

A Hybrid approach for Wholesale Fulfilment Strategy in the Fashion Industry

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Abstract

Even though the fashion market has experienced some changes in the last years, the wholesale channel still accounts for a significant percentage of sales worldwide. For a company performing in the field of logistics within the fashion business, the value proposition must be focused upon the optimization of its supply chain. Particularly, HUUB works as an orchestrator of the supply chain of fashion brands, coordinating all the tasks associated with it, and ensuring the optimization of logistics costs and operations is fundamental to stay competitive within the B2B segment.

The scope of this thesis relies on the redefinition of the fulfilment strategy for the wholesale channel by proposing a hybrid approach that combines cross-docking and traditional warehousing operations. The purpose underlying this analysis concerns the objective of reducing storage capacity levelled by the stock peaks in the beginning of each season and improving the handling time per item by transforming the reception to stock and picking operation into a single flow activity.

Three different configurations for the hybrid approach were designed: the first design presented a more oriented cross-docking approach, while the second aimed to optimize shipping costs and the last strategy, comprising three variations, focused on the perspective of the level of service provided by HUUB to its clients. The second and third configurations include a feature of temporary storage, essential to allow the allocation of products to orders and shipping them when the required conditions are met. A total of five different scenarios were proposed and a simulation developed in *Python* allowed to conduct a cost analysis based on fulfillment and shipping costs.

The results showed that all the scenarios proposed present savings when compared to the current situation, with the exception of the first proposal. Regarding fulfillment costs, the first scenario achieving a maximum reduction of 24%, due to the absence of temporary storage. Concerning the shipping costs, the second scenario achieved the best results when compared to the AS-IS cost structure, economizing a total of 24%. Overall, the scenario with optimization of shipping costs presented a more favourable solution when considering the cost structure, with a 21% reduction from the AS-IS situation, while the proposal closest to a pure cross-docking strategy presented the worst performance.

The decision-making process should include other factors besides the cost structure, such as the brand satisfaction, as a result of the service level provided, the operational risk associated with the implementation of this process and the flexibility of the operation associated with the new process. For this reason, an Analytic Hierarchy Process (AHP) was conducted, to rank the decision alternatives based on the four criteria presented. The results concluded that the scenario with optimization of shipping costs represented the best recommendation.

Resumo

O mercado da indústria da moda caracteriza-se por várias mudanças nos últimos anos. No entanto, o canal de vendas de *wholesale* continua a representar uma percentagem significativa das vendas a nível mundial. No contexto de uma empresa logística a operar na indústria da moda, a proposta de valor foca-se na optimização da *supply chain*. A HUUB realiza a gestão da *supply chain* de marcas de moda, sendo responsável pela coordenação de todas as atividades e garantindo a otimização dos custos logísticos que é fundamental para manter uma posição competitiva no segmento de *wholesale*.

O enquadramento da presente dissertação prende-se com a redefinição da estratégia de abastecimento do canal de *wholesale* através da proposta de um modelo híbrido que combina estratégia de armazenamento tradicional e *cross-docking*. O propósito desta análise tem como objetivos a redução da capacidade de *stock*, que é nivelada por picos de *stock* que ocorrem no início de cada estação, e a transformação das operações de receção para *stock* e de *picking* num único fluxo.

Três configurações do modelo híbrido foram propostos: um primeiro desenho que se aproxima de um processo de *cross-docking*, uma segunda configuração que visa otimizar os custos de transporte e ainda um último modelo, que inclui três variações distintas, que impõe restrições para manter o nível de serviço atual para os clientes. A segunda e terceira configurações prevêm a inclusão de uma zona de armazém destinada a armazenamento temporário, uma característica que se revela fundamental para permitir a alocação de produtos a encomendas e corresponder às condições definidas para o seu envio. Um total de cinco cenários distintos foram propostos e a respetiva estrutura de custos foi analisada, com o recurso a uma simulação desenvolvida em *Python*, baseada na obtenção de custos de armazém e de transporte.

Os resultados obtidos evidenciam que todos os cenários propostos, à exceção da primeira configuração, apresentam poupanças de custos em relação à situação atual. Relativamente aos custos de armazém, o primeiro cenário apresenta uma poupança máxima de 24%, devido à ausência da zona de armazenamento temporário. No que diz respeito a custos de transporte, o segundo cenário apresenta a melhor estrutura de custos, com uma redução de 24% face à situação implementada à data. Globalmente, a segunda configuração que visa otimizar os envios realizados apresenta a estrutura de custos mais favorável, com uma redução de 21% relativamente aos custos atuais, ao passo que a primeira formulação, correspondente a uma estratégia de *cross-docking*, demonstra o pior desempenho.

O processo de decisão deve ter em conta outros fatores qualitativos além do custo. Assim, foi conduzido o procedimento de *Analytic Hierarchy Process* (AHP), de modo a incluir os critérios de satisfação da marca, risco operacional e flexibilidade num modelo de priorização das alternativas de decisão. Os resultados concluíram que o segundo cenário se apresenta como a melhor recomendação tendo em conta os quatro critérios analisados.

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*"Para ser grande, sê inteiro: nada
Teu exagera ou exclui.
Sê todo em cada coisa. Põe quanto és
No mínimo que fazes."*

Ricardo Reis

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Acronyms and Symbols

AHP	Analytic Hierarchy Process
B2B	Business to Business
B2C	Business to Customer
CRM	Customer Relationship Management
KPI	Key Performance Indicator
SC	Supply Chain
SCM	Supply Chain Management
SKU	Stock Keeping Unit
WMS	Warehouse Management System

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Chapter 1

Introduction

Warehouses are a key part of supply chain and their optimized management is crucial in any industry. Even though the fashion industry has been going through some changes over the past years with the growth of e-Commerce, the market is still characterized by two distinct seasons per year that influence the logistics of every brand. From a supply chain point of view, and given the average product life cycle time, fashion brands present an annual stock pattern with two significant peaks, coincident with the beginning of these seasons Autumn/Winter and Spring/Summer.

This dissertation was carried out in a logistics company, HUUB, whose goal is to offer fashion brands an end-to-end solution for managing their entire supply chain by adding value to the company at a competitive cost. In light of this, the optimization of warehouse management is crucial for HUUB. An efficient management of supply chain involves the reduction of logistic costs, and storage and handling operations in the warehouse represent a big driver of these costs. Therefore, there is a need to look for the best practices to maximize the trade off between level of service provided to customers and cost efficiency.

Considering the aforementioned arguments, this project addresses the design of warehouse fulfillment strategy for the wholesale (B2B) channel, by evaluating the potential of developing a hybrid approach between traditional warehousing processes and cross-docking, in order to optimize the cost structure by redefining stock and handling policies without compromising service quality. The present chapter describes the project and the problem tackled, as well as the methodology used to achieve the objectives envisaged.

1.1 Company Overview

HUUB is a technology startup company founded in 2015 with the purpose of disrupting logistics in the fashion industry by becoming the logistics platform for fashion brands. HUUB's mission is to democratize the access to a fully established supply chain for independent distinctive fashion brands. This is accomplished through a collaborative platform that positions HUUB at the center of a dynamic ecosystem composed by brands, end users, suppliers and alliance partners. It provides an end-to-end logistics service that is able to link all stakeholders involved in the system, and that is

adapted to the current global era, shaped by information, user experience and collaboration. With this value proposition, HUUB takes on the responsibility of managing the entire supply chain of its clients with the commitment of pursuing sustainable growth for everyone's business by leveraging the power of information and technology.

At the moment, HUUB is operating with one warehouse in Portugal through a partnership. HUUB provides its clients services regarding warehouse management and distribution by establishing contracts with warehouses and several carriers. By combining the transportation of products from different brands, HUUB is able to attain economies of scale with carriers and negotiate better prices than fashion brands would have access without outsourcing, specially small brands who have potential but lack the resources to set up a complex logistic operation.

As a technology and data-driven organization, HUUB developed a platform named SPOKE, which enables partner fashion brands to get an overview and monitor their supply chain without the efforts of managing the daily operations. This allows companies to focus on growing their core business, promoting innovation and cultivating the relationship with final consumers.

HUUB's clients are fashion brands that work either through wholesale (B2B), e-Commerce (B2C) or that combine both channels. The service provided is convenient to brands since HUUB charges a standardized cost per item that includes all the warehouse services and a fee per transportation, close to carriers' cost with a margin for HUUB.

Throughout its activity, HUUB has worked with several fashion brands in different segments and has established its operations beyond borders, shipping items to a vast number of countries. With a perspective of pursuing further expansion, the optimization of warehouse management is crucial for HUUB to achieve sustainable growth.

1.2 Problem Definition

Given that many of the fashion brands in HUUB's portfolio still have a strong presence in physical retail locations, the wholesale channel accounts for a significant part of the items processed through HUUB's operation. At the beginning of each season, the suppliers who work with fashion brands send large purchase orders of items to the warehouse with the purpose of being delivered to clients during the next months, either physical retailers in the B2B channel or directly to final consumers in B2C channel. This causes storage peaks in the warehouse due to a large volume of receptions within a relatively short period of time.

The current commitment of fashion partners for providing HUUB with an anticipated forecast of receptions in the warehouse and shipments to retailers is low, which doesn't allow an accurate prediction of space requirements, and results in losses for the warehouse. Consequently, the planned maximum capacity contracted for each season to ensure that there is space available to receive suppliers' deliveries is unused for part of the season, as the items destined to B2B start being shipped to stores not long after being received in the warehouse.

Previous analysis conducted in the early stages of this project has shown that a significant percentage of items received in HUUB's warehouse already had sales orders created in system at

the moment of reception. This implies that the reception to stock activity, subsequently followed by picking operation constitute an inefficient approach, with clear potential for improvement. By replacing the current processes with a hybrid approach between traditional warehousing and cross-docking, featuring a sorting procedure between reception and shipment, the accumulations of stock can be avoided. This results in a reduction of storage costs and time spent processing an item by warehouse operators.

1.3 Project Objectives

The focus of this dissertation is to design a solution for HUUB to manage the fulfillment strategy for the wholesale channel, with a flow that pursues better utilization of warehouse capacity and resources, achieving a reduction in logistics costs.

The goal is to balance the stock peaks verified throughout the year due to the accumulation of stock at the beginning of each season.

Moreover, the current processes at HUUB causes a redundancy in operations and excess of human and material resources used. With the introduction of a direct operation of sorting from reception to shipping under specific circumstances (to be defined in this thesis), the aim is to save costs and allow for a different allocation of human and material resources. Consequently, this will also reduce the handling time per item. As a result of this process change, the company will also be able to reduce its minimum lead time, since it becomes feasible for items to be received and shipped from the warehouse within the same day or in the following day.

This project aims to position HUUB as a more competitive player in the B2B segment. Simultaneously, it allows the company to take on more fashion brands as clients with the space currently available in the warehouse, increasing its business volume.

1.4 Methodology

The first phase of the project consisted in a deep dive into HUUB's business model and the current situation of warehouse operations, understanding the process of inbound, outbound and returns. Afterwards, in the stage of project definition, a collection of data and respective analysis was developed in order to verify the possible impact of the proposal. A deeper evaluation of the B2B business indicators was conducted with the Global Operations team, to get a more in-depth understanding of the issues involved.

After achieving an overview of the problem, a literature review was carried out to assess the work developed in the field and become aware of the best practices that could be implemented.

The next phase focused on the definition of different scenarios for the project, considering the changes in the warehouse processes and the business rules associated to each one, given that alterations in the business rules produce effects through other stages of the supply chain and in the relationships with clients.

From this point, the project comprised an analysis of each of the scenarios to evaluate the cost structure associated with the different proposals, as well as other relevant indicators (e.g. operational risk at the warehouse, service level) to support an informed decision making process for the company.

Finally, a risk evaluation was elaborated with a Failure Mode and Effects Analysis (FMEA) and the analysis of the root causes of each risk, as well as control measures to be minimize its occurrence and impact were identified. In order to support the decision-making process regarding the possible implementation of this process, an Analytic Hierarchy Process (AHP) was developed, to consider other relevant factors aside the cost structure in the decision process.

1.5 Thesis Outline

The present dissertation is composed by six chapters, organized as follows. The next chapter presents a literature overview of the topics addressed in this project, providing the theoretical background for the work done. The focus relies on supply chain and warehouse management, including all the operations encompassed in the warehouse logistics flow. The technology innovations that have been used to improve warehouse operations in recent years are also reviewed. Special attention is given to the different types of cross-docking processes, the inclusion of temporary storage and hybrid warehouses.

The third chapter elaborates the context of the problem being analysed. The first section is dedicated to the AS-IS situation within the company, describing the inbound and outbound processes. The second one is focused in the B2B operation within the AS-IS context, presenting an overview of the relevance of this sales channel in HUUB's business and the main challenges to be tackled in the project.

Subsequently, the fourth chapter is dedicated to the methodology of the project, approaching the data preparation step and the overview of the definition of the new operational model, describing the design of the process, the alterations to business rules and technology integration. Three different models of implementation are described, with a total of five scenarios, and the business rules associated with each of the proposals are analyzed. The methodology used in the simulation of costs for each scenario is further explored.

In the fifth chapter, the focus concerns the discussion of the results obtained for the five scenarios proposed. A Failure Mode and Effects Analysis (FMEA) is conducted in order to identify risks relevant to the implementation of the alternative scenarios proposed. After analysing the cost structure of the scenarios proposed, other factors relevant to the decision-making process are addressed and included in the Analytic Hierarchy Process (AHP) procedure, to provide a ranking of the decision alternatives.

The last chapter provides a perspective about the main outcomes of the project with a reflection about their impact for HUUB and its operations. It is also discussed the potential generalisation of the results to other setting, by discussing how cross-docking and the traditional warehousing approach can successfully coexist. Finally, opportunities for future developments are identified.

Chapter 2

Literature Review

The present chapter provides an overview of the state of the art in the areas addressed in this dissertation. Following an introduction to the concepts of supply chain and supply chain management, there is a review about warehouse management, the main operations performed and third party logistics providers as a connecting bridge in the supply chain. Moreover, a deeper analysis about cross-docking is conducted, exploring the differences of this process compared to traditional warehousing, the distinction between alternative types of cross-docking and the utilization of temporary storage. A discussion about the concept of hybrid warehouses and developments in this field are presented. Finally, an overview regarding the Analytic Hierarchy Process is introduced along with its applications in the context of supply chain and a conclusion about the relevance of these topics in the scope of the thesis is outlined.

2.1 Supply Chain and Supply Chain Management

In an environment characterized by an intensification of competition, with a geographic scope widening beyond borders, companies look for a way to leverage their supply chain as a driver to promote value creation whilst ensuring operational efficiency (Ganesan et al., 2009). The global market is defined by various sources of external pressures and the trade-offs between costs and response time to final customer increased complexity to logistics management (Wilding, 2006). The importance of establishing control of end-to-end processes in the retail business enhances the role of supply chain management in creating a seamless flow of goods (Christopher and Holweg, 2011). In order to successfully manage this complexity, a key factor relies in the integration of all organizations involved in physical, information, financial and knowledge flows throughout the supply chain.

In the fashion industry, the power has shifted towards the final consumer and the globalization has been widely present, often causing a distribution of many links of the supply chain through several locations. This spread reflects whether by the selection of suppliers located in developing countries to reduce production costs or the setup of an operation with a network of warehouses placed strategically to reduce lead time to final consumer. More recently, a growing pressure to

make supply chains more sustainable has emerged, both from governmental policies and from a more environmentally aware society, adding to the complexity of meeting consumer's demands at a competitive cost (Turker and Altuntas, 2014).

The concept of supply chain management is defined by Ayers (2006) as "design, maintenance and operation of supply chain processes, including those that make up extended product features, for satisfaction of end-user needs". Mentzer et al. (2001) highlight that although the definition of this concept may vary in literature, supply chain management is commonly classified within three categories: a management philosophy, implementation of a management philosophy and a set of management processes.

According to Ayers (2006), supply chain encompasses activities of manufacturing, procurement, distribution, marketing & sales, product design, and information technology. Within the scope of this project, HUUB works as an orchestrator and is responsible to manage the logistics activities for its clients. Therefore the activities related to both product design and marketing & sales continue to be handled directly by the clients and hence will not be further explored in this dissertation.

2.2 Third Party Logistics

Outsourcing can be described as the strategy of using third parties to replace a company's own capacity to perform non-core activities that it is not able to fulfill competitively with good financial income (Ellram and Cooper, 1990). It is usually carried out in order to reduce financial risk while the company is able to focus on developing its core business.

Moreover, external factors such as the desire to achieve global markets, provide lower lead times to consumers and operate with a long-range logistics network demand a challenging management from brands. This fact contributed to the emergence of third party logistics providers, which is currently a business in expansion. These companies specialized in logistics activities achieved a stronger position in the market due to the challenges of creating a more flexible supply chain able to fulfill the necessities of a business at a competitive cost (Hertz and Alfredsson, 2003).

A third party logistics provider is an external company that manages logistics activities for a supplier. This logistic alliance can assume a more formal or informal character, not losing sight of the aim of being mutually beneficial. Hertz and Alfredsson (2003) identify some of the main advantages of these alliances, consisting of gains in terms of economies of scale and scope, efficiency of operations, bargaining power, range of services, knowledge sharing, implementation of new systems and a reduced investment base. These benefits also produce effects to activities downstream in the supply chain, as a supplier can become more competitive and therefore upgrade the level of service offered to customers.

2.3 Warehouse

Inventories exist alongside various stages of the supply chain to serve different purposes, either as finished products in a warehouse or as "in-transit" work in progress throughout the pipeline. Since carrying these inventories can represent a cost from 20% to 40% of their annual value, retailers wish to maintain minimal stock levels to reduce the costs incurred (Ganeshan, 1999).

Despite being associated with a source of expenses within the logistics network, Bartholdi and Hankman (2014) demonstrate the importance of warehouses and define the rationale behind their utilization as a way to create a better match between supply and demand, providing agility to the supply chain. In retail markets characterized by high surges in demand, it would be very difficult to respond to those peaks without the possibility of product storage. From a different perspective, in periods with unexpected collapses in demand, a warehouse also provides the possibility to store products for longer periods, providing a buffer to the supply chain. Another factor that supports this rationale is the consolidation of products, combining goods from different suppliers to orders downstream the supply chain, reducing transportation costs while simultaneously providing a better level of service to customers. In addition to these reasons, Hompel et al. (2007) present warehouses as a way to optimize logistic performance, ensure high productivity levels, and provide additional services, thus becoming a value-adding stage in the supply chain.

According to Hompel et al. (2007), warehouse management comprises functions of control and optimization of warehouse and distribution systems. In order to meet requirements for efficient distribution with a optimized cost structure, the introduction of a warehouse management system (WMS) becomes a necessary condition to ensure transparent processes and a disciplined execution of tasks.

Ramaa et al. (2012) define a warehouse management system as a data driven application to improve the efficiency of the operations performed in the warehouse by registering all transactions and maintaining accurate stock records.

2.4 Warehouse Operations

According to Bartholdi and Hankman (2014), the operations performed in a warehouse are classified as receiving, put-away, order-picking and shipping. The first two are associated with inbound process (receiving and put-away), while order-picking and shipping and part of outbound process. Frazelle (2002) presents a more detailed sequence of operations, as described in Figure 2.1, which include receiving, put-away, storage, order picking, packaging and/or pricing, sort and packaging and shipping.

2.4.1 Receiving

Receiving may start before the items arrive to the warehouse, with a notification of arrival. This procedure allows the warehouse to schedule its operation in order to guarantee an efficient flow of goods throughout the activities. Once the cargo from supplier arrives at the warehouse, the

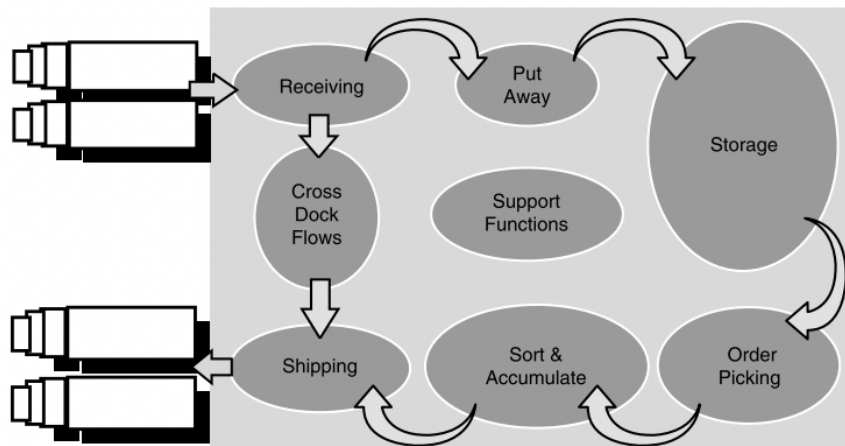


Figure 2.1: Warehouse Operations. Source: Frazelle (2002)

receiving activity involves its unloading from trucks. Typically, products arrive in large quantities and often in pallets, which may require for mixed pallets to be broken out or loose cartons to be palletized, according to storage policies (Bartholdi and Hankman, 2014). During this operation it is common practice for goods to be scanned to update stock records and report any inconsistencies regarding quantities or quality, with a visual quality control process (Frazelle, 2002).

2.4.2 Put-away

The put-away operation refers to the process in which a product is moved to the storage location where it has been allocated. Bartholdi and Hankman (2014) highlights the importance of the put-away operation in determining the time and cost spent in posterior order picking processes. Therefore it is essential to balance the trade-off between put-away and order picking operations to determine the most adequate strategy, since every time a product is put down, it will necessary be picked up, either as a part of an order picking or to be moved to a different storage location.

This activity is labour intensive, given that a product may need to be moved to a storage location within a considerable distance from the receiving station, representing about 15% of warehouse operating expenses (Bartholdi and Hankman, 2014).

2.4.3 Order Picking

Order picking consists in collecting different products from the respective storage locations, according to customer's orders and placing them in containers to be shipped. This is the most time and cost consuming operation in a warehouse, estimated to account for about 55% of the total warehouse operating expenses (de Koster et al., 2007).

The outbound process is triggered by the reception of a customer order, which is then processed through the warehouse's WMS and, if no discrepancies in stock are found, is clustered and

scheduled to be included in picking lists. A pick list can be organized in different ways and represents the sequence of storage locations a warehouse should visit and the respective quantity of SKUs to be picked. It can be presented in a physical form (sheet of paper), by voice transmission, by light or by a technology equipment (PDA) (Bartholdi and Hankman, 2014).

de Koster et al. (2007) describes four main order picking problems: storage (determining the locations where a product is stored), order batching (rule to define which orders to combine in a picking tour), zone picking (dividing the storage area into smaller zones) and routing (setting the optimized route for the picking list).

Several assignment methods are presented to solve the storage problem. Forward-reserve allocation is characterized by separation of bulk stock and pick stock, where the area dedicated to pick stock is restricted in order to reduce travel time during the picking operation (Frazelle et al., 1994). Regarding the assignment of locations within both the reserve and forward storage areas, the most frequently types of storage assignment used are random storage, closest open location storage, dedicated storage, full turnover storage and class based storage (Petersen, 1997; Hausman et al., 1976; Heskett, 1963).

Order batching policy is a method consisting of grouping a set of orders so that each sub-set created is picked within one picking tour. When creating a batch of orders there are two main criteria applied: picking positions or time windows. When performing proximity batching each group of orders is created based on the proximity of the SKUs to be picked. In time window batching, groups of storage positions to be visited are created based on a time interval to perform the operation (de Koster et al., 2007).

To understand the effects that batching can have on the global performance of the warehouse, Petersen and Aase (2004) tested the multiple warehouse picking policies. The authors claim that batching has the largest impact on reducing total fulfillment time, especially when the orders are small. However, one important note is the assumption that even though the orders were batched it was possible to maintain the individual integrity of each one. If the batching requires orders to be split, the following sorting operation to consolidate the orders could make the saved time disappear on this extra operation.

Zoning constitutes an alternative to order picking that aims to reduce the distance travelled during the operation by dividing the order picking area into zones. The main downside associated with this strategy relies on the fact that orders are split in order for each picker to pick the items that fall in his area and then they need to be consolidated before packing.

In Petersen and Aase (2004), a study of the impact of picking, routing and storage policies on order pick travel is conducted, in order to assess which factors have a more significant effect on system performance. This analysis verified that using volume-based or class-based storage, rather than a random storage policy, may lead to the increase of warehouse congestion, without significantly increasing the savings (around 1%). In Zhang et al. (2017), the importance of warehouse layout problems is emphasized, demonstrating the relevance of having an efficient and flexible layout, in order to improve material flow and to improve space utilization. The determination of a warehouse layout is usually a tactical decision that derives from decisions to a strategic level.

Dekker et al. (2004) address this problem by decomposing the order-picking time in several fractions - traveling between product locations, picking products, packaging, dropping off products and receiving information by voice directed picking -, demonstrating that picking and traveling times account for most of the time spent performing the operation.

2.4.3.1 Put-to-light

Boysen et al. (2019) propose a model to improve the efficiency of order consolidation required by batching and zoning picking to separate customer orders after the process of picking. This is accomplished by the implementation of put walls to manually consolidate orders. A batch of orders is picked and then distributed over several bins destined to customer orders through a conveyor system with a put-to-light mechanism which signals the correct bin to place an item when it is scanned. On the other side of the wall, packers are able to pick the complete bins and start the packing operation.

As an expansion of the previous work, Boysen et al. (2020) address optimization of put-to-light order picking systems to invert the basic logic of conventional picker-to-parts systems. The study proposed a model where a picker moves a box containing multiple units of a Stock Keeping Unit (SKU) along a lane of boxes destined to different orders. The orders demanding the current SKU as signaled by a light, so that the picker places the indicated number of items in the box. In cases where several orders demand the same SKU, this put-to-light process saves time and cost by reducing picking walking distance.

2.4.4 Shipping

After order picking, products need to be sorted and packed to be ready for shipment. Packing can be a labour-intensive operation in situation where items need to be dealt with individually in this activity. This operation constitutes a good quality check for order accuracy since the individually processing of goods allows to recheck the items allocated to a given order before packing, contributing to an improvement of level of service provided to customer Bartholdi and Hankman (2014). During this processes, products are normally consolidated into fewer containers (cases, pallets) and every procedure related to outbound documents is completed. Shipping is a very similar process to receiving, where products are loaded into a carrier at the shipping dock and leave the warehouse Gu et al. (2007).

2.5 Cross-Docking

From the warehouse operations previously mentioned, storage and picking are the most time and cost consuming, as they are labour intensive operations in which items are dealt with individually. To improve warehouse efficiency, cross-docking emerged as a strategy to eliminate these two processes from the warehouse flow.

Throughout the years, cross-docking has been widely explored in the literature as a logistics strategy for improving operational efficiency. According to Apte and Viswanathan (2000), cross-docking is a warehousing strategy that incorporates the flow of materials directly from receiving to shipping docks with minimum time in between these operations.

Besides improving the performance within the actions in the warehouse, cross-docking is also perceived as a strategy to reduce transportation costs. Kinnear (1997) describes this process as receiving product from a supplier or manufacturer for several end destinations and consolidating this product with other suppliers' items based on final delivery destinations. The consolidation of shipments and consequent economies in transportation costs is described by some authors as the primary purpose of this logistics strategy (Kinnear, 1997; Apte and Viswanathan, 2000).

Within the traditional network structures, Apte and Viswanathan (2000) describes the concept of a mixed warehouse, where inputs from different suppliers arrive to the warehouse. Then, the cargo is broken and consolidated to create multi-product shipments to be delivered to customers. In a traditional mixed warehouse operation, products spend several days or weeks in storage before being shipped again. The process is exhibited in Figure 2.2.

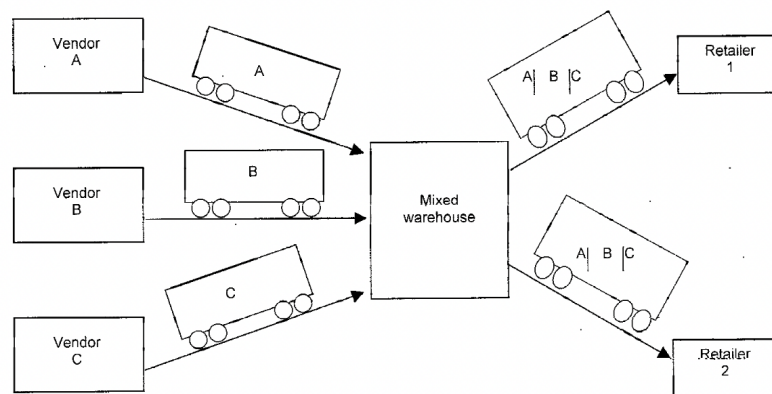


Figure 2.2: Network structure for Traditional Mixed Warehouse. Source: Apte and Viswanathan (2000)

In contrast with traditional warehousing, in a cross-docking warehouse goods remain virtually untouched except for unloading and loading operations and there is no record of these items in warehouse stock. The Table 2.1 illustrates the differences between traditional warehousing and cross-docking, according to Apte and Viswanathan (2000).

Table 2.1: Key Differences Between the Traditional Mixed Warehouse and the Cross Docking Warehouse, adapted from Apte and Viswanathan (2000)

Traditional Mixed Warehouse	Cross-Docking Warehouse
Items are put away to storage or order picking areas and reside in the warehouse for at least more than a day	Items typically flow in and out the through the warehouse in a single day without being put away to storage or order picking areas
Items enter the inventory records in the warehouse system	Items need not enter the inventory records in the warehouse
Relabelling and packaging activity may be carried out in the warehouse	May function without any relabelling or repackaging

Vis and Roodbergen (2008) address the advantages of cross-docking compared with traditional warehouse storing strategies. These are associated with the reduction of lead times and inventories and a reduction in logistics costs structure. The savings in warehousing costs are driven by the reduction of stock levels and the shorter handling time when compared to storage and picking operations in the traditional warehousing. The faster inventory turnover flow within the warehouse contributes to a shorter lead time for delivery to customer, since an item can arrive to the warehouse and be shipped to the customer in the same day, and allow for an improved service level. Van Belle et al. (2012) compare this strategy with point-to-point deliveries, discussing the benefits of consolidation of shipments and improvement in resource utilization regarding the fulfillment rate of trucks, hereby resulting in reductions in transportation costs.

Cross-docking related problems have been addressed in the literature from different perspectives, analysing this logistic process from a long term point of view concerning strategic and tactical decisions, and from a shorter term view, regarding operational features. Regarding strategic decisions, the main topics analysed rely on location and layout of the cross-dock (Bartholdi and Gue, 2004). Following the configuration of the cross-docking network, the tactical decision defines how the items will flow through the warehouse and the alignment of supply and demand to comply with a desired service level. Operational aspects of cross-docking are widely explored in the literature, addressing issues as vehicle routing, dock door assignment, truck scheduling and temporary storage. The present work will further explore the concept of hybrid warehousing, considering a cross-docking process for part of the items that flow through the warehouse, analysing the conditions necessary to implement this process involving temporary storage.

2.5.1 Suitability of Cross-Docking

Apte and Viswanathan (2000) identify the factors that impact the suitability of utilization of cross-docking as an alternative to traditional distribution. The first feature analysed is product demand rate, as cross-docking will not be a recommended strategy if the demand rate is unstable, with fluctuations between incoming and outgoing cargo. Unit stock-out cost is recognized as a second factor considering that in a cross-docking process the possibility of occurrence of a stock-out is

higher. Hence, if the cost associated with a stock-out situation is low, the benefits of cross-docking can surpass the cost incurred.

The relation between the two aspects above mentioned and the suitability of cross-docking or traditional warehousing in each scenario is illustrated by the Figure 2.3, evidencing cross-docking as the preferred strategy in a situation of low unit stock-out cost and stable product demand rate.

		<i>Product demand rate</i>	
		Stable and constant	Unstable or fluctuating
<i>Unit stock-out costs</i>	High	Cross-docking can be implemented with proper systems and planning tools	Traditional distribution preferred
	Low	Cross-docking preferred	Cross-docking can be implemented with proper systems and planning tools

Figure 2.3: Suitability of cross-docking (adapted from Apte and Viswanathan (2000)). Source: Van Belle et al. (2012)

Van Belle et al. (2012) highlight other factors that can determine the suitability of a cross-docking implementation, such as the demand quantity and distance from suppliers, warehouse and final customer, as a greater distance will benefit more from a consolidation in transportation costs.

Additionally, a critical attribute that has been widely addressed in literature is the synchronization of inbound and outbound trucks, in which the compliance of the supplier with the inbound time represents an important driver (Yu and Egbelu, 2008).

The approach presented by Vahdani and Zandieh (2010) explores the problem with an implementation of five different meta-heuristics, developing a multiple objective decision making model to minimize operation time considering an infinite temporary storage buffer. The results concluded Variable Neighbourhood Search (VNS) was the meta-heuristic recommended for this type of problems.

Serrano et al. (2017) provides the example of a cross-docking applied to the automotive industry considering repackaging operations and high diversity of packages' dimensions and rules as a constraint that escalate the complexity of the problem analysed.

2.5.2 Types of Cross-Docking

The existent state of the art distinguishes several types of cross-docking attending to various characteristics. One definition presented in literature is based on the number of touches or stages. Gue and Kang (2001) propose a distinction between a single-stage cross-docking, as shown in Figure 2.4, where products are received and directly loaded in an outbound vehicle, also denominated as pure cross-docking. Moreover, they identify a two-stage cross-docking (see Figure 2.5) in which the items received in inbound trucks are sorted and then loaded into shipping trucks.

A key characteristic used to define types of cross-docking is the moment when a customer is assigned to individual products. According to Yan and long Tang (2009) and Tang and Yan (2010), two types of cross-docking are defined as pre-distribution and post-distribution operations. In the first situation, the customer is assigned to an order before the shipments leaves the

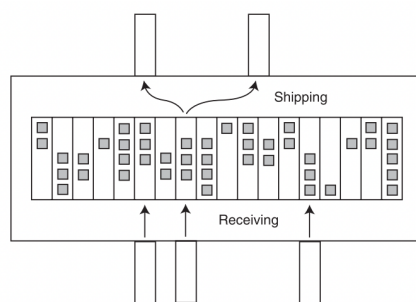


Figure 2.4: Single-stage cross-docking. Source: Gue and Kang (2001)

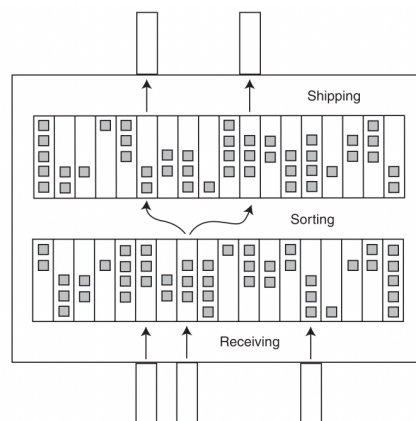


Figure 2.5: Two-stage cross-docking. Source: Gue and Kang (2001)

supplier, who is responsible for the process of attaching bar codes, labelling and pricing goods. Then, through the cross-docking network, the items are delivered to each retailer. In contrast, in a post-distribution cross-docking the supplier transfers all items to a cross-docking facility closer to final retailers and the operations associated with the preparation distribution of goods are performed in the cross-dock location, as it succeeds in the project in analysis. Tang and Yan (2010) highlight that operational costs in the cross-dock facility are higher in the post-distribution situation. However, the delay of sorting procedure to the cross-docking stage can confer benefits in reducing the uncertainty faced by each store and the possibility of posterior transshipment between stores to meet demand.

Other definitions can still be found in literature, as Kulwiec (2004) lists six different types of cross-docking: full pallet load operation, case-load order makeup, hybrid cross-docking, opportunistic cross-docking, truck/rail consolidation and short-term storage.

2.5.3 Temporary storage

Cross-docking is characterized as a process where the items arriving in inbound trucks are directly transported to outbound freight. This is difficult to implement successfully since it would require a very rigorous scheduling of inbound and outbound vehicles. Therefore, the option of temporary storage has emerged as a solution to this problem and is often necessary from an operational point

of view to ensure an effective implementation of a cross-docking flow in a warehouse (Van Belle et al., 2012).

The main problems associated with the implementation of a cross-docking process with temporary storage rely on the scheduling of inbound and outbound flows, the optimization of the layout of the warehouse and the best staging strategy.

Regarding the issue of scheduling inbound and outbound flow, Yu and Egbelu (2008) approaches the problem of scheduling of inbound and outbound trucks considering an infinite buffer of temporary storage in front of the shipping dock. To meet the objective of minimizing total operation time (makespan), the strategy was to transfer as many as items as possible directly from inbound to outbound vehicle. Three different approaches were proposed, but due to the complexity of time requirements, the heuristic algorithm achieved better results by overcoming the computational limitation of the mathematical mode, even though an optimal solution was not guaranteed.

Boloori Arabani et al. (2011) propose an extent to the work presented by Yu and Egbelu (2008) and analyse a type of cross-docking including reception and sorting of items in the temporary storage with the same purpose, focusing on an effective coordination between inbound and outbound trucks with a presentation of a multi-objective model to minimize total operation time and total lateness. The study proposes three different algorithms for the purpose of solving multi-objective problems, non-dominated sorting genetic algorithm-II (NSGA-II), strength Pareto evolutionary algorithm-II (SPEA-II), and sub-population genetic algorithm-II (SPGA-II). The performance of the algorithm was measured by hyper-area measure, spacing measure, mean ideal distance measure and the rate of achievement to two objectives simultaneously, where it was possible to conclude that SPEA-II produced the best results.

Concerning the tactical decision of the warehouse layout, determining the optimal location for temporary storage within the warehouse to minimize travel distance during the processing of items is also explored in the literature. Vis and Roodbergen (2008) define a mathematical model as a minimum cost flow problem and a algorithm based on the number of unloading and loading docks and the capacity of the storage rows within the warehouse to minimize the travel time. With the resource of several numerical experiments, authors show the proposed algorithm can reduce up to 40% in travel distance from commonly used heuristic methodologies.

The staging methods were approached by Sandal (2005) who focused its work in determining the appropriate staging strategy in a cross-docking environment. The problem is outlined using a mathematical model and a simulation experiment is conducted with a profit function to quantify and compare the results of different scenarios. The author proposes an analysis of three distinct strategies: (i) pure cross-docking where the items are directly loaded from inbound to outbound freight without staging; (ii) all the cargo is staged before it can be loaded to outbound vehicles and (iii) a simultaneous approach where the items are either loaded or staged, based on scheduling. For the scenarios where staging is considered, two strategies are further explored, random staging in a single queue, following a First-Come-First-Serve (FCFS) criteria or zoned staging, in which the staging area is divided into zones by priority of loading. The results of the simulation experiments conducted provide a recommendation of zoned staging strategy for the items that can not

be directly loaded to outbound trucks. A combination of zoned staging with simultaneous loading improved by 21% the total operation time compared with processes currently in place.

2.6 Hybrid warehouses

Cross-docking is not necessarily used as an exclusive strategy within a warehouse. In order to take advantage of the benefits of both traditional warehousing and cross-docking, Apte and Viswanathan (2000) report the case of hybrid warehouses, where some items are processed through a cross-docking strategy while others follow the traditional warehouse flow and are received to stock. This approach can be adjusted to the types of items in storage, by comparing the storage costs with the cost of losses in service level. To use a cross-docking process, the demand of items that arrive to the warehouse should be quickly in order not to create large buffers. With a stable demand, a more accurate forecast and planning can be achieved, therefore contributing to a more successful implementation of this strategy.

Hybrid cross-docking is addressed by Kulwiec (2004) as one type of cross-docking, being a solution to the problems faced by a pure cross-docking strategy. In this work, some difficulties as late changes in customer orders, canceled orders, incomplete production runs, shippers running out of stock, outbound vehicles not filled to economic capacity impose barriers to an efficient process of cross-docking, making it difficult to implement these strategy, even with technology developments. The Figure 2.6 represents the flows in this hybrid plan, compromising a solution between cross-docking and storage or staging, depending on the time the items stay in the warehouse.

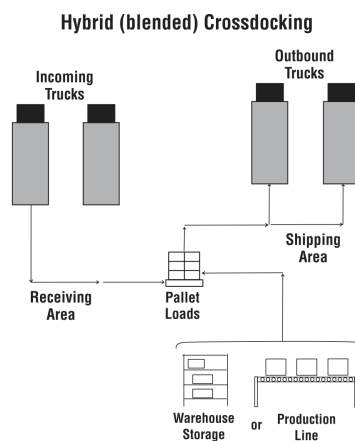


Figure 2.6: Hybrid Cross Docking. Source: Kulwiec (2004)

Benrqya (2019) provides a contribution to this field by exploring a case study in Fast Moving Consumer Goods (FMCG) industry with a configuration of a hybrid warehouse where 70% of the products are moved through a process of cross-docking with pick-by-line and the remaining 30% of items are processed through a traditional warehouse flow. The study presented a reduction in supply chain costs due to the increase in vehicle's fill rate and decreasing picking costs.

2.7 Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) is a decision-making procedure proposed by Saaty (1986) to solve multi-criterion (or attribute) decision-making (MCDM) problems by establishing priorities and representing the elements in the form of a hierarchy.

Multi-criteria decision-making problems can be solved analytically when the parameters involved are quantitative. However, many decision-making problems include subjective and qualitative criteria (Wang et al., 2012). AHP is a technique that allows to evaluate both quantitative and qualitative criteria within the same model. This is accomplished by introducing pair-wise comparison between the criteria in evaluation, which represent the perception of the decision-maker or of experts in the area (Goodwin and Wright, 2014).

The process of AHP initiates with the definition of a list of the criteria considered to be relevant to the decision-making process and the decision alternatives. Subsequently, these criteria should be assigned a weight that represents the criterion's relative importance in the problem based on pair wise comparisons following the fundamental comparison scale matrix presented in Appendix A. Furthermore, a rating for each criteria should be assigned to each decision alternative to illustrate how that alternative satisfies each criteria. After obtaining a weight for each criteria and a rating for each alternative, it is possible to compute a score for each alternative.

Regarding supply chain problems, AHP has been used in several decision-making situations, from the decision where to outsource an operation, analysed by Liu et al. (2008), to the problem of selecting the warehouse operator network (Korpela et al., 2007). Korpela and Lehmusvaara (1999) use an AHP model as a way to provide a more holistic and customer oriented view over a warehouse network decision, which is typically based on cost or profit optimization. This model is based in three main criteria, reliability (subdivided into delivery time, quality and quantity), flexibility (subdivided into urgent deliveries, frequency, special requests and capacity) and logistics costs.

In the fashion industry, Chan and Chan (2010) propose the application of an AHP model for the problem of supplier selection, as a solution to balance operational performance translated into factors as delivery, quality, assurance of supply, flexibility and cost with features concerning business structure, as perceived risk, technological and environmental issues.

Wang et al. (2012) address the risk of implementing green initiatives in the fashion supply chain based on the criteria proposed by (Chan and Chan, 2010), with a large emphasis in the performance assessment parameters.

2.8 Connecting the Literature and the Project

The current process implemented at HUUB can be described as a traditional mixed warehousing, as the products arrive from different suppliers for each brand and the items go through all the warehouse operations described above, being received and placed in storage before being picked and packed in each order.

The proposal of introduction of a hybrid approach for the fulfillment strategy aims to combine the flows of traditional warehousing and cross-docking. Due to the fact that brands in HUUB's portfolio present both B2B and B2C sales channels, an exclusive cross-docking strategy is not feasible since it can not be applied to e-commerce orders due to its unpredictability and reduced lead time. Therefore, a hybrid approach is introduced, with the possibility of performing a cross-docking inspired process for the wholesale orders while part of items that arrive to the warehouse are received to stock.

In the particular case addressed in this thesis, the products arrive in bulk from different suppliers and need to be sorted into the different orders, whether from wholesale or e-commerce channels. This process constitutes a situation of post-distribution cross-docking since the warehouse prepares the orders, which forces the operation to comprise a sorting operation between the reception and shipment.

The sorting operation increase the complexity of scheduling of inbound and outbound processes, hence the solution of integrating a buffer, designed as temporary storage. This feature provides the operation with some flexibility that facilitates the fulfillment of orders and enables the introduction of restrictions to optimize the cost structure.

Chapter 3

Problem Framework

This chapter presents the framework of the problem to be tackled and the assessment of the AS-IS situation. The first section focuses on the relevance of external partners in the operation. The second one is dedicated to the current operation, describing the warehouse flows of inbound and outbound. Moreover, an analysis regarding the sales channels covered by HUUB's current operation is conducted, with a deeper review regarding the wholesale channel in order to frame the relevance of the problem introduced.

3.1 External Partners

Following the vision of becoming the logistics platform for fashion brands, HUUB offers a plug-and-play integrated solution to its clients. To achieve it, the company works as an orchestrator between all the links in the supply chain and establishes several relationships that are crucial for leveraging growth. It is therefore important to understand the role of all the main stakeholders of the supply chain in HUUB's current operation. The main stakeholders in HUUB's network are Brands, Suppliers, Warehouses, Carriers and End-Customers.

Brands

Within the network of stakeholders, brands represent HUUB's main target, as they provide the revenue source for the company. For this reason, there is a nurture of the relationship between HUUB and fashion brands in order to understand the needs and the features most suited to each client, as well as to ensure the services agreed are successfully fulfilled.

Suppliers

This stakeholder is responsible for guaranteeing the production of items according to brand's requests regarding the quantity of each product and the date they should be delivered to the warehouse. Regarding the transportation to the warehouse, a manual regarding packaging procedures and rules for booking a delivery of cargo to the warehouse is provided by HUUB. Additionally, when a supplier books a delivery, a standard label that should be placed in every box is sent by HUUB. The performance of this stakeholder in terms of compliance to the delivery windows

agreed, the accuracy of quantities of goods delivered and the correct labelling of products are important factors in the supply chain that produce effects towards downstream activities.

Warehouses

Warehouses are a crucial partner to deliver HUUB's operation. This part of the operation is outsourced by HUUB to an external warehouse, therefore this stakeholder represents a very significant role in the business. This partner is responsible for receiving items from suppliers, storing them and processing the orders for shipment according to indications provided by HUUB. The levels of performance of the warehouse are constantly monitored, as the compliance of the service level agreed with brands is highly dependent of the warehouse operation. Within the relation between HUUB and the warehouse partner, HUUB is responsible to send a daily planning of items to receive and orders to prepare for shipment, as well as a weekly and monthly forecast. In order to promote a successful management of the supply chain highly dependent on this partner, it is crucial for HUUB to think in a value proposition for the warehouse, so that the partnership produces benefits for both parties. That value proposition relies on the simplification of processes for the management of a multiple retailer one warehouse model, as HUUB strives to make the operation as streamline as possible and to standardize processes for all brands to improve productivity. The overall performance of HUUB is highly dependent on this partner.

Carriers

Outsourced carriers are responsible for the transportation of orders shipped from the warehouses. Since transportation costs are a big driver of overall logistic costs, the optimized choice of carrier and negotiation of transportation features and fees is relevant for HUUB to be able to control quality of service and expenses, whilst maximizing its profit margin. This choice relies on several factors, such as origin and destination point, as well as the weight and volume of cargo to be transported. To be able to achieve this and to allow HUUB to serve all the geographic area targeted by the partner fashion brands, HUUB works with a vast network of carriers, who provide the services to ship orders and process returns from within and outside European Union.

End-Customers

HUUB operates B2B and B2C channels, therefore its end-customers are retailers, in the whole-sale channel and individual clients who place e-commerce orders through these brands' websites. Even though fashion brands are the direct clients of HUUB, all the clients are part of supply chain. At the moment of purchase, these customers are not aware of how their order will be fulfilled, but they expect to receive their order in good conditions within the presented time windows. The compliance of the service level agreements is essential for end-customers to be satisfied with the brand, and therefore for the client to be satisfied with HUUB's service.

3.2 Operation AS-IS

3.2.1 Inbound process

The inbound process at the warehouse presents several phases described in Figure 3.1 and further detailed below.

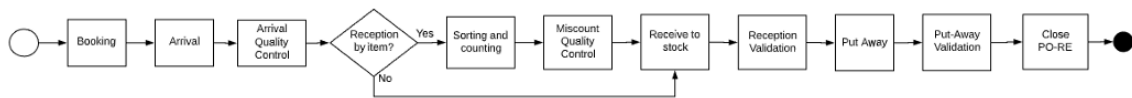


Figure 3.1: Inbound process.

Booking

The process starts with the booking of a delivery at the warehouse that should be requested to HUUB by the brand or the supplier, within the prearranged deadline. In case all the data required for the booking is correct, HUUB will manage the communication with the partner warehouse through a Customer Relationship Management (CRM) software and create a purchase order reception to be delivered. The warehouse will receive the booking request and compromise to book a delivery slot in the closest dock available in order to minimize transportation inside the facility.

Arrival and Quality Check

When the cargo arrives to the warehouse within the agreed schedule, the reference of delivery is compared with the list of purchase orders planned to be received in that day. Afterwards, the unloading process includes a quality control stage where the operator checks whether the truck's condition is compliant, if the number of boxes matches the planned order and the condition of boxes, to guarantee there was no damage in transportation. The cargo might arrive palletized or as carton loose, according to the indication provided in the booking request. In the case of non-palletized deliveries, the warehouse should palletize the boxes, as this is the preferred option. After the unloading process, pallets are moved to a staging area in the warehouse where a deeper quality control takes place.

Sorting and Counting

The inbound cargo that goes through the receiving process can present the following characteristics: boxes may be either mono or multi SKU and the reception may be performed at a box or at an item level. HUUB provides the warehouse a sequence by which purchase orders should be received daily. Pallets to be received in each day are transported to the ground floor of the mezzanine. The step of sorting and counting should be applied to all receptions by item. A pallet of items is placed next to the inbound station and the operator opens the box sent by supplier and starts to scan item by item with the resource of an excel file. This excel will provide a color corresponding to a drawer in which operator should place the item. There are six different drawers in the inbound station, which may contain up to three different EAN (product code), depending on the occupancy rate of each drawer, not to excessively increase complexity of the picking operation.

This sorting operation allows to identify several non-conformities that could affect the operation in downstream stages. When receiving, the items can be found without label or with an unreadable barcode or an extra item can be found in a box received from the supplier. In any of the cases, the operator should place the items in the inbound issue area and the customer support reports the issues to HUUB.

Reception to stock

In the case supplier sends a mono-SKU box, the box should be labelled, scanned and an opening to allow picking is cut in one side of the box, but items are kept in the original box. If the reception has multiple SKU's per box, the operator is responsible to choose the size of box most appropriate to store the items of a given product, based on its quantity and volume and the support guidelines provided by HUUB.

Reception Validation

After all boxes are received, a reception validation is processed to ensure all boxes are received only once and all discrepancies are identified.

Put away

Each pallet is transported to the designated area in warehouse storage, depending on the brand. The put away operation starts by allocating a box ID, unique to each box, to a rack location. The box should be placed in a way that the box label side is on the back side of the picking face. Depending on the size of the boxes used, a warehouse rack location can have more than one box allocated to it.

Put away Validation

The put away validation consists in checking whether there are any items still attributed to a staging location that have not been allocated to a stock position.

3.2.2 Outbound B2B process

The following steps describes the warehouse processes for the fulfillment of wholesale orders.

Order communication

The outbound process begins with the communication of order details to warehouse. In the particular case of wholesale orders, the ones to be fulfilled in each day must be communicated in the previous day, until a defined cutoff time to allow for the warehouse resource planning. During the communication phase, the mandatory fields are verified to ensure the information is complete to be integrated in the partner's WMS. The communication is followed by the process of creating the orders in the warehouse's WMS and the allocation the orders is based on the stock available. In this last stage, some stock discrepancies may occur since the items in an order may not be available in the requested quantity in the warehouse.

Planning

A detailed plan is sent by HUUB to the warehouse daily, in order to allow the organization of resources. Orders in backlog which were planned to previous days are could not be fulfilled have priority and the remaining orders planned for a given day are distributed by pickers. Additionally, the orders are also allocated to a packing station to ensure an even distribution throughout the several stations available to avoid delays.

Picking

In the beginning of each shift, a picker receives the picking list with the orders to pick. This picking may be done by model or follow the pick path indicated in the picking list, depending on whether the brand requests picking by model. Each picker will pick only one wholesale order at a time and once the picker completes the boxes in the picking car, he will drop them in the packing station and continue the process. If an item listed in the picking list is not found in the indicated location, it should not be picked from another location and it should be reported to the customer support team.

Packing

For this stage of the outbound process, brands may require a specific packing procedure that should be followed by the warehouse. According to FIFO criteria, packers will process the orders in each packing station. The packer scans the identification of order in the box and then scans each item individually, checking if all items are in the box. Afterwards, the box is weighted and measured and the information about each pack is registered. Any discrepancies found in this stage should be reported to customer support for resolution.

After all the boxes of the order are closed, the labels for the shipment and the necessary documents are printed according to the destination and when the packing is complete a trigger message is sent to HUUB confirming the update of the order status.

Shipping

After verifying all boxes are correctly labelled and the necessary documents required by the carrier are printed, the orders are placed in a dedicated pallet in the expedition area, according to the carrier who will perform the pickup.

3.2.3 Outbound B2C process

The following steps describes the warehouse processes for the fulfillment of e-commerce orders.

Order communication

Regarding e-commerce orders, the outbound process starts with the communication of the orders details from HUUB to the warehouse. In order for the communication to succeed, the integration requires some mandatory fields of information. Similarly to the process for wholesale channel, after the communication, orders should be created at warehouse's WMS and a trigger message is sent to HUUB after the completion of this step. Following their creation, orders are

allocated depending on the existing stock levels for the products required. An order is fully allocated when all items have stock available or partially allocated in case not all items in the order have enough stock to complete its fulfillment. If all items in the orders do not have stock, the orders should be cancelled.

Wave planning

As e-commerce orders are traditionally small orders, this step differs from the previous process where orders were picked individually. In B2C orders, waves are created to optimize the picking procedure. To every order integrated in the warehouse WMS, a wave will be attributed to plan the picking operation. Currently, these waves are planned at two moments in each shift at a designated time and follow the carrier criteria to guarantee that all the orders to be shipped by one carrier are completed at the same time to be ready for pick-up.

Wave picking

This operation is carried out with picking carts, which are prepared with one slot per order to be picked in each wave. The car should have a label identifying the wave to be picked and each box carries a label to be associated with one order.

The first task of the picker is to scan the label identifying the wave. Afterwards, the picker follows the picking list, moves to the location of the following item and scans the item before placing it in the correct box. If the operator is not able to find the item in the location listed in the picking list, he must signal the stock discrepancy and the order which has a missing item. In the case the picker detects a non-conforming piece, this exception must also be signaled. All orders that could not be completed must be dropped in customer support area.

Packing

For the packing procedure, HUUB informs the warehouse about specific packaging specifications that may be requested by a brand. The orders should be taken from the picking cars one by one and in sequence. The packer scans the label identifying the order and afterwards each item in the box. Afterwards, the most suitable box based on volume of the items should be picked and weight and measure are registered.

Shipping

After printing the label and all the necessary documents, the logistic operator places the order in the dedicated carrier pallet and these pallets are placed near the door where the carrier will pick up the cargo. When the carrier picks up the items from the warehouse an automatic message is triggered to HUUB.

3.3 Sales Channels

HUUB works mainly through two different sales channels: wholesale (B2B) and e-commerce (B2C). Within wholesale, the company is responsible for supplying end-customers, either represented by stores or brand with the upcoming collection. For the period in analysis, between 2018

and 2019, this channel accounts for the largest part of the volume transported through HUUB's flow and is characterized by orders with a large number of items. Each client generally places a reduced number of orders per season. However, considering that these orders have high volumes, and stores may present a turnover of products throughout the same season and lack the capacity to receive and store the entire collection, orders are decomposed into drops that are shipped along the season. The number of drops for a order may vary from brand to brand and from customer to customer. Nevertheless, these partial shipments normally follow a schedule where the first drop is sent before the beginning of the season in order for the stores to prepare the launch of the collection. A second shipment takes place after the launch of the season to refill the stock and a third delivery may happen closer to the end of the season to sell the remaining stock. Moreover, if the sales exceed the predicted volumes, clients may place reorders in order to refill the stock.

Regarding the e-commerce channel, brands usually launch the collection in their websites after the beginning of the season to provide physical stores a period of exclusivity and to promote sales in this channel. End-customers are individual consumers that place orders through the brand's website. This procedure results in a large number of orders of small volume.

A significant part of wholesale orders is placed before the beginning of the season and before the reception of items in the warehouse, therefore allowing to plan beforehand the volumes to expect and a provisional schedule of shipments. However, the scheduling process faces a relevant blocker in the business caused by the payments of B2B clients to brands. The delays in payments cause brands to keep items in the warehouse longer than initially expected and the trigger for the picking and shipping of the order may not happen with a lot of time in advance, hindering the optimized planning of warehouse operations.

Contrarily, in e-commerce, HUUB does not have visibility over the amount of orders in advance, which may originate peaks of demand and makes forecasting less accurate, creating a more difficult planning process to allocate resources. As B2C orders are placed in brand's website and communicated to HUUB, the lead time is lower as HUUB needs to comply with the agreed service level so that the brand is able to fulfill the service requested by the end-customer. This creates the need for an agile and optimized operation, highlighting the importance of sales forecasting in order to avoid incurring in costs that cut HUUB's margin.

3.3.1 B2B channel in the AS-IS context

To analyse the relevance of the wholesale sales channel within the company's operation, data from a range of brands from HUUB's portfolio was analysed for a period of two different seasons between 2018 and 2019. This allowed the exclusion of influence from the COVID-19 pandemic within the fashion market. The values presented throughout the study in sections below represent a proportion of the real data to preserve the accuracy of the study.

During this period, it was possible to verify that the B2B channel accounted for a low percentage of the number of orders processed by HUUB (19%) as shown in Figure 3.2a. However, when analysing the data associated with the total number of items it is possible to verify that the wholesale orders represent a significant 86% of all goods shipped from the warehouse (Figure

3.2b). This conclusion falls in line with the pattern of the sales channels described before, since the wholesale channel presents a lower number of orders with a larger volume of items per order.



Figure 3.2: Percentage of sales orders and quantity of items in Wholesale and E-Commerce.

3.3.2 Main challenges and relevance of the project

The importance of the wholesale channel illustrated in the previous section determines the relevance of this segment in terms of operational costs, given that the large quantities of items in stock account for a large proportion of storage space that HUUB needs to purchase to the warehouse every season. This segment is also responsible for a significant part of the picking costs, given the large number of items in each order. This causes an imbalance of stock with peaks prior to the beginning of a new season and an uneven operation, with a large volume of orders concentrated in the start of a season, creating the need to increase warehouse capacity in order to fulfill every shipment.

Following an analysis to the AS-IS situation within the aforementioned period represented in Figure 3.3, it is possible to assess that the stock presents two peaks within the period of a year. These peak does not correspond to the average stock level in the warehouse. However the stock capacity needs to be levelled by the maximum quantity, increasing the stock costs for HUUB.

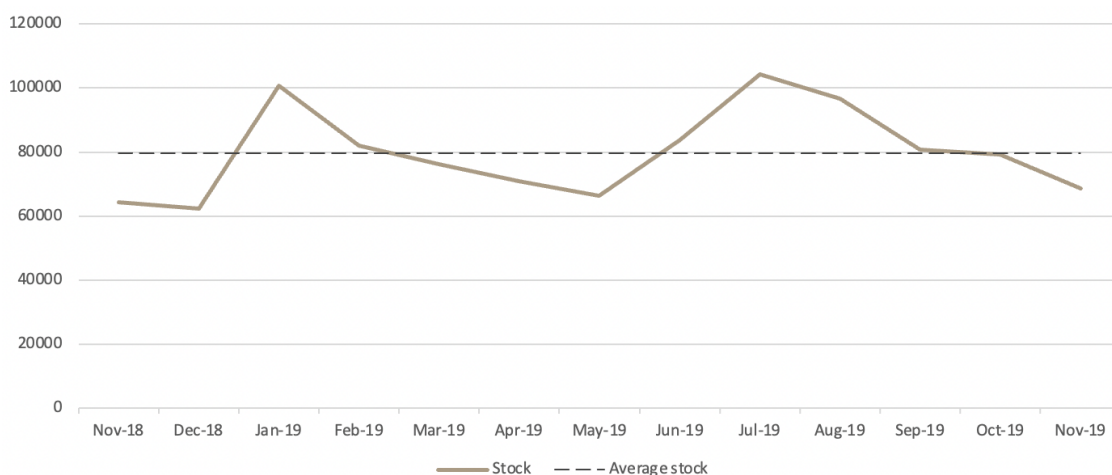


Figure 3.3: Evolution of quantities received, shipped and stock in warehouse.

Simultaneously, the pattern of the communication of sales orders by the brands is characterized by most of the orders being placed before each season, with exception to a small number of reorders to fulfill unexpected demand peaks, which creates the opportunity to explore the allocation of items at the moment of reception in the warehouse. The Figure 3.4 below illustrates the gap between the moment brands create sales orders relative to the wholesale channel, the arrival of the items in the warehouse and the shipment of orders. This supports the fact previously stated that brands place the sales orders before the suppliers deliver the items to the warehouse and the items start being shipped not long after being received to stock.

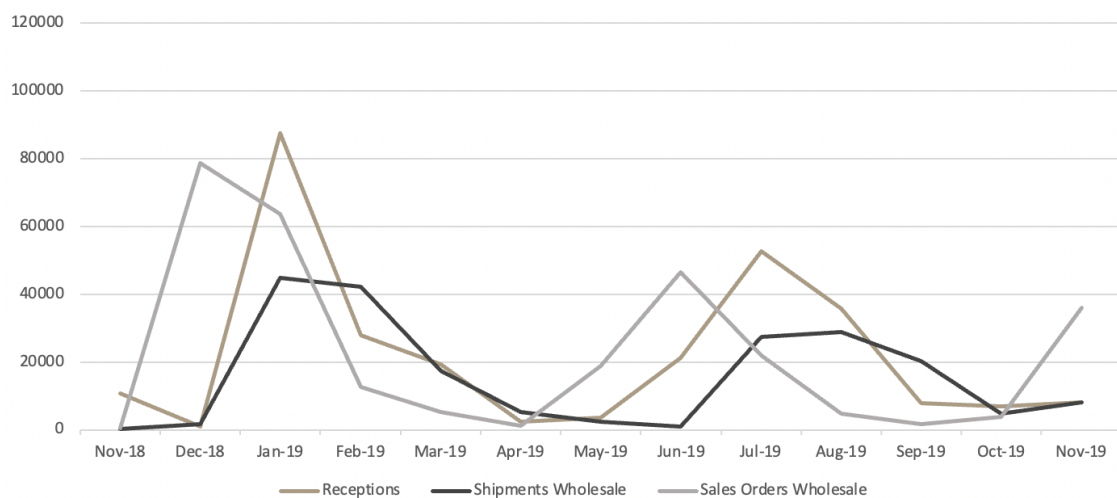


Figure 3.4: Evolution of receptions and placement of sales orders.

From this chapter, it is possible to conclude that, at the moment, wholesale and e-commerce orders go through the same warehouse flow and the current fulfillment strategy is able to support both sales channels. Nevertheless, for HUUB to be able to scale up its business, the constant drive for continuous improvement is essential to strive for a cost optimization perspective that will enable the company to become a more competitive player in the market by proposing more attractive fees that will raise more clients.

3.4 Next Steps

Bearing this rationale, the present project aims to study the potential to implement a different process for the wholesale items that go through the warehouse, introducing a hybrid approach inspired in cross-docking and assess if the implementation of a new process in the warehouse with increased complexity can provide benefits for HUUB.

The current pattern of receptions, placement of sales orders by the brands and the shipments provides an overview over the fact that HUUB has visibility over wholesale orders before the items arrive to the warehouse. This opens up the opportunity to set up a more direct process, further explored in the next chapter, to move the items directly from the inbound trucks and allocating them to the orders that are in system, which reduces the necessary storage space and simultaneously

improves the warehouse operators' productivity by replacing the put-away and picking operators, which are more time consuming, by a single operation.

When evaluating the challenges to this process, it is important to consider that AS-IS processes will continue to exist, as the warehouse will continue to receive part of the items to stock and to fulfill e-commerce orders at the same time. Hence, not all products received in the warehouse are destined to wholesale orders and therefore a part of the inbound cargo will be received to stock. This process requires an effective coordination and streamline standardization of all flows an item can go through in the warehouse.

Chapter 4

Process Outline

The present chapter describes the framework adopted for the design of the new warehouse process and the analysis developed to verify its relevance. Firstly, an overview regarding the information used to conduct the study and the methodology used in the construction of the simulation is presented. Then, a second section focuses on the TO-BE operation, the design of the new processes and the redefinition of business rules. The chapter closes with the description of the different scenarios proposed and an overview regarding the simulation model developed to evaluate the cost structure.

4.1 Data Preparation

In order to assess the potential of implementing a new process within the warehouse, several brands from HUUB's portfolio were selected. These brands presented different profiles in terms of the predominant sales channel, with some brands focusing on e-commerce while others still rely heavily on wholesale business. Nevertheless, it is important to assure that all brands present sales through wholesale channel, the focus of this project. Moreover, the overall volume of sales of these brands is also different, to represent the different profiles of brands in HUUB's business.

After the selection of a group of brands, it was important to define a period to analyse historical data. The period analysed comprised one year, to allow a study of two different fashion seasons (Spring/Summer and Autumn/Winter) without any effects from exceptional external factors. Attending to the recent disruptions in business caused by COVID-19 pandemic, which heavily conditioned fashion business, specially the brands focused on the wholesale channel, this period considered ranged between November 2018 and November 2019.

The research required a phase of data cleaning, where the data sets used as an input for the analysis were verified and prepared. This step consisted in filtering all cancelled orders and removing all receptions to the warehouse from returns. Moreover, as the study dealt with different brands, a proxy for the number of items that can be shipped in each one of the available box sizes was calculated, for the purpose of measuring shipping costs.

4.1.1 Cost Quantification

Following the goal of evaluating and comparing the performance of different scenarios for the new process proposed, understanding the cost structure is an essential phase to support the decision making action.

The major costs associated to HUUB's operation can be divided into two distinct categories: Warehouse Costs and Transportation Costs.

The warehouse costs comprise the storage costs, which are associated with the square footage utilized per day, and the handling costs, translated in an individual cost per item. The handling fee per item includes the operations of reception to stock, picking and packing.

Regarding the transportation costs, apart from depending on the origin, destination and service level contracted, these costs depend on the volumetric weight of the box that is shipped, a criteria defined by the carriers. Thus, a cost was associated to each one of the four types of boxes used in the warehouse to ship orders, based on the average cost provided by the carriers working with HUUB.

4.2 Process Outline - Operation TO-BE

The redefinition of this process focuses on merging the current inbound and outbound processes, approaching a cross-docking process with the inclusion of the possibility of temporary storage. Ultimately, this process conducts to a reduction of the time an operator spends handling each item and the maximum capacity of storage needed.

It is important to note that this approach does not replace the processes previously described, since the warehouse will maintain the operation of reception to stock and posterior pick and pack, considering the e-commerce channel does not meet the necessary conditions to implement this process.

4.2.1 Design of new processes

The new operation transforms the inbound and outbound individual processes into a single flow, reducing the number of touches per item an operator will perform throughout its period in the warehouse. Combining a cross-docking approach with the traditional warehousing operation with the inclusion of the possibility of temporary storage, this process reduces the stock peaks in the warehouse, as well as the overall productivity by reducing the handling time per item.

Nevertheless, in order to successfully carry out the implementation of this new process, a few requirements need to be met, from the point of view of the relationship with brand, described in the following section and from the implementation to the warehouse, regarding the technology developments necessary to ensure this process.

The flowchart in Figure 4.1 illustrates all the phases of the proposed process.

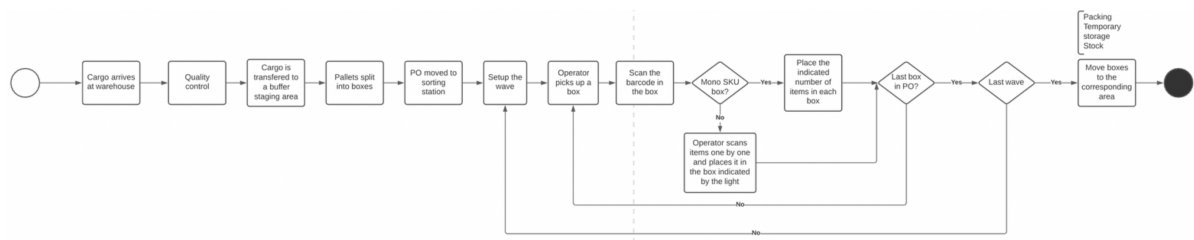


Figure 4.1: Flowchart of new process.

As described above, the beginning of the process is common to the current inbound process, where the cargo that arrived to the warehouse goes through a visual quality control, followed by the unloading operation and the transfer to a staging area in the warehouse.

Afterwards, the sorting operation concentrates the most relevant differences in the redefinition of the process, requiring a new station to enable this activity. The sorting station should be designed as an U shape, in order to promote productivity and minimize distance travelled to perform the operation, and features a sorting wall with several rack locations, in which orders will be stored. The utilization of a put-to-light technology aims to increase productivity and to avoid the error-proneness that characterizes this activity.

The first step of sorting stage is setting up the wave in the sorting wall, which will feature a limited number of sales orders, each represented by a box which is placed in a rack location by scanning the label with the order number on the box and the identification of the location. One location will be reserved for items destined to be received to stock.

The creation of waves with limited capacity resulted from the analysis of the number of orders to which it was possible to allocate items to. The higher the number of orders to allocate items, the higher the probability of the logistic operator making an error in this process and the greater the distance travelled and time to complete the process. Furthermore, the warehouse area available to setup this new station is limited. The combination of these factors contributed to an introduction of a sorting wall with limited capacity, originating the creation of waves of orders to allocate orders. This decision requires a setup time for each wave, however this delay is compensated by the factors evidenced above.

Subsequently, the action to be performed is the processing of the items in the received boxes, by sorting them accordingly to the allocation provided by an algorithm, whether to a sales order or destined to stock.

The operator starts by scanning the outside label of the box and then proceeds to open the box and scan each item individually. At each scan a light will signal the location where to place the item.

Within the same reception, multiple waves may need to be set if the number of sales orders with items allocated in the reception is above the maximum capacity of the sorting station. In this case, the process starting with the wave setup is repeated until all items in the reception are sorted.

The technology of put-to-light system in the sorting station also allows to signal with a different sound when a box is complete and is ready to be packed. In the location designated to allocate

items to stock, the box will be ready to be placed in stock when it reaches full capacity or when three to five different models are stored in the box, depending if the items are distinctive, which represents a warehouse rule in order to facilitate picking.

When a box is ready to be packed or received to stock, a light will appear on the outside of the sorting station, and the box is moved back so that the operator can place a new box in the shelf and continue the operation.

After the sorting operation, boxes can either proceed to pack and ship area, moved to temporary storage or placed in storage. The packing and shipping operations that succeed this procedure follow the AS-IS current standards.

4.2.2 Redefinition of business rules

Regarding the business established with brands, there are some important factors that contribute to the success of this implementation.

Firstly, the visibility over inbounds and the creation of sales orders by brands as early as possible in the season is a critical driver to enable the new process. Moreover, one key factor to take into account that affects the current operation is the dependence on the B2B final customers, the retailers, on payments for the orders to be processed. Therefore, orders can only have products allocated after the brands confirm this payment and a joint effort should be made in order to provide this confirmation as soon as possible, so as to reduce the average time an item is in storage.

After the orders are created and items are allocated, the brands are not allowed to perform alterations to the order and in case an order with items allocated that is staged in temporary storage is cancelled, an internal flow of reception to stock is created.

Regarding the operation, each reception is received individually following the current criteria established with the partner and ensuring the service level agreement.

4.2.3 Technological integration

In order to successfully achieve the implementation of this proposal, it is necessary to take into account the technological integration to accomplish with the third-party logistic partner.

From the point of view of HUUB, the visibility over the receptions and sales orders is crucial to create a tool to ensure the allocation of items that arrive to the warehouse to the sales orders in system. The information about the inbounds scheduled for each day to pass to the warehouse will include the feature about item allocation.

Regarding the warehouse, an implementation in the partner's WMS is necessary to introduce the put-to-light system in sorting station, so as to the operator's PDA is able to allocate the orders in a specific box to the racks in the sorting station and to receive information about the allocation of each item.

4.3 Scenario definition

In order to analyse the best format for the implementation of this process, three different scenarios were studied. A first one, with a pure cross-docking approach where all the items arriving to the warehouse with a possible allocation are shipped, a second scenario focusing on the optimization of shipping costs and a third scenario including some restrictions regarding the preference of the brands.

4.3.1 Scenario A - Cross Docking

The first scenario proposed is the closest to a pure cross-docking operation. In this situation, the operation assumes that all items received which can be allocated to a sales order in HUUB's system will be shipped, independently of the quantity that is allocated to an order.

This scenario does not account for the existence of temporary storage and minimizes the quantity of items in stock at the warehouse. However, concerning the two pillars of cost drivers proposed for the decision making process, while this proposal minimizes the storage costs, it is not an ideal scenario regarding shipping costs.

The fact that any quantity allocated can be shipped does not take into account the optimization of the standardized box sizes in utilization in the warehouse, which can increase the transportation costs charged by carriers to HUUB. Additionally, when attending to the brand perspective, the retailer, the end-customer in the wholesale channel, expects to receive a collection as a whole or in a few deliveries, with a significant amount of items arriving in each drop, ready to be exposed. This scenario originates a higher number of smaller deliveries to retailers, which undermines the level of service HUUB is able to provide to brands.

4.3.1.1 Weekly Consolidation - Scenario A1

A variation of the scenario A where the receptions from a brand within a week are consolidated and processed weekly was considered as a solution to attempt to increase the volume of items allocated to each sales order and minimize the shipments with a low quantity of items.

In the analysis performed, it is possible to conclude the consolidation increases the difficulty of the sorting operation, with an increase of items per operation, forcing the creation of more waves of orders and increasing the probability of error occurrence.

Moreover, in weeks of peak, coinciding with the beginning of each season, this scenario is likely to be particularly difficult to implement, and the space available for a staging buffer to hold the receptions before being processed through the sorting operation may become a critical issue for the warehouse design. The stage of staging before the sorting operation can also increase the probability of lost items.

Beyond the restrictions of capacity, this consolidation also increases the complexity of the sorting operation. With the growth of items to be processed, emerges the need to create more

waves of orders to allocate all the items and increase the probability of occurrence of errors. Moreover, this delay increases the time to market for brands.

For the reasons presented above, this scenario was not considered feasible and therefore will not be attended to in the presentation of the cost structure in the following chapter.

4.3.2 Scenario B - Cross Docking with transportation constraints

Following the disadvantages that emerged from the scenario A presented above, regarding the possible increase of shipping costs which would represent a big impact in overall costs for the company, a second scenario was designed.

In this hypothesis, the goal is to optimize the shipping operation, guaranteeing that all the shipments made use the standard box and the number of items per box corresponds to the maximum capacity, minimizing the shipment cost for item.

When the items allocated from a receptions are not enough to fill a box for shipment, the items are still assigned to the sales orders and then placed in a zone destined to temporary storage.

4.3.2.1 Temporary storage

The nature of HUUB's business includes different suppliers for each brand, which does not support a pure cross-docking strategy, as an order needs items from different deliveries from suppliers to be fulfilled. To cope with this issue and facilitate the shipment of orders after the consolidation, it is useful to define a buffer after the sorting operation prior to the shipping process.

The main disadvantage of the Scenario A concerns the high number of shipments with low quantity of items per box. To improve this metric, the scenarios B and C present a buffer after the sorting operation, designated as a temporary storage, in order to be able to impose restrictions to determine the trigger point to ship orders.

The definition of a temporary storage feature is often utilized in cross-docking approaches and in this particular case, demands the definition of a different storage area in the warehouse destined to store the boxes referent to sales orders with items allocated which are not enough to send a full box.

In following receptions, the orders in temporary storage area are given priority in item allocation so as to minimize the capacity of temporary storage needed.

4.3.3 Scenario C1 - Cross Docking with retailer constraints

The third scenario maintains the feature of temporary storage introduced in the last scenario, but focuses on maintaining the current service level provided to brands, in order not to damage the relationship of HUUB with brands due to the redefinition of the process.

As mentioned in Chapter 3, the sales orders destined to wholesale channel created by brands are often split in a few deliveries, according to the prior agreement with clients. Therefore, it is relevant to consider a scenario where items are allocated to orders but these are only shipped when the percentage of the order arranged with the brand for deliver is complete.

Similarly to the process described in the last scenario, items are allocated as each reception is processed and they are staged in temporary storage until the trigger to process shipment is reached.

Relatively to the previous situation, the orders in temporary storage maintain priority in further receptions. Nevertheless, the space required for this purpose may increase, since one order may require several boxes to be staged in temporary storage until it is ready to be sent to the final customer. Additionally, when compared to the previous scenario, the restriction of shipping boxes at maximum capacity is not maintained, which may lead to a slight increase in shipping costs. On the other hand, the reduction of the number of deliveries per order improves the service level provided, from the point of view of the retailer, the end-customer.

4.3.3.1 Variations of Scenario C

To perform the analysis of the pattern of deliveries per order, a study of the historical data of the total of orders placed and the shipments for each brand was performed to reach an average ratio for the client.

The scenario C presented above aims to meet the number of deliveries per order in the average for each brand. However, depending on the size of the orders, sending the order in one or two deliveries may represent high quantities of items in temporary storage.

For this reason and as a complementary analysis, two additional scenarios were computed - C2 and C3 - where the average number of deliveries per order was increased by one and two units, respectively. These variations were studied with the purpose of minimizing the amount of stock in temporary storage, without compromising greatly the level of performance provided to brands.

The parameter corresponding to the number of deliveries per order was computed as a variable of the model detailed in the following section, to analyse the effects of this variation.

The Table 4.1 below sums up the scenarios presented in this chapter, enhancing two distinctive characteristics: the inclusion of temporary storage and shipping restrictions.

Table 4.1: Description of the scenarios in evaluation.

	Scenario A	Scenario B	Scenario C1	Scenario C2	Scenario C3
Temporary Storage	No	Yes	Yes	Yes	Yes
Shipping restrictions	No (Pure Cross-Docking)	Yes, a standard box at maximum capacity	Yes, the number of deliveries per order in the AS-IS situation	Yes, the number of deliveries per order of C1 increased by one unit	Yes, the number of deliveries per order of C1 increased by two units

4.4 Data Analysis

Due to the high volume of data as an input from the sample of brands analysed, the simulation of costs according to the new proposed model was not possible to compute using a spreadsheet. Therefore, the numerical simulation was developed with the utilization of *Python*, to allow the achievement of the desired performance within a reasonable computational time. The code was developed with the resource of the libraries *Pandas* and *Numpy*, which are open source data analysis and manipulation tools. This allowed to build the simulation using the data sets with the lists of receptions and sales order for each brand as inputs.

The simulation was conducted with a deterministic approach. This was due to the fact that each brand presents a unique profile and a statistical variability of one brand would not guarantee a reliable representation of other possible clients in HUUB's future.

For this reason, and since this thesis conducted a study of the feasibility and risk of implementing the new process, the decision was to construct a model in which the observed data sets are given as inputs. This ensures that this tool may be used in the future for tests with data from any brand based on selected rules regarding the allocation of products to orders, compute the costs of each possible formulation of implementation, represented by the scenarios detailed in the previous section.

Three models were developed, representing the three different formulations presented in the scenarios described in Section 4.3. The inputs used were the observed data sets of receptions and sales orders of each brand, and the proxy for number of items per box, which was computed per brand per season. In further developments of this work, it would be desirable that the model could estimate the number of items per box based on the real dimensions of the items that are allocated to each order.

The logic of this model was developed with the aim to be as similar as possible to the logic required to ensure the execution of this process in the future. The process consisted in analysing each reception at the time of arrival and allocating the items according to the orders in system prior to that time. The items without allocation are assigned to storage locations. In the cases of the scenarios B and C, where the feature of temporary storage is available, these orders in storage with items allocated have priority in the allocation over other orders in system.

With data on the total number of items that arrive to the warehouse, the allocation of items to orders and corresponding shipments, and registration of items received to stock or placed in temporary storage is estimated. This allows to compute warehouse and shipment costs.

The results obtained with these models will be presented in the following chapter.

Chapter 5

Discussion of Results

The present chapter aims to provide an overview regarding the cost structure of each scenario for the sample of brands analysed. Moreover, it is important to note that the selection of the best scenario should not be based exclusively on the cost criterium. Other factors, such as the risk associated with the process and the probability of operational errors, as well as the flexibility and the level of service provided to clients should be used as additional criteria. Thus, this chapter also presents the use of Analytic Hierarchy Process (AHP) to rank the scenarios according to multiple criteria.

5.1 Cross-Docking Potential

As described in the previous chapter, this study was conducted with a sample of brands from HUUB's portfolio. All the selected brands present sales through the wholesale channel. Overall, the data analysed corresponds to approximately 55% of the items processed through the warehouse in the period under study. The brands present different profiles concerning the proportion of items sold through wholesale and e-commerce and different business volumes. Moreover, fashion brands have different temporal patterns for the placement sales orders and for the scheduling of arrival of items to the warehouse. For these reasons, not all brands have the same propensity for cross-docking.

This analysis evidences differences in the potential for cross-docking among the brands analysed, as depicted in Table 5.1. The potential of cross-docking through the seasons analysed is associated with the percentage of items from each brand that arrived to the warehouse with pre-sale, with the possibility of being directly shipped to an existing order. A high value in this metric contributes to a successful implementation of the proposed process, since the pre-sale of items upon the arrival to the warehouse is crucial for the possibility of proceeding to a cross-docking operation.

Table 5.1: Percentage of items with orders placed at the moment of reception in the warehouse.

Brand	Cross-Docking Potential
1	76,89%
2	72,44%
3	71,99%
4	62,07%
5	60,23%
6	50,63%
7	49,10%
8	27,67%
9	23,90%

5.2 Comparison of cost structure for each scenario

The cost structure studied for each scenario relies on the two cost drivers presented previously: shipping cost and warehouse costs (including cost of storage, temporary storage and handling). These represent direct costs for HUUB charged by its partners (i.e. the warehouses and the carriers). In order to assess the relative performance of the different scenarios, a cost evaluation was conducted to assess several parameters necessary to compute the warehouse and shipping costs. These parameters concern the cost of shipping per type of box, the cost of storage per day per rack location and the cost per operation of handling an item as parameters for the analysis of the scenarios.

The parameters regarding the warehouse costs were used as a real representation based on the current operation installed. However they can be adapted to other warehouse third party logistics providers in case HUUB considers implementing the new process with a new partner in the future.

Concerning the shipping, an average of the current costs provided by the different carriers operating with HUUB was considered. This input may be variable, as the shipping costs depend on the location of the warehouse and the location of retailers. With an addition of a new brand to HUUB's portfolio, it is important to assess the location of its retailers, so as to evaluate the shipping costs with a higher degree of accuracy.

To obtain the cost structure of each scenario presented in the following sections, the number of shipments and the quantity of items in stock following the allocation for each scenario were obtained by the simulation model.

5.2.1 Scenario A

The scenario A, as mentioned above, is the scenario that resembles the most a pure cross-docking strategy, by considering the direct shipment of all the items arriving to the warehouse that can be allocated to an order in system.

The major disadvantage of this scenario relies in the higher number of shipments with low volume of items, increasing shipping costs and registering a low occupancy rate of the boxes sent. In overall costs, the first scenario represents the higher total costs, with shipping costs representing

93% of the total of this scenario, considering the combination of all brands, as exhibited in Figure 5.1. On the other hand, the total storage costs, one of the components of warehouse costs, are minimized as this hypothesis does not contemplate the existence of temporary storage.

5.2.2 Scenario B

The scenario B promotes the optimization of the shipping costs, by establishing the rule of shipping an order when it is possible to fulfill an entire box, and including a zone destined to temporary storage where the orders with items allocated are placed before reaching the state to be shipped. The warehouse currently uses four types of boxes, characterized by the following measurements (60x40x40 cm, 60x40x30 cm, 60x40x20 cm, 40x30x20 cm). For this proposal, the boxes considered for shipments are the most common, 60x40x40 cm, with the exception of the final items of each order, which are allocated to the most suitable box.

Relatively to the scenario A, the warehousing costs increase due to the existence of temporary storage. However, the number of shipments will reduce, leading to a decrease in these costs which presents significant values. These differences resulted in an overall decrease of costs of 22%, comparing to the previous scenario. Additionally, it is possible to assess the distribution of the cost has also changed, since shipping costs now represent around 44% and stock temporary to account for 3% of overall costs, as observed in Figure 5.1.

The scenario B is the scenario that minimizes the overall cost structure, highlighting the importance of the shipping costs when compared to the fulfillment costs of storage and handling.

5.2.3 Scenario C

The third proposal, scenario C1, aimed to maintain the service provided to brands in what regards the number of deliveries the retailers receive per order placed. Comparatively to the previous scenario, the orders will tend to be staged in temporary storage for a longer period of time before being shipped, since most of the brands have agreed to receive the orders in two separate deliveries or in a single delivery. This scenario represents a delivery pattern similar to the AS-IS situation and results in a high quantity of items in stock when considering both regular stock and temporary stock, since the percentage of receptions that fulfill an entire order of half an order, depending on the brand, is low.

It is, therefore expected an increase in the costs of capacity required for stock temporary. The need to access all boxes in temporary storage for shipping can constitute an obstacle to building a storage in height which would require a forklift to place boxes and collect them for shipping. The option of not using storage in height, on the other hand, demands a significant area within the warehouse to dedicate to this purpose, reducing the potential savings in space dedicated to stock.

The number of shipments presents a reduction from the scenario B as this constraints of this scenario originate fewer shipments with more items per shipment. This scenario present a decrease of 16% in costs when in comparison with scenario A. However, the increase in storage costs and

the absence of the optimization of the boxes shipped result in higher overall costs for this scenario, with an increase of 7% from the scenario B.

Two variations of this scenario - scenarios C2 and C3 - are proposed to reduce the need of capacity storage. They consist of a variation of the parameter of number of deliveries per order for each brand, with an increase of one and two deliveries per order relatively to scenario C1, respectively. The number of maximum deliveries per brand provided as an input for the model to define the minimum percentage of the order to be shipped in each delivery can be seen in Appendix B. The aim is to achieve a trade-off between maintaining a high service level for the brand with only a few deliveries per order (instead of shipping each box individually, as in the scenario B), and reducing the amount of boxes in temporary stock at the warehouse.

The results for scenarios C2 and C3 did not evidence significant differences when compared to scenario C1. For these two new scenarios (C2 and C3), the shipping costs increased due to the higher number of shipments. Nevertheless, the reduction in temporary storage costs compensated this difference, resulting in overall costs with differences of less than 1%.

The differences between scenarios C2 and C3 would produce larger effects when dealing with orders with larger volumes, in which the restriction of shipping in one or two deliveries represents a larger volume of items in temporary storage.

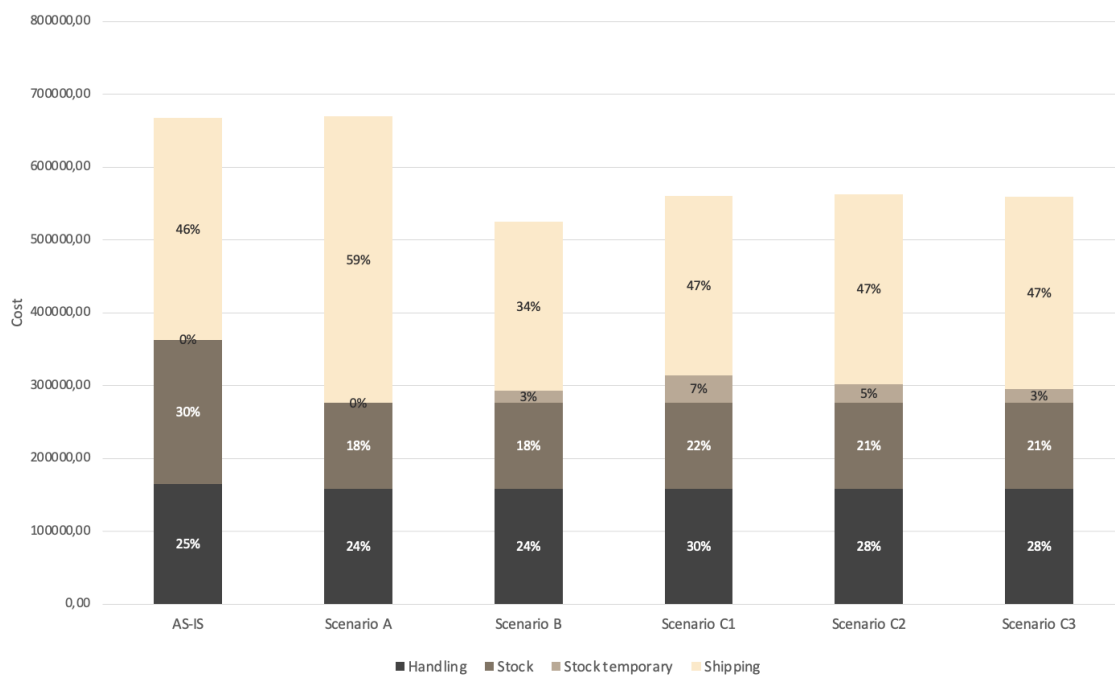


Figure 5.1: Cost structure for the proposed scenarios.

From the results presented in the Figure 5.1 above, it is possible to conclude the scenario A presents significantly higher costs than the other scenarios proposed. Hence, it is not recommended, from a perspective of the high shipping costs and the service level provided to brands.

Therefore, the existence of temporary storage is considered as essential to the implementation of this process.

When comparing the scenarios regarding shipping and fulfillment costs, which incorporates the storage, temporary storage and handling costs, it is possible to verify that scenario A represents the best performance regarding fulfillment, as a pure cross-docking approach, while simultaneously presenting the worst cost structure in shipping activity. Besides the comparison between the scenarios, it is important to note the contribution of the alternatives proposed when comparing to the AS-IS process in place. From the previous graph, it is possible to conclude that only the scenario A presents a worse overall cost structure than the current situation. The Table 5.2 presents the variations between the performance of the scenarios in these two pillars of cost compared to the AS-IS costs.

Table 5.2: Comparison of the scenarios cost structure with the AS-IS situation.

	Scenario 1	Scenario 2	Scenario 3	Scenario 3.1	Scenario 3.2
Fulfillment	-23,9%	-19,1%	-13,4%	-16,8%	-18,8%
Shipping	29,4%	-24,0%	-19,2%	-14,1%	-12,9%

Regarding the shipping costs, the scenarios B, C1, C2 and C3 have lower costs than the current process, while the scenario A exhibits the worst performance due to the pure cross-docking approach without the temporary storage, which originates a higher number of shipments. Scenario B is the one which presents the best overall result, as mentioned previously, due to the focus on optimizing the boxes shipped to minimize the cost per item.

In what concerns the fulfillment costs, it is possible to conclude that all the scenarios proposed allow savings when compared to the AS-IS situation. Moreover, the scenario A presents the most favourable cost structure because of the absence of temporary storage. Regarding the scenario C and its variations, the scenario C1 includes a higher cost relative to temporary storage which is reduced in the following variations with the increase of the number of shipments per order.

5.3 Other relevant metrics

Apart from the costs, other important indicators were defined in order to support the identification of the best alternative. The first criterium, designated as brand satisfaction, aims to account for the level and quality of service provided to brands. This is very important in what regards the brand perception of the service provided by HUUB. Receiving a collection in many shipments or receive deliveries with just a few items per box is not an ideal scenario from the point of view of the retailer (the final customer in the wholesale channel). Therefore the service level cannot be disregarded by HUUB in the redefinition of the process.

The brand satisfaction metric is not a direct cost incurred by HUUB. Nevertheless, due to the fact that a redefinition of a warehouse process should not produce a negative effect towards the fashion brands working with HUUB, the level of satisfaction of the clients is therefore a relevant

driver. This criterium is therefore based on the number of deliveries per order. The values obtained for this metric are presented in Table 5.3.

Table 5.3: Number of deliveries per order in each scenario.

Brand	Scenario A	Scenario B	Scenario C1	Scenario C2	Scenario C3
1	4,09	2,23	1,06	1,98	2,31
2	4,36	2,11	1,35	1,89	2,13
3	4,36	2,11	1,35	2,31	3,23
4	7,13	2,89	1,18	1,92	2,31
5	9,73	2,95	3,30	3,73	4,13
6	8,23	2,73	2,22	2,86	3,31
7	6,33	2,13	1,94	2,60	2,94
8	9,89	3,29	2,27	3,03	3,55
9	3,36	2,17	1,26	2,04	2,10

In order to assess the performance of the scenarios proposed in terms of both cost and brand satisfaction, the matrix presented in the Figure 5.2 was developed. As concluded previously, scenario A exhibits the worst performance in both parameters, while the scenario B presents the best overall cost structure and the scenario C1 corresponds to the best service level provided to customers.



Figure 5.2: Position of each scenario relative to cost and brand satisfaction criterion.

The second metric to be considered is the occupancy rate of the boxes shipped from the warehouse. The shipment costs charged by carriers represent a significant portion of the overall logistic costs and in order not to compromise the margin HUUB is able to obtain on these cost, the quantities of items per boxes shipped need to be optimized in order to minimize the shipping cost per item.

The distribution of the occupancy rate of the boxes shipped for each scenario is represented in the boxplots in the Figure 5.3. It is possible to understand the scenario A presents the lowest

average occupancy rate due, while the scenario B exhibits an average occupancy rate to 100%, thus minimizing the shipping cost per item. Concerning to the scenarios C1, C2 and C3, although the occupancy rates are not very different, the best results correspond to scenario C1.

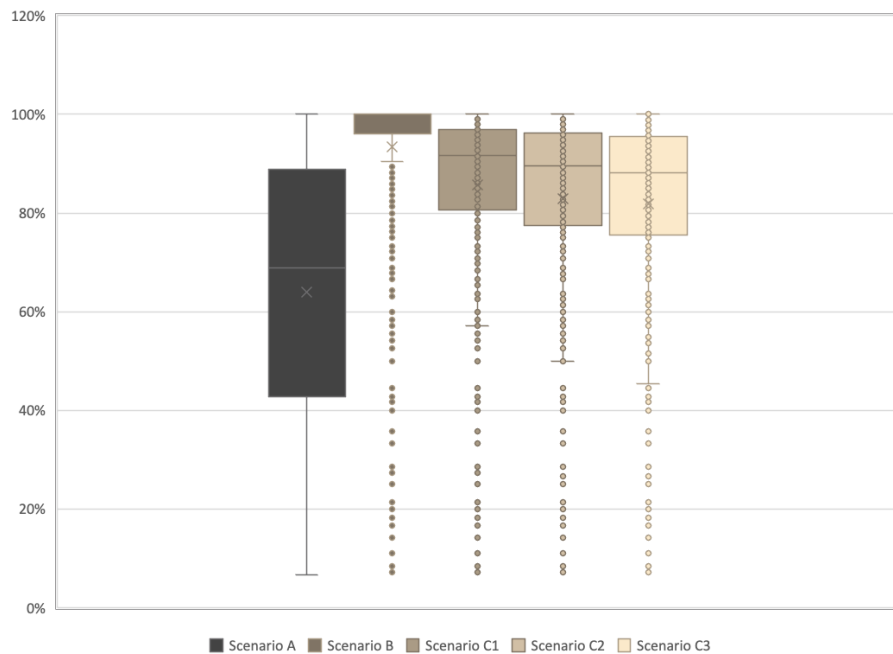


Figure 5.3: Occupancy rate of boxes shipped in each scenario.

5.4 Risk analysis

One of the factors to consider in the process of decision-making is the risk associated with the process. For this reason, a Failure Mode and Effects Analysis (FMEA) was conducted in Figure 5.4

Using a Risk Prioritization Number (RPN), the failures associated with the process are categorized according to their severity, occurrence and detection. The identification of the failure modes as well as the quantification of their effects was done through several interviews with HUUB's operational team and the warehouse operators, and includes risks already present in the AS-IS process that may be exacerbated by the redefinition of the process and new risks that emerge with the new operation.

This process FMEA analyses several stages of the process, from the moment items are received in the warehouse, to the point orders are packed to be shipped. The accuracy from suppliers is a current risk in the AS-IS situation and its relevance is extended in the new process, since the particular case of missing items due to supplier error that were allocated to orders may generate partial shipments or may delay the deliveries to retailers.

Moreover, the new sorting activity carries some risks associated with particular relevance in the process. The operation of setting up the wave, and associate a box with an order identification

and with a compartment in the sorting station is essential to guarantee that items are allocated to the correct order. Additionally, in the scenarios B and C, which include the utilization of temporary storage, the process of moving the boxes to temporary storage and back to the sorting station in following receptions may create errors.

There are control measures in place in order to oversee that the possible errors in the operation will not propagate to the final customer. However, the occurrence of errors, even when detected, creates a process of incidence management which requires extra time by the warehouse operators spent in its resolution.

Activity	Requirements	Potential Failure Mode	Potential Effects of Failure	Severity	Potential Causes of Failure	Occurance	Current Process Controls	Detection	RPN
Reception (Quality check)	Scheduling time windows for delivery is met	Cargo arrival outside of arranged time window	Cargo cannot be received by the warehouse in the established deadline	7	Supplier failure/Problem during transportation	4	Scheduled time windows for delivery	1	28
	Cargo arrived to the warehouse in established conditions	Cargo arrives in bad conditions	Cargo may need to be returned	10	Supplier failure/Problem during transportation	3	Visual quality control (All boxes need to be opened and checked)	1	30
Reception (by Item)	Accuracy from supplier in matching box labels and products	Missing items in a box	Register discrepancies	9	Supplier error	7	Outbound Issue Management SOP is shared with suppliers to reduce the occurrence of the errors	3	189
		Extra items in a box	Create new PO	3		7		3	63
	Item with polybag with current label	Item without polybag and/or without label	Items need to be refurbished before receiving	5		5		1	25
	Box with correct label	Mislabelled box	Originates discrepancies that	6		3	Quality control at arrival during	3	54
Wave setup In sorting wall	Match each location in sorting station with SO id	SO id matched incorrectly with location in sorting wall	Orders shipped incorrectly	10	Operational error	5	Re-scanning of items in packaging	4	200
	Collect orders from temporary storage to allocate items	Pick wrong order from temporary storage		10		5		5	250
Sorting	Scan items and place them in the designated box	Wrong quantity of items placed in a given box	Extra time in recounting and correcting	10	Operational error	5	Recount/Re-scanning of items in packaging	3	150
		Items switched between boxes		10		6		3	180
Temporary stock	Orders with allocated items should be confirmed	Brand cancel/changes an order in temporary storage	Items need to be received to stock - internal flow of reception	7	Client cancellation	3	Confirmation before allocating items to orders	4	84
	Each order in temporary storage has a location assigned	Error in allocating an order id to a temporary storage location	Orders incorrect to customer	9	Operational error	5	Re-scanning of items and box label in packaging	4	180
Packaging	Items scanned individually and order is packed	Wrong quantity of items placed in a given box	Orders incorrect to customer	6	Operational error	6	Re-scanning of items in packaging	3	108
		Items switched between boxes in the same wave		6	Operational error	7		3	126
		Item not matching any order in the wave		7	Mislabelling from supplier/Operational error	5		3	105

Figure 5.4: Failure Mode and Effects Analysis.

5.5 Analytic Hierarchy Process

With the aim of supporting a multi-criteria decision-making process, an AHP procedure was implemented, in order to balance the cost with other qualitative factors.

Overall, four relevant criteria were defined based on the analysis explored in previous sections. The first criteria is cost, the quantitative part of the analysis previously conducted. Additionally, the brand satisfaction was defined as the second metric, due to its importance in terms of the business. This indicator, as explained above, was measured by the difference between the average number of deliveries per order in one scenario and the number of deliveries per order established with the brand in the AS-IS situation.

The other criterion defined concerns the operational risk, as the occurrence of errors leads to an incidence management procedure and the possibility of an error producing effects in following stages of the supply chain is harmful for the company as it undermines the perceived quality of service provided.

Finally, the last metric concerns the flexibility of the operation. This factor relates to dealing with changes or cancellation of orders. This factor represents a value added service HUUB is able to provide to brands, as the restriction of not being able to do any changes in the orders may be a negative point from the client's perspective. Nevertheless, this flexibility is not unlimited and, depending on the situation, may pose an extra cost to the brand. This flexibility is also linked to the warehouse capacity, as a larger capacity allows to stage orders and ensure a buffer able to deal with any delays.

A pairwise comparison among the four criteria defined was performed by the operations team, as represented in the Table 5.4, to provide an holistic view from the perspective of the decision maker. The fundamental scale used is represented in Appendix A.

Table 5.4: Pairwise comparison matrix for AHP criteria.

Criteria	Cost	Operational Risk	Brand Satisfaction	Flexibility
Cost	1	8	7	9
Operational Risk	0,125	1	0,333	2
Brand Satisfaction	0,143	2	1	3
Flexibility	0,111	0,5	0,333	1

After obtaining the comparison matrix it is possible to calculate the relative weight of each criteria in the final decision. The cost was the criterion with the highest importance, with a weight of 71%, followed by brand satisfaction, which accounted for 15% of the decision. Operational risk and flexibility present a weight of 9% and 6%, respectively. In order to guarantee the coherence of the analysis, the consistency ratio was computed, obtaining a value of 0,008, below the threshold of 0,1 to which a decision is considered acceptable.

The following step consisted in developing the pairwise comparison matrix for each of the four criteria, to evaluate the decision alternatives according to the metrics proposed.

Regarding the cost matrix (see Table 5.5), the assessment was more objective due to the quantitative character of this criterion. The scenario B obtained a higher priority in this metric, followed by scenarios C1, C2 and C3, with no significant differences among them.

Table 5.5: Pairwise comparison matrix for decision alternatives in the cost criterion.

	Scenario A	Scenario B	Scenario C1	Scenario C2	Scenario C3
Scenario A	1,000	0,143	0,200	0,200	0,200
Scenario B	7,000	1,000	5,000	5,000	5,000
Scenario C1	5,000	0,200	1,000	1,000	1,000
Scenario C2	5,000	0,200	1,000	1,000	1,000
Scenario C3	5,000	0,200	1,000	1,000	1,000

The brand satisfaction criterion has been explored in Section 5.3, with scenario C1 exhibiting the higher score within this parameter, while the scenario A presents the worst performance. The pairwise comparison matrix is found in Table 5.6.

Table 5.6: Pairwise comparison matrix for decision alternatives in the brand satisfaction criterion.

	Scenario A	Scenario B	Scenario C1	Scenario C2	Scenario C3
Scenario A	1,000	0,250	0,143	0,200	0,333
Scenario B	4,000	1,000	0,250	0,500	2,000
Scenario C1	7,000	4,000	1,000	3,000	5,000
Scenario C2	5,000	2,000	0,333	1,000	2,000
Scenario C3	3,000	0,500	0,200	0,500	1,000

Concerning the metric of operational risk, the comparison between the decision alternatives is presented in Table 5.7. The risk is lowest in the scenario A with the pure cross-docking when facing with the four scenarios which present the temporary storage feature. The movement of orders to temporary storage and back to the sorting station increases the probability of error within one of the stages of the process. This risk is higher in the scenario C1 because the quantity of items and boxes of each order stored in temporary storage is higher.

Table 5.7: Pairwise comparison matrix for decision alternatives in the risk criterion.

	Scenario A	Scenario B	Scenario C1	Scenario C2	Scenario C3
Scenario A	1,000	3,000	7,000	6,000	5,000
Scenario B	0,333	1,000	4,000	3,000	2,000
Scenario C1	0,143	0,250	1,000	0,500	0,333
Scenario C2	0,167	0,333	2,000	1,000	0,500
Scenario C3	0,200	0,500	3,000	2,000	1,000

Finally, the flexibility of the operation concerns the possibility of changing or cancelling orders in the case it is requested by the brand, dealing with possible errors from suppliers regarding missing items, items mislabelled or delays in arrivals to warehouse scheduled. The scenario A, with a direct cross-docking strategy, presents the worst performance in this criterion, as it is very sensitive to the scheduling of inbound and outbound trucks and an error from the supplier may imply that the items may not be included in the planned shipment. The evaluation of the different scenarios in this criterion is shown in Table 5.8 below.

Table 5.8: Pairwise comparison matrix for decision alternatives in the flexibility criterion.

	Scenario A	Scenario B	Scenario C1	Scenario C2	Scenario C3
Scenario A	1,000	0,333	0,200	0,250	0,333
Scenario B	3,000	1,000	0,333	0,500	1,000
Scenario C1	5,000	3,000	1,000	1,000	1,000
Scenario C2	4,000	2,000	1,000	1,000	1,000
Scenario C3	3,000	1,000	1,000	1,000	1,000

Subsequently, after obtaining the priorities of each decision alternative for the criteria, the overall priority for each scenario was computed by multiplying the priorities of the criteria by the priority of the scenario according to each criterion. The result allows to establish the ranking of alternatives presented in Table 5.9.

Table 5.9: AHP ranking of the decision alternatives.

Decision Alternative	Priority
Scenario A	8,4%
Scenario B	43,3%
Scenario C1	19,3%
Scenario C2	15,2%
Scenario C3	13,8%

The scenario B presents the highest priority with 43%, mostly due to the relative importance of the cost criterion. The scenario C1 follows as the second best alternative, with an overall priority of 19%. This priority is mainly justified by the priority of this scenario concerning the cost criterion, considered as the most relevant within the four criteria analysed. On the other hand, it is possible to verify the Scenario A presents the worst performance of the five alternatives analysed, emphasizing the relevance of the temporary storage within this formulation.

In other to design a plan of implementation for this process, other relevant exogenous factors that should be taken into account are identified in the following section.

5.6 Exogenous Factors

These external factors involve other stakeholders in HUUB's ecosystem, therefore not all of them are under the company's control.

The first factor relies on the warehouse where to implement this process, since several features should be analysed. It is important to understand if the warehouse already uses put-to-light technology or a sorting station with a similar technology that can be adapted to fulfill this process. Otherwise, the need to acquire the technology equipment arises and may require extra costs that are relevant for the decision.

This technology can be used in the e-commerce channel as a sorting station for the orders after performing the picking operation as a batch of several B2C orders. Hence, some warehouses already have this technology in place for this purpose, and in the case an investment is made, it can also be used to improve the operation in the e-commerce channel. In the case this is a required investment for the process, it can increase the cost the warehouse will charge HUUB, therefore the cost structure will suffer changes.

Moreover, the creation of the sorting station and the zone dedicated to temporary storage require warehouse space. Hence, the layout of the warehouse needs to be assessed so as to evaluate if it is possible to install these two areas and ensure an optimized flow throughout the movement of the several phases.

Another factor that impacts particularly the shipping costs is the geographic location of the main retailers working with brands. As the e-commerce channel started to evolve in the past years and more recently, due to the COVID pandemic, it is normal that more brands will be focused mostly in this channel in HUUB's portfolio. Hence, this process may be applied to only a few brands. For the brands that keep the wholesale channel, and are eligible for the new process, it is relevant to evaluate information about their clients to assess the distances and shipping costs with more accuracy.

Due to the process being implement for just some brands, it is important to ensure the warehouse is able to maintain the AS-IS process and the new process going on at the same time as separate flows.

A factor that has been mentioned previously as one of the liabilities of the current process and that can pose an obstacle to this implementation is the confirmation of the wholesale orders, triggered by the payments from the retailer. Wholesale orders are usually high volume orders, therefore the indication to start processing the order is currently given after that confirmation. With this redefinition of this process, if this confirmation is not provided until the date the items are received in the warehouse, there is the risk that an order allocated and ready to be shipped needs to be received to stock. Additionally, the items blocked in that order could have been allocated to others orders, undermining the lead time provided.

Finally, it is important to note that a plan for this implementation requires work from different teams when it comes to the relationships with its partners and clients in the redefinition of the business rules and to ensure these are carried out.

Chapter 6

Final Considerations and Future Work

The purpose of the work presented in this dissertation was to develop a process that allows HUUB to redefine its warehouse fulfillment strategy to reduce the capacity of storage required in the warehouse and to reduce the time an operator handles each item. As a logistics company, HUUB is responsible for managing the supply chain of its clients and to successfully manage the flow through the supply chain. In order to achieve it, is crucial to closely manage the relationship with warehouse partners as they are an important link in the process.

At the start of the project, the process followed a traditional warehousing strategy with a pick and pack fulfillment strategy, with two separate flows. In the inbound process, all items arriving to the warehouse are received to stock, whilst in the outbound flow the orders are picked and packed to be shipped.

The storage peaks coincide with the beginning of each fashion season, and are due to all the new collections arriving to the warehouse within a relatively short period, before the brands start to sell the new collection through their sales channels. These channels can be brick-and-mortar stores in the case of retailers in the wholesale channel, and e-commerce through website sales directly to the final consumer.

An important analysis that enabled to design this process concluded that at the moment the items arrive to the warehouse from the suppliers of each brand, HUUB already has in the system the sales orders to which part of the items will be allocated.

The cross-docking approach with a feature of temporary storage has been explored in the literature mostly as a buffer to enable any delays and misalignment between the scheduling of inbound and outbound procedures. However, the type of cargo received at the warehouse requires a sorting operation between the reception and shipping process, increasing the difficulty of the process. In the case in analysis, the temporary storage is crucial to allow to respond to some restrictions from clients and also to optimize the ratio of items per box in shipments performed.

This methodology was designed for a particular case in the Fashion Industry. However, with the growth of e-commerce and the coexistence of the e-commerce and wholesale channels, this hybrid approach may be applied to other areas as a way to improve the logistics process within the supply chain.

The new hybrid approach combining the principals of cross-docking and traditional warehouse fulfillment (the process currently in place) is designed as a new flow to the warehouse. Different variations of the operation are proposed and analysed in order to assess the relevancy of this redefinition within the warehouse and which is the best scenario to implement. Moreover, as the objective to provide the information on different criteria that underlie a conscious decision making process, several criteria besides the cost structure of each scenario are presented.

6.1 Main Outcomes

This project presents several variations for a possible implementation of a new fulfillment strategy for wholesale channel and the comparison between the scenarios and their respective cost structures.

The existence of temporary storage, which is the main feature distinguishing the first and the other two scenarios revealed to be essential for an optimization of the proposed flow. HUUB works with a multiple retailers, one warehouse model and each fashion brand often presents more than one supplier who deliver items to the warehouse each season. Due to the multiple receptions for each brand spaced over time, it is not possible to implement a pure cross-docking model as the orders shipped aggregate items from different receptions. This is confirmed by the cost structure of the first scenario, where the shipment costs are very high and do not make this hypothesis a valid option.

In the second and third scenarios, with the existence of temporary storage, it is possible to optimize the ratio of items per box to control the shipments costs. The decrease in shipping costs surpasses the increase in storage costs, therefore these two scenarios present a more favourable cost structure.

The second scenario presents an overall best cost structure, however the business rules may not enable the shipments of individual boxes, from the point of view of the client. Therefore, a variation of the last scenario would probably represent a more realistic trade-off between optimization of logistic costs and the service HUUB's clients are looking for.

This project presents other relevant factors to the decision making process, such as technological necessities or the conditions available in the warehouse, as well as risk analysis to account for the new difficulties imposed by the implementation of the process.

The qualitative criteria of brand satisfaction, operational risk and flexibility were introduced in the decision-making process through a AHP procedure. This process, which provided a larger emphasis in the cost criteria, allowed to conclude that the Scenario B, that consisted in the optimization of shipments with the restriction of allocating a full box of items, the best overall scenario.

6.1.1 Impact at HUUB

The current fulfilment strategy follows the traditional warehousing process of receiving the items to stock and then picking them order by order. However, from the point of view of a logistics

service provider as HUUB, the goal to raise more clients depends on the competitiveness it can offer to its clients, on price and reliability of service provided.

The current AS-IS operation enables HUUB to fulfill the needs of its clients, however the goal is to increase the competitiveness as a logistics company provider and this is directly linked to the operational efficiency and the logistics cost structure.

The new process designed in this project is a possible solution to try to increase the competitiveness in the wholesale segment, as with a reduction in costs, HUUB can offer a lower fee per item to its clients. Simultaneously, the reduction in storage space utilized in the warehouse, the possibility to have more brands in the same space utilized at the moment is an advantage to the company.

6.2 Opportunities for Future Developments

Inevitably, the decision to include a brand in this hybrid process will have to be made individually, by analysing the brand profile at the moment of its onboarding to the company. It is essential to be able to standardize this analysis, so as to allow the team responsible for the contact with the brands to know which information is necessary to collect. The brand development team is also responsible for ensuring the client acknowledges and commits to the business rules in place and the requirements desired to facilitate the introduction of the process. The most crucial business rules deal with the visibility over the receptions and sales orders, as well as defined deadlines for brands to confirm sales orders are ready to be shipped, following the payment from the retailer.

Furthermore, the next step of this project consists in an implementation plan that should be designed and aligned with the strategy of the company for the following quarters, to assess the best timing to start implementing the process in light of the projects in place and guarantee all the conditions necessary.

In the design stage of the implementation plan, after the warehouse location where to implement the process is chosen and identifying hard constraints concerning capacity, one study that should be carried out, relies in the optimization of the warehouse layout. This topic is one of the main focus of the research regarding cross-docking strategy. In this situation, the design of a new sorting station and a new area dedicated to temporary storage require a redesign of the warehouse space available. Therefore, this reformulation should optimize the new flow of material in the warehouse so as to minimize distance travelled in the process. This study can be developed using a simulation software, in order to test the performance of different layout possibilities and assess the best option prior to the implementation.

Moreover, in order to fulfill the implementation of this new process, a new technological feature will need to be designed by HUUB to allow the integration with the warehouse. So as to fulfill the allocation of orders, the warehouse needs to receive, along with the list of receptions expected to be received in each day, the allocation of each item in a way it can be integrated with the warehouse's WMS to be received directly into the PDA when an operator scans a box or an item.

An additional improvement that can be included in further iterations of this project is to adapt this process to be prepared for a multi-warehouse network to allow the operation to follow changes set up by HUUB in the warehousing strategy. Moreover, a categorization of the priority of each order by brands could be a feature made available as a value added service, as it can be interesting for the clients to have the flexibility to pose orders with shorter lead time.

This project is aligned with HUUB's aim to continuously improve its operation, provide a better service to its clients and achieve a more competitive position in the market to support the growth of its network.

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Appendix A

Fundamental Scale of AHP

Table A.1: The Comparison scale for the importance of Criteria using AHP. Source: Saaty (1986)

Intensity of importance on an absolute scale	Definition	Explanation
1	Equal importance	Two elements contribute equally to the objective
3	Moderate importance of one over another	Experience and judgment moderately favor one element over another
5	Essential or strong importance	Experience and judgment strongly favor one element over another
7	Very strong importance	An activity is strongly favoured and its dominance demonstrated in practice
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between the two adjacent judgments	When compromise is needed

Appendix B

Parameter Variation - Scenario C

Table B.1: Number of deliveries per order per brand in each variation of Scenario 3.

Brand	Number of deliveries per order		
	Scenario C1	Scenario C2	Scenario C3
1	1	2	3
2	1	2	3
3	2	3	4
4	1	2	3
5	4	5	6
6	2	3	4
7	2	3	4
8	2	3	4
9	1	2	3