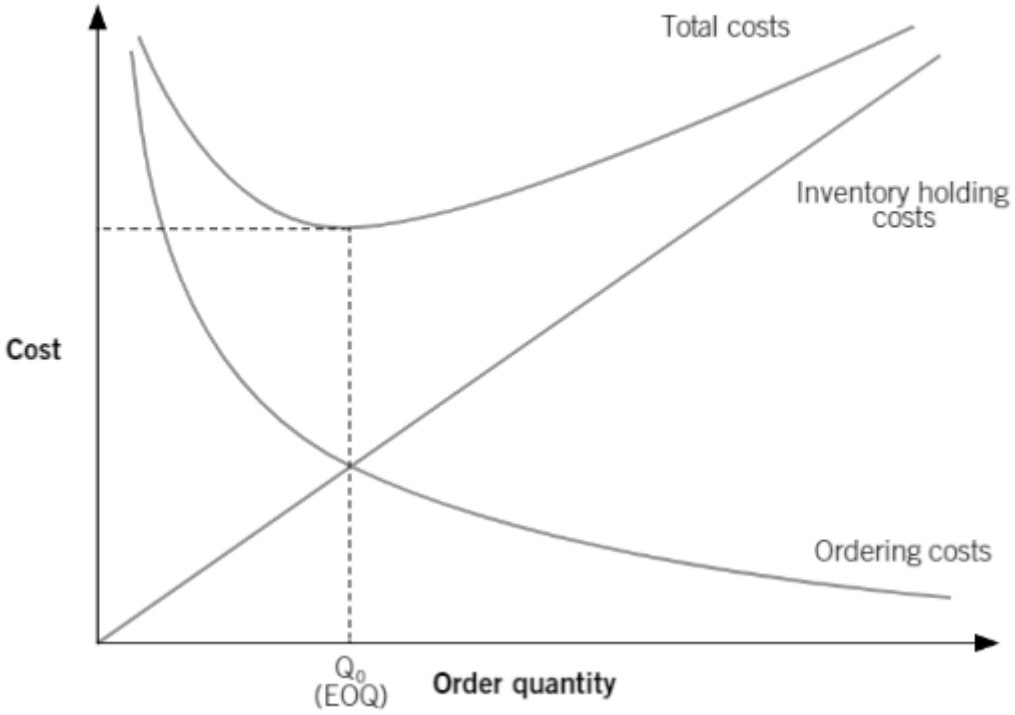


*Figure 4. EOQ cost trade-offs (Adapted from Swink et al, 2014)*

In the EOQ calculations presented above, historical demand is used. However, an annual forecast can also be used instead of historical numbers. In that case, if a trend or an external insight shows reflection on future demand, the economic order quantity will be reflective accordingly. (Vandeput, 2020) Therefore, we have:

Economic Order Quantity = Squareroot ((2 x yearly Forecast) x unit ordering cost)/(cost of item x annual holding cost))

### 2.4.1 Calculation of holding costs - K factor

K factor illustrates the amount of money per inventory value per year a company needs to spend to keep their inventory in stock. K factor is usually shown as a percentage. For examples, a K factor as 25 percent tells that the company is spending 25 cents per inventory dollar every year. In case of a dead item (no sales in long time) which values 1 dollar, it would cost 25 cents to keep the item in stock after the first year, 50 cents in total after the second year, and 75 cents in total after the third year. (Muller, 2019)

One method of calculating K factor described by Muller (2019) is summing up different expenses relating directly to the carrying inventory, which is referred as traditional accounting method. Table 4 below show an example on calculating K factor using traditional accounting method:

*Table 4 Traditional Accounting Method (Muller, 2019)*

| **Traditional Accounting Method** | |
|---|---|
| Warehouse Space | 130 000 USD |
| Taxes | 65 000 USD |
| Insurance | 40 000 USD |
| Obsolescence/Shrinkage | 23 000 USD |
| Material Handling | 64 800 USD |
| Cost of Money Invested | 200 000 USD |
| Total Annual Costs | 552 800 USD |
| $\frac{Total\ annual\ costs}{Average\ Inventory\ Vaue} = \frac{552\ 800}{2\ 000\ 000} = 26\%\ K\ Factor$ | |

## 2.5 Summary

The theory chapter describes, firstly, theories around inventory management which is a concept of managing the quantity of inventory on hand and the frequency of making orders. Next, the flow in the logistics is presented concerning material flow and information flow which are the main flows related to this research. In this session, cost reduction as a driver in improving return on investment and delivery performance are explained in deeper level. Afterwards, kitting knowledge is described including the how kitting can benefit the company, its relation to the manual work at warehouse. Lastly, economic order quantity (EOQ) is presented with its theories and calculation. The chapter ends with calculation of holding cost – K factor with an example.

# 3 METHOD

This chapter illustrates the method that will be using in this research paper including motivation of the choice of method, respondents, engagement design, research approach and analysis of the data, validity and reliability.

A methodology is described as an approach (or protocol) which outlines defined tasks according to a preferable sequence and nature of the method, and the approach in which results shall be analyzed and interpreted in the context of specified research objectives. When conducting scientific research, there are broad and variety directions to follow. There have been cases when cost has been involved as a result of not well-defined approach. Therefore, thoughtful decision on the type of methodology to be used should be made to avoid those avoidable costs. The method should also provide a flexibility to include special contents depending on each research case. (Mukherjee 2019)

## 3.1 Choice of method - action research

The methodology used in this research paper was action research which aimed at both taking action and creating knowledge. According to Coghlan and Shani (2018:10), "action research is also viewed as a managerial approach to taking action and while doing so embedding in the practice a scientific discovery process that can enhance both the action and generate a deeper level understanding of the issue at hand." It is an ideal method when there is a need for fulfilling academic performance and practical organization improvement. (Coghlan and Shani 2018)

Table 5 below explains an overview of three main research approaches: positivist science, interpretist, and action research. Positivist science is conducted based on natural sciences and aims at building an objective science by separating fact from value which can be materialized by scientific method of hypothesis formulation, investigation, verification. On the other hand, interpretist approaches aims at exploring "the meanings that organizational members hold about events in the organization" (Coghlan and Shani 2018:19). However, both positivist science and interpretist approaches focus on generating knowledge. As also explained in the previous paragraph, action research is

conducted based on different foundations, action, or participation and focuses on organizational improvement and seeks for actionable knowledge. (Coghlan and Shani 2018)

*Table 5. Comparing forms of research (Coghlan and Shani 2018)*

| | Positivist science | Interpretist | Action research |
|---|---|---|---|
| Research question | What can be proven? | What is interesting? | What is useful? |
| Data gathering methods | Detached | Participation observation | Active engagement |
| Data analysis | Statistical | Contextual | Participatory |
| Qualification | Internal | External and internal validity | Experiential |
| Quality | Validity | Credibility | Actionability |
| Role of researcher | Detached | Detached | Engaged |
| Audience | Academics | Academics | Academics and practitioners |

Action research was chosen for this research paper because of the actual need raised by the company which was to evaluate the current setting of the kit (inbound/outbound) and make a decision if the kitting type shall be changed to the other. As described below in table 6, the company's development process consisted of steps that corresponded to this research's progress when action research was conducted. As we can see from the table 6, there are two cycles of actions.

*Table 6. Aligned research progress with company's development process*

| | **Cycle of action** | **Company's development process** | **Research's progress** |
|---|---|---|---|
| TIME | First cycle | Kick-off project - problems identified | Problem statements formed |
| | | Getting insights from different teams: interviews | Data collection: interviews |
| | | Analysing and action planning | Data analysis and action planning |
| | | Taking action | Taking action |
| | Second cycle | Review: interviews | Review: interviews |
| | | Analysing and action planning | Data analysis and action planning |
| | | Taking action | Taking action |
| | | Review: interviews | Review: interviews |
| | | Project wrap up | Discussion and conclusion |

## 3.2 Respondents

This session provides details on respondents who involved into the action research.

### 3.2.1 First, second, third-person approach in action research

Action research involves three practices: first, second, and third person (Coghlan and Shani 2018):

- First-person approach: the research conductor paid high attention to her own learning-in-action. The researcher directly engaged in the action research cycle, shaped the problems, presented hypotheses, suggested actions.
- Second-person approach: engagement in collaborative work and shared action with others acting on mutual concerns (by dialogue, conversation, and action).
- Third-person approach: contribution of the research to the audience who do not directly involve (through reporting, publishing, being examined)

In this research, second-person approach and third-person approach were chosen.

### 3.2.2 Profiles of respondents

Table 7 below explains key people directly involved in the collaboration process who got important knowledge, experience, insights needed for the research and were invited to interviews (second-person approach). The research involved discussions with the business controller and four different team: planning team, product development team, distribution center team, logistics team. The kitting type evaluation process described in this research happened in planning team.

*Table 7. Second-person approach profile*

| Approach | Profile | Team | Earlier Involvement | Input |
|---|---|---|---|---|
| Second person | Team member 1 | Planning team | She has been taking care of the planning for creating inbound kits | Difficulties in inventory planning for creating inbound kits in the past and its pros and cons |
| Second person | Key user (a senior with profound knowledge) | Planning team | Knowledge of kits planning | Knowledge of kits planning |
| Second person | Team manager | Planning team | Knowledge of kits planning, team's KPI knowledge | Key KPIs which would be affected by this research. Suggestion on some good practices |
| Second person | Product development team manager | Product development team | His team has been creating of new kits | Current practice on creating new kits, difficulties, suggestion, his team's objectives |
| Second person | Distribution center manager | Distribution center | He has been overseeing the operation for the whole distribution center | Difficulties in kitting in warehouse side, objectives |

| | | | | |
|---|---|---|---|---|
| Second person | Logistics team member and Logistics manager | Logistics team | They have been interacting with distribution center directly and monitor the flow of goods | The situation of kits creation in inbound and outbound, and how their costs are managed. |
| Second person | Business controller | Business controller | Cost management | Calculation of holding costs |

Planning team oversees the inventory planning and purchasing of kits in the business as well as collaborates across departments to ensure the availability of kits when there are sales orders. From planning team, one team member, key user, and team manager were interviewed. The team member was the current in-charge-person for the inventory planning of inbound kits. She had the most updated knowledge of current practices in inventory planning and difficulties that they were facing. Key user, who was a senior team member with profound knowledge across fields, was interviewed since he had involved in similar project before regarding kitting and had good general knowledge of kits planning and other related key performance indicators (KPI). Lastly, team manager was interviewed since he had general knowledge of kitting as well as well understanding of team's KPI and direction for the research.

Product development team is responsible for monitoring customer needs and suggest the creation of new kits if there is a need. Kit creation request has always come from product development team.

The kitting activities happen at distribution center where kit parts are assembled and stored. There was a need to understand the situation at warehouse, their workload and practice to make good stocking decision so that workload at warehouse was manageable to give optimal results.
The logistics team interacts directly with distribution center and monitors closely the flow of goods inside distribution center. They also have the knowledge of how cost of each type of kitting is calculated.

Business controller does the financial report monthly and has the updated information of the financial result for the inventory at distribution center. She is familiar with cost calculations.

After the research was completed, the result of the research was published internally in the company which all employees would have access to. Employees might read the description of the tool for general knowledge or future reference when needed, which is described in table 8 below.

*Table 8. Third person approach profiles*

| **Approach** | **Profile** | **Team** | **Earlier Involvement** | **Gain** |
|---|---|---|---|---|
| Third person | Other employees | All teams | Possibly some experience/none | Getting the knowledge of the process for future reference |

## 3.3 Engagement design

This session explains how to design the engagement with key people mentioned in point 3.2 in the proposed action and knowledge generation and how to develop partnership with them.

As described by Schein (2009) cited in Coghlan and Shani (2018), pure inquiry is a useful approach to engage with second-person. The interviewer listens carefully to others' experience of the issues and explores the story of what was happening. Some examples of pure inquiry interventions used are: "Tell me what happened?", "What is the situation?", "Who explained what to whom?". This approach was chosen in this research to fully explore the current practices and procedures being done by other teams.

The second engagement approach used was diagnostic inquiry. Diagnostic inquiry is designed to guide the respondents' thinking process by asking questions that triggered causal thinking. Some examples of diagnostic inquiry interventions used are: "What do you think was going on?", "How do you understand the process?". (Schein 2009 cited in

Coghlan and Shani 2018) Thanks to this approach, the researcher was able to get underlined thinking behind the process done and other teams' understandings towards it.

The third engagement approach was confrontive inquiry which is used when researcher shares her idea and challenges the respondents to think from a different angle, described by Schein (2009) cited in Coghlan and Shani (2018). Examples are: Have you thought about this approach? Might this be an explanation? Regarding this research, the researcher was able to explore innovative perspectives from different teams towards the kitting process.

## 3.4 Research approach and analysis of the data

The action research was designed according to meta-cycle of action research presented by Coghlan and Shani (2018) in figure 5 below:

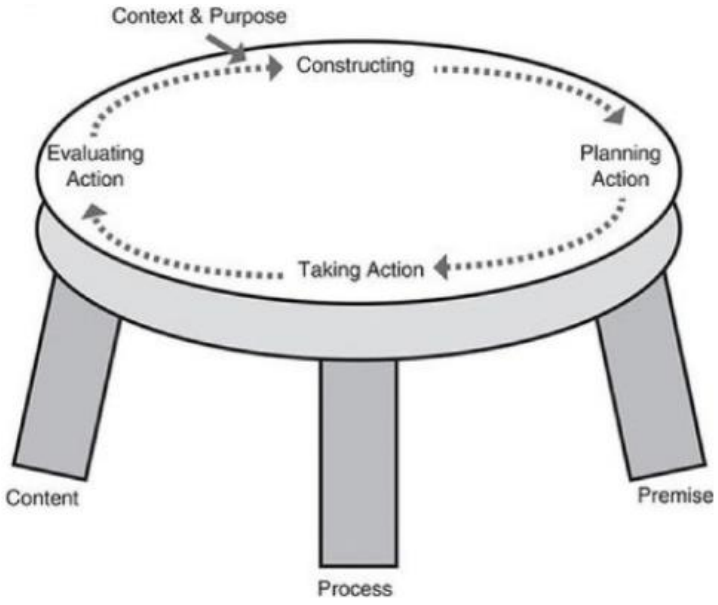


*Figure 5 Meta-cycle of action research (Coghlan and Brannick, 2014)*

The research started with constructing. Constructing involved identifying key issues as a working theme for the purpose of defining which action to be planned and taken (Coghlan and Shani 2018). In this research context, first round interviews were organized with the team member, key user of the planning team. The interviews were constructed in order to identify problems they were facing. Another interview was done with the planning team

manager to specify context of the development, and goals to be achieved. Follow up communication was done with the planning team afterward to ensure aligned vision and timeline. Next, the interviews were done with the product development team manager, distribution center manager, logistics team, and the business controller to achieve multi-perspective knowledge on the matter.

Second phase was planning action. Following by the exploration of context and goals, action planning focuses on mapping the steps to be carried out. A timeline was put down ensuring that there was enough time for evaluation and replan. Actions were then allocated between project team members and deadlines were set.

Third phase was taking action. The researcher acted as planned according to timeline. During this phase, project meetings were organized on weekly basis with the mentor from the company to keep track of plan and enhance collaboration amongst the team. Meanwhile, research was documented in terms of "what" actions were taken, "how" the initial impact was, "how" the reactions to changes were.

After acting phase, the research came through evaluation phase which was to observe some aspects of the changes. The impact was observed by collecting feedback from stakeholders (second-person) through a second round of interviews and other operational data. Afterward, the outcome was analyzed to assess if the original goals were reached. The author came to conclusion that there needed to be another cycle of action research. This research included cycle 1 and cycle 2 according to figure 6 below. After going through re-constructing, re-planning action, re-taking action, re-evaluating action, the research was concluded with the desired outcome.

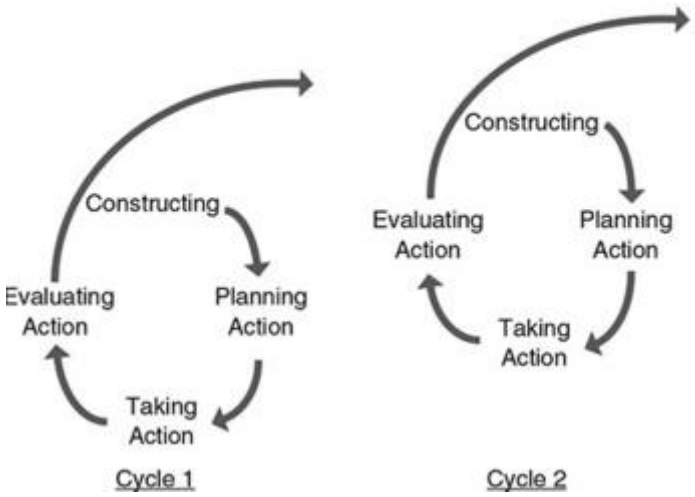


*Figure 6 Cycles of action and reflection (Modified from source: Coghlan and Brannick 2014)*

### 3.4.1 Data collection through interviews

Data collection method used in this research was qualitative interview. The interviews were carried out twice with planning team and once with product development team, logistics team, distribution center manager, business controller. Since the existing knowledge of current practices was limited, interview as a data collection method was needed to get most data possible including their knowledge, experience, objectives, and suggestion.

The interviews were designed with semi-structure format. With semi-structured format, even though topic was formatted with basic questions, interviewer had the possibility to modify sequence of questions depending on participants. Follow-up questions were formulated according to participants' responses. Researcher formulated questions in order to trigger free-range conversations. (Flick 2017)

The interview guides (see Appendix 1) in general included 3 main parts. Firstly, general background questions were placed to the interviewees for the purpose of re-assessing the relevancy of the respondents' backgrounds with different knowledge gaps. Secondly, more specific questions were placed mainly to discover the knowledge of the existing practices including disadvantages and advantages. Finally, the interviewer placed

questions to seek for innovation, suggestions, preference, expectation of the respondents towards the new practice to be developed. The structure presented here is in high level. Since respondents came from different backgrounds, the interviewer had to adjust the questions range and their depth according to the profiles.

The interviews were taken place online via Teams platform. There were 10 interviews carried out in total, which lasted from 30 to 45 minutes in average. The first round of interview happened in July 2022 in data collection phase (first cycle). The second round of interview happened from August to September 2022 in review phase (second cycle).

### 3.4.2 Data analysis method - thematic analysis of interviews data

The data analysis method used in this research is thematic analysis. According to Gibson and Brown (2009), thematic analysis enables a mean to link diverse experiences or ideas together, represent and recontextualize the data in a way that create new readings and rendering. The data analysis method suited well in this research since the process involved many teams with different experience and objectives towards the process. There are three sets of aims of thematic analysis Gibson and Brown (2009):

- Examining commonalities: aiming at capturing commonalities across data set which will be analysed further later. Commonalities in this research might include similar in objectives across teams, similar practices in handling kitting.

- Examining differences: aiming at identifying differences across data set and their relevance to the defined problems. Differences in this research might include conflict of interest across team, different practices in handling kitting.

- Examining relationships: aiming at how different aspects contributed to overall analysis and understanding of the issues. Relationship in this research might include how conflict of interest could be compromised in the overall process.

The interviews were recorded and transcribed into text within 24 hours after the interviews taking place. The data analysis consisted of six steps, following the steps described by Braun and Clarke (2006):

1) Researcher got familiar with the data through reading, re-reading the transcripts and other related data many times.

2) Initial codes had been generated by organizing data into a structured manner to present concrete meanings by colour coding and note taking.

3) Exploration of themes had been done by studying how codes were relatable to each other in forming overall themes. All responses were taken in consideration to formulate themes that cover across the answers.

4) Themes identified in step 3 had to be reviewed, modified, and developed further. The number of themes was narrowed down to a reasonable number, some themes were combined when there was big overlapping.

5) Researcher defined the themes and generate enhancement of the themes.

6) The researcher wrote the report by filtering themes which contributed greatly to the answers to the research questions.

## 3.5 Validity and reliability

Validity, as defined by Jupp (2006a:311), is the "extent to which conclusions drawn from research provide an accurate description of what happened or a correct explanation of what happens and why." While using action research as the method for the research, everything researcher has done is considered to be an intervention (Coghlan and Shani 2018). Interviews are interventions into the system and could be seen as an impact on the validity of the data, especially when the researcher is also working in the same company. However, these interventions could be seen as an advantage to understand better the context and interviews' results. The researcher aimed at not showing personal opinions and prevented any interference as most as possible.

On the other hand, reliability described the degree that what measured was measured accurately. Since the interviews were aiming to explore different teams' objectives towards a common procedure - kitting, through a joint interest, there might be a possibility that interviewees were not completely honest when giving an answer. For examples, one's objective might be exaggerated during the interview so that they would compensate less

in the joint effort with other teams. To tackle this issue, researcher made sure all interviewees were informed about the purpose of the research and the harmonization between teams. During and after the interviews, researcher was to recognize exaggerations and treated them correctly.

### 3.5.1 Ethical issue

The company is to remain anonymously in this research as agreed with the company. The objectives of the research and the nature of it were communicated well to all interviewees before proceeding further into the research.

Informed consents were collected from all interviewees, blank form to be presented in Appendix 2. It was informed in the consents that the transcripts from the interviews would not be disclosed in any circumstances, only relevant extracts would be added to the research's result. The interviews would be recorded and stored under One-Drive of student account at Arcada University of Applied Sciences server. Interviews were to be transcribed within 24 hours after they were taken place. In the transcription, all the names would be coded to ensure confidentiality for all participants. All recordings would be destroyed as soon as the research completed.

# 4 RESULTS

This chapter describes the final results of the research, presented according to the two research questions:
Research question 1: What are the factors that affect the decision whether inbound or outbound kitting to be used?
Research question 2: How to make a decision to switch to the more cost-effective kitting type?

## 4.1 Factors affecting the decision whether inbound or outbound kitting to be used

Regarding research question 1, the collection of data from the interviews with experts in the company reviewed that the factors below affected the suitability of each kitting type in different situations:

- Technical changes: As outbound kits are formed in outbound area together with normal sales orders, no assembly activities or technical changes can be done. Outbound area is only able to do pick and pack activities. However, inbound kits might involve assembly activities or technical changes.
- Demand: In outbound area, pick and pack activities of the components are done against sales orders one by one. On the other hand, in inbound area, pick and pack components can be done in bigger quantities depending on the inventory planning. Therefore, if the demand is big and frequent, it takes considerably less time to prepare the kit in inbound area. Additionally, outbound kits, which take time to prepare, are done together with normal orders. Frequent demand outbound kits create pressure for outbound to meet the deliveries requirement.
- Cost of creation of kit: The cost for assembling and picking and packing in inbound area is calculated differently from the cost for picking and packing in outbound area.
- Number of components: Pickings of components for outbound kits are mostly done by the automatic conveyor belt. On the other hand, pickings of components for inbound kits are done manually. In terms on inventory planning for inbound kits, it is harder to execute the planning if the number of components is too high.
- Dimensions of components: if the components are bigger than the bins which are used in the automatic conveyor belt, they must be picked manually onto a pallet.
- Obsolescence risk: since inbound kits are stored as individual SKUs, there is higher risk for them to become obsolete if the demand drops.
- Variability of a family of kits: there are families of kits (kits which are little different from each other) which are difficult to maintain inventory planning in inbound area.

- Criticality: There are critical kits which the company must always ensure their availability. Availability can be managed easier if the critical kits are maintained as inbound kits.

The author recognized that the factors can be categorized into two groups: planning factors and design factors as following:

- Planning factors: demand, cost of creation of kit, obsolescence risk, criticality. They are factors which bring a different result on annual cost depending on what kind of kitting is used.
- Design factors: technical changes, numbers of components, dimensions of components, variability of a family of kits. They are factors which are defined in the product development phase. They do not bring a different result on annual cost regardless of what kind of kitting is used.

## 4.2 Kitting type evaluation tool

After collection and analysis with the data for research question number 1, the author created a tool in form on an Excel sheet which reviewed all the current kits (outbound and inbound) and gave the decision if the kitting type had to be change from one to another, see Appendix 3. The fundament of the tool was calculating annual cost for the current kitting type and estimation annual cost for the other kitting type. The annual cost if kitting type is inbound was done based on economic order quantity theory for past demand. The annual cost if kitting type is outbound was done based on actual past demand. The tool can be briefly described as below:

- The author calculated holding costs - K factor according to the year-to-date data provided by the business controller.
- Data was taken from the system which included SKU, current kitting type, number of components, last one year demand, cost of creation in inbound if current kitting type is inbound, total value of all components.
- The tool calculated annual cost when a kit is inbound and outbound.
- A control table was created with values A, B, C, D below which were decided by the management of the company, see Appendix 3:

    - Upper bound for absolute Inbound (A): If demand is higher than this value, kit must be inbound kit.
    - Lower bound for absolute Outbound (B): If demand is lower than this value, kit must be outbound kit.
    - The difference between two costs must exceed this value (in percentage): C (%)
    - The difference between two costs must exceed this value (in monetary value): D (EUR)
- The tool made initial decision which kitting type has lower cost based on logic:
    - If yearly demand is higher than A, kitting type must be inbound.
    - If yearly demand is lower than B, kitting type must be outbound.
    - If B<yearly demand<A, kitting type should be the one with lower annual cost.
- The tool made final decision if kitting type should be changed to the other type following logic:
    - If current kitting type is outbound and yearly demand is zero, kitting type should remain as outbound
    - If current kitting type is outbound and yearly demand is not zero, kitting type should be changed to inbound if the cost difference is higher than both C (%) and D (EUR)
    - If current kitting type is inbound, kitting type should be changed to outbound if the cost difference is higher than both C (%) and D (EUR)

The tool suggested to change a certain quantity of outbound kits to inbound kits, which resulted in a decrease of 8.5% of total number of outbound kits sales order lines. This decrease would substantially release pressure in outbound area to meet the require delivery performance (delivery on the requested date by customers) as outbound kits take much more time to prepare than normal deliveries.

In overall, the tool forecasted to make a saving impact of 8% total costs for both types of kitting in the first year. The impact was calculated by how much in monetary values the company could have saved by changing the kitting type to the other type in case all the suggestions made by the tool are approved.

# 5 DISCUSSION

In this chapter, the results from the data collection, actions taken and methodology used are discussed. The results presented in chapter 4 are discussed more deeply regards their data, their relationships towards each other, and meaningful findings. The author used action research as the methodology and qualitative semi-structured interviews as a method of data collection.

## 5.1 Discussion of results

The discussion of results is presented for each of the research question, which also follows timeline of two cycles of action in action research as specified in chapter 2. The first cycle of action gathered the data to answer research question 1 and put foundation for shedding light on research question 2. A preliminary tool (version 1) was created by the author at the end of first cycle of actions. The second cycle of actions gathered feedbacks and suggestions on the preliminary tool. The tool was completed at the end of second cycle of action (version 2).

### 5.1.1 Factors affecting the decision whether inbound or outbound kitting to be used

The author conducted interviews with experts in the field to distinguish the factors which affect the decision whether inbound or outbound kitting shall be used. As specified in chapter 4, they are: technical changes, demand, cost of creation of kit, numbers of components, dimensions of components, obsolescence risk, variability of a family of kits, criticality. As also mentioned in chapter 4, the factors can be categorized into two groups: planning factors, and design factors. In other words:

- Planning factors (demand, cost of creation of kit, obsolescence risk, criticality): They are factors which bring a different result on annual cost depending on what kind of kitting is used.
- Design factors (technical changes, numbers of components, dimensions of components, variability of a family of kits): They are factors which are defined in

the product development phase which do not bring a different result on annual cost regardless of what kind of kitting is used.

Table 9 below illustrates the data which defined the factors and the reasons each factor belongs to the categorization.

*Table 9. Factors and elaborations on why they belong to different category*

| Category | Factors | Elaborations |
|---|---|---|
| Planning factors | Demand | Demand remains the same for both kitting types. However, demand affects how effective the distribution center works, as distribution center cannot handle too big volume of outbound kit.<br>As also mentioned by warehouse manager, outbound kits affect the normal orders and increase the backlog situation: "*we have a dedicated amount of packing desks where we can do the overall daily work for the outbound... people need to do outbound kits next to the normal daily business*", "*So probably real important orders are left behind on that day*".<br>As mentioned in chapter 2, on time delivery of goods is specified as highly important factor in delivery performance measures, which thereby determines customer satisfaction.<br><br>Therefore, high demand kits should have inbound kitting type. |
| | Cost of creation of kit | Each kitting type has different method to calculated their cost.<br><br>Depending on the type of kitting, the cost generated annually will be different |

| | | |
|---|---|---|
| | Obsolescence risk | Inbound kit is stored as separate SKU. Therefore, if the inbound kit demand drops, they will become obsolete as whole kit. Outbound kit is not packed together until the sales order is generated. Therefore, there is no obsolescence risk for the outbound kit.<br><br>Depending on which kind of kitting type is chosen, the obsolescence kit will exist or not. |
| | Criticality | The company has "*lower power to maintain certain quantity available in stock if kit is outbound"*, mentioned by the Manager of the Planning team.<br><br>Therefore, if kit is critical (there needs to be always some quantity in stock), kitting type should be inbound. |
| Design factors | Technical changes | Technical changes are defined in design phase by the product development team. |
| | Number of components | Number of components is defined in design phase by the product development team. |
| | Dimensions of components | Dimensions of components are defined in design phase by the product development team. |
| | Variability of a family of kits | Variability of a family of kits is defined in design phase by the product development team. |

The design factors are independent from each other. They are defined from the planning phase, and the change of this factor will not affect the other factor. For examples, the technical changes do not change the number of components or vice versa. Indeed, as mentioned in chapter two, Hanson and Medbo (2016) described numbers of components (mentioned as "number of parts per kit"), dimensions of components (mentioned as "part

size" and "part weight"), variability of a family of kits (mentioned as "part commonality (within kit or batch)) as context aspects. These factors, in relation to research question 2, do not contribute the model as they do not bring changes to the cost-effectiveness annually.

On the other hand, the planning factors affect each other as:

- When the demand is frequent and high, there is less chance of the kits becoming obsolete as stated by the manager of Planning team: *"For the high-movers, there's less chance for them to become obsolete.*"
- When a kit is critical (there should be always a quantity available in stock), there is a higher risk of being obsolete.
- The cost of creation of kit is calculated differently for each kitting type. Therefore, with different demand, the cost of creation annual will be different.

The planning factors related closely to the cost-effectiveness annual; therefore, they were included in the research question 2.

The results taken from research question 1 had significantly contributed to the formation of the tool regarding research question 2. In other words, they gave a foundation to explain how certain methods were chosen in the evaluation tool.

### 5.1.2 Kitting type evaluation tool

With the data collected from the first round of interviews, the author moved forward to creating the tool which evaluates the current kitting type. The tool, in form of an Excel sheet, calculated the cost for the current kitting type and estimated cost for the other kitting type annually. As mentioned in chapter 5.1.1, the four planning factors which were to be considered in answering research question 2 were demand, cost of creation of kit, obsolescence kit, criticality.

The author started with creating the first version of the tool. Regarding inbound kits, they are stored as separate SKUs, which means obsolescence risk and holding cost are applicable as a whole kit. The inventory planning for inbound kits also requires extra administrative cost and ordering cost. Therefore, annual total cost for the economic order

quantity model was determined to be the most suitable calculation. In fact, the company uses economic order quantity in the inventory planning platform as a basic foundation. As mentioned by Mercado (2007), the key point is finding a balance which holding cost and ordering cost sum up the least. The author created the total annual cost using EOQ model with:

- Annual usage: previous year demand, taking data from enterprise resourcing planning system (ERP)
- Holding cost: taking data from financial report. Calculation was based on the traditional accounting method presented in chapter 2.4.1.
- Cost of item: taking data from ERP
- Unit ordering cost: defined value from other study in the company

The total cost for inbound kits was calculated with formula:

- Total cost(inbound) = holding cost + ordering cost = order quantity/2 × (cost of item × annual holding cost) + (annual usage/order quantity) × unit ordering cost
- Economic Order Quantity = Square root ((2 x annual usage) x unit ordering cost)/(cost of item x annual holding cost))

Regarding the annual cost for outbound kits, cost was calculated based on number of sales orders. Therefore, total annual cost for outbound kits was simply:

- Total cost(outbound) = number of sales orders * cost per sales order.

Afterwards, the two costs were compared. The kitting type with lower annual total cost was chosen. This was the end of first cycle of action.

To start the second cycle of action, the author conducted the second round of interviews with the interviewees to get their feedback on the tool. Feedbacks and their corrective actions were compiled in table 10 below:

*Table 10. Feedbacks from interviews round 2 and their corrective actions*

| Feedback | Corrective actions |
|---|---|
| Key user from Planning team: "*A kit should not be switching from one type to another every time the analysis is done as the change takes time and extra work. There should be a "gray area" where the difference can be tolerated".* | C value and D value were defined and included in the tool with:<br>- C (%) as the difference between two costs must exceed this value (in percentage).<br>- D (EUR) as the difference between two costs must exceed this value (in monetary value). |
| Team member from Planning team: *"when the demand is too high, outbound area will be under much pressure"*. | A value was defined and included in the tool with logic:<br>- If yearly demand is higher than A, kitting type must be inbound. |
| Team member from Planning team: *"when the demand is too low, outbound kit should be recommended"*. | B value was defined and included in the tool with logic:<br>- If yearly demand is lower than B, kitting type must be outbound. |

The author completed the tool according to feedback and corrective actions. Completed Excel tool is presented in Appendix 3. C and D values needed to be defined by the manager of Planning team. Therefore, to help the decision-making, the author compiled a table of possible impact on annual cost saving when C and D vary with color range, see Appendix 3.

Table 11 below illustrated the advancement from the tool version 1 to the tool version 2.

*Table 11. Advancement from the tool version 1 to the tool version 2*

| Version 1 | Version 2 |
|---|---|
| Holding cost calculation | Holding cost calculation with accurate data from financial report |
| Total annual cost for inbound kit using EOQ method | Total annual cost for inbound kit using EOQ method |
| Total annual cost for outbound kit | Total annual cost for outbound kit with more accurate cost factor |
| Initial kitting decision if a kit should be inbound or outbound | Initial kitting decision if a kit should be inbound or outbound with constraints A value and B value |
| | Final decision to check if the kitting type should be changed to the other with constraint C value and D value |
| | Table of possible impact on annual cost saving when C value and D value vary. |

## 5.2 Discussion of method

The author chose action research aiming at taking meaningful action for the company and creating knowledge. The method of data collection was qualitative interviews in form of semi-structure interviews. The interviews were conducted only via Teams according to the timeline despite the difficulties in organizing the interviews due to summer holiday.

The action research method had allowed the author to match the research's target with the company's need. Due to having two cycles of action, the method allowed the research to get sufficient data, take actions, get feedbacks on the actions, correct the actions. Therefore, the action research helped the author to meet the expectation from the commissioned company. The action research method was, indeed, the most suitable method to be used in this research because if other methods were chosen, they would not have provided the author the possibility to do second round of interviews to get feedback and conduct corrective actions.

Qualitative interviews in form of semi-structure interviews provided the author great flexibility to alter the questions to get more in-depth answers from the interviewees. As the interviewees had years of profound knowledge in the field, it was important for the author to utilize the interviews and get as much data as possible.

In general, the reliability and validity of the research are fulfilled. Regarding validity, the interviewees have relevant profiles and knowledges to answer the questions from the author. The author compiled interviews to get enough data. Data collected was aligned with each other, and the author decided to stop organizing more interviews when she projected that no new and valuable data could be collected. Regarding reliability, interviews were conducted and recorded via Teams. The connection was stable, and the environment was silent. Therefore, the author was able to get clear audio record and accurate transcript.

# 6 CONCLUSIONS

This research aimed at creating an evaluation tool on current type of kitting (outbound or inbound) and decide if some kits shall be changed from one type of setting to the other. Research question 1 was: What are the factors that affect the decision whether inbound or outbound kitting to be used? Research question 2 was: How to make a decision to switch to the more cost-effective kitting type?

Regarding research question 1, there were 8 factors which were determined to affect the decision whether inbound or outbound kitting shall be used. They were categorized into two groups:

- Planning factors: demand, cost of creation of kit, obsolescence risk, criticality. They were factors which brought a different result on annual cost depending on what kind of kitting is used. The planning factors were included to be shed light on research question 2.
- Design factors: technical changes, numbers of components, dimensions of components, variability of a family of kits. They were factors which are determined in the product development phase. They were factors which did not bring a different result on annual cost regardless of what kind of kitting is used.

Regarding research question 2, a tool (in form of an Excel sheet) was created, see Appendix 3 with all the Excel formulas included. The tool calculated the cost for the current kitting type and estimated cost for the other kitting type annually with:

- Annual cost for inbound kits was calculated based on Economic order quantity concept
- Annual cost for outbound kits was calculated based on number of sales orders.

The tool then compared the two annual costs and suggest which kitting type had lower annual cost. With the constraints A, B, C and D values, the tool made the final decision if the kitting should be switched to the other kitting type in which:

- Upper bound for absolute Inbound (A): If demand is higher than this value, kit must be inbound kit.

- Lower bound for absolute Outbound (B): If demand is lower than this value, kit must be outbound kit.
- The difference between two costs must exceed this value (in percentage): C (%)
- The difference between two costs must exceed this value (in monetary value): D (EUR)

The tool suggested to change a certain quantity of outbound kits to inbound kits, which resulted in a decrease of 8.5% of total number of outbound kits sales order lines, which would increase the delivery performance. The tool forecasted to make a saving impact of 8% total costs for both types of kitting in the first year which was calculated by how much in monetary values the company could have saved by changing the kitting type to the other type in case all the suggestions made by the tool were to be approved.

In overall, the research had helped the company to gather critical knowledge and information on the kitting type selection and made it transparent to the internal employees. The tool, as a result, had also created a fundamental foundation for the company to make good decisions on the kitting type and further developments in the future.

## 6.1 Limitations of the study

The terms inbound and outbound kitting are not universal but rather specific to the company's context. Therefore, the author could not find relevant theories which studied inbound and outbound kitting specifically. Instead, only theories about kitting in general were indicated.

## 6.2 Suggestions for further studies

For further studies, the author suggested that the company should conduct further actions on how to change the kitting type in their operation activities. As the feeding concept is different, it is crucial to carefully do the changes to avoid out-of-stock situation. Furthermore, it would be considerably beneficial for the company to conduct a tool to select the kitting type when the kits are created for the first time by the product

development teams. By that, the kitting type will be selected correctly from the start, which reduces the work later on in changing the kitting type.

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# APPENDICES

## Appendix 1

Interview guide 1:

**Theme: Availability management of inbound kits**

Context: I'm writing a thesis to create evaluation tool to decide if kit should be inbound or outbound. The aim is to understand how inbound kits availability handling has been so far and their pros and cons.

*Responsibilities related to kits:

Could you please tell me about what kind of activities have you been involving in kits?

How often do you do these activities and how much time does it take for each activity every week?

Do you think you could potential spend less time on preparing kits availability?

*Difficulties and potential developments:

What difficulties have you been experiencing in managing availability of inbound kits?

What are the main factors that cause those difficulties?

Regarding those factors, what do you think could help to ease the work?

What kind of kits usually get availability easier than the others?

Please specify the objectives you consider if a kit should be inbound or outbound.

Do you need involvement from other team when preparing inbound kits? If yes, which team are they and what is their involvement? How do you understand the process?

Did you notice any difficulties in the process? If yes, what are they?

Can you tell me an example of a situation when someone comes back to you to ask questions about a kitting decision?

How do you think the procedure should be improved?

*Call for action

After the calculation and model is finished, I will schedule a feedback interview with you. Afterwards, it would be best to test the models with existing kits and I would need support from you.

Thank you for taking part in this research. Is there anything you would like to add to the subject or anything you still would like to define better?

Interview guide 2:

**Theme: Availability management of inbound kits**

Context: I'm writing a thesis to create a lean procedure in making the decision if kit should be inbound or outbound. The aim is to understand how inbound kits availability handling has been so far and their pros and cons.

*Responsibilities related to kits:

Could you please tell me about what kind of activities have you been involving in deciding the set-up for kits?

How often do you do these activities and how much time does it take for each activity?

*Pros and cons of each method:

What do you think would be the pros and cons if we have too many materials with inbound set-up?

What are the KPIs that got affected? How are those KPIs calculated?

What do you think would be the pros and cons if we have too many materials with outbound set-up?

What are the KPIs that got affected? How are those KPIs calculated?

Please specify the objectives you consider if a kit should be inbound or outbound.

What should be the KPI for measuring if kitting decision is working well?

Who else do you think I should interview with?

*Call for action

After the calculation and model is finished, I would like to schedule a feedback interview with you. I hope to be in contact with you in good time.

Thank you for taking part in this research. Is there anything you would like to add to the subject or anything you still would like to define better?

Interview guide 3:

**Theme: Assembly reality at distribution center**

Context: I'm writing a thesis to create a decision-making model to decide if kit should be inbound or outbound. The aim is to understand the handling of kits assembly in inbound and outbound area, and their pros and cons.

*Inbound and outbound area capacity:

Could you please share with me the general workload in outbound and inbound area at the moment?

How is the assembly area in inbound and outbound set up? What are the differences between them?

What kind of assembly activities can be done at each area?

How do you estimate the capacity in each area?

*Assembly cost:

How do you calculate the assembly cost in each area?

*Assembly time:

Could you please briefly describe the process if a kit goes through assembly in inbound and outbound area?

Which area usually have quicker completion time?

What are the factors that affect the assembly time? How do they affect in each area inbound and outbound? (What kind of kits that take the most time to assemble?)

*Difficulties:

What kind of difficulties have you encountered for each area?

*Call for action

If I have more questions about assembly time and cost, who can I contact from your team?

Thank you for taking part in this research. Is there anything you would like to add to the subject or anything you still would like to define better?

Interview guide 4:

**Theme: Handling of selecting kitting type in product development team**

Context: I'm writing a thesis to create a decision-making model to decide if kit should be inbound or outbound. The aim is to understand how the kitting type selection has been handled so far.

**Background questions:**

*Team scope:

Could you please briefly tell me about your team's scope of responsibilities?

From which activities do you involve with kits?

*Experience with kitting

How often does your team create new kits?

How do you decide if a kit should be inbound or outbound?

Where does your team get data for evaluation?

From whom do you need to get approval?

Please specify the objectives you consider if a kit should be inbound or outbound.

Have you thought about involving planning team in the kit create phase?

Do you need involvement from other team when considering creating new kits? If yes, which team are they and what is their involvement? How is the collaboration with them?

Did you notice any difficulties in the process? If yes, what are they?

Can you give me an example of a situation when someone comes back to you to ask questions about your kitting decision?

How do you think the procedure should be improved?

*Call for action

During my project, I would suggest ideas and need validation from your team, who can I contact?

Thank you for taking part in this research. Is there anything you would like to add to the subject or anything you still would like to define better?

Interview guide 5:

**Theme: Kitting situation at distribution center**

Context: I'm writing a thesis to create a decision-making model to decide if kit should be inbound or outbound. The aim is to understand the situation of kits assembly in inbound and outbound area, and how their costs are managed.

*Workload at distribution center:

Could you please share with me your view on the general workload in outbound and inbound area at the moment?

What are the reasons causing the backlog situation?

How do you evaluate the backlog situation? What is the latest update on that?

*Assembly cost:

Could you please tell me how is the packing cost outbound kit calculated? How is it invoiced to the company?

*Storage cost:

If we change a kit from outbound to inbound, more materials will be stored in stock. How do you calculate storage cost?

How are costs managed? Is it fixed or based on how many storage locations used?

*Difficulties:

What kind of difficulties with kits management have you noticed from distribution center?

*Call for action

Thank you for taking part in this research. Is there anything you would like to add to the subject or anything you still would like to define better?

Interview guide 6:

**Theme: Calculation of holding cost factor**

Context: I'm writing a thesis to create a decision-making model to decide if kit should be inbound or outbound. The aim of today's interview is to understand how to calculate holding cost factor for the whole stock.

Inbound kits will be stored in stock, therefore, EOQ concept has been determined as an suitable method to define order quantity which gives the smallest total cost annually. To calculate EOQ, holding cost calculation is needed.

*Holding cost calculation:

What are the costs which are generated from holding inventory?

What is formula for calculating holding cost factor in the company?

*Data:

How often is the financial result updated?

*Call for action:

In the future, is it possible for the person who runs the analysis to contact you and get fresh financial data?

Thank you for taking part in this research. Is there anything you would like to add to the subject or anything you still would like to define better?

Interview guide 7:

**Theme: Feedback on the kitting type evaluation tool version 1**

Context: I'm writing a thesis to create a decision-making model to decide if kit should be inbound or outbound. Thank you for joining the research in the first round of interviews. I have now compiled the first version of the tool. The aim of today's interview is to introduce to you the first version of the tool and get your feedbacks on it.

*Presenting the Excel tool to the interviewee

*Feedback:

What do you think about the method of calculating annual cost for inbound kits? Is there anything which is incorrect or could be improved?

What do you think about the method of calculating annual cost for outbound kits? Is there anything which is incorrect or could be improved?

What do you think about the method of selecting the suitable kitting type? Is there anything which is incorrect or could be improved?

What are other factors which have not been considered yet in the tool?

*Call for action:

Thank you for taking part in this research. Is there anything you would like to add to the subject or anything you still would like to define better?

## Appendix 2

Consent form

**Consent Form**

**The process of categorizing Outbound and Inbound kitting - company study case**

**Contact Information of Researcher:**

Anh Tran

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----------@arcada.fi

(+358) ----------

• I have read the Study Information sheet provided and been given adequate time to consider it.

• I have been given the opportunity to ask questions about the Study and any questions have been answered to my satisfaction.

• I understand that my participation in the Study is voluntary.

• I understand that taking part in the Study will involve me being interviewed and I agree to this interview being audio-recorded.

• I understand that my personal details such as name and employer will not be revealed to people outside the project.

• I understand that my words may be quoted in publications, reports, web pages, and other research outputs, but data collected about me during the Study will be anonymized before it is submitted for publication.

• I understand that I can withdraw from the Study at any time and I will not be asked any

questions about why I no longer want to take part.

• I understand that If I withdraw from the Study my data will not be used.

Name of participant: _____ Signature: _____ Date: _____

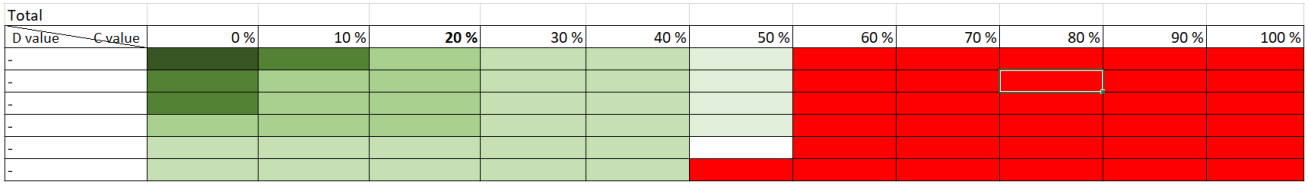
Name of researcher: Anh Tran _____ Signature: _____ Date: _____

## Appendix 3

Control table with A, B, C, and D values:

| Parameter | Value | Unit of measure |
|---|---|---|
| Upper bound for absolute Inbound (A) | -- | pc |
| Lower bound for absolute Outbound (B) | -- | pc |
| Difference between two costs (C%) | -- | % |
| Difference between two costs (D eur) | -- | EUR |

Table of possible impact on annual cost saving when C and D vary:




Kitting type evaluation tool (in form of Excel):

| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Date of analysis | 01.01.20xx | | | | | | | | | | | | | |
| 2 | Outbound cost | Packing cost | | | | | | | | | | | | | |
| 3 | | Line picking cost | | | | | | | | | | | | | |
| 4 | Inbound cost | Holding cost | | | | | Total | Outbound -> Inbound | Inbound -> Outbound | | | | | | |
| 5 | | Ordering cost | | | | Annual cost saving impact | =SUM(H5+I5) | =SUMIF(O:O;"Change to YNOR";M:M)-SUMIF(O:O;"Chan | =SUMIF(O:O;"Change to ERLA";J:J)-SUMIF(O:O;"Change to ERLA";M:M) | | | | | | |
| 6 | | | | | | No of materials changed | =SUM(H6:I6) | =COUNTIF(O:O;"Change to Inbound") | =COUNTIF(O:O;"Change to Outbound") | | | | | | |
| 7 | | | | | | Outbound lines deducted from outbound /month (lines) | =COUNTIF(O:O;"Change to YNOR") | =SUMIF(O:O;"Change to Inbound";L:L)/12 | =SUMIF(O:O;"Change to Outbound";L:L)/12 | | | | | | |
| 8 | | | | | | | | | | | | | | | |
| 9 | | | | | | | Inbound | | | Outbound | | | | | |
| 10 | Material code | Current kit setting | Number of components | Yearly demand (pcs) | Assembly cost in inbound per piece | Total value of all components | 1 year assembly cost | EOQ | Total cost Inbound | Qty per sales order line | No. ERLA lines | Total cost Outbound | Kitting decision | To change setting | Note |
| 11 | ABC123456789 | Inbound/Outbound | -- | -- | -- | -- | =Yearly demand * Assembly cost/piece | =ROUNDUP(SQRT(2*Ordering cost*Yearly demand/(Holding cost*Total value of all components));0) | =IF(EOQ=0;0;Yearly demand/EOQ*Ordering cost+Yearly demand/2*Holding cost*Total value of all components+1 year assembly cost) | -- | =Yearly demand/Qty per sales order line | =Yearly demand*packing cost+Number of components*line picking cost*Yearly demand/qty per sales order line | =IF(Yearly demand<B value;"Outbound";IF(Yearly demand>A value;"Inbound";IF(Total cost Inbound>Total cost Outbound;"Outbound";"Inbound" | =IFERROR(IF(Current kit setting="Outbound";IF(Kitting decision="Inbound";IF(Yearly demand=0;"";IF(AND(((Total cost Outbound-Total cost Inbound)/Total cost Outbound)>C value;(Total cost Outbound-Total cost Inbound)>D value);"Change to Inbound";""));"");IF(Kitting decision="Outbound";IF(AND(((Total cost Inbound - Total cost Outbound)/Total cost Inbound)>C value;(Total cost Inbound - Total cost Outbound)>D value);"Change to Outbound";"");""));"") | |