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## **Impact of E-commerce on Warehouse Management of a Retail Company**

Inês Filipa Teixeira Homem Batista

Master in, Management

Supervisor:

Professor Sofia Kalakou, Department of Marketing, Operations and Management,  
ISCTE Business School

November, 2021





**BUSINESS  
SCHOOL**

Department of Marketing, Operations and Management

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Inês Filipa Teixeira Homem Batista



## **ACKNOWLEDGEMENTS**

I would like to express how overwhelming it is to submit this master thesis that marks the end of 5 incredible years of friendship and learning at ISCTE.

First, I want to thank everyone from logistics department for welcoming me very well and for helping me anytime I needed.

To my supervisor, Professora Sofia Kalakou, I would like to thank for all the support throughout these months, for the availability, motivation and guidance.

To my parents and my brother for believing in me, for their patience and motivation, for always encouraging me along this path.

Last but not least, to my friends Beatriz, Diana and Juliana for the unconditional emotional support and friendship.





# **Impact of E-commerce on warehouse management of a retail company**

## **ABSTRACT**

Over the last years, with the rise of digitalization and customers' expectations, E-commerce has been a crucial tool of companies' competitive advantage in order to achieve customer satisfaction. Companies are challenged with the integration of omnichannel on warehouse operations to deliver perfect orders at a lower cost as fast as possible. Warehouse is one of the key elements of a supply chain and from the several activities within, order picking is the most labor-intensive and costly activity, representing around 50% of the total of the costs of the warehouse operation (Frazelle, 2002; Koster, Le-Duc, & Roodbergen, 2007).

This study focuses on the assessment of picking performance in the warehouse of IKEA Loures store, a Swedish company classified as the world's largest furniture retailer. Based on direct observation and archival records, the impact of Hybrid Project implementation on picking activity is analyzed through the calculation of Key Performance Indicators.

The results show that significant labor-savings are possible and picking efficiency improved.

**Keywords:** Warehouse Management, Performance, E-commerce, Logistics, Picking, Key Performance Indicators

**JEL Classification System:** L80 – General; L810 – Retail and Wholesale Trade; e-Commerce;



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### **RESUMO**

Ao longo dos últimos anos, com o aumento da digitalização e das expectativas dos clientes, o E-commerce tem sido uma ferramenta crucial de vantagem competitiva para atingir a satisfação dos clientes. As empresas são desafiadas com a integração do omnichannel nas operações do armazém, de forma a entregar encomendas perfeitas a um custo baixo e o mais rápido possível. O armazém é um dos elementos-chave de uma cadeia de abastecimento e das várias atividades nele existente, o processo de picking é a atividade que requer trabalho mais intenso e a mais cara, representando cerca de 50% dos custos totais da operação do armazém (Frazelle, 2002; Koster, Le-Duc, & Roodbergen, 2007).

Este estudo foca-se na avaliação do desempenho do picking no armazém da loja IKEA Loures, uma empresa sueca classificada como a maior retalhista de móveis do mundo. Com base na observação direta e registos em arquivo, o impacto da implementação do Projeto Híbrido na atividade de picking é analisado através do cálculo de Key Performance Indicators.

Os resultados mostram que a poupança na mão de obra é possível e que a eficiência do picking melhorou.

**Palavras-chave:** Gestão de Armazém, Performance, E-commerce, Logística, Picking, Key Performance Indicators

**JEL Classification System:** L80 – General; L810 – Retail and Wholesale Trade; e-Commerce;



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## **LIST OF ABBREVIATIONS**

CCD: Central Customer Delivery  
CDC: Customer Distribution Centre  
CPU: Customer Parcel Units  
ERP: Enterprise Resource Planning  
FSFA: Full-Serve Furniture Area  
HFB: Home Furnishing Business  
KPI: Key Performance Indicator  
LCD: Local Customer Delivery  
MHS: Möbel Hus System  
PUP: Pick Up Point  
RDT: Radio Data Terminal  
SGF: Store Goods Flow  
SKU: Stock Keeping Unit  
SL: Sales Location  
SLM: Sales Location Management  
SM: Sales Method  
SSFA: Self-Serve Furniture Area  
TSP: Transport Service Provider  
ZL: Zone link



# Impact of E-commerce on warehouse management of a retail company

## 1. INTRODUCTION

### 1.1 Problem statement

Nowadays, the rise of digitalization pushed retailers to redefine their business models towards omnichannel retail (Buldeo Rai, Verlinde, & Macharis, 2018). The way consumers shop today, their behavior and expectations, are having a significant effect on how retailers engage with their customers. Retailers need to become more innovative within their supply chains to increase productivity and be more efficient, reduce cost and inventory while improving customer service in order to reduce their order lead times (Richards, 2014).

E-commerce is possibly the most promising application of information technology in recent years, it is transforming supply chain management and has enormous potential for manufacturing, retail and service operations (Gunasekaran, Marri, McGaughey, & Nebhwani, 2002). Over the last years, the growth of e-commerce and increasing demand from consumers has seen a steep change in warehouse operations. Last year, covid-19 changed the way consumers started buying and a lot of companies had to adapt to survive in the market and fulfil customers' needs through digital services.

IKEA is the largest furniture retailer in the world, known by low cost flat-pack furniture and well-designed stores. In 2020 e-commerce accounted for more than 16% of total retail sales compared to 10% in 2019. This sharp increase in online sales was mainly due to the coronavirus, but IKEA had already incorporated the online channel as a part of its digital transformation strategy.

This research focuses on Loures's store. Currently, this facility has been challenged with many transformations at its infra-structures to become the Customer Distribution Centre in Portugal in a few years. The first stage is the implementation of the Hybrid Project in the store's warehouse, which is a forward reserve area for efficient order picking.

According to Koster, Le-Duc, & Roodbergen, (2007) among the warehouse's various operations, order picking has been identified as the most labor-intensive and costly activity, representing about 50% of the warehouse total operating expense. Any underperformance in order picking can lead to unsatisfactory service and high operational cost for the warehouse. Reducing the travelling distances across the warehouse could be a way to improve the picking process.

Considering the several challenges that logistics operation is currently facing, this project aims to analyze the picking performance after the implementation of the Hybrid Project, based

on Key Performance Indicators to conclude if improved efficiency of the logistics operation was achieved.

## **1.2 Project Milestones**

The main goal of the dissertation is the assessment of picking performance in the warehouse after the Hybrid Project implementation. To accomplish this objective, the following milestones should be achieved:

- a) Describe warehouse processes – receiving, storage, replenishment, picking and shipping.
- b) Definition and measurement of Key Performance Indicators based on performance objectives.
- c) Present the results and assess the impact on the current situation

## **1.3 Structure of the project**

This project will be structured in the following way:

### **Chapter 1 – Introduction**

The first chapter presents the research problem, respective milestones, and structure of the project.

### **Chapter 2 – Literature Review**

In this chapter, it will be presented the theoretical support for the execution of the project, developing the main concepts and strategies under analysis related to logistics management, warehouse activities and performance measure.

### **Chapter 3 – Methodology**

In the third chapter, the methodology applied to achieve the main goal will be explained.

### **Chapter 4 – Case study description**

In this chapter, there is going to be a brief overview of the company, followed by the description of logistics operations and the implementation steps of the Hybrid Project. After, the evaluation of picking performance is studied.

### **Chapter 5 – Conclusion**

In the last chapter, the project conclusions are present as well as the limitations and further recommendations for the future.



## 2. LITERATURE REVIEW

### 2.1 Logistics Management

Logistics plays a crucial role in today's progressing environment, as a part of the supply chain, being a resource to gain competitive advantage and provide the highest quality service to fulfil customers' satisfaction. In this subchapter, its concept is presented as well as the various activities it represents.

#### 2.1.1 Logistics Concept

The definition of logistics has been changing over the time with the increase of globalization and digital transformation and it is not easy to define since it depends on the environment where it lies in.

The Council of Supply Chain Management (2016) states that logistics is "the part of the supply chain responsible for planning, implementing and controlling the efficient and effective flow and storage of goods, services and related information from the point of origin to point of consumption in order to meet customer requirements".

Carvalho, et al. (2012) supports that logistics in a service logic, presents the ability to provide a certain service in a given time unit, referring to the expected customers, in the right quantity, arriving at the service at the right time and being able to be served at the right cost. From a customer perspective, logistics aims to offer highest level of service in a short time response with the lowest service costs.

The notion of logistics may differ from point of view, but overall it is agreed that it manages physical and informational flows between suppliers and the market to provide products or services in the more cost-efficient way (Carvalho, et al., 2012).

Logistics must be dynamic and flexible enough to change accordingly to the various constraints and demands imposed upon it and accomplish the optimal performance (Rushton, Croucher, & Baker, 2014).

It is expected to manage different types of resources that imply planning, implementation and controlling logistics activities, allowing companies to differentiate from competitors and sustain competitive advantage through effective logistical process, thus creating value.

From upstream to downstream, suppliers provide the purchasing orders, whether they are raw materials, work in progress products or finished goods. Downstream, it will be necessary to receive, confirm the orders, storage and therefore do picking to be dispatched and delivered

to customers. Direct and inverse logistics activities must be planned and executed with the least number of resources and costs to generate effective results (Carvalho, et al., 2012).

The complexity of logistics may decrease when companies fully understand the three dimensions: Time, Cost and Service Quality, which must be balanced as much as possible, being designated as “Trade-offs”.

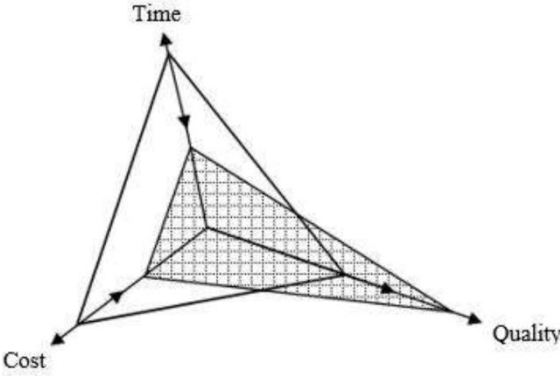


Figure 2.1 Logistics Attributes

The upper attribute represents how long it takes to perform logistics service, where the main goal is to perform in the least time possible. The attribute cost is related with efficiency, that is, the cheaper the process is, the more efficient the logistic process is. Regarding the third attribute, service quality, the better the service provided, the more valuable the process becomes.

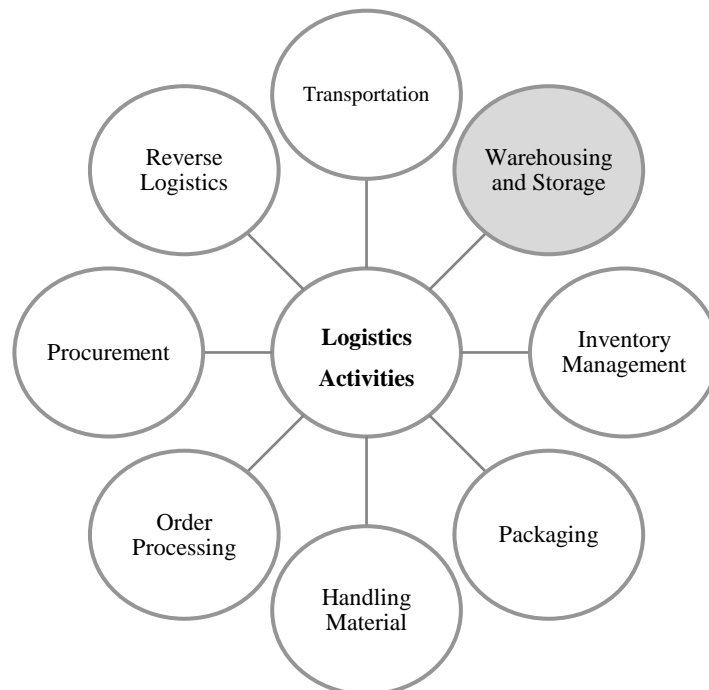
The product or service provided should be delivered at the shortest time, at the lowest cost and with the highest service quality. However, the struggle is recognized since it is not sustainable to pursue all of them at the same time so the solution is to combine two of these dimensions (Carvalho, et al., 2012).

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### 2.1.2 Logistics Activities

Rushton et al. (2010:7) “All of these functions and sub-functions need to be planned in a systematic way, in terms both of their own local environment and of the wider scope of distribution system as a whole”. Depending on the researcher, literature can identify several logistics activities that support companies to fulfil customers’ needs in the shortest possible time, at the lowest cost and with the best service quality (Rushton, Croucher, & Baker, 2014; Carvalho, et al.,2012).

Waters (2003) and Carvalho, et al. (2012) mention the main set of logistics activities are the ones presented in Figure 2.2. Due to the scope of this project, the following literature will focus on the warehousing and storage.



*Figure 2.2 Logistics Activities*

## **2.2 Warehouse Management**

Warehousing can be defined as “that part of a firm’s logistics system that stores products (raw materials, parts, goods-in-process, finished goods) at and between point of origin and point of consumption, and provides information to management on the status, condition, and disposition of items being stored” (Lambert, Stock, & Ellram, 1998; Bowersox, Closs, & Cooper, 2002).

Warehouse is an integral part of every logistics system, plays a vital role providing a desired level of customer service at the lowest possible total cost, and is an important link between the producer and the customer. Over the years, warehousing has developed from a minor facet of a firm’s logistics system to one of its most relevant functions (Lambert, Stock, & Ellram, 1998).

The main objective of most warehouses is to facilitate the movement of goods through the supply chain to the end customer. Production and consumption occur in different places, and there is no reliable transport with a short delivery time, at a reasonable cost, to place products quickly near customers. The existence of storage puts the products close to the market, allowing for a quicker response to the customer, thus improving service quality. The need to build up stock arises when supply and consumption behave differently over time: demand occurs continuously while production occurs frequently (Rushton, Croucher, & Baker, 2014).

Richards (2014) affirms that the role of a supply chain, and therefore a warehouse within that chain is to deliver the right products, in the correct quantity, to the right customer, at the right place, at the right time, in the right condition, at the right price – the seven rights of customer service. Today, “at the right cost environmentally” can be included as the eighth right.

Warehouse plays a crucial role in this process. Delivering the right product in the right quantity relies on the warehouse picking and dispatching products accurately. Delivering to the right customer at the right place, on time, requires the product to be labelled correctly and loaded onto the correct vehicle with sufficient time to meet the delivery deadline. The warehouse also needs to ensure the product leaves the warehouse clean and damage free. For the sake of delivering at the right price, we require a cost-efficient operation that provides value for money (Carvalho, et al., 2012).

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### 2.2.1 Warehouse Layout

When choosing a warehouse layout, it is important to consider that it should aim to minimize the total distance travelled by human resources, being more efficient, and therefore, reducing the associated costs. On the other hand, a warehouse layout that allows easy access to stored items also allows for quicker and error-free responses (Carvalho, et al., 2012).

Rushton, et al. (2014) and Carvalho, et al. (2012) explains the products flow inside a warehouse depends on the warehouse layout, which can be classified as directional or through-flow and broken or U-flow.

In directional flow (Figure 2.3 – left side), the receiving and shipping areas are located on opposite sides, so the major advantageous of this layout is the reduction of traffic congestion.

In broken flow (Figure 2.3 – right side), the receiving and shipping areas are adjacent to each other on the same side. The main advantage is the decrease in the average travelled distance, mainly in storage and picking activities.

Lambert, Stock, & Ellram (1998) states that regardless of the layout companies select for its warehouse, it is vital that all available space be utilized efficiently as possible.

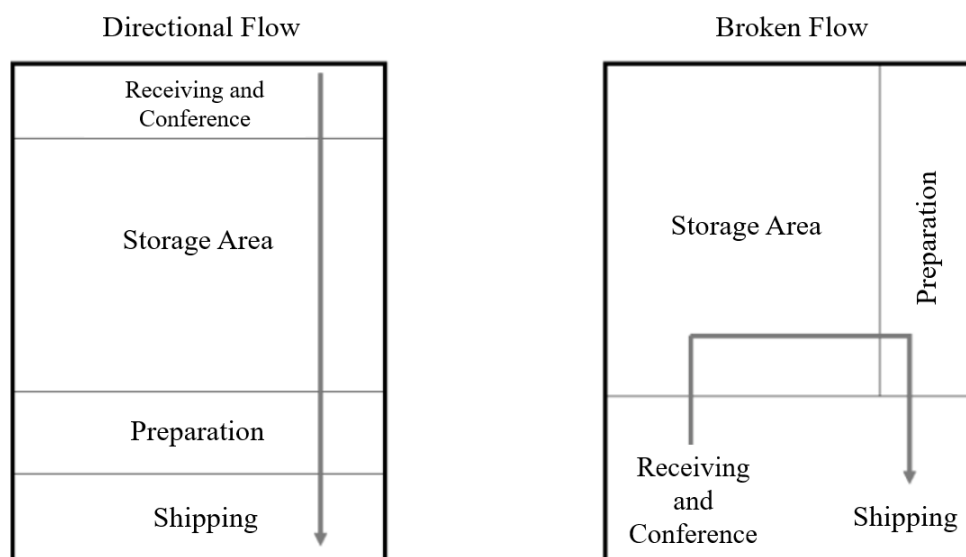


Figure 2.3 Warehouse Layout (Adapted from Carvalho, et al., 2012)

### **2.2.2. Warehouse Activities**

Each warehouse has its internal activities adapted to its business flows. However, there are four main activities common to all of them (Lambert, Stock, & Ellram, 1998; Carvalho, et al., 2012; Frazelle, 2002; Bowersox, Closs, & Cooper, 2002): Receiving, Storage, Picking and Shipping. Bowersox, Closs, & Cooper, 2002 (2002) state that the purpose of warehouse is to efficiently receive inventory, possibly store it until required by the market, assemble it into complete orders, and initiate movement to customer.

#### **2.2.2.1 Receiving**

The first activity, receiving, begins with the physical unloading of incoming transport, checking against purchase orders and recording the incoming goods into the computer system. It can also include such activities as unpacking and repackaging in a suitable format for the subsequent warehouse operations. Quality control checks may be undertaken to verify if there is any irregularity with the goods and if so the return process should be triggered, otherwise are stored in the warehouse (Rushton, Croucher, & Baker, 2014).

To avoid congestion at the unloading docks and in the reception area, arrivals should be previously scheduled through an operational information system. In this way, it becomes easier to manage the unloading docks, as well as human resources (Carvalho, et al., 2012).

Carvalho, et al. (2012) refers that reception and conference may consists in seven steps: arrivals planning; the arrival of the vehicle; physical unloading; checking the goods; palletizing; define storage location; update in the system.

#### **2.2.2.2 Storage**

Storage activity does not add value to the product, however, it does contribute to deliver value to the customer (Carvalho, et al., 2012). According to Frazelle (2002), storage is the physical containment of merchandise while it is awaiting a demand.

After the receiving of product and having assigned to a location, products have to be stored in the warehouse (Emmett, 2005).

Carvalho, et al. (2012) refers that the methodology used to define storage can have a significant impact on the efficiency of handling and moving products within the warehouse. There are two methods of storing products:

**Fixed Location Storage:** Assigns a fixed area for each product in the warehouse - which can be previously defined based on different criteria, such as, turnover, number of entry and exit

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movements, volume, volume/number of movements ratio, among others. The main disadvantage of this method is the creation of underutilization spaces because the space required for each product must be dimensioned for the maximum stock, but this rarely happens simultaneously for all references, resulting in many empty spaces. Another issue is the difficulty to increase the storage area when demand increases. However, it facilitates the workflow developed by pickers, since they know where products are (Carvalho, et al., 2012; Emmett, 2005).

**Random Location Storage:** The location of products in the warehouse is randomly defined at the time of reception, taking into consideration the available spaces within the warehouse. This method means that product may never be stored in the same place again, which requires coworkers to be more aware of its location (Carvalho, et al., 2012).

Also, both methods described can be combined being characterized by different storage zones, where each product is assigned to fixed area, but stored randomly within it (Carvalho, et al., 2012).

### **2.2.2.3 Picking**

After the products have been received and stored, the picking activity is triggered by the receipt of customers' orders. Frazelle (2002:18) defined picking as "the process of removing items from storage to meet a specific demand". Carvalho, et al. (2012:308) states that picking activity has an impact on logistics attributes in which "the faster the picking, the quicker is the customer delivery (Time); the more efficient the picking, the lower the cost to the customer (Cost); and the more effective the picking, without errors, the higher is service quality (Quality)".

Richards (2014) and Rushton, et al. (2014) affirms that order picking is the costliest activity within warehouse, usually accounting for about 50% of labor costs, and impacts directly on customer service. According to Rushton, et al. (2014) managers target the picking operation as the area in which productivity and efficiency improvements can make a significant difference to overall costs, and for this reason, the strategy adopted needs to be wisely chosen

Carvalho, et al., (2012) defends that picking could be performed throughout the storage area or there may exist a specific area in the warehouse. As storage area, in most of warehouses, occupies a relatively large space, picking activity in that area may implies greater travelled distances by human resources. This way, to avoid wasting time moving there is the possibility of having a warehouse dedicated to picking. This method allows a wide range of products to be placed in that area, where the stocks levels will be low and the replenishment needs to be

frequently, in order to guarantee speed picking and no stockouts. The products placed in this area should be those with high rotation and with medium dimensions. The existence of two storage locations for the same product within the same warehouse – in the central and in the picking area – should be provided through computer systems for inventory management.

Productivity depends on the technique used for picking by considering the profile/type of orders. Carvalho, et al. (2012); Rushton, et al., (2014); Frazelle (2002) and Emmett (2005) defend the following four picking methods:

- Picking by Order – picker travels the warehouse to collect all the items of an order. This method reduces errors but productivity is lower due to the time spent travelling.
- Picking by Line – it is defined a specific product sequence collection, where picker follows this route collecting at each location the quantity of SKU needed to satisfy several orders. The sequence is defined to minimize the distance travelled and, in this way, the productivity is high, but the chance of errors may be higher.
- Zone Picking – each picker is allocated to one zone and only does picking in that zone, collecting the SKUs for each order located in its area. In the end, the order is merged in one zone. Zone picking is basically a picking by order, divided by several zones. The probability of errors is low and productivity is higher. This method is suitable when there are several storage systems in the same warehouse, in which operators assigned to each zone works with the same type of equipment.
- Batch Picking – this method is similar to picking by line, but for a set of orders instead the total of orders. The picker collects the quantity of SKUs for the total of this set and then separate them by orders. The greater the number of orders, the productivity is higher, but the possibility of errors is also higher.

#### **2.2.2.4 Shipping**

Preparation and shipping are the last activities within warehouse to satisfy customer's orders. The preparation consists in placing the products in the specific dock area and strap the pallet for then loading onto a vehicle (Carvalho, et al., 2012).



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### **2.3 Performance management**

Supply chain continues to evolve and there is a way of saying how well it works at the moment and how it can be improved. Managers in every organization have to measure the performance of logistics otherwise they have no idea whether things are improving or not. The question is finding what to measure and how to measure it.

Measures helps managers in making decisions about supply chain, such as comparing the current performance logistics with performance in the past and compare the performance of different parts of the supply chain (Waters, 2003).

#### **2.3.1 Operations management performance objectives**

According to (Slack, Brandon-Jones, & Johnston, 2013) there are five operations performance objectives to contribute to competitiveness by being able to satisfy customers' requirements:

- Cost – minimizing cost without compromising quality and making a profit.
- Quality – first time right, influence customers' level of satisfaction.
- Speed – delivering as fast as practicable, minimizing lead time.
- Dependability – doing things in time for customers.
- Flexibility – being adaptable to internal and external changes.

(Frazelle, 2002) and Buzacott (2000) recognizes the necessity for trade-offs in order to handle the variety and complexity of the needs of different customers with the speed and efficiency of performing the required tasks.

## **2.4 Forward-Reserve Allocation**

Among the various activities that take place in warehouses and distribution centres, order picking is responsible for more than half of the costs. A common strategy to reduce the amount of work, is to divide the warehouse area into a forward area and a reserve area. The forward area is used for efficient order picking while the reserve area holds the bulk storage and is used for replenishing the first one (Berg, Sharp, Gademann, & Pochet, 1998).

According to (Gu, Goetschalckx, & McGinnis, 2007) it is a common practice in warehousing to create a separate physically compact forward area for picking high-demand and fast-moving products. This reduces order picking costs but requires additional material handling to restock the forward area from the reserve area. The problem address is deciding which products should be stores in the forward area and in what quantities.

## Impact of E-commerce on warehouse management of a retail company

### 3. METHODOLOGY

This project is focused on studying the results of Hybrid Project implementation in the warehouse at Loures IKEA store. It is intended with this chapter to present and describe the project's methodology.

#### 3.1 Methodology Approach

According to Yin (2014), case studies are the preferred strategy when “how” or “why” questions are being posed, when the investigator has little control over events, and when the focus is on a contemporary phenomenon within some real-life context. Such explanatory cases can be complemented by two other types: exploratory and descriptive cases studies (Yin, 2014).

This research is a descriptive and exploratory study. It is descriptive because it describes in detail the logistic processes, using qualitative data obtained through direct observation and questionnaire. To gather the quantitative data, it was used archival records. It is also exploratory research because it explores the research question, being able to develop pertinent hypotheses. Qualitative data is obtained through interviews and quantitative data via participant observation.

#### 3.2 Case Study Steps

This project was developed following several consecutive steps described in Figure 3.1.

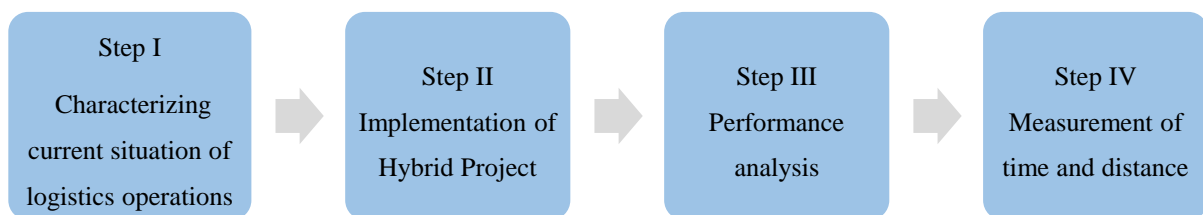


Figure 3.1 Research steps

##### Step I - Current situation of logistics operation

On a first stage, it is described the main components of the store to understand the customer experience in a commercial sight. Then, the current warehouse layout, facilities structure, and allocation of articles will be characterized. To collect this data, an unstructured interview was conducted to the Logistics Manager, while a store tour was carried out.

Next, the current warehouse activities are described. Receiving and storage were explained by the Inflow Team Leader, to understand and visualize the respective flows. To achieve a detailed mapping of processes, informal questions related to the daily tasks have been asked.

Also, a picker demonstrated the picking process to map all the steps in the process. The Outflow Team Leader was also interviewed, this time attempting to clarify more specific points, concerning different fulfilment flows.

Through participant-observation, storage and picking activities were performed during one week for a better understanding and to ensure the information validation. In this current situation, archive records were also used as a source, such as warehouse plants and WMS information.

To conclude this first step, the “as is” picking activity will be mapped.

## **Step II – Implementation of Hybrid Project**

During this research, the Hybrid Project is implemented in the warehouse. The group project is composed by: Project Implementation Manager; co-worker from Self-Service team; co-worker from Outflow team and the researcher. The implementation of this project is the main key for the development of this research. The project will be explained in chapter 4.3.

## **Step III – Performance Objectives assessment**

According to the data collected about warehouse operations, key performance indicators are defined for each performance objective to analyse delivery service and picking performance.

This study will be carried out for three different periods. Therefore, data is collected from company’s ERP to calculate the KPI’s and then line graphs are computed for each one in order to compare the values between periods.

## **Step IV - Measurement of time and distance**

Considering the allocation of SKUs, the distance travelled between merge area and each sales location is measured through participant observation. Also, time is measured while taking distance travelling.

Therefore, the current scenario will be compared to verify the improvements that hybrid area impact in picking efficiency.

# Impact of E-commerce on warehouse management of a retail company

## 4. CASE STUDY DESCRIPTION

IKEA is a Swedish multinational retailer specialized in furniture sale and home accessories founded in 1943 by Ingvar Kamprad. The company's name is an acronym that combines the founder's initials (Ingvar Kamprad) with the first letters of the family farm (Elmtaryd) and the village where he grew up (Agunnaryd).

Currently, the IKEA Retail business is operated in 60 markets, with almost 450 stores. In Portugal there are five stores, being Loures store the one with more potential to be the center of e-commerce.

### 4.1 IKEA Store

The store presented in this project is in Loures and was opened in 2010. IKEA stores are characterized by its iconic format and colors, blue and yellow, which are the national colors of Sweden. They usually follow the same layout and are designed in an on-way, leading customers to go through all Home Furnishing Business (HFB) area. It is divided in eight main store areas:

**1. Showroom** – an exhibition space, where customers can view and test the articles, writing down the references they search, which is composed by following HFB:

- HFB01 – Living Room Seating
- HFB02 – Store and organize furniture
- HFB03 – Workspaces
- HFB04 – Bedroom furniture
- HFB05 – Mattresses
- HFB06 – Bathroom
- HFB07 – Kitchen
- HFB08 – Dining
- HFB09 – Children's IKEA

**2. Market Hall** – area with home accessories, including the following HFB:

- HFB06 – Bathroom accessories
- HFB10 – Lighting
- HFB11 – Bed and Bath textiles
- HFB12 – Home textiles
- HFB13 – Rugs
- HFB14 – Cooking

- HFB15 – Eating
- HFB16 – Decoration
- HFB18 – Home Organisation

**3. Self-Serve Furniture Area** – storage area, where customers pick the articles, they have seen presented, including.

**4. Full-Serve Furniture Area** – warehouse of products to be picked by co-workers for handout to customers, which is not accessible to customers.

**5. Goods receiving** – an area where products are received into IKEA store.

**6. Customer Service** – where customers go for after-sales services like transportation service, exchange and returns.

**7. Restaurant, Bistro and Loja Sueca** – areas managed by IKEA Food, that provide traditional Swedish food as well as country local specialties at affordable prices.

# Impact of E-commerce on warehouse management of a retail company

## 4.2 Current situation of logistics operation

In this chapter, the current situation of logistics operation is presented, regarding the layout and operations areas, Warehouse Management System (WMS), warehouse activities and fulfilment flows.

### 4.2.1 Layout and operational areas

IKEA Loures warehouse is divided in two main areas: Self-Serve Furniture Area (SSFA) and Full-Serve Furniture Area (FSFA). The facility has three floors, with the ground level being used for the operation and the 1<sup>st</sup> floor for the store's showroom and the offices. The merge area is used to confirm and dispatch the orders to the underground floor, where the Outbound Area is located. The warehouse and main areas are present in Figures 4.1 to 4.3.

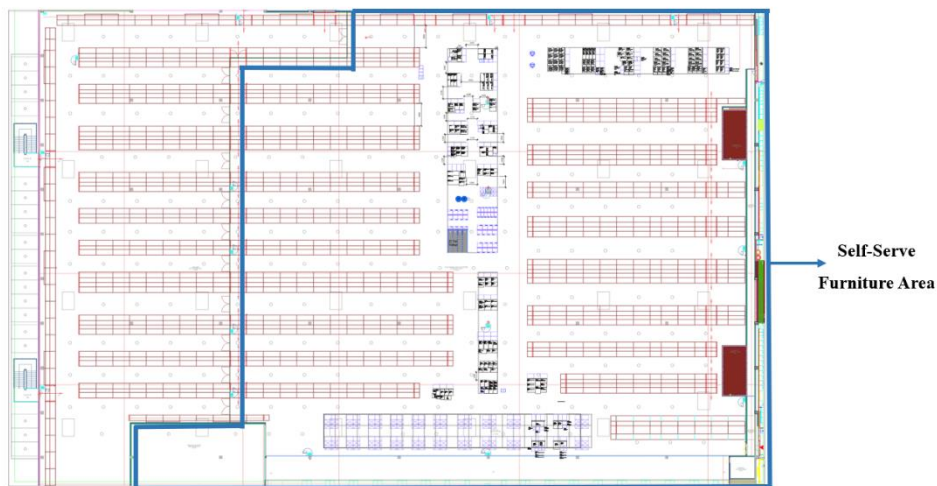


Figure 4.1 Self-Serve Furniture Area

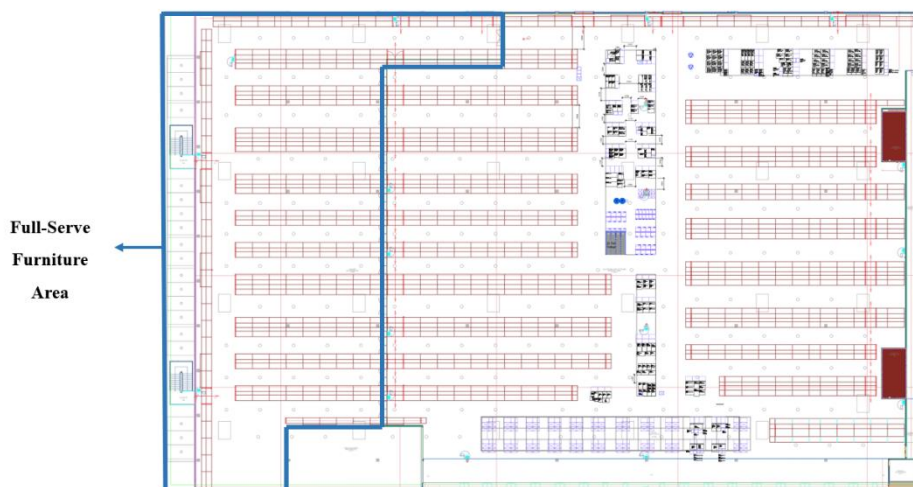


Figure 4.2 Full-Serve Furniture Area

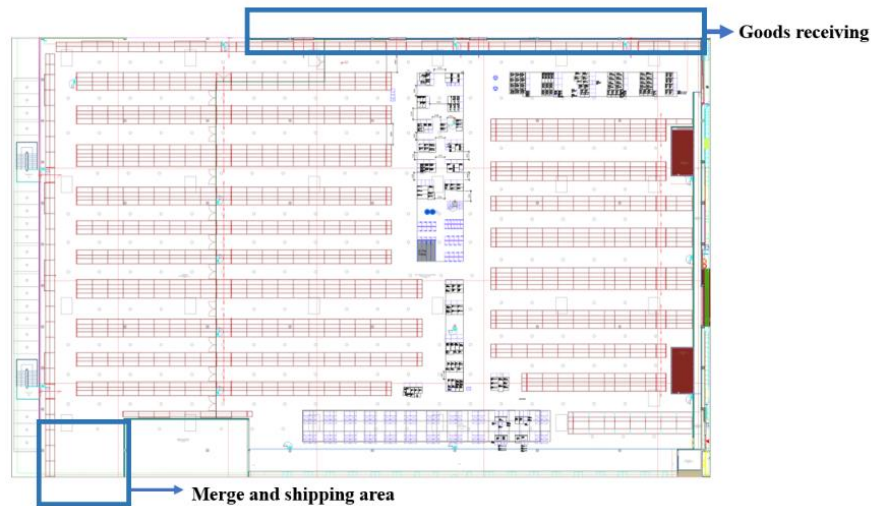


Figure 4.3 Goods receiving and shipping area

SSFA range offers articles that customers can collect while FSFA range include products that are larger, heavier, and more complex to collect like a kitchen or a sofa.

SSFA is composed of forty aisles, where on the left side have the pair aisles and on the right side have the odd aisles. Also has four commercial merchandizing that offers possibilities to sell large volumes of products, enabling direct flows and maximize sales at lowest retail cost. FSFA has twenty-four aisles. Warehouses aisles are presented in Figures 4.4 and 4.5.

The warehouse follows a directional flow since receiving and shipping activities occurs in opposite sides.

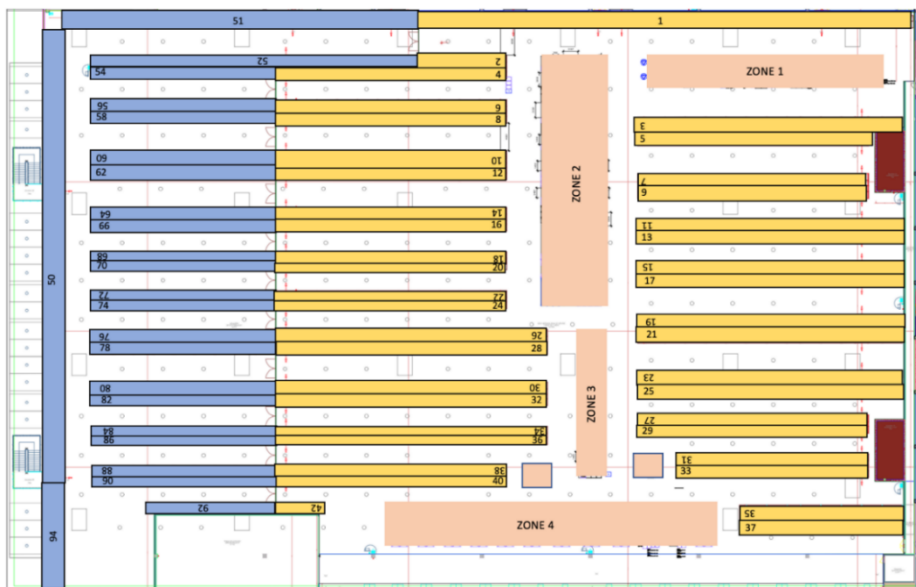
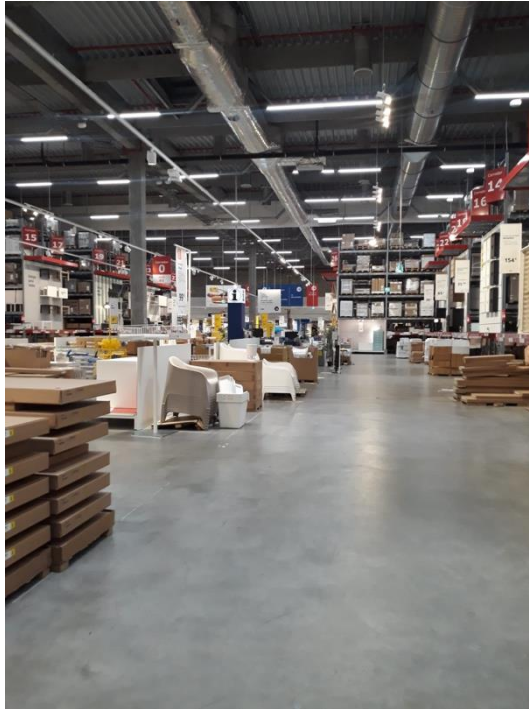


Figure 4.4 Warehouse aisles



## Impact of E-commerce on warehouse management of a retail company



*Figure 4.5 Pair and odd aisles*

### 4.2.2 WMS

The Enterprise Resource Planning (ERP) system used in IKEA for warehouse operations is MHS – Möbel Hus System. This system is employed to manage the overall logistics operation within store, by integrating and coordinating the warehouse activities performed, as well as the handling of stock throughout the store.

According to each activity, the WMS has specific features to support their execution and help monitoring processes. MHS is composed by four different systems:

- Store Goods Flow (SGF) – supports stores in daily logistics operations, from goods receiving, replenishment, picking, inventory and stocks handling.
- Sales Location Management (SLM) – supports sales space efficiency considering forecast, stock, available space and incoming deliveries.
- Customer Picking Service (CPS) – manages and provides information of all picking orders.
- Article Management – provides all the information of each article (sales, stock, replenishment, sales location, availability, inventory).

Although each one supports different activities, they are all interlinked and do not operate without information of each other.

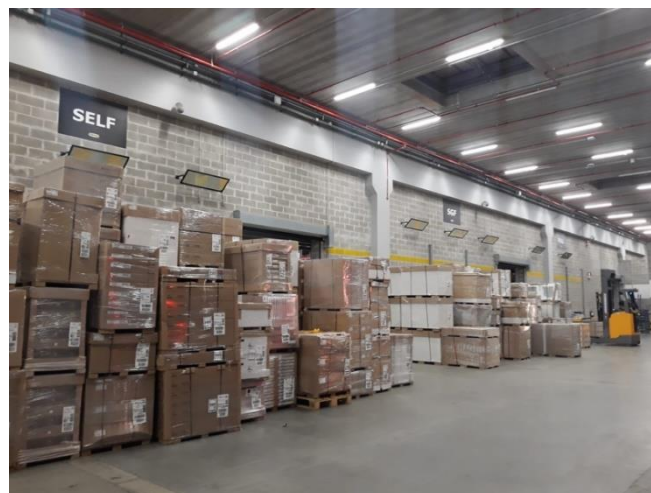
### 4.2.3 Warehouse activities

According to (Myerson, 2015), the main warehousing activities are receiving, putting away and storage, picking and shipping. The warehousing activities performed within IKEA store are present in this chapter. Considering this project scope, the storage and picking activity is addressed in more detail.

The Logistics Department is divided in three sections: Inflow, Outflow and Sales & Supply Support. The Inflow team works during night until the store opens and is responsible for discharging the trucks, storing the merchandise and replenishing sales locations. The Outflow team is responsible for managing FSFA and performing several tasks: store, replenish, pick, confirm and dispatch orders. The Sales & Supply Support is responsible for the integration of sales department on supply chain, analyzing the forecast and demand stock to fulfil customer's needs, and responsible for inventory management and its handling.

#### 4.2.3.1 Receiving

The receiving activity occurs in goods receiving area, starts at 2AM and trucks are allocated to the available docks. Firstly, the co-worker checks the Shipment truck and the MHS system starts processing the articles that will get into the inventory. Then, while unloading the goods and if there are no anomalies to report, the co-worker verifies the label of each pallet to know the respective location and put away in the respective area on the dock - MH, Self, Full or SGF.



*Figure 4.6 Goods receiving area*

## **Impact of E-commerce on warehouse management of a retail company**

### **4.2.3.2 Replenishment and Storage**

The replenishment activity starts at 1AM to distribute the merchandise stored in the store's warehouse to the respective sales locations to be replenished. The description of stock is generated through MHS the day before when the store closes, where the system analyses the stock availability and incoming deliveries, generating the quantity required for the sales location. This information discriminates which products need to be moved, their storage locations and the sales location to be replenished. Until trucks start arriving, this stock should be distributed.

The goods received placed on dock, whether they are directly replenished on the sales location or stored in the warehouse. The Full-Serve items that need to be restocked are put away in the respective area and replenished by Outflow workers.

Receiving, replenishment and storage are three activities done simultaneously by the Inflow team. There is at least one worker in each HFB to fill the sales location, using RDT to check space capacity and quantity required. If the pallet quantity is bigger than the space quantity at the sales location, it must be stored in the warehouse, which is called backflow.

The store opens at 10AM so these activities must be completed in the customer areas. Full-Serve has the advantage to be an internal warehouse and a restricted area for customers, so replenishment and storage can be performed during the day.

### **Storage method**

Each article is associated to one Sales Method (SM), which represents the type of product and identifies the area where the item is located. There are four SM:

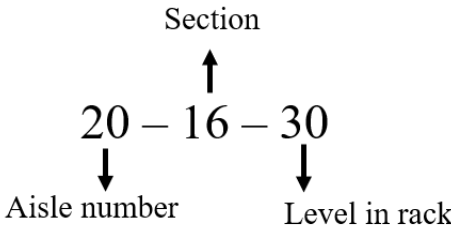
- Sales Method 0 (SM0) – articles designated as Home Furnishing Accessories, located in Showroom, Market Hall and SSFA;
- Sales Method 1 (SM1) – articles designated as furniture, located in SSFA;
- Sales Method 2 (SM2) – articles designated as furniture, located in FSFA;
- Sales Method 3 (SM3) – articles designated as furniture, delivered directly from Customer Distribution Centre (CDC).

Regarding the storing method, the products follow a fixed location storage method for the customer sales location. However, when stored in warehouse racks, the system allocates the product randomly, taking into consideration the available spaces and other criteria's such as the dimension of pallet, the sales method, and the distance from the sales location.

**Storage systems**

There are three types of racking for unit loads that are handled and stored in the IKEA unit: EURO, IKEA and IKEA XL. EURO are the smallest and it is only possible to storage pallets with length of up to 1250mm. IKEA aisles, stores pallets up to 2150mm in length. IKEA XLong rack, only there is one in the FSFA, and it stores unit loads with 2350mm.

As described in subchapter 4.2.1 and identified in Figure 4.7, aisles are identified by a number. The corridors are divided in sections, that can vary depending on the length of the row, considering the floor space occupied by the operational areas. Usually, each rack has 6 levels where stock can be allocated, being 0 and 10 the levels where customers reach to collect items. All storage locations in which stock can be allocated, have an identification code that supports the tracking of the items within warehouse. The general structure of this code is presented in an example below – aisle 20, 16 section, 3<sup>rd</sup> level.



*Figure 4.7 Location identification code*

# Impact of E-commerce on warehouse management of a retail company

## 4.2.3.3 Picking

This process starts when customer has paid or ordered the goods either online or at store. All the orders appear on CPS menu, represented in Figure 4.8.

The screenshot shows the CPS menu interface for picking orders. It includes a search bar, filter tabs for 'Estado do', 'Estado de', 'Area picking', 'Order Type', and 'Customer Type', and a main table of orders. The table columns are: ID picking, Ref. venda, Tempo, Data, Peso, Itens, Estado, Progress, Priorit, Order Type, Delivery Method, E, Area picking, and Pick Ready Time. The table contains 18 rows of order data.

| ID picking    | Ref. venda | Tempo | Data       | Peso | Itens | Estado       | Progress | Priorit | Order Type | Delivery Method                  | E | Area picking       | Pick Ready Time  |
|---------------|------------|-------|------------|------|-------|--------------|----------|---------|------------|----------------------------------|---|--------------------|------------------|
| Iniciar 61053 | 1224325409 | 21.37 | 2021-09-11 | 3    | 8     | Não iniciado | 0%       |         | Collect    | Pick up at Store                 |   | Markethall         | 2021-09-13 03:00 |
| Iniciar 60628 | 1224207001 | 17.20 | 2021-09-11 | 15   | 7     | Não iniciado | 0%       |         | Collect    | Pick up at Store                 |   | Markethall         | 2021-09-13 09:00 |
| Iniciar 60941 | 1224275475 | 19.15 | 2021-09-11 | 15   | 14    | Não iniciado | 0%       |         | Collect    | Pick up at Store                 |   | Markethall         | 2021-09-13 09:00 |
| Iniciar 45446 | 1218687742 | 17.47 | 2021-08-20 | 188  | 204   | Não iniciado | 0%       |         | Transporte | Delivery indoor standard central |   | Markethall         | 2021-09-13 11:00 |
| Iniciar 45447 | 1218687742 | 17.47 | 2021-08-20 | 388  | 30    | Não iniciado | 0%       |         | Transporte | Delivery indoor standard central |   | Self-Serve         | 2021-09-13 11:00 |
| Iniciar 45448 | 1218687742 | 17.47 | 2021-08-20 | 151  | 7     | Não iniciado | 0%       |         | Transporte | Delivery indoor standard central |   | Full Serve interno | 2021-09-13 11:00 |
| Iniciar 47297 | 1219449021 | 18.08 | 2021-08-23 | 23   | 26    | Não iniciado | 0%       |         | Transporte | Delivery indoor standard central |   | Markethall         | 2021-09-13 11:00 |
| Iniciar 47298 | 1219449021 | 18.08 | 2021-08-23 | 710  | 144   | Não iniciado | 0%       |         | Transporte | Delivery indoor standard central |   | Full Serve interno | 2021-09-13 11:00 |
| Iniciar 48505 | 1220017267 | 14.46 | 2021-08-25 | 358  | 60    | Não iniciado | 0%       |         | Transporte | Delivery indoor standard central |   | Full Serve interno | 2021-09-13 11:00 |
| Iniciar 50792 | 1220788881 | 16.37 | 2021-08-28 | 5    | 11    | Não iniciado | 0%       |         | Transporte | Delivery indoor standard central |   | Markethall         | 2021-09-13 11:00 |
| Iniciar 50793 | 1220788881 | 16.37 | 2021-08-28 | 69   | 12    | Não iniciado | 0%       |         | Transporte | Delivery indoor standard central |   | Self-Serve         | 2021-09-13 11:00 |
| Iniciar 54018 | 1222005646 | 19.13 | 2021-09-01 | 138  | 6     | Não iniciado | 0%       |         | Transporte | Delivery indoor standard central |   | Self-Serve         | 2021-09-13 11:00 |
| Iniciar 54358 | 1219801903 | 12.14 | 2021-09-02 | 111  | 7     | Não iniciado | 0%       |         | Transporte | Delivery indoor standard         |   | Self-Serve         | 2021-09-13 11:00 |

Figure 4.8 CPS menu

As exemplified in Figure 4.8, the order picking is assigned to one of the following Order Type:

- Customer – orders for immediate hand over to the customer, picked in Full-Serve;
- Transport – orders picked in store and hand over to the Transport Service Provider;
- Click & Collect – orders from web to be collected by customer in store at a specific time;
- Pick Up Point (PUP) – orders hand over to the Transport Service Provider and be collected by customer at an assigned PUP;
- Internal – internal orders request and hand over to an employee;
- After Sales – correction of customers' orders returns, hand over to the Transport Service Provider;
- Parcel – orders from customer, picked by Customer Distribution Centre and delivered through CTT;

Transport, Click&Collect and PUP are the only ones connected to online flow. Also, the defined pick areas are three, according to SM:

- Markethall
- Self-Serve

- Full-Serve

If the paid sales order consists of articles from different areas, the system splits into different pick IDs. For example, ID Picking 45446, 45447 and 45448 is one order, divided in 3 orders, one per each picking area and then will be merged. The ‘Pick Ready Time’ column indicates the deadline of picking operation. This dashboard is managed by the Outflow team taking into consideration prioritizations, volume, and resources available.

Through RDT, pickers go to the menu and select the Pick Area and Order Type. Then, a Pick ID should be selected. When there is pick ID marked in red text, it indicates an order, which is prioritized by the system and should always be selected first. After selecting a pick ID, Figure 4.9 represents the Pick Items screen.

| Recolher Itens                 |                               |                                      |    |   |   |
|--------------------------------|-------------------------------|--------------------------------------|----|---|---|
| Entrada:                       | <input type="text" value=""/> | <input type="button" value="Enter"/> |    |   |   |
| ID Pick:                       | 56234                         |                                      |    |   |   |
| R/Q                            | Artigo                        | LPick                                | P  | E | ! |
| 0/1                            | 202-758-14                    | 00-01-01                             | 13 | 0 |   |
| KALLAX EST 77X77 BR            |                               |                                      |    |   | ⊙ |
| 0/1                            | 301-805-04                    | 25-20-10                             | 9  | 0 |   |
| NORBERG MES AB REB PD 74X60 BR |                               |                                      |    |   |   |
| 0/2                            | 104-349-79                    | 31-09-00                             | 3  | 0 |   |
| KYRRE BC AZ                    |                               |                                      |    |   |   |
| 0/1                            | 904-613-46                    | 35-02-00                             | 3  | 0 |   |
| TORPARÖ MES VARAND 50 BR       |                               |                                      |    |   | ⊙ |
| 0/2                            | 702-787-06                    | 58-38-00                             | 9  | 0 |   |
| LÖNSET ESTD RIP 70X200         |                               |                                      |    |   | ⊙ |
| 0/1                            | 402-694-21                    | 60-39-00                             | 32 | 0 |   |

Figure 4.9 Pick ID list

Each line represents one article, identified by article number and the name. The order quantity is defined by letter Q and the picked quantity is described by letter R. The picking location is represented by LPick and the total weight of items is represented by P. The analysis of the picking list is necessary because it is not organized according to a specific criterion and for this reason, the picker must have the knowledge of the locations, weight and dimensions of the articles.

After picking all the items and scanning the barcode with RDT, picking is complete and an internal document is printed and used as order identification and attached to the order. However, if one sales location is empty, the picker should check whether there is stock on other sales location and the availability on SGF. If the article is not available, the picker registers an oversell.

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Then, the picker places the orders in a handover area to be merged. Merging is the part of process where Pick-ID's from different sales methods are physically consolidated into one complete customer order. After merging the picked articles of all connected Pick IDs, he hands over the complete order to another co-worker that will check the order.

Regarding the picking method, Self and Markethall are performed with picking by order. Full orders are performed by zone picking, because orders are very heavy and must be done with forklifts, which requires forklift driving license. In this way, specific employees are allocated to do Full pickings.

Figure 4.10 describe picking process in the warehouse.

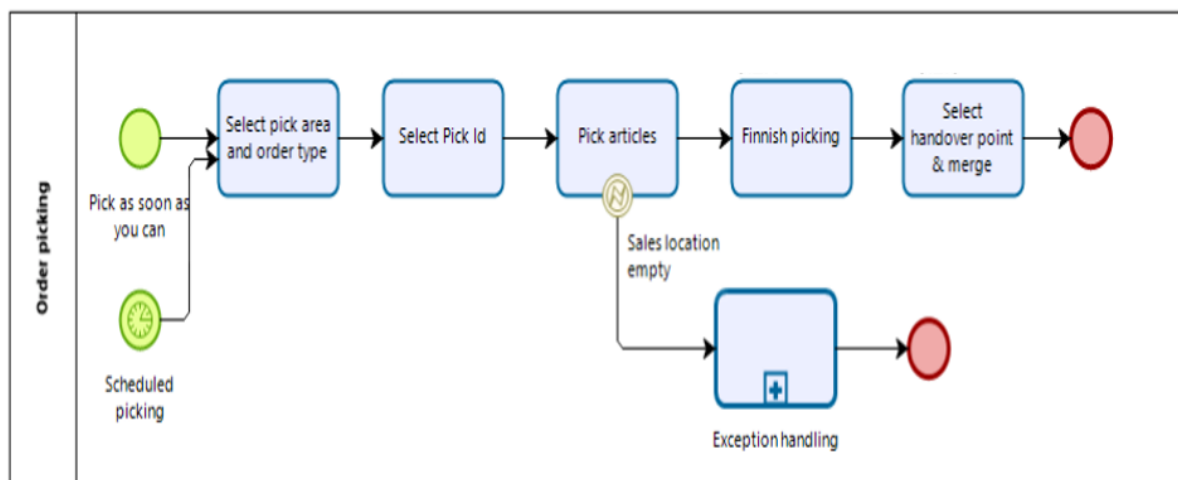


Figure 4.10 Order Picking Process

### 4.2.3.4 Shipping

This process includes the fulfilment of the shipping orders according to the daily plan designed by Transport Service Provider, which is outsourced. Click&Collect orders are delivered in customers parking lot in a specific area for the service. Transport, PUP and after sales are handed to TSP Outbound area, located in an underground floor.

#### 4.2.4 Fulfillment flows

IKEA has twelve different fulfillment flows to deliver goods to customers, as described in Table 4.1 and Figure 4.11.

*Table 4.1 Fulfillment Flows description*

| <b>Fulfillment Flow</b>        | <b>Description</b>  |
|--------------------------------|---|
| Cash and Carry<br>(Customer)   | Customer picks goods in store and transports goods home;  |
| Cash and Carry<br>(Full Serve) | Customer orders in store, IKEA picks the goods in Full-Serve (store) and the customer transports goods home;                            |
| CCD (Parcel)                   | Customer orders in store, IKEA picks the goods in a distribution center and transports goods to the customer's home by parcel delivery; |
| CCD (Truck)                    | Customer orders in store, IKEA picks the goods in a distribution center and transports goods to the customer's home by truck delivery;  |
| Click and Collect              | Customer orders online, IKEA picks the goods in store and the customer transports goods home;   |
| Click and Deliver<br>(CDC)     | Customer orders online, IKEA picks the goods in a distribution center and transports goods to the customer's home by truck delivery;    |
| Click and Deliver<br>(CPU)     | Customer orders online, IKEA picks the goods in a distribution center and transports goods to the customer's home by parcel delivery;   |
| Click and Deliver<br>(Store)   | Customer orders online, IKEA picks the goods in store and transports goods to the customer's home;                                      |
| LCD (Customer)                 | Customer picks goods in store and IKEA transports goods to the customer's home;   |
| LCD (Full Serve)               | Customer orders in store, IKEA picks the goods in Full serve (store) and IKEA transports goods to the customer's home;                  |
| Pick and Deliver               | Customer orders in store, IKEA picks the goods in store and IKEA transports goods to the customer's home or PUP;                        |
| Picking in Store               | Customer orders in store, IKEA picks the goods in store and the customer transports goods home.   |



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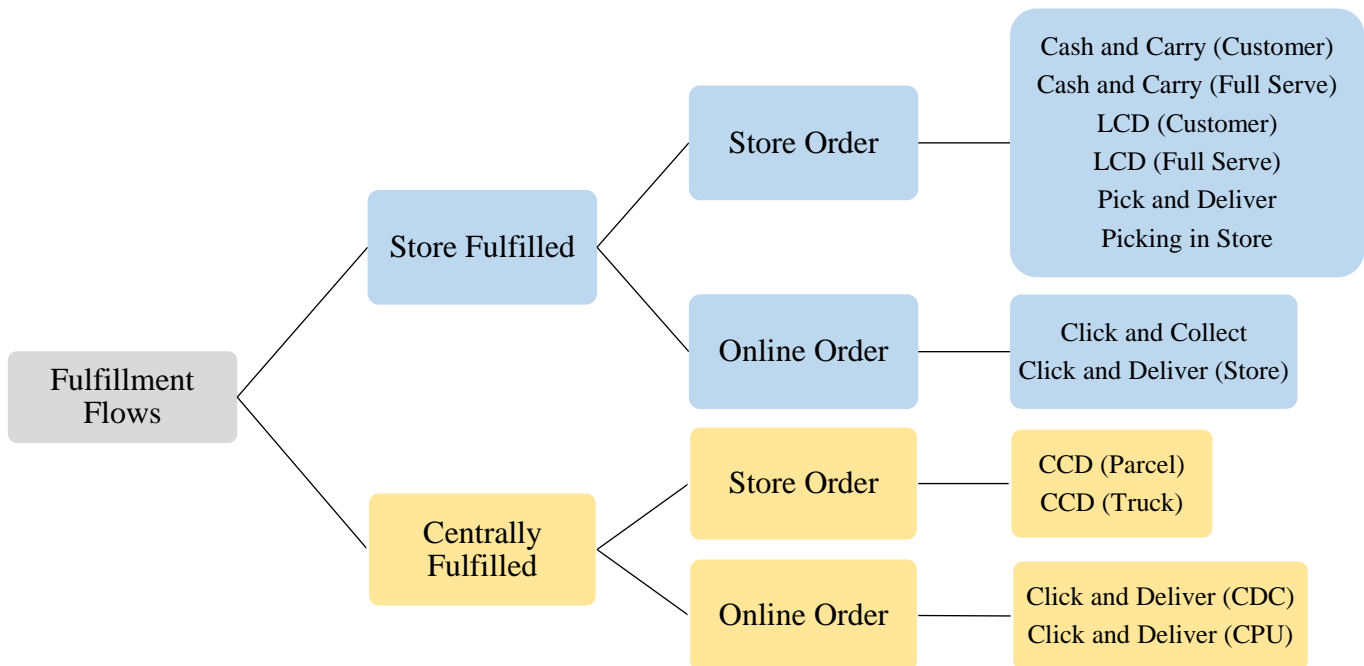


Figure 4.11 Fulfilment Flows

From all the fulfillment flows, four of them are directly fulfilled by CDC in Barcelona to customer's home. The store fulfils customers' orders through eight different flows, where only six of them are picked. Moreover, it is possible to customer transports goods home or buy the service to IKEA transports goods to the customer's home.

Regarding E-commerce, there are four methods to fulfill orders: two of them are fulfilled through the store – Click & Collect and Click & Delivery; while the other two are centrally fulfilled – Click and Delivery via Truck or Parcel. IKEA product range in Portugal has about 13000 SKU but stores only have capacity for almost 12000 SKU. When a customer orders online, if the stock is in store, the customer may choose to pick up the articles at the store (Click & Collect) or receive them at home or at a Pick Up Point (Click & Delivery). If the goods are only available in CDC, then customer received through central at his home – Click & Delivery (CDC). Customer Parcel Units (CPU) represents orders from items up to 5kg, which also comes from CDC.

Furthermore, stores have specific postal codes to satisfy, so orders are allocated to the respective store. Pick up Points are collection points where any customer can collect the goods wherever he wants, within twenty options: Aveiro, Beja, Bragança, Cascais, Castelo Branco, Coimbra, Évora, Guarda, Guimarães, Leiria, Madeira, Ovar, Portalegre, Santarém, São Miguel, Setúbal, Viana do Castelo, Vila Nova de Gaia, Vila Real and Viseu.

### 4.3 Implementation of Hybrid Project

Loures store is stated as a Store with Fulfillment Capabilities which means is a store with possibilities to fulfill more than one distribution channel. Customer fulfillment is about meeting customer expectations by having IKEA products and services available when and where customers want them. This is a key to growing IKEA in existing and new markets. People shop more online, expect better delivery services, and are more careful about their spending, as the need for affordable solutions and value for money have become increasingly important.

To achieve an efficient fulfillment process, Loures store has ongoing development projects, including the Hybrid Project which regards order picking. This setup allows a forward reserve area, having the same article in different locations, this case, in Self-Serve and in Full-Serve.

Since in-store stock is available for customer, whether in store or online, it is possible that physical customer collects the products that online customer has just purchased. The main goal of this project is to ensure stock availability for both processes, in-store and online, avoiding pickers and customers grabbing for the same article in the same location. Besides this, picking activity becomes more efficient once pickers cover less walking distance to collect the article and move less outside of Full-Serve.

The main decision is to define which articles would benefit from moving to Hybrid Locations to satisfy omnichannel customer's needs and enable a more efficient picking service.

#### 4.3.1 Methodology

This chapter describes the steps taken to implement the project. The approach used is represented in the Figure 4.12.



Figure 4.12 Hybrid Project steps

#### Step I – Define range

Hybrid articles are intended to be the ones that have higher quantities of online sales, higher turnover and higher demand. As said before, these articles are only from SM1. In this way, to define which articles would benefit from moving to Hybrid area, sales quantity per each online fulfillment flow (Click&Collect and Click&Delivery) was collected from WMS. The other

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article information as sales method, turnover, forecast, quantity per pallet and sales space size optimization were extracted from WMS.

After data treatment, the final list of range has a total of 126 articles to be stored in this area.

### Step II – Define layout

After predicting the hybrid range and its quantity, it is possible to define the space needed to store the articles. The initial idea was to move the gates from Full Serve to Self-Serve, so that hybrid area can be between the two areas, in order to make easier the replenishment and picking process. In this way, the gates moved 9 locations from aisle four to twenty-six. The final hybrid layout is presented in Figure 4.13.

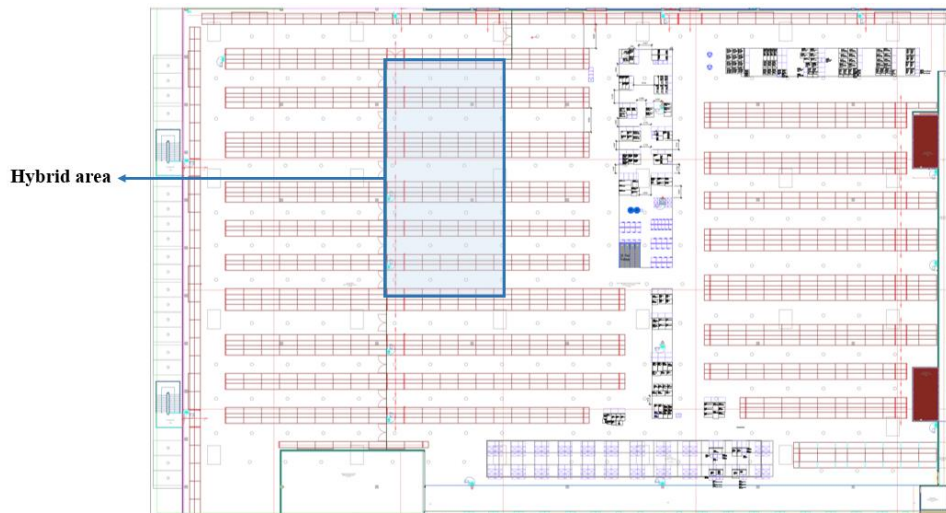


Figure 4.13 Hybrid layout

### Step III – MHS systems parameters settings

Regarding parameterization in computer systems, it is required to set up MHS to create the new locations designation. This step is important so that the location where stock is stored is linked to the replenishment location, to be as close as possible. The Hybrid area was set up as a Speciality Shop inside Self-Serve to keep range as SM1.

The link zone has the purpose for a certain range of articles to remain in a determined area whether on the floor or SGF. For example, looking at Figure 4.14, an article located in ZL70, must be parameterized linked to ZL70, so when it is replenished on the floor, the traffic plan

be more efficient. If it is the case to store the pallet in SGF and all the locations are full, the system indicates the next higher ZL, considering type of rack.

Therefore, ZL40 and ZL45 were designated as hybrid zones, corresponding to EURO rack and IKEA rack respectively. So, all the hybrid articles in Self-Serve are linked to one of this ZL, to maintain stock on SGF of hybrid zone and down during the day if necessary.

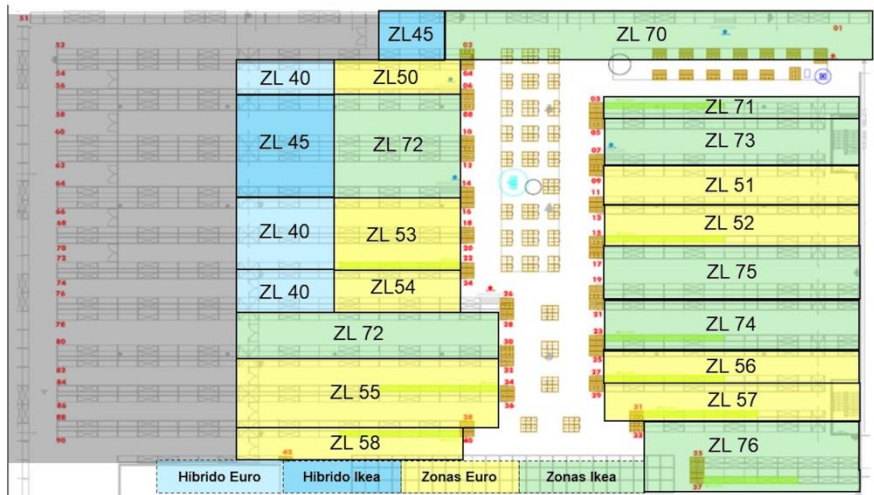


Figure 4.14 Link zone map

Storage unit loads on SGF in the warehouse follow the Random Location Storage method. However, the random location is defined through some priorities as represented in Figure 4.15. The system search for a location following the sequence numbers, for example Sales Method 1: first search a location with same SM; second with the nearest ZL, third with the less picking distance and last the height, length and width.

| CI  | MV | HFB | HMT | Compr | Lar | Altura | ZL | Dist. pick | Freq. picking | Freq. picking palette |
|-----|----|-----|-----|-------|-----|--------|----|------------|---------------|-----------------------|
| MV0 | 0  | 1   | 2   | 0     | 3   | 4      | 5  | 6          | 0             | 7                     |
| MV1 | 0  | 1   | 0   | 5     | 6   | 4      | 2  | 3          | 0             | 0                     |
| MV2 | 0  | 1   | 0   | 4     | 5   | 3      | 0  | 2          | 0             | 0                     |
| ORD | 0  | 0   | 0   | 0     | 0   | 0      | 0  | 0          | 0             | 0                     |

Figure 4.15 Storage priorities

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### Step IV – Update communication

In this step, the identification labels of articles were adapted and printed for co-workers to recognize hybrid items easier. Regarding Self-Serve area, as shown in the illustrative example in Figure 4.16, a blue strip was added to the beam sign for workers to know that the article is in hybrid zone.



Figure 4.16 Identification of hybrid items in Self-Serve

Concerning the hybrid area, it was updated all the SGF labels according to the new sales locations designation. Also, was printed a symbol that signs the item as hybrid, exemplified in Figure 4.17. The identification of locations in racks were also updated.



Figure 4.17 Identification of hybrid items in hybrid area

### Step V – Define Sales Location

In this step it was planned a fixed location, in the floor, for each item. Firstly, it was tried to maintain the self location and hybrid location in the same aisle to facilitate replenishment. Hence, ensure that the customer's buying process has been maintained. Finally, there are different types of racks and different sizes of pallets, so SKUs were allocated to optimize the space.

The main methodology to define the fixed location was through field observation. A total of 126 SKUs were allocated in 178 hybrid locations.

## **Step VI – Implementation**

Finally, the implementation phase where all previous steps are executed in the warehouse. First, the move of gates occurred overnight between 8<sup>th</sup> of July to 10<sup>th</sup> of July of 2020, through a subcontracted company: on 8<sup>th</sup> gates from aisle 4 to 10; on 9<sup>th</sup> gates from aisle 12 to 18 and on 10<sup>th</sup> gates from aisle 20 to 26.

Then, simultaneously with the previous step, the stock was being removed from Self locations to replenish in hybrid locations. While removing stock from Self-Serve to replenish on hybrid area, the item had to be located on WMS through RDT, introducing sale location and respective quantity.

These steps were implemented overnight so that stock and respective information would be correct for customers in the morning, Also, the communication locations labels were updated on sales location. At the end of the Project, an official document was created, explaining the concept and main configurations to be used in future hybrid implementations. It was presented to Sales and Logistics department to explain the new working method.

## Impact of E-commerce on warehouse management of a retail company

### 4.4 Performance analysis

In this stage of the project, key performance indicators are defined considering performance objectives and then, their impact is assessed.

#### 4.4.1 Performance Objectives assessment

Slack et al. (2013) describes five performance objectives that can be applied to operations, to analyze performance: quality; speed; dependability, flexibility, and cost. The lack of performance measure highlights the great need for having performance indicators both defined and evaluated. Considering that logistics attributes should be balanced as much as possible, and the main purpose is reducing picking time, stockouts and improve service delivery, the performance objectives under analyses are: quality, speed, dependability and flexibility. Based on data provided by the company, key performance indicators were defined for each performance objective, represented in Table 4.2.

*Table 4.2 Key Performance Indicators*

| <b>Performance Objective</b> | <b>Performance Indicator</b>                                  | <b>Measure</b>  |
|------------------------------|---|---|
| <b>Quality</b>               | Perfect Order Rate  | number of orders delivered without any issue, (e.g. damage, inaccuracies or delays)       |
| <b>Speed</b>                 | Average Time;<br>Time and Distance travelled in order picking | average time between start and finish picking;<br>time and distance between two locations |
| <b>Dependability</b>         | On Time Delivery  | rate of on-time deliveries  |
| <b>Flexibility</b>           | Stockouts   | ratio of items not available in inventory when a customer places an order                 |

Average time is the only indicator extracted directly from ERP. The performance indicator Time and Distance travelled will be collected through direct observation and explained in subchapter 4.4.2. The other three indicators will be calculated using formulas presented:

**Perfect Order Rate (percentage):**

$$POR = \% \text{ orders delivered on time} \times \% \text{ of orders complete} \times \% \text{ of orders damage free} \quad (1)$$

**On-Time Deliveries (percentage):**

$$OTD (\%) = \frac{\text{orders delivered on time}}{\text{total of orders delivered}} \times 100 \quad (2)$$

**Stockouts (percentage):**

$$\text{Stockouts} = \frac{\text{number of items out of stock}}{\text{number of items ordered}} \times 100 \quad (3)$$

**4.4.1.1 Data details**

To analyze performance evolution and compare values, three different periods were defined:

- $P_1$  - 6 months before implementation (from September of 2019 to February of 2020);
- $P_2$  - 6 months during implementation (from March to August of 2020);
- $P_3$  - 6 months after implementation (from September of 2020 to February 2021).

Initially, it is essential to extract the number of online orders and the respective quantity of items. Regarding the picking order type (subchapter 4.2.3.3), the following were selected: after sales, Click&Collect, PUP and transport, to consider only the online pickings. This information can only be withdrawn per week due to the ERP settings. Besides, average time picking and number of stockouts, are collected along with previous data. The number of stockouts are only those related to SM1 and SM2 (subchapter 4.2.3.2).

After knowing how many online orders were placed, it is necessary to know how many orders were not delivered and why, or if delivered, without any issues. Therefore, if the orders were not delivered on time, there are two reasons: item stockout or the contract was redone for other reasons, such as errors in the delivery documents or assembly service. Also, orders can be delivered to the customer without satisfying their needs. That is, the customer receives his order, but with delay, damaged products or wrong items. It is important to highlight that orders with damaged or wrong items only appears in company's ERP system if customers complain.



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In this way, to calculate perfect order rate and on time delivery, data was collected from company's ERP.

All data were gathered, and an example is presented in the following Table 4.3. The full table for each period is presented in Annex A.

*Table 4.3 Data collected from 2<sup>nd</sup> of September to 27<sup>th</sup> of October*

| Week            | Customer orders | Number of items | Contract redone | Oversell | Damaged packaging and/or product | Delay in delivery service | Wrong product sold | Orders not delivered | Orders delivered |
|-----------------|-----------------|-----------------|-----------------|----------|----------------------------------|---------------------------|--------------------|----------------------|------------------|
| 2/sep - 8/sep   | 1112            | 12717           | 21              | 4        | 20                               | 6                         | 12                 | 25                   | 1087             |
| 9/sep - 15/sep  | 1078            | 13087           | 27              | 4        | 15                               | 4                         | 8                  | 31                   | 1047             |
| 16sep - 22/sep  | 992             | 11190           | 22              | 4        | 18                               | 6                         | 8                  | 26                   | 966              |
| 23/sep - 29/sep | 1115            | 13782           | 17              | 1        | 10                               | 7                         | 5                  | 18                   | 1097             |
| 30/sep - 6/oct  | 1125            | 13322           | 11              | 4        | 13                               | 9                         | 3                  | 15                   | 1110             |
| 7/oct - 13/oct  | 1204            | 12959           | 24              | 5        | 8                                | 2                         | 6                  | 29                   | 1175             |
| 14/oct - 20/oct | 979             | 12888           | 19              | 1        | 16                               | 6                         | 6                  | 20                   | 959              |
| 21/oct - 27/oct | 964             | 12478           | 10              | 2        | 10                               | 6                         | 3                  | 12                   | 952              |

Afterwards, to calculate perfect order rate and on time delivery, the number of orders delivered on time, the orders completed and the orders of damage free per week were used. Table 4.4 is a representative example. For example, the week of the 2<sup>nd</sup> of September until the 8<sup>th</sup>, from 1112 orders, 97,21% were delivered on time, 96,67% were delivered completed and 95,95% were delivered damage free. Annex B gives detailed information.

*Table 4.4 Orders delivered on time, orders completed and orders damage free from 2<sup>nd</sup> of September to 27<sup>th</sup> of October*

| Week            | Customer orders | Orders delivered on time | Orders delivered on time (%) | Orders completed | Orders completed (%) | Orders of damage free | Orders of damage free (%) |
|-----------------|-----------------|--------------------------|------------------------------|------------------|----------------------|-----------------------|---------------------------|
| 2/sep - 8/sep   | 1112            | 1081                     | 97,21%                       | 1075             | 96,67%               | 1067                  | 95,95%                    |
| 9/sep - 15/sep  | 1078            | 1043                     | 96,75%                       | 1039             | 96,38%               | 1032                  | 95,73%                    |
| 16sep - 22/sep  | 992             | 960                      | 96,77%                       | 958              | 96,57%               | 948                   | 95,56%                    |
| 23/sep - 29/sep | 1115            | 1090                     | 97,76%                       | 1092             | 97,94%               | 1087                  | 97,49%                    |
| 30/sep - 6/oct  | 1125            | 1101                     | 97,87%                       | 1107             | 98,40%               | 1097                  | 97,51%                    |
| 7/oct - 13/oct  | 1204            | 1173                     | 97,43%                       | 1169             | 97,09%               | 1167                  | 96,93%                    |
| 14/oct - 20/oct | 979             | 953                      | 97,34%                       | 953              | 97,34%               | 943                   | 96,32%                    |
| 21/oct - 27/oct | 964             | 946                      | 98,13%                       | 949              | 98,44%               | 942                   | 97,72%                    |

Lastly, using previous data as input and using Excel tool, Key Performance Indicators calculations were done based on formulas mentioned in subchapter 4.4.1. and the results are presented in Annex E.

During  $P_1$ , before implementation of Hybrid Project, an average of 1100 online pickings were made per week. From  $P_1$  to  $P_2$ , online orders increased more than 200% due to mandatory quarantine caused by the pandemic. The store was closed on week 12 (16<sup>th</sup> of March of 2020) and reopened on week 25 (15<sup>th</sup> of June of 2020). In  $P_3$ , customers orders grew slightly, from an average of 2600 orders per week in  $P_2$  to 3000. Also, in this period, the store was closed again on 25<sup>th</sup> of January of 2021.

**4.4.1.2 Performance analysis**

In this subchapter, a graph is presented for each KPI for three periods, in order to compare the results obtained.

**Average Time**

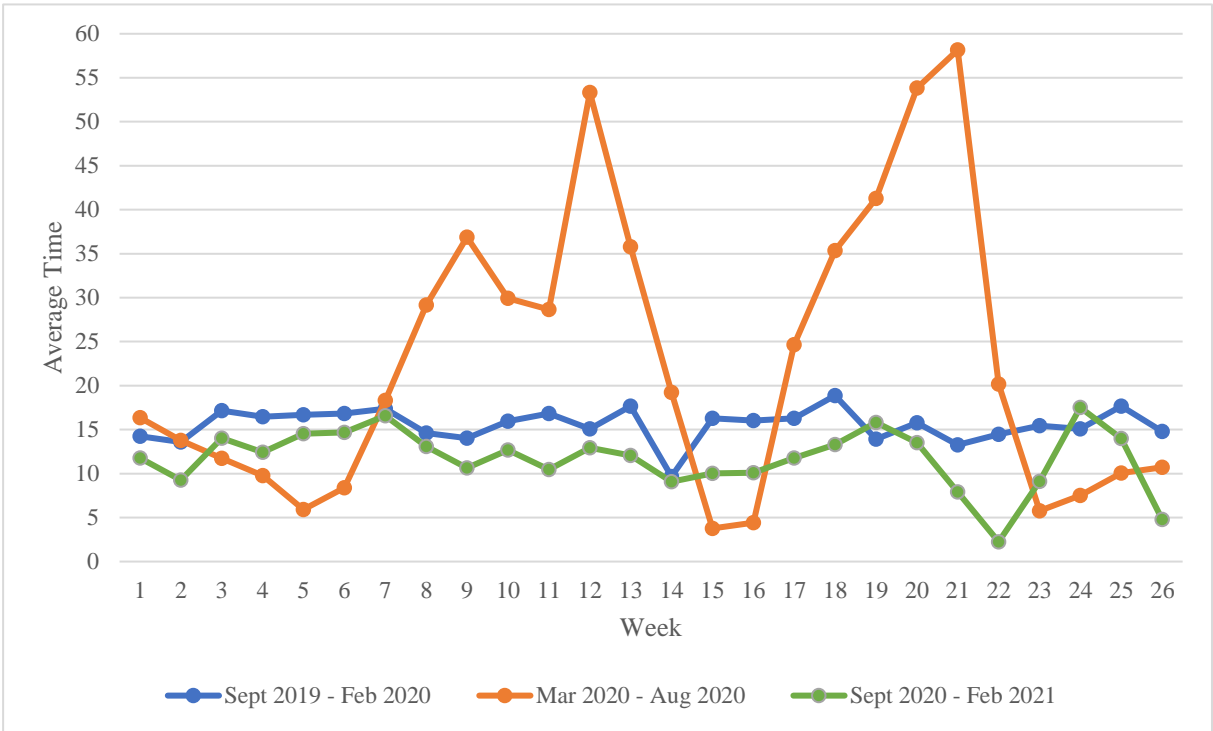


Figure 4.18 Average Time

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In Figure 4.18, it is outstanding that  $P_2$  was the most instable period as it is the period of the implementation and the beginning of the pandemic. During quarantine, the values increased, reaching 53,33 minutes per picking which is high compared to  $P_1$ . Later, during the opening week, it reached the minimum value but then increased over the weeks and got the maximum value of 58,15 minutes. Throughout  $P_3$ , values were always below  $P_1$ , except two weeks that were slightly higher.

Regarding human resources allocated for picking activity it was not possible to extract this information. However, by observation of the researcher, during lockdown on  $P_2$ , it was needed more resources due to increase of customer orders. A lot of co-workers from other departments without experience in picking process were allocated to do pickings, which leads to higher average time picking. Also, part-time people were hired to do pickings through this time, which takes more time to train them and obtain some experience.

Moreover, due to the lack of RDT for each picker, it was necessary to print customer orders and use paper instead of, which is not functional and increase picking time, once picker cannot consult order or articles information.

## Perfect Order Rate

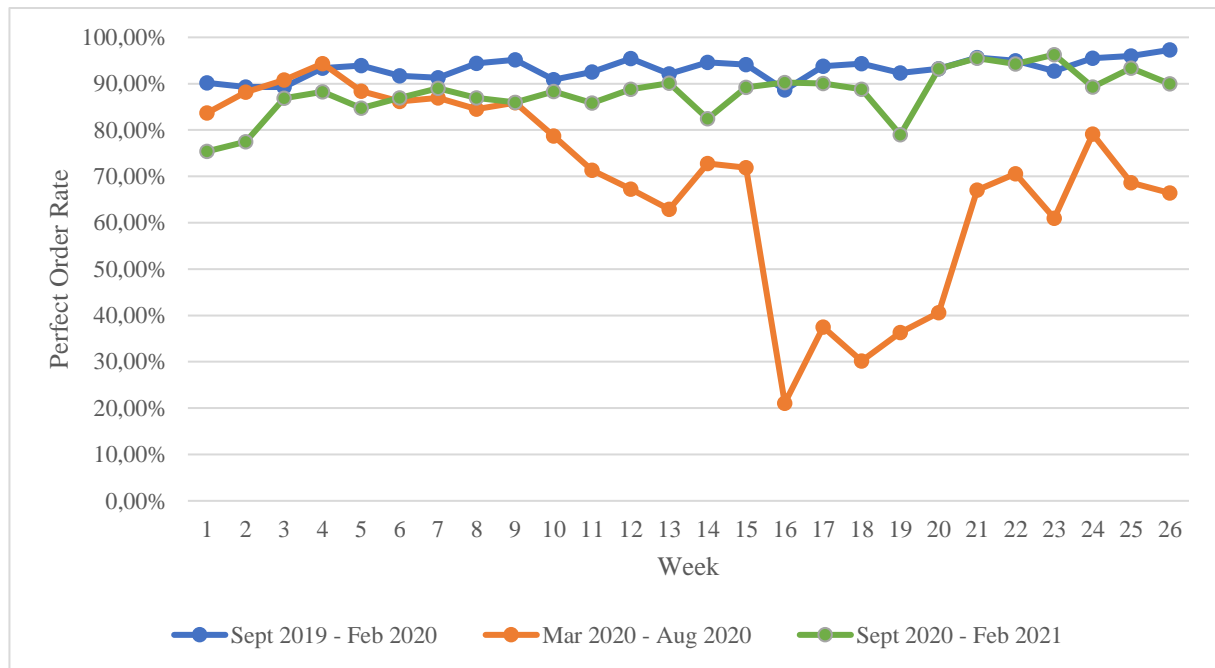


Figure 4.19 Perfect Order Rate

About Perfect Order Rate (Figure 4.19),  $P_1$  is the period with high values and the difference from weeks are slightly. Once more,  $P_2$  was the more difficult phase, reaching 20% has the lowest value, which means at least 75% of orders were delivered with errors. This signifies extra work in returns and after sales contracts to solve. These low values through  $P_2$  are the result of having inexperienced co-workers doing pickings, generating more inaccuracies deliveries. Besides that, due to the high volume and the need to be faster, there were more damages caused by co-workers and TSP. In  $P_3$ , the values start growing over the weeks because operational processes were adapted to the online flow and warehouse operations started to stabilize.

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### On Time Delivery

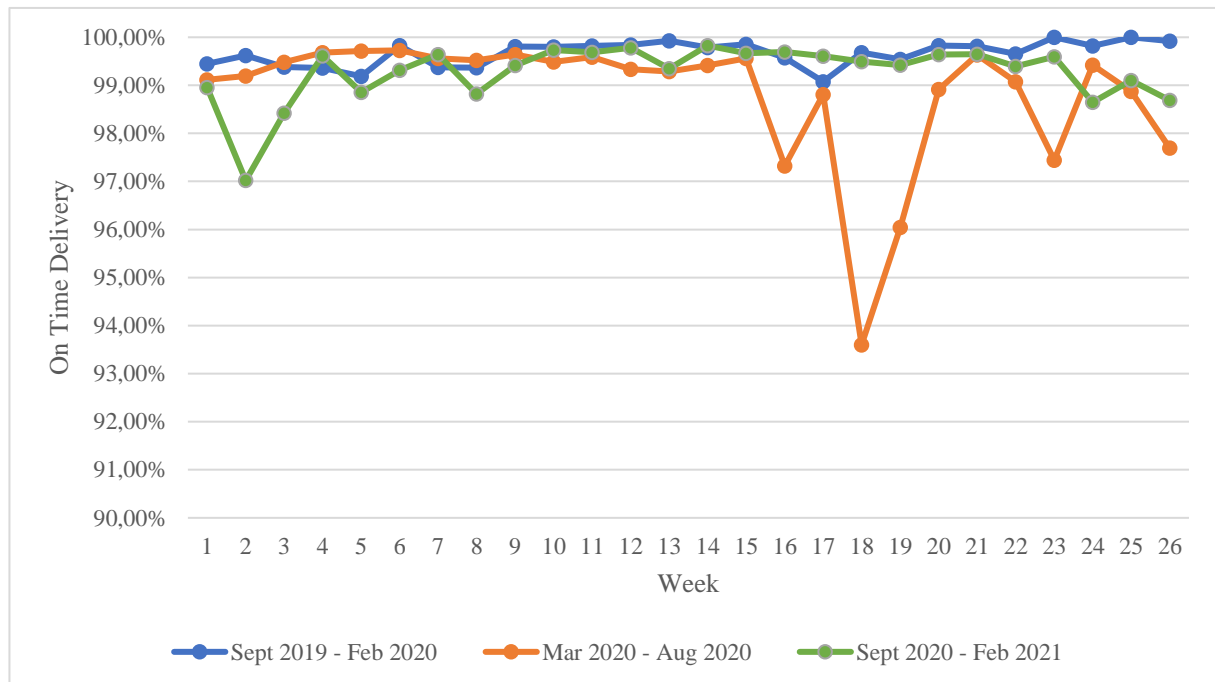


Figure 4.20 On Time Delivery

Regarding On Time Delivery (Figure 4.20), in  $P_1$  the values are always above 99%, having 2 weeks with 100%. During  $P_2$ , there is a decrease when the store reopened, and then reaching a minimum value of 93,6%. In the beginning of  $P_3$ , there is a slightly decrease but then values got stable, having percentages very similar to  $P_1$ . One more time,  $P_2$  was the most unstable period since the lead time of suppliers increased due to the lack of raw material. Throughout this time, store received much less stock than supposed to, causing delays in delivering orders on time to customers. Also, the TSP had to adjust its working method due to the high increasing volume of deliveries, causing some delays.

**Stockouts**

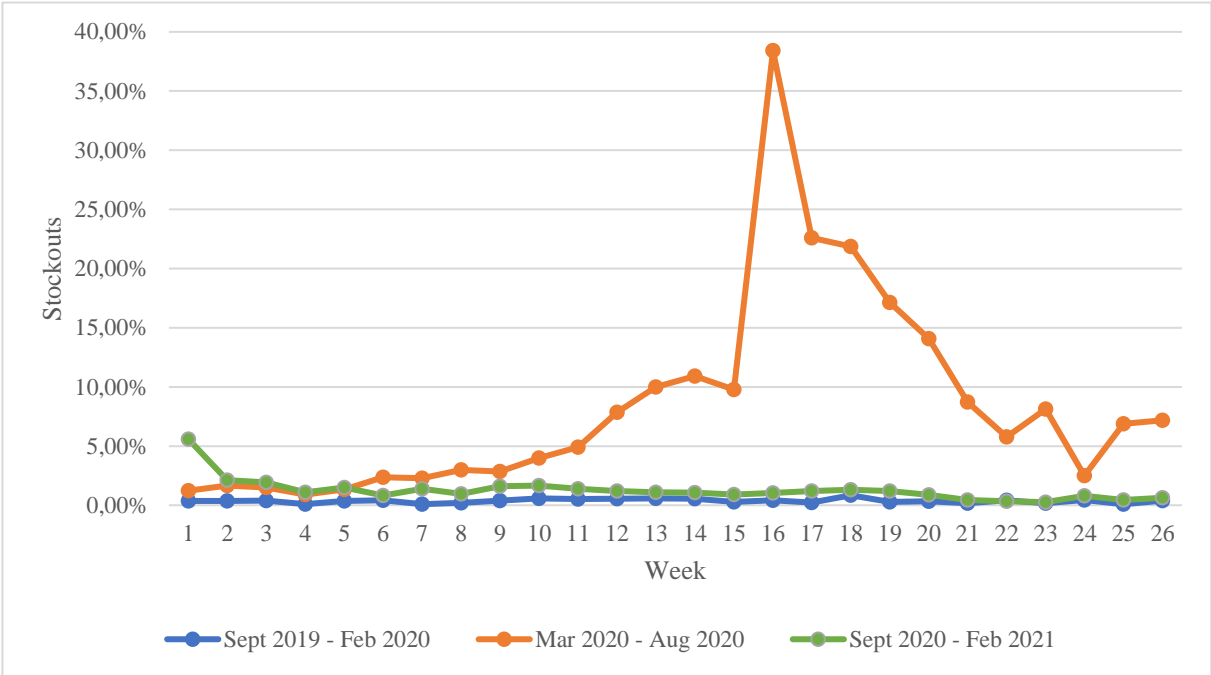


Figure 4.21 Stockouts

Stockouts is one of the KPI for Outflow team and the goal is keeping it below 0,20%. Looking at Figure 4.21, although percentages are less than 1%, only 5 weeks fulfilled this goal. Throughout  $P_2$ , this KPI reached extremely high values comparing to previous period. On reopening week, it had reached a maximum percentage of 38,41. Then it started to decrease over the weeks reaching 7,17% at the end of August. The last period had constant values, very similar to  $P_1$ , however did not achieve the goal any week. Important to highlight that the number of items out of stock are related only to Sales Method 1 and Sales Method 2, excluding articles from Markethall.

One of the main reasons for stockout is stock inaccuracy. Despite inventory management being a daily routine, with a big store and a lot of variety of items, it is complicated to have stock accuracy. With the pandemic, the supply chain was heavily affected: some suppliers closed for a while, there was lack of raw materials, less units produced and longer lead times due to transportation flows. All these reasons increased the stockout rate.

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### **4.4.2 Measurement of time and distance picking**

This subchapter addresses the data collection and evaluation of time and distance travelled during picking activity.

#### **4.4.2.1 Data collection**

For the operational assessment of different scenarios – before and after hybrid implementation – some important data were collected.

The data related to the stock was obtained through the ERP. As mentioned in subchapter 4.3.1, 126 SKUS were allocated in 176 storage locations within Hybrid area. Also, these SKUS are storage in 200 locations within Self-Serve. The final list presents 126 SKUS in 376 storage locations. Each SKU can have multiple sales locations, so all possible locations were collected for attaining different solutions.

The distances in meters from the merge area to each of the 376 storage locations have been collected on-site through direct observation, as well, as the time. The total distances and time consider two way route, from the initial location to the article location and vice-versa. The route selected was random. The full table is available in Annex D.

After collected the data mentioned previously, to verify the advantage if the picker collects within hybrid zone instead Self area, it was calculated the difference between the hybrid location distance and the Self location distance for each SKU. As well, the difference between the time of the hybrid location and the time of the Self location. For SKUs with multiple sales locations, all possible variations were assumed. The full table is available in Annex E.

The results obtained were highlighted with green or red color. If the variation is positive, which indicates that there is a saving it is marked in green. If the variation is negative, this is, the implemented solution consumes more time and cover distance, it is underlined in red. In Table 4.5, for SKU with reference 00103343, instead of picker going to location 24-00-00, collects at location 76-32-00, it saves 1 minute and 33 seconds and 51,48 meters in the route. Considering the other Self location, instead of collecting at location 26-24-00 collect at 76-32-00, saves 1 minute and 14 seconds and 48,44 meters.

Table 4.5 Time and distance difference of SKU with reference 00103343

| Reference | Self-Serve Location | Hybrid Location | Time difference | Distance difference |
|-----------|---------------------|-----------------|-----------------|---------------------|
| 00103343  | 24-00-00            | 76-32-00        | 00:01:33        | 51,48               |
|           | 26-24-00            |                 | 00:01:14        | 48,44               |

#### 4.4.2.2 Evaluating examples

In this step, considering that there could be several variations for articles with multiple sales locations, two alternative examples will be presented.

##### Example A

It is intended to conclude what is the best saving in time and distance during the picking process after hybrid implementation. In this way, it is chosen the best solution for each SKU, this is the higher saving between the two locations. The full table is in Annex F.

##### Example B

It is intended to assume the lowest saving in time and distance covered during the picking process after hybrid implementation. Contrasting example A, it is chosen the lowest saving between two locations for each SKU. The full table is in Annex G.

#### Performance Evaluation

The results of both examples are shown in Table 4.6, showing that after hybrid implementation there is a highest total saving of 1305,64 meters in travelling distance and 1 hour, 8 minutes and 47 seconds. Comparing to example B, demonstrates there is at least a total of 1107,83 meters saves in distance and 1 hour, 5 minutes and 1 second.

Table 4.6 Comparison between examples

| Example A – highest saving       | Example B – lowest saving      |
|----------------------------------|--------------------------------|
| 1305,64 meters                   | 1107,83 meters                 |
| 1 hour, 8 minutes and 47 seconds | 1 hour, 5 minutes and 1 second |



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However, from 126 articles implemented in the hybrid area, 21 articles did not improve in distance and time. Besides that, there were 21 articles that only decreased in time, with the distance being worse than before implementation. Also, only 1 article decreased in distance.

To sum up, 81 SKUs improved in time and distance travelled and 45 SKUs should be reviewed, which can be seen in Annex E.

### **4.5 Challenges phased during the transition period**

The logistics operation has gone through some challenges over the last year and half. The global pandemic accelerated the digital transformation in retail market, which impacted customer's needs and warehouse operations.

During the lockdown, store closed, online orders increased exponentially and so warehouse activities had to be adjusted due to the orders volume. Most of co-workers allocated to picking activity and customer service had no previous experience in these processes, which led to more errors and more time to do tasks. There was training to explain the tasks in general but as employees were always being allocated to different tasks, it was difficult to keep the workload organized. Also, the portuguese stores shared and collaborate among themselves, how they were adapting their processes.

The lack of electronic devices and the use of paper instead, created some inefficiency in picking, because if locations were empty there was no way to check stock availability or other sales location.

As the whole supply chain has been affected, suppliers increased the lead time due to the lack of raw materials. The store received much less supplies than expected, causing delays in delivering orders and stockouts.

With the increase of Click&Collect flow, it was built a pickup point in the parking lot for customer's collects its orders, which was important to divide physical flows. Meanwhile, the shipping area was transformed into an Outbound Area, meaning that orders are divided by flows and delivery directly to the customer's home. Before that, the orders were delivered to TSP, which store them in its warehouse until they were delivered.

Currently, warehouse activities are more adapted to omnichannel due to several improvements: the merge of logistics and costumer relations departments; the split into different physical flows considering fulfillment flow; the increase of merge area. However, stock availability is still an issue due to suppliers' constraints, affecting customer's needs and customer service.

Although the hybrid area is a benefit for order picking, it has a main challenge which is maintaining the area replenish. There are workers allocated as responsible for the area and sales locations are replenished when an alert message appears in the system. However, if the picker finds the place empty, it is easier and faster to collect the article in Self-Serve location than ask and wait while another colleague refill the hybrid locations. As there is the possibility to unload the stock from the rack anytime, it is not considered as a priority task.

## Impact of E-commerce on warehouse management of a retail company

### 5. CONCLUSIONS

E-commerce is placing increased pressure on managing demand and planning up and down the supply chain (Tarn, Razi, Wen, & Perez Jr, 2003). This study was focused on the assessment of picking performance within warehouse of IKEA store after the implementation of the hybrid area, which was implemented to suppress online orders bottlenecks and improve picking activity.

To accomplish the main goal of evaluate “before” and “after” scenarios, it was necessary to characterize warehouse activities, define performance indicators and collect the data to finally compare the main KPI’s and distance and time travelled. From the literature review, it was possible to understand the importance of warehouse activities in supply chain and its impact on competitive advantage, focusing on order picking.

Considering the aim of Hybrid Project and available data information, four different KPI’s were defined taking into consideration operations performance objectives: average time, perfect order rate, on-time deliveries and stockouts. Through the analysis of the results and considering three different periods, all indicators reveal still worse outcomes than before hybrid implementation. It is important to highlight that these results were highly affected by the consequences of the pandemic since online sales grew by 300% in 2020 and warehouse activities had to be constantly adapted. Overall,  $P_1$  presented better results than  $P_2$  and  $P_3$ . However,  $P_3$  present superior results comparing to  $P_2$ , and slightly differences compared to  $P_1$ .

To complement the assessment and check whether the picking activity benefited with the allocation of SKUs in hybrid area, distance and time travelled were collected to compare the scenarios. Through the analysis of scenarios, it is possible to conclude that any of the tested scenarios presents benefits to the previous one. However, 45 SKUs locations need to be review since did not improve in time and distance travelled. The hybrid zone, designated as Forward-Reserve Allocation, besides labor-time savings and minimizes distance travelled, it allows co-workers of using forklifts which is more ergonomic. Also, it reduces the risk of accidents once customers are not allowed on the zone. Last, one of the major benefits is the stock buffer in this area, being able to replenish during the day and turning this area into one of the most profitable within warehouse.

During the research, several limitations were found. The detailed information from ERP is only recorded for 3 months, so as the analysis was done for 18 months there was little information that could be extract, for example, customers’ orders had to be weekly. Besides, due to the COVID-19 pandemic, hybrid projected was suspended for four months.

Nevertheless, some recommendations are proposed for further improvements, which can make the process more efficient:

- Allocate stock to empty locations.
- Review and improvement of the allocation of products considering online forecast, avoiding overstock of stock for SKUs with little handling and preventing stockouts for SKUs with lots of handling.
- Keep the zone with updated communication to facilitate the operation.
- Implementation of voice picking.

Overall, the project met the objectives and taking into consideration the results obtained, it is possible to conclude that the picking process improved and became more efficient by implementing hybrid area.

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### 7. ANNEXE

#### Annex A

The following tables refers to the number of online orders per week and the number of orders with issues, whether delivered or not. Each table represents one period.

*Table 7.1 Customer orders in Period 1*

| Week            | Customer orders | Number of items | Contract redone | Oversell   | Damaged packaging and/or product | Delay in delivery service | Wrong product sold | Orders not delivered | Orders delivered |
|-----------------|-----------------|-----------------|-----------------|------------|----------------------------------|---------------------------|--------------------|----------------------|------------------|
| 2/sep - 8/sep   | 1112            | 12717           | 21              | 4          | 20                               | 6                         | 12                 | 25                   | 1087             |
| 9/sep - 15/sep  | 1078            | 13087           | 27              | 4          | 15                               | 4                         | 8                  | 31                   | 1047             |
| 16sep - 22/sep  | 992             | 11190           | 22              | 4          | 18                               | 6                         | 8                  | 26                   | 966              |
| 23/sep - 29/sep | 1115            | 13782           | 17              | 1          | 10                               | 7                         | 5                  | 18                   | 1097             |
| 30/sep - 6/oct  | 1125            | 13322           | 11              | 4          | 13                               | 9                         | 3                  | 15                   | 1110             |
| 7/oct - 13/oct  | 1204            | 12959           | 24              | 5          | 8                                | 2                         | 6                  | 29                   | 1175             |
| 14/oct - 20/oct | 979             | 12888           | 19              | 1          | 16                               | 6                         | 6                  | 20                   | 959              |
| 21/oct - 27/oct | 964             | 12478           | 10              | 2          | 10                               | 6                         | 3                  | 12                   | 952              |
| 28/oct - 3/nov  | 1055            | 11610           | 8               | 4          | 11                               | 2                         | 3                  | 12                   | 1043             |
| 4/nov - 10/nov  | 1020            | 13432           | 20              | 6          | 11                               | 2                         | 5                  | 26                   | 994              |
| 11/nov - 17/nov | 1136            | 14080           | 17              | 6          | 12                               | 2                         | 4                  | 23                   | 1113             |
| 18/nov - 24/nov | 1280            | 14190           | 6               | 7          | 16                               | 2                         | 2                  | 13                   | 1267             |
| 25/nov - 1/dec  | 1401            | 15831           | 19              | 8          | 27                               | 1                         | 4                  | 27                   | 1374             |
| 2/dec - 8/dec   | 1426            | 16330           | 13              | 8          | 8                                | 3                         | 4                  | 21                   | 1405             |
| 9/dec - 15/dec  | 1376            | 14938           | 19              | 4          | 9                                | 2                         | 3                  | 23                   | 1353             |
| 16/dec - 22/dec | 1218            | 12382           | 35              | 5          | 15                               | 5                         | 4                  | 40                   | 1178             |
| 23/dec - 29/dec | 877             | 10127           | 8               | 2          | 14                               | 8                         | 4                  | 10                   | 867              |
| 30/dec - 5/jan  | 950             | 10552           | 5               | 8          | 12                               | 3                         | 1                  | 13                   | 937              |
| 6/jan - 12/jan  | 1105            | 10552           | 18              | 3          | 17                               | 5                         | 2                  | 21                   | 1084             |
| 13/jan - 19/jan | 1197            | 10016           | 19              | 4          | 10                               | 2                         | 2                  | 23                   | 1174             |
| 20/jan - 26/jan | 1082            | 12716           | 9               | 2          | 12                               | 2                         | 1                  | 11                   | 1071             |
| 27/jan - 2/feb  | 1163            | 12651           | 7               | 5          | 15                               | 4                         | 5                  | 12                   | 1151             |
| 3/feb - 9/feb   | 1124            | 13674           | 22              | 2          | 9                                | 0                         | 3                  | 24                   | 1100             |
| 10/feb - 16/feb | 1143            | 13361           | 9               | 5          | 6                                | 2                         | 2                  | 14                   | 1129             |
| 17/feb - 23/feb | 1185            | 16961           | 12              | 1          | 7                                | 0                         | 2                  | 13                   | 1172             |
| 24/feb- 1/mar   | 1314            | 15021           | 3               | 5          | 8                                | 1                         | 3                  | 8                    | 1306             |
| <b>TOTAL</b>    | <b>29621</b>    | <b>340847</b>   | <b>400</b>      | <b>110</b> | <b>329</b>                       | <b>92</b>                 | <b>105</b>         | <b>510</b>           | <b>29111</b>     |

Table 7.2 Customer orders in Period 2

| Week            | Customer orders | Number of items | Contract redone | Oversell    | Damaged packaging and/or product | Delay in delivery service | Wrong product sold | Orders not delivered | Orders delivered |
|-----------------|-----------------|-----------------|-----------------|-------------|----------------------------------|---------------------------|--------------------|----------------------|------------------|
| 2/mar - 8/mar   | 1301            | 15882           | 44              | 16          | 29                               | 11                        | 5                  | 60                   | 1241             |
| 9/mar - 15/mar  | 1917            | 19696           | 30              | 32          | 24                               | 15                        | 11                 | 62                   | 1855             |
| 16/mar - 22/mar | 2382            | 21909           | 28              | 36          | 14                               | 12                        | 9                  | 64                   | 2318             |
| 23/mar - 29/mar | 4755            | 15626           | 35              | 43          | 19                               | 15                        | 6                  | 78                   | 4677             |
| 30/mar - 5/apr  | 4675            | 28651           | 113             | 62          | 17                               | 13                        | 10                 | 175                  | 4500             |
| 6/apr - 12/apr  | 3845            | 29095           | 84              | 91          | 16                               | 10                        | 8                  | 175                  | 3670             |
| 13/apr - 19/apr | 4065            | 21813           | 74              | 93          | 22                               | 17                        | 15                 | 167                  | 3898             |
| 20/apr - 26/apr | 3309            | 25239           | 67              | 99          | 14                               | 15                        | 14                 | 166                  | 3143             |
| 27/apr - 3/may  | 4063            | 20326           | 68              | 116         | 25                               | 14                        | 12                 | 184                  | 3879             |
| 4/may - 10/may  | 3369            | 24165           | 81              | 134         | 22                               | 16                        | 13                 | 215                  | 3128             |
| 11/may - 17/may | 3253            | 20585           | 84              | 160         | 21                               | 12                        | 14                 | 244                  | 2922             |
| 18/may - 24/may | 2893            | 20733           | 73              | 227         | 53                               | 17                        | 13                 | 300                  | 2562             |
| 25/may - 31/may | 2585            | 19826           | 64              | 258         | 87                               | 16                        | 13                 | 322                  | 2254             |
| 1/jun - 7/jun   | 2815            | 19539           | 55              | 307         | 68                               | 15                        | 22                 | 362                  | 2567             |
| 8/jun - 14/jun  | 3298            | 23822           | 59              | 322         | 42                               | 13                        | 24                 | 381                  | 2981             |
| 15/jun - 21/jun | 953             | 24463           | 48              | 366         | 47                               | 16                        | 29                 | 414                  | 598              |
| 22/jun - 28/jun | 1473            | 7538            | 61              | 333         | 50                               | 13                        | 20                 | 394                  | 1090             |
| 29/jun - 5/jul  | 1381            | 11944           | 72              | 302         | 48                               | 62                        | 17                 | 374                  | 969              |
| 6/jul - 12/jul  | 1624            | 10929           | 79              | 278         | 33                               | 47                        | 10                 | 357                  | 1189             |
| 13/jul - 19/jul | 1698            | 11244           | 76              | 239         | 43                               | 14                        | 37                 | 315                  | 1289             |
| 20/jul - 26/jul | 2463            | 13451           | 67              | 215         | 55                               | 8                         | 13                 | 282                  | 2181             |
| 27/jul - 2/aug  | 2507            | 21710           | 100             | 145         | 51                               | 21                        | 17                 | 245                  | 2262             |
| 3/aug - 9/aug   | 1748            | 20056           | 82              | 142         | 67                               | 39                        | 19                 | 224                  | 1524             |
| 10/aug - 16/aug | 1832            | 13876           | 59              | 46          | 62                               | 10                        | 25                 | 105                  | 1727             |
| 17/aug - 23/aug | 1770            | 15836           | 52              | 122         | 69                               | 18                        | 17                 | 174                  | 1596             |
| 24/aug - 30/aug | 1841            | 14736           | 58              | 132         | 78                               | 38                        | 17                 | 190                  | 1651             |
| <b>TOTAL</b>    | <b>67815</b>    | <b>492690</b>   | <b>1713</b>     | <b>4316</b> | <b>1076</b>                      | <b>497</b>                | <b>410</b>         | <b>6029</b>          | <b>61671</b>     |



## Impact of E-commerce on warehouse management of a retail company

*Table 7.3 Customer orders in Period 3*

| Week            | Customer orders | Number of items | Contract redone | Oversell   | Damaged packaging and/or product | Delay in delivery service | Wrong product sold | Orders not delivered | Orders delivered |
|-----------------|-----------------|-----------------|-----------------|------------|----------------------------------|---------------------------|--------------------|----------------------|------------------|
| 31/aug - 6/sep  | 1736            | 13340           | 17              | 97         | 99                               | 17                        | 8                  | 114                  | 1622             |
| 7/sep - 13/sep  | 2115            | 13219           | 90              | 45         | 43                               | 59                        | 10                 | 135                  | 1980             |
| 14/sep - 20/sep | 2279            | 17209           | 15              | 44         | 91                               | 35                        | 9                  | 59                   | 2220             |
| 21/sep - 27/sep | 2377            | 18886           | 32              | 26         | 93                               | 9                         | 15                 | 58                   | 2319             |
| 28/sep - 4/oct  | 2356            | 19666           | 48              | 35         | 83                               | 26                        | 21                 | 83                   | 2273             |
| 5/oct - 11/oct  | 2413            | 19729           | 52              | 20         | 68                               | 16                        | 29                 | 72                   | 2341             |
| 12/oct - 18/oct | 2878            | 23935           | 38              | 40         | 73                               | 10                        | 12                 | 78                   | 2800             |
| 19/oct - 25/oct | 3134            | 25964           | 48              | 30         | 143                              | 36                        | 13                 | 78                   | 3056             |
| 26/oct - 1/nov  | 3190            | 27768           | 72              | 51         | 61                               | 18                        | 22                 | 123                  | 3067             |
| 2/nov - 8/nov   | 3515            | 28394           | 57              | 58         | 52                               | 9                         | 21                 | 115                  | 3400             |
| 9/nov - 15/nov  | 3657            | 28164           | 96              | 51         | 88                               | 11                        | 4                  | 147                  | 3510             |
| 16/nov - 22/nov | 3702            | 31487           | 54              | 44         | 114                              | 8                         | 13                 | 98                   | 3604             |
| 23/nov - 29/nov | 3756            | 32227           | 38              | 41         | 101                              | 24                        | 21                 | 79                   | 3677             |
| 30/nov - 6/dec  | 3668            | 32543           | 167             | 39         | 46                               | 6                         | 17                 | 206                  | 3462             |
| 7/dec - 13/dec  | 4001            | 27684           | 56              | 36         | 135                              | 13                        | 23                 | 92                   | 3909             |
| 14/dec - 20/dec | 3375            | 27585           | 44              | 35         | 78                               | 10                        | 15                 | 79                   | 3296             |
| 21/dec - 27/dec | 2341            | 27008           | 24              | 28         | 63                               | 9                         | 13                 | 52                   | 2289             |
| 28/dec - 3/jan  | 2423            | 18723           | 28              | 32         | 59                               | 12                        | 31                 | 60                   | 2363             |
| 4/jan - 10/jan  | 2606            | 21488           | 147             | 31         | 30                               | 14                        | 12                 | 178                  | 2428             |
| 11/jan - 17/jan | 3400            | 20691           | 29              | 30         | 37                               | 12                        | 11                 | 59                   | 3341             |
| 18/jan - 24/jan | 4332            | 28953           | 29              | 19         | 22                               | 15                        | 16                 | 48                   | 4284             |
| 25/jan - 31/jan | 3169            | 33005           | 30              | 11         | 24                               | 19                        | 19                 | 41                   | 3128             |
| 1/feb - 7/feb   | 4930            | 28350           | 29              | 13         | 25                               | 20                        | 15                 | 42                   | 4888             |
| 8/feb - 14/feb  | 1898            | 41452           | 32              | 15         | 28                               | 25                        | 17                 | 47                   | 1851             |
| 15/feb - 21/feb | 3730            | 13336           | 38              | 17         | 32                               | 33                        | 24                 | 55                   | 3675             |
| 22/feb - 28/feb | 2418            | 30210           | 39              | 15         | 36                               | 31                        | 22                 | 54                   | 2364             |
| <b>TOTAL</b>    | <b>79399</b>    | <b>651016</b>   | <b>1349</b>     | <b>903</b> | <b>1724</b>                      | <b>497</b>                | <b>433</b>         | <b>2252</b>          | <b>77147</b>     |

## Annex B

The following table refers to the number of orders per week, delivered on time, completed and damage free. Each table represents one period.

*Table 7.4 Orders delivered on time, orders completed and orders of damage free in Period 1*

| <b>Week</b>     | <b>Customer orders</b> | <b>Orders delivered on time</b> | <b>Orders delivered on time (%)</b> | <b>Orders completed</b> | <b>Orders completed (%)</b> | <b>Orders of damage free</b> | <b>Orders of damage free (%)</b> |
|-----------------|------------------------|---------------------------------|-------------------------------------|-------------------------|-----------------------------|------------------------------|----------------------------------|
| 2/sep - 8/sep   | 1112                   | 1081                            | 97,21%                              | 1075                    | 96,67%                      | 1067                         | 95,95%                           |
| 9/sep - 15/sep  | 1078                   | 1043                            | 96,75%                              | 1039                    | 96,38%                      | 1032                         | 95,73%                           |
| 16sep - 22/sep  | 992                    | 960                             | 96,77%                              | 958                     | 96,57%                      | 948                          | 95,56%                           |
| 23/sep - 29/sep | 1115                   | 1090                            | 97,76%                              | 1092                    | 97,94%                      | 1087                         | 97,49%                           |
| 30/sep - 6/oct  | 1125                   | 1101                            | 97,87%                              | 1107                    | 98,40%                      | 1097                         | 97,51%                           |
| 7/oct - 13/oct  | 1204                   | 1173                            | 97,43%                              | 1169                    | 97,09%                      | 1167                         | 96,93%                           |
| 14/oct - 20/oct | 979                    | 953                             | 97,34%                              | 953                     | 97,34%                      | 943                          | 96,32%                           |
| 21/oct - 27/oct | 964                    | 946                             | 98,13%                              | 949                     | 98,44%                      | 942                          | 97,72%                           |
| 28/oct - 3/nov  | 1055                   | 1041                            | 98,67%                              | 1040                    | 98,58%                      | 1032                         | 97,82%                           |
| 4/nov - 10/nov  | 1020                   | 992                             | 97,25%                              | 989                     | 96,96%                      | 983                          | 96,37%                           |
| 11/nov - 17/nov | 1136                   | 1111                            | 97,80%                              | 1109                    | 97,62%                      | 1101                         | 96,92%                           |
| 18/nov - 24/nov | 1280                   | 1265                            | 98,83%                              | 1265                    | 98,83%                      | 1251                         | 97,73%                           |
| 25/nov - 1/dec  | 1401                   | 1373                            | 98,00%                              | 1370                    | 97,79%                      | 1347                         | 96,15%                           |
| 2/dec - 8/dec   | 1426                   | 1402                            | 98,32%                              | 1401                    | 98,25%                      | 1397                         | 97,97%                           |
| 9/dec - 15/dec  | 1376                   | 1351                            | 98,18%                              | 1350                    | 98,11%                      | 1344                         | 97,67%                           |
| 16/dec - 22/dec | 1218                   | 1173                            | 96,31%                              | 1174                    | 96,39%                      | 1163                         | 95,48%                           |
| 23/dec - 29/dec | 877                    | 859                             | 97,95%                              | 863                     | 98,40%                      | 853                          | 97,26%                           |
| 30/dec - 5/jan  | 950                    | 934                             | 98,32%                              | 936                     | 98,53%                      | 925                          | 97,37%                           |
| 6/jan - 12/jan  | 1105                   | 1079                            | 97,65%                              | 1082                    | 97,92%                      | 1067                         | 96,56%                           |
| 13/jan - 19/jan | 1197                   | 1172                            | 97,91%                              | 1172                    | 97,91%                      | 1164                         | 97,24%                           |
| 20/jan - 26/jan | 1082                   | 1069                            | 98,80%                              | 1070                    | 98,89%                      | 1059                         | 97,87%                           |
| 27/jan - 2/feb  | 1163                   | 1147                            | 98,62%                              | 1146                    | 98,54%                      | 1136                         | 97,68%                           |
| 3/feb - 9/feb   | 1124                   | 1100                            | 97,86%                              | 1097                    | 97,60%                      | 1091                         | 97,06%                           |
| 10/feb - 16/feb | 1143                   | 1127                            | 98,60%                              | 1127                    | 98,60%                      | 1123                         | 98,25%                           |
| 17/feb - 23/feb | 1185                   | 1172                            | 98,90%                              | 1170                    | 98,73%                      | 1165                         | 98,31%                           |
| 24/feb- 1/mar   | 1314                   | 1305                            | 99,32%                              | 1303                    | 99,16%                      | 1298                         | 98,78%                           |

## Impact of E-commerce on warehouse management of a retail company

*Table 7.5 Orders delivered on time, orders completed and orders of damage free in Period 2*

| <b>Week</b>     | <b>Customer orders</b> | <b>Orders delivered on time</b> | <b>Orders delivered on time (%)</b> | <b>Orders completed</b> | <b>Orders completed (%)</b> | <b>Orders of damage free</b> | <b>Orders of damage free (%)</b> |
|-----------------|------------------------|---------------------------------|-------------------------------------|-------------------------|-----------------------------|------------------------------|----------------------------------|
| 2/mar - 8/mar   | 1301                   | 1230                            | 94,54%                              | 1236                    | 95,00%                      | 1212                         | 93,16%                           |
| 9/mar - 15/mar  | 1917                   | 1840                            | 95,98%                              | 1844                    | 96,19%                      | 1831                         | 95,51%                           |
| 16/mar - 22/mar | 2382                   | 2306                            | 96,81%                              | 2309                    | 96,94%                      | 2304                         | 96,73%                           |
| 23/mar - 29/mar | 4755                   | 4662                            | 98,04%                              | 4671                    | 98,23%                      | 4658                         | 97,96%                           |
| 30/mar - 5/apr  | 4675                   | 4487                            | 95,98%                              | 4490                    | 96,04%                      | 4483                         | 95,89%                           |
| 6/apr - 12/apr  | 3845                   | 3660                            | 95,19%                              | 3662                    | 95,24%                      | 3654                         | 95,03%                           |
| 13/apr - 19/apr | 4065                   | 3881                            | 95,47%                              | 3883                    | 95,52%                      | 3876                         | 95,35%                           |
| 20/apr - 26/apr | 3309                   | 3128                            | 94,53%                              | 3129                    | 94,56%                      | 3129                         | 94,56%                           |
| 27/apr - 3/may  | 4063                   | 3865                            | 95,13%                              | 3867                    | 95,18%                      | 3854                         | 94,86%                           |
| 4/may - 10/may  | 3369                   | 3112                            | 92,37%                              | 3115                    | 92,46%                      | 3106                         | 92,19%                           |
| 11/may - 17/may | 3253                   | 2910                            | 89,46%                              | 2908                    | 89,39%                      | 2901                         | 89,18%                           |
| 18/may - 24/may | 2893                   | 2545                            | 87,97%                              | 2549                    | 88,11%                      | 2509                         | 86,73%                           |
| 25/may - 31/may | 2585                   | 2238                            | 86,58%                              | 2241                    | 86,69%                      | 2167                         | 83,83%                           |
| 1/jun - 7/jun   | 2815                   | 2552                            | 90,66%                              | 2545                    | 90,41%                      | 2499                         | 88,77%                           |
| 8/jun - 14/jun  | 3298                   | 2968                            | 89,99%                              | 2957                    | 89,66%                      | 2939                         | 89,11%                           |
| 15/jun - 21/jun | 953                    | 582                             | 61,07%                              | 569                     | 59,71%                      | 551                          | 57,82%                           |
| 22/jun - 28/jun | 1473                   | 1077                            | 73,12%                              | 1070                    | 72,64%                      | 1040                         | 70,60%                           |
| 29/jun - 5/jul  | 1381                   | 907                             | 65,68%                              | 952                     | 68,94%                      | 921                          | 66,69%                           |
| 6/jul - 12/jul  | 1624                   | 1142                            | 70,32%                              | 1179                    | 72,60%                      | 1156                         | 71,18%                           |
| 13/jul - 19/jul | 1698                   | 1275                            | 75,09%                              | 1252                    | 73,73%                      | 1246                         | 73,38%                           |
| 20/jul - 26/jul | 2463                   | 2173                            | 88,23%                              | 2168                    | 88,02%                      | 2126                         | 86,32%                           |
| 27/jul - 2/aug  | 2507                   | 2241                            | 89,39%                              | 2245                    | 89,55%                      | 2211                         | 88,19%                           |
| 3/aug - 9/aug   | 1748                   | 1485                            | 84,95%                              | 1505                    | 86,10%                      | 1457                         | 83,35%                           |
| 10/aug - 16/aug | 1832                   | 1717                            | 93,72%                              | 1702                    | 92,90%                      | 1665                         | 90,88%                           |
| 17/aug - 23/aug | 1770                   | 1578                            | 89,15%                              | 1579                    | 89,21%                      | 1527                         | 86,27%                           |
| 24/aug - 30/aug | 1841                   | 1613                            | 87,62%                              | 1634                    | 88,76%                      | 1573                         | 85,44%                           |

Table 7.6 Orders delivered on time, orders completed and orders of damage free in Period 3

| Week            | Customer orders | Orders delivered on time | Orders delivered on time (%) | Orders completed | Orders completed (%) | Orders of damage free | Orders of damage free (%) |
|-----------------|-----------------|--------------------------|------------------------------|------------------|----------------------|-----------------------|---------------------------|
| 31/aug - 6/sep  | 1736            | 1605                     | 92,45%                       | 1614             | 92,97%               | 1523                  | 87,73%                    |
| 7/sep - 13/sep  | 2115            | 1921                     | 90,83%                       | 1970             | 93,14%               | 1937                  | 91,58%                    |
| 14/sep - 20/sep | 2279            | 2185                     | 95,88%                       | 2211             | 97,02%               | 2129                  | 93,42%                    |
| 21/sep - 27/sep | 2377            | 2310                     | 97,18%                       | 2304             | 96,93%               | 2226                  | 93,65%                    |
| 28/sep - 4/oct  | 2356            | 2247                     | 95,37%                       | 2252             | 95,59%               | 2190                  | 92,95%                    |
| 5/oct - 11/oct  | 2413            | 2325                     | 96,35%                       | 2312             | 95,81%               | 2273                  | 94,20%                    |
| 12/oct - 18/oct | 2878            | 2790                     | 96,94%                       | 2788             | 96,87%               | 2727                  | 94,75%                    |
| 19/oct - 25/oct | 3134            | 3020                     | 96,36%                       | 3043             | 97,10%               | 2913                  | 92,95%                    |
| 26/oct - 1/nov  | 3190            | 3049                     | 95,58%                       | 3045             | 95,45%               | 3006                  | 94,23%                    |
| 2/nov - 8/nov   | 3515            | 3391                     | 96,47%                       | 3379             | 96,13%               | 3348                  | 95,25%                    |
| 9/nov - 15/nov  | 3657            | 3499                     | 95,68%                       | 3506             | 95,87%               | 3422                  | 93,57%                    |
| 16/nov - 22/nov | 3702            | 3596                     | 97,14%                       | 3591             | 97,00%               | 3490                  | 94,27%                    |
| 23/nov - 29/nov | 3756            | 3653                     | 97,26%                       | 3656             | 97,34%               | 3576                  | 95,21%                    |
| 30/nov - 6/dec  | 3668            | 3456                     | 94,22%                       | 3445             | 93,92%               | 3416                  | 93,13%                    |
| 7/dec - 13/dec  | 4001            | 3896                     | 97,38%                       | 3886             | 97,13%               | 3774                  | 94,33%                    |
| 14/dec - 20/dec | 3375            | 3286                     | 97,36%                       | 3281             | 97,21%               | 3218                  | 95,35%                    |
| 21/dec - 27/dec | 2341            | 2280                     | 97,39%                       | 2276             | 97,22%               | 2226                  | 95,09%                    |
| 28/dec - 3/jan  | 2423            | 2351                     | 97,03%                       | 2332             | 96,24%               | 2304                  | 95,09%                    |
| 4/jan - 10/jan  | 2606            | 2414                     | 92,63%                       | 2416             | 92,71%               | 2398                  | 92,02%                    |
| 11/jan - 17/jan | 3400            | 3329                     | 97,91%                       | 3330             | 97,94%               | 3304                  | 97,18%                    |
| 18/jan - 24/jan | 4332            | 4269                     | 98,55%                       | 4268             | 98,52%               | 4262                  | 98,38%                    |
| 25/jan - 31/jan | 3169            | 3109                     | 98,11%                       | 3109             | 98,11%               | 3104                  | 97,95%                    |
| 1/feb - 7/feb   | 4930            | 4868                     | 98,74%                       | 4873             | 98,84%               | 4863                  | 98,64%                    |
| 8/feb - 14/feb  | 1898            | 1826                     | 96,21%                       | 1834             | 96,63%               | 1823                  | 96,05%                    |
| 15/feb - 21/feb | 3730            | 3642                     | 97,64%                       | 3651             | 97,88%               | 3643                  | 97,67%                    |
| 22/feb - 28/feb | 2418            | 2333                     | 96,48%                       | 2342             | 96,86%               | 2328                  | 96,28%                    |

**Impact of E-commerce on warehouse management of a retail company**

## Annex C

The tables presented below represents the values of Key Performance Indicators per week, in each period.

*Table 7.7 Key Performance Indicators in Period 1*

| <b>Week</b>     | <b>Average Time (min)</b> | <b>Perfect Order Rate</b> | <b>On Time Delivery</b> | <b>Stockouts</b> |
|-----------------|---------------------------|---------------------------|-------------------------|------------------|
| 2/sep - 8/sep   | 14,23                     | 90,17%                    | 99,45%                  | 0,36%            |
| 9/sep - 15/sep  | 13,58                     | 89,27%                    | 99,62%                  | 0,37%            |
| 16sep - 22/sep  | 17,17                     | 89,31%                    | 99,38%                  | 0,40%            |
| 23/sep - 29/sep | 16,47                     | 93,34%                    | 99,36%                  | 0,09%            |
| 30/sep - 6/oct  | 16,68                     | 93,90%                    | 99,19%                  | 0,36%            |
| 7/oct - 13/oct  | 16,83                     | 91,69%                    | 99,83%                  | 0,42%            |
| 14/oct - 20/oct | 17,38                     | 91,27%                    | 99,37%                  | 0,10%            |
| 21/oct - 27/oct | 14,62                     | 94,40%                    | 99,37%                  | 0,21%            |
| 28/oct - 3/nov  | 14,03                     | 95,15%                    | 99,81%                  | 0,38%            |
| 4/nov - 10/nov  | 15,95                     | 90,88%                    | 99,80%                  | 0,59%            |
| 11/nov - 17/nov | 16,82                     | 92,53%                    | 99,82%                  | 0,53%            |
| 18/nov - 24/nov | 15,08                     | 95,46%                    | 99,84%                  | 0,55%            |
| 25/nov - 1/dec  | 17,67                     | 92,14%                    | 99,93%                  | 0,57%            |
| 2/dec - 8/dec   | 9,67                      | 94,63%                    | 99,79%                  | 0,56%            |
| 9/dec - 15/dec  | 16,27                     | 94,09%                    | 99,85%                  | 0,29%            |
| 16/dec - 22/dec | 16,03                     | 88,63%                    | 99,58%                  | 0,41%            |
| 23/dec - 29/dec | 16,27                     | 93,75%                    | 99,08%                  | 0,23%            |
| 30/dec - 5/jan  | 18,87                     | 94,32%                    | 99,68%                  | 0,84%            |
| 6/jan - 12/jan  | 13,93                     | 92,33%                    | 99,54%                  | 0,27%            |
| 13/jan - 19/jan | 15,77                     | 93,22%                    | 99,83%                  | 0,33%            |
| 20/jan - 26/jan | 13,27                     | 95,63%                    | 99,81%                  | 0,18%            |
| 27/jan - 2/feb  | 14,47                     | 94,93%                    | 99,65%                  | 0,43%            |
| 3/feb - 9/feb   | 15,43                     | 92,71%                    | 100%                    | 0,18%            |
| 10/feb - 16/feb | 15,08                     | 95,52%                    | 99,82%                  | 0,44%            |
| 17/feb - 23/feb | 17,67                     | 96,00%                    | 100%                    | 0,08%            |
| 24/feb- 1/mar   | 14,78                     | 97,28%                    | 99,92%                  | 0,38%            |

## Impact of E-commerce on warehouse management of a retail company

*Table 7.8 Key Performance Indicators in Period 2*

| Week            | Average Time<br>(min) | Perfect Order<br>Rate | On Time<br>Delivery | Stockouts |
|-----------------|-----------------------|-----------------------|---------------------|-----------|
| 2/mar - 8/mar   | 16,35                 | 83,67%                | 99,11%              | 1,23%     |
| 9/mar - 15/mar  | 13,78                 | 88,19%                | 99,19%              | 1,67%     |
| 16/mar - 22/mar | 11,75                 | 90,77%                | 99,48%              | 1,51%     |
| 23/mar - 29/mar | 9,77                  | 94,35%                | 99,68%              | 0,90%     |
| 30/mar - 5/apr  | 5,92                  | 88,39%                | 99,71%              | 1,33%     |
| 6/apr - 12/apr  | 8,4                   | 86,15%                | 99,73%              | 2,37%     |
| 13/apr - 19/apr | 18,33                 | 86,96%                | 99,56%              | 2,29%     |
| 20/apr - 26/apr | 29,17                 | 84,53%                | 99,52%              | 2,99%     |
| 27/apr - 3/may  | 36,88                 | 85,88%                | 99,64%              | 2,86%     |
| 4/may - 10/may  | 29,93                 | 78,74%                | 99,49%              | 3,98%     |
| 11/may - 17/may | 28,65                 | 71,32%                | 99,59%              | 4,92%     |
| 18/may - 24/may | 53,33                 | 67,22%                | 99,34%              | 7,85%     |
| 25/may - 31/may | 35,78                 | 62,92%                | 99,29%              | 9,98%     |
| 1/jun - 7/jun   | 19,22                 | 72,76%                | 99,42%              | 10,91%    |
| 8/jun - 14/jun  | 3,77                  | 71,91%                | 99,56%              | 9,76%     |
| 15/jun - 21/jun | 4,42                  | 21,08%                | 97,32%              | 38,41%    |
| 22/jun - 28/jun | 24,67                 | 37,50%                | 98,81%              | 22,61%    |
| 29/jun - 5/jul  | 35,35                 | 30,19%                | 93,60%              | 21,87%    |
| 6/jul - 12/jul  | 41,27                 | 36,34%                | 96,05%              | 17,12%    |
| 13/jul - 19/jul | 53,83                 | 40,63%                | 98,91%              | 14,08%    |
| 20/jul - 26/jul | 58,15                 | 67,03%                | 99,63%              | 8,73%     |
| 27/jul - 2/aug  | 20,18                 | 70,60%                | 99,07%              | 5,78%     |
| 3/aug - 9/aug   | 5,78                  | 60,97%                | 97,44%              | 8,12%     |
| 10/aug - 16/aug | 7,53                  | 79,13%                | 99,42%              | 2,51%     |
| 17/aug - 23/aug | 10,07                 | 68,61%                | 98,87%              | 6,89%     |
| 24/aug - 30/aug | 10,73                 | 66,44%                | 97,70%              | 7,17%     |

Table 7.9 Key Performance Indicators in Period 3

| <b>Week</b>     | <b>Average Time (min)</b> | <b>Perfect Order Rate</b> | <b>On Time Delivery</b> | <b>Stockouts</b> |
|-----------------|---------------------------|---------------------------|-------------------------|------------------|
| 31/aug - 6/sep  | 11,78                     | 75,41%                    | 98,95%                  | 5,59%            |
| 7/sep - 13/sep  | 9,25                      | 77,48%                    | 97,02%                  | 2,13%            |
| 14/sep - 20/sep | 14,02                     | 86,89%                    | 98,42%                  | 1,93%            |
| 21/sep - 27/sep | 12,43                     | 88,21%                    | 99,61%                  | 1,09%            |
| 28/sep - 4/oct  | 14,52                     | 84,74%                    | 98,86%                  | 1,49%            |
| 5/oct - 11/oct  | 14,67                     | 86,96%                    | 99,32%                  | 0,83%            |
| 12/oct - 18/oct | 16,57                     | 88,98%                    | 99,64%                  | 1,39%            |
| 19/oct - 25/oct | 13,08                     | 86,97%                    | 98,82%                  | 0,96%            |
| 26/oct - 1/nov  | 10,63                     | 85,97%                    | 99,41%                  | 1,60%            |
| 2/nov - 8/nov   | 12,68                     | 88,33%                    | 99,74%                  | 1,65%            |
| 9/nov - 15/nov  | 10,47                     | 85,83%                    | 99,69%                  | 1,39%            |
| 16/nov - 22/nov | 12,93                     | 88,83%                    | 99,78%                  | 1,19%            |
| 23/nov - 29/nov | 12,05                     | 90,13%                    | 99,35%                  | 1,09%            |
| 30/nov - 6/dec  | 9,07                      | 82,41%                    | 99,83%                  | 1,06%            |
| 7/dec - 13/dec  | 10,02                     | 89,21%                    | 99,67%                  | 0,90%            |
| 14/dec - 20/dec | 10,08                     | 90,25%                    | 99,70%                  | 1,04%            |
| 21/dec - 27/dec | 11,77                     | 90,04%                    | 99,61%                  | 1,20%            |
| 28/dec - 3/jan  | 13,3                      | 88,80%                    | 99,49%                  | 1,32%            |
| 4/jan - 10/jan  | 15,82                     | 79,02%                    | 99,42%                  | 1,19%            |
| 11/jan - 17/jan | 13,52                     | 93,19%                    | 99,64%                  | 0,88%            |
| 18/jan - 24/jan | 7,92                      | 95,52%                    | 99,65%                  | 0,44%            |
| 25/jan - 31/jan | 2,25                      | 94,27%                    | 99,39%                  | 0,35%            |
| 1/feb - 7/feb   | 9,13                      | 96,27%                    | 99,59%                  | 0,26%            |
| 8/feb - 14/feb  | 17,52                     | 89,29%                    | 98,65%                  | 0,79%            |
| 15/feb - 21/feb | 13,98                     | 93,34%                    | 99,10%                  | 0,46%            |
| 22/feb - 28/feb | 4,8                       | 89,97%                    | 98,69%                  | 0,62%            |



**Impact of E-commerce on warehouse management of a retail company**

## Annex D

The following table refers to the distance and time between from merge area to each location and vice-versa.

*Table 7.10 Time and distance from merge area to each location*

| Article Reference | Self-Serve Location | Time Self (min) | Distance Self (m) | Hybrid Location | Time Hybrid (min) | Hybrid Distance (m) |
|-------------------|---------------------|-----------------|-------------------|-----------------|-------------------|---------------------|
| 00103343          | 24-00-00            | 00:03:45        | 215,86            | 76-32-00        | 00:02:12          | 164,38              |
|                   | 26-24-00            | 00:03:26        | 212,82            |                 |                   |                     |
| 00239233          | 28-24-00            | 00:02:52        | 172,28            | 60-32-00        | 00:03:17          | 221,06              |
| 00251135          | 36-04-00            | 00:02:54        | 186,50            | 72-35-00        | 00:02:26          | 178,52              |
|                   | 36-05-00            | 00:02:52        | 184,84            |                 |                   |                     |
| 00251338          | 36-06-00            | 00:02:50        | 183,64            | 72-32-00        | 00:02:19          | 172,28              |
| 00263850          | 03-00-00            | 00:04:57        | 304,86            | 62-31-00        | 00:03:02          | 206,5               |
| 00272307          | 00-02-06            | 00:04:42        | 137,94            | 58-38-10        | 00:03:35          | 235,27              |
|                   |                     |                 |                   | 58-39-10        | 00:03:37          | 238,77              |
| 00272326          | 08-20-10            | 00:03:20        | 229,46            | 60-39-10        | 00:03:34          | 234,76              |
|                   | 08-21-10            | 00:03:18        | 227,66            |                 |                   |                     |
| 00272388          | 18-21-00            | 00:03:08        | 195,76            | 62-34-10        | 00:03:10          | 212,78              |
|                   |                     |                 |                   | 62-35-10        | 00:03:12          | 214,6               |
|                   |                     |                 |                   | 62-36-10        | 00:03:14          | 216,48              |
| 00320134          | 28-35-00            | 00:02:28        | 149,40            | 64-39-00        | 00:03:17          | 220,78              |
| 00360484          | 28-34-00            | 00:02:30        | 151,14            | 64-38-00        | 00:03:14          | 218,84              |
| 00392041          | 22-02-00            | 00:04:45        | 217,16            | 70-34-00        | 00:02:27          | 181,36              |
| 00473546          | 36-17-00            | 00:02:30        | 160,32            | 72-31-00        | 00:02:17          | 170,2               |
|                   | 36-18-00            | 00:02:28        | 158,64            |                 |                   |                     |
| 00476984          | 28-13-10            | 00:03:14        | 193,84            | 74-31-10        | 00:02:12          | 166,94              |
|                   |                     |                 |                   | 74-32-10        | 00:02:14          | 168,74              |
| 00476998          | 18-10-00            | 00:03:32        | 218,00            | 68-32-00        | 00:02:33          | 185,64              |
|                   | 18-11-00            | 00:03:30        | 216,26            |                 |                   |                     |
|                   | 18-12-00            | 00:03:28        | 214,42            |                 |                   |                     |
| 10234942          | 26-04-00            | 00:03:22        | 210,88            | 76-39-10        | 01:02:28          | 178,28              |
| 10242739          | 06-03-00            | 00:04:21        | 276,16            | 56-37-00        | 00:03:38          | 247,08              |

## Impact of E-commerce on warehouse management of a retail company

| Article Reference | Self-Serve Location | Time Self (min) | Distance Self (m) | Hybrid Location | Time Hybrid (min) | Hybrid Distance (m) |
|-------------------|---------------------|-----------------|-------------------|-----------------|-------------------|---------------------|
| 10244516          | 18-04-00            | 00:03:48        | 229,88            | 68-33-00        | 00:02:35          | 187,56              |
|                   | 18-05-00            | 00:03:44        | 227,94            |                 |                   |                     |
|                   | 18-06-00            | 00:03:42        | 226,16            | 68-34-00        | 00:02:37          | 189,68              |
|                   | 18-07-00            | 00:03:40        | 224,24            |                 |                   |                     |
| 10272241          | 28-12-10            | 00:03:18        | 196,08            | 70-34-10        | 00:02:27          | 181,36              |
|                   |                     |                 |                   | 70-35-10        | 00:02:29          | 183,22              |
| 10272335          | 30-29-10            | 00:02:26        | 145,80            | 64-39-10        | 00:03:17          | 220,78              |
| 10307165          | 14-18-00            | 00:03:14        | 212,36            | 64-34-00        | 00:03:05          | 210,54              |
| 10354166          | 10-19-10            | 00:03:44        | 226,38            | 58-31-10        | 00:03:19          | 222,25              |
|                   | 10-20-10            | 00:03:42        | 224,70            |                 |                   |                     |
|                   | 10-21-10            | 00:03:38        | 222,70            |                 |                   |                     |
| 10366777          | 20-02-00            | 00:03:56        | 221,74            | 76-35-00        | 00:02:19          | 170,42              |
| 10385950          | 24-09-00            | 00:03:20        | 195,94            | 70-38-00        | 00:02:35          | 189,34              |
| 10458767          | 24-16-00            | 00:03:00        | 182,14            | 74-32-00        | 00:02:14          | 168,74              |
| 10482512          | 22-16-00            | 00:03:14        | 188,30            | 74-39-00        | 00:02:28          | 182,46              |
| 20169559          | 06-05-00            | 00:04:14        | 271,40            | 56-31-00        | 00:03:26          | 235,54              |
| 20228709          | 08-02-00            | 00:04:00        | 264,48            | 58-31-00        | 00:03:19          | 222,25              |
| 20244511          | 16-08-00            | 00:03:30        | 213,16            | 66-33-00        | 00:02:38          | 194,42              |
|                   | 16-09-00            | 00:03:28        | 211,30            | 66-34-00        | 00:02:41          | 197,12              |
|                   | 16-10-00            | 00:03:24        | 209,06            | 66-35-00        | 00:02:43          | 198,94              |
|                   |                     |                 |                   | 66-36-00        | 00:02:45          | 200,68              |
| 20249472          | 12-10-00            | 00:03:28        | 233,04            | 64-36-00        | 00:03:10          | 214,8               |
| 20272392          | 30-15-10            | 00:02:56        | 174,32            | 54-39-10        | 00:03:46          | 254,66              |
| 20298132          | 10-15-10            | 00:03:54        | 234,84            | 60-34-10        | 00:03:22          | 224,76              |
|                   | 10-16-10            | 00:03:52        | 232,52            | 60-35-10        | 00:03:24          | 227                 |
|                   | 10-17-10            | 00:03:50        | 230,64            |                 |                   |                     |
| 20393662          | 22-04-00            | 00:03:39        | 212,98            | 54-39-00        | 00:03:46          | 254,66              |
| 20403595          | 20-17-00            | 00:03:16        | 191,16            | 74-37-00        | 00:02:24          | 178,76              |
| 20424362          | 30-01-00            | 00:03:24        | 202,24            | 62-33-00        | 00:03:06          | 210,46              |
| 20476964          | 28-10-10            | 00:03:22        | 200,00            | 70-38-10        | 00:02:35          | 189,34              |
|                   | 28-11-10            | 00:03:20        | 198,06            | 70-39-10        | 00:02:37          | 191,18              |
| 30160209          | 18-01-00            | 00:03:56        | 236,06            | 70-37-00        | 00:02:33          | 187,52              |

| Article Reference | Self-Serve Location | Time Self (min) | Distance Self (m) | Hybrid Location | Time Hybrid (min) | Hybrid Distance (m) |
|-------------------|---------------------|-----------------|-------------------|-----------------|-------------------|---------------------|
| 30228718          | 12-01-00            | 00:03:48        | 252,16            | 62-38-00        | 00:03:20          | 220,4               |
|                   | 12-02-00            | 00:03:44        | 251,12            |                 |                   |                     |
| 30236025          | 26-04-10            | 00:03:22        | 210,88            | 74-31-10        | 00:02:12          | 166,94              |
| 30249546          | 28-28-00            | 00:02:44        | 163,94            | 64-39-00        | 00:03:17          | 220,78              |
| 30272339          | 28-01-10            | 00:03:42        | 218,74            | 74-37-10        | 00:02:24          | 178,76              |
|                   | 28-02-10            | 00:03:40        | 216,90            |                 |                   |                     |
| 30298235          | 12-14-10            | 00:03:18        | 225,58            | 62-33-10        | 00:03:06          | 210,46              |
|                   | 12-15-10            | 00:03:14        | 222,82            |                 |                   |                     |
| 30298240          | 30-22-10            | 00:02:40        | 160,00            | 70-37-10        | 00:02:33          | 187,52              |
| 30372503          | 10-15-00            | 00:03:56        | 234,84            | 58-31-00        | 00:03:17          | 221,05              |
| 30403571          | 00-01-06            | 00:05:11        | 311,26            | 62-34-00        | 00:03:10          | 212,78              |
| 30446354          | 14-19-00            | 00:03:12        | 209,88            | 64-37-00        | 00:03:12          | 216,92              |
| 40249471          | 12-04-00            | 00:03:40        | 247,04            | 62-39-00        | 00:03:23          | 222,4               |
|                   | 12-05-00            | 00:03:38        | 245,08            |                 |                   |                     |
| 40249541          | 18-03-00            | 00:03:50        | 232,42            | 70-33-00        | 00:02:25          | 179,08              |
| 40263103          | 12-13-00            | 00:03:20        | 227,24            | 62-32-00        | 00:03:04          | 208,78              |
| 40269421          | 08-08-00            | 00:03:48        | 253,52            | 60-38-00        | 00:03:32          | 232,9               |
|                   | 08-09-00            | 00:03:46        | 251,78            | 60-39-00        | 00:03:34          | 234,76              |
| 40272225          | 10-01-10            | 00:04:28        | 262,92            | 58-32-10        | 00:03:21          | 223,65              |
|                   | 10-02-10            | 00:04:26        | 260,88            |                 |                   |                     |
|                   | 10-03-10            | 00:04:24        | 259,04            |                 |                   |                     |
|                   | 10-04-10            | 00:04:22        | 256,82            |                 |                   |                     |
|                   | 10-05-10            | 00:04:20        | 254,94            | 58-33-10        | 00:03:23          | 225,37              |
|                   | 10-06-10            | 00:04:18        | 253,10            |                 |                   |                     |
|                   | 10-07-10            | 00:04:16        | 250,90            |                 |                   |                     |
| 40272287          | 28-28-10            | 00:02:44        | 163,94            | 64-33-10        | 00:03:02          | 208,68              |
| 40307164          | 12-09-00            | 00:03:30        | 235,70            | 64-32-00        | 00:03:00          | 206,98              |
| 40393661          | 22-05-00            | 00:03:36        | 211,18            | 54-37-00        | 00:03:42          | 250,52              |
| 40395245          | 28-08-00            | 00:03:26        | 204,16            | 62-35-00        | 00:03:12          | 214,6               |
| 40400478          | 01-03-00            | 00:05:58        | 409,92            | 60-35-00        | 00:03:24          | 227                 |
| 40407922          | 01-01-00            | 00:06:04        | 413,64            | 60-37-00        | 00:03:29          | 230,76              |
|                   | 01-02-00            | 00:06:01        | 411,82            |                 |                   |                     |

## Impact of E-commerce on warehouse management of a retail company

| Article Reference | Self-Serve Location | Time Self (min) | Distance Self (m) | Hybrid Location | Time Hybrid (min) | Hybrid Distance (m) |
|-------------------|---------------------|-----------------|-------------------|-----------------|-------------------|---------------------|
| 50160208          | 16-02-00            | 00:03:42        | 224,96            | 70-39-00        | 00:02:37          | 191,18              |
| 50242737          | 06-01-00            | 00:04:28        | 279,64            | 56-36-00        | 00:03:35          | 244,52              |
| 50244468          | 18-15-00            | 00:03:20        | 208,06            | 68-31-00        | 00:02:31          | 183,98              |
| 50244487          | 16-17-00            | 00:03:04        | 195,36            | 64-34-10        | 00:03:05          | 210,54              |
|                   | 16-18-00            | 00:03:02        | 193,52            | 64-35-10        | 00:03:07          | 212,6               |
| 50248428          | 06-04-00            | 00:04:17        | 272,72            | 56-38-00        | 00:03:40          | 248,68              |
| 50272300          | 08-04-10            | 00:03:58        | 261,38            | 58-36-10        | 00:03:30          | 231,01              |
|                   | 08-05-10            | 00:03:56        | 259,54            |                 |                   |                     |
| 50307168          | 28-13-00            | 00:03:14        | 193,84            | 64-31-00        | 00:02:58          | 204,8               |
| 50322847          | 20-04-00            | 00:03:50        | 218,04            | 54-38-00        | 00:03:44          | 252,56              |
| 50403589          | 20-20-00            | 00:03:08        | 185,00            | 76-36-00        | 00:02:21          | 172,58              |
| 50454908          | 26-14-00            | 00:02:56        | 190,32            | 76-34-00        | 00:02:17          | 168,6               |
| 50476953          | 16-22-00            | 00:02:52        | 185,24            | 66-31-00        | 00:02:34          | 191,02              |
|                   | 16-23-00            | 00:02:48        | 183,36            | 66-32-00        | 00:02:36          | 192,88              |
| 50482614          | 08-02-00            | 00:04:02        | 265,90            | 64-33-00        | 00:03:02          | 208,68              |
| 60239273          | 20-12-00            | 00:03:28        | 201,10            | 54-35-00        | 00:03:37          | 246,78              |
| 60244463          | 12-00-00            | 00:03:54        | 257,06            | 68-35-00        | 00:02:39          | 191,6               |
|                   | 16-11-00            | 00:03:22        | 207,32            |                 |                   |                     |
|                   | 16-12-00            | 00:03:18        | 205,36            | 68-36-00        | 00:02:41          | 193,22              |
|                   | 16-13-00            | 00:03:14        | 203,30            |                 |                   |                     |
| 60249470          | 08-04-00            | 00:03:58        | 261,38            | 58-37-00        | 00:03:33          | 233,57              |
|                   | 08-05-00            | 00:03:56        | 259,54            |                 |                   |                     |
| 60272234          | 08-15-10            | 00:03:32        | 239,76            | 60-36-10        | 00:03:27          | 228,44              |
|                   | 08-16-10            | 00:03:30        | 237,48            |                 |                   |                     |
|                   | 08-17-10            | 00:03:28        | 235,56            |                 |                   |                     |
|                   | 08-18-10            | 00:03:26        | 233,96            |                 |                   |                     |
| 60322130          | 26-12-00            | 00:03:02        | 194,54            | 74-38-00        | 00:02:26          | 180,64              |
| 60366789          | 20-08-00            | 00:03:40        | 208,94            | 76-38-00        | 00:02:25          | 176,42              |
| 60403579          | 14-07-00            | 00:03:40        | 234,38            | 54-36-00        | 00:03:39          | 248,62              |
| 60403602          | 24-05-00            | 00:03:34        | 203,44            | 54-33-00        | 00:03:32          | 242,36              |
| 60453588          | 28-31-10            | 00:02:36        | 157,78            | 76-39-10        | 02:02:28          | 178,28              |
|                   | 28-32-10            | 00:02:34        | 155,90            |                 |                   |                     |
|                   | 28-33-10            | 00:02:32        | 153,84            |                 |                   |                     |
| 60473548          | 36-19-00            | 00:02:26        | 155,98            | 76-31-00        | 00:02:10          | 162,42              |
| 60490449          | 10-21-00            | 00:03:38        | 222,70            | 60-36-00        | 00:03:27          | 228,44              |

| Article Reference | Self-Serve Location | Time Self (min) | Distance Self (m) | Hybrid Location | Time Hybrid (min) | Hybrid Distance (m) |
|-------------------|---------------------|-----------------|-------------------|-----------------|-------------------|---------------------|
| 70178170          | 06-11-00            | 00:04:02        | 259,74            | 56-34-00        | 00:03:31          | 241,18              |
| 70214192          | 34-20-00            | 00:02:26        | 165,72            | 76-33-00        | 00:02:14          | 166,08              |
| 70217973          | 36-03-00            | 00:02:56        | 188,42            | 72-33-00        | 00:02:21          | 173,64              |
| 70244523          | 28-14-10            | 00:03:12        | 191,94            | 74-33-10        | 00:02:16          | 170,5               |
|                   | 28-15-10            | 00:03:10        | 190,04            |                 |                   |                     |
| 70272262          | 30-30-10            | 00:02:22        | 143,88            | 76-32-10        | 00:02:12          | 164,38              |
|                   |                     |                 |                   | 76-33-10        | 00:02:14          | 166,08              |
| 70272417          | 28-24-10            | 00:02:52        | 172,28            | 76-37-10        | 00:02:23          | 174,48              |
|                   | 28-23-10            | 00:02:54        | 174,14            | 76-38-10        | 00:02:25          | 176,42              |
| 70278344          | 14-21-00            | 00:03:06        | 206,14            | 58-34-00        | 00:03:26          | 227,31              |
| 70278706          | 08-21-00            | 00:03:18        | 227,66            | 58-38-00        | 00:03:35          | 235,27              |
| 70290459          | 22-19-00            | 00:03:04        | 182,06            | 56-33-00        | 00:03:29          | 238,90              |
| 70298139          | 28-22-10            | 00:02:56        | 175,84            | 76-31-10        | 00:02:10          | 162,42              |
| 70366784          | 24-06-00            | 00:03:30        | 201,88            | 54-32-00        | 00:03:30          | 240,50              |
| 70403569          | 20-09-00            | 00:03:36        | 207,02            | 76-39-00        | 00:02:28          | 178,28              |
| 70403593          | 24-07-00            | 00:03:26        | 199,40            | 74-31-00        | 00:02:12          | 166,94              |
| 70403606          | 20-13-00            | 00:03:24        | 198,80            | 54-31-00        | 00:03:27          | 238,68              |
| 70477008          | 28-17-10            | 00:03:06        | 186,06            | 76-35-10        | 00:02:19          | 170,42              |
|                   | 28-18-10            | 00:03:04        | 184,36            | 76-36-10        | 00:02:21          | 172,58              |
| 80125124          | 28-29-00            | 00:02:42        | 161,91            | 62-37-00        | 00:03:17          | 218,22              |
| 80213074          | 34-01-00            | 00:02:54        | 197,42            | 72-34-00        | 00:02:24          | 176,4               |
| 80214549          | 26-03-00            | 00:03:26        | 212,86            | 74-33-00        | 00:02:16          | 170,5               |
| 80228711          | 12-03-00            | 00:03:42        | 249,22            | 62-36-00        | 00:03:14          | 216,48              |
| 80249469          | 10-18-00            | 00:03:46        | 228,50            | 58-39-00        | 00:03:37          | 238,77              |
| 80249474          | 14-14-00            | 00:03:24        | 220,38            | 64-35-00        | 00:03:07          | 212,6               |
| 80249539          | 18-02-00            | 00:03:52        | 234,32            | 70-31-00        | 00:02:20          | 175,6               |
| 80272252          | 08-10-10            | 00:03:44        | 249,54            | 60-33-10        | 00:03:19          | 222,94              |
|                   | 08-11-10            | 00:03:42        | 247,82            |                 |                   |                     |
|                   | 08-12-10            | 00:03:40        | 245,80            |                 |                   |                     |
|                   | 08-13-10            | 00:03:38        | 243,66            |                 |                   |                     |
|                   | 08-14-10            | 00:03:36        | 241,80            |                 |                   |                     |
| 80272327          | 08-07-10            | 00:03:52        | 255,36            | 60-32-10        | 00:03:17          | 221,06              |
|                   | 08-08-10            | 00:03:48        | 253,52            |                 |                   |                     |
|                   | 08-09-10            | 00:03:46        | 251,78            |                 |                   |                     |

## Impact of E-commerce on warehouse management of a retail company

| Article Reference | Self-Serve Location | Time Self (min) | Distance Self (m) | Hybrid Location | Time Hybrid (min) | Hybrid Distance (m) |
|-------------------|---------------------|-----------------|-------------------|-----------------|-------------------|---------------------|
| 80298134          | 12-16-10            | 00:03:12        | 221,10            | 62-37-10        | 00:03:17          | 218,22              |
|                   | 12-17-10            | 00:03:10        | 219,56            | 62-38-10        | 00:03:20          | 220,4               |
|                   | 12-18-10            | 00:03:08        | 217,82            |                 |                   |                     |
| 80298233          | 10-13-10            | 00:04:02        | 238,70            | 60-37-10        | 00:03:29          | 230,76              |
|                   | 10-14-10            | 00:04:00        | 236,76            | 60-38-10        | 00:03:32          | 232,9               |
| 80307162          | 08-20-00            | 00:03:20        | 229,46            | 58-32-00        | 00:03:21          | 223,65              |
| 80309241          | 26-02-00            | 00:03:30        | 214,78            | 74-35-00        | 00:02:20          | 174,38              |
| 80411272          | 28-23-00            | 00:02:54        | 174,14            | 60-33-00        | 00:03:19          | 222,94              |
| 80424745          | 24-14-00            | 00:03:08        | 185,94            | 72-38-00        | 00:02:32          | 184,62              |
| 90124534          | 16-01-00            | 00:03:46        | 227,16            | 70-36-00        | 00:02:31          | 185,1               |
| 90160211          | 26-00-00            | 00:03:37        | 218,67            | 70-35-00        | 00:02:29          | 183,22              |
| 90217972          | 36-01-00            | 00:03:00        | 192,42            | 72-36-00        | 00:02:28          | 180,2               |
|                   | 36-02-00            | 00:02:58        | 190,55            |                 |                   |                     |
| 90248426          | 06-02-00            | 00:04:25        | 278,20            | 56-35-00        | 00:03:33          | 243,20              |
| 90264690          | 20-09-00            | 00:03:36        | 208,00            | 70-31-00        | 00:02:20          | 175,6               |
| 90272256          | 12-11-10            | 00:03:26        | 231,18            | 64-31-10        | 00:02:58          | 204,8               |
|                   | 12-12-10            | 00:03:22        | 229,28            |                 |                   |                     |
|                   | 12-13-10            | 00:03:20        | 227,24            |                 |                   |                     |
| 90278343          | 28-36-00            | 00:02:26        | 147,54            | 58-36-00        | 00:03:30          | 231,01              |
| 90309245          | 24-04-00            | 00:03:37        | 205,34            | 74-36-00        | 00:02:22          | 176,22              |
| 90349326          | 06-00-00            | 00:04:34        | 288,30            | 60-34-00        | 00:03:22          | 224,76              |
| 90372519          | 10-13-00            | 00:04:02        | 238,70            | 58-33-00        | 00:03:23          | 225,37              |
| 90392046          | 20-07-00            | 00:03:42        | 211,78            | 72-37-00        | 00:02:30          | 182,74              |
| 90403587          | 14-06-00            | 00:03:42        | 236,70            | 54-34-00        | 00:03:35          | 244,82              |
| 90404799          | 08-18-00            | 00:03:26        | 233,96            | 58-35-00        | 00:03:28          | 229,43              |
| 90482513          | 20-06-00            | 00:03:46        | 213,86            | 76-37-00        | 00:02:23          | 174,48              |
| 90489449          | 08-01-00            | 00:04:04        | 267,76            | 60-31-00        | 00:03:15          | 219,04              |

## Annex E

The following table show the differences of time and distance travelled between each sales location of hybrid articles.

*Table 7.11 Time and distance difference of hybrid items*

| Article Reference | Self-Serve Location | Hybrid Location | Time difference | Distance difference |
|-------------------|---------------------|-----------------|-----------------|---------------------|
| 00103343          | 24-00-00            | 76-32-00        | 00:01:33        | 51,48               |
|                   | 26-24-00            |                 | 00:01:14        | 48,44               |
| 00239233          | 28-24-00            | 60-32-00        | 00:00:25        | 48,78               |
| 00251135          | 36-04-00            | 72-35-00        | 00:00:28        | 7,98                |
|                   | 36-05-00            |                 | 00:00:26        | 6,32                |
| 00251338          | 36-06-00            | 72-32-00        | 00:00:31        | 11,36               |
| 00263850          | 03-00-00            | 62-31-00        | 00:01:55        | 98,36               |
| 00272307          | 00-02-06            | 58-38-10        | 00:01:07        | 97,33               |
|                   |                     | 58-39-10        | 00:01:05        | 100,83              |
| 00272326          | 08-20-10            | 60-39-10        | 00:00:14        | 5,30                |
|                   | 08-21-10            |                 | 00:00:16        | 7,10                |
| 00272388          | 18-21-00            | 62-34-10        | 00:00:02        | 17,02               |
|                   |                     | 62-35-10        | 00:00:04        | 18,84               |
|                   |                     | 62-36-10        | 00:00:06        | 20,72               |
| 00320134          | 28-35-00            | 64-39-00        | 00:00:49        | 71,38               |
| 00360484          | 28-34-00            | 64-38-00        | 00:00:44        | 67,70               |
| 00392041          | 22-02-00            | 70-34-00        | 00:02:18        | 35,80               |
| 00473546          | 36-17-00            | 72-31-00        | 00:00:13        | 9,88                |
|                   | 36-18-00            |                 | 00:00:11        | 11,56               |
| 00476984          | 28-13-10            | 74-31-10        | 00:01:02        | 26,90               |
|                   |                     | 74-32-10        | 00:01:00        | 25,10               |
| 00476998          | 18-10-00            | 68-32-00        | 00:00:59        | 32,36               |
|                   | 18-11-00            |                 | 00:00:57        | 30,62               |
|                   | 18-12-00            |                 | 00:00:55        | 28,78               |
| 10203610          | 22-21-00            | 72-39-00        | 00:00:23        | 7,78                |
| 10234942          | 26-04-00            | 76-39-10        | 00:00:54        | 32,60               |
| 10242739          | 06-03-00            | 56-37-00        | 00:00:43        | 29,08               |
| 10244516          | 18-04-00            | 68-33-00        | 00:01:13        | 42,32               |
|                   | 18-05-00            |                 | 00:01:09        | 40,38               |
|                   | 18-06-00            |                 | 00:01:07        | 38,60               |
|                   | 18-07-00            |                 | 00:01:05        | 36,68               |
|                   | 18-04-00            | 68-34-00        | 00:01:11        | 40,20               |
|                   | 18-05-00            |                 | 00:01:07        | 38,26               |
|                   | 18-06-00            |                 | 00:01:05        | 36,48               |
|                   | 18-07-00            |                 | 00:01:03        | 34,56               |
| 10272241          | 28-12-10            | 70-34-10        | 00:00:51        | 14,72               |
|                   |                     | 70-35-10        | 00:00:49        | 12,86               |
| 10272335          | 30-29-10            | 64-39-10        | 00:00:51        | 74,98               |



## Impact of E-commerce on warehouse management of a retail company

| Article Reference | Self-Serve Location | Hybrid Location | Time difference | Distance difference |
|-------------------|---------------------|-----------------|-----------------|---------------------|
| 10307165          | 14-18-00            | 64-34-00        | 00:00:09        | 1,82                |
| 10354166          | 10-19-10            | 58-31-10        | 00:00:25        | 4,13                |
|                   | 10-20-10            |                 | 00:00:23        | 2,45                |
|                   | 10-21-10            |                 | 00:00:19        | 0,45                |
|                   | 20-02-00            |                 | 76-35-00        | 00:01:37            |
| 10385950          | 24-09-00            | 70-38-00        | 00:00:45        | 6,60                |
| 10458767          | 24-16-00            | 74-32-00        | 00:00:46        | 13,40               |
| 10482512          | 22-16-00            | 74-39-00        | 00:00:46        | 5,84                |
| 20169559          | 06-05-00            | 56-31-00        | 00:00:48        | 35,86               |
| 20228709          | 08-02-00            | 58-31-00        | 00:00:41        | 42,23               |
| 20244511          | 16-08-00            | 66-33-00        | 00:00:52        | 18,74               |
|                   |                     | 66-34-00        | 00:00:49        | 16,04               |
|                   |                     | 66-35-00        | 00:00:47        | 14,22               |
|                   |                     | 66-36-00        | 00:00:45        | 12,48               |
|                   | 16-09-00            | 66-33-00        | 00:00:50        | 16,88               |
|                   |                     | 66-34-00        | 00:00:47        | 14,18               |
|                   |                     | 66-35-00        | 00:00:45        | 12,36               |
|                   |                     | 66-36-00        | 00:00:43        | 10,62               |
|                   | 16-10-00            | 66-33-00        | 00:00:46        | 14,64               |
|                   |                     | 66-34-00        | 00:00:43        | 11,94               |
|                   |                     | 66-35-00        | 00:00:41        | 10,12               |
|                   |                     | 66-36-00        | 00:00:39        | 8,38                |
| 20249472          | 12-10-00            | 64-36-00        | 00:00:18        | 18,24               |
| 20272392          | 30-15-10            | 54-39-10        | 00:00:50        | 80,34               |
| 20298132          | 10-15-10            | 60-34-10        | 00:00:32        | 10,08               |
|                   |                     | 60-35-10        | 00:00:30        | 7,84                |
|                   | 10-16-10            | 60-34-10        | 00:00:30        | 7,76                |
|                   |                     | 60-35-10        | 00:00:28        | 5,52                |
|                   | 10-17-10            | 60-34-10        | 00:00:28        | 5,88                |
|                   |                     | 60-35-10        | 00:00:26        | 3,64                |
| 20393662          | 22-04-00            | 54-39-00        | 00:00:07        | 41,68               |
| 20403595          | 20-17-00            | 74-37-00        | 00:00:52        | 12,4                |
| 20424362          | 30-01-00            | 62-33-00        | 00:00:18        | 8,22                |
| 20476964          | 28-10-10            | 70-38-10        | 00:00:47        | 10,66               |
|                   |                     | 70-39-10        | 00:00:45        | 8,82                |
|                   | 28-11-10            | 70-38-10        | 00:00:45        | 8,72                |
|                   |                     | 70-39-10        | 00:00:43        | 6,88                |
| 30160209          | 18-01-00            | 70-37-00        | 00:01:23        | 48,54               |
| 30228718          | 12-01-00            | 62-38-00        | 00:00:28        | 31,76               |
|                   | 12-02-00            |                 | 00:00:24        | 30,72               |
| 30236025          | 26-04-10            | 74-31-10        | 00:01:10        | 43,94               |
| 30249546          | 28-28-00            | 64-39-00        | 00:00:33        | 56,84               |
| 30272339          | 28-01-10            | 74-37-10        | 00:01:18        | 39,98               |
|                   | 28-02-10            |                 | 00:01:16        | 38,14               |
| 30298235          | 12-14-10            | 62-33-10        | 00:00:12        | 15,12               |
|                   | 12-15-10            |                 | 00:00:08        | 12,36               |

| Article Reference | Self-Serve Location | Hybrid Location | Time difference | Distance difference |
|-------------------|---------------------|-----------------|-----------------|---------------------|
| 30298240          | 30-22-10            | 70-37-10        | 00:00:07        | 27,52               |
| 30372503          | 10-15-00            | 58-31-00        | 00:00:39        | 13,79               |
| 30403571          | 00-01-06            | 62-34-00        | 00:02:01        | 98,48               |
| 30446354          | 14-19-00            | 64-37-00        | 00:00:00        | 7,04                |
| 40249471          | 12-04-00            | 62-39-00        | 00:00:17        | 24,64               |
|                   | 12-05-00            |                 | 00:00:15        | 22,68               |
| 40249541          | 18-03-00            | 70-33-00        | 00:01:25        | 53,34               |
| 40263103          | 12-13-00            | 62-32-00        | 00:00:16        | 18,46               |
| 40269421          | 08-08-00            | 60-38-00        | 00:00:16        | 20,62               |
|                   |                     | 60-39-00        | 00:00:14        | 18,76               |
|                   | 08-09-00            | 60-38-00        | 00:00:14        | 18,88               |
|                   |                     | 60-39-00        | 00:00:12        | 17,02               |
| 40272225          | 10-01-10            | 58-32-10        | 00:01:08        | 39,27               |
|                   | 10-02-10            |                 | 00:01:06        | 37,23               |
|                   | 10-03-10            |                 | 00:01:04        | 35,39               |
|                   | 10-04-10            |                 | 00:01:02        | 33,17               |
|                   | 10-05-10            |                 | 00:01:00        | 31,29               |
|                   | 10-06-10            |                 | 00:00:58        | 29,45               |
|                   | 10-07-10            |                 | 00:00:56        | 27,25               |
|                   | 10-01-10            | 58-33-10        | 00:01:05        | 37,55               |
|                   | 10-02-10            |                 | 00:01:03        | 35,51               |
|                   | 10-03-10            |                 | 00:01:01        | 33,67               |
|                   | 10-04-10            |                 | 00:00:59        | 31,45               |
|                   | 10-05-10            |                 | 00:00:57        | 29,57               |
|                   | 10-06-10            |                 | 00:00:55        | 27,73               |
|                   | 10-07-10            |                 | 00:00:53        | 25,53               |
| 40272287          | 28-28-10            | 64-33-10        | 00:00:18        | 44,74               |
| 40307164          | 12-09-00            | 64-32-00        | 00:00:30        | 28,72               |
| 40393661          | 22-05-00            | 54-37-00        | 00:00:06        | 39,34               |
| 40395245          | 28-08-00            | 62-35-00        | 00:00:14        | 10,44               |
| 40400478          | 01-03-00            | 60-35-00        | 00:02:34        | 182,92              |
| 40407922          | 01-01-00            | 60-37-00        | 00:02:35        | 182,88              |
|                   | 01-02-00            |                 | 00:02:32        | 181,06              |
| 50160208          | 16-02-00            | 70-39-00        | 00:01:05        | 33,78               |
| 50242737          | 06-01-00            | 56-36-00        | 00:00:53        | 35,12               |
| 50244468          | 18-15-00            | 68-31-00        | 00:00:49        | 24,08               |
| 50244473          | 30-13-10            | 54-37-10        | 00:00:42        | 72,38               |
|                   |                     | 54-38-10        | 00:00:44        | 74,42               |
|                   | 30-14-10            | 54-37-10        | 00:00:44        | 74,24               |
|                   |                     | 54-38-10        | 00:00:46        | 76,28               |
| 50244487          | 16-17-00            | 64-34-10        | 00:00:01        | 15,18               |
|                   |                     | 64-35-10        | 00:00:03        | 17,24               |
|                   | 16-18-00            | 64-34-10        | 00:00:03        | 17,02               |
|                   |                     | 64-35-10        | 00:00:05        | 19,08               |
| 50248428          | 06-04-00            | 56-38-00        | 00:00:37        | 24,04               |

## Impact of E-commerce on warehouse management of a retail company

| Article Reference | Self-Serve Location | Hybrid Location | Time difference | Distance difference |
|-------------------|---------------------|-----------------|-----------------|---------------------|
| 50272300          | 08-04-10            | 58-36-10        | 00:00:28        | 30,37               |
|                   | 08-05-10            |                 | 00:00:26        | 28,53               |
| 50307168          | 28-13-00            | 64-31-00        | 00:00:16        | 10,96               |
| 50322847          | 20-04-00            | 54-38-00        | 00:00:06        | 34,52               |
| 50403589          | 20-20-00            | 76-36-00        | 00:00:47        | 12,42               |
| 50454908          | 26-14-00            | 76-34-00        | 00:00:39        | 21,72               |
| 50476953          | 16-22-00            | 66-31-00        | 00:00:18        | 5,78                |
|                   |                     | 66-32-00        | 00:00:16        | 7,64                |
|                   | 16-23-00            | 66-31-00        | 00:00:14        | 7,66                |
|                   |                     | 66-32-00        | 00:00:12        | 9,52                |
| 50482614          | 08-02-00            | 64-33-00        | 00:01:00        | 57,22               |
| 60239273          | 20-12-00            | 54-35-00        | 00:00:09        | 45,68               |
| 60244463          | 12-00-00            | 68-35-00        | 00:01:15        | 65,46               |
|                   | 16-11-00            |                 | 00:00:43        | 15,72               |
|                   | 16-12-00            |                 | 00:00:39        | 13,76               |
|                   | 16-13-00            |                 | 00:00:35        | 11,7                |
|                   | 12-00-00            | 68-36-00        | 00:01:13        | 63,84               |
|                   | 16-11-00            |                 | 00:00:41        | 14,1                |
|                   | 16-12-00            |                 | 00:00:37        | 12,14               |
|                   | 16-13-00            |                 | 00:00:33        | 10,08               |
| 60249470          | 08-04-00            | 58-37-00        | 00:00:25        | 27,81               |
|                   | 08-05-00            |                 | 00:00:23        | 25,97               |
| 60272234          | 08-15-10            | 60-36-10        | 00:00:05        | 11,32               |
|                   | 08-16-10            |                 | 00:00:03        | 9,04                |
|                   | 08-17-10            |                 | 00:00:01        | 7,12                |
|                   | 08-18-10            |                 | 00:00:01        | 5,52                |
| 60322130          | 26-12-00            | 74-38-00        | 00:00:36        | 13,9                |
| 60366789          | 20-08-00            | 76-38-00        | 00:01:15        | 32,52               |
| 60403579          | 14-07-00            | 54-36-00        | 00:00:01        | 14,24               |
| 60403602          | 24-05-00            | 54-33-00        | 00:00:02        | 38,92               |
| 60453588          | 28-31-10            | 76-39-10        | 00:00:08        | 20,5                |
|                   | 28-32-10            |                 | 00:00:06        | 22,38               |
|                   | 28-33-10            |                 | 00:00:04        | 24,44               |
| 60473548          | 36-19-00            | 76-31-00        | 00:00:16        | 6,44                |
| 60490449          | 10-21-00            | 60-36-00        | 00:00:11        | 5,74                |
| 70178170          | 06-11-00            | 56-34-00        | 00:00:31        | 18,56               |
| 70214192          | 34-20-00            | 76-33-00        | 00:00:12        | 0,36                |
| 70217973          | 36-03-00            | 72-33-00        | 00:00:35        | 14,78               |
| 70244523          | 28-14-10            | 74-33-10        | 00:00:56        | 21,44               |
|                   | 28-15-10            |                 | 00:00:54        | 19,54               |
| 70272262          | 30-30-10            | 76-32-10        | 00:00:10        | 20,5                |
|                   |                     | 76-33-10        | 00:00:08        | 22,2                |
| 70272417          | 28-23-10            | 76-37-10        | 00:00:31        | 0,34                |
|                   |                     | 76-38-10        | 00:00:29        | 2,28                |
|                   | 28-24-10            | 76-37-10        | 00:00:29        | 2,2                 |
|                   |                     | 76-38-10        | 00:00:27        | 4,14                |

| Article Reference | Self-Serve Location | Hybrid Location | Time difference | Distance difference |
|-------------------|---------------------|-----------------|-----------------|---------------------|
| 70278344          | 14-21-00            | 58-34-00        | 00:00:20        | 21,17               |
| 70278706          | 08-21-00            | 58-38-00        | 00:00:17        | 7,61                |
| 70290459          | 22-19-00            | 56-33-00        | 00:00:25        | 56,84               |
| 70298139          | 28-22-10            | 76-31-10        | 00:00:46        | 13,42               |
| 70366784          | 24-06-00            | 54-32-00        | 00:00:00        | 38,62               |
| 70403569          | 20-09-00            | 76-39-00        | 00:01:08        | 28,74               |
| 70403593          | 24-07-00            | 74-31-00        | 00:01:14        | 32,46               |
| 70403606          | 20-13-00            | 54-31-00        | 00:00:03        | 39,88               |
| 70477008          | 28-17-10            | 76-35-10        | 00:00:47        | 15,64               |
|                   |                     | 76-36-10        | 00:00:45        | 13,48               |
|                   | 28-18-10            | 76-35-10        | 00:00:45        | 13,94               |
|                   |                     | 76-36-10        | 00:00:43        | 11,78               |
| 80125124          | 28-29-00            | 62-37-00        | 00:00:35        | 56,31               |
| 80213074          | 34-01-00            | 72-34-00        | 00:00:30        | 21,02               |
| 80214549          | 26-03-00            | 74-33-00        | 00:01:10        | 42,36               |
| 80228711          | 12-03-00            | 62-36-00        | 00:00:28        | 32,74               |
| 80249469          | 10-18-00            | 58-39-00        | 00:00:09        | 10,27               |
| 80249474          | 14-14-00            | 64-35-00        | 00:00:17        | 7,78                |
| 80249539          | 18-02-00            | 70-31-00        | 00:01:32        | 58,72               |
| 80272252          | 08-10-10            | 60-33-10        | 00:00:25        | 26,60               |
|                   | 08-11-10            |                 | 00:00:23        | 24,88               |
|                   | 08-12-10            |                 | 00:00:21        | 22,86               |
|                   | 08-13-10            |                 | 00:00:19        | 20,72               |
|                   | 08-14-10            |                 | 00:00:17        | 18,86               |
| 80272327          | 08-07-10            | 60-32-10        | 00:00:35        | 34,30               |
|                   | 08-08-10            |                 | 00:00:31        | 32,46               |
|                   | 08-09-10            |                 | 00:00:29        | 30,72               |
| 80298134          | 12-16-10            | 62-37-10        | 00:00:05        | 2,88                |
|                   | 12-17-10            |                 | 00:00:07        | 1,34                |
|                   | 12-18-10            |                 | 00:00:09        | 0,40                |
|                   | 12-16-10            | 62-38-10        | 00:00:08        | 0,70                |
|                   | 12-17-10            |                 | 00:00:10        | 0,84                |
|                   | 12-18-10            |                 | 00:00:12        | 2,58                |
| 80298233          | 10-13-10            | 60-37-10        | 00:00:33        | 7,94                |
|                   |                     | 60-38-10        | 00:00:30        | 5,80                |
|                   | 10-14-10            | 60-37-10        | 00:00:31        | 6,00                |
|                   |                     | 60-38-10        | 00:00:28        | 3,86                |
| 80307162          | 08-20-00            | 58-32-00        | 00:00:00        | 5,81                |
| 80309241          | 26-02-00            | 74-35-00        | 00:01:10        | 40,40               |
| 80411272          | 28-23-00            | 60-33-00        | 00:00:25        | 48,80               |
| 80424745          | 24-14-00            | 72-38-00        | 00:00:36        | 1,32                |
| 90124534          | 16-01-00            | 70-36-00        | 00:01:15        | 42,06               |
| 90160211          | 26-00-00            | 70-35-00        | 00:01:08        | 35,45               |
| 90217972          | 36-01-00            | 72-36-00        | 00:00:32        | 12,22               |
|                   | 36-02-00            |                 | 00:00:30        | 10,35               |
| 90248426          | 06-02-00            | 56-35-00        | 00:00:52        | 35,00               |

## Impact of E-commerce on warehouse management of a retail company

| Article Reference | Self-Serve Location | Hybrid Location | Time difference | Distance difference |
|-------------------|---------------------|-----------------|-----------------|---------------------|
| 90264690          | 20-09-00            | 70-31-00        | 00:01:16        | 32,40               |
| 90272256          | 12-11-10            | 64-31-10        | 00:00:28        | 26,38               |
|                   | 12-12-10            |                 | 00:00:24        | 24,48               |
|                   | 12-13-10            |                 | 00:00:22        | 22,44               |
|                   | 28-36-00            |                 | 58-36-00        | 00:01:04            |
| 90309245          | 24-04-00            | 74-36-00        | 00:01:15        | 29,12               |
| 90349326          | 06-00-00            | 60-34-00        | 00:01:12        | 63,54               |
| 90372519          | 10-13-00            | 58-33-00        | 00:00:39        | 13,33               |
| 90392046          | 20-07-00            | 72-37-00        | 00:01:12        | 29,04               |
| 90403587          | 14-06-00            | 54-34-00        | 00:00:07        | 8,12                |
| 90404799          | 08-18-00            | 58-35-00        | 00:00:02        | 4,53                |
| 90482513          | 20-06-00            | 76-37-00        | 00:01:23        | 39,38               |
| 90489449          | 08-01-00            | 60-31-00        | 00:00:49        | 48,72               |

## Annex F

The following table show the best saving solution for each SKU.

Table 7.12 Highest saving - Example A

| Article Reference | Self-Serve Location | Hybrid Location | Time difference | Distance difference |
|-------------------|---------------------|-----------------|-----------------|---------------------|
| 00103343          | 24-00-00            | 76-32-00        | 00:01:33        | 51,48               |
| 00239233          | 28-24-00            | 60-32-00        | 00:00:25        | 48,78               |
| 00251135          | 36-04-00            | 72-35-00        | 00:00:28        | 7,98                |
| 00251338          | 36-06-00            | 72-32-00        | 00:00:31        | 11,36               |
| 00263850          | 03-00-00            | 62-31-00        | 00:01:55        | 98,36               |
| 00272307          | 00-02-06            | 58-38-10        | 00:01:07        | 97,33               |
| 00272326          | 08-20-10            | 60-39-10        | 00:00:14        | 5,30                |
| 00272388          | 18-21-00            | 62-34-10        | 00:00:02        | 17,02               |
| 00320134          | 28-35-00            | 64-39-00        | 00:00:49        | 71,38               |
| 00360484          | 28-34-00            | 64-38-00        | 00:00:44        | 67,70               |
| 00392041          | 22-02-00            | 70-34-00        | 00:02:18        | 35,80               |
| 00473546          | 36-17-00            | 72-31-00        | 00:00:13        | 9,88                |
| 00476984          | 28-13-10            | 74-31-10        | 00:01:02        | 26,90               |
| 00476998          | 18-10-00            | 68-32-00        | 00:00:59        | 32,36               |
| 10203610          | 22-21-00            | 72-39-00        | 00:00:23        | 7,78                |
| 10234942          | 26-04-00            | 76-39-10        | 00:00:54        | 32,60               |
| 10242739          | 06-03-00            | 56-37-00        | 00:00:43        | 29,08               |
| 10244516          | 18-04-00            | 68-33-00        | 00:01:13        | 42,32               |
| 10272241          | 28-12-10            | 70-34-10        | 00:00:51        | 14,72               |
| 10272335          | 30-29-10            | 64-39-10        | 00:00:51        | 74,98               |
| 10307165          | 14-18-00            | 64-34-00        | 00:00:09        | 1,82                |
| 10354166          | 10-19-10            | 58-31-10        | 00:00:25        | 4,13                |
| 10366777          | 20-02-00            | 76-35-00        | 00:01:37        | 51,32               |
| 10385950          | 24-09-00            | 70-38-00        | 00:00:45        | 6,60                |
| 10458767          | 24-16-00            | 74-32-00        | 00:00:46        | 13,40               |
| 10482512          | 22-16-00            | 74-39-00        | 00:00:46        | 5,84                |
| 20169559          | 06-05-00            | 56-31-00        | 00:00:48        | 35,86               |
| 20228709          | 08-02-00            | 58-31-00        | 00:00:41        | 42,23               |
| 20244511          | 16-08-00            | 66-33-00        | 00:00:52        | 18,74               |
| 20249472          | 12-10-00            | 64-36-00        | 00:00:18        | 18,24               |
| 20272392          | 30-15-10            | 54-39-10        | 00:00:50        | 80,34               |
| 20298132          | 10-15-10            | 60-34-10        | 00:00:32        | 10,08               |
| 20393662          | 22-04-00            | 54-39-00        | 00:00:07        | 41,68               |
| 20403595          | 20-17-00            | 74-37-00        | 00:00:52        | 12,4                |
| 20424362          | 30-01-00            | 62-33-00        | 00:00:18        | 8,22                |
| 20476964          | 28-10-10            | 70-38-10        | 00:00:47        | 10,66               |
| 30160209          | 18-01-00            | 70-37-00        | 00:01:23        | 48,54               |

## Impact of E-commerce on warehouse management of a retail company

| Article Reference | Self-Serve Location | Hybrid Location | Time difference | Distance difference |
|-------------------|---------------------|-----------------|-----------------|---------------------|
| 30228718          | 12-01-00            | 62-38-00        | 00:00:28        | 31,76               |
| 30236025          | 26-04-10            | 74-31-10        | 00:01:10        | 43,94               |
| 30249546          | 28-28-00            | 64-39-00        | 00:00:33        | 56,84               |
| 30272339          | 28-01-10            | 74-37-10        | 00:01:18        | 39,98               |
| 30298235          | 12-14-10            | 62-33-10        | 00:00:12        | 15,12               |
| 30298240          | 30-22-10            | 70-37-10        | 00:00:07        | 27,52               |
| 30372503          | 10-15-00            | 58-31-00        | 00:00:39        | 13,79               |
| 30403571          | 00-01-06            | 62-34-00        | 00:02:01        | 98,48               |
| 30446354          | 14-19-00            | 64-37-00        | 00:00:00        | 7,04                |
| 40249471          | 12-04-00            | 62-39-00        | 00:00:17        | 24,64               |
| 40249541          | 18-03-00            | 70-33-00        | 00:01:25        | 53,34               |
| 40263103          | 12-13-00            | 62-32-00        | 00:00:16        | 18,46               |
| 40269421          | 08-08-00            | 60-38-00        | 00:00:16        | 20,62               |
| 40272225          | 10-01-10            | 58-32-10        | 00:01:08        | 39,27               |
| 40272287          | 28-28-10            | 64-33-10        | 00:00:18        | 44,74               |
| 40307164          | 12-09-00            | 64-32-00        | 00:00:30        | 28,72               |
| 40393661          | 22-05-00            | 54-37-00        | 00:00:06        | 39,34               |
| 40395245          | 28-08-00            | 62-35-00        | 00:00:14        | 10,44               |
| 40400478          | 01-03-00            | 60-35-00        | 00:02:34        | 182,92              |
| 40407922          | 01-01-00            | 60-37-00        | 00:02:35        | 182,88              |
| 50160208          | 16-02-00            | 70-39-00        | 00:01:05        | 33,78               |
| 50242737          | 06-01-00            | 56-36-00        | 00:00:53        | 35,12               |
| 50244468          | 18-15-00            | 68-31-00        | 00:00:49        | 24,08               |
| 50244473          | 30-13-10            | 54-37-10        | 00:00:42        | 72,38               |
| 50244487          | 16-17-00            | 64-34-10        | 00:00:01        | 15,18               |
| 50248428          | 06-04-00            | 56-38-00        | 00:00:37        | 24,04               |
| 50272300          | 08-04-10            | 58-36-10        | 00:00:28        | 30,37               |
| 50307168          | 28-13-00            | 64-31-00        | 00:00:16        | 10,96               |
| 50322847          | 20-04-00            | 54-38-00        | 00:00:06        | 34,52               |
| 50403589          | 20-20-00            | 76-36-00        | 00:00:47        | 12,42               |
| 50454908          | 26-14-00            | 76-34-00        | 00:00:39        | 21,72               |
| 50476953          | 16-22-00            | 66-31-00        | 00:00:18        | 5,78                |
| 50482614          | 08-02-00            | 64-33-00        | 00:01:00        | 57,22               |
| 60239273          | 20-12-00            | 54-35-00        | 00:00:09        | 45,68               |
| 60244463          | 12-00-00            | 68-35-00        | 00:01:15        | 65,46               |
| 60249470          | 08-04-00            | 58-37-00        | 00:00:25        | 27,81               |
| 60272234          | 08-15-10            | 60-36-10        | 00:00:05        | 11,32               |
| 60322130          | 26-12-00            | 74-38-00        | 00:00:36        | 13,9                |
| 60366789          | 20-08-00            | 76-38-00        | 00:01:15        | 32,52               |
| 60403579          | 14-07-00            | 54-36-00        | 00:00:01        | 14,24               |
| 60403602          | 24-05-00            | 54-33-00        | 00:00:02        | 38,92               |
| 60453588          | 28-31-10            | 76-39-10        | 00:00:08        | 20,5                |
| 60473548          | 36-19-00            | 76-31-00        | 00:00:16        | 6,44                |

| 60490449          | 10-21-00            | 60-36-00        | 00:00:11        | 5,74                |
|-------------------|---------------------|-----------------|-----------------|---------------------|
| Article Reference | Self-Serve Location | Hybrid Location | Time difference | Distance difference |
| 70178170          | 06-11-00            | 56-34-00        | 00:00:31        | 18,56               |
| 70214192          | 34-20-00            | 76-33-00        | 00:00:12        | 0,36                |
| 70217973          | 36-03-00            | 72-33-00        | 00:00:35        | 14,78               |
| 70244523          | 28-14-10            | 74-33-10        | 00:00:56        | 21,44               |
| 70272262          | 30-30-10            | 76-32-10        | 00:00:10        | 20,5                |
| 70272417          | 28-23-10            | 76-37-10        | 00:00:31        | 0,34                |
| 70278344          | 14-21-00            | 58-34-00        | 00:00:20        | 21,17               |
| 70278706          | 08-21-00            | 58-38-00        | 00:00:17        | 7,61                |
| 70290459          | 22-19-00            | 56-33-00        | 00:00:25        | 56,84               |
| 70298139          | 28-22-10            | 76-31-10        | 00:00:46        | 13,42               |
| 70366784          | 24-06-00            | 54-32-00        | 00:00:00        | 38,62               |
| 70403569          | 20-09-00            | 76-39-00        | 00:01:08        | 28,74               |
| 70403593          | 24-07-00            | 74-31-00        | 00:01:14        | 32,46               |
| 70403606          | 20-13-00            | 54-31-00        | 00:00:03        | 39,88               |
| 70477008          | 28-17-10            | 76-35-10        | 00:00:47        | 15,64               |
| 80125124          | 28-29-00            | 62-37-00        | 00:00:35        | 56,31               |
| 80213074          | 34-01-00            | 72-34-00        | 00:00:30        | 21,02               |
| 80214549          | 26-03-00            | 74-33-00        | 00:01:10        | 42,36               |
| 80228711          | 12-03-00            | 62-36-00        | 00:00:28        | 32,74               |
| 80249469          | 10-18-00            | 58-39-00        | 00:00:09        | 10,27               |
| 80249474          | 14-14-00            | 64-35-00        | 00:00:17        | 7,78                |
| 80249539          | 18-02-00            | 70-31-00        | 00:01:32        | 58,72               |
| 80272252          | 08-10-10            | 60-33-10        | 00:00:25        | 26,60               |
| 80272327          | 08-07-10            | 60-32-10        | 00:00:35        | 34,30               |
| 80298134          | 12-16-10            | 62-37-10        | 00:00:05        | 2,88                |
| 80298233          | 10-13-10            | 60-37-10        | 00:00:33        | 7,94                |
| 80307162          | 08-20-00            | 58-32-00        | 00:00:00        | 5,81                |
| 80309241          | 26-02-00            | 74-35-00        | 00:01:10        | 40,40               |
| 80411272          | 28-23-00            | 60-33-00        | 00:00:25        | 48,80               |
| 80424745          | 24-14-00            | 72-38-00        | 00:00:36        | 1,32                |
| 90124534          | 16-01-00            | 70-36-00        | 00:01:15        | 42,06               |
| 90160211          | 26-00-00            | 70-35-00        | 00:01:08        | 35,45               |
| 90217972          | 36-01-00            | 72-36-00        | 00:00:32        | 12,22               |
| 90248426          | 06-02-00            | 56-35-00        | 00:00:52        | 35,00               |
| 90264690          | 20-09-00            | 70-31-00        | 00:01:16        | 32,40               |
| 90272256          | 12-11-10            | 64-31-10        | 00:00:28        | 26,38               |
| 90278343          | 28-36-00            | 58-36-00        | 00:01:04        | 83,47               |
| 90309245          | 24-04-00            | 74-36-00        | 00:01:15        | 29,12               |
| 90349326          | 06-00-00            | 60-34-00        | 00:01:12        | 63,54               |
| 90372519          | 10-13-00            | 58-33-00        | 00:00:39        | 13,33               |
| 90392046          | 20-07-00            | 72-37-00        | 00:01:12        | 29,04               |
| 90403587          | 14-06-00            | 54-34-00        | 00:00:07        | 8,12                |
| 90404799          | 08-18-00            | 58-35-00        | 00:00:02        | 4,53                |



**Impact of E-commerce on warehouse management of a retail company**

| <b>Article Reference</b> | <b>Self-Serve Location</b> | <b>Hybrid Location</b> | <b>Time difference</b> | <b>Distance difference</b> |
|--------------------------|----------------------------|------------------------|------------------------|----------------------------|
| 90482513                 | 20-06-00                   | 76-37-00               | 00:01:23               | 39,38                      |
| 90489449                 | 08-01-00                   | 60-31-00               | 00:00:49               | 48,72                      |

## Annex G

The following table show the lower saving solution for each SKU.

Table 7.13 Lowest saving - Example B

| Article Reference | Self-Serve Location | Hybrid Location | Time difference | Distance difference |
|-------------------|---------------------|-----------------|-----------------|---------------------|
| 00103343          | 26-24-00            | 76-32-01        | 00:01:14        | 48,44               |
| 00239233          | 28-24-00            | 60-32-00        | 00:00:25        | 48,78               |
| 00251135          | 36-05-00            | 72-35-01        | 00:00:26        | 6,32                |
| 00251338          | 36-06-00            | 72-32-00        | 00:00:31        | 11,36               |
| 00263850          | 03-00-00            | 62-31-00        | 00:01:55        | 98,36               |
| 00272307          | 00-02-07            | 58-39-10        | 00:01:05        | 100,83              |
| 00272326          | 08-21-10            | 60-39-11        | 00:00:16        | 7,10                |
| 00272388          | 18-21-02            | 62-36-10        | 00:00:06        | 20,72               |
| 00320134          | 28-35-00            | 64-39-00        | 00:00:49        | 71,38               |
| 00360484          | 28-34-00            | 64-38-00        | 00:00:44        | 67,70               |
| 00392041          | 22-02-00            | 70-34-00        | 00:02:18        | 35,80               |
| 00473546          | 36-18-00            | 72-31-01        | 00:00:11        | 11,56               |
| 00476984          | 28-13-11            | 74-32-10        | 00:01:00        | 25,10               |
| 00476998          | 18-12-00            | 68-32-02        | 00:00:55        | 28,78               |
| 10203610          | 22-21-00            | 72-39-00        | 00:00:23        | 7,78                |
| 10234942          | 26-04-00            | 76-39-10        | 00:00:54        | 32,60               |
| 10242739          | 06-03-00            | 56-37-00        | 00:00:43        | 29,08               |
| 10244516          | 18-07-00            | 68-34-00        | 00:01:03        | 34,56               |
| 10272241          | 28-12-10            | 70-35-10        | 00:00:49        | 12,86               |
| 10272335          | 30-29-10            | 64-39-10        | 00:00:51        | 74,98               |
| 10307165          | 14-18-00            | 64-34-00        | 00:00:09        | 1,82                |
| 10354166          | 10-21-10            | 58-31-10        | 00:00:19        | 0,45                |
| 10366777          | 20-02-00            | 76-35-00        | 00:01:37        | 51,32               |
| 10385950          | 24-09-00            | 70-38-00        | 00:00:45        | 6,60                |
| 10458767          | 24-16-00            | 74-32-00        | 00:00:46        | 13,40               |
| 10482512          | 22-16-00            | 74-39-00        | 00:00:46        | 5,84                |
| 20169559          | 06-05-00            | 56-31-00        | 00:00:48        | 35,86               |
| 20228709          | 08-02-00            | 58-31-00        | 00:00:41        | 42,23               |
| 20244511          | 16-10-00            | 66-36-00        | 00:00:39        | 8,38                |
| 20249472          | 12-10-00            | 64-36-00        | 00:00:18        | 18,24               |
| 20272392          | 30-15-10            | 54-39-10        | 00:00:50        | 80,34               |
| 20298132          | 10-17-10            | 60-35-10        | 00:00:26        | 3,64                |
| 20393662          | 22-04-00            | 54-39-00        | 00:00:07        | 41,68               |
| 20403595          | 20-17-00            | 74-37-00        | 00:00:52        | 12,4                |

## Impact of E-commerce on warehouse management of a retail company

| Article Reference | Self-Serve Location | Hybrid Location | Time difference | Distance difference |
|-------------------|---------------------|-----------------|-----------------|---------------------|
| 20424362          | 30-01-00            | 62-33-00        | 00:00:18        | 8,22                |
| 20476964          | 28-11-10            | 70-39-10        | 00:00:43        | 6,88                |
| 30160209          | 18-01-00            | 70-37-00        | 00:01:23        | 48,54               |
| 30228718          | 12-02-00            | 62-38-00        | 00:00:24        | 30,72               |
| 30236025          | 26-04-10            | 74-31-10        | 00:01:10        | 43,94               |
| 30249546          | 28-28-00            | 64-39-00        | 00:00:33        | 56,84               |
| 30272339          | 28-02-10            | 74-37-10        | 00:01:16        | 38,14               |
| 30298235          | 12-15-10            | 62-33-10        | 00:00:08        | 12,36               |
| 30298240          | 30-22-10            | 70-37-10        | 00:00:07        | 27,52               |
| 30372503          | 10-15-00            | 58-31-00        | 00:00:39        | 13,79               |
| 30403571          | 00-01-06            | 62-34-00        | 00:02:01        | 98,48               |
| 30446354          | 14-19-00            | 64-37-00        | 00:00:00        | 7,04                |
| 40249471          | 12-05-00            | 62-39-00        | 00:00:15        | 22,68               |
| 40249541          | 18-03-00            | 70-33-00        | 00:01:25        | 53,34               |
| 40263103          | 12-13-00            | 62-32-00        | 00:00:16        | 18,46               |
| 40269421          | 08-09-00            | 60-39-00        | 00:00:12        | 17,02               |
| 40272225          | 10-07-10            | 58-33-10        | 00:00:53        | 25,53               |
| 40272287          | 28-28-10            | 64-33-10        | 00:00:18        | 44,74               |
| 40307164          | 12-09-00            | 64-32-00        | 00:00:30        | 28,72               |
| 40393661          | 22-05-00            | 54-37-00        | 00:00:06        | 39,34               |
| 40395245          | 28-08-00            | 62-35-00        | 00:00:14        | 10,44               |
| 40400478          | 01-03-00            | 60-35-00        | 00:02:34        | 182,92              |
| 40407922          | 01-02-00            | 60-37-00        | 00:02:32        | 181,06              |
| 50160208          | 16-02-00            | 70-39-00        | 00:01:05        | 33,78               |
| 50242737          | 06-01-00            | 56-36-00        | 00:00:53        | 35,12               |
| 50244468          | 18-15-00            | 68-31-00        | 00:00:49        | 24,08               |
| 50244473          | 30-14-10            | 54-38-10        | 00:00:46        | 76,28               |
| 50244487          | 16-18-00            | 64-35-10        | 00:00:05        | 19,08               |
| 50248428          | 06-04-00            | 56-38-00        | 00:00:37        | 24,04               |
| 50272300          | 08-05-10            | 58-36-10        | 00:00:26        | 28,53               |
| 50307168          | 28-13-00            | 64-31-00        | 00:00:16        | 10,96               |
| 50322847          | 20-04-00            | 54-38-00        | 00:00:06        | 34,52               |
| 50403589          | 20-20-00            | 76-36-00        | 00:00:47        | 12,42               |
| 50454908          | 26-14-00            | 76-34-00        | 00:00:39        | 21,72               |
| 50476953          | 16-23-00            | 66-32-00        | 00:00:12        | 9,52                |
| 50482614          | 08-02-00            | 64-33-00        | 00:01:00        | 57,22               |
| 60239273          | 20-12-00            | 54-35-00        | 00:00:09        | 45,68               |
| 60244463          | 16-13-00            | 68-36-00        | 00:00:33        | 10,08               |
| 60249470          | 08-05-00            | 58-37-00        | 00:00:23        | 25,97               |
| 60272234          | 08-18-10            | 60-36-10        | 00:00:01        | 5,52                |

| Article Reference | Self-Serve Location | Hybrid Location | Time difference | Distance difference |
|-------------------|---------------------|-----------------|-----------------|---------------------|
| 60322130          | 26-12-00            | 74-38-00        | 00:00:36        | 13,9                |
| 60366789          | 20-08-00            | 76-38-00        | 00:01:15        | 32,52               |
| 60403579          | 14-07-00            | 54-36-00        | 00:00:01        | 14,24               |
| 60403602          | 24-05-00            | 54-33-00        | 00:00:02        | 38,92               |
| 60453588          | 28-33-10            | 76-39-10        | 00:00:04        | 24,44               |
| 60473548          | 36-19-00            | 76-31-00        | 00:00:16        | 6,44                |
| 60490449          | 10-21-00            | 60-36-00        | 00:00:11        | 5,74                |
| 70178170          | 06-11-00            | 56-34-00        | 00:00:31        | 18,56               |
| 70214192          | 34-20-00            | 76-33-00        | 00:00:12        | 0,36                |
| 70217973          | 36-03-00            | 72-33-00        | 00:00:35        | 14,78               |
| 70244523          | 28-15-10            | 74-33-10        | 00:00:54        | 19,54               |
| 70272262          | 30-30-10            | 76-33-10        | 00:00:08        | 22,2                |
| 70272417          | 28-24-10            | 76-38-10        | 00:00:29        | 2,28                |
| 70278344          | 14-21-00            | 58-34-00        | 00:00:20        | 21,17               |
| 70278706          | 08-21-00            | 58-38-00        | 00:00:17        | 7,61                |
| 70290459          | 22-19-00            | 56-33-00        | 00:00:25        | 56,84               |
| 70298139          | 28-22-10            | 76-31-10        | 00:00:46        | 13,42               |
| 70366784          | 24-06-00            | 54-32-00        | 00:00:00        | 38,62               |
| 70403569          | 20-09-00            | 76-39-00        | 00:01:08        | 28,74               |
| 70403593          | 24-07-00            | 74-31-00        | 00:01:14        | 32,46               |
| 70403606          | 20-13-00            | 54-31-00        | 00:00:03        | 39,88               |
| 70477008          | 28-18-10            | 76-36-10        | 00:00:43        | 11,78               |
| 80125124          | 28-29-00            | 62-37-00        | 00:00:35        | 56,31               |
| 80213074          | 34-01-00            | 72-34-00        | 00:00:30        | 21,02               |
| 80214549          | 26-03-00            | 74-33-00        | 00:01:10        | 42,36               |
| 80228711          | 12-03-00            | 62-36-00        | 00:00:28        | 32,74               |
| 80249469          | 10-18-00            | 58-39-00        | 00:00:09        | 10,27               |
| 80249474          | 14-14-00            | 64-35-00        | 00:00:17        | 7,78                |
| 80249539          | 18-02-00            | 70-31-00        | 00:01:32        | 58,72               |
| 80272252          | 08-14-10            | 60-33-10        | 00:00:17        | 18,86               |
| 80272327          | 08-09-10            | 60-32-10        | 00:00:29        | 30,72               |
| 80298134          | 12-18-10            | 62-38-10        | 00:00:12        | 2,58                |
| 80298233          | 10-14-10            | 60-38-10        | 00:00:28        | 3,86                |
| 80307162          | 08-20-00            | 58-32-00        | 00:00:00        | 5,81                |
| 80309241          | 26-02-00            | 74-35-00        | 00:01:10        | 40,40               |
| 80411272          | 28-23-00            | 60-33-00        | 00:00:25        | 48,80               |
| 80424745          | 24-14-00            | 72-38-00        | 00:00:36        | 1,32                |
| 90124534          | 16-01-00            | 70-36-00        | 00:01:15        | 42,06               |
| 90160211          | 26-00-00            | 70-35-00        | 00:01:08        | 35,45               |
| 90217972          | 36-02-00            | 72-36-00        | 00:00:30        | 10,35               |
| 90248426          | 06-02-00            | 56-35-00        | 00:00:52        | 35,00               |

## Impact of E-commerce on warehouse management of a retail company

| Article Reference | Self-Serve Location | Hybrid Location | Time difference | Distance difference |
|-------------------|---------------------|-----------------|-----------------|---------------------|
| 90264690          | 20-09-00            | 70-31-00        | 00:01:16        | 32,40               |
| 90272256          | 12-13-10            | 64-31-10        | 00:00:22        | 22,44               |
| 90278343          | 28-36-00            | 58-36-00        | 00:01:04        | 83,47               |
| 90309245          | 24-04-00            | 74-36-00        | 00:01:15        | 29,12               |
| 90349326          | 06-00-00            | 60-34-00        | 00:01:12        | 63,54               |
| 90372519          | 10-13-00            | 58-33-00        | 00:00:39        | 13,33               |
| 90392046          | 20-07-00            | 72-37-00        | 00:01:12        | 29,04               |
| 90403587          | 14-06-00            | 54-34-00        | 00:00:07        | 8,12                |
| 90404799          | 08-18-00            | 58-35-00        | 00:00:02        | 4,53                |
| 90482513          | 20-06-00            | 76-37-00        | 00:01:23        | 39,38               |
| 90489449          | 08-01-00            | 60-31-00        | 00:00:49        | 48,72               |