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Master's Thesis

Overcoming issues in last mile delivery to improve consumer driven logistics

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ABSTRACT

Last mile logistics is the last leg of the supply chain, where the final delivery is made to the customer's doorstep. This last mile delivery from the warehouse to the customer's door is known to be the costliest and least efficient part of the entire supply chain process. This thesis will discuss why it is so by taking a deeper look into the main issues faced and the key performance indicators in the last mile delivery to finally propose the best solution.

The main reason causing the last mile to be inefficient and so expensive is the failure to deliver orders from the first attempt and then reattempting to deliver them another time. 6% of deliveries fail on their first attempt, with a single failed delivery costing the company around $17. The most common reason for a delivery failure as it will be seen later on is the customers' unavailability at the delivery address. Several other issues will also be discussed such as damaged/lost deliveries.

E-commerce was increasing on a steady rate until the Covi-19 outbreak which accelerated the growth of retail e-commerce 6 years in advance. The pandemic changed the consumer's purchasing habits, as more people started shopping online, which increased the total number of online orders and hence forced last mile companies to increase their capacity by hiring more delivery drivers and buying extra delivery vehicles. This increase of delivery vehicles on the road increased the greenhouse gas emissions as well as traffic congestions in cities, which raised a lot of concern. The leading companies in retail, e-commerce and last mile however are aware of the environmental impact and have a plan to reduce their carbon emission by converting all their traditional delivery vehicles into electrical ones. This is a good idea, but not the optimal one, as vehicle electrification will only reduce the emissions and not traffic congestion nor failed, damaged or lost deliveries.

The optimal solution that will be discussed more in detail later on in this thesis is the installation of open parcel lockers which will help decrease the cost and increase the efficiency of the last mile by solving all the main issues often encountered.

Contents

Chapter 1

Introduction

1.1 What is Supply Chain Logistics

Supply chain is a long and complicated process with a main objective of delivering the final product/service to the customer.
The whole process starts when consumers demand a certain product/service, and to supply that product/service to the final consumer, the supply process will focus on the activities of transporting and transforming raw materials into final products and distributing them to the end consumer. See figure 1.

The supply chain process can be divided into four main categories, and each category can be subdivided into several forms. Hence the main steps of the entire supply chain process are:

- **Logistics**: It is the process of managing how goods and services are handled and transported to their final destination, whether it's a manufacturer, distributor or the final customer. Logistics is a crucial part of the business, hence if it's done poorly, it will have a huge impact on the entire process. So, the main goal of logistics is to deliver resources from point A to B on time at a good price.
- **Operations**: This step of the supply chain covers the manufacturing of products (transforming raw material into final goods), the management of inventory, and the efficient use of space inside the warehouse to store the raw material coming in and the finished products to be shipped.
- **Marketing and Sales**: This is an important step for the business's efficiency and profitability. It is the process responsible for advertising, building communications and external connections to convince customers to purchase a certain product/service.
- **Customer service**: Once customers are found, the role of the customer service kicks in. It is the process of retaining customers and improving their experience to keep selling and growing the business. Losing a customer is much more expensive that obtaining a new one.

As we have seen previously, logistics is just a section of the whole supply chain process with the function of planning, controlling, storing and moving all goods and services from their root source to their final station.

Logistics is divided into three main forms in the following order:

1. **Inbound Logistics**: which is the first step in the logistics chain. It involves the movement and storage of raw material from the supplier through the manufacturing site;
2. **Outbound Logistics**: which is the final step to deliver the final product to the customer. This includes storing the final product to be shipped, and the actual delivery of that product;
3. **Reverse Logistics**: it involves the return of products back through the supply chain. This occurs when the product delivered is defective and the final user refuses it, hence returning it back to its owner.

The main focus will be about outbound logistics. Outbound logistics consists of several main activities of which are:

- **Warehouse and Storage Management**: The role of outbound logistics here is to store and organize a certain amount of finished goods securely in the right conditions to meet demand. outbound logistics fulfills orders sent straight to customers.
- **Inventory Management**: It is a process that identifies the best place to store final products in the warehouse for an efficient picking and packing process. The goal of inventory management is also to protect the products from any theft or damage.
- **Transportation**: The way in which the final good gets delivered depends on the product itself. Some goods need refrigeration, others need to be carefully handled (chemicals, or highly breakable material), and some don’t need special care. The mode of transport also differs, goods could be transported by trucks, vans, airplanes, boats…
- **Delivery**: Delivering the right product to the right customer at the right time with no defects is crucial to the success of every company. The final product of a company could be directly sold to the final consumer (delivering the product directly to his/her door), or sold to an intermediary (delivering to wholesalers or retailers). There are several distribution methods and channels, hence it is crucial to choose the right one.
- **Last-mile Delivery**: the last leg of the delivery is called the “Last mile”, where each unit of product is handled individually and must be delivered

to a specific address. The last mile is known to be the most expensive and inefficient part of the entire supply chain.

- **Delivery Optimization**: Optimization involves reducing cost and increasing efficiency. Generating routes more efficiently using updated software, and always exceeding customer expectations.

1.2 The Last Mile

The goal of last mile delivery is to deliver the customer's order to his/her desired location. When a customer orders an item through an online platform, his/her order will be processed, picked, and packed to be sent to his/her desired address. In most cases, the delivery of online orders is done by a last mile delivery service provider which is a separate independent entity from the online retailer. For example, if you order an item from eBay, the driver that will deliver that item to your house is not an eBay employee, but an employee of a third-party delivery service provider like FedEx and UPS. There is an agreement between the two companies where eBay pays the delivery service provider to deliver the parcels to their customers. On the other hand, some big leaders in retail e-commerce such as Amazon and Walmart which used to deliver their customer’s orders through a third-party delivery service provider, are now entering the market of last mile delivery so they can deliver directly to their customers without the need of a third-party delivery service provider. Now there are players more than ever in the market of last mile delivery due to the rapid increase of e-commerce.

The last mile delivery, however, is the most expensive and inefficient part of the entire supply chain, a problem that has been there for a long time and is now escalating with the increase of online shopping. This increase, as it will be explained later on, also has negative external effects on sustainability, urbanization and the environment.

The objective of the following chapters will be to dive deep into the last mile delivery to understand why it is so expensive and inefficient by exploring all the main issues and problems faced by the last leg and try to find the optimal solution that fits all stakeholders.

Note that the last mile delivery referred to in this discussion is a Business to Consumer (B2C) parcel delivery.

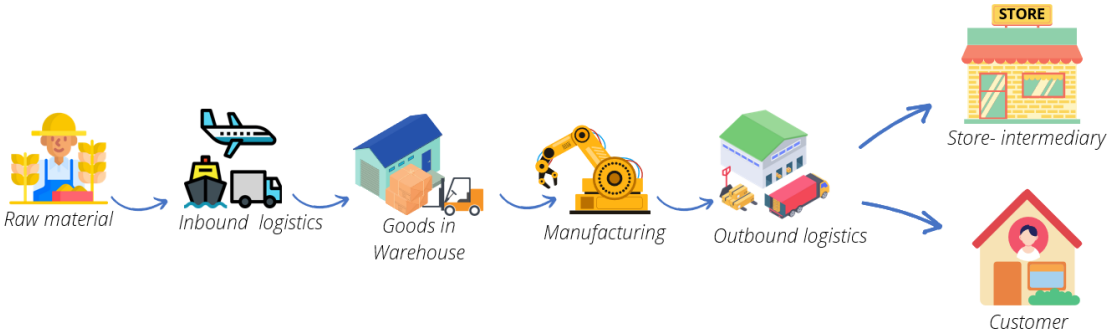

Figure 1: a simplified representation of a supply chain process

Chapter 2

Last Mile Delivery

2.1 The Rapid Growth in Online Shopping

Online shopping is not something new, it started several years ago after the computer was invented in 1979, and the first e-commerce company was launched in 1982. Back then it wasn't popular as much, but with the rapid improvements in technology such as the invention of online banking and smartphones, more people started getting into e-commerce. But the real and fast escalation of online shopping started in 2010. In 2010, 5% of the retail sales was from online shopping, amounting to a global e-commerce sale of $570 Billion. Now in 2021, 19.5% of retail sales is from online shopping, amounting to a global e-commerce sale of $4.921 trillion. This number will keep on growing over the next few years, as online shopping is becoming a daily habit for many. This rapid growth in e-commerce was mainly due to the Covid-19 pandemic which forced many people to stay home. For many households, the only solution was to shop online for groceries and other goods. Without the outbreaks of the virus, we wouldn't have seen this drastic increase, just few months after the outbreak (the first quarter of 2020), the global e-commerce sales increased to $876 billion, an increase of 38%, which would've taken up to 6 years to reach.

Internet access is no longer something scarce, all countries around the world have internet access, even in poorer countries the adoption rate is rapidly increasing. Almost all digital devices now have internet connection, allowing people to make an online purchase easily from wherever they are. Just in Europe, 74% of the people who have internet access, have made an online purchase. Online shopping is now a habit among consumers, purchasing goods and/or services in stores is decreasing compared to previous years, because people started to prefer online purchases. A lot of people are shopping online due to convenience, variety and better pricing. In 2021, more than 2.14 billion people purchased goods and/or services online, a huge increase from 2016 where 1.66 billion people were shopping online. In 2020, more than 2 billion people bought goods and or services online. In that very same year, sales from e-retail was more than $4.2 trillion worldwide. Figure 2 shows the change in retail e-commerce sales around the world between from 2014 and a forecast for 2025.

2020 was a challenging year for all countries. Countries in North America experienced a dramatic increase in retail e-commerce sales. In 2020 Argentina experienced a sales growth in retail e-commerce of 100.60%, becoming the leading country in sales growth. Countries also like Mexico and Brazil had a sales growth of 65.2% and 50.1% respectively. Figure 3 shows the other leading countries in sales growth from retail e-commerce in 2020.

The United States retail e-commerce sales in 2020 was $794.5 billion and is expected to grow to $834.15 billion by the end of 2021. Nevertheless, China remains the leading country in retail e-commerce sales worldwide, with an estimated sale of $2,779.31 billion in 2021. Figure 4 shows the ranking of other leading countries by retail e-commerce sales in 2020.
China's fast progress in e-commerce is fascinating, as just one decade ago it accounted for less than 1% of the global e-commerce market. There are several reasons that led China into becoming the leader in e-commerce that fast, which are:

- **Internet users increased rapidly in the country**. In 2018, 30 million people in China used the internet for the first time. The Chinese population were among the early adopters for the internet, in 2005, there were already more than 100 million internet users. The internet users in China today are more than the internet users of the United States, Brazil, and Indonesia combined [29].

- **They love online shopping**. In 2018, even before the outbreak of the pandemic, 70% of the internet users in China have already purchased something online. The Chinese population are among the early adopters of online shopping. In 2017, during the biggest event of e-commerce, the sales of Alibaba, the biggest e-commerce in China, surpassed $25 billion in just 24 hours. A number never reached before. If we want to compare it with the e-commerce sales in the United States at that time, the sales during the season of Thanksgiving, Black Friday and Cyber Monday (which is the peak season sales for e-commerce), amounted to $14.5 billion [29].

- **A dramatic increase in mobile payments.** The usage of mobile phones in China is so high, as 98% of the internet users in China browse the web through their mobile phones, that is double the population of the United States. 90% of online shopping transactions occur through mobile payments [29].

- **Efficiency in delivery orders**. Unlike all the other countries, the Chinese giants in e-commerce have developed an efficient network

to handle the high order number. They have a collaboration with last mile delivery providers that are able to handle around 30 million orders in a single day [29]. They provide next day and same day delivery more efficiently than all the other countries. We will see how they do so in further chapters.

- **Middle and low class are diverting towards online shopping.** The population of low-class income usually do not purchase items online, they tend to go to stores nearby as they are seen to be cheaper. In China however, the low-middle income families living in small and underdeveloped cities have difficulty accessing well equipped stores, hence they tend to purchase items online for a wider variety.

The biggest market player in e-commerce is Amazon. Amazon offers a wide range of consumer products and online services with a market capitalization of around $1,735 billion. The company ranking second worldwide is Alibaba with a market capitalization of $615 billion. Alibaba is the second worldwide but the first in China.

The Covid-19 pandemic had a huge impact on consumer shopping behavior and the economy. The global economy was destroyed during the pandemic, but not for e-commerce companies. E-commerce experienced a huge revenue growth as consumers were forced to stay home and had no other option but to shop for goods online. This forced many retailers to quickly convert into digital to survive. E-commerce companies experienced 6 years of growth in one single year. The growth in online sales is very likely to continue with its upward trend.

This rapid growth in internet shopping and the change in the delivery mode from a retail shop to a customers' front door has made last mile delivery even more challenging and demanding. We have mentioned before that this last leg of delivery is the least efficient and most expensive part of the supply chain, accounting for more than 40% of the total transportation cost.
Why is it that the last mile delivery is the costliest section and least efficient one in the whole supply chain? To understand this better, we should dive deep into the last mile delivery and discover the problems they are facing and try to formulate solutions to increase efficiency and reduce cost.

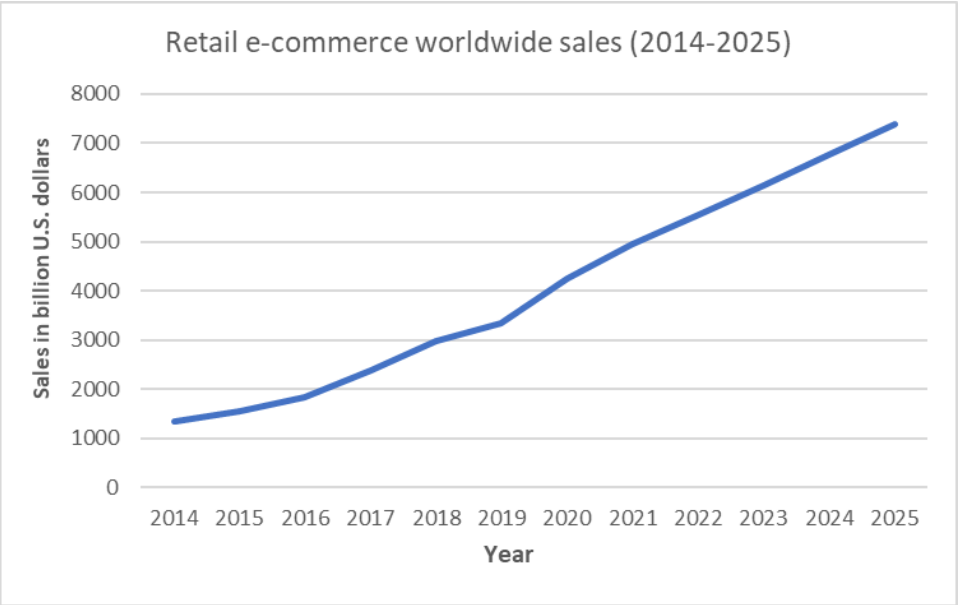

Figure 2: E-commerce retail sales worldwide from the year 2014 till 2025 in billion U.S. dollars.

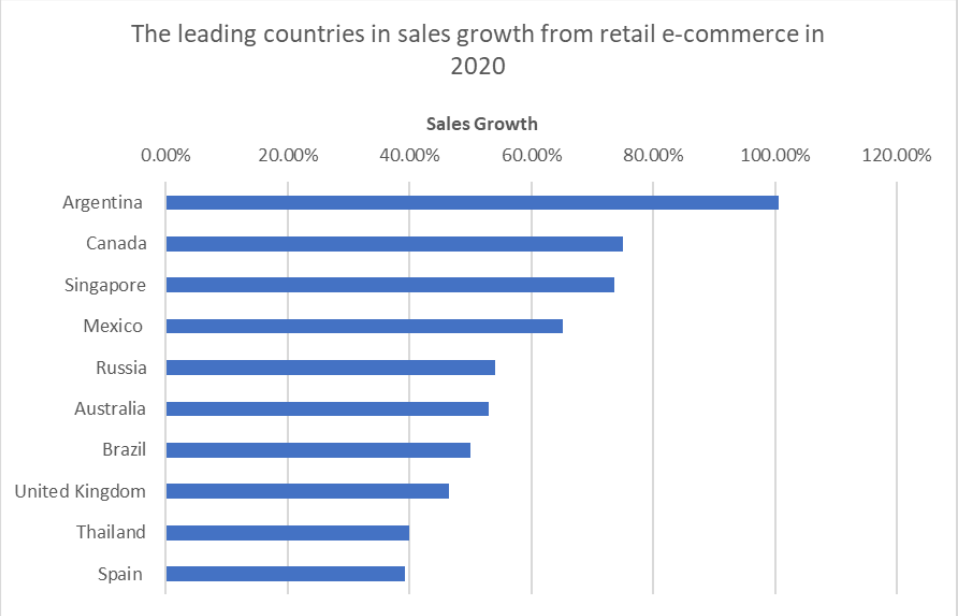

Figure 3: The leading countries in e-commerce retail sales growth for the year 2020.

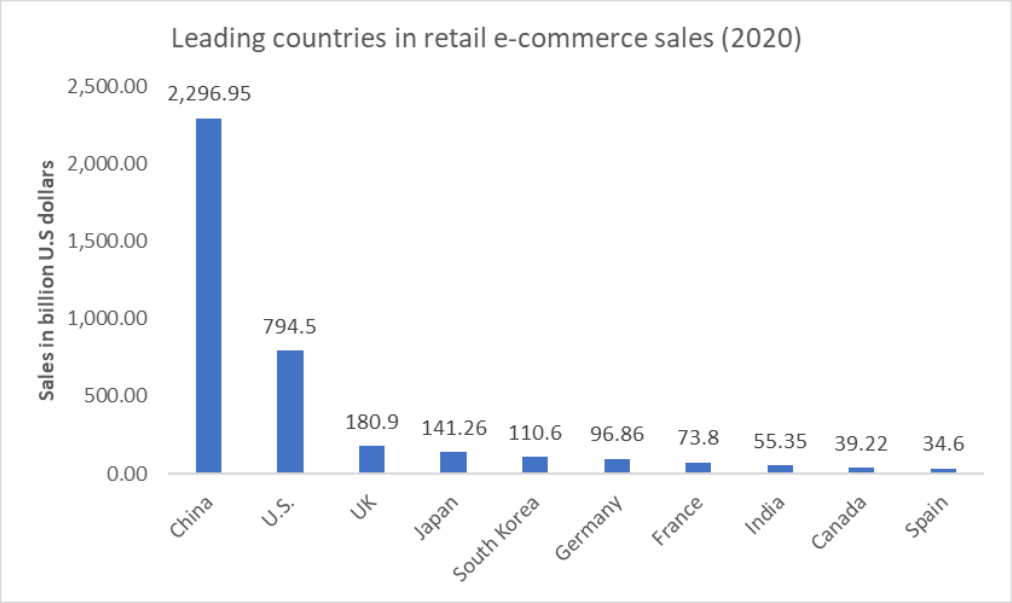

Figure 4: Leading countries in e-commerce retail sales for the year 2020.

2.2 The Main Issues Faced in Last Mile Delivery

The goal of last mile delivery service providers and ecommerce companies is to deliver the parcel to the customers' desired location, at the promised delivery date, with no defects. But are they managing to do so effectively? Not really. The last mile delivery just keeps on getting more challenging, last mile delivery companies are not being able to meet their goals fully, they are all facing the same recurring problems.

What are the issues facing last mile delivery which is setting them back from fully accomplishing their goal? Why aren't all customers receiving their order at the right time? What's so hard about that? There are several reasons why customers may not receive their parcel on the promised date, some of the reasons could be:

- **Wrong Address**
  It could happen that a customer entered by mistake a wrong address for his/her delivery location. The main errors are usually that customers forget to enter the house number, or they type the wrong house number, or even the address itself is wrong or does not exist. In some cases, when the delivery address is a building, the driver does not find the name of the customer written on the interphone nor on the letter box, in this case the driver will assume that the customer does not reside in this building. But this does not always mean that the customer who ordered the package is not in that building, it could be that the customer lives with other people

whose name instead is written on the interphone. All the above errors are made by the customer.

- **The Parcel was not on board**
  There are several cases when the driver arrives at the customers' location but does not find the parcel inside his/her delivery van. The chances are that the driver either dropped it while he/she was loading his/her van in the warehouse, the parcel was not even with the rest of the parcels while he/she was loading the van, the parcel was in the van but the driver was not able to find it until he/she had finished delivering all the packages, or that the parcel ended up being with another driver.

- **The customer was not present**
  That's the most common and frequent case. It happens on a daily basis that drivers pass to the customers' house and not find them there. In some cases, the driver can leave the parcel in the letter box if it fits or leave it in a safe place if the customer has indicated so. Otherwise, the driver cannot do anything else but to put back the parcel inside the van and try again later or the next day.

- **The Picking point/store/business was closed**
  Most ecommerce/logistics companies have agreements with stores such as tobacconists, convenience stores, stationery stores, postal offices, etc. to drop off parcels at their stores so customers could come pick them up when they can. It happens that when the driver passes by the store to drop off the parcels, he/she finds that the store is closed. It also happens in the case of businesses who make orders for themselves, but during the delivery day the business was closed. Hence the delivery should be reattempted.

- **The Road was blocked**
  Sometimes drivers face issues due to unexpected road work which leads to road blockage and hence the driver cannot reach the customer's address. Forcing his/her to reattempt the delivery another day.

- **The parcel was damaged**
  There are several reasons that could lead to a damaged parcel. The damage could occur at any point throughout the shipping process. It could be due

to improper handling, not enough protective wrapping, the parcel size is much bigger than the item inside it… if the parcel is detected as damaged by the workers in the warehouse, or by the driver when delivering, then the parcel can no longer be delivered to the customer, but it should be sent back to the retailer. Sometimes though, customers report having received a damaged item. In this case it couldn't have been detected previously from the packaging that the item inside is damaged.

- **The parcel was lost**
  The parcel could get lost at any point of the entire shipping process from the retailer to the customer. The reason for that could be that the parcel could've fallen off or misplaced. In many cases it occurs that the driver delivers the parcel to the customers' door, but the customer later marks it as missing. Hence this means that the parcel was stolen. The case of theft is not something rare, the cases keep on increasing. In most cases, when the customers' parcel is marked as damaged or stolen, the retailer will have to either issue a refund to the customer or replace the item with a new one. It depends on what the customer chooses to do. Some retailers will have a different approach for such a case, they will have the courier company held responsible.

As we have seen, there are several reasons for the parcel not being delivered on the promised day, which translates as a big loss for the company. The last mile delivery accounts for 40-55% of the total supply chain cost. Hence if the parcel is not delivered on the promised day, or it gets lost or damaged, then the cost will escalate even more. Attempting to deliver the parcel another time in the following days will not only increase the cost, but will affect the brand loyalty, with the risk of customers switching to other suppliers. Winning a new customer is four times harder than retaining an existing one. Dissatisfied customers can hurt your business, not only with the chance of switching supplier, but with word of mouth which can have a greater effect on existing customers or potential ones.

2.3 Key Performance Indicators

In all businesses, no matter the sector, managers should always keep track of their company's performance using a variety of appropriate metrics related to their industry. Hence to measure your company's success, managers are using the so-called Key Performance Indicators (KPIs), which are a set of quantifiable measurements used by managers to determine the company's long-term success versus a set of targets, objectives and their competitors in the

industry. It offers an effective way to measure the strengths and weaknesses of your company.

In the industry of supply chain and logistics, it is highly important to focus on the last mile due to its several inefficiencies. Logistics companies are using KPIs to measure their accuracy, cost and utilization. This has helped them gain more visibility to improve the process of the last mile delivery by eliminating waste and reduce cost.

How do last mile delivery service providers measure delivery success? There are several ways in which delivery service providers can measure their success, but the main metrics are:

1. On Time Delivery.

On time delivery is the most important metric in Last mile. When you provide your customer with a promised delivery date, you have to stick to it. Customers are becoming less patient and expect their delivery to arrive as soon as possible. Once you fail to deliver the parcel on the promised date, you have already committed to a big loss.

What kind of loss are we talking about? The first and most important loss is the customer's loyalty, and especially if the customer had paid for the delivery to arrive early. Usually, customers pay extra for a delivery because they are in a hurry for the item they ordered. If the parcel did not arrive on time, this customer will be so frustrated that he/she would switch suppliers, express his/her anger about the retailer on social media platforms which might influence other customers, write a bad review on the retailer's site, suggest friends and family to avoid ordering from the retailer, etc. The customer can hurt the business more than you can imagine.

We should note that when the customer orders online from a retailer, he is not aware of which delivery service provider will be delivering his/her package, hence all the blame will be on the retailer. Hence the retailer will have to deal with the delivery service provider privately, and in case of constant bad performance, the retailer will definitely change the delivery service provider.

The second loss is that if the package was sent for delivery, and the courier was not able to deliver it due to the customer's unavailability (most common reason), or any other issue he/she encountered on the road (issues previously discussed), then this package will have to be attempted again the next day. Just failing to deliver on the first attempt will cost the retailer an average of $17 per order, which

per year will amount to an average of $199,127 considering that 6% of parcels fail on the first attempt.
The average delivery success rate on the first attempt is around 94%, it is subject to change depending on the country, season, and the delivery driver. The rate of successful deliveries on the first attempt is higher than in the past, and the reason for that is the Covid-19 pandemic which forced a lot of people to stay at home and smart working became more common.
But what will happen after the Covid-19 restrictions are lifted? Will the rate of successful deliveries drop or stay high?

Hence delivering parcels on time, on their first attempt will increase customer's loyalty and decrease cost, which can be an indicator of how successful the service provider is.

2. Damaged/Lost Parcels

According to a recent study, what frustrates customers the most with online deliveries is receiving a damaged parcel which ranks first, followed by a lost parcel. A customer receiving a damaged parcel, or not even receiving it in the first place will leave him/her so frustrated, which will affect the customer's loyalty towards the retailer. We have discussed in the previous section how a frustrated customer can harm the retailer, and how it is easy for unhappy customers to change retailers due to the large market and low switching cost.
That's not the only harm the retailer would suffer if the customer reported that he/she received a damaged parcel or that he/she never received the parcel, in such a case the retailer will have to either replace the item with a new one, or refund the price of the item, depending on what the customer wants. Receiving a damaged parcel, or not receiving it due to theft is not a rare condition. Around 50% of customers have received at some point a damaged parcel, and around 40% have experienced theft of their parcel.
Replacing a damaged or a lost parcel can cost a retailer up to 17 times more than its original cost of shipping the parcel.

Handling the parcel properly and delivering it safely to the customer will ensure customer loyalty and a significant decrease in cost from concession. This could also be a great indicator of how successful the service provider is.

3. Average Service and Transit Time

The service time is the time the driver needs in order to park his van, get out of the vehicle, deliver the parcel to the customer and get back to his vehicle. While transit time is the time the driver needs on the road to get from delivery stop 1 to delivery stop 2.

Estimating the total average service and transit time for the delivery driver to complete all the deliveries is extremely essential. By overestimating or underestimating the time the driver needs to complete the entire delivery route, you are losing money. By overestimating the time, you are missing the chance of being able to deliver more parcels, while by underestimating the time, you are risking the chance of not being able to deliver all the parcels on the promised day. As they say, time is money. Hence the more it takes the company time to deliver the parcel to the customer, the more money it will be losing. But this also means that the company is not able to handle many orders, which again implies that the company is losing money by not being able to serve other customers. It is therefore essential for all last mile delivery services providers to have a good routing system to optimize the total time it takes for a successful delivery.

Route Optimization is a process of finding the shortest, most effective and efficient route between any two points on a map. There are several logistics companies that use some sort of route optimization software. Recently with technology development, platforms are using Artificial Intelligence based technology to enhance routing optimization and overcome common issues. The routing software will predict both the service and transit time for each delivery by tracking real time data of the driver during delivery in previous days to the same location over a period of time and then give an average estimated time for a better prediction. The service time a driver needs to drop off a single parcel at a specific location will not be the same for other locations. It could be that a service time for a single parcel be 1 minute and 12 seconds at a specific address, while for another single parcel at a different address be 2 minutes and 46 seconds. The software also takes into account the size of the parcel, the number of parcels, the average service time in the area/neighborhood, and also as we mentioned previously the time it will take to find a parking spot and park. Just to note that if the driver has several parcels to deliver in a single stop that does not always mean that the service time must be much higher than delivering a single parcel, it could be that to deliver 4 parcels the driver's service time is 1 minute and 54 seconds or 8 minutes and 10 seconds. The average and service times should always be updated for accuracy by using machine learning to constantly track the driver's average timings.

When courier service providers are able to efficiently use the time on road to deliver all the parcels, then this can also show how successful the service provider can be.

4. Total Delivery Cost

As we have mentioned several times before, last mile delivery is the most costly leg of the whole supply chain, hence a cost optimization is essential to avoid further decrease in profits. According to a study done by Statista, in 2021 there

were 2.2 billion online shoppers worldwide, and this number is expected to rise to 3.45 billion by 2025. Having that many users will increase the cost in last mile delivery. Now what customers want is to receive their parcel faster and not to pay an extra cost for delivery. Customers won't care about helping last mile delivery service providers to reduce their cost.
The problem is that the average cost per delivery is $10, which is a lot. It is big companies that are able to absorb such costs, not small businesses. The main costs of on road delivery takes into account the hourly rate of the driver, the fuel cost, and the maintenance cost of the vehicle.

The most costly asset is the delivery driver. The salary of the delivery driver accounts for 50 to 60 percent of the expenses incurred in the last mile delivery, depending on the country. On the other hand, the fuel cost can account from 10 to 25 percent of the overall last mile delivery expenses. The percentage depends on the capacity of the company, and how big it is. Once the business expands, covering more geographic markets, its consumption of fuel will increase.
We have mentioned in the previous section how the routing optimization software helps in generating the most efficient route, but it also helps in reducing transportation cost. It cannot for sure reduce the fuel consumption rate per vehicle, but it will help plan efficient routes that will affect the fuel consumption in a positive way.

5. Vehicle Capacity Utilization

It is very essential to plan shipping so as to use the maximum vehicle capacity. Empty space in the delivery drivers' van is a waste of money. Monitoring closely the capacity of the van per route will affect the cost of transportation, as it determines the number of stops the driver has to do in order to complete his/her route. It is not possible to reach a vehicle capacity of 100%, as there are other factors that play a role. The driver has a maximum time to be on road, other than that the driver should be delivering in a specified area/zone. Parcels cannot be in 2 separate areas that are too far from each other. Whenever there is a lot of space left in the drivers' van, this means that the route is inefficient, hence either the route should be more loaded, or merged with another route. By sending a delivery on the road without utilizing the maximum capacity that can be reached, the company is wasting money.

Out of all the reasons of delivery failure mentioned above, customer not available is the most frequent one. One of the main reasons why customers are not always present at the delivery location is because they are not informed beforehand about the delivery day/timing of arrival of the parcel. Smaller companies usually are not specific with the arrival date, they rather communicate to the customers the latest

delivery day of arrival (example, “Your parcel will arrive within 2 to 5 working days”, or “Your parcel will arrive between 5/1/2022 and 10/1/2022”). While bigger companies on the other hand are more specific with the date of arrival, but they don’t usually specify the time of arrival.

Customers cannot stay home all the time waiting for their parcel to arrive, they also have other obligations. Customers are also frustrated when they know that their delivery was attempted but they were not home. If customers are provided with the parcels’ arrival time window (example, “Your parcel will arrive today between 10:00 - 11:00), then the cases of drivers not finding the customer will drop a bit, if customers were given a time frame of 1 hours, some could fix their schedule to be present at home when the delivery arrives. The time window can be estimated and reduced to less than 1 hour, since the route optimization platform does the whole planning of the route for the driver. If the driver starts his/her route on time and follows the planned route on his/her device, then the driver must be able to deliver the parcels according to the communicated timing that was sent to the customers. Of Course, that's an optimistic point of view, because there are some factors which could sometimes be out of reach, unpredictable events could occur such as a delay in the warehouse which could be due to a delay from the upper stages of the supply chain, or the last mile delivery driver experienced traffic, road blockage, vehicle breakdown, more time spent in one delivery, which are all uncontrollable events. Tracking the driver on the road using the latest technologies could be a solution to reduce the issue of not finding the customers at home, but not the best one, as there are uncontrollable factors and a lot of optimization is further needed for the system.

Chapter 3

Last Mile Delivery Driver

3.1 What is it like being a Delivery Driver

The job of the delivery driver is much more complicated than we think it is. Each company has different rules towards its drivers and the way they should be delivering. The bigger the company and the bigger its geographical market means that it can withstand high order volumes, which most probably means that the last mile delivery drivers will be more loaded with parcels to deliver. Not only the size of the company matters, but also the country, because some countries have strong unions towards employees while others don't. For example, in the United Kingdom if a delivery driver working for company X is performing poorly, the company has the right to fire him. While in Italy it's not quite the case, especially for employees with an undetermined contract, if the delivery driver is poorly performing, his/her employer cannot fire him/her easily.

Depending on the company and the contract between the employer and the driver, the driver can be paid by the number of parcels successfully delivered, by the total number of hours it took to deliver all the parcels given to him/her, or a fixed salary (which is usually a shift of 8 to 9 hours). Each type of contract will affect the performance of the driver in a different way. A driver with a fixed salary will not be worried as much as a driver who's pay depends on the number of parcels he/she's going to deliver. Drivers that are paid per delivered parcel will do their best to mark the parcel as delivered no matter what it'll cost, because they don't want it to impact their final payment. Not to mention that each company has different rules regarding failed attempts, parcels not delivered, damaged parcels, lost parcels, and many others that also affect the driver's performance. If a company makes the driver pay for a parcel marked as missing/stolen, then the driver would be more careful when delivering to the client, in the sense that he/she won't be reluctant to leave the parcel in an unsafe place or attempt to steal it.

When it comes to the number of parcels a single delivery driver has to deliver in a day, it can range from 40 all the way to 400 parcels. What matters more to the drivers is not the number of parcels they will be delivering, but the number of vehicle stops they have to make. The number of stops can range from 30 to 200, it

all depends on the size of the company (its capacity), the delivery zone/area, the duration of the shift, the vehicle capacity, and the number of drop offs per stop.

Let's give an example, consider 3 delivery drivers, all working an 8/9-hour shift, and share the same efficiency. For the sake of this example, exclude any unpredicted events that could happen on the road, such as traffic, accidents, vehicle breakdown.
Table 1 represents for a given day, the route for each of the 3 drivers considering the total number of parcels they have to deliver, the total number of stops they have to do, their zone of delivery, the distance they have to drive from the warehouse to reach the first stop on their route, the total time it's going to take to reach that first stop, and the overall time it will take to complete the entire route and deliver all the parcels.

	Driver A	**Driver B**	**Driver C**
Number of Parcels	74	400	195
Number of Stops	59	121	134
Delivery Area	Mountains	City Center	Suburbs
Km to reach 1st stop	110 km	22 km	30 km
Time to reach first stop	1h 20 min	35 min	25 min
Overall time	8h	8h 30 min	8h 30 min

Table 1

From the table we can notice a huge difference between the number of parcels and the number of stops each driver has to make, although they all finish their route more or less at the same time. Driver A has 326 parcels less than driver B (5.4 times less), and 121 parcels less than driver C (2.635 times less). The reason for that difference is that Driver A has to deliver the parcels in the mountains, an area that is 110 km far away from the warehouse (were he/she picked the parcels from), and takes 1 hour and 20 minutes to reach, hence driver A is losing 2 hours and 40 minutes just driving to and from the warehouse (which are referred to as inbound and outbound times in logistics), which is 1 hour and 30 minutes more than driver B, and 1 hour and 50 minutes more than driver C to complete the inbound and outbound distance. When it comes to comparing the difference between the number of stops and number of parcels each driver has, that of driver B can look odd. Driver B has 579 more parcels compared to the number of stops,

while driver A has just 15 more parcels compared to the number of stops. The reason for driver B is that in the city center the buildings are so close to each other that the driver in a single stop can deliver several parcels, it could be that there are 3 deliveries to different apartments in the same building, where each customer has ordered more than a single parcel, and in the building next to it there are also several deliveries. Hence in just a single vehicle stop a driver can drop 10+ parcels, but that is not the only reason, a bulk drop off in a single stop is also due to pick-up points, which could be either a store or a locker. A delivery to a pick-up point may have 20+ parcels. As for driver A, in the mountains, the majority of the infrastructure is houses rather than buildings, which are not close to each other, hence the driver will have to drive from one customer to the other. Pick-up points and lockers are more common in the city than in the mountains due to the number of inhabitants.
All companies wish to reach a vehicle utilization of 100% at all times, but that is not possible, other factors must also be taken into account such as time utilization.

You might wonder that driver A is more relaxed than drivers B and C, and that is true. Driver A's overall time is just 30 minutes less than that of the other two drivers, but the difference is that driver A was driving calmly, not stressed out that he/she might not be able to finish the route on time, or worried that he might find difficulties parking or encountering traffic on the road. Drivers B and C are more stressed out as they have to move faster, encounter the traffic of the city, a lot of traffic lights, and difficulty in finding a parking spot… If driver A was delivering with the same speed as drivers B and C, then he/she would definitely complete his/her route earlier. On the contrary, drivers B and C could sometimes not be able to deliver all the parcels on time.

Drivers that are always fully loaded, either in the sense of a high number of parcels, or the high number of stops, often complain about having to drive fast, park in unsafe places, sometimes skip lunch break, and finding difficulty in accessing restrooms. All those will contribute in the long term to a deterioration in the driver's health and well-being. Once an employee is not satisfied with his/her work, then the chance of quitting becomes higher.

We have to mention also that the last mile delivery drivers are subjected to a high risk during their work. Driving for several hours increase the risk of accidents and could lead in the long term to poor eyesight. Parcel delivery drivers also have a high risk of getting attacked and robbed. There are several cases where armed personnel approach delivery drivers and steal parcels from their vans, some drivers are left unharmed, while others have been hurt. Driving around with lots of parcels of high value can sometimes be dangerous.

Before the Covid-19 pandemic, companies were facing a shortage in delivery drivers, which is becoming a main point of concern as they are experiencing an increase in order volume. This shortage should raise the awareness of companies towards how they're treating drivers. The main reasons why companies are increasing the workload of drivers is due to the increase in order volume, shortage in drivers, and the high cost of labor. Companies should start focusing on the well-being of drivers and find another approach to deal with the increasing volumes and the limited pool of drivers.

What companies care about the most is their customer's satisfaction. When customers buy online, their parcel will be delivered by a last mile delivery driver. Hence delivery drivers are the direct point of contact between the company and the customer, which implies that a great part of the customer's satisfaction depends on the driver.

Last mile logistics companies should always remember the fact that without the delivery driver, they are worth nothing, hence they should rethink the way they engage with drivers and start considering their satisfaction and well-being at work. Once drivers are satisfied with the work they're doing and feel that their work is being appreciated, then they will exert a greater effort while delivering to customers.

3.2 What is Meant by Satisfaction

An employee is satisfied with his/her work when all the essential compensations and benefits are provided, when the working environment is safe, healthy and non-toxic, when colleagues treat each other with respect and show appreciation, and finally how the job is affecting a person's personal life and mental health. The main reasons why drivers are not satisfied with their work is due to the lack of appreciation and the increasing workload.

When delivery drivers are given a fair amount of workload, then they no longer have to be stressed about finishing the delivery on time, driving fast on the road (which increases the risk of accidents), skipping breaks (which are essential for the driver's safety on the road), and parking in unsafe spots. When a company reduces the workload of drivers, then they have already contributed in increasing the driver's well-being and safety on the road, which will be appreciated by the drivers and understood as a way of showing care. Another essential act of expressing appreciation to drivers is by thanking them for their hard work and sharing with them the positive feedback given by the customers. This alone will motivate the driver to keep on the good work.

For companies, a driver does a good work once:

- All parcels are delivered on time to the customers with no delay.
- They give enough time for customers to answer the door (as many customers have complained about the fact that driver don't give time for the customer to answer the door, they directly leave).
- Parcels are not marked by customers as "Parcel not received" or "Parcel left in an unsecure location".

Last mile delivery drivers are the final link in a distorted supply chain. Unforeseen events such as traffic, workload, difficulty finding a parking spot are all out of the driver's control, which will impact their final delivery. Most delivery drivers enjoy their jobs, but sometimes it's intolerable due to the amount of work, which makes them less patient and stressed out.

Companies must take the time to listen to their drivers, salute them every morning and check up on how their doing, ask if they are facing any problems while delivering parcels to customers, and how can you help, encourage them to report any issue they encounter and motivate them to recommend any ideas they may have that can improve the efficiency while delivering (drivers are the ones delivering to the customers, and not their managers, hence they may know some information that their manages are not aware off), make them feel as part of the team and assure them that all the work they are doing in delivering the parcels to the customers wouldn't have been possible without them. Make their work less stressful by giving them the appropriate amount of parcels to deliver and not always loading them with extra parcels.
Logistics companies should change the way they engage with their drivers and set aside the mentality that the driver's job is just to deliver parcels to the customers for whatever it takes without complaining and causing trouble because they are already being well paid. They should think of incentives to encourage drivers and not increase their workload.

The working conditions of delivery drivers differ from one company to the other, and the driver's performance is affected by the terms of his/her employer, their payment structure, and the incentive structures.

So, to wrap it up, if the company's main objective is the customer's satisfaction and on time delivery, then one of the solutions is in the hands of the drivers, because they are the ones delivering to customers. Once they are treated well by giving them the fair amount of parcels to deliver, appreciating their work and making them feel as part of the team, then this will have a great contribution on the customer's satisfaction and on time delivery.

Chapter 4

The Effects on Sustainability

4.1 How is the Last Mile Worsening the Environment?

The issue here of reducing the driver's load while the demand on e-commerce just keeps on escalating means that last mile logistics companies will have to increase the number of drivers and vans on the road. This alone is another problem for sustainability.

The increase in last mile logistics vehicles on the road will increase the emission of greenhouse gasses, air pollution, noise pollution, congestion, traffic and accident rates. According to the International Energy Agency (IEA), back in 2019, around 25% of the global greenhouse gas emissions are just due to transportation, of that 25%, 74% were related to road transport [11]. As for the emissions from road transport related to the last mile delivery account for a considerable amount, but not exact data was available to demonstrate.

During the Covid-19 pandemic in 2020, 44% of the global population purchased goods online. This great increase of B2C e-commerce increased the demand on road transport to distribute the goods. If no action is taken towards reducing the number of delivery vans on the road, then the number of delivery vans is expected to increase by 36% in 2030 [12]. In 2019, 19 million metric tons of greenhouse gasses were emitted from delivery vans in the 100 largest cities in the world [12]. Emissions in cities will keep on increasing from the increase of freight flow which is due to urbanization, increase in online retailing, globalization and densification. The global urban population is expected to reach 6.7 billion in 2050 from 4.4 billion in 2020 [13].

Cities are accountable to around 70% of the global emissions [12]. The number of delivery vans is high with respect to passenger cars. The increase of delivery vans which is related to the growth of online shopping will transform cities into a challenging place to live due to air pollution, noise pollution, second lane parking increasing accident rates, traffic congestions and stress rates.

With the increase in volume from e-commerce, customers are becoming more demanding than ever. Customers are shopping online like never before, even for

small items costing less than $4 which could be found in the store across the street. Once customers order online, they expect their shipment to arrive as soon as possible (even the very same day), and without having to pay extra for delivery. Customers have little information about how their choices from online shopping are affecting sustainability. Some customers are aware of the impact but are not ready to pay more to improve logistics services. A survey done in Brazil reported that 65% of the participants said that information regarding the environment is of little importance to them when they purchase online [14].

When customers are prioritizing cost and speed over sustainability is putting more pressure on the environmental impact from greenhouse gas emissions.

The carbon footprint from last mile deliveries can range from 21 grams to 650 grams per kg of goods [15]. That's other than a failed delivery. A 10% failure rate can increase the greenhouse gas emissions by 15% [16].

We have seen that last mile logistics is not only the most expensive and inefficient leg of the entire supply chain, but also the most polluting.

Last mile logistics should be designed in a way to be less costly, more efficient, and environmentally friendly. Most companies focus more on the cost, efficiency and what pleases customers more than how this is negatively affecting the environment.

A study conducted by the World Economic Forum found that around one-third of the total shipping costs is from the last mile [31]. This increased the motivation of companies to make the delivery of the last mile more efficient.
The leading companies in retail, e-commerce and last mile delivery companies are aware of the environmental impact they are contributing in, and hence have set targets for the future to reduce their greenhouse gas emission by converting their diesel delivery vans into electric ones. Most of those companies have only taken small steps to electrify their delivery vehicles. They have failed to submit clear data that can be accessible to show the current measures they're taking and the progress they are doing. Most of such companies have made a commitment to reduce their carbon emission to either zero or net-zero by the year of 2040 or 2050 [12], but nothing is clear. Most of them are just starting with the implementation of electrifying delivery vehicles, they will definitely need to speed up their progress if they want to achieve their own sustainability goals that they have set.

Retail, e-commerce and last mile delivery companies must accelerate their efforts in electrifying their delivery vehicles as soon as possible. Local authorities can play a big role by forcing new policies and regulations on logistics companies to reduce their carbon emissions. Electrifying delivery vehicles should be combined with other changes to reduce the number of delivery vans in cities to reduce the congestion, and the best way to do so is by installing more pick-up points and

promoting their use in order to decrease home deliveries. Replacing home deliveries with deliveries to pick-up points can reduce the greenhouse gas emissions by 60% but will also reduce the cost by 3 times. All the main issues faced in last mile delivery could be solved through the use of pick-up points.

Chapter 5

Pick-Up Points

5.1 What are Pick-Up Points?

Pick-up points are predefined locations where customers can collect their online order from. Pick-up points could be either stores or lockers. Stores (or Hubs as we will be naming them) could be any shop that has a collaboration with a specific e-commerce or delivery company to drop off parcels at their store for customers to pick up their orders when they want to during their opening hours. Such stores are mainly tobacconists, post office and stationery stores. The service though is not free, the delivering company pays the store a specific amount per parcel, the amount ranges from $0.15 to $1.5 per parcel [1]. Lockers on the other hand are self-service. Once the delivery driver places the customer's parcel inside the locker, a message/email will be sent to the customer with a code in order for him/her to be able to access the locker and collect his/her order. Lockers can be located inside facilities or outdoors in public spaces.

The discussion below will demonstrate how Pick-up points can help e-commerce and last mile delivery companies solve the frequent issues faced in the last mile such as failed deliveries, lost parcels due to theft, delivery cost, Greenhouse gas emissions and customer satisfaction.

The main advantages of pick-up points are the reduction of delivery failures due to the customer's unavailability or a wrong address and the reduction in the number of vehicle stops and distance traveled as more parcels will be delivered in a single vehicle stop. Drivers will no longer have to struggle and waste time searching for a wrong address or waste time driving to a customer's address searching for a parking spot, knocking at the door and in the end not finding anyone there. What's causing cost inefficiencies the most is a second delivery attempt due to a delivery failure. By reducing the total traveled distance and avoiding second attempt deliveries (hence no failed deliveries), the total delivery cost will drop as more parcels are being delivered by fewer drivers (hence less vans on the road) in less time and less mileage. This will not only improve cost efficiency, but it will generate a better route for each driver and improve the environmental conditions by decreasing the greenhouse gas emissions. This is also confirmed by the urban mobility plan adopted in the city of Rome, Italy, that

the use of pick-up points is one of the main methods to improve environmental sustainability.

Let’s try and elaborate more on that.

When a driver has to deliver several parcels to different addresses around the city, having to stop several times within a few meters means that he/she will have a low driving average speed. The way in which delivery drivers drive can be observed through repeated rapid intervals of deceleration, stopping to park, and then accelerating again. This has a significant impact on the fuel consumption and average speed. Last mile delivery drivers spend a lot more on gas because they are spending more time on the road to cover the same distance.

When a delivery driver stops his/her van for a parcel drop off, he/she must turn off the vehicle and lock the doors, but most drivers tend to do the opposite especially for fast drop offs. They tend to keep the vehicle in idle mode when searching for the parcel in the van and handing it over to the customer. A vehicle spends more gas when it's idle than it does when it is restarted. Not to mention all the other unavoidable idle stops at traffic lights in a crowded city.

Failed deliveries as we have mentioned earlier are one of the costliest operations in last mile delivery. A single failed shipment has an average cost of $17, still with that, last mile deliveries have a failure rate of 5%.

So, if drivers had to deliver only to pick-up points, then they will be spending less time on the road because of less vehicle stops and more consolidated stops, which will decrease their gas consumption for the same distance traveled. During a bulk drop off the driver will spend a little bit more time searching and collecting parcels from his/her van to deliver them to the store or placing them in the locker, forcing the driver to turn off the vehicle as the time spent at the stop will be more than a single parcel drop off, decreasing gas consumption. And finally, all drop offs to pick-up points can rarely fail, decreasing significantly the percentage of failed deliveries that otherwise would have been reattempted another time, increasing the costs.

Deliveries to pick-up points can help reduce the gas consumption by 74-87% per parcel or 36% per m^3 [3]. This can demonstrate that the operational cost of delivering to pick-up points is much cheaper than that of individual deliveries [2].

Figure 5: A representation of a parcel locker

5.2 Customer's Preference and Acceptance

Until now we have discussed the benefits of pick-up points and how they can help in reducing the main issues faced in last mile logistics, but we did not assess the customers' willingness to shift from home delivery to pick-up point delivery, and what are the attributes that can affect their preferred choice of delivery. This step is crucial for the successful implementation of pick-up points.

Several studies have been conducted to assess the e-consumers' acceptance towards the use of pick-up points services and what are the factors that govern their choices. The two main factors affecting the choice of customers towards the use of pick-up points instead of home delivery are: Location, how far is the pick-up point from their home/work/school, and Accessibility, mainly the operating hours. There are other factors as well that play a role in the choice of pick-up points. Factors such as consumer's demographics, frequency of online shopping, level of education, price of delivery, reliability, convenience and privacy [5].

The online habits of consumers such as the frequency of online shopping and their overall experience and service affects the customer's choice of using pick-up points [6]. Customers who are extremely satisfied with their orders always arriving in time and are present to receive it, are two times less likely to switch to pick-up point deliveries than unsatisfied customers who often miss their delivery because they are often not at home or never receive the delivery [5].

As for the age range and level of education, according to the literature, young and highly educated customers are more likely to switch to pick-up point delivery [7, 8]. The majority of those consumers as well are even more willing to switch the service if they know that it can reduce greenhouse gas emissions, hence being more sustainable.

Consumers who use their car to travel to the city center are more likely to pick up their order from a click and collect point. This group of consumers probably believe that collecting their order from the click and collect points on their way home is a good idea that saves time [5]. Since car use to the city center is closely related to consumers' acceptability, location of the click and collect points should be chosen so as to provide easy car access and proximity to car parks [4].

Customers who use their car to move around the city rather than using public transport believe that picking up their order from a pick-up point is convenient and time saving and are hence more likely to use pick-up points as a delivery option [5]. From those customers we should note that the location of pick-up points should be easily accessible by cars and close to car parking [5].

Customers who are time conscious, and hence are not willing to stay home all day just to receive the delivery once it arrives find the pick-up point service to be convenient and hence can pick up their order when they are free. Also customers who are all day at work/school and have no one at home to receive the parcel once it arrives are willing to shift to pick-up point delivery as they find it more convenient.

Income on the other hand affects the willingness to switch to pick-up point delivery. Rich people are less likely to switch to pick-up delivery even if home delivery is more expensive than pick-up point delivery [5]. High income people favor convenience over cost.

5.3 Who Should Pay for the Service?

The operation of all kinds of pick-up points should be feasible for it to work. This is possible however if either the e-commerce/last mile delivery provider or

customers pays for the service. We have discussed previously how last mile delivery service providers can significantly reduce their costs by replacing home delivery with pick-up point delivery. Hence it is fairer if the company pays for the service rather than the customer [9]. Another reason why it is important that companies pay for the pick-up point service and not the customer, is to promote its use and encourage people to use the service more. A study showed that a high percentage of people would use the pick-up point service (74.7%), but they would rather not pay for the service (71.6%) [5].

A 2020 Statistics showed that the main reason for internet users worldwide to purchase goods online rather than in store was the free delivery option. Figure 6 shows the other reasons for why internet users decide to shop online.

Since price is a crucial factor for low income and price sensitive customers, then it is even better and more encouraging for all customers if the pick-up points are cheap and way more expensive compared to home deliveries. An optimal solution to encourage more people to switch from home delivery is to provide the service for free for a limited period of time and stress the benefits it has towards a more sustainable environment.

A marketing campaign is extremely essential to attract more customers. The campaign should aim at promoting the positive effects this service can bring to the environment, especially that online shopping is increasing and the problem could escalate even further, making the city a challenging place to live in. Another point that should also be stressed out in the promotional campaign is the lower price of delivery with respect to the traditional home delivery.

For the success of this project, it requires the support of all the stakeholders. The customers to switch the service, e-commerce and last mile delivery services to adopt the service, owners of stores to integrate pick-up deliveries, and owners of private/public spaces to rent them in order to install lockers.

Governments and public authorities can have an effective role in forcing/pressuring retailers, e-commerce and last mile delivery companies into reducing emissions by introducing new policies and regulations. Local authorities should facilitate the process and permissions to install parcel lockers. Choosing the right location is not something easy. The installation of lockers has a high investment cost, and the orders from customers are inhomogeneous, which means that a careful study should be done to select the best locations to maximize its use and optimize the use of urban space.

After covering customers' acceptance and behavior towards pick-up points, and how promotional campaigns are essential to encourage customers into switching from home delivery to a pick-up point delivery, it is extremely important that the

location of pick-up points is optimized to ease the collection process of customers.

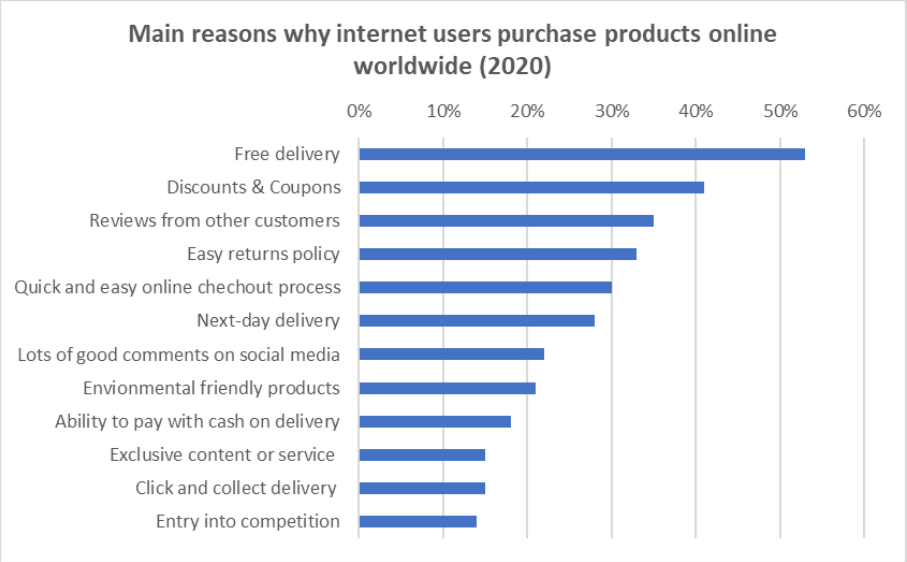

Figure 6: The main reason why people worldwide purchase products online, a study conducted in the year 2020.

5.4 Where Should Pick-up Points be Located?

We have mentioned earlier how location and accessibility are the main factors to customers if they had to pick up their order from a pick-up point. Their location should be convenient to the customer. So, if a customer commutes to work on a daily basis by train or public transport, then it will be convenient for him/her to have the pick-up point in the train station or on his/her way walking home. On the other hand though, customers who go to work by car will find it more convenient that the pick-up point is on their way home and there is a parking spot next to it, a great option could be a gas station. As for other customers though, it is more convenient if they can collect their order while doing other things, for example while they're shopping in the mall, or for groceries. Other customers though prefer having a pick-up point close to their home.

If the location of pick-up points is not convenient for customers, then promotional campaigns will not be beneficial at all. Where to locate lockers is extremely crucial for the success of this service, a deep analysis should be conducted before deciding on the final location. It should be noted though that the optimal location

for lockers will not be the same for all the cities. Data should be collected and studied to identify the behavior, culture and the most used mode of transport of inhabitants.

A Hub depends on the location of the existing store, hence there are a lot of areas not covered with stores which accept parcel drop offs for customers. For all those areas though, it is essential that parcel lockers are installed. Even for areas with Hubs, it can be also useful to install lockers especially if the demand from customers is high in the area.

5.5 More of Lockers or Hubs?

As we have mentioned earlier, Hubs are stores which accept the collection of parcels at their store so customers could pick them up (Hubs are mainly bars, tobacconist, post office, stationery store). The partnership between the delivery services and stores is an advantage for both parties. The benefit for stores is that first they get paid per parcel, and at the same time they will have more visitors to their store. The only drawback though to most customers is that they are limited to the operating hours of the store, which makes it even more annoying when such stores close around midday for lunch break. On the other hand, lockers do not face this issue, they do not have opening and closing hours, they are accessible 24 hours, 7 days a week. The above statement is true if lockers are not placed inside a facility, such as in grocery stores and malls which have their own operating hours, so when the grocery stores closes at night, you can no longer access the facility to reach the locker, even though the locker functions. The installation of lockers outdoors is the optimal solution for all, as customers will no longer have to worry if the facility will be closed or not when they arrive. Although this is an optimal solution, it is always easier said than done. In some countries, the installation of parcel lockers on public land creates a lot of conflict with the public authority and it could take a lot of time to go through legal procedures in order to issue a permit, and it is not always granted. Another minor issue with installing lockers outdoors in public space is its security against vandalism and theft. Cameras and alarms must be placed on lockers, which will help decrease the risks. Those are the main reasons why lockers are more often installed indoors in private places rather than outdoors on public streets. Authorities should ease the process of parcel lockers and encourage their use, because online orders will keep on increasing, hence increasing the amount of delivery vehicles on the road, which will increase greenhouse gas emissions, as well as increasing traffic and congestion in cities which will only make life more challenging.

Some customers avoid using hubs because there is a chance of finding a queue at the store, so they have to wait for their turn and hand in the necessary documents

to get their order. Not all customers find it pleasant to wait in line and show their documents to the store owner in order to get their order. Lockers are a better option as there is no human contact nor queues. The customer has to only insert the code sent to him/her by email/message on the screen of the locker so that the appropriate door containing his/her parcel will open up automatically. Customers though have to collect their parcels from the locker within 3 days of arrival, while they have 5 to 7 days to collect it from the hubs. The number of days a customer has to collect his/her parcel from a pick-up point does not often influence their choice between a locker and a hub, as some data shows that 70% of all parcels are collected by the customers within 24 hours [10].

The size, quantity and content of parcels can sometimes be a limitation when it comes to locker delivery. Lockers have a fixed size, and can hence fit parcels with a maximum weight and size. Inpost, one of the first leaders in the business of parcel lockers in Europe, allows parcels with a maximum weight of 25 kg and a maximum dimension of 41cmx38cmx64cm. As for the parcels' content, extremely expensive items and flammable/hazardous materials are not allowed to be placed inside lockers due to safety and security measures (such measures can be different for different countries, as each has its own rules and regulations). Lockers as well have limited compartments, ranging from 20 to 100+ compartments of different sizes, where each compartment can contain a maximum of 1 parcel. Note that when a driver wants to drop off parcels at a locker with 50 compartments for example, that does not mean that he/she will be able to fit 50 parcels, because there could still be parcels inside some lockers from 1 or 2 days before, but as we have mentioned previously that the majority of parcels are collected by customers within the first 24 hours.

Hubs on the other hand have no restrictions regarding the weight, dimension and content of the parcel. Taking into consideration only the weight and size of a parcel, a customer ordering a large or heavy item will not prefer its delivery to a pick-up point as it's inconvenient for him/her to carry heavy or large items home, it is more convenient to have it delivered to his/her home address.

When it comes to the drivers' preference in home delivery or pick-up point delivery, they all prefer pick-up points. The reason for that is the fewer number of vehicle stops, less time on the road, better routing, and almost no delivery failure. As for their preference between hubs and lockers, it usually depends, as some drivers could encounter technical issues while dealing with lockers, which could sometimes be frustrating, and will require previous training. As for hub deliveries, the main drawbacks that drivers could encounter is that they might have to wait in the store in case of a queue, or find that the store is closed without a previous notice, which will affect the delivery success rate.

Lastly, moving on to the cost difference between hubs and lockers, hubs are often less expensive, but lockers could be more convenient if more customers started using lockers, which requires a huge network of lockers, hence its more convenient for economies of scale. The barriers allocated with the installation of parcel lockers are mainly the initial high investment cost which consists of the structural cost, installation cost, land tax, and the driver's training cost. Not to mention the periodical maintenance cost. Hubs on the other hand have a lower activation cost, it only requires a confirmed deal with the store owner, and a fixed fee per parcel (between $0.15 and $1.5).

Lockers are innovative, more efficient and more convenient for customers than hubs, but is there a way to avoid the high investment costs associated with the installation of lockers? The answer is YES. The way retailers, e-commerce and last mile delivery services can avoid those costs is by joining a network of open parcel lockers instead of installing their own lockers which would cost a lot and may not allow them to gain profit out of it.

5.6 What are Open parcel lockers and how can they be a better option?

The majority of us have seen parcel lockers around the city, but what we know is that the owners of such lockers are the only users with access to it. To give an example, Amazon has a lot of lockers, but who has access to their lockers? Only their carriers and customers who have ordered an item from their store and want to pick it up. Hence, DLH, UPS, ebay and other carriers have no access. Those types of lockers are called Closed Lockers, their owners are their only users. On the other hand though, Open Lockers are accessible by anyone no matter who is the entity delivering the parcel. The owners of open lockers are private companies focused on the development of a system of lockers.

How can closed lockers be an issue and what are the advantages of opened lockers?

The market for parcel lockers is increasing, as more players are entering the market of closed parcels there is a struggle for location. Owners of closed parcels are reluctant as they are all installing lockers in the same location which only creates more trouble, as none of them will have their lockers working at full capacity. Lockers that are always filled with parcels signify big profits to the locker owner, while empty lockers signify big losses/costs. Owners of closed lockers have a lack of knowledge towards economies of scale. The key for success in the market of lockers is scale/density. The more opened parcels present in the

city (with a precise location that has been carefully studied for the convenience of as many users as possible) with the support of all retailers, e-commerce and last mile delivery services participating in the network of lockers to deliver parcels to their customers, is the best deal for all stakeholders involved.

E-commerce and last mile delivery services will avoid the high investment costs in lockers but can still benefit from them to reduce the costs of home delivery. But for them to use the lockers they will have to pay a small fee per locker compartment, or a subscription fee per month. It depends on what the locker owners want to implement, but it will definitely be cheaper than home deliveries. Open parcel lockers are so rare and hard to find in Europe, but are widely spread in China and neighboring countries. HiveBox is the biggest player and owner of open parcel lockers in China and around the world. In 2020 it had a network of 170,000 parcel lockers, handling over 9 million parcels in a single day. HiveBox charges couriers around 0.7 CNY per locker compartment. This might sound ridiculously cheap, just $0.11 per locker? We cannot actually compare the prices and cost of living in China with that of America or Europe, as in China they are significantly lower. What helped the success of opened parcel lockers in China is the support it got from the Chinese government. HiveBox is willing to expand its network even further with the rapid increase in volume the market is experiencing. Its main strategic objective for the future is to expand even more inside cities, where it currently operates in more than 100 cities across China.

Other countries should learn from China and adopt similar services. The overall spread of parcel lockers in most European countries is low. In Rome, Italy, the data shows that there is low knowledge for parcel lockers (22.1%), and a low usage rate (8.2%) [4]. Poland, Germany, Spain and Finland have a wider spread in parcel lockers with respect to Italy, UK and the Netherlands. In Germany, parcel lockers are widely spread throughout the country, where 90% of their population are able to reach a locker in 10 minutes, while in Italy only 12% of the population can reach a parcel locker in 10 minutes [4].

Governments in Europe should encourage companies with open parcel lockers rather than closed ones especially for the better use of urban spaces. Governments should also limit the number of players in the market to make it profitable for the current players. The volume of online orders will keep on increasing throughout the years with more new entrants to the market of parcel lockers which will create a competition for price and hence a decrease in profit margin.

Chapter 6

Other Innovations in the Market

6.1 Drones

Due to inefficiencies in the last mile delivery, many people thought of different ways to overcome inefficiencies with the use of technology. One of those innovative technological solutions was the use of "Drones".
The idea of using drones as a last mile delivery option was first introduced by Amazon. The main idea of a drone was faster delivery, the customer will be able to receive his/her order only 30 minutes after he/she has made the order online. Using drones is more sustainable as they emit no greenhouse gasses and will not add to the traffic congestion, but most importantly customers will no longer have to wait for their orders to arrive. But are drones really effective?

The use of drones could sound like something cool, but are they a good solution? Not really. Drones have a lot of limitations which are listed below.

- **Delivery Area**

  Drones cannot fly far away from the warehouse, it has a limited radius of 15km. Not only can they deliver to customers nearby, but there are some restricted airspaces such as military zones and airports. A drone delivery is only possible for customers who live in a house with a yard, and is not suitable for people living in apartments, as drones will drop the parcel in an open space, which should be on the customer's property.

- **Altitude**

  Drones cannot fly at a high altitude, they have to stay low. Flying at a low altitude will risk collision with objects (even with the use of Artificial Intelligence, it's too early for perfection). Flying at a low altitude will contribute to the noise pollution, as drones have a high disturbing noise.

- **A parcel's Weight and Size**

  Drones are small devices; hence they are not capable of carrying heavy parcels nor large ones.

- **Safety**

  Drones deliver the parcel to the customer by dropping it from a height to land on the customers' yard. Dropping it from a height will increase the risk of falling on someone's head or may damage the parcel's content.

- **Weather Conditions**

  A drone cannot fly on a bad weather day. The small size and light weight of a drone cannot withstand heavy rain, strong winds and thunder.

- **Risk of Theft**

  Since drones fly at a low altitude, and are prone to collision, they are more susceptible to theft.

- **Less Productive**

  A single drone can only carry a single parcel of a limited weight and size, and the delivery time of a single parcel by a drone can reach up to one hour.

6.2 Robots

Similar to drones, delivery robots are designed for a fast and sustainably delivery. The difference however is that delivery robots travel on the ground and not in the air. The robot is basically a delivery box with 4/6 wheels, fully equipped with sensors and cameras and is fully electric, traveling autonomously from the warehouse to the customer's location to deliver their order. It is true that the robots navigate on their own, but they are monitored by a human who can also control it. This can be seen as a minor limitation, but delivery robots like drones have a lot of other limitation which are:

- **Delivery Area**

  Robots are designed to travel in uncrowded areas such as the suburbs, gated communities and campuses to be able to drive easily on the sidewalk with pedestrians and on bike lanes with cyclists. Robots as well cannot travel a long distance away from the warehouse. Delivering in only specific and uncrowded areas at a limited distance from the warehouse is a big disadvantage.

- **A Parcel's Weight and Size**

  The delivery robot can only deliver a single order per travel. The item being delivered however, can only be of a limited weight and size in order to fit in the delivery box. Hence not all deliveries are successful with a robot.

- **Safety**

  Since delivery robots are totally autonomous, they can be subjected to some errors and malfunction which can cause collisions with cars, pedestrians, or cyclists. Some cases have also been reported of robots catching fire.

- **Congestion**

  If robots are to be implemented, then there will be several of them on the road, which will add to the congestion of sidewalks making it annoying and difficult for pedestrians to walk on.

- **Risk of Theft**

  Robots are equipped with sensors and cameras, which makes their theft harder, but that does not eliminate the chances of them being stolen.

- **Road Conditions**

  In case of a road blockage on pedestrian streets due to construction work, this can cause trouble for the robot, blocking its way to the customer which will increase the risk of a failed delivery.

- **Less Productive**

  The fact that robots can only make a single delivery of a short distance in some specific areas carrying an item of a specific weight and size, having to go back to the warehouse after every delivery and to be charged once it runs out of battery makes it a less efficient and less productive mode of delivery.

This final chapter showed how drones and robots have a lot of limitations and are not so efficient as parcel lockers in solving the issues faced in the last mile

delivery. Other similar innovative products are being introduced to the market, but they are just highly optimistic solutions.

The focus should be more on more realistic solutions that can be applicable everywhere and most importantly in cities in order to combat the problems facing the last mile before it becomes more difficult with the rise of online orders.

Conclusion

We have discussed throughout this thesis the main issues faced in last mile delivery and how they are impacting the efficiency and total cost of the chain. Re-attempting a failed delivery due to a customer's unavailability is the main problem to be solved, and by solving it we also solve the other issues. We have also mentioned the importance of drivers' engagement and how they are main players in the success rate of a delivery. To elevate the customers' satisfaction and the delivery success rate, companies should reconsider the workload given to their drivers and how they engage with them. But the main solution discussed in this thesis was the use of Open parcel lockers which is a network of shared parcel lockers which can please all stakeholders. For the service to work people should be willing to shift from the traditional home delivery into the pick-up point delivery which should bring them more value. We have discussed some techniques to help companies encourage customers to use lockers, which is to offer the service for free, or for a much lower price compared to a home delivery. It is fairer for the company to cover a locker delivery cost since by using this service they will be saving a lot of money. The other problems that are solved by using lockers are wrong addresses entered by customers, parcel theft, closed businesses, and environmental issues.

Just by implementing the right business and marketing strategies with the help and support of the local authorities, lockers can be the best long-term solution for e-commerce, retailers and last mile delivery services to decrease their cost and improve their process efficiency. The sooner companies start introducing open parcel lockers, the better, as orders online will increase even further in the upcoming years.

However, it should be noted that the solutions and practices discussed may be successful in some cities but not in others. Their success depends on the culture, geographical area and conditions, customer's buying habits, and the willingness of customers and companies to get involved.

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