Logistics Network Optimization: The case of United Parcel Service

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Abstract Modern global markets are characterized by fast pacing and dynamic processes, which sets pressure to companies' supply chains, in continuous searching for operational improvements. In addition, customers' empowerment, through globalization and e-commerce has been shifting the distribution paradigm. Thereby, companies are unceasingly on the hunt for efficiency enhancement opportunities, often targeting critical and costly activities, such as transportation and distribution.
In this context, the current project focus on a leading logistics' provider, UPS Portugal, with closer look to last-mile logistics model. The company wants to optimize its logistics network, by adding a new level to the grid, placed closer to final customer. This infrastructure, named UPS Access Point aims to reduce reverse logistics complex processes and at the same time, improve the network's convenience and flexibility. Thus, it was assessed which Postal code locations in Lisbon area are eligible to hold UPS Access Points from an economical point of view but also taking into account UPS requirements for customer proximity and comfortability. Compared to UPS current distribution network, the suggested network solution with implementation of Access Point locations represents an economical benefit from operational cost optimization, but also an upgrade in customer proximity with the deployment of pick-up/delivery points located close to end customer.
Keywords: Supply Chain Management, Last-Mile Logistics, Location-Routing Problem, Reverse Logistics, Cross-Docking, UPS Access Point

1. Introduction

The rise of e-commerce has been boosting online retail and contributing to shaping new consumer habits. E-business is more customer-oriented, since buyers are more demanding and empowered. Therefore, companies operating online are feeling the pressure on their supply chains. On one hand, it is imperative to improve efficiency on the last-mile segment, which has been increasing complexity with individual home deliveries. On the other hand, customers request greater flexibility, when dealing with deliveries and pickups. According to UPS, from 2016 to 2020 online retail globally is expected to outgrow the rate of gross domestic product in 3.5 times (UPS, 2017). Thus, UPS identified the necessity of restructuring its Portuguese logistics network tocope with increasing demand of e-commerce. A new profilefor UPS customers was strategically defined as "on-the-go"shoppers that demand more capacity and flexibility. On thatsense, UPS Access Point network was developed to present a more flexible distribution network that provides convenient delivery or pickup locations alongside smallbusiness stores – Access Points.

In this context, the present work emerges, which aims to analyse, in an economical perspective, the current UPS distribution chain versus the implementation of UPS Access Point network, as well as to suggest the locations of these pick-up/delivery points for each Postal code area.

Taking these goals into consideration, the paper is divided into 6 main sections. The first one is Introduction an intends to give some contextualization of the problem and pinpoint the main objectives for the project development. Then, Section 2 presents the case study by giving some clarification about UPS group history and also the main features of UPS supply chain. Section 3 holds the literature review on the concepts most relevant to the problem under study and lay the foundations for section 4, where all data gathering and forecasting takes place, but also to section 5 where case study resolution is developed with a cost optimization formulation, followed by a thorough sensitivity analysis. Finally, section 6 prepares paper's conclusions, as well as potential future work that can help UPS achieve a more efficient distribution network.

2. Case-Study: UPS Access Point

UPS is one of World's biggest freight forwarders and has been trying to shape its supply chain to cope with the pressure done by increasing e-commerce. For that reason, UPS is always looking for continuous innovation and has been pushing improvements specially on the last-mile level. The most recent advance was the implementation of Access Point in many different countries. In order to understand the benefits of bringing Access Point network to Portugal, this chapter intends to provide context to case study problem. First, UPS activities as a group will be depicted, with special detail for the services portfolio and strategic operation areas. Afterwards, further drill down is presented for UPS activity in Portugal, in particular at Porto and Lisbon Hubs. The activities integrated in Portuguese supply chain will be detailed, with special interest in urban last-mile logistics.

2.1. UPS Portugal Operation

UPS is currently operating in Portugal through two sorting hubs located respectively in Porto's airport and Lisbon, Prior Velho as portrayed in figure 1. From the European Air Hub, home for UPS international operation located in Cologne Germany, packages are sent to Oporto by plane on a daily-basis. These planes can accommodate 30 air cargo containers. In addition to air transportation, there is a daily road connection (1-3 FTL trucks) Benavente-Porto and

Benavente-Lisbon. Once the plane arrives at Porto's airport, the cargo tagged for Porto is transferred to UPS sorting facility, located at the back of the airport. The rest of the cargo remains at the airplane and UPS adds all packages tagged for Lisbon that arrived at Porto's sorting hub from local pick-ups. Then, the airplane flies to Lisbon. The ETA-Expected Time of Arrival at Lisbon airport is 7.05 from Tuesday to Friday and 6.45 at Monday, while ETD-Expected Time of Departure from Lisbon is 19.15, from Monday to Friday. The air cargo arriving at Lisbon contains at least 1 container from Porto, 1 container from EU Community countries and 1 container extra EU Community. When the airplane lands in Lisbon it is unloaded and the

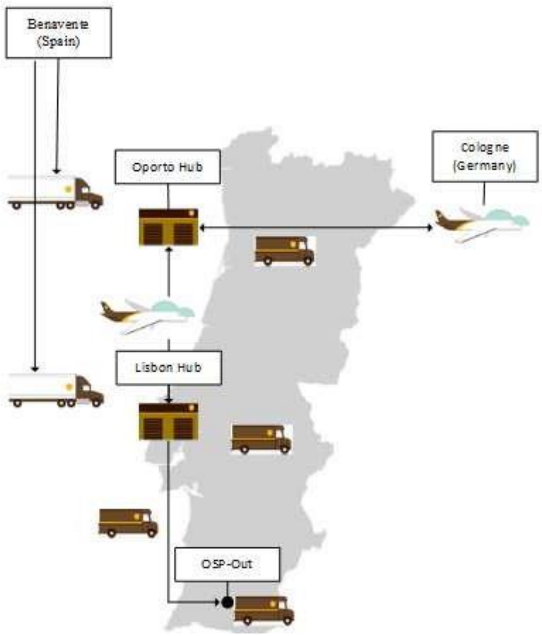

Figure 1- UPS Portugal supply chain network

cargo leaves by truck to UPS Lisbon sorting hub. After sorting process, packages follow to delivery by local network. The plane that arrives at Lisbon's airport, after being unload, is filled with packages tagged for Porto and International and now follows the inverse transportation route Lisbon-Porto. There, packages tagged for Porto are unloaded and International packages are added. Finally, the plane leaves again to International Air Hub in Germany, completing the full distribution cycle. Figure 1 also depicts a connection between Lisbon hub and an outside service provider (OSP-Out) warehouse, located in Algarve. Everyday 1 to 2 small FTL makes the connection between the two locations. The OSP-Out warehouse works as a X-docking aggregation point, where packages are combined according to delivery location.

Outbound Logistics: Packages with origin in inbound logistics are unloaded in two different docks, 1 and 2. Dock 1 is exclusively for air cargo containers Dock 2 is used to unload FTL trucks. Thus, there is a physic separation for air and ground operation and although there are distinct loading areas, according to the mode of transportation, once packages are unloaded, they will converge to the same conveyor belt, around the X-Ray area. As soon as packages reach the wright conveyor, each driver is responsible for picking the assign parcels.

Inbound Logistics: For inbound process, packages are unloaded, exclusively in a determined conveyor belt, to assure packages are scanned with DWS machine - Dimension, Weight, Scan, in order to measure its exact size and weight. Inbound Logistics process is slightly different from Outbound procedure. All air cargo must go through X-Ray machine, to assure the safety of the plane. Instead of separating all air cargo from ground freight, UPS scans all packages with X-Ray. To avoid complexity between the two levels that separate air and ground cargo, the inbound operation is processed in cycles of air and ground freight.

2.2. Last-Mile Urban Logistics

As noted above, the boom of e-commerce is putting pressure in companies' supply chains in a transversal way, but with specific emphasis on last-mile segment with home deliveries. UPS last-mile logistics operation take place from the moment each truck leaves UPS sorting hub to deliver its packages. Each vehicle has an assigned area, with specific Zip codes. As mentioned before, FTL trucks are loaded at UPS Sorting hubs, and must leave the facilities at most at 10 a.m. to start parcel's delivery. UPS Portugal operates subcontracted pick-up and delivery fleets, leaving the complex urban last-mile logistics to three different independent operators. In addition, packages have different time intervals for delivery, i.e., express might have a time window until noon, while UPS standard can be delivered until 6 p.m. Subcontractors must manage the different time windows and vehicle routing problems. The cost structure related to last-mile subcontractors is based on delivery/pickup stops, but also the volume of packages that take part at each delivery/pickup stop. Besides these two variables, a failed attempt for delivery (usually unattended home delivery) is also considered as operational cost.

2.3. UPS drivers for change

As noted above, the boom of e-commerce is putting pressure in companies' supply chains in a transversal way, but with specific emphasis on last-mile segment. Growing e-commerce keeps pressure on UPS's supply chain network, as it constantly experiences failed home deliveriesthat need to return to the sorting hub for a second delivery perform on the next day. Failed deliveries and consequent operational workflow are constantly increasing last-mile logistics costs and that is one of the main reasons why UPS seeks for innovation and ways to reduce costs, but still improve network flexibility. On that note, the main drivers for UPS Access Point implementation are aggregated in two core categories:

• Unattended home/business deliveries as mentioned before are a result of increasing local deliveries. In short-term, the main consequence for unattended deliveries is a growing number of delivery's retries and consequently cost increase for last-mile. In the long-run however, there is a growth in reverse logistics volume.

• Packages Returns & Sending are also growing as a result of general e-commerce deliveries. Whenever a customer requests for package return/sending, a pickup must be scheduled. The main drawback is that customer might not be available during pickup schedule. Thus, packages return/sending lack in flexibility and can lead to customer's unsatisfaction.

2.4. UPS Access Point solution

Using the same strategy as in many other countries, UPS wants to implement Access Point Network in Portugal. The end-goal is to create another level in the supply chain, closer to customer and redesign the urban distribution network. Figure 2 displays future implementation of Access Point Network and the respective changes on the distribution network illustrated with dotted lines. Each vehicle routing is rearranged if there is enough volume to consider the location of UPS Access Point. In addition, drivers are notified if they must go to the Access Point or straight to UPS sorting hub, depending if there are any packages. Whenever there are unattended home deliveries,packages can be transferred to the closest Access Point, avoiding the complex process of reverse logistics.

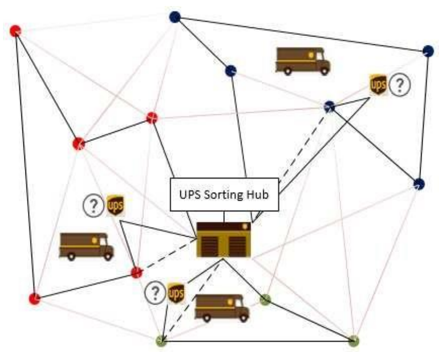

Figure 2- Access Point network design

3. Literature Review

3.1. Supply Chain

The supply chain concept has been evolving over the years, from early 1950s a basic understanding of logistics in a military perspective was perceived as the science responsible for searching, maintenance and transportation of materials, people and facilities Throughout the years different definitions of supply chain have been presented. According to Ballou (2006), supply chain is a wide scope of functional activities (i.e. transportation, inventory management) that can be repeated along the network, by which raw materials are transformed in finish products, with added value for the end-customer, and considering an upstream and downstream flow of materials and information. Customer's demand patterns have been evolving rapidly and moreover, request products to be delivered faster, on time, in a global market. This complex demand, combined with rapidly evolving technology, have been leading to a more dynamic market, calling for greater flexibility in supply chain relations. Consequently, over the 1990s, supply chain management (SCM) began risen attention. While there is not much controversy about the definition of supply chain, SCM finds in literature different point of views for its definition. According to the Council of Supply Management Professionals (CSCMP, 2013), SCM aggregates the planning and management of all type of activities involved in sourcing and procurement, conversion, logistics management operations and both interfunctional coordination and interorganizational collaboration. More synthetized, SCM integrates supply and demand management, both within and transversely to companies. After comparing different SCM definitions in literature, Mentzer et al. (2001) defined SCM as the strategic coordination of traditional business units, both within a single company and all the other business functions across the supply chain, with the common purpose of improving the performance of individual companies and the supply chain as a whole. Stock & Boyer (2009) shared the same definition and distinguished different business units including material suppliers, purchasing, production facilities, marketing and sales, logistics, and systems that somehow facilitate the direct and reverse flow of materials, services, information and finances from production to end-customer. For the authors, SCM is a tool to create added value, maximize efficiencies and fulfil customer's requirements.

3.2. Transportation

Supply chain management has been maturing towards activity integration in recent years. However, the impact of different activities to the overall cost of the supply chain can be very unlike. Although transportation adds no value to the product, it provides place and time utility, by moving goods efficiently and effectively to the right place, at the right time (Coyle et al., 2011). In addition, transportation can account for one to two thirds of all logistics costs (Ballou, 2004) making it a key activity, not only because of the impact in the supply chain dynamics but also cost wise.

3.2.1. Transportation modes and features

Transportation is a relevant activity within a company's supply chain and the decision about transportation mode is critical for transport management and lies on the trade-off between transportation costs and customer service. Basic modes of transportation include airlines, motor carriers, railroads, water carriers and pipelines.

The evaluation necessary to choose the best fit in terms of transportation mode for a specific business model relies on the comprising between the following fundamental characteristics of each transport: price; transit time variability; flexibility; capacity; frequency; losses and damage (Crespo de Carvalho, 2012). Each transportation mode performs differently for each fundamental characteristic and the best mode for a business must be assessed taking into account the overall performance against what are the companies' business model requirements.

3.3. Reverse Logistics

Reverse logistics is a specialized segment of logistics concerned with management and movement of products and resources, post-sale and after delivery to customer (CSCMP, 2013). From cost perspective, reverse logistics can be defined as the set of processes of receiving returned products, either to recapture value or for disposal (Greve & Davis, 2012). Reverse logistics is often seen as a cost of doing business and is frequently undermanaged. However, according to an Aberdeen Group study (2010), the average manufacturer will spend 9% to 15% of total revenues in returns. Reverse logistics presents specific challenges distinct from forward-moved supply chains. Some companies try to manage reverse logistics through forward logistics channels, but often find increasing operational complexity and costs (Deloitte, 2014). Reverse logistics costs are less than 4% of total supply chain costs for most companies (Greve & Davis, 2012). To operate a successful and efficient reverse logistics network, robust IT tools and personal skills are required. Often, companies do not have this expertise and choose to outsource to third-party logistics (3PL) providers. When outsourcing reverse logistics activities, companies need to assess whether to outsource the entire reverse network, or specific activities, i.e. transportation or sorting. A successful management of reverse logistics is related with how managers want to address the reverse flow of materials. Thus, companies can build dedicated reverse logistics networks to deal with the specifications of these channels, and turn returned goods in competitive advantages (Deloitte, 2014).

3.4. Last-Mile logistics for urban delivery

According to the last study performed by the International Post Corporation (IPC, 2016), 76% of consumers prefer home delivery service and 72% of respondents refer to have used the post for final delivery. On the other hand, 94% of customers mention to have used the post for parcel returns, strengthen the idea that logistics providers often try to avoid the complex reverse logistics processes. Although Post companies take such a huge role in parcel distribution, through their wide network of assets and infrastructures, some companies have struggled to adjust their business model from light documents to parcels. Home delivery can be performed by traditional postal mail companies, courier services or crowd-shippers. As an alternative to home delivery, automated parcel stations (APS) equipped with parcel lockers and pick-up points (PP) are fast-growing solutions (Augereau & Dablanc, 2008). Table 1 presents a SWOT analysis for the pick-up points (PP) network solution for parcel delivery. The SWOT analysis rests on the idea that PP network enhances flexibility and allows cost optimization, through mileage and reverse logistics decrements. However, the main down side lies in the fact that increased flexibility demand for customer to perform initial/last mile. From threats perspective, growing e-commerce may present challenges to PP density and consequently, increasing mileage. The opportunities exhibited by PP network might reflect in final price reduction, but also in efficiency improvements to parcel's operators.

4. Problem data analysis

The original problem driving the change of UPS last-mile logistics model arises from a conjugation of structural market changes namely once, a market focused in B2B segment changed to a more and more B2C delivery business. Growing along the B2C segment is UPS residential deliveries' operation and consequently unattended home deliveries. From 2015 to 2017 residential stops rate has been growing around 3% to 4%. As UPS Portugal logistics network is built around a compensatory subcontracted model, guided by number of packages and number of stops, performed for delivery and pickup services, unattended home deliveries represent extra costs. As portrayed in Figure 3, current residential delivery process operates unattended home deliveries returning packages to the hub for a next day delivery. The alternative for unattended residential deliveries is to leave the goods at the closest UPS Access Point (UAP). Although it also accounts for one extra stop, there is a special compensation fee, which fluctuates between 30% to 60% less, considering the Spanish compensation fees for stops at UAP.

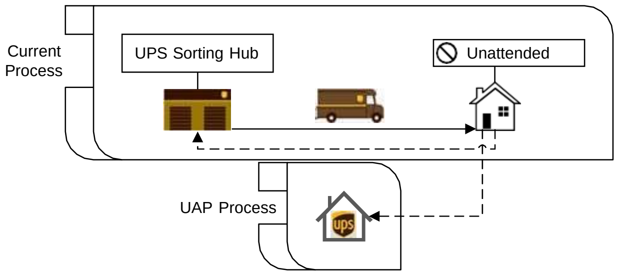

Figure 3- UPS current distribution process vs UAP

4.1. Data processing

Data processing is a very time-consuming activity, vital to create a solid representation of the real problem. On that basis, data collection, Big data simplification and necessary assumptions are meticulously justified. To achieve a consistent optimization model, it is necessary to breakdown this data processing in two ground stages, such as data collection, where all relevant information is gathered and preselected, and data treatment, which intends to give meaning to raw data. Afterwards, a forecast process takes place, in order to develop future data that will input the cost optimization formulation.

Table 1- SWOT analysis for PP network. Adapted from Iwan et al. (2016) and Morganti et al. (2014)

Strengths	Weaknesses
• Customers can access their packages during off-hours operation time and are informed of deliveries via SMS or e-mail • Reduction of transportation mileage • Reduction of emissions, noise and energy consumption • Low delivery costs • Reducing Reverse Logistics operations	• The last-mile or the initial-mile must be made by the costumer • Complex IT system to keep package's tracking and run algorithms for constant flow optimization
Opportunities	**Threats**
• Efficiency gains for logistics providers • Price reduction for end-consumer	• Growing e-commerce can lead to a denser PP network, thereby increasing mileage. • Local business reluctance to share store space • New technologies for home delivery: Drones

4.1.1. Data collection

Data collection took place mainly at UPS Lisbon Hub, at the operation department. Numerous visits to UPS facility contributed to the gathering of Big Data, related to UPS logistics business model. These visits were relevant to collect all data that will give input to the optimization formulation, namely the number of failed home delivery attempts performed between 2015 and 2017, but also the details about the costs associated with subcontracted outside service providers (OSP), here described as LI1, LI2 and LI3.Furthermore, precise data related to UPS Access Point (UAP) operation, such as UAP store fees and operation costs, were achieved through UPS Spain, where UAP are already operating and also with cooperation with UPS Belgium, which leads the implementation of UAP in Europe. Frequent appointments at UPS Lisbon Hub aid the understanding of the operation behind UPS logistics, leading to a more objective data collection. In addition, a close contact with the operation sustained the constant rearrange of the analysis model, so to incorporate specific details related with UPS operation. Most data collection was supported by a complex database, held by Oracle, with detailed daily information on every package processed by UPS. Data narrowing down was made over consecutive queries, followed by information filtering, according to specific software procedures.

4.1.2. Data treatment

Data Treatment is a central activity, to guarantee a solid representation of reality, but also to prearrange the information that is going to feed the mathematical formulation. The software to deal with data treatment used was Microsoft Excel, as this is very used by the company. Three Excel files, were considered, with 160K, 209K and 252K lines of UPS Residential delivery data, corresponding to 2015, 2016 and 2017, respectively. To deal with dimensions requirements, it was introduced an Excel add-in, named Kutools, which uses exact coding to process Big Data. In addition, Macros were developed through Visual Basic for Applications, to assist data treatment.
To breakdown data into more suitable input to the optimization formulation, some procedures had to be followed, specifically the dissection of Lisbon area into different areas, according to population density and the processing of delivery costs associated with the three different subcontracted companies. The unit of time to be considered was also defined. As a result, the following subsections detail how the course of action takes place.

4.1.2.1. Demand and Zip code locations

Zip Code locations behave as aggregation demand areas, which means that customers are distributed according to their geographical location. To better assess the results and take into to account the location of the different Zip codes, it will be set up three distinct areas of evaluation:

- **Lisbon Urban Area**- Includes all Zip codes 1xxx and it is characterized by high population density.
- **Other Urban/Suburban Areas**- Includes all Zip codes 26xx and 27xx, categorized by a mix of urban and suburban areas, located in Oeiras, Cascais, Sintra, Amadora, Odivela and Loures.
- **South shore of Tejo River**- Includes all Zip codes 28xx and is mainly featured by suburban and rural areas, with exception made for Seixal and Barreiro, where there is higher population density.

Within these areas, the scope of the current work requires to assess demand not as the volume of packages delivered but as “delivery paid send again” volume, which represent the volume of unattended home deliveries.

4.1.2.2. Costs

Costs can be grouped in two distinct ways. The first type of costs is associated with transportation and it is reflected in transportation fees, paid to subcontracted companies. These fees include cost per stop (CpS) and cost per package (CpP). As exhibit in figure 4, compensation fees are calculated based on quantity tiers, according to inverse proportion. Thus, the more stops and packages’ delivery, the smaller the corresponding fee. Each outside service provider (OSP), described as LI1, LI2 and LI3 has its own fee’s contract, based on travelling distance and number of packages delivered.

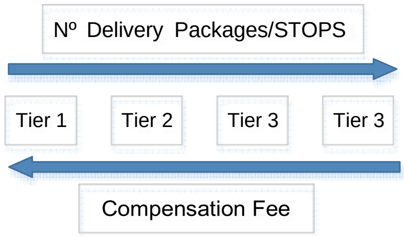

Figure 4- Fee proportion for packages and stops

Both CpP and CpS are calculated taking into account the monthly average cost, noting that for each OSP there is a specific monthly compensation according to the number of packages and stops. Outside service providers operation is done according to the following procedures: LI1 and LI3 share the delivery operation in Lisbon, Oeiras and Cascais, where there is a higher population density and hence a smaller average travelling distance for package delivery. On the other hand, LI2 holds the highest CpP and CpS, since it operates in the south bank of Tejo’s River, where in average it must drive longer distances to deliver a package.
To calculate the average annual CpP and CpS per Zip number, first it is required to aggregate all the deliveries made to a certain Zip code and account the corresponding cost, according to the OSP provider and its matching fee at the time. The second category of costs is related with UPS Access Points (UAP) operation, according to the number of delivered packages and population density. As portrayed in Table 2, UAP fees are directly proportional to population density $CAP_{j1} > CAP_{j2} > CAP_{j3}$, translating the higher business costs of urban stores. In addition, there is a fixed cost CFAP associated with the installation of UAP point of sale. Still in UAP cost’s category, there are special cost per package (CpPAP) and cost per stop (CpSAP) fees, resulting from an improved delivery and pickup system, compared to residential operations.

Table 2- UAP store fee for population density- CAPj

Population Density	Super Urban	Urban	Suburban/Rural
Fee/Package Delivered	CAP_{j1}	CAP_{j2}	CAP_{j3}

4.2. Forecast

Considering the progress of residential delivery for B2C segment and consequently the increment of unattended home deliveries, it is relevant to present some future sustainability to the project. For that matter, it will be used a forecast approach that considers the years between 2015 and 2017, and intends to conjecture the years of 2018, 2019 and 2020. Failed residential delivery volumes behaviour at Zip number detail has broad fluctuations and in order to achieve a suitable representation of the real case study, UPS set some requirements around a multi-scenario analysis, ranging from a Pessimist, Most-likely and Optimum scenario, accordingly to three main variables: number of Delivery Paid Send Again, Cost per Package (CpP) and Cost per Stop (CpS). Most likely scenario is created by using the forecasted values, while Pessimist setup is shaped with the upper confidence values from Delivery Paid Send Again, CpP and CpS. On the other hand, Optimistic scenario is built around lower confidence values from Delivery Paid Send Again, CpP and CpS, considering best case scenario where the number of failed deliveries corresponds to an absolute minimum. On the other hand, Pessimistic scenario is created with higher values of Delivery Paid Send. The formulas used in forecasting data, through Microsoft Excel, run the AAA version of the Exponential Smoothing (ETS) algorithm, which is based on Holt-Winters method. Microsoft Excel is the eligible tool to be used in the forecast process because it is a reliable forecasting tool and it is aligned with UPS requirements for a common and user-friendly tool that can be easily shifted for further future analysis. The exponential Smoothing method is chosen, particularly due to its effectiveness for short-term forecasting precision, taking advantage of a prior forecast plus a weighted correction error. The forecasts were evaluated for the 66 Zip numbers under assessment in the current work, setting a 95% confidence interval. Figure 5 exhibits an example of forecasting for Delivery Paid Send Again, regarding Zip number 1350, with corresponding statistics parameters.

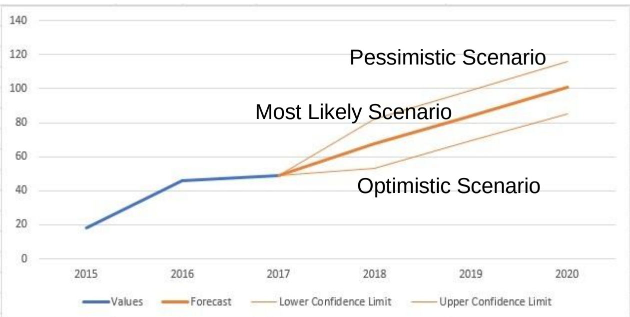

Figure 5- Delivery paid send again forecast for Postal code 1350

5. Case study resolution

To optimize UPS global distribution network in Lisbon area, current chapter intends to bring clarification on which locations should UPS open an UAP. Therefore, three distinct scenario approaches are run in the linear optimization formulation built on Microsoft Excel and the different results are compared. UAP location process is complex and relies on different performance tools as displayed in a framework for case study resolution exhibit in figure 28 Case study resolution process framework starts with obtaining UAP Zip locations, the process is designed to find the best locations for the UAP within the Zip code, searching for the APNID (Access Point Need ID). APNID are broader areas with potential to setup UAP locations andtheir calculation relies on two distinct metrics - PSI and NCI.PSI stands for Proximity Satisfaction Index and it is a measure on the distance between customers and UAP locations. PSI is inversely dependent on population densityrange. NCI-Network Convenience Index measures theavailability of the network in terms of opening hours. Jogos Santacasa mediators are considered to present the best solution options and assure NCI, since it is mandatory to beopen at least 8 hours daily, from Monday to Friday and Saturday morning. To design the most suitable solution, it ismandatory to use software MapPoint, which portrays an image of distribution volume and complement it with Google Maps tools for visual enhancement of UAP potential locations. In order to achieve a more comprehensive study that will assess the viability of UAP locations from an economical point of view, but also takes into account customer satisfaction with the assurance of proximity (PSI) and convenient working hours (NCI) it was also required tostudy UPS market positioning against its rivals. To evaluatethe necessity to open strategic UAP locations from a market shares' perspective the last-mile logistics network of UPS's main competitors was also in for analysis by using Chronopost pickup network locator, DHL service point locator and GLS parcel shop locator.

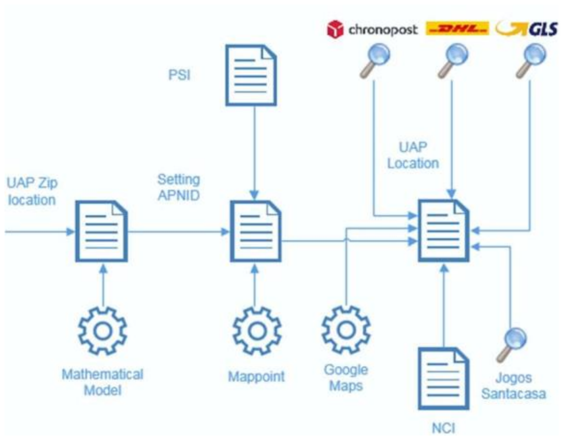

Figure 6- Case study operative framework resolution

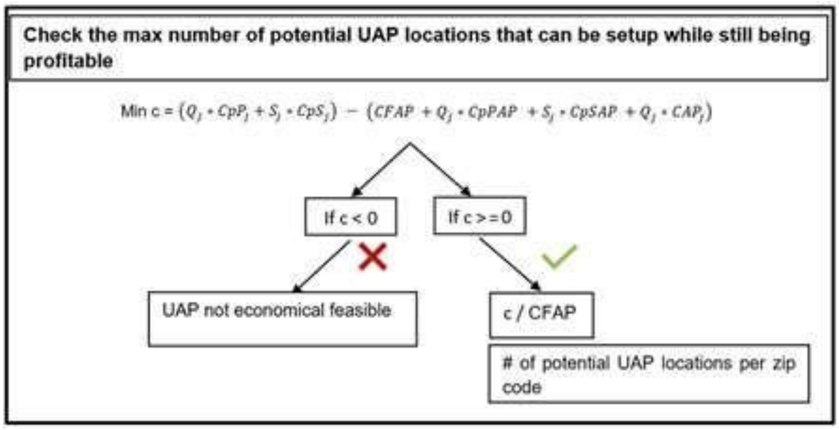

Figure 7- Mathematical formulation to minimize operational cost for each Postal code

5.1. Cost optimization formulation

Cost optimization consists on the minimization of a single function that is created based on UPS delivery standards and closely related with the operation costs associated with the different postal zones (J). The cost for each Zip code is assessed using the function c portrayed in figure 7, which runs a comparison between costs associated with UAP implementation (second term) like fixed costs of installing an UPS terminal at the UAP (CFAP), specific delivery costsby package (CpPAP) and by stops (CpSAP) and UAP fee per package delivered (CAP_j); and costs related to StandardUPS operation (first term). After the evaluation of every Postal code, if the cost difference is negative, it means thatUAP is not a profitable solution at this point and it will not be considered for the specific Zip Code. On the other hand, if the cost difference is not negative as displayed on the right branch of figure 7, the value will then be divided by CFAP (Fixed Cost for setting up an UPS Access Point), to determine how many potential UAP locations can be setup. In order to have a clear understanding of figure 7 here follows the details for the set and parameters used in objective function c. All parameters related with UPS Access Point operation with exception for CFAP are dependent on Postal Code zone j.

Set

J – Set of all different Postal codes j

Parameters

- Qj – Number of Residential Deliveries in postal zone j
- Sj – Number of Stops in postal zone j
- CpPj – Cost per Residential Package delivered in postal zone j
- CpSj – Cost per Residential Stop in postal zone j
- CpPAPj - Cost per Package delivered at UPS Access Point
- CpSAPj - Cost per Stop at UPS Access Point
- CFAP – Fixed Cost for setting up an UPS Access Point
- CAPj – Fee payed per package delivered at UPS Access Point in postal zone j

5.1.1. Lisbon urban area

For the 23 Zip numbers located in Lisbon urban area the results for the three different scenarios present the same conclusions, regarding the absolute value and location of UAP. Optimist scenario is developed from failed deliveries´ perspective and from that viewpoint, the fewer unattended deliveries, less costs related to failed deliveries. On the other hand, pessimistic scenario is built around the premises of more failed deliveries and thus, higher transportation costs. Table 8 displays the three different scenarios, with a binary variable that simulates the decision to open (1) or not to open (0) a UAP at a specific Zip number. In addition, the number of UAP (# UAP) column, refers to the potential number of UAP that can be open, so that it is still preferable to UPS current operation model, cost-wise. Looking at the results presented in table 8 it is possible to infer that the decision on which Zip Codes to open UAP locations it is not affected by the variation on failed delivery attempts and also the fluctuation of both costper package (CpP) and cost per stop (CpS) based on the Upper and Lower bounds of the forecasts. Nevertheless, thenumber of potential UAP locations are different across the three different scenarios.

Table 3- Number of potential UAP locations in Lisbon Urban area

	Most Likely		Pessimist		Optimist	
ZIP#	Bin. Var.	# UAP	Bin. Var.	# UAP	Bin. Var.	# UAP
1000	0	0,1	0	0,3	0	-0,1
1050	1	1,6	1	1,7	1	1,5
1070	1	1,9	1	2,1	1	1,7
1100	0	0,2	0	0,4	0	0,0
1150	0	0,0	0	0,0	0	-0,1
1170	0	0,0	0	0,0	0	0,0
1200	1	5,4	1	5,6	1	5,2
1250	1	1,7	1	2,0	1	1,5
1300	1	1,7	1	1,8	1	1,6
1350	0	0,3	0	0,4	0	0,3
1400	1	1,5	1	1,5	1	1,4
1495	1	2,5	1	2,6	1	2,3
1500	1	5,3	1	5,8	1	4,9
1600	1	5,3	1	5,8	1	4,8
1675	0	0,5	0	0,6	0	0,4
1685	0	0,4	0	0,5	0	0,4
1700	0	0,2	0	0,4	0	0,0
1750	0	0,2	0	0,3	0	0,0
1800	0	0,2	0	0,3	0	0,1
1885	0	0,1	0	0,1	0	0,0
1900	0	0,2	0	0,2	0	0,1
1950	0	0,1	0	0,1	0	0,0
1990	0	0,1	0	0,3	0	0,0

5.1.2. Other urban/suburban areas

The 29 different Zip numbers located in other urban/suburban areas present similar absolute solutions on where to open UAPs. Nevertheless, differently from Lisbon urban area where there was no impact on the Zip Codes where to open UAP locations for all three scenarios, table 4 reveals that for Other Urban/Suburban area there are some differences on the locations of UAP. Assessing these differences, it is possible to sustain that Zip code 2635 should not open a UAP location for Optimistic scenario, but can open 1 UAP, both for the Most Likely and Pessimist scenarios. In this particular case, the reduction of failed deliveries results in a decrease of the operation costs and ultimately leads to a higher economic benefit using UPS standard distribution process. On a different note, Zip number 2750 which presents the highest volume of unattended deliveries can benefit from UAP for Most Likely and Pessimist scenarios and according to Optimistic setup is preferable not to open UAP. It might come out strange how such a high volume suggests that no UAP location is opened, but when compared against the Lower Bound forecasting of the Optimistic scenario for CpP and CpS, the cost for UPS standard logistics turns out to be lower than setting up UAP locations.

Table 5- Potential UAP locations in other urban/suburban areas

	Most Likely		Pessimist		Optimist	
ZIP#	Bin. Var.	# UAP	Bin. Var.	# UAP	Bin. Var.	# UAP
2605	1	1,7	1	1,9	1	1,4
2610	1	1,6	1	1,6	1	1,6
2620	0	0,9	1	1,0	0	0,8
2635	1	1,1	1	1,25	0	0,9
2645	0	0,4	0	0,7	0	0,2
2650	1	2,1	1	2,4	1	1,8
2675	1	2,3	1	2,6	1	1,9
2680	0	0,5	0	0,6	0	0,5
2685	1	2,5	1	2,6	1	2,4
2695	0	0,7	0	0,8	0	0,6
2700	1	3,6	1	4,2	1	3,1
2705	0	0,1	0	0,2	0	0,1
2710	0	0,4	0	0,6	0	0,2
2720	1	2,3	1	2,6	1	2,0
2725	0	0,6	0	0,8	0	0,4
2730	0	0,4	0	0,4	0	0,4
2735	1	2,3	1	2,4	1	2,1
2740	0	0,0	0	0,0	0	0,0
2745	1	3,1	1	3,5	1	2,8
2750	1	1,0	1	1,5	0	0,6
2755	0	0,0	0	0,0	0	0,0
2760	0	0,0	0	0,1	0	0,0
2765	0	0,2	0	0,2	0	0,1
2770	0	0,0	0	0,0	0	0,0
2775	0	0,5	0	0,8	0	0,3
2780	0	0,4	0	0,5	0	0,3
2785	0	0,3	0	0,5	0	0,1
2790	1	1,4	1	1,4	1	1,3
2795	1	1,1	1	1,2	1	1,1

5.1.3. South shore of Tejo river area

The 14 Zip codes located in south shore of Tejo River area reveal resembling absolute values for UAP location, with exception for Postal code 2815, as displayed in table 5, which only sustains an UAP location for Pessimist scenario. Most Zip codes 28xx present smaller failed delivery volumes than other Postal codes from Lisbon urban/suburban areas. Still, almost all locations from South shore of Tejo river could benefit from UAP solutions, in opposition with other Postal codes in urban Lisbon with higher unattended delivered volumes, where it would not be profitable. The main reason for that is the specifics of the operational cost structure of Zip codes located in this area. Costs per package delivered (CpP) and cost per stop (cpS) presents much higher operational costs, especially when it is taken under consideration the costs per stop, which represent the biggest stake of the cost structure, the area of South shore displays almost twice the costs of Lisbon urban/suburban area. The significant cost difference that makes UAP solution very suitable to the area of South shore relies on the premises that in average the distance between deliveries is much higher for Zip Codes 28xx, due to the geographical nature of the area. In that sense, the financial impact of a failed delivery is much higher for the South shore area, despite the relative lower volume of unattended home deliveries, resulting in a very big advantage for UAP solution.

Table 4- potential UAP locations in South Shore of Tejo River

	Most Likely		Pessimist		Optimist	
ZIP#	Bin. Var.	# UAP	Bin. Var.	# UAP	Bin. Var.	# UAP
2800	1	3,6	1	4,1	1	3,1
2805	0	0,1	0	0,1	0	0,0
2810	1	3,2	1	3,4	1	2,9
2815	0	1,0	1	1,1	0	0,8
2820	1	4,4	1	4,5	1	4,3
2825	1	4,1	1	4,7	1	3,6
2830	1	4,5	1	4,8	1	4,1
2835	1	3,4	1	3,7	1	3,1
2840	1	3,4	1	3,6	1	3,1
2845	1	3,6	1	3,9	1	3,4
2855	1	5,4	1	6,1	1	4,7
2860	1	3,2	1	3,2	1	3,1
2870	1	4,2	1	4,3	1	4,1
2890	1	2,3	1	3,0	1	1,7

5.2. APNID and UAP potential locations

After previous section, in which the number of potential UAP locations per Zip code lane were established based on cost optimization, now it is mandatory to perform another assessment in order to find the exact number of UAP locations and consequently the exact cost. On that note, here it will be performed a small review on UAP location set up methodology. As portrayed in figure 6, APNID points are calculated based on Proximity Satisfaction Index, which are tightly connected to population density. The tool used to assist the UAP network design is MapPoint, indicating residential delivery volume. For a better understanding on UAP design network model, APNID location settings for Zip code 1050 will be presented below, under a more detailed analysis in order to explain the methodology used and the steps followed to find the optimal UAP locations. Postal code 1050 Campo Pequeno/Picoas is in a super urban area, with relevant residential delivery volume and consequent failed delivery attempts. Considering optimization, exhibit on table 3, it is beneficial to open 1,6 UAP locations for this area, comparing against the current standard UPS distribution network. Since 1,6 locations is infeasible in reality, the assessment on the number of UAPs must be done in terms of integer numbers, so in this case the decision is whether to open 1 or 2 locations. As previously portrayed in figure 6 the framework for the definition of the optimum number of UPS Access Points and their location in each Zip code can be illustrated for the specific Postal code 1050 in following steps:

- **Step 1**: Identify the respective PSI for Zip code 1050. Proximity Satisfaction Index defined for a super urban area 0.8 Km. In this case, it is possible to verify in figure 8 that one UAP location would be enough to fulfil the requirement of 0.8 Km distance and the optimal solution cost-wise is to setup one UAP.
- **Step 2**: Use MapPoint to identify the areas with greater delivery volumes and evaluate the number of UAP locations necessary to respect the 0.8 Km distance and still cover all customers in that residential area.
- **Step 3**: Assure NCI (Network Convenience Index) as a measure of convenience in terms of UAP working hours. Once step 2 is complete and the best areas for UAP locations are identify it is time to look for the best options in terms of working hours. Taking under evaluation MapPoint software, presenting residential volume as displayed in figure 9, the potential UAP location should be preferential in the lower section of Zip code 1050, closer to Picoas where the biggest delivery volume is concentrated. Some potential locations for UAPs are highlighted in figure 8: 1- Papelaria do Andaluz. Address: R. de Santa Marta 28, 1050-121 Lisboa; 2- Gabi. Address: Av. António Augusto de Aguiar 1, 1050 Lisboa; 3- Papelaria São Marcos Lda. Address: R. Sousa Martins 35, 1050-129 Lisboa; 4- Livraria Almedina. Address: Praça Duque de Saldanha 1, 1050-094 Lisboa.
- **Step 4**: Account for relative positioning against UPS's main competitors. UPS requirements for the development of current research project comprehend the assessment of UPS's competitors positioning in terms of pickup/drop off locations for all Zip Codes evaluated. One UAP location is the optimal solution cost-wise and it is also in accordance with competition since Chronopost has two locations, DHL a single location and only GLS does not provide any pickup/delivery point in this area.

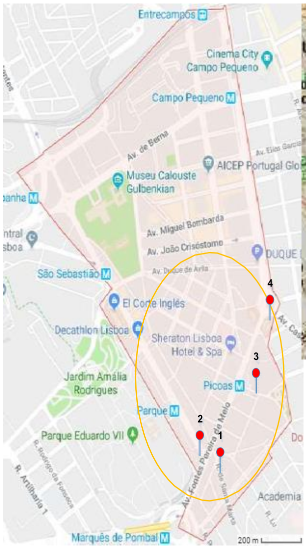

Figure 8- UAP potential location

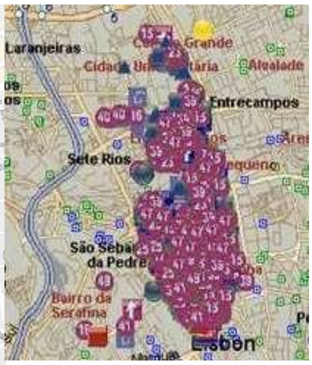

Figure 9- Residential Volume

5.3. UPS Access Point optimization

After assessing UPS Access Point solution and respective cost optimization in section 5.1. it is imperative to consider the constraints associated with Proximity Satisfaction Index (PSI), addressed in section 5.2. Thus, present section aims to bring clarity on the costs of Proximity Satisfaction Index (PSI), since it will evaluate the cost difference between opening 1 UAP per Zip code for those areas where UAP bring economic benefit versus opening the number of UAP locations necessary to fulfil the distance requirement (PSI). Focusing on Table 15 and comparing the results for total cost regarding a single UAP per Postal code and a solution considering Proximity Satisfaction Index, it is verified that the cost difference associated with PSI is around 8530 monetary units (mu), since total cost is 193052 mu and 201583 mu respectively and the gap between the number of required UAP locations is 14 (48-34). Thus, it is perceptible that there is an extra cost associated with UPS's Proximity Satisfaction Index, which determines that for a specific Postal Code each customer's house should be located within a certain distance. Despite the cost difference around 8530 um associated with PSI, still the benefit versus current UPS solution with complex reverse logistics, it is clear that, not only there is a savings potential of 26474 um, in total but also an improvement in service level by setting up 48 UAP location that work as nearby points for the end-customer.

Table 6- Cost for single UAP location vs PSI vs current costs for standard solution

Scenario	Area	Cost (mu) 1 UAP/Zip Code	UAPs	Cost (mu) PSI	UAPs (PSI)	Cost (mu) UPS current
Most Likely	Lisbon Area	74358	9	76538	13	84139
	Urban/Suburban areas	88491	13	93207	20	95590
	South shore of Tejo River	30203	12	31838	15	48330
	Total	193052	34	201583	48	228057

5.4. Sensitivity analysis

During the development of this work, there is a clear distinction between the costs associated with a standard residential delivery and UPS Access Point delivery. Accordingly, it is important to evaluate the uncertainty impact of the parameters that affect final costs. Since residential CpP and CpS are well known parameters, negotiated with the distribution service providers, the sensitivity analysis will focus on the costs associated with UPS Access Point activities. These costs related with UAPs are based on theoretical estimates indexed to UPS Spanish model and represent higher variability and uncertainty. The emphasis of sensitivity analysis will be on CpPAP, the cost for each package delivered at a UPS location; cost per stop at UAP location (CpSAP); cost for fee paid at the UPS store for each package delivered at UAP location CAP. CpPAP is evaluated for a variation of +/- 13% in the first sensitivity analysis range and +/-26% for second range. Both cases reveal a robust CpPAP since there is no impact in UPS network configuration in terms of UAP locations and only a slight cost variation. Similarly, CAP considering a variation of 10% around the original values would result in a difference of only 0.72% in total costs and no impact in the number of UAP locations. Cost per stop at UAP location (CpSAP) is the highest absolute cost value and in this case, according to UPS, it is performed a variation of about 10% in both ways around the original scenario and also a comparison against an increase of 20% of CpSAP as portrayed in table 7.

Table 7- Sensitivity analysis on cost per stop at UAP location

	Cost per Stop at UAP location (CpSAP)							
Total Cost	**- 10%**	**UAPs**	**Original**	**UAPs**	**10%**	**UAPs**	**20%**	**UAPs**
Lisbon Area	73473	14	76538	13	79526	13	82021	10
Urban/Suburban areas	89156	23	93207	20	94257	14	96602	13
South shore of Tejo River	29995	16	31838	15	33669	15	35370	15
Total	192623	53	201583	48	207453	42	213993	38
Difference %	-4,44%	10%			2,91%	-12,50%	6,16%	-20,83%
Difference to Original	-8960	5			5870	-6	12411	-10

Considering Table 7, a 10% variation on the parameter CpSAP has different effects on total cost and number of UAP locations. Total cost is more sensitive to cost per stop at UAP location reduction, even though the number of UAP locations has a higher variation for CpSAP increment. In addition, a 10% variation around original scenario will have a higher impact in the number of UAP locations for urban and suburban areas. However, if a 20% increase is performed in cost per stop at UAP location, the scenario changes and the most affected region in terms of UAP locations is Lisbon area. The most robust region in terms of UAP locations is South shore of Tejo River, which keeps 15 locations regardless of the 20% increase and only adds 1 site for a 10% decrease in CpSAP. The robustness of this parameter in South shore of Tejo River is due to the fact that cost per stop for standard delivery is very high in this area. In sum, after evaluating potential cost variations, a reduction in CpSAP around 10% would result in higher total cost variation than a 10% increase. In a different perspective, it is also clear that the number of UAP locations is more sensitive to cost increase and cost per stop at UAP location has the biggest weight in both total costs and number of UAP locations. On the other hand, CpPAP and CAP are robust parameters, almost unaffected with variations between 26% and 10% respectively.

6. Conclusion

The boom of e-commerce is undeniable in modern world and companies have been adjusting their supply chains, in order to cope with that. Since e-commerce does not operate traditional physical stores, there is the need to create an additional transportation service closer to end customer. Thus, last-mile logistics has been increasing its importance in organizations that operate e-commerce driven supply chains. Last-mile logistics brings specific challenges to companies, namely the need for an efficient management of unattended deliveries and reverse logistics. Given the amount of data related with UPS operation, the complexity inherent to this work is quite considerable and some specific computational tools like Kutools were used to deal with big data. Considering all analysis performed, achieved results show substantial improvements, especially with potential savings ranging from 14.5% to 16.1% for overall costs regarding the scenario of a single UAP location per Zip code versus standard UPS. The cost to fulfil UPS requirements for customer distance to UAP location, would suggest a reduction on savings from 15.3% to 11.6%, accounting for 8530 mu.

For future work, the model should be extended to the city of Porto, to have a broader study for the implementation of UPS Access Point network. Secondly, new request for quotation (RFQ) should be performed to bring more OSP, specialized in certain delivery areas, which can lead to efficiency improvements. Finally, with the boom of e-commerce it could be interesting not only to understand weather it could be a competitive advantage for UPS to implement its American business model, with its own UPS branded stores, closer to urban centre, but also whether UPS should consider the implementation of sustainable measures, like an electrical fleet that could lead to substantial operational cost's reduction, as well as tax benefits for decreasing pollution.

In conclusion, regardless of potential future improvements, the expectations behind this work lead to a contribution concerning a real case in the parcel's delivery industry, providing a solid tool for UPS decision of UAP implementation in Portugal.

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