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Transition in the Transportation Management System: the Esselunga's delivery e-commerce case

TESI DI LAUREA MAGISTRALE IN
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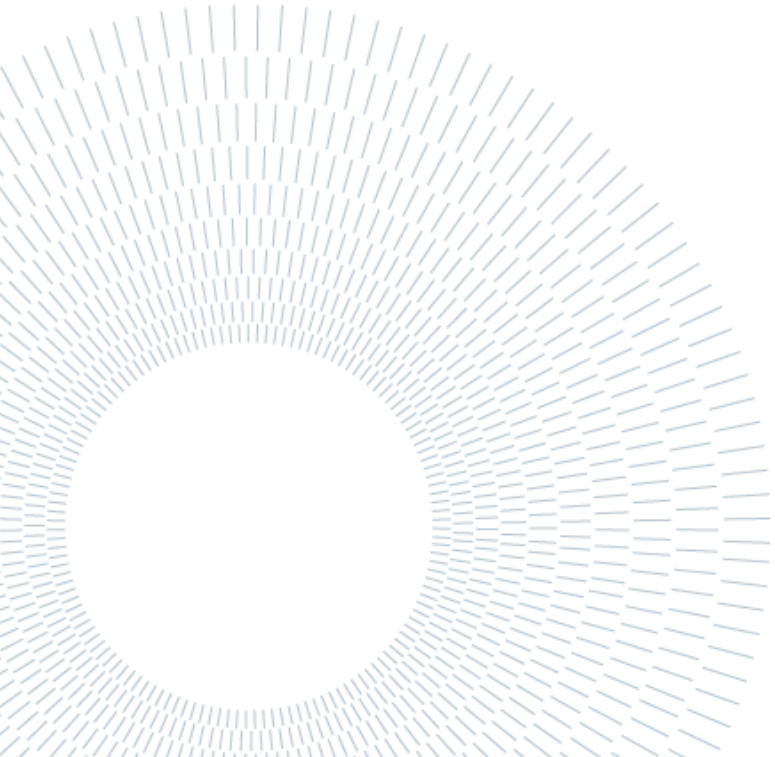


Abstract

The e-commerce has experienced a rapid expansion in the last years. Technological development has forced companies to invest in adapting their infrastructure to meet the demands of customers, who are increasingly willing to make purchases using online channels. Companies are pursuing a multichannel approach to avoid losing significant market shares, because of the change in customers' purchasing habits.

One of the sectors where the percentage of sales through online channels as a percentage of total sales is increasing is e-grocery. E-grocery is a highly competitive industry with low profit margins, so it is critical to focus on customers to provide them with a high level of service. Within the e-grocery, the service most valued by customers is home delivery. Last-mile deliveries, however, represent a significant cost to bear for the companies because there are many factors to consider in order to meet customer expectations.

The purpose of this thesis is to study how the online sales industry is developing, with a focus on obstacles and trends affecting the management and planning of last mile delivery logistics. These issues will initially be addressed from a theoretical perspective through a review of the state-of-the-art literature, followed by a practical case presentation with the aim of studying how the issues addressed theoretically are dealt with in a real case scenario.

The case study presented is about the e-commerce of Esselunga, one of the main companies in the Italian retail supermarket scene and a market leader in the online sales. The case study will have as its main theme the development and implementation of a new Transportation Management System, as the result of the needs for efficiency and innovation required by the market. In addition, there will also be room to discuss possible future developments, regarding especially the Dynamic Time Slotting system, which could radically change the logic of online order booking and planning, with greater influence towards final customers but at the same time with potential positive results for the company in terms of turnover.

Key-words: e-commerce, e-grocery, home delivery, last-mile delivery, time slotting.

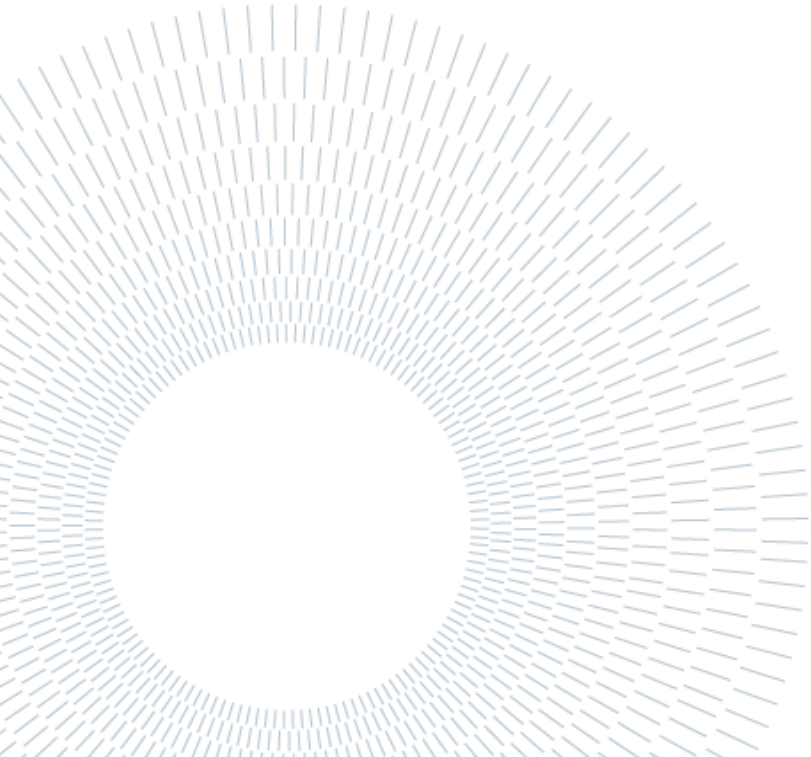
Abstract in italiano

Il commercio elettronico ha conosciuto una rapida espansione negli ultimi anni. Lo sviluppo tecnologico ha costretto le aziende a investire per adattare le proprie infrastrutture alle richieste dei clienti, i quali sono sempre più propensi nel fare acquisti utilizzando i canali online. Le aziende stanno perseguendo un approccio multicanale per evitare di perdere quote di mercato significative, come conseguenza del cambiamento delle abitudini di acquisto dei clienti.

Uno dei settori in cui la percentuale di vendite attraverso i canali online sul totale delle vendite è in aumento, è quello dell'e-grocery. L'e-grocery è un settore altamente competitivo con bassi margini di profitto, nel quale è di fondamentale importanza concentrarsi sui clienti per fornire loro un servizio di alto livello. Soprattutto nell'ambito dell'e-grocery, il servizio più apprezzato dai clienti è la consegna a domicilio. Le consegne dell'ultimo miglio, tuttavia, rappresentano un costo significativo per le aziende per via dei molteplici fattori da considerare per soddisfare le aspettative dei clienti.

Lo scopo di questa tesi è studiare come si sta sviluppando il settore delle vendite online, con particolare attenzione agli ostacoli e alle tendenze che influenzano la gestione e la pianificazione della logistica delle consegne dell'ultimo miglio. Questi temi saranno inizialmente affrontati da una prospettiva teorica attraverso una revisione dello stato dell'arte della letteratura e successivamente, attraverso la presentazione di un caso pratico con l'obiettivo di studiare come le questioni affrontate teoricamente vengono affrontate nella realtà aziendale. Il caso studio presentato riguarda l'e-commerce di Esselunga, una delle principali aziende nel panorama della grande distribuzione italiana, leader di mercato nelle vendite online. Il caso studio avrà come tema principale lo sviluppo e l'implementazione di un nuovo Sistema di Gestione dei Trasporti, frutto delle esigenze di efficienza e innovazione richieste dal mercato. Si analizzeranno inoltre i possibili sviluppi futuri, riguardanti il sistema di time slotting dinamico, che potrebbe cambiare radicalmente le logiche di prenotazione e pianificazione degli ordini, con potenziali risultati positivi per l'azienda in termini di fatturato.

Parole chiave: e-commerce, e-grocery, consegne a domicilio, fascia oraria.



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1 E-commerce introduction

In the new millennium, with the ever-increasing development of technology and global and interconnected markets, the concept that the business was becoming globalized, firstly expressed by Theodore Levitt in a 1983 Harvard Business Review article "The Globalization of Markets", has become a reality. The globalization of the value chains has been also made possible by the Internet technology development. The rise of the Internet technology has transformed people's lives. From social, economic and political perspectives, the Internet has brought great transformation across the globe. In the innovation of the traditional commerce approached, the Internet has played a significant role. The rise of e-commerce is one of the remarkable contributions of digitalization today. [1]

The increased communication and information gathering through digital platforms have further improved the existing trade patterns. Today, with increased access and ease of use, e-commerce platforms have become even more common regardless of the potential barriers and differences. The importance of e-commerce can be determined by the fact that the global e-commerce trade is expected to cross over 5.55 trillion dollars by the end of 2022. This figure is further estimated to grow significantly in the upcoming years, indicating it as providing potentially profitable opportunities for online retailers worldwide. In 2019, there were only 17.9% of total sales recorded in the e-commerce sector. But today, the expectation is to reach 24.5% by the end of 2026. On economic terms, the retail worldwide e-commerce sales are forecasted to grow reaching about 8.1 trillion dollars by 2026. [2]

An increased e-commerce dependency and preference, on the other hand, lead to retailers' utmost concern towards improved services, products, and effective customer-centric approaches. Consequently, these considerations lead to customer loyalty and a stronger trust in the online retailers and service providers. Technological progress and structural network improvements that have affected all economic and production sectors have radically changed the way consumers approach the market, changing their buying habits and relying more and more on the digital world to choose the products that best suit their needs. As the years go by, the distrust of this new way

of purchasing products, without the possibility of physically seeing them before buying, is also decreasing. [3]

The e-commerce world was born at the beginning of the new millennium as a new business opportunity for the companies, a new sales channel that implies the creation of a direct line connection with final consumers, without the possibility of human interactions. In response to the disadvantages associated with the lack of human interaction in online contexts, marketers have invested in new tools to enhance online customer experiences, often centered on the use of "humanizing" artificial intelligence technologies, such as chatbots, avatars, and virtual assistants with the aim of supporting customers in various tasks during the ordering process. [4]

The continuous innovations in technology, that have been occurring very quickly over the past several years, have profoundly changed the people's habits, behaviors and daily life routines. They have changed the relationship consumers have with the external environment, the way they communicate, inform themselves, and, as result, even their path to purchase has been directly influenced. People currently can order what they want at any time through online website, mobile apps or e-commerce platforms. New distribution planning systems, new automated warehouses and new technologies in logistics make it possible to deliver products to customers within few days and, in some cases, within hours, potentially handling a high volume of orders at the same time. This makes it possible to significantly reduce the lead time between the receipt of the order and the time of delivery, appearing through customers' eyes as a reliable and convenient service. [5]

The rapid development of information technology has not only led to an increasing number of people shopping directly through online channel, but also led many manufacturers to follow a dual-channel approach, complementing their existing physical retail channels with an online channel, which provides them with an opportunity to serve more customers who would otherwise have no intention or possibility to buy the manufacturers' products. [6]

The growth of e-commerce in the world has also been driven by the development of smartphones, which exploiting mobile connectivity allow everyday final customers to place orders online anytime and from anywhere, in few simple guided steps. This also gave rise to the theme of paying attention to the final customer's expectations, who from an online purchase require efficiency in terms of accessibility and intuitiveness but at the same time are willing to have a shopping experience with the possibility of customizing their order to their liking. It is particularly important to follow the

customer through all stages of purchase, from initial information gathering to after-sales support. [7]

1.1. Online sales challenges

The online sales industry is inherently dynamic. For the companies is essential to pursue a constant path of innovation in order to adapt and conform to customer demands and needs in the best way possible. Within the e-commerce world, these themes are particularly significant in the food and beverage sector, the so-called e-grocery industry. At the basis of the industry's transformations, takes place the evolution of the relationship consumers have with food and beverage. It is no longer only a necessity for survival, but it has turned into a real experience. Shopping for online groceries reserves some benefits including the saving in cost and time for busy people as well. The services quality of the e-grocery system is typically higher than the prices and discounts on offer, and the success of these systems rely extensively on the strong relationship between positive attitudes towards the frequency of online shopping. The e-grocery system provides convenience and smooth distribution of products and services so that the marketing dimension can result in broader access to customers. [8]

The challenge for companies is once again to be able to grasp the transformations and innovations taking place and to provide solutions that best fit with consumer needs for price, quality, convenience, selection and experience. In the e-commerce sales channel, those who can better understand and consequently meet the demands of end customers create a competitive advantage over their competitors in the industry, which is often difficult to go afterwards. [9]

The continued growth of e-commerce throughout the world has accelerated in 2021, as Covid-19 has rewritten the rules of the retail sector. Between January 2019 and June 2020, retail platforms experienced an extraordinary increase in global traffic. The websites of retail businesses received nearly 22 billion visits in June 2020, marking a 35.5% increase year-on-year. In the same year, in the United States, the share of e-commerce in total retail sales rose from 11.8 to 16.1% between the first and second quarters, and in the United Kingdom from 20.3 to 31.3%. In the EU-27, retail sales via online paths, in April 2020, increased by 30% compared to April 2019, while total retail sales diminished by 17.9%. Lockdown measures have driven new consumers to pursue online channels in order to avoid busy physical stores. The shopping frequency of

previous cyber-customers has increased and a multitude of businesses which did not yet have an online presence have launched such initiatives. E-commerce has become the only feasible option for many traditional brick-and-mortar stores during the pandemic. [10]

The Covid-19 pandemic has necessarily accelerated the changes that were already taking place over time in the purchasing habits of consumers. If before the pandemic mainly young people were used to get through home delivery services, now adults have also begun to exploit the services. Home delivery services are an ever-expanding industry that are estimated to grow in the future, year by year. Consumer expectations of local stores changed since they are expecting to use home delivery services also in the future. [11] [12]

Amidst the unstoppable growth of e-commerce, while electronic transactions travel through data networks, the physical products being purchased still need to be transported and delivered to final consumers. This increase has resulted in increased pressure on last mile logistics. During the first months of the pandemic, transportation and distribution of goods became one of the main causes of disruptions in the supply chain and affected the supply of essential items. [10]

The words in a 2021 interview of Roberto Liscia, president of Netcomm, a consortium of more than 400 companies operating in the global e-commerce and digital retail sector, perfectly summarize the challenges of the current situation: "The consumer is looking for efficiency, but also for an increasingly personalized, simple and intuitive experience. On the seller's side, this translates into the need to focus on certain aspects such as detailed descriptions, personalized suggestions and offers, a smooth interface, secure payments, on-time delivery and pickup of goods, but also an increasing focus on sustainability aspects. In summary, in the Fast Moving Consumer Goods (FMCGs) context, digital is primarily an indispensable marketing tool. The fact that e-commerce is destined to consolidate over time, also for FMCGs, implies that all realities, from manufacturing companies to intermediaries to distribution companies, will necessarily have to review their way of doing business and their relationships along the supply chain, questioning current production, commercial and operation logics. The most careful companies are already thinking about innovation projects that combine the new demands of demand with a renewed way of delivering supply, leveraging the most promising technologies. New production logics, new data flows and new competitive territories will be the key words for FMCGs companies in the coming years." [13]

The concept that the president of Netcomm wanted to convey through his words was that customers who shop online have different requirements with respect to the traditional channels' customers. Through the Internet, customers have access to more information about companies and their products. Customers of online channels are very demanding, as result of the delivery fee they are willing to pay, they expect the highest level of service. In a traditional store, customers find shelves with many types of products in front of them, should one of these not be available on the shelf for different reasons, customers still have the option of picking up a similar one, perhaps choosing another brand or opting toward another type of product. The common factor between the traditional stores is that the product choice is always wide. In online sales, this wide choice of products customers have until the order has been placed. Once the latter is placed, the customer expectation becomes to receive exactly the products ordered. With this premise, if some expected products are not received, customers would be dissatisfied. Online customer dissatisfaction, nevertheless, is precisely what the world's largest companies do not want because it implies a loss of trust that could potentially turn into the loss of that particular customer. [14]

1.2. Components of logistics value

Logistics value is a construct which consists of variables related to convenience, communication, experience and time. The value of convenience bears on both the lack of the need for the customer to move around to purchase products and on the simple and quick chance to select products anywhere, anytime and with any electronic device. The value of communication refers to the way of contacting the customer since, unlike traditional sales, e-commerce lacks direct contact between the seller and the buyer. Therefore, customers ask for more frequent contact, which will provide them with information about their orders and quick answers to their questions. The value of experience is based on the customer's experience connected with the purchasing process carried out using the e-commerce platform. [15] It involves the use of the customer's emotions and refers to the lifestyle, fashion, trends and social affiliation. Experience bears upon the purchasing process itself but also what happened before and after the transaction, for example, after returning the product. Due to the declared lack of direct contact between the seller and the buyer, and the lack of instantaneous access to the purchased products, the time category is of great importance in shaping the customer value. [16]

A product ordered through e-commerce platforms must be delivered to the place indicated by the customer. The possibility to choose the place of delivery or collection of the goods makes the customer influence the configuration of their value chain. The product must be delivered to the customer also at the right time. On account of that, it is essential for the seller to determine the time of order processing, in particular the time of order preparation and delivery. More and more often, customers have the option to choose between several delivery times and thus can influence the total order processing time. The online customer does not like to wait too long. The delivery should, therefore, be as fast as possible preferably within the next working day or even the same day. Same-day deliveries are expensive services because most often they are connected with direct delivery from the sender to the receiver, omitting intermediate points. [17]

Products ordered online must be delivered to the customer as indicated in the order. It is of great importance that the customer provides not only the exact address to which the purchase is to be sent, but also additional contact details, such as a telephone number or a mail address. The sellers should guarantee information about the progress of the order fulfillment and the place of delivery or collection of goods, the concept of real time delivery monitoring. The customers have access to the data about the order status and the information transmitted should not be redundant. It shall be selective and tailored to the customer, to her or his expectations. This increases the feeling of security and thus contributes to a repurchase from the same dealer. [18]

Online shopping involves the chance that the customer will not appreciate the products for some reasons or simply will change its decision. Therefore, it must be possible for the customer to return such products back. Returning is not an enjoyable activity as they take extra time and the seller often must pay for the shipment. Customers do not always know where and how to report a return, how to prepare the package, how a courier or where to take the package. As it happens, it should be easy for the customer to return back, in light of the fact that a very simple and efficient return procedure can leave the customer with a positive experience that will make them happy to repurchase from the same retailer. [19]

2 Methodology

The general overview of the online sales industry given in the introductory section will be taken up and detailed during the thesis work. The thesis work has been developed along with the following scheme: a first theoretical section of literature review and a second more practical section through the illustration of a real case concerning a major company operating in the large-scale retail sector in Italy which is facing the challenges listed in the theoretical part.

The theoretical literature review has been divided into two macro areas. In the first part, the world of e-commerce has been defined through a state-of-the-art review, highlighting especially the differences from the sphere of the traditional sales. In the second part has been highlighted the last mile delivery management, from both the logistics and planning standpoints, which represents the main difference compared to the traditional channels, with a focus on the grocery sector. The last leg of the chain represents one of the biggest problems of the e-commerce, making the least efficient part of the supply chain. This is due to the possibility of receiving the ordered products, via web or via mobile app, directly at home in a specific day and time window agreed upon, with a lead time between order generation and actual delivery of even less than 24 hours. This enormous challenge, referred to as Attended Home Delivery, is a challenge for the industry both in terms of costs and the risks linked with high exposure to final customers. The key element of success in the field of Attended Home Delivery can be operationally translated into a logistics and scheduling problem, better known as Vehicle Routing Problem, to be declined in the various situations and sectors to which it belongs.

The real-life case that has been presented in the second part of the thesis work belongs to the food sector, i.e., the sector that potentially presents the most difficulties and critical issues about home deliveries. The purpose of presenting a real case is to show the situation and the challenges depicted in the literature review through a practical case.

2.1. Literature review: Methodology

The methodology adopted to get a comprehensive overview of the topics covered was done by following mainly three phases for each step of the literature review:

1. Information research
2. Information review
3. Information selection

In order to do a state-of-the-art review of the literature with verified information in retail e-commerce two databases were mainly considered to perform the research, Scopus and Google Scholar, as they are considered among the most reliable and comprehensive database in the web.

Web sites, book sections and newspaper articles were also consulted as supporting tools, along with the use of the two databases, to collect articles, reports and documents.

The first research step has been to check which and how many papers were reported in the e-commerce retail sectors, particularly in the e-grocery field.

The keywords used in the first step were as follows: "e-commerce", “e-grocery”, "food retail," "consumer behavior," "online sales," and "supply chain". Scopus allowed to cross-search results by considering more than one keyword at a time through logical operators, specifically the AND operator, to interlink the filters. These keywords were selected either in the title or in the abstract of the documents.

After a first introductory step to review the e-commerce state-of-the-art in literature, the research proceeded with a second step. In the second step, the focus was on documents dealing with the area of distribution, planning and logistics, especially about the last mile delivery till the final consumers.

The same keyword approach of the first step was again followed. In this case, the keywords used were as follows: “logistics”, “last mile delivery”, “delivery service”, “vehicle routing problem”, “home delivery logistics”, “routing” and “capacity planning”.

From the documents that came out as outputs of the research, 18 were initially selected since were considered most pertinent to the topic of the thesis work, i.e., those related to economically and demographically relevant geographic areas, such as Europa, Asia and America and those that were recent in terms of year of publication, within 5 years.

Through the reading of the first documents found, 32 other cited documents have been identified useful to the thesis work and as result were 50 final documents.

The use of the Google Scholar database has been especially useful in snowballing search the papers found through the first and the second steps. The title and author of the papers from the snowballing search have been inserted into the Google Scholar database, which has been considered as the most reliable in finding documents from title and authors.

The consultation of websites, online newspaper articles, and corporate reports was very helpful to integrate the information obtained through papers from the two databases,

Among websites, newspaper articles and corporate reports, additional sources of information were added, resulting in a total of 86 bibliographic sources.

2.2. Case study: Methodology

In order to analyze from a practical and operational point of view what has been described in the review of the state of the art of e-commerce and last-mile logistics, as mentioned before, in the second part a real case study has been presented. This case study was addressed in a six-month internship at Esselunga, one of the most important players in the large-scale retail sector in the Italian territory.

The internship opportunity has been addressed in the e-commerce sector, since Esselunga has been opening its sales horizons through the use of the web channel for the past two decades, as reported in the company website, *"in 2001 the first version of the Esselunga e-commerce site was born, Clicca il Pomodoro"*, and now represents a leader in the Italian online market sales. [20]

In recent years, the company has registered tremendous growth in the e-commerce sales channel, especially after the advent of Covid-19 pandemic, which has radically reshaped the buying habits of Italians. As a consequence, in order to keep up with volume growth and do not decrease the quality of the level of service offered to final customers, major investments have been made on new projects.

One of these investment projects was the choice of developing a new Transport Management System (TMS) software and its adoption in all the routing planning for the central-warehouses and the transit points operating in the company's web network, during the 2022. The decision to the replacement of the TMS, that is the home

delivery route planning software, after years, has been made as a result of the growth trend of orders through the online channel occurring for the last years and that inevitably resulted in exponential growth after the Covid-19 Pandemic began in 2020.

This change has been considered as necessary by Esselunga in order to optimize the vehicle's delivery routes, that goes beyond simply sequencing deliverables according to a specific area and time.

The purpose of presenting a real case in a company operating in the e-grocery sector is to highlight and find from a practical point of view what challenges companies really face, thereby also making a comparison with what has been found in the literature review. In this specific case, the object of study will be last-mile delivery logistics and home delivery route planning. In the case study presentation, the objective will be to analyze the change in the logic of routes planning for delivery vehicles and the requirements that brought about the implementation of that shift.

An initial description of the old planning system through both the strengths and weaknesses of the system highlighted, will be the starting point of the description of the functioning of the new one.

The advantages and current disadvantages of the system will also be explained together with the ongoing adjustments. Finally, the continuous development of the system will be analyzed in order to improve it both from the standpoint of layout graphics and from the optimization standpoint.

Additionally, the potential future developments will also be proposed to make sure that the route planning system is constantly linked to the composition of slots made available to end customers, divided by time slot and delivery area.

Food products delivery involves the customer booking a specific time window during the day. The time slot to be offered should be as narrow as possible to prevent food spoilage, for instance. Offering a narrow time window, however, it follows that logistical costs increase due to increased management complexity. The vision of Esselunga in this regard is to not offering slots to the customer in a static way and to not stopping the route optimization just after the order arrivals, but to develop the system in order to dynamically address the time slot purchase by the customer in such a way that the whole routing is being constantly optimized taking into account many constraints, such as the capacity of the warehouse, the capacity of the vehicle in terms of orders weight and volume, and the respect of the booked time windows.

3 Literature review

3.1. E-commerce

3.1.1. Definition and overview

Electronic commerce is defined in an article published in 2017 by Rahimzad and Heydari as a new form of buying goods or services which is over the Internet without a physical intermediary. The basic process of e-commerce is searching goods, selecting products, making payment and waiting for the product delivery from different parts of the world. Due to its technological and geographical necessities, e-commerce requires consumers to have access to the Internet network. Since, in general, the middle class in emerging markets is one group that uses computers with high frequency, hence online shopping has become indispensable in their daily lives, especially among young people. [21]

E-commerce has been the fastest growing channel in the retail industry over the last decade. Online buying and selling have become increasingly prevalent, even though there are early adopters like the United Kingdom and the Netherlands, and countries that started later and at a slower rate as Spain and Italy. [22] As reported in the "E-commerce Italy 2021: The most promising online sectors and eye-catching development" report, in 2020, China had the highest product e-commerce sales penetration worldwide with 24%, that equals 1.191 billion euro. This 24% means that of all products sold on the Chinese market, 24% is sold online. USA followed with a product e-commerce penetration of 20% and then Europe with 13%. All three had an average growth rate between 16% and 18% compared to the year before. [23]

E-commerce has increased competition since as more businesses chose to sell their products online. There is a strong indication that the Internet marketing platforms are very important and beneficial to both the marketers and the consumers who are engaged. Marketers side, the motivation to use the Internet comes along with some of its major disadvantages such as the ability to reduce the cost of operations. Similarly, the cost of using the Internet has also been the reason why a number of customers have

also been encouraged to change their lifestyle from shopping from the traditional market to shopping online. [21]

3.1.2. Business models

In the e-commerce supply chain, business owners choose from two options through which they can sell their products online: (1) a business develops its own website where all transactions take place between the business organization and consumer directly or (2) a business sells its products on an online marketplace where the information infrastructure has been built and is owned by a third party. [24]

Online retailers face some daily unique challenges compared to those selling their products using the traditional brick-and-mortar selling models. To remain competitive in the market, it is significant for online retailers to grasp their supply chain issues and to manage their supply chain effectively in order to reduce costs and to improve customer satisfaction. [25]

There are six major e-commerce business models:

- Business to Consumer (B2C);
- Business to Business (B2B);
- Business to Government (B2G);
- Business to Business to Consumer (B2B2C);
- Consumer to Consumer (C2C);
- Consumer to Business (C2B).

A typical supply chain includes multiple stages, ranging from suppliers, manufacturers, distributors, retailers, and finally, to customers. In the e-commerce supply chain, an additional party may be needed to operate an e-marketplace. [24]

B2C is when a company markets its products or services directly to final users. In e-commerce, there are five different B2C business models: direct sellers, online intermediaries, advertising-based, community-based, and fee-based.

1. Direct selling is when consumers buy products from online retailers;
2. Online intermediaries are online businesses that collect sellers and consumers and take consideration of each transaction made;
3. In the advertising-based model, information is given away for free and money is made from advertising on the site;

4. In the community-based model, websites make money from targeting ads to users based on their demographics and location;
5. The fee-based model involves companies that sell information or entertainment to consumers for a fee, like Netflix or subscription-based newspapers.

In recent years, online B2C sales have been trending upward. Many traditional brick-and-mortar retailers have either been closing, or adding in digital channels to their strategy as shoppers go online for the things they need. This hybrid approach is when companies have both a traditional brick-and-mortar presence and an online shopping platform. [26]

B2B is when a company markets its products or services directly to other businesses, this e-commerce category can be deconstruct into two methodologies, vertical and horizontal. Vertically oriented businesses sell to customers within a specific industry, while with a horizontal approach, the sales are toward customers across multiple industries. B2B businesses had always been a few steps behind their direct-to-consumer counterparts, especially when it came to commerce innovation and digital sales due to problems in price negotiation and collaboration. Despite the slow adoption of new digital strategies, B2B brands have focusing more and more on e-commerce to keep up with consumers. A recent report by Gartner uncovered a recent dramatic shift with B2B digital commerce initiatives surpassing B2C. Gartner assumes that "By 2025, 75% of B2B manufacturers will sell directly to their customers via digital commerce." [26] [27]

Business to government (B2G) is when a company commerces its products and services directly to a government agency.

In B2B2C e-commerce, a company sells products to another company and then sold to consumers. An example of a B2B2C arrangement is when a wholesale seller merchandise to retail stores that then sell the merchandise to final users. The B2B2C model is comprised of three parts: the first business, an intermediary, and the end user. The primary advantage of the B2B2C business model for e-commerce companies is the acquisition of new customers enabling a rapidly grow of the customer base. [26]

In the C2B e-commerce business model, individuals sell goods and services straight to companies. This can be perceived most commonly in websites that allow contractors or freelancers to share work or services they are experienced in. Often, businesses will put in a request or a proposition for that person’s time and will pay the person through that platform.

3.1.3. Technology for e-commerce

In the era of e-commerce, Internet of Things (IOT) technology is an essential technical tool for e-logistics supply chain management. There are three main aspects in supply chain management: information flow, logistics and capital flow, involving operational aspects such as procurement, production, distribution and capital operations. The contention among modern enterprises requires them to improve efficiency through integration in production and procurement, avoid stagnation of the production due to problems in specific parts of the supply chain and optimize production rhythm. IOT technology connects any item to the Internet for information exchange and communication to achieve electronic identification, location, tracking, monitoring and management, which is the basis of electronic supply chain logistics. [28]

Technology is in the process of disrupting several actions of the online value chain, from user experience to order preparation to the last mile. With technological advancements, business models and operations that are unprofitable today could become more sustainable in the future. In the longer term, technological advancements could make online grocery less costly to operate than physical grocery, enabling grocers to propose lower prices online than in stores. If these will happen, physical retail would lose a significant part of its advantage, and new consumer segment will be shifting online and creating a boom for the online grocery market. [29]

3.1.4. Online customers behavior and expectations

Online consumer behavior is the process of how consumers make decisions to purchase products in e-commerce.

Previous research pertaining to the Internet grocery shopping has focused on comparing online and offline purchase behavior in terms, for instance, of brand loyalty, shopping behavior, the importance of brand names and consumers' perceptions of the advantages and disadvantages of shopping online for groceries. Another important stream of research has examined the consumer traits of Internet shoppers, either in terms of their general shopping orientation, their web-usage-related lifestyle, or psychographic characteristics. Regardless of this, home delivery of items purchased online is appealing to those for whom going out to shop is difficult for various reasons, such as physical disability, the need to care for small children, the lack of adequate or convenient transportation or a busy lifestyle. [30] [31]

As consumer's purchase habits shift from shopping at traditional brick-and-mortar stores to shopping online, online product discovery has gained significance. Originally, web search was the primary source for product discovery, but recent surveys show the growing clout of e-commerce search engines as they become the first option for product search. [32]

The Covid-19 pandemic has changed people's life profoundly and e-commerce has played an even more important role in maintaining the economic health of society. According to Euromonitor International, in 2020, the amount of goods bought online globally grew by 24%, reaching a total of USD 4.2 trillion worldwide, while store-based sale declined by 7%. The pandemic accelerated the shift towards e-commerce, as many consumers experimented and became reliant on the digital channel while in isolation. [24]

The emergence of electronic commerce has placed home delivery service at the heart of an effective e-supply chain system. A good home delivery service ensures that an e-commerce retailer can integrate speed, response, convenience, quality, care, and a seamless experience for online customers. Home delivery service providers need to meet customers' expectations, in terms of on-time delivery, special handling of perishable products, pleasant interactions with the delivery person, proper instructions and documentation, assuring convenience. Customer satisfaction of home delivery service depends on the service quality of the delivery personnel, the perceived value of the service, and customers' trust in the service. Service quality results in three possible outcomes in relation to customer satisfaction: if the actual service delivered is below expectation, customers will be dissatisfied; if the actual service delivered is equivalent to expectations, customers will be satisfied; and if the service exceeds the customer's needs, they would be pleased or extremely satisfied. [33] Customers' perceptions of the service level can affect their satisfaction as well. They compare the service with their expectation and the cost they expend for this service. If the customer values the service more than the cost, satisfaction will occur. Therefore, customers' perceived value is posited as a significant predictor of customer satisfaction. In the online grocery sector, home delivery service represents an ability to render an efficient, convenient and customized service and is seen as an opportunity to better satisfy customers, gain competitive advantage and build long-term relationship. [34]

A recent article published by Linnsworks identified six significant e-commerce behaviors and shopping trends as result of the COVID-19 pandemic [35]:

1. Convenience, as the capability to run through an online store and check out as a guest;
2. Easy access across all devices throughout a buying journey;
3. Access to omnichannel shopping by focusing on various marketplaces where consumers spend their time;
4. Effortless and flexible payment options;
5. Fast and reliable delivery;
6. Shipping transparency.

The key to success for retailing in e-commerce is the understanding of the evolving and complex trends set forth by customers. For retailers, meeting and exceeding customer expectations defined by even-evolving online shopping trends are antecedents to creating the best customer journey possible. [35]

3.1.5. Websites' goals

As confirmed by an article published by McKinsey in March 2022, while stores remain as the key channel for most grocers, online grew dramatically during the pandemic, with many retailers quickly adjusting their offerings and operations to meet consumer demand [36]. Regardless, the online market is still in the process of taking shape. The growth of the online market has attracted a record level of investment. Venture Capital (VC) funds and consumer-packaged-goods (CPG) companies seeking to develop their own direct-to-consumer offering have joined the fray. Players that can secure funding for future growth will likely lead the disruption. However, other factors could shape the market's development, including new regulations that could make online grocery less attractive to investors. [29]

The goal of the e-commerce web sites is to replicate customer in-store interactions and experiences that lead to purchases, by improving customer engagement. Business owners and customers have opposite goals, customers want to find the best quality at the cheapest price whilst businesses want to maximize profits. Customers visit e-commerce sites to accomplish a goal, that can be simple or complex. Complex goals typically involve a combination of several simple goals, considering that a simple goal is when a customer is simply interested in just one item. [37]

The customer journey can span multiple sites and offline interactions. Customers search for competing brands and products within and across e-commerce businesses,

both online and at physical stores. This is partly because a given e-commerce site has a limited set of products and brands, but also because of the customer's interest in finding the best quality at the best price. This behavior is known as comparison shopping. [9] Shopping websites serve many users and account for a significant portion of the revenues. As online shoppers search and compare product information before making purchase decisions, they evaluate website quality, which would predict their loyalty. The same shopping website can frequently be evaluated differently by several users as quality perception can include many categories including system quality, information quality and service quality. Such potential low evaluations can bring shoppers about disappointment and reduce their purchases, directly harming revenues and threatening shopping websites' survival. This problem is also challenging for e-commerce since other users may seek information or comments from rating forums or social networking service and this can have a negative effect in the purchase decisions. To prevent low evaluations, an e-commerce website should be made considering the various quality categories. [34]

The system quality reflects how the system facilitates interaction with users and comprehends four dimensions: *flexibility* as the ability of the system to be adapted to meet a diversity, *timeliness* in the sense of how users' requests are quickly responded to, *reliability* as the degree to which the system operates rigorously and the *accessibility* as the ease with which the system is reached. Information quality is also important as it builds trust and enhances satisfaction. It comprehends four dimensions as well: *format* as how much easy to understand the information is presented, *completeness* as the extent to which comprehensive information is provided to meet user requirements, *accuracy* as the extent to which the provided information is correct and error-free and finally the *currency* as the degree to which the most recent information is provided. The service quality instead comprises five dimensions: first, *tangibility* as the degree to which the system is by sight appealing. Second, *service reliability* indicates that the provider delivers its contracted services. Third, *assurance* is the degree to which users feel confident and safe in using the service. Fourth, *responsiveness* is how quickly the provider addresses user needs. Fifth, *empathy* is the extent to which the provider gives users individual attention. [34]

Customer satisfaction is important for business profits but is only one of the many criteria that a business needs to record towards the goal of optimizing profit. This aspect is further pointed out in the e-commerce, considering the products deliveries till home and the direct connection with the costumers. Profit optimization comes from several strategies which have short-term and long-term effects. Typical strategies

include cross-selling, enticing customers to purchase additional products, up-selling, inducing customers to purchase a more profitable version of a product, and down-selling, encouraging customers to purchase by matching their budget. For brand consistency it is always essential to show to the customers, products that align with the business' brand image. E-commerce search engines include business logics that reflect marketing decisions for both online and offline markets. The search and marketing teams should work together so that the customer experience transitions smoothly from offline to online and vice versa. [9]

3.1.6. Challenges

The understanding and conceptualization of challenges being faced by the e-commerce providers hold significance as relevant area of enquiry in the literature review. The analysis of the e-commerce associated research articles reveals the following key challenges faced by the e-commerce providers, infrastructure, government policies and regulations, competition, customer, cognitive and organizational. [38]

The infrastructure challenges are attributed to the four types of market imperfections as technology, IT education, financial and other basic configurations. The technology imperfection concerns the slow speed of Internet, limited connectivity as well as low Internet penetration. The IT education defect concerns lack of technology awareness and skills among the masses, especially in the developing economies. The financial defect concerns low financial inclusion and lack of credit card penetration among much of the target segment, especially in the developing economies as well. The other infrastructure related imperfections involve lack of reliable essential infrastructure like electricity, warehouses, transportation and roads network across the developing economies. [38]

Regarding the inefficient government policies and regulations concerning the online commerce, the regulatory challenges implicate lack of clear and updated policies and framework for the e-commerce providers in terms of fairness of competition, online customer data security and privacy, consumer rights, clarity on taxation and foreign investments, and reliability of payment gateways. [38]

The third challenge is concerning the highly competitive type of market driven by low entry barriers, lack of product or service differentiation, high bargaining power of buyers, low switching costs for buyers and price-based competition. The fourth

challenge is regarding the customer orientation towards e-commerce as compared to traditional commerce. This challenge is attributed to the four types of situational factors as the lack of awareness, the need for accessibility, the need for availability and the price sensitivity. Regarding awareness, customers lack clarity, physical look-and-feel experience and access to the reliable data sets with respect to the comparative benefits of offerings by different e-commerce providers. Regarding accessibility and availability, customers prefer to purchase when needed and expect quick delivery to their location without add-on delivery charges. Regarding affordability, customers are driven by pricing discounts, cashbacks, and other sales offers. [38]

The fifth challenge is regarding the cognitive perception and attitude of the customer toward e-commerce. This challenge is attributed to the following factors: heterogeneity, behavioral attributes and lack of technology skills. On the heterogeneity, the e-commerce providers need to design their business model considering the heterogeneous socio-economic and cultural context. The heterogeneity of buyers necessitates the e-commerce providers to focus on desired segmentation approach and have clarity on the target segment before implementing the business model. Regarding behavioral attributes, the customers while moving from offline to online channels lack trust, confidence, and reliability in terms of making an online purchase without the in-person experience of the value offering, sharing personal details online, and making online payments. Regarding technology skills, there exist a significant proportion of the global population that does not possess computer skills. [38]

The sixth challenge relates to the inadequacy of last-mile channels and scarcity of organizational resources including long-term patient capital and skilled manpower. The inadequacy of public and private setup related to last-mile channels for delivery and support pose complexities for the e-commerce providers in terms of delivery commitments, accessibility and cost inflation. Also, e-commerce providers are constrained by the limited availability of long-term uncomplaining capital as well as skilled manpower having ability and skills to manage the e-commerce business. The e-commerce organizations need to focus on identifying the strategic choices for all these challenges in order to become sustainable and gain competitive advantage over the market. [38]

3.1.7. Sustainability

The issue of sustainability has become central to various aspects of e-commerce not only because of the requirements from customers, but also because of a general convenience that can be built. The dilemma of whether e-commerce is less impactful from the standpoint of courier trips compared to those of customers to the physical store has been measured. The definitive analysis explains that with e-commerce there is a saving of between 4 and 9 times in favor of e-commerce, which obviously also reduces traffic: a delivery van saves in fact about 50 car trips. Overall, the CO_2 impact of e-commerce is 2.3 times less than the physical distribution chain physical. [39]

More than 2,000 companies worldwide representing more than the GDP of the United States are committed to emission reduction targets. Companies that succeed in translating climate commitments into concrete action will achieve sustainable leadership status. The growth of e-commerce represents also a unique opportunity to give second-hand materials a second life, enabling the development of reuse, repair, upcycling or Do-It-Yourself. [40]

Players are exploring many options to reduce their impact and address the changing demand of the consumers. These options may relate to packaging but even supply chain, energy, omnichannel commerce and logistics affecting infrastructure and transportation. [41]

There are many areas for which e-commerce retailers can make a difference [42]:

- Packaging;

Packaging is an issue for selling through transportation given the impact on the disposal system of cities now invaded by e-commerce cardboard. The impact is not limited to cardboard: 15% of plastics released for consumption in Italy come from e-commerce. Because of that, operators are implementing strategies as the use of packaging with recycled materials or compostable materials with products derived from corn or vegetable fibers or closing tapes with non-toxic glues. Finally, there are strategies for optimizing the use of packaging, like the sending a single package even with products purchased from different brands. [42]

- Delivery methods;

Deliveries, especially in metropolis centers are necessarily made by electric vehicles or by bike or on foot due to the new city rules. [42]

- Cargo ships;

Regarding international sea transport, the main retail sale chains such as Inditex, Amazon and Patagonia have joined the Cargo Owners for Zero-Emission Vessels (coZEV) and are working towards carbon-free shipments by 2040. Sea shipping now accounts for 3% of all global emissions and could rise to 10% by 2050 if the industry keeps relying on carbon-intensive fuels [43].

- Pick-up points;

Avoiding last-mile delivery might be the most advantageous system nowadays for CO_2 impact. A study carried out by a collection point operator, Easybox, showed that CO_2 emissions are reduced by 20.5% compared to home delivery. [44]

- Re-commerce;

The circularity of sold products can be get by promoting repair, reuse, recycle and re-commerce. On the latter, eBay is running a promotional campaign linked to raising awareness of the fact that each family has on average more than a thousand dollars' worth of items that could be sold online. Some operators, such as Zalando, are handling "pre-owned" product categories for pieces of clothing, allowing the customers to sell their clothes in exchange for a credit on the e-commerce website for a donation. To extend the life of their furniture, Ikea has leasing and repurchasing programs. Vaude, the sustainable clothing brand, sells leftover PVC-free fabrics from manufacturing on eBay.

- Datacenter energy;

The data centers in the world produce the same CO_2 emissions as all the airlines. In Europe, they produce 6% of all CO_2, reaching the relative majority stake. Because of that, many new zero-impact proposals are emerging in line with the European Community's goal of making all datacenters carbon neutral by 2030. [45]

- Customers nudging;

Making the customer choose the best option based on environmental impact can be the responsibility of the operator, such as showing the CO_2 impact in the different delivery options. [46]

3.2. Last mile delivery

Online shopping has increased the demand for last mile delivery services. Increased online shopping deliveries are likely to affect the structure and performance of the

urban freight chain in producing additional and fragmented delivery systems, higher delivery frequencies of smaller orders and shipments and supply chains which include consumers. As such, freight transport responses to online shopping, which often involve deliveries directly from terminal to the end consumer, are particularly evident on the last mile. Last mile is the final link in the supply chain between production, terminals and end consumers. [47]

Due to the increasing number of goods vehicle movements especially in urban areas, modern cities are facing congestion, lack of public space, air pollution and noise, which are reducing life quality. To cope with this situation, city municipal administrations are already implementing several sustainability initiatives such as urban consolidation centers, intelligent fleet management systems, use of green vehicles, and putting in place various freight regulations such as vehicle sizing, access timing restrictions, and congestion pricing in line with the goal set by EU of a reduction of at least 60% of GHGs by 2050 with respect to 1990 is required from the transport sector. [48]

3.2.1. Definition and objectives

Last mile delivery bears on the last step of the delivery process when a package is moved from the nearest transportation hub to its final destination, which usually is a personal residence or retail store. The term is commonly used in the contexts of food delivery, enterprise supply chains and transport for delivery businesses. The term originally comes from telecommunications, where the last mile is the connection from the ISP (Internet Service Provider) to the location of the customer basis equipment, such as a user's home or office. In delivery businesses, the hubs along delivery routes are located at sites near to the center point of common delivery locations. Deliveries between these hubs normally require trucks moving large quantities of packages. Because of the greater number of potential locations involved, the use of large vehicles is not cost-effective for last mile delivery and smaller vehicles such as vans are used instead. But it may also be necessary to make multiple delivery attempts, which can further increase costs and make the last mile delivery the least efficient leg of the delivery process. [49]

For the shippers, last-mile delivery is the most complex and expensive part of the product's journey. Last-mile logistics enable brands to get their products to consumers quickly and cost-effectively. Shippers have begun to focus on refining their last-mile logistics, especially as e-commerce and omnichannel retail continue to grow. [50]

The superior goal of last-mile delivery is to enable every delivery to reach its destination every time, on time, accurately, efficiently, and sustainably. Getting the delivery experience right is of great importance for shippers and carriers in an increasingly e-commerce-driven world. Product and price are no longer the only considerations to winning sales and delighting consumers. Last-mile logistics have taken center stage as a key factor that consumers evaluate when deciding where to purchase their online goods. A great delivery experience is a great competitive advantage, especially in an increasingly e-commerce driven world. [50]

The last mile delivery is a process composed of multiple steps. Once a customer places an order online, the web browser or mobile application directly communicates with the retailer or e-commerce provider's server. The order is sent to a centralized order management system which confirms stock availability and provides the customer with an option to pay online. It then sends a request to the warehouse hosting the stock to dispatch the products to the final customer. The shipper sends an agent to pick up the customer's item from the warehouse. The agent then loads the parcel in his vehicle and delivers it to a predetermined hub. Then from the hub an agent picks up the parcel and delivers it to the customer's doorstep. All these might appear to be simple but in reality it is not. There are multiple moving parts in the last mile ecosystem and the quality of execution depends a lot on internal and external factors. To ensure a seamless execution of all these disparate processes, businesses are adopting modern logistics solutions. [51]

To be competitive in the market, retailers try different transportation planning strategies to lower the delivery cost. Faster deliveries might cause higher transportation costs, but at the same time might lead to more customer satisfaction and therefore more demand and profit for the company. The main challenge is solving a tradeoff between low delivery cost and low customer waiting time in which a good performance with respect to one factor may result in lower performance for the other factor. Planning and managing product delivery are not simple and different managerial strategies should be considered. The chosen strategy can be different for different companies under various circumstances and considerations. [50]

3.2.2. Trends and challenges

Last-mile delivery, i.e., all logistics activities related to the delivery of shipments to private customer households in urban areas, is a hot topic in cities all over the globe.

Its high relevance is mainly triggered by the following general developments and challenges:

- Increasing volume;

Two global mega-trends, in particular, urbanization and e-commerce, are strong drivers for an ever increasing demand for last-mile delivery services. Urbanization denotes the trend that more and more people move into urban areas in general and into "megacities," with 10 million inhabitants and more. There are estimates that by 2050, 70% of the world's population, approximately 6.3 billion people, will live in major cities. Furthermore, e-commerce is in a steady increase and many commercial goods are ordered online. In 2018, e-commerce still showed a worldwide growth rate of 23.3%. [52]

More geographic concentration and increasing online orders per person lead to a steady increase in parcel volumes to be handled. In Germany, for instance, it is forecasted that by 2023, 4.4 billion shipments will need to be handled per year compared to 1.69 billion in 2000. [53]

- Sustainability;

Increasing urban parcel demands induce a much higher number of delivery vans entering the city centers, which additionally weights on the existing infrastructure, adds to congestion, and has negative impacts on health, environment, and safety. As a consequence, increasing customer awareness and new governmental legislation drive delivery services to intensify the efforts for sustainable and environment-friendly operations. [54] One example for a public policy directly impacting last-mile deliveries is, for instance, that some regions of the world, e.g., British Columbia (2019), allow (single-person) electric vehicles on their high-occupancy vehicle (HOV) lanes, which are normally reserved for cars with multiple occupants. Such a policy could be an incentive for delivery services to electrify their delivery feet in order to access urban areas faster via uncongested HOV lanes. [55]

Traffic congestion is a dramatic problem in every country. People have to queue in their cars daily to reach their working place, to take children to school, to perform any regular activity. Green areas are transformed in parking spaces. Traffic jams are not an exceptional event but rather, especially in urban areas, a regular event that causes delays and stress. Delays in turn have huge economic and social consequences. The number of traveling vehicles can be reduced only by reducing the number of people in need of travel and/or by increasing the number of people transported in the same vehicle. [56]

- Costs;

Traditional attended home delivery by delivery vans is costly. Relevant drivers for high costs are traffic jams and missing parking spaces in congested streets as well as customers not at home to receive their parcels. Thus, especially alternative delivery concepts allowing an unattended delivery or customer self-services are a promising alternative to lower costs. [56]

- Time pressure;

The increasing package volumes are mainly triggered by increasing e-commerce activities. Most online retailers, however, have made next- or even same-day deliveries to one of their basic service promises, so that last-mile deliveries face tight deadlines and considerable time pressure. Moreover, online deliveries vary over the year, with peaks workload over the week and peaks due to seasonal sales. Thus, last-mile deliveries also face strongly varying workloads, so that last-mile concepts are required that are easily scalable on short notice. [56]

- Aging workforce.

The aging workforce in many industrialized countries enlarges the problem of employers hiring the required manpower, especially in a physically demanding environment such as parcel delivery where the press frequently reports on harsh occupational conditions and low payments. [57]

Given these challenges and the recent (and ongoing) technological developments, such as autonomous driving, drones, and delivery robots, it is anything but surprising that plenty of novel last-mile delivery concepts have been promoted during the recent years. These concepts range from already practiced alternatives such as cargo bikes, over evaluated prototypes such as parcel delivery by drones [58] up to ideas for the even farther future such as Amazon's patent for flying warehouses, i.e., airships circling over city centers from where drones are launched. [59]

The status-quo delivery concept that is applied all over the world to process the vast majority of shipments is based on delivery vans departing from a central depot, each driven by a human delivery person. On a tour along customer homes, the delivery person stops the van at the roadside, approaches a customer home, and hands over a parcel directly to the customer via attended home delivery.

3.2.3. Models

Operational research has contributed to decision making in several areas of supply chain management. The systemic direction suggests that better solutions to problems can be identified when broader parts of the supply chain are jointly modeled and optimized. In fact, several research efforts have already been made in recent years in this direction. [56]

In the area of vehicle routing, several papers have studied more global problems with respect to the classical routing problems aimed at finding the routes of vehicles only, given locations, demands of customers, time windows. Integrated vehicle routing problems is the expression increasingly used to denote the class of problems where the routing decisions are tackled together with other decisions. Location-routing problems jointly optimize location and routing. Inventory-routing problems combine routing and inventory management. Production-routing problems integrate production, routing, and usually also inventory decisions. Multi-echelon routing problems optimize the routes of vehicles in distribution systems comprising two or more echelons. [56]

The most basic problem is the Vehicle Routing Problem (VRP), where customers, each with a given demand, must be served with a fleet of identical vehicles, where each vehicle performs exactly one route. All routes start and end at the depot. The decisions to be taken concern the assignment of customers to vehicles and the sequencing of the customers assigned to each vehicle in such a way that the total routing cost is minimized. The main objective in this problem is to obtain a set of routes for vehicles starting and ending at a depot to visit customers' locations. The problem also considers several practical operational constraints. These may include vehicle capacity or compartment volume, distance or duration, customers' time windows (i.e. hard or soft), and other related customer, product, resource or specific requirements. [60]

The knowledge gained on these problems and the technological advancements allow researchers to reduce the gap between scientific literature and real-life applications. VRPs literature shows a clear trend towards the study of more complex problems to reduce the gap with real world applications.
Problems may differ because of additional features a route must satisfy, such as a constraint on time duration, the respect of time windows or of pickup and delivery sequences of operations. [60]

The most classical VRP is the Capacitated VRP (CVRP).

Each vehicle starts from a depot and returns to the same depot. The number of homogeneous vehicles available is given and coincides with the number of routes as each vehicle performs at most one route. All routes can start at the same time. All customers must be served. The demand of each customer is entirely served by one vehicle. A single commodity is considered. Routes must be created, that is, customers must be assigned to vehicles and the customers assigned to each vehicle must be ordered. The objective is the minimization of the routing cost subject to the following constraints: each vehicle performs at most one route, the total demand of the customers served in the same route does not exceed the vehicle capacity, no customer is visited more than once. CVRP is the simplest variant of the VRP, as the only constraint taken into consideration is the capacity of the vehicles, which is assumed to be identical in terms of actual capacity space and costs. [61]

This is the most basic formulation of the CVRP, based on [62].

The binary decision variable x_{ij} takes on the value 1 only if the route goes from customer i to j directly, for $i, j \in N$. N are all vertices associated to the customers and the depot vertices 0 and $n+1$. Two vertices are used to represent the same single depot at which all vehicle routes start and end. Also, y_j is a continuous decision variable corresponding to the cumulated demand on a route that visits vertice $j \in N$ up to the visit of j.

Minimize $$\sum_{i=0}^{n+1} \sum_{j=0}^{n+1} c_{ij} x_{ij} \quad (1)$$

s.t. $$\sum_{j=1, j\neq i}^{n+1} x_{ij} = 1, \qquad \forall i = 1, \ldots, n, \quad (2)$$

$$\sum_{i=0, i\neq i}^{n} x_{ih} - \sum_{j=1, j\neq h}^{n+1} x_{hj} = 0, \qquad \forall h = 1, \ldots, n, \quad (3)$$

$$\sum_{j=1}^{n} x_{0j} \leq K, \quad (4)$$

$$y_j \geq y_j + q_j x_{ij} - Q(1 - x_{ij}), \qquad \forall i, j = 0, \ldots, n+1 \quad (5)$$

$$d_i \leq y_i \leq Q, \qquad \forall i = 0, \ldots, n+1 \quad (6)$$

$$x_{ij} \in \{0,1\}, \qquad \forall i,j = 0,\dots,n+1 \qquad (7)$$

The objective function (1) minimizes the transportation costs, calculated by multiplying the cost of traversing an edge (c_{ij}) with the binary decision variable x_{ij}.

Constraints (2) make sure that all customers are visited exactly once. Constraints (3) are flow preservation constraints, meaning that an incoming vehicle to vertice $h \in N$ must also depart from this vertice. Constraints (4) limit the maximum number of routes to the number of vehicles K. Both Constraints (5) and Constraints (6) guarantee that the vehicle capacity is not exceeded. Constraints (5) are also subtour elimination constraints. Subtours are cyclical routes that do not pass through the depot, i.e., yield infeasible solutions.

Different types of constraints are proposed in the literature to impose vehicle capacities and/or avoid subtours. Constraints (5) and (6) have as advantage that the model has a relatively low number of constraints in terms of the number of customers, but as disadvantage that the lower bound of the relaxation is relatively weak in comparison with other formulations.

In most cases, the CVRP is combined with other variants, with the most frequent being the Vehicle Routing Problem with Time Window (VRPTW), which adds more constraints to the setting of the problem. The VRP with time windows is the most relevant extension of the VRP in last mile logistics.

The VRPTW is an extension of the CVRP, in which customer time windows are imposed for the visits. A time window corresponds to a time interval $\{w_i^a, w_i^b\}$ which imposes that the service at node $i \in N$ cannot start earlier than the time instant w_i^a nor later than w_i^b . If the vehicle arrives before than w_i^a, then it has to wait until this instant to start servicing the node. To each arc (i,j), we assign a travel time t_{ij}, which respects triangle inequality. Also, each node i has a service time t_i that corresponds to the minimum amount of time that the vehicle has to stay in a visited node. Since the delivery cannot be done instant, i.e., it takes some time s_i to deliver the package after arrival at i.

Letting w_i be a continuous decision variable representing the time instant that the service

starts at node i $\in N$, a model for the VRPTW can be obtained by adding the following constraints to the previous formulation (1 – 7).

$$w_j > w_i + (s_i + t_{ij})x_{ij} - M_{ij}(1 - x_{ij}), \quad i = 0,\dots,n;\ j = 1,\dots,n+1 \qquad (8)$$

$$w_i^a \le w_i \le w_i^b, \qquad i = 0,\dots,n+1 \qquad (9)$$

Constraints (8) ensure that travel time and delivery time are correctly calculated, with M_{ij} being a large value ($M_{ij} = max\{w_i^b - w_i^a, 0\}$. Constraints (9) than ensure that delivery is done within the indicated time window.

Among the many variants of the vehicle routing problems there is also one focusing on the fleet kinds. Particularly, the Heterogeneous Fleet Vehicle Routing Problem (HFVRP) is a generalization of the classical capacitated VRP by assuming that the fleet of vehicles is composed of different types of vehicles, each characterized by different capacities and costs. [63] [64]

The closest CVRP variant is the distance constrained VRP (DVRP). In the DVRP, capacity-related constraints are changed with other constraints such that the length of a route must not surpass the defined distance range. Another practical VRP variant is known as the VRP with pickup and delivery (VRPPD). This problem is finding a set of vehicle routes for a group of requests. This can be very relevant for Logistic Service Providers (LSPs) who wish to simultaneously or subsequently serve pickup and delivery customers in the same route. There are also other variants of the VRPPD available in the literature. In the case of real-time vehicle routing optimization, dynamic VRP formulations can be used for dispatching vehicles to serve customers. Some parts of the transport plan must be decided beforehand, and the plans may need to be revised regularly in practice. This makes the routing problem more complex but practical for the logistics industry.

Another important variant is known as the production routing problem in the literature. This problem considers a more complex but practical planning problem that jointly optimizes production, inventory, distribution and routing. In the study of Shahrabi et al. (2021) [65], the authors studied the same problem with time windows, deterioration and split delivery. The authors specifically looked at the bi-objective (i.e. economic and social sustainability) model for a single product.

4 Case study: Esselunga

For addressing the research questions of the study, an "exemplary" case study will be developed and presented. The case will not only exemplify the current trends on last mile logistics delivery in the e-grocery sector in the Italian market but will also allow to analyze the current technologies applied and investigate potential areas of improvement.

4.1. Company presentation

Esselunga S.p.A. is an Italian company operating in the large-scale retail trade in northern and central Italy with supermarkets and superstores. It is a subsidiary of *Supermarkets Italiani*, which is an Italian company that has been active in large-scale retail distribution with supermarkets and superstores since 1957, as well as in finance and real estate development. The company is, thanks to its subsidiary Esselunga, the 23rd largest Italian company in terms of turnover, fourth largest profitable company in large-scale retailing sector in Europe, in proportion to its size. [66]

Esselunga S.p.A. operates in Italy mainly in the large-scale retail food sector through a sales network consisting of more than 170 stores located in the regions of Lombardy, Liguria, Veneto, Piedmont, Emilia-Romagna, Tuscany and Lazio and 11 laESSE stores. The most southern Esselunga supermarket in Italy is in Lazio, in Aprilia, and was opened in 2014. Instead, in 2017 has been opened the first store in the Italian capital, Rome.
LaESSE stores are a new concepy store of the Esselunga's Group, defined in the company's website as "*The Supermarket near home, positioned in the city's strategic points, excellent for all kind of shopping and not only*". [20]

As reported in the Esselunga's website [20], the history of the Esselunga's Group began in 1957 with the founding of Supermarkets Italiani S.p.A. and the opening of Italy's first supermarket on Viale Regina Giovanna in Milan.
The founding partner, American business tycoon Nelson Rockefeller, was joined by several minority partners, including Bernardo Caprotti. In post-World War II Italy, the concept of the supermarket, self-service and one-stop shopping was a new paradigm and gave rise to an innovative model of shopping, contributing to delineating the figure of the modern consumer. The business model for supermarket expansion is characterized from the outset by large commercial areas, which are very similar to each other: an aspect, this, which allows an easier and more efficient re-assortment of the various stores.

The development in the Milan area has been very rapid to the extent that several stores were opened in the city in few years. In 1961 signed the first opening also in Florence. The new paradigm of supermarket allowed, in 1964, the opening 16 more stores, 10 in Milan, 5 in Florence and 1 in Pistoia. During the same year, the brand with the long "S" was born, designed by a Swiss graphic designer, Max Huber.

In 1964 opened also the centralized warehouse in Limito di Pioltello, near the city of Milan, in which in 1987 was born a new completely automatized warehouse system. The company developed very quickly and expanded its business over the years. In 1990, the internal production of gastronomic products began, and in 1991 the General Merchandise (GEM) department was created, which added new items to traditional food products. Audio-video-photo departments and assisted perfumery were also created in the supermarkets. In 2013, the Parma plant was opened where fresh and filled pasta and baked goods are produced. In 2018, the exclusive Elisenda bakery was born, and in 2019 the new neighborhood format laEsse was inaugurated. Elisenda is the Esselunga's project of internally producing cakes and pastries in the Limito di Pioltello's plant, with the consultation of Enrico and Roberto Cerea, three stars Michelin chef and Vittorio's sons, founder of the homonymous restaurant.

The company over the years has strived to pursue a path of customer loyalty and perception of high-quality products and services offered. At the same time, many promotional campaigns have also been carried out with the aim of reducing product prices in order to show special attention to its customers even from the point of view of economic needs.

Esselunga is nowadays the leading company in the Italian retail industry. In terms of economic and financial performance, as reported in the 2022 Esselunga's Financial Statement [67], total sales in 2021 reached 8,561.2 million euros, signing an increase of +2.2% over 2020 (+2.9% was registered in 2020). Nevertheless, sales performance in the two half-years of 2020 was also affected by Covid-19-related effects that had penalized the first 6 months of 2020 while the second half of 2020 had benefited from fewer restrictions.

4.2. Multichannel approach

From the company's Financial Statement, it is said that as business model, Esselunga's organization is characterized by a strong centralization of procurement, production and logistics activities, which make it possible to guarantee freshness and quality of products delivered daily to stores and e-commerce warehouses.
The development and planning of promotional policies, as well as communication and marketing initiatives, take place through an ongoing analysis of the market, in relation to customers' purchasing power, their references and the demand for specific services.

Sales are managed on a multichannel basis to meet the needs of all customers. The structures of the Commercial Management and Quality Assurance Management periodically carry out inspections at the production facilities of suppliers of fresh and Esselunga-branded products. Subsequently, the Logistics Department organizes and optimizes the store replenishment system from production plants and processing and distribution centers. Customer contact is strengthened by the loyalty program, which attracts and retains customers through specific initiatives and additional services.

Esselunga in parallel with being a leader in Italian large-scale retail trade is at the same time a true Food Company, a direct producer of sweets, fresh pasta, bread, ethnic dishes, sushi, and many gourmet recipes in its own production plant. This vocation has been present since 1959, when the first factory was built to produce fresh pasta and ice cream and to roast coffee. Indeed, the company has, over time, been equipped with three in-house production and processing centers divided by commodity category, which receive raw materials from selected suppliers and, upstream of the processing process, carry out thorough checks to ensure quality and food safety by taking advantage of their advanced technologies.

In the figure below is represented the geographical breakdown of assets as of 31 December 2021.

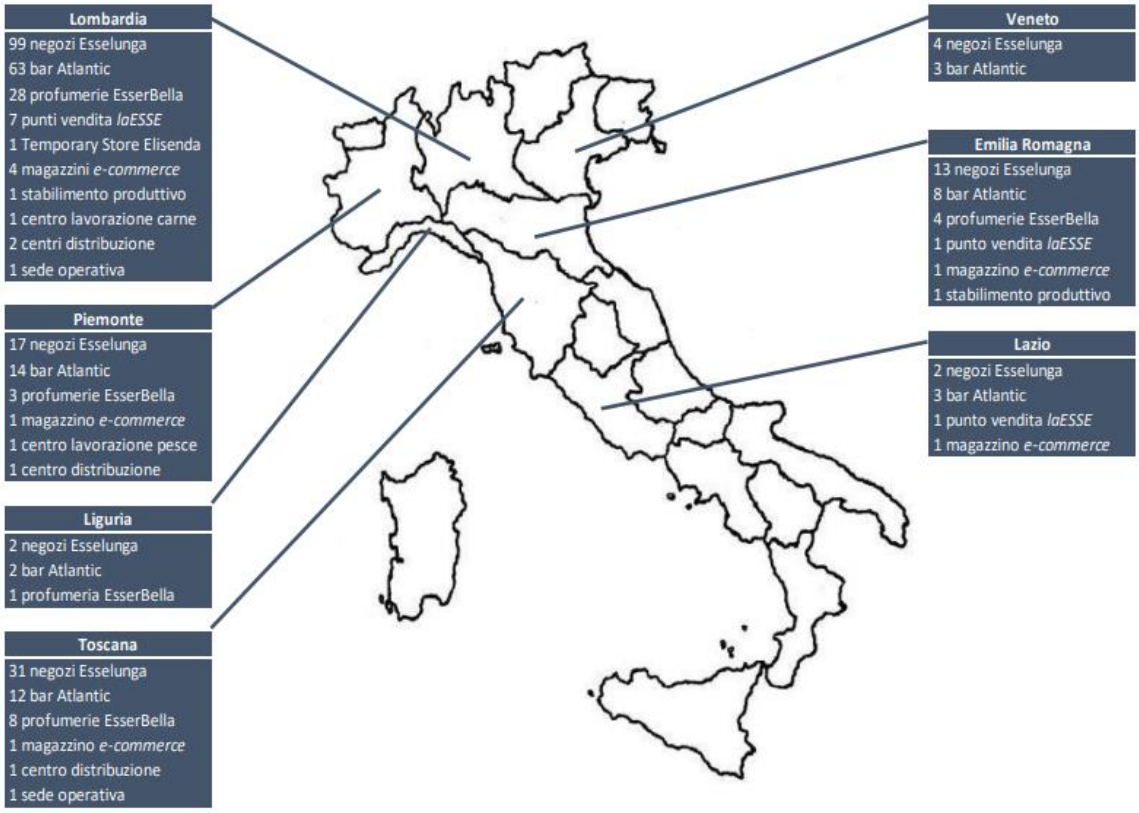

Figure 1: Esselunga's geographical breakdown

The three processing centers are located as follows in:

- Limito di Pioltello, for gastronomy, fresh pastries and meat;
- Parma, for fresh pasta lines, stuffed pasta and all baked goods;
- Biandrate, for fresh seafood processing and the preparation of sushi and ready meals.

Following the manufacturing process, finished products are checked and transported from production sites to Distribution Centers (Ce.Di italian acronym of "Centri di Distribuzione"). In order to maintain the values of craftsmanship and freshness even at these stages, foods are prepared and transported considering the daily replenishment needs of individual stores and e-commerce warehouses, thus ensuring the preservation of the highest nutritional and quality levels and enabling important reductions in food waste.

Centralized logistics ensures daily supply to stores thanks to the strategic location of the four Distribution Centers at Limito di Pioltello, Biandrate, Sesto Fiorentino/Campi Bisenzio and Chiari. All the Distribution Centers, with the exception of Campi Bisenzio and Chiari, and the Parma plant have automated warehouses, operating 24/7. The geographic location of the Ce.Di.'s makes it possible to cover all stores in a capillary manner and ensure rapid supply to them. The stores execute orders for all merchandise categories on a daily basis, even with the help of forecast systems for reordering individual references.

Through the company's Sustainability Policy report [68] it is explained how every day Esselunga strives to improve its customers' quality of life by offering an easy and pleasant shopping experience, with products of the utmost excellence and freshness and the highest quality of services, at the most affordable prices, online as well as in stores that are unrivalled on the market. The Group, since its foundation, upholds the value of acting sustainably in economic, social and environmental matters. Therefore, the Policy has been updated with the aim of promoting the integration of sustainability in the company's strategy and activities and it embodies the whole evolution process of Esselunga in the management of social and environmental issues.

The concepts of sustainability and circular economy are intrinsic in Esselunga's business model. It contributes concretely to the achievement of Sustainable Development Goals (SDGs) 4 and 13 of the 2030 Agenda, as common goals signed by the 193 member countries of the United Nations.

The main sustainability targets are as follows:

- Climate change: 30% reduction in greenhouse gas emissions by 2025;
- Education: more than 100 million euros in school supplies distributed to Italian schools between 2018-2025 through the "Friends of School" initiative.

Esselunga's sustainability strategy is indeed founded on 5 main pillars: Clients, Employees, Suppliers, Environment, and Community. Its main scopes are minimizing CO2 emissions, sustainable packaging, and waste reduction. One of the most important examples of this commitment is the fact that in the last 20 years, Esselunga eliminated secondary packaging by using 2 million reusable and washable cases in internal circuits. The company's sustainable packaging strategy is mainly meant to reduce, recycle and replace plastic mixed with other materials and to decrease the use of over-packaging. At the same time, Esselunga wants to ensure the quality of its products from the perspective of food security, ensuring an appropriate shelf life of its products and therefore reducing potential waste. By 2025, the Company wants to

ensure that 100% of Esselunga products packaging is made of compostable, recyclable, or recycled materials.

Esselunga pursues this scope by involving its upstream suppliers and their downstream consumers, using a scientific approach, also supported by the Life Cycle Assessment (LCA) method: Esselunga everyday evaluates the impact of its packaging choices through indicators, such as plastic and water consumption, CO_2 emissions, and circularity. In July 2021, Esselunga moreover joined the EU Code of Conduct on Responsible business and marketing practices in the food supply chain, one of the first tangible results of the Farm to Fork strategy, signing its commitment to some of the objectives published within the Sustainability Plan 2020-2025.

In addition, Esselunga has established its commitment to sustainability by joining the United Nations Global Compact, the world's largest initiative for sustainable development, founded on ten universal principles relating to respect for human rights, labor, the environment and the fight against corruption.

4.2.1. Brick-and-mortar stores

Esselunga has approximately 8.7% control of sales in Italian supermarkets and hypermarkets with more than 170 outlets present in the regions of Lombardy, Veneto, Piedmont, Emilia-Romagna, Tuscany, Liguria and Lazio.

Esselunga's organization in brick-and-mortar stores is divided into large and very large stores. In addition to having a greater presence in northern Italy, the company has made the strategic choice to locate stores almost exclusively in large cities or in their immediate surroundings.

Another key feature is related to turnover per square meter, which makes Esselunga an international best practice. According to the new edition of the Observatory on Italian and international food retail groups produced by Mediobanca's research area, Esselunga in 2020 has carved out an international record: it is first in the world in terms of sales per square meter, given that with 15.3 billion euros it precedes the British J Sainsbury and Wm Morrison.

The Supermarket, with a purely "food" inclination, has over the years expanded its range of products and services to other non-food commodities, such as perfumery and beauty items, newspapers and books, toys, stationery, intimate apparel, flowers, and photo development service.

Inside the stores there are actual production and processing departments, such as the delicatessen, where Esselunga's specialists prepare some of the ready meals with selected ingredients according to the most traditional recipes. In addition to gastronomy present in 163 stores with counters (161 traditional stores and 2 laESSE) and in 13 stores without (8 traditional stores and 5 laESSE), the sales network includes: 137 bakery departments, 168 meat departments, which carry out the processing and packaging stages, and 117 fishmongers, which offer fresh fish.

Esselunga Group Consolidated 25 sushi produced in the Fish Processing Center in Biandrate, and a wide range of Ready to Cook products. The offer was further expanded with the introduction of Elisenda confectionery in 115 stores (110 traditional stores and 5 LaESSE) and parapharmarcy in 34 stores. [67]

4.2.2. E-commerce channel

Esselunga's e-commerce service has been in operation since 2001.

The website *Esselunga a casa* is nowaydays Italy's first online sales site for physical products, with a continuous growth over the years. According to the 2021 Esselunga's Financial Statement, e-commerce sales registered an increase in the sales of 18 % with respect to the 2020.

The e-commerce assortment consists of more than 15000 reference of items including fresh products such as fruits, vegetables, meat, fish, dairy products, and delicatessen products. The groceries are packed a few hours before delivery and travel on refrigerated vehicles with differentiated temperatures (for frozen and fresh) to ensure compliance with the cold chain. Customers of the e-commerce service, in addition to taking advantage of all the discounts of traditional Esselunga stores, can choose from a wide range of dedicated promotions, such as reductions on the delivery fee and free gifts linked to the purchase of products online. In addition, to meet customers' online purchasing needs, Esselunga continues the expansion of the number of references offered on the e-commerce sales channel.

Esselunga's online shopping service currently covers 47 provinces and 7 regions, Lombardy, Veneto, Emilia-Romagna, Tuscany, Piedmont, Liguria and Lazio. In 2021 the service has been extended also in the western part of the Liguria.

The e-commerce sales distribution is divided as follows:

- From Central-warehouses, also known as Dark Stores, and Transit points;

- From Web departments in brick and mortar stores.

The web-side offering to the customers also expands throughout the use of Lockers and Click and Collect services.

The web stores are brick and mortar stores that together with the traditional selling, have added the web as service. There is no specific stock of item for web, but the goods picked are those in the aisles of the store. Now there are 96 Lockers and 25 Click and Collect services available for the customers distributed in the 7 regions covered. These two services have the peculiarity that, differently from the Home Delivery service, have no extra delivery costs for customers.

The Lockers are large "cabinets" divided into refrigerated cells, distributed mainly in the parking lots of the supermarket outlets so that people can choose the one closest to their homes. The customer selects a day and time slot to pick up and, simultaneously with the order sending, receives a QR code with information about the cabinets where his or her groceries have been placed. The QR code is the recognition tool for opening the cabinets.

The Click and Collect service allows customers to place orders online till 2 hours before the pickup, with the option of picking up their groceries directly by own car. The customer after placing the order can then go on to pick up the groceries at dedicated pick-up centers or at the Customer Service of the selected store.

The substantial difference between Locker and Click and Collect services is that while in the former case the customer independently picks up the groceries from the drawers, in the latter case he or she does not even need to get out of the car because Esselunga staff will load the requested groceries directly into the vehicle once it has arrived. The customer has until a few hours before pickup to place or modify the order.

The central warehouses of the retail e-commerce channel are placed among the 7 regions covered by the service as follows:

- 5 in Lombardy;
- 1 in Piedmont, in Nichelino (Turin);
- 1 in Tuscany, in Campi Bisenzio (Florence);
- 1 in Emilia-Romagna, in Castel Maggiore (Bologna);
- 1 in Lazio, in Rome.

Of the 5 central-warehouses in Lombardy, 4 are placed around the city of Milan and are meant to serve the city and its suburbs. The remaining one in Lombardy is located

near the city of Bergamo and is used both to serve Bergamo city and the province and to serve the areas of competence of 2 transit points.

Transit points are temporary storage points for goods arriving from the main warehouses. The use of transit points is intended to reduce the reach of the warehouses, which would otherwise be too large and risks of reduction in the level of service provided would be considerable. There are currently 12 transit points in use.

The transit points are distributed in the Italian regions as follows:

- 2 in Lombardy: in Piacenza and Brescia;
- 4 in Liguria: in Genoa, Albenga, Arma di Taggia and Sarzana;
- 3 in Tuscany: Livorno, San Vincenzo and Florence;
- 2 in Emilia-Romagna: in Cesena and Parma;
- 1 in Lazio, in the south of Rome.

The Brescia and Florence ones are traditional brick and mortar stores in which a dedicated zone is present to allow the parking of the van and the unloading of the truck. The transit point of Florence was not born for transportation needs due to high distances from the central-warehouse, but because Esselunga, from 2019, decided to serve the Florence' city center only with electric vans. In particular, Esselunga was the first company in Italy to use electric vans with zero environmental impact in the sector of e-commerce grocery home delivery.

As mentioned before, the transit points are used to serve as many regions as possible, without the investment of many central-warehouses. The transit points are then just a loading/unloading point. In this case, the truck coming from the central-warehouse is unloaded and the vans, parked in the transit points, are loaded with the customer' orders. Transit point locations are refrigerated to keep the cold chain of the products. Among the 9 central-warehouse, 5 of them are used to serve the transit points. The 4 center-warehouse located near Milan are not intended to be used to serve transit points. In particular, the following table summarizes how many transit points are served from each central-warehouse.

Table 1: Number of transit point served per central-warehouse

Central-warehouse	**#Transit points served**
Bergamo	2
Nichelino (Turin)	3
Campi Bisenzio (Florence)	4
Castel Maggiore (Bologna)	2
Roma	1

4.2.2.1. Capacity management

This paragraph will explain what activities are done daily within the management of the online sales channel.

The home delivery web service provided by Esselunga is very challenging to manage. The company's goal is to provide its customers with a high level of service, as is the experience within traditional supermarkets. Thus, the goal is to provide a service perceived by customers as quality service, as if it were an added value compared to the classic way of grocery shopping, so as well to justify the delivery cost that is charged on a basic basis.
On the web side, Esselunga home delivery service provides customers with the option of receiving orders over the course of an entire day, from 7:00 AM until 11:00 PM, through the division into 2-hour-long delivery time slots. Only in some cases the time window slots are even, with the beginning at 8:00 AM and the end at 10:00 PM.

In the web service, customers have visibility of 7 days in advance delivery ranges. This means that a customer can place both same-day orders or up to the following 7 days, at the same time. Customers can place orders with a minimum amount of 40€, in order to justify the delivery cost expenditures.

Recently, a fast delivery service, called Presto a Casa, has been activated as well, which allows customers to choose between time slots of only 1 hour, with the option of placing the order up to an hour before the start of the delivery time slot. This is an attempt by the company to enter the Quick Commerce market, which is having good results, but nevertheless is still in the developing stage. This service is currently active only on some areas of the Milan' city, from the warehouses of Dione Cassio and Settimo Milanese, but as the Esselunga's business sales director said, the aim is to expand the service to the major cities in which the company is present.

As previously mentioned, the areas covered by Esselunga's web service are many, wide and continuously expanding. Each warehouse has its own zone of competence, in some cases supported by transit points. Managing the relationship between supply and demand in all the zones covered by each warehouse at aggregate level would be almost impossible. For this reason, the zones of responsibility of the warehouses and transit points are divided into many small portions of areas, called delivery areas, into which several towns close to each other are inserted within. For each town, it is also

indicated in which streets the service is being opened. So, in each delivery area there is a list of streets that are aggregate in a single portion of area.

Regarding the business of home delivery, the activities that are carried out in order to manage the e-commerce business in Esselunga in the best possible way are the following:

- Capacity management with different time horizons;
- Delivery routes planning;
- Monitoring delivery vans and managing customer contacts.

If the last activity turns out to be purely operational in nature, the first two listed have a more strategic value. On activities of a strategic value will depend the effectiveness of operational activities.

The following chapter will focus on the second activity listed, which is the planning of delivery routes. Specifically, the tool used for planning will be analyzed. To properly understand what is meant by planning delivery routes, however, it is necessary to delve into the first point, capacity management at the different time horizon levels.

The time horizon~~s~~ considered in the capacity management are long term and short term. Long-term means a monthly or at most a quarterly horizon. Short-term means a daily, next-day, or even same-day view.

Long-term capacity management includes forecasting end-customer demand, divided by warehouses and transit points. This is a particularly complex activity because demand can be influenced by many factors. Some of these factors, such as seasonality, trend or cyclicality, are more easily predicted using models. Other factors, such as the outbreak of Covid-19 in 2020 or, more recently, the increase in positive cases due to the development of new variant forms, are very difficult to predict. All this aside, the prediction of the number of orders that will come in the next weeks must be translated into the number of delivery routes, considering also the number of means available and their different characteristics, and communicate to the delivery companies.

Esselunga in terms of the orders transportation part, last mile delivery, uses the services of third-party delivery companies. These delivery companies are responsible for delivering orders to end customers on behalf of Esselunga. While as for the picking part, which includes mainly restocking the warehouse shelves and preparing future

orders for delivery, the company has contracts with several cooperatives. The company's in-house operators are responsible for more value-added activities, such as the preparation of gastronomy, ready-to-eat, fish, and bakery products.

Communication of demand forecasting with a medium to long time horizon, therefore, has a twofold objective:

1. Communicate in advance to the delivery companies how many delivery rounds should be guaranteed, including an expected average value and a maximum weekly peak;

2. Properly sizing the warehouse staff, both picking and Esselunga.

These two elements require that the demand forecast be as accurate as possible. If, on the one hand, demand will be overestimated, costs will rise in the following weeks as a result of lower operational saturation. On the other hand, if demand will be underestimated, this will result in loss of potential sales and potential customers. The trade-off between supply and demand must always be managed to maximize profits.

For a company such as Esselunga, the balance of the trade-off will constantly be on the supply side, this is because it is much more important to show availability to customers even in the face of a slight increase in costs to be incurred.

The management of today for tomorrow, and today for today, consists of allocating a certain number of availability slots throughout the day and in different delivery areas. In operational terms today is called the day “A”, tomorrow is the day “B”, and so on. From now on, A x A stands for the management of today per today while A x B represents the management of today on a vision of tomorrow.

The people who manage short-term supply capacity must be skilled at constantly monitoring from the back-office, that is the back-end of the *Esselunga a casa* website, the progress of incoming orders, on which time slots and on which delivery area, on all the warehouses and transit points simultaneously because Esselunga's goal is to show as much availability as possible to customers in all the covered zones.

Based on the maximum number of daily round trips communicated in advance to delivery companies, the activity that can be carried out is to modulate the availability of the slots. For instance, moving slots from one delivery to another one rather than to another time slot.

On Day A, delivery companies are notified of how many delivery routes are scheduled to be made on Day B. This communication occurs at morning time, and it is useful for the delivery company to set up the personnel needed to satisfy the Esselunga's requests. Up to the time of official planning, this communication may be subject to change. Round trips can be added if there is a need for them, at the same time they can also be removed if there is no need for them, due to lack of incoming orders or as a result of optimization of the planning software. There is a continuous communication between Esselunga management and the delivery companies.

The activity of adding delivery trips is more limited in the context of transit points. These are served by a truck that carries the prepared orders within the warehouse to the transit point. The trucks have a defined capacity in terms of weight and volume, which is translated into equivalent number of vans that can be transported. In the case of the planned truck is not completely saturated, the adding of slots equivalent to a van from the back-office can be done without any worries. It might also happen that, faced with the complete saturation of the planned trucks, there would be an opportunity to add new availability to customers. In such cases, careful consideration must be made because the addition of new availability would mean using an additional truckload, which is particularly costly especially if it will not be fully saturated.

Short-term capacity management activity is carried out by people with strong field knowledge, because experience in these cases helps to know and predict customer behavior in advance. Some examples might be that central morning time slots receive more orders on average than central afternoon time slots, or that some delivery areas similarly receive more orders than others. Experience helps to know where and when to dare more, versus where and when to take a more cautious line. Moreover, for the daily short-term capacity management Esselunga has some tools that allow the real-time monitoring of the number of orders entered from the online platform during the day or in a period of time. This is a further help in the forecasting of what is going to happen for the following hours and days for the people who needs to handle the short-term capacity.

The next chapter will be dedicated to the explanation of the delivery routing plannings, an important activity done daily several times per day from the delivery e-commerce management. The explanation of this activity will be introductory to the description of Transport Management System software used for the planning, especially the root causes of the switch from an old to a new one.

5 Transporation Management System

Especially after the Covid-19 epidemic, Esselunga experienced a considerable increase in the number of orders from online channels. Due to the considerable costs involved in ensuring a quality home delivery service, an increase in costs was also observed, as can be observed in the company's Financial Statement for the year 2021.

The increase in the number of orders in 2020 prompted the company to invest even more strongly in the web channel. One of the objectives established at the basis of these investments has been the expansion of the areas served, combined with the concept of optimizing the available resources in order to reduce costs efficiently.

The expansion project was already began from 2019. Till the beginning of the 2019 Esselunga for the e-commerce had 2 main central-warehouse, in Milan and in Campi Bisenzio (Florence). During the 2019, Esselunga opened 4 central warehouses in a row. In the two-year period, 2020-2021, Esselunga opened 3 other central warehouses, reaching the amount of 9.

In order to make more efficient the planning activity, one of the many proposed investments was the development and implementation of the new Transport Management System (TMS) for home deliveries. The TMS is the software tool that is used to plan van routings. The routing of a van consists of the time sequence of delivery of a certain number of orders, in the most optimized possible way, according to certain constraints to be respected, in a single van. The TMS, substantially, is a software tool that has the task of solving in short time a large and complex optimization problem, in which the objective function is to minimize various parameters by translating them into costs by complying with constraints with a certain level of priority, while maximizing the number of planned orders.

Regarding the management and planning of delivery rounds, since 2020 Esselunga has decided to establish a centralized e-commerce operation headquarters. This operational headquarters has been named Control Room and is located above the central-warehouse in via Dione Cassio , in Milan, opened in the same year.

The second key activity mentioned in Section 4.2.2.1 performed by the Control Room is in indeed the planning of delivery trips.

Esselunga's e-commerce network, as previously mentioned, consists of 9 central warehouses and 12 transit points between northern and central Italy. A variety of vans depart from these points every day to deliver customer orders.

Every day, from the Control Room, the delivery schedules of all the van departing from central-warehouses and transit points are planned. Only after that the planning is done and sent to the warehouses can the system cascade begin, which has as its starting point in the preparation of orders in boxes by the picking operators, followed by the loading onto the vans of the boxes and the actual delivery activity to the end customers.

The sending of the planned rounds to the central-warehouses from the Control Room is divided into two times within the day. In the evening of day A, the morning rounds of the following day, day B, are planned and sent. Morning planning generally includes the morning time windows, starting from 7:00/9:00 AM until 3:00/5:00 PM in the odd case.

Delivery rounds that include the afternoon and evening time windows, from 3:00/5:00 PM to 9:00/11:00 PM, are sent on the morning of Day A for the same day in the afternoon. In addition to this, in order to provide customers with as much availability as possible for the same day as well, vans whose routing is sent by late morning are handled by the Control Room operators.

The 3:00/5:00 PM slot turns out to be in the middle of the day. This delivery slot in some warehouses is included in both the morning and afternoon vans, while in others it is left only for the afternoon vans as the first time slot of the trips.

To sum up, from the Control Room are planned and sent the routings for the orders to be delivered from the central-warehouses and transit point. The routings are sent in several moments during the day.

In general, for the central-warehouses the routings are sent in 3 times:

- In the evening of day A are sent the routings related to the morning of the following day (A x B);
- In the early morning of day A are sent the routings related to the afternoon and evening of the same day (A x A);
- In the late morning of day A are sent the routings for the last evening exits of the same day (A x A);

For the transit point, due to the less flexibility in the capacity management, the routings are sent in 2 times. The majority are sent the evening of the day A for the activities of

day B (A x B), but some of them are also sent the morning of day A for the afternoon and night deliveries of the same day (A x A)

From this data, the activity of routing planning through the TMS other than being delicate and strategic for the company, it is also time consuming for the quantity of routings to be planned and for how many times during the day they must be generated.

Scheduling and delivery of routings to central-warehouses are done by adhering to agreed schedules for several reasons. Aside from ensuring a quality level of service to final customers, the main reasons can be summarized as follows:

- Enable central-warehouse picking departments to prepare planned orders on time, avoiding both hours of downtime and rush work;

- Indicate to the central-warehouse where to place the boxes containing the goods to be delivered and the van ready for the loading phase, in order to better manage the space available especially within the central-warehouses;

- Provide to delivery companies drivers with a sequence of order delivery with criteria in order to deliver the orders to the customers on time with respect to the time slot booked, by completing the task in the shortest possible time, having also traveled the shortest distance.

Routing planning has been done for years, from 2009, with the same software. Esselunga's e-commerce expansion project has caused an increase in planning activities to be done. The increased volume of activities to be done exposed more of the limitations of the old system, which were the starting point for the development of the new software. The following paragraphs will describe both software used, with an analysis of the limitations of the old software and an explanation of the development activities that are continuously carried out to optimize the new software step by step.

5.1. Previous Routing System: PTV SmartTour

In this paragraph will be described the old software used by Esselunga for performing routing planning. A section regarding the pros and cons of the system will be the introductory part of the new Transportation Management System adopted by the

company, as the cons of the old system have been the first remarkable points to be overcome by the new software.

5.1.1. Description of the software

PTV Group is a german-based company with several offices in Italy. The company provides software solutions and consultation services for planning and optimizing transport logistics, from transport scheduling to route planning till the last mile to customers.

PTV was the external provider of the software that Esselunga requested as an adaptation of another software provided by PTV, according to the requirements of a software useful for planning last mile delivery routings. This software adaptation, namely PTV SmartTour, was one of the first software used by the company in the area of planning orders for delivery since it made the decision to enter the world of e-commerce home delivery, in the early 2000s.

In the early years of the new millennium, that coincide with the first years of Esselunga in the e-commerce, the concept of home delivery was not fully spread among people. Online orders as a consequence were getting to low volumes. Over the years, the e-commerce channel has developed and reached higher and higher volumes. Each year there has been a gradual growth in the turnover of the online channel. [69]

The system underlying the operation of PTV SmartTour as planning software is the composition of delivery vans. Van composition refers to the distribution of orders according to time windows, the so-called CMAX. This system is still the logic that guides the loading of availability slots on the back-office, that is the back-end of online website showed to the customers. After years of Esselunga experience in the home delivery field, has been set an agreement with the delivery companies about the maximum level in terms of the number of orders that can be allocated in a single van. Based on this, different CMAXs are created and loaded as slots of availability for customers in the back-office.

These were the steps that planners followed to do a complete routing on PTV SmartTour:

1. Import incoming orders from customers through an external application;

2. Select the necessary CMAXs by indicating the number of corresponding vans to be created, based on how the availability slots in the different time slots had

previously been created on back-office. This step was essential to indicate how many customer orders from the same time slot could be allocated in a single van; (Figure 2)

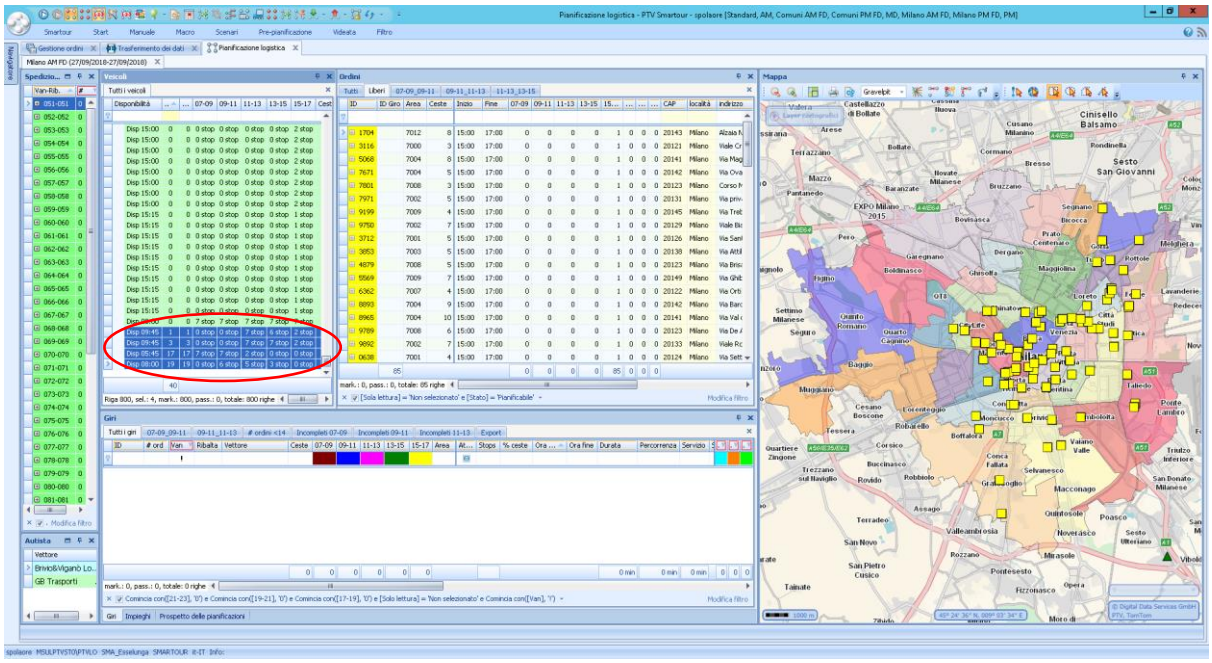

Figure 2: C-MAX and quantity of van selection

2.1 In cases where vans were also planned to be scheduled in the Municipalities' areas, differently from the City ones, appropriate C-MAXs that also took into account delivery area shares had to be selected from the folder “Condivisione” (Figure 3). Basically, specific vans had to be used that had within them the ability to go to multiple shared delivery areas. Once the appropriate CMAXs and amount of van needed were selected, the optimization algorithm could be launched. There were two separate algorithms to optimize the delivery areas separately for deliveries in the City and Municipal delivery areas.

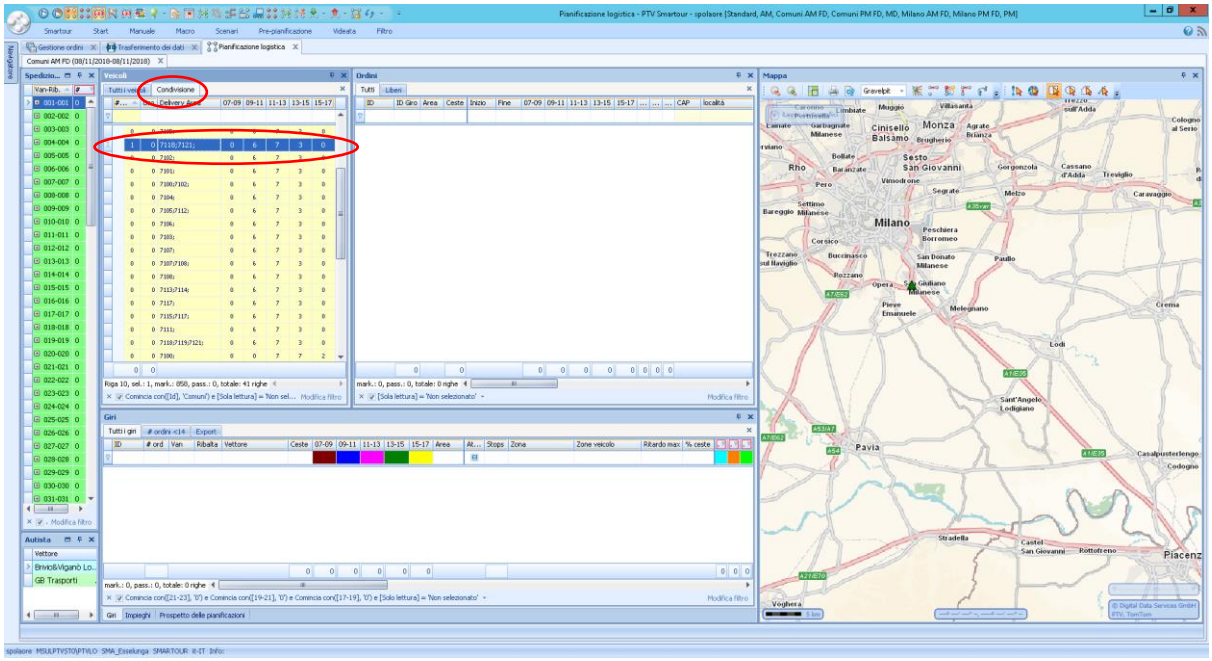

Figure 3: Municipalities' area van selection

3. Once the execution of the optimization algorithm was finished, graphically the following indications were presented (Figure 4):

   - Planned trips amount, with the indication of the distribution of the orders in the time windows (Figure 4, bottom side);

   - Not planned orders, with the indication of the belonging delivery area code and time windows (Figure 4, upper side);

   - Graphical representation of the planned trips in the map, with a difference in the color according to the different time windows (Figure 4, right side).

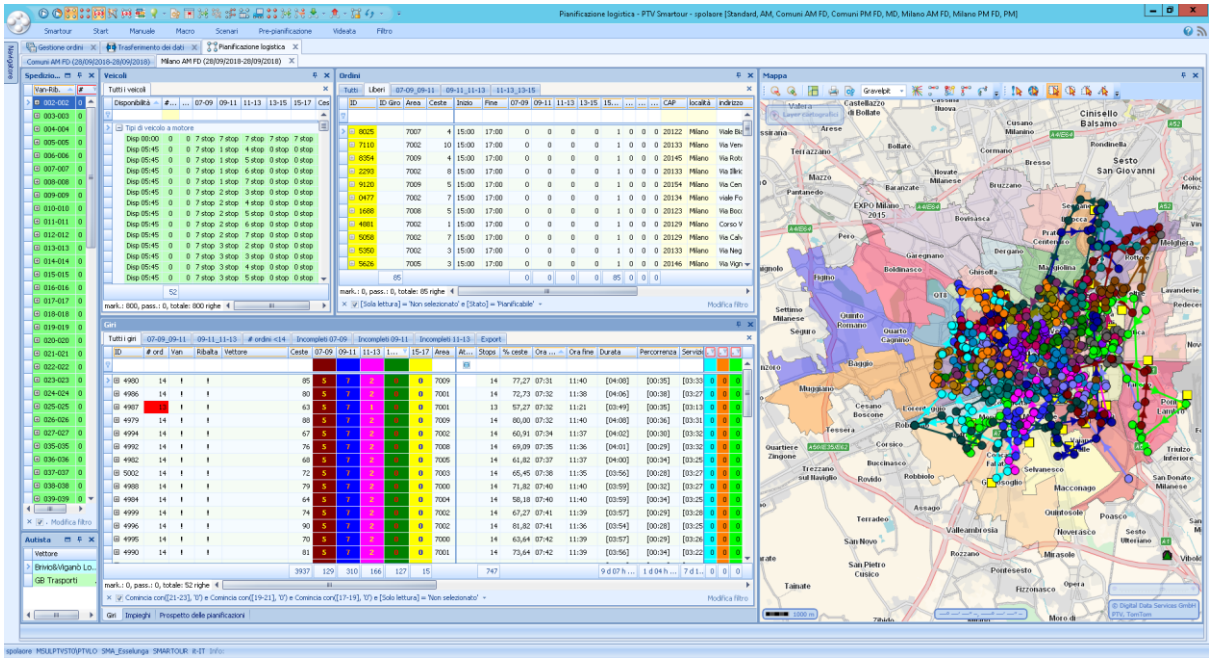

Figure 4: Graphical representation after algorithm running

To place the unplanned orders inside the appropriate vans, it was necessary to select them and drag and drop them inside the considered not completely loaded van, helped also by the graphical representation of the tour in the map. A van was considered as not completely loaded in the case in which the software had allocated less orders in comparison with the C-MAX set. To get a better optimization of the route, it was possible, later, to optimize the sequence again through a specific button. This functionality aimed to minimize the overall distance of the delivery round by creating an appropriate sequence respecting the time windows of the orders.

4. Once the routes were totally completed, an identification number and a corresponding loading door had to be assigned manually for each route. These two indications are useful for warehousing and monitoring: the number is used to indicate which orders should be kept together on a single van, the loading door is used to indicate to the picking operators where exactly to place the boxes and van for the loading phase.

5. Similarly, it was necessary to manually assign to each route created, the delivery company that will be the one in charge of delivering those planned orders on that van.

6. When the work was completed, all the routes had to be highlighted and exported through the same external application used during import.

5.1.2. Pros and cons

PTV SmartTour had the main advantage in that it matched perfectly with the logic of slot loading on the back-office, based on the C-MAX. Therefore, at the planning stage, by setting up the required vans with the same logic as the loading in back-office, there was virtually certainty about where the orders would be allocated. In the case in which the system did not plan any orders, the planner in most of the cases knew which van to put them on.

Beyond this, another benefit of this software was the graphical display of the map. The map graphics were remarkably detailed and allowed a graphical indication of the different delivery areas based on the color.

In addition, the different coloring of the orders according to the time slot they belonged to, was a great help in placing the order in the most correct position within the sequence created and in visualizing the final sequence.

On the other hand, the limitations of the system were several, which ultimately did not allow to achieve levels of accuracy that were in line with the growth of the e-commerce channel.

These limitations could not be overcome by PTV SmartTour and can be summarized as follows:

- The weight and the volume of the orders were not taken into consideration;

The fact that the optimization algorithm did not take into consideration the weight and volume of orders to be planned as limiting constraint was probably, among all, the greatest limitation of the system. This aspect limited the concept of saturation, i.e., van fill rate, only on the side of the number of orders planned within the same van.

- There was no distinction between types of means available, in terms of available capacity to be loaded;

The only distinction between the van within the system was basically on the type of C-MAX to be used and the note on which delivery area could go. It was understood that C-MAXs that comprised fewer deliverable orders corresponded to van types with less range, weight, volume, and battery life available.

- The hours of a single van's delivery activity could not be limited, combined with the fact that the system did not consider a defined time for loading and unloading the van;

The algorithm logic sought to optimize the delivery sequence by minimizing the travel time with the following restrictions:

  - The central-warehouse or transit point was to be both the starting point and the return point of the trip;
  - The orders to be planned were to be enclosed in the delivery areas enclosed in the C-MAX setting of the van;
  - The maximum number of orders to be allocated per time window.
  - Compliance with a delivery time to customer derived from an external algorithm based on the number of boxes, its weight, and the information coming from the profiling of the customer.

By not having time duration limits, the system could potentially go so far as to consider excessively long work durations.

Another drawback of the system was the following:

- The time to complete routings in the software was too long.

In the procedure for doing routings described in Section 5.1.1, it is immediately apparent that there were not a few steps to follow and were all manual. The manual steps unfortunately often led to excessive time wasting.

All these negative points mentioned above, were the elements that had been driving Esselunga to think about investing on the project of changing the TMS for years.

The increase in orders from the e-commerce channel, especially after the COVID-19 pandemic, further drove the need to raise the company's standards, which resulted operationally in the design of a new, more optimizing and accurate TMS, which will be described in the next paragraphs. The requests in the initial phase of the research for a new software focused mainly on overcoming the above-mentioned cons of PTV SmartTour.

5.2. New Routing System: ORTEC Routing and Dispatch

The solution that Esselunga chose to overcome the limitations of the previous routing system is the software ORTEC Routing and Dispatch, provided by a Dutch company, ORTEC.

ORTEC is a software and consultancy company operating around the world leading supplier of mathematical optimization software and advanced analytics for, amongst other, workforce planning and vehicle routing.

The followings paragraphs will be dedicated to a description of the new Transportation Management System provided by ORTEC, together with its pros and cons.

Furthermore, since it is a new software and needs to be tuned step by step, there will be an explanation of the work of ongoing adjustments carried on during the last months, specifically after April 2022.

These ongoing adjustments, implemented in parallel with the switch of all Esselunga central-warehouses and transit points from the old to the new routing system, brought results that will be presented in a related section.

5.2.1. Description of the software

The Transport Management System software proposed by ORTEC is the one chosen by Esselunga to mark a change and to enhance company' standards regarding the e-commerce sales channel in the field of delivery route planning. As the delivery e-commerce manager stated, the first objective for the route optimization is to maximize the number of orders planned, whilst minimizing the planning cost adhering to some business rules set as constraints to be respected. The second objective, more of an operational nature, is to have an efficient routing system, easy to use by the planners and quick in the execution of the planning optimizations.

As a sub-objectives, the route optimization includes:

- Minimization of the total number of used vehicles;
- Minimization of the total working hours.

The minimization of the total planning cost is achieved because the cost of a single shift is based on the fixed cost per shift, the cost per kilometer and the cost per hour of delivery activity. The software, furthermore, makes differences according to the van typology. Different costs can be setup accordingly to the resource type.

The visualization of the system, as it has been initially presented by ORTEC, is composed of three main graphics: (Figure 5)

- The orders' graphic, in which are displayed some main information about the orders, planned or to be planned, as the order ID, the weight and volume (in terms of boxes), the delivery area code, the stop task duration (the time needed for the delivery as the difference between the departure and arrival times of the van from the delivery location), the delivery city and some more customizable data;

- The route templates' graphic, in which are displayed all the shift templates as resources available to be used for planning;

- The routes' graphics, in which are displayed all the shift templates, planned or to be planned, rolled out for a specific date from the available shifts in the route templates graphics.

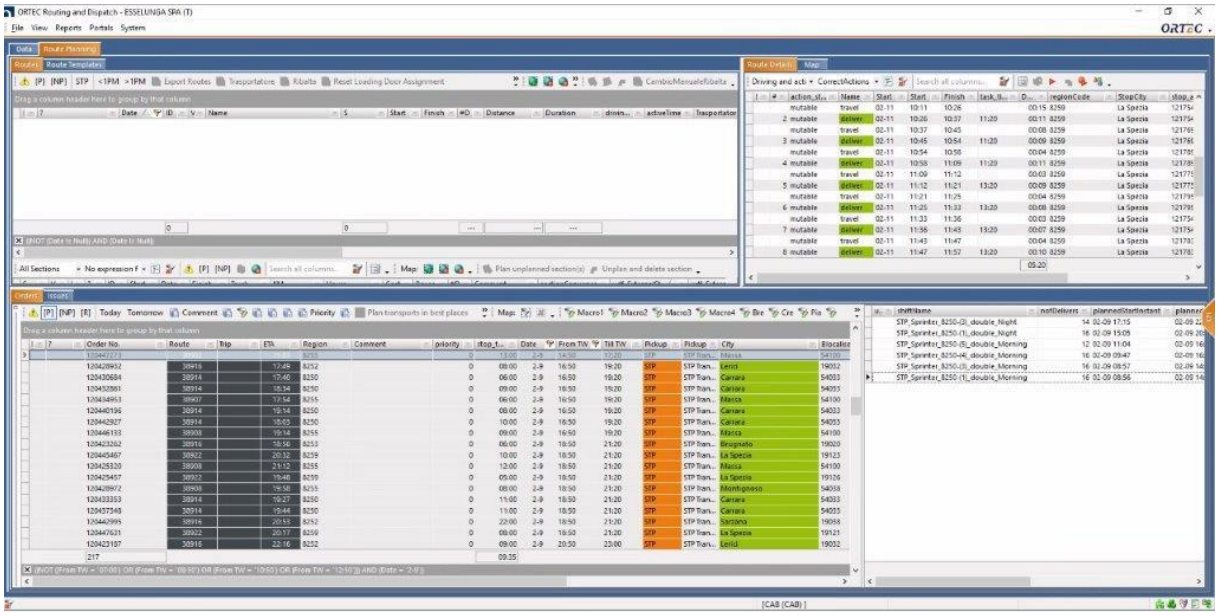

Figure 5: Initial software visualization (Orders and Routes graphics)

Based on the number of delivery time windows and the number of actual exits from the depot during the day, two types of shift template were ideally created:

- Double shift templates;
- Triple shift template.

Doubles are those vans that go out on delivery twice during the day, taking orders from three delivery time windows. Triples, on the other hand, go out for delivery three times during the day, but only cover orders of two-time windows. The Triple typology has been designed basically for two reasons:

1. To be able to have, with equal resources employed, the ability to deliver more orders during the day. Made X the amount of orders potentially allocable on a van, Double going out twice can deliver an amount equal to 2X, Triple instead 3X;

2. To cope with limitations inherent in the available vehicles. For example, some electric vehicles have both reduced range of battery life and less capacity to be loaded, so it was appropriate to shorten their delivery activity.

The first step on the TMS was to create the amount of resources over each central-warehouse and transit point in such a way that all the physical resources were represented. Each shift resource could have associated the Double or the Triple configuration. The Double configuration is divided into Morning and Night typology, while the Triple one is divided into Morning, Afternoon and Night.

Basically, the vehicle with Double configuration are those which can make deliveries in more faraway delivery area from depot, whilst the vehicles with Triple route configuration deliver close to depot.

Regarding the shift templates, the system has been set up in such a way that:

- There are no duplicate routes of the same resource with the same activity time span;

- There is no overlap between the delivery routes of a same resource. For instance, the Morning route and the Afternoon route of the same resource, otherwise the activity of Afternoon route will take as earliest start the time in which the Morning one will be ended its activity.

The following list represents all the business rules the model considers as constraints during the routes' optimization planning:

- The optimization is performed only on the selected routes and the selected orders;

- Each order from the import has one given pickup location and one given delivery location. Transport data are considered fixed. The pickup locations are the central warehouses or transit point whilst the delivery locations are the customers' home addresses;

- An order has a specific date and an earliest and latest delivery time in which needs to be delivered to respect the terms and conditions reported in the *Esselunga a casa* website;

- Orders imported in one warehouse cannot be combined in the same trip with orders belonging to another warehouse;

- Travel times are calculated based on the road type and the average speed for that road type. Travel times are precalculated by the map provider and can be further modified by the historical congestion data;

- For the calculation of the loading/unloading time of the boxes on the vehicles, the optimizer considers a fixed customizable time. This handling times have been calculated and set on the driver activity time considering the necessary times for the vehicle positioning, for the loading and checking activity performed on the loading door and finally for the unloading activity concerning the empty boxes or the boxes not delivered;

- The delivery unloading time, namely the stop task duration to the customer, is treated by the software as a fixed time per delivery stop. This time comes from an algorithm external to the routing software. This time represents the time to perform any parking as well as the actual unloading of the goods from the vehicle, taking into consideration the unloading location (floors, elevator presence etc), the number and the weight of boxes to be unloaded;

- All the shifts are provided with a known vehicle profile. The vehicle resource has a configuration assigned to it for the optimization to use for planning the correct volumes. For each vehicle typology there is the possibility to set the maximum constraints in volume and weight. The unit of measure of weight is kilograms, while the volume is translated into number of boxes. The weight of the orders will take into account also the boxes weight. Each empty box has a fixed weight of 2.2 kilograms.
  In route optimization planning, the optimizer considers that the total amount of the orders loaded of the shift template does not exceed the capacity of the resource, weight or boxes, whichever is reached first;

- Some resources are only allowed to visit customers in specific plan regions. For each shift template there is the possibility to assign an unlimited number of delivery areas. The optimization considers only plan regions for which each shift can deliver orders to allowed plan regions. For example, it may be the case in which only electric vehicle can do deliveries in city center streets to respect city regulations;

- Resource must start and finish their route at the same depot, central-warehouse or transit points, where the loading phase take place;

- There is the possibility in the roll out shift templates phase, for each one, to set an earliest start time and a latest finish time, during which the delivery activities must be performed, in a specific date;

- The optimizer must respect the maximum allowed working time per shift route;

- Roads can be blocked via the map editor. The optimizer will not use these roads, once they are blocked. There is also the possibility to specific for which type of vehicle these roads have been prohibited;

- Segment road speeds can be edited even if this activity it is not suggested. The road speeds can differ according to the vehicle profile;

The optimization is based on an algorithm that translates all the variables into a cost calculation which must respect at the same time all the aforementioned business rules.

The optimization objectives are the maximization or minimization or some parameters as follows:

- Maximization of all the selected orders to be planned, that is, plan as much orders as possible;

- Minimization of the penalized plan costs. This point can be translated into the minimization of violations during planning. System violations can occur when the business rules are not respected.

  There are 2 main types of system violations:
  - Time violations, occurring when orders' time window are not respected resulting in late deliveries, or when shift routes overcome the available time set;
  - Payload violations, occurring when the orders planned in a single shift overcome the weight or the maximum number of boxes set as constraint for that vehicle kind.

- Minimization of the number of planned vehicles;

- Minimization of the shift worktime;
- Minimization of the total distance.

The planning cost includes as the cost per vehicle used, the cost per kilometer and the cost per hour. The costs have a different weight according to the priority level assigned in the objective function.

5.2.2. Pros and cons

The first months of operational use of the new software have helped to delineate a picture of what are the real positives and areas for improvement in the system.

The new TMS software provided by ORTEC Routing and Dispatch has many pros compared to the previous, PTV Smart Tour, but there is also room for further improvements.

The most important pros of the new system can be listed as:

- The consideration of the order volumes and weights in the optimization algorithm as limiting constraints;
- The consideration of capacity limits in terms of maximum boxes and weight to be stored per vehicle profile;

  This is a real step forward compared to the previous one. Previously the orders allocation inside a single van had as main rule to be respected the C-MAX, meaning that the goal was reaching the fixed maximum number of orders inside the van with the order time window as only fixed constraint. The allocation respecting only the C-MAX could cause some problems in the loading of the van, especially in the case when among the orders there were some with a high number of boxes or weight. There could be real space problems that in some cases during the year lead also to use more vehicle compared to those planned.

- The optimization algorithm considering all the delivery area of the central-warehouse/transit point;

  In PTV Smart Tour, together with the C-MAX there were, as already mentioned, differences between the delivery area. Indeed there were for instance two different optimization algorithms for city and other delivery area. This was a great limitation of the previous system. There could be the case in which two orders located in the borders of two different delivery area, were not being allocated in the same van just because the delivery area restrictions.

  This is something that is overcome by the new TMS. In each shift template can be assigned from one to an unlimited amount of delivery areas of the corresponding depot or transit point. Generally, it is worthy to insert as many delivery areas as possible in the shift template because in this way the algorithm has a higher optimization span.

  It may be the case of electric vans, for instance, that have shift templates with less delivery area inside, in order to restrict the possibility of allocating orders in delivery area closer to the trip starting point or delivery area in which is mandatory to go with electric vans as for some of the city centers.

- The possibility to limit the resource activity in time;

  In the loading phase of the shift templates, a start time and a finish time can be set. These correspond respectively to the earliest time at which the resource can start the loading activity and to the latest time at which the resource must come back at the depot. It is very useful to set these times, considering that in most cases the same resource of the morning activity must come back in time at the depot in order to start the night delivery activity. It is of fundamental importance to start the activity in time. For each minute of delay in starting the activity after the planning time, the probability of late deliveries enhances. Late deliveries are something that Esselunga cannot tolerate, because the customers perceived it by bad delivery service.

- The system possibility to be customized;

The possibility of great customization is a peculiarity of the TMW provided by ORTEC. The customization is basically from two points of view: the graphic design and the constraints to be set.

Regarding the graphic design, ORTEC leaves the possibility of selecting as many details to be displayed. The details information can be shown in such a way that the planner prefers.

Regarding the constraints part, ORTEC gives the possibility of creating many business rules, called rule group in the software, to be assigned in a second moment to the shift templates. In case of not respect of rule groups, the system gives as output some violations, as for the time and the payload violations.

Some of most useful rule groups requested by Esselunga are:

- Maximum stops per shift as the maximum amount of orders to be allocated in a single shift template route. The weight of the penalized cost in the total planning cost associated with the allocation of more orders than set up, can be parameterized;
- Maximum working time of a resource in minutes terms. The weight of the penalized cost associated with the late working time can be parameterized.

There are still many others rule groups available but are yet to be used. These two have been enough so far.

- The immediate graphical display, through icons, of what violations to business rules are found in planned shifts;

The basic assumption is that the algorithm does not tolerate any violations in the planning, because the minimization of the penalized cost is the second priority cost to be minimized.
Having the ability to set limits during optimization is a good thing, but at the same time in some cases it can collide with the company's requirement to deliver and therefore schedule orders on the resources at the moment available. Hence, it may happen that optimization leaves some orders out of the schedule,

for various reasons. These orders can be entered manually by planners within the planned shifts. Once the orders have been inserted in the routes, ORTEC allows the shifts to be reoptimized through a specific feature. Manual order entry can often lead to the creation of some violations, compared to the established rules.

- The traffic congestion coefficients;

  For the calculation of the travel times the optimization algorithm can have the possibility of taking into consideration different traffic coefficients on the average road speeds. These traffic coefficients are the results of historical data and they can be continuously updated in the software.

A limitation of the map provider is instead that the optimization algorithm does not consider live traffic, road maintenance or restriction data or something that cannot be predictable, as strikes for instance, as well as the considerations of the toll costs in the total planning cost of a shift.

The main drawback of the software, as reported by the Shift Supervisor of the Control Room e-commerce personnel, is the map utilization.

The map display appears not iterative at all. It appears slow in the update and difficult in the navigability. This is the one area where the old software had an advantage.

The purpose of the map visualization would be the display of the planned routes graphically in such a way to aid planners in the manual entering of the orders within the trips, according to the delivery area and the time windows information. This would be an important aspect on which Esselunga, together with ORTEC, is working on the development of the tool.

5.2.3. Ongoing adjustments

The transition from PVT Smart Tour to ORTEC Routing and Dispatch was gradual. The process took nine months, from January to September 2022, where at about monthly intervals all the warehouses with their respective transit points were switched over to routing planning with the new software.

In between the handover of one central-warehouse to another, test planning had to be done so that appropriate constraints could be set to the condition of each warehouse. Each warehouse has its own peculiarities.

During these months of transition, a software development activity was furthermore carried on in parallel, refining little details derived from experience. The new software needed further improvements and adjustments. For this purpose, from April 2022, Esselunga installed a new staff member fully dedicated to this project. The goal was to take all the feedbacks from the operational activity performed by the planners through the software and to translate all of them into operational requirements and updated to be installed to improve the system and its performance outputs.

The interlinked development goals set at the beginning in April were:

- Enhance the service level to customers;

Increasing the service level has been translated into an attempt to reduce late deliveries to final customers. This purpose has also coincided with increasing the feasibility of delivery trips from the drivers point of view.

- Simplify routing planning tasks for Control Room planners;

On this regard, the initial goals were on the one hand to introduce updates to speed up the delivery time of planned routings to the warehouses, and on the other hand to minimize manual iterations during route optimization. The latter point was deemed as necessary to take full advantage of the software's potential to avoid potential human planning errors.

- Improve business cost performances;

Improving cost performance was necessarily included among the goals of ongoing system development as a tangible measure of the outcomes of the first two purposes mentioned above. The process of cost efficiency was measured in the various warehouses mainly by the daily calculation of planned orders out of the total number of vehicles used, by the calculation of the average kilometers traveled between one customer and the next, by the calculation of the average time between customers and by the number of late deliveries.

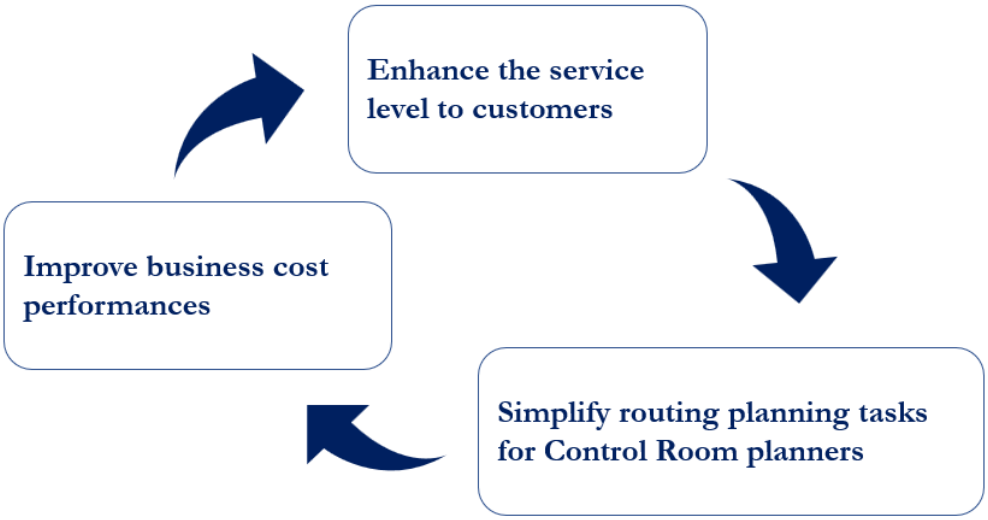

Figure 6: New TMS ongoing adjustments' goals

The translation of the system needs into required developments led to the introduction of the following updates within the software:

- Specific graphic filter configuration on each depot;

A series of graphical filters have been created, within each department's page, on the three system graphics. On the order graphic, on the shift template graphic and on the shift planned or ready to be planned graphic.

The filter configurations created for on the three graphical parts for each warehouse page allowed for much easier and graphically immediate navigation within the system. Each warehouse page has its own filters.

Filters were created on the necessary items to be selected such as (Figure 7; Figure 8; Figure 9) :

- The vehicle typology;
- The shift template typology: Double (2X), Triple (3X), Morning (M), Afternoon (A), Night (N);
- The central-warehouse and transit point belonging to the same department.

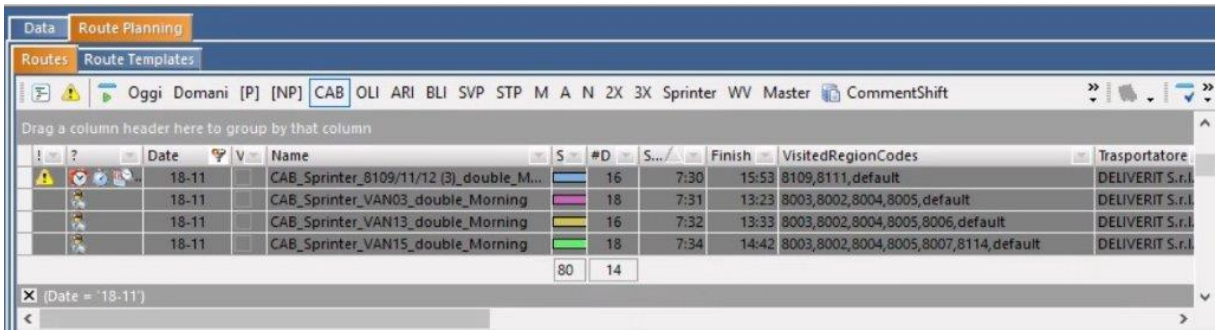

Figure 7: Routes' filter configuration tab

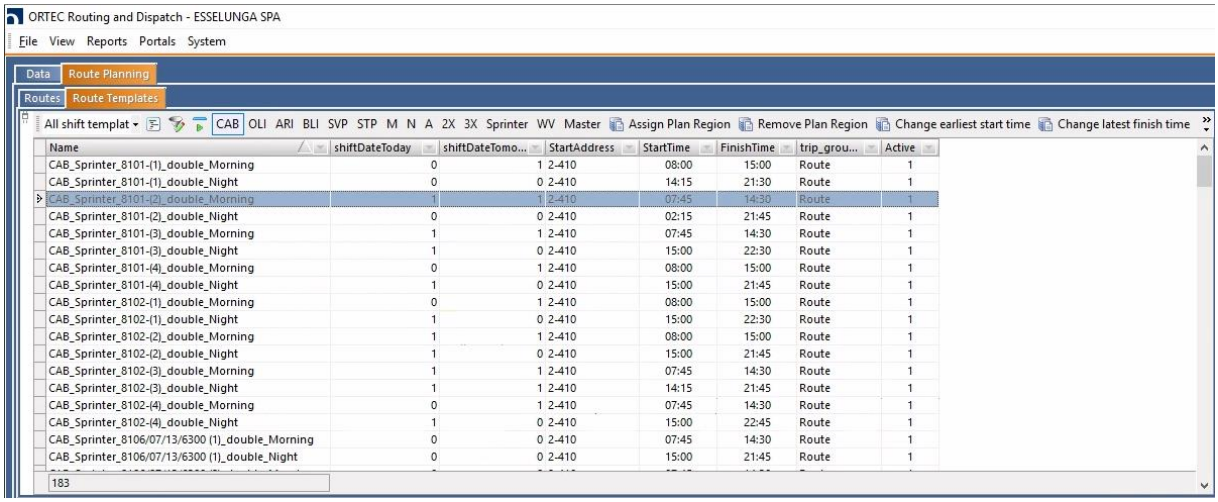

Figure 8: Route Templates' filters configuration tab

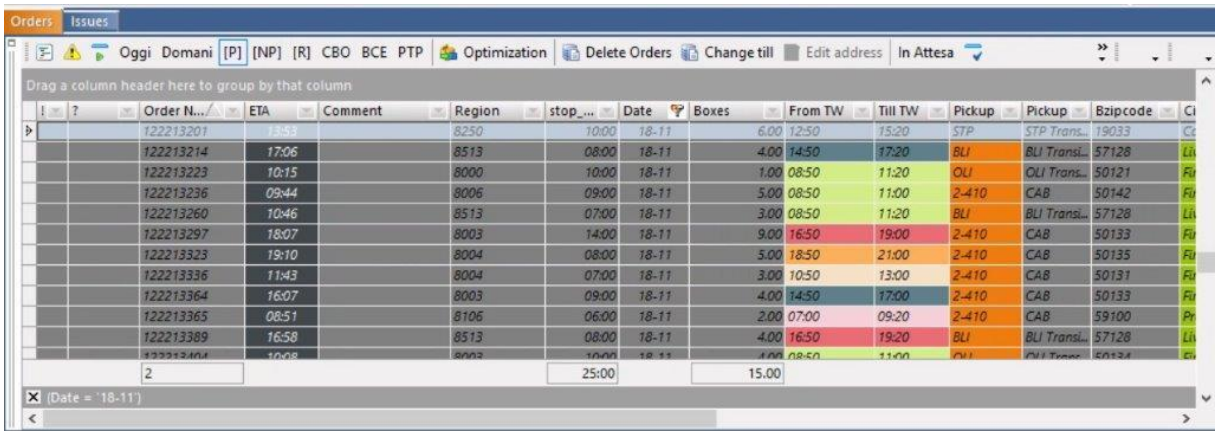

Figure 9: Orders' filters configuration tab

- A new column in the orders grid (Figure 10);

The purpose of this new column deployment has been to help the planners in the manual inserting of not planned orders in already planned shift. Basically, by selecting

the not planned order in this new column it is displayed the time windows at which all the already planned shifts for the same day visit the same delivery area of order to be planned. This simplify a lot the planners' activity since it is only request to them to search for the planned shift which goes in the delivery area at the most appropriate time window and manually insert into it in the correct position of the sequence.

Figure 10: Column of Time Windows visited

- Different color of orders based on the time window in the orders grid (Figure 11);

Differentiating orders graphically according to the time window they belong to helps to know immediately how to treat the order. In addition, after the route optimizer has created the order delivery sequence, it can be useful to check even only graphically whether the constraints of the time windows have been correctly met.

Figure 11: Time window' order grid color

- Time window initial and final tolerance according to the delivery area in minute terms (Figure 12);

During the import of each order, in compliance with the contractual rules as explained in the *Esselunga a casa* website, some tolerances in terms of minutes are set on the delivery window start and finish.

However, this update allows for the ability to manually set directly on the software the tolerance of the beginning and end of the time window (Figure 11) . This request was intended to limit the allocation of a certain number of orders per time window, as it has been verified that too many orders within the same time window were not feasible for the drivers from a human perspective and simultaneously increased the probability of late deliveries. The reduction of the time window was necessary, especially for the city delivery areas in which the route optimizer tends to allocate orders more easily, due to the small distances between customers.

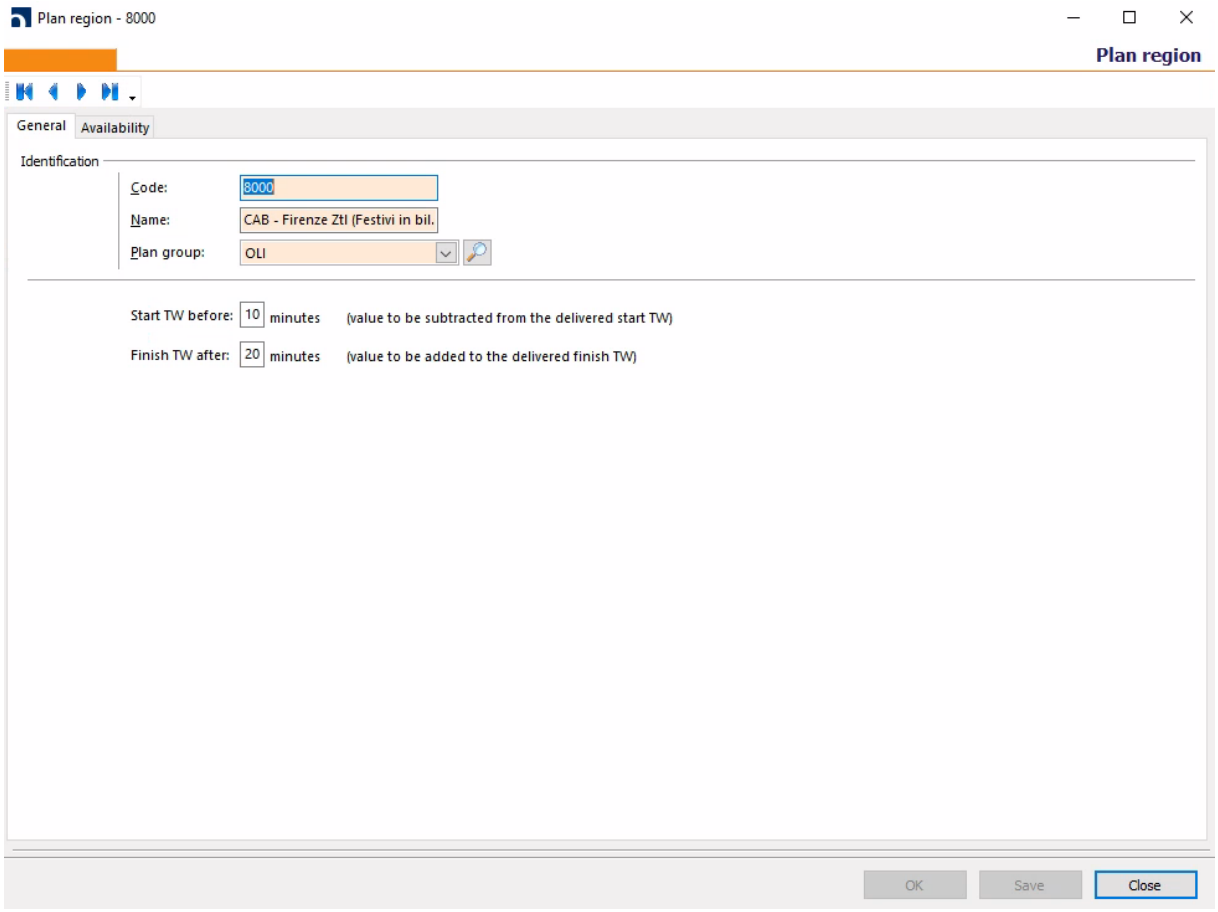

Figure 12: Start and Finish time window tolerances

- Rule groups for maximum stops per shift and maximum working time for resource (Figure 13);

These rule groups were created and manually associated with the shift templates of each van starting point as needed.

Limitations on the maximum amount of expenditures that could be allocated on the same shift were since optimization tended to allocate many orders on the same van, especially in city areas. Since it is counterproductive for Esselunga to increase van saturation at the expense of customer service level and the expense of human feasibility of delivery rounds, limiting the order allocation in some cases was necessary.

The limitations on working time are mainly due to two reasons:

- Contractual constraints agreed upon with delivery companies to be observed;
- The requirement for the same physical resource, a vehicle or even the driver, to do both morning and afternoon delivery activities.

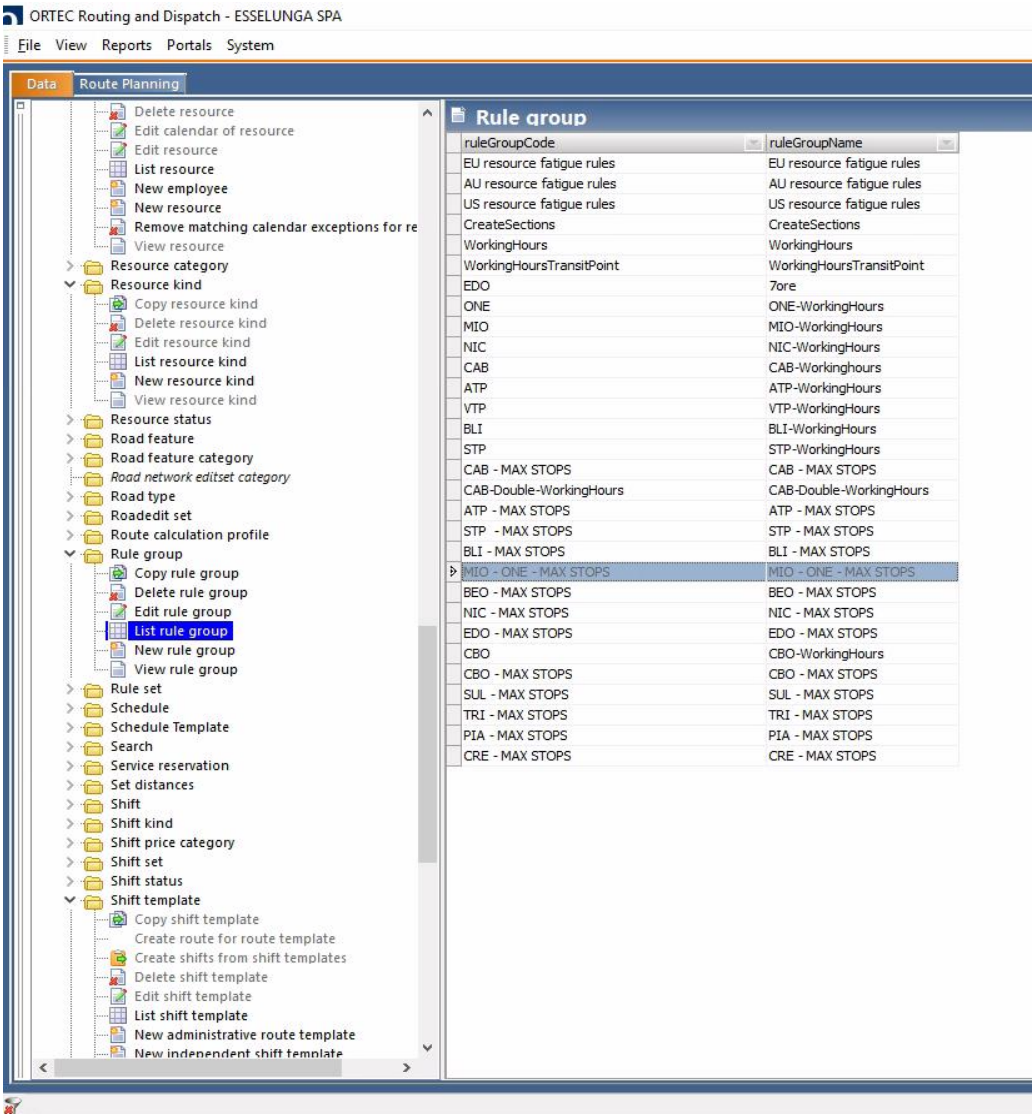

Figure 13: List of rule group created

The implementation in the software of these operational adjustments took place, as mentioned earlier, starting in April 2022.

During the following months, positive results were obtained after the implementation of these changes. These positive results will be analyzed in the next section.

5.2.4. Implementation operative results

The main purpose of the switch to a new Transportation Management System at Esselunga was, as reported by the Delivery E-commerce Manager, to rise company

standards in the routing planning based on the needs and challenges facing last mile delivery in the market.

The results before the software provided by ORTEC Routing and Dispatch was made operational, based on the internal features of the system, were to achieve the following:

- Real saturation of the vehicles, both in terms of number of orders and space occupation;
- Overall better delivery sequences' optimization, considering the delivery area as a whole;
- Higher availability to the customers in terms of numbers of orders to be placed for the same physical resources deployed.

For the overall performance measurement of the new software has been conducted an analysis highlighting the differences between an equal period from 2021, with the software PTV Smarting, to 2022, with ORTEC Routing and Dispatch.

The main parameters and variables taken into account in the analysis have been:

- The number of orders delivered;
- The amount of late deliveries, with a special focus on deliveries occurred after 30 minutes from the finishing of the time window booked by the customers;
- The number of planned trips;
- The distances of the planned trips in terms of kilometers.

These parameters gave the possibility to calculate some major number equations as follows:

- $Vehicle\ saturation = \frac{\#Orders\ delivered}{\#Planned\ trips}$
- $Incidence\ of\ late\ deliveries\ [\%] = \frac{\#Late\ deliveries}{\#Orders\ delivered} \times 100$

- $Average\ distance\ between\ customers = \frac{Planned\ trip\ distances\ [km]}{\#Orders\ delivered}$

To sum up the results, the overall vehicles saturation, in the period considered, has reached a higher quantity. In percentage terms, there was a 5.5% increase in vehicle saturation, which resulted in a 5.1% saving from the perspective of planned trips compared to the last year.

In the meantime, the company, as results of the investing and incentives policies, reached a +17.3% of orders booked from online channels. In spite of the expansions of the territories served by the Esselunga web network, the new TMS outperformed the old one, signing a -13% in the average distance between two consecutive customers. This was the result of a better planned sequencing optimization, without considering the delivery area as constraints but leaving the route optimizer free to create the best trips with a wider range of application.

The only performance indicator that appears to have worsened has been the incidence of late deliveries after 30 minutes. Specifically, it went from 0.61% in the reporting period of 2021, to 1.09% in 2022. This was consistent with the choice of a different scheduling logic, which resulted in having more orders to be delivered within the same trip. However, reducing the considered period to the most recent weeks, it can be seen an improvement in the index, an indication of the good outcome of the ongoing adjustment as the limitation in the number of orders allocable in a single trip and the reduction of the latest finish time window.

Summarizing, the overall balance of the new routing system has been generally positive. One point of attention is the lowering of the incidence of late deliveries, because it has a significative impact on the service level perception by the customers. The opportunity to achieve a high level of customization within the software allows for much more development work, based on continuous detailed performance analysis on the various depots. On the planners' side, the upgrades introduced also seem to have been beneficial, in the sense that just as the manual iterations required are decreasing, late routing deliveries are also occurring with decreasing frequency.

6 Future developments: Dynamic Time Slotting

This chapter will outline what Esselunga's idea is as a future development of the implementation of the new Transportation Management System. The main idea is to combine the order booking system with delivery routing planning. This union is called Dynamic time slotting.

This development work Esselunga plans to pursue over the next few months, specifically using the previous staff resource dedicated to ORTEC Routing and Dispatch performance analysis.

In the next section there will be a review of the state of the art on the implementation of Dynamic time slotting in the e-commerce world, followed by an in-depth look at Dynamic pricing, which is a key element in moving consumers toward the final choice of order booking.

Next, it will be described how dynamic time slotting is thought to be dropped into Esselunga's reality, what are the goals and expectations of this new development implementation.

6.1. Dynamic Time Slotting in Attended Home Deliveries

Attended home delivery (AHD), with the boom of e-commerce, has imperceptibly changed consumption habits of customers benefiting from its convenience and efficiency. AHD services emphasize that customers must be present to receive deliveries. AHD might be needed for security reasons (e.g., high value goods), perishable goods (e.g., groceries), physically large goods (e.g., home appliances), or because services are performed (e.g., product installation). Many companies that use AHD services provide their customers with time slots for choosing the delivery moment. Delivery time slots are offered to provide a high customer service and

prevent costly delivery failure. When delivery has failed, the goods must be offered for delivery on a different moment, which will result in additional storage, transportation and planning costs. In case of perishable goods, the costs of a delivery failure are even higher, since the goods may be spoiled before the next delivery opportunity. [70]

When customers must attend the delivery of products, they expect narrow delivery time slots that fit their personal schedules. For retailers, these expectations come at increasing cost, as narrow time slots limit the flexibility of route planning. When retailers use their own fleet of vehicles and drivers or reserve a sub fleet of fixed size from a delivery service provider, the variable cost of individual deliveries is negligible. Instead, the largest share of costs in such settings is related to labor and, hence, fixed since labor contracts are strictly regulated. In such a setting, aiming to deliver during each customer's preferred time can cause wasteful waiting times in the routing planning, as not all time slots are equally popular. Dynamic slotting helps planners to maintain profitability through limiting of the set of time slots offered to individual customers. Customer choice means that tailoring offers to customers to attract them to select less popular time slots can create a more even distribution of deliveries. Dynamic slotting decisions proposed by the system must depend on the current request, the already accepted orders, and orders still expected to arrive in the remainder of the order horizon. [71]

The link between AHD and the Dynamic time slotting represents a vivid research field, with contributions focusing on tactical, operational, quantitative, and qualitative aspects. Current research advises the use of demand management policies to profitably assign delivery time slots to customers. Demand management considers characteristics of the current order request, such as boxes value, delivery location, and time slot, to evaluate the feasibility and profitability of offering delivery options. The Attended home delivery service model represents a challenge specifically for the e-grocery sector, which is the field that in the e-commerce has experienced a persistent grow over the last decade as underlined by a study conducted by Nielsel Company in 2017, in which it was found that 57% of people who have never shopped for groceries online were willing to use that method. [72]

A high customer service level through the provision of service time slots of limited extent is one of the main reasons why customers decide to shop online, e-grocers specifically need to manage the trade-off between efficient logistical operations and a high service level for customers. Since the e-grocer sector is characterized by low profit

margins and a highly competitive market, the management of that trade-off is particularly important to maintain profitability and remain competitive in the market. [73]

As it is stated from ORTEC [74], it would be simpler and more efficient if customers were not able to pick a time slot and got an estimated time of arrival. Since most of customer don't want to be home all day waiting for groceries to arrive, retailers therefore offer multiple delivery time slots. Open and available time slots are typically calculated in a split second on an app or website, and most companies are using simple capacity rules to do this calculation. For example, they base the availability of time slots on a maximum number of stops per hour even if this is often not enough to mitigate high costs. Generally, a time slot should be made more attractive for a customer to pick if there are orders booked in the vicinity or expected orders to be delivered close by. This would make it easier to fit orders together in a single route, making the delivery more efficient and less costly.

The time slot management problem is a traditional revenue management problem that can be solved by using quantity-based and price-based approaches. In the time slot management field, quantity-based approaches are related with the decision of setting which delivery time window to offer, while price-based approaches use delivery fees as a tool to manage demand. A retailer can apply both options at different moments of the process in a static or dynamic way. The static approaches are based on forecasts and manage demand tactically based on a set of conditions. The decisions are valid during the whole booking horizon and are not updated when new customers arrive at the system. The dynamic problems manage demand on real-time, as the demand management policies are updated as soon as new information is available. Usually, dynamic approaches are suitable for short-term, whilst static approaches for medium-long term. [75]

Operational time slot management can be strived to maximize either revenue or profit. Revenue is the gain from ordered goods and delivery fees, while profit maximization considers revenues minus delivery cost. Campbell and Savelsbergh in their proposed model use incentives to nudge customers toward time slots that allow the highest overall profit, treating the problem as a revenue management problem with limited delivery capacity per time slot and delivery area. [76]

That model has been further updated by introducing sophisticated demand management and anticipation techniques, by differentiated pricing variants based on a systematic calculation of AHD planning costs. [77]

As examples of contributions that go beyond revenue and profit, Ehmke and Campbell consider the reliability of delivery, addressing congestion and uncertain travel times in metropolitan regions. [78] However, the authors do not solve a multi-criteria optimization problem. Instead, they provide alternative approaches for maximizing accepted requests under various degrees of reliability. It has also been evaluated the overall number of acceptable orders resulting from different approaches to offering either short or long time slots. [79]

Restrepo, Semet and Pocreau (2019) take a more general view of the dynamic slotting problem by allowing for multiple pick-up and delivery locations. In addition, the authors extend the problem to the tactical level by proposing slotting to create schedules for couriers, which can consider measures of robustness and work-shift considerations. [80]

Esselunga could benefit of the Dynamic time slotting implementation for bringing the actual static way of slot availability loading to the back-office into a dynamic way, which is able to modulate real time the offers according to the orders already booked. In this way the company expects to be able to offer the best delivery to the customers resulting in more orders booked and more enhanced customer loyalty. The expectation is moreover to offer more available slots by using the same physical resources, since the orders will be clustered in delivery area closer to each other and in time windows in such a way to reduce the idle times.

6.1.1. Dynamic pricing strategies in AHD

A dynamic pricing system, according to the article *"How dynamic pricing will change retailing strategies for future"* written by Simon Cunnell in 2022, is an automated pricing based on how much a consumer is willing to pay at a specific time, with a price generated based upon pre-set business rules. This is a system that can be used where customers looking to book goods or services may be willing to pay for a time slot, depending on convenience. Dynamic pricing is set to become one of the core capabilities in AHD since the difference is that it also allows organizations to balance both convenience and profitability as they can offer increased convenience while offsetting the costs through dynamically priced booking slots. [81]

Organizations can impose dynamic pricing on top of pre-existing dynamic routing and scheduling tools. Then, it will influence when the customer books to maximize orders on the already dynamically planned routes ensuring maximum route density (orders

per route) and profitability. [82] Dynamic pricing is nowadays widely applied in many contexts: airlines, trains, car rental, accommodation, ticketing (concerts, theaters, amusement parks), retail and ecommerce. Firms usually use different ways of varying prices, including personalized prices, markdowns, promotions, coupons, discounts, sales, auctions and price negotiations, in order to respond to market fluctuations and uncertainty in demand. [83]

The dynamic pricing process can be derived from the process for a generic revenue management system with some advice: the data collection is focused on capture price sensitivity of customers in relation to products and obviously using the price as control variable. The final output of the process is the optimal pricing strategy: a rule or an algorithm that explains what the best price is to be applied at each moment of the selling period. The form of this strategy depends on the business considered and should be investigated in every context. In many industries, the selling goods are perishable in a short time, or they have low salvage values when the sales season is over. In these cases, the strategy used by the firms is a price reduction, called markdown pricing in order to clear excess inventory before the end of the season. Indeed, firms prefer selling inventory while they can, even at a low price, rather than salvage it. This technique is used in industries as apparel, sporting goods, high-tech, and perishable-foods retailing. [84]

There are mainly three types of price strategy to be applied in e-commerce [85]:

- Static pricing, where price remains constant from day-to-day;

- Variable pricing, where prices vary based on the week' day, but does not move during the day;

- Dynamic pricing, where prices vary during the day, considering an increase or a decrease through several or many price points based on the capabilities of the underlying e-commerce platform. Depending on the sophistication of the e-commerce system implemented, prices can either increase or decrease automatically or may require manual adjustments.

One method to custom the pricing strategy is by implementing differential fees [86]. For instance, for peak hours can be establish a higher delivery fee than during slower hours in terms of requests. This approach has a few benefits:

- It satisfies budget-conscious consumers, who can choose the lower-price timeslots, while the less price-sensitive shoppers can take the decisions for convenience;

- By adapting fees based on time of use, demand can be reshaped to smooth out the peaks and valleys, which helps the management of the resources and minimize capacity issues during busy times;

- By reducing capacity issues, there can be focus more on guarantee a comfortable order process, improving customer satisfaction.

Whichever pricing option has been chosen, the key part of an e-commerce strategy should be full transparency to the customers. It is critical that it is clear what customers are paying for and how they are paying it. By being clear and honest about pricing, the e-commerce platform gives the shopper control over the decision-making process, and this can be as important as price. It is important to remember that even though customers want low prices, they don't necessarily always demand them. The pandemic proved that shoppers are willing to pay more in certain circumstances. Consider the delivery charges, service fees, and tip that are added on to an online restaurant meal ordered through a third-party delivery provider. In this case and in many others, control is more important to the shopper [87].

Esselunga could benefit from the implementation of the dynamic pricing to influence the consumers to select some time windows slot in such a way that the overall saturation of the vehicles is reached. Through this implementation the expectation is indeed to receive order bookings also from time windows usually less popular. Consequently, the result that may be reached is to have more optimized delivery routing sequencings.

6.2. Dynamic Time Slotting development in Esselunga

After the introduction of the new Transport Management System by the software ORTEC Routing and Dispatch, Esselunga is looking to improve the way logistics operations are planned for the home delivery e-commerce. Currently, as aforementioned, the structure and logic for the time slot loading and booking is largely manually steered and rigid. Also, the time slot booking is disconnected from the operational routing plan. ORTEC proposal is to replace the current setup with another software provided by the Dutch company, namely ORTEC Home Delivery (OHD), which is a standard software solution that is going to automate and optimize the planning processes of time slot booking, route planning and execution.

The new solution will support Esselunga in the achievement of the following future goals set by the e-commerce Delivery Manager:

- Maximize utilization of capacity drops per working hour;
- Sell the fulfillment capacity in the most profitable way;
- Maintain and improve on-time delivery performances.

The link between time slot booking and route planning would allow the calculation of available time slots for the incoming customer orders based on the delta effect considering as variables the transportation, distance and duration costs. Route planning and execution will have a focus on the batch planning process, that automatically plans confirmed transport orders to available routes and manage the execution of those routes.

The following are the benefits proposed by the ORTEC Home Delivery solution:

- Offer the best delivery option by improving the last mile customer experience through timely and sustainable delivery options;

- Offer more time slots resulting in more booked orders and increased customer loyalty;

- Execute more deliveries with the same fleet by continuously optimizing scheduled orders.

The planning process that would be followed using OHD is described below:

1. Define the available shift capacity to create time slots for consumers;

2. In case of new customers, the first step is geocoding the address. The OHD geocoding API returns the latitude and the longitude of the address based on the text input provided by the Esselunga e-commerce platform. Once geocoded, Esselunga can keep the customer master data, including the geocodes. For each geocoded address, the results are returned with a score value, which indicates the accuracy of the geocoding. If an address is badly geocoded, with a low score, an automated workflow item is created in which the order can be manually geocoded.

3. The customers can ask for available time slots via the Esselunga e-commerce platform either at the start or end of their customer journey. Once the customer asks for the available time slots, the e-commerce platform will communicate with OHD to get the time slot availability for a number, to be defined, of days in advance. The selected time slot can be further updated at any point of the customer journey.

4. Once the customer selects the desired time slot, a message is sent to OHD to "create an order". The order is then automatically scheduled in OHD and the generated order-ID is shared with the Esselunga e-commerce platform for further updated or delete.

5. The cut-off time is the last moment until the customer can place an order for a specific time window. Until the cut-off time for a given planning period, OHD allows the insertion of received orders into the routing plan. Overall re-optimization of the plan is automatically triggered.

6. The cut-off time is the last moment until the customer can place an order. Until the cut-off time for a given planning period, OHD allows the insertion of received orders into the plan. Overall re-optimization of the plan is automatically triggered.

7. If needed, the planners can review the route automatically planned by OHD, applying ad-hoc changes to the deal with exceptions using the OHD Operational Planner User Interphase.

8. In OHD can be done also another step forward. The execution of the plan route can be followed-up in real time by using the Dispatcher UI. In this case, OHD must receive the GPS coordinates and realizations from the field. This information is then used to re-calculate the Estimated Time of Arrival (ETA) based on the realizations. The Dispatcher can handle exceptions by re-triggering optimization by dynamically re-sequencing stops in a trip or by manually adjusting the plan.

Typically, an average value is used for time slot capacity requests coming at the start of the customer journey. Since most often customers prefer to check for available time slots upfront, for the efficiency of the available time slot calculation it is important to provide realistic amount of estimated order volumes and delivery durations to OHD. This is a point of attention, since Esselunga currently does not take into consideration the order volume during the time slot reservation process. This point needs to be further developed by the Esselunga internal team together with the OHD developers.

Regarding the time slots pricing, Esselunga is currently using a static approach. With the development of OHD time slot booking, Dynamic Pricing will be possible, but this needs to be further developed by Esselunga.

In the time slot response coming from OHD, each available time slot option is reported with its delta effect on transportation cost, duration and distances parameters. According to these delta reported, business rules and logics can be created on the e-commerce platform by Esselunga to dynamically assign prices to time slots based on the company's needs. This possibility is probably going to be implemented on a second phase of the development process, after the validation of the connection between the order booking and the planning routing system by the Esselunga internal team.

7 Conclusions

This thesis work aimed to take an overview of the world of online sales through e-commerce platforms, focusing more on one of its distinctive elements, which is the possibility of choosing home delivery as a delivery option. From the review of the state of the art reported in the first section of the thesis, it can be seen that e-commerce is a developing industry, especially as a result of the radical shift in customers' buying habits that occurred after the outbreak of the Covid-19 pandemic. Since this event, companies have become increasingly aware of how relevantly e-commerce can be a complementary way of selling products and services to the traditional way of shopping that sees customers physically go to stores.

This fact was perfectly intuited by Esselunga, when in 2001 it decided to go the e-commerce route, creating a specific site for placing orders online. The actual case reported shows how even a company like Esselunga, with a significant competitive advantage over its direct competitors in online sales in the Italian territory, decided to make changes to its order delivery routing planning system, after years of using old software.

The implementation of the new software, as explained in detail, brought a significant change in the allocation of orders on the vans. It has moved from static allocation based on a maximum number of orders per delivery time slot, to dynamic allocation based on data and parameters set in a punctual and customized manner. The development of the new software will still go on, but it has already been evident that it has brought positive results from multiple perspectives, even as a result of the ongoing adjustments introduced over the months.

For Esselunga, the implementation of the new Transportation Management System was only the first step in a larger development project of linking together the process of order generation by final customers with the system of planning orders to be delivered through vans.

This will be a project that will be pursued during 2023 by Esselunga's internal development team assisted by ORTEC's development team. The implementation of this new system of order booking plus automatic routing generations is expected to bring significant economic benefits to Esselunga as a result of an expected increase in incoming orders through the e-commerce platform and improved efficiency in delivery route planning, following in the footsteps of the logic brought forward by the ORTEC Routing & Dispatch software.

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