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A structured method for the optimization of the existing last mile logistic flows

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Dissertation presented as partial requirement for obtaining the Master’s degree in Information Management

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A STRUCTURED METHOD FOR THE OPTIMIZATION OF THE EXISTING LAST MILE LOGISTIC FLOWS

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Dissertation presented as partial requirement for obtaining the Master's degree in Information Management/ Master's degree in Information Management, with a specialization in Business Intelligence.

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ABSTRACT

In a fast-moving world some business exists due to the interconnectivity between countries. This happens because transports are able to reach the other side of the globe within few days and without being too expensive compensating the lower costs of production and competitive advantages. This is true for well-organized and big supply chains but even them can benefit from integration with disconnected and more complex supply chain as it is the case of e-commerce chains. The transaction of small packages from online shopping required in a totally distinct country of the place of production have very specific characteristics as they are spot flows, hard to predict and to combine with other goods owing to the fact that the destination of flows are different every time and it is not always worth it to dedicate a transport for such a small goods value and in addition most times, logistics have to answer to some challenging marketing requirements meaning they have time windows to fulfil. Last mile is a big part of logistics transports and is one important part of it that can really help companies having better prices and revenues for their transports. Last mile solutions need to be easy to implement and really have to translate in quick gains to logistic companies that are largely reducing their margins to increase competitiveness. In this context, the study aims to investigate and define a method following design Research Methodology hopping to draw some innovative solutions for the problem of last mile.

In this respect, the work developed intends to study the solutions already implemented and extract insights on how distribution is made and how to maximize last mile profit through the mature of an algorithm able to reduce inefficiencies in a simple way without having to wiggle too much the structure of businesses as resources of last mile service providers are understood to be scarce as many last mile companies are small sized and running under big logistic players.

The solution aims to attain the different marketing requirements exactly as it was defined without having to compromise anything but still being able to make good profit margins and perhaps make room for new opportunities to arise that previously were not profitable.

KEYWORDS

Last mile; Logistic flows; Cost reduction; Supply chain management; e-commerce.

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LIST OF ABBREVIATIONS AND ACRONYMS

B2B Business-to-business

B2C Business-to-consumer

BI Business Intelligence

CEP Courier express parcel

C2X Consumer-to-all-parties

DSR Design science research

EDI Electronic data interchange

EOQ Economic order quantity

EPQ Economic production Quantity

FTHR First time hit rate

FTL Full-truckload

ICT Information and communications technology

IPA Intelligent Process Automation

LTL Less-than-truckload

OLAP Online Analytical Processing

RPA Robotic process automation

SCM Supply Chain Management

SCM Shipping container marker

SDVRP Split delivery vehicle routing problem

TL Truckload

UPC Universal product code

VRP Vehicle Routing Problem

1 INTRODUCTION

1.1 FRAMEWORK

''*The supply chain encompasses all activities associated with the flow and transformation of goods from raw materials stage (extraction), through to the end user, as well as the associated information flows. Material and information flow both up and down the supply chain. Supply chain management (SCM) is the integration of these activities through improved supply chain relationships to achieve a sustainable competitive advantage''*.(B Handfield & EL, 1999).

The second half of XIX century was characterized on a big revolution propelled by the second industrial revolution. Following the second industrial revolution, it was initialized a process of mundialization where large sectors gained prominence as it was the case of transports and communication that really intensified trade and lead to big increases of migration movements. Beyond that, European capitals had an outflow to where raw materials exist as a course of action to decrease costs of European industries. This process was adjourned by the two great wars along with economic recession. Regardless of this set back, war brought a lot of innovations especially in the information field. In tune with it, mundialization concept got bigger and a new and broader meaning arose from it and from the wide dissemination of values, cultural products, and lifestyles. And so, society got into globalization where economic transactions extended to cultural and social transactions. The mundialization trade was even more evident with the integration of national space in one, free trade, and decrease of customs tariffs. All these led to an exponential growth of trade that had on its genesis the selling of exceeding goods in countries that for some reason did not have it, or they do have it but not in the necessary amounts, yet still need it. Trade between countries developed itself to the competition principle in which countries try to get the most profit from their activities instead of getting advantages of having different products elapsed from specialization. (João Pais et al., 2009)

Given this context, the complexity of operations just gained a new dimension after globalization, due to the necessity of controlling the merchandise in different points of the supply chain. In this new reality transports had a leading role to place goods in consuming points, since global economy was giving the first steps on a new economic approach in which production not only was displaced from consuming points what was true before this phenomenon, but production was placed beyond country boarders involving a better planning and capacity to make the products available to consumers at the time requested complying with the marketing service levels. Transports had to be optimized, and concepts as scale economy were behind this process of costs decrease to reduce inefficiencies, optimizing the fixed costs and decreasing the variable costs.

Supply chain costs can easily account to 30% of the total costs of the goods sold (Berger et al., 2004) being that when it comes to last-mile costs (provision of travel services from the nearest transportation node to the customer's home or another destination), they are the ones that weight heavily in the entire supply chain representing about 40-50% of these cost(Montgomery, 2018) overdue to many reasons, one of them is the low drop rate that is dependable of the receiver availability being that these leads to higher cost that can account up to 28% of the total delivery costs (Snoeck et al., 2020) (Snoeck et al., 2020).

Nowadays this subject of last mile is very studied due to market transformations that have seen an exponential increase of online shopping and e-commerce. This door-to-door delivery brought a big number of Vans to the streets and a lot of constrains with it, such as pollution increase, traffic growth and congestion (Bates et al., 2018). Door-to-door delivery has lots of pressure to be efficient due to the constants oil rise, inconstancy of deliveries in terms of density in each area, bringing all together the enhancement of price fluctuations (Bates et al., 2018).

Along with all shifts previous mentioned, supply chain strategies also changed due to information systems propeller that enabled a logistic paradigm shift consisting in reducing the risk associated with stocks. While some companies accept the risk of supply chain inefficiency with too much supply and some others avoid the exact same risk related to inventory excesses that constitute capital investment inefficiency- Opportunity cost, expensive markdowns, needless handling costs and possession cost that can have the most diverse nature like obsolescence, insurance, taxes, robbery (Contracts, 2004). In the other hand, too much demand can generate the opportunity costs of lost margins (Contracts, 2004). The shift allowed the minimization of all these costs being that with the tools available is possible to reduce forecast and both replenishment and production are driven by demand. It is clear that supply chain has a lot of pressure to be efficient and a lot of timings that need to be performed to comply with demand and so, the production and transport times, need to be coherent with supply requirements without losing efficiency that may be provoked by just in time model.

1.2 MOTIVATION

The COVID-19 pandemic brought a new pick of online shopping and enhanced the necessity of a good integrated logistic system able to fulfil the increasingly complex consumers demand. With the lockdown in many countries and the uncertainty about the disease that spread across the globe, many people resorted to the use of online shopping as a safe alternative avoiding crowds and queues and, in some cases, complying with the restrictions in shopping places to acquire both essential and non-essential goods. Overall online purchases increased by 6 to 10 percentage points across most products categories being that consumers in emerging economies have made the greatest shift to online shopping (*Covid-19 and E-Commerce. Findings from a Survey of Online Consumers in 9 Countries*, 2020).

According to Anderson and Marshall , the COVID-19 pandemic has accelerated digital transformation in 59 percent of organizations surveyed and 66 percent said they have been able to complete initiatives that previously encountered resistance (Anderson & Marshall, 2020). This culture shift is in part defensive: reducing costs is the top benefit attributed to transformation initiatives. According to (*COVID-19 Pandemic Accelerated Shift to e-Commerce by 5 Years, New Report Says*, n.d.) the COVID-19 pandemic has accelerated the shift away from physical stores to digital shopping by about five years.

All these shifts should be made in a sustainable way, reducing inefficiencies that can easily be found in goods transport since it is known that for example in Europe one in two vehicles operating domestic transport outside of its country of registration runs empty since domestic transport performed by foreign hauliers, is subject to restrictions. As a consequence, operators face difficulties in optimising their operations (*Transport in the European Union*, 2019). The use of this existing flow along with innovative solutions and an integrated information system able to perform ponderations on how to optimize daily operations is the key to have a more efficient supply chain. This change is necessary once ecommerce is still growing and according to (*Covid-19 and E-Commerce. Findings from a Survey of Online Consumers in 9 Countries*, 2020) "consumers from emerging economies more often anticipate that they will shop more online in the post-COVID-19 future" and on top of this, cities will not be capable to deal with all the inflow of vans resulted of a bad management of flows since in UK only, there is an ecommerce growth projection of 10-12% until 2021 and since 1993 to 2015 the number of vans grew 82% (Bates et al., 2018).

1.3 Objective

The goal of this research is to propose a structured method for the optimization of the existing last mile logistic flows.

To achieve this goal, the following intermediate objectives are defined:

- Study the related scientific literature;
- Analysis the of existing last mile logistic flows in order to identify the main issues, benefits and drawbacks of the current solutions;
- Propose a method to optimize last mile deliveries;
- Validate the method.

1.4 Study Relevance and Importance

Companies worked hard to improve their manufacturing operations with several techniques they deem better in order to attain better performances, once they did it, they started focusing on the efficiency of logistic and distribution operations (Apte & Viswanathan, 2000) striving to reduce logistic costs that account to more than 30% of the sales (BALLOU, 1999).

Despite all studies and research about the topic of last mile there are still companies struggling to find the best options to reduce the costs and establish procedures to diminish the impact of their activity. The aim of this research is to create a sense of unity and collaboration between companies with no disregard of times that are part of the offered service, and it is imperative that these times are fulfilled without a failure. The purpose is to provide an approach for all companies to apply in their daily transportation's activities in which last-mile is planned in advance in order to obtain the best possible outcomes in terms of pricing, timings and maximization of the allocated resources of all companies involved to ensure that a new delivery request does not create a new and unnecessary transport flow.

The exponential growth verified in e-commerce highly influences last-mile logistics, and carriers struggle to reach and maintain profitability (Vanelslander et al., 2013) showing once again the need for companies to implement better solutions capable of providing alternatives to the low transport margins situation.

Meeting the objectives previously established, will result in a practical solution for companies to adapt their transport systems to the already existing flows and reduce inefficiency through the optimization of collaboration between different carriers and shippers making their space/shipments necessities available. In that way transport can have better truck loads resulting from having additional cargos made available in existing websites. The decision of having additional cargo must not be made randomly as it can easily occur in additional unexpected costs in service and time and often might dismiss cargo for not considering all variables and for that reason a criteria for additional cargo must be establish to support carriers to accepting an additional delivery based on a pre-existing itinerary for a given day resulting in time and costs savings as it avoids mistakes from being made and supports decision on what cargo to accept based on scientifical methods and key influencing variables that might prevent additional transport to happen having in consideration the requisites of the existing itinerary or boost trucks capacity for having in consideration optimization variables of transports e.g., consolidation.

2 METHODOLOGY

The structured method for the optimization of the existing last mile logistic flows can be understood as an artifact and, thus, Design Science Research is considered the appropriate approach to the requirements of this project.

This dissertation intends to have as an output a roadmap theory to maximize last-mile gains through the implementation of an information system capable to make the decision of when to allocate resources to a given transport inside of a logistic company, being this a known way to classify an object of knowledge from Design Science Research, without any physical output, either a service or product, just a theoretical output, a design construct, method, theory, model, design principle or technological rule (Gregor & Hevner, 2013). The theory is built according to a problem-solving approach, with the first step defined as business needs identification, which will lead to the most suitable roadmap to a product implementation in an organization (Hevner et al., 2004). The work conclusions can be used as directive guidelines that organizations can use to make solutions out of their problems (Gregor & Hevner, 2013).

2.1 DESIGN SCIENCE RESEARCH

Design Science Research (DSR) Methodology is followed to meet the research goal and understand the requirements for effective design-science research (Hevner et al., 2004). As it is stated in the Design Science Research methodology proposed by (Hevner et al., 2004) "An artifact may have utility because of some as yet undiscovered truth". The end result of DSR is an artifact, that, being an artifact, is created to address an organizational problem and it is meant to describe something that can be transformed into a real or artificial object or a process (Hevner et al., 2004).

The methodology presented by (Peffers et al., 2007), has a variety of suggested steps that consist in six steps:

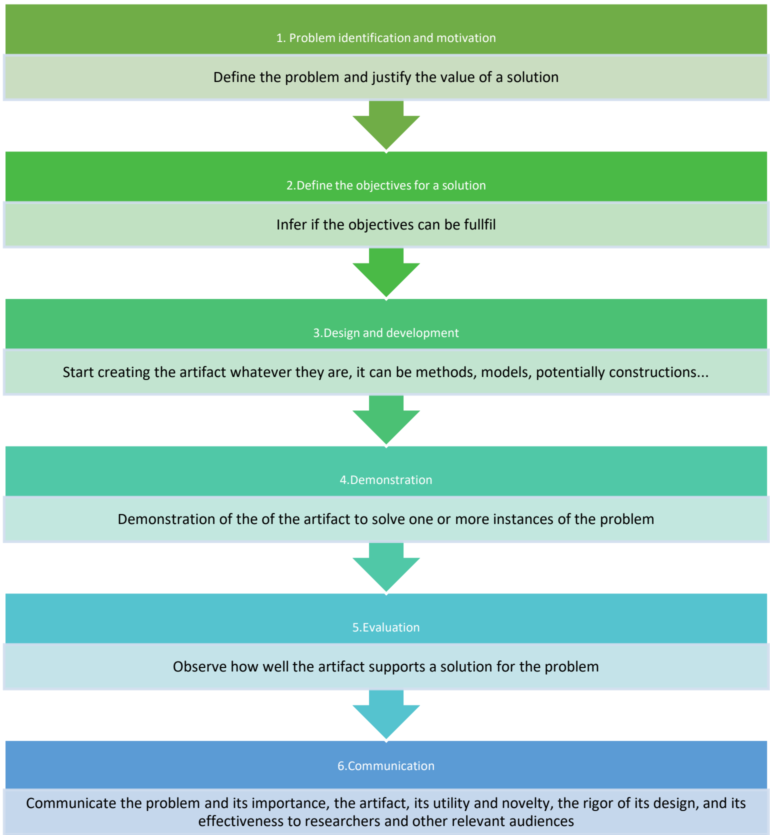


Figure 1 – Design Research Methodology adaptation (Peffers et al., 2007)

This methodology is not rigid and so the steps does not really have to be followed in this precise order as stated by the authors.

Problem and motivation definition

The design research study intends to reason and to address a specific problem which usually consists by defining the main research problem. Based on the problem definition an artifact is built in order to provide an effectively and valuable solution for the stakeholders and shareholders (Peffers et al., 2007).

Objective's definition and solution

It is necessary to identify qualitative and quantitative objectives and requirements needed to define the solution based on the defined problem (Peffers et al., 2007). In order to achieve a proper solution, it is essential to have a clear and objective problem (Hevner et al., 2004). It is important to have the knowledge regarding the current state of the problems, solutions and their effectiveness.

Design and Development

This step is responsible for the artifact construction having in sight knowledge creation for future applications (Gregor & Hevner, 2013). It is important the justification and understanding of the solution advantages grounded by theoretical background for a consistent and functional design (Peffers et al., 2007). The Work developed in this section must answer all the identified needs

(Hevner et al., 2004) being that these needs also require theoretical background on the problem state and solution with analysis on their efficiency (Peffers et al., 2007).

Demonstration

Once the artifact is developed, it is necessary to demonstrate its ability to provide a solution for the identified problem. The artifact should be used in an experimentation, use case, or other appropriate activity as a way of demonstrating the effective knowledge it provides.

Evaluation

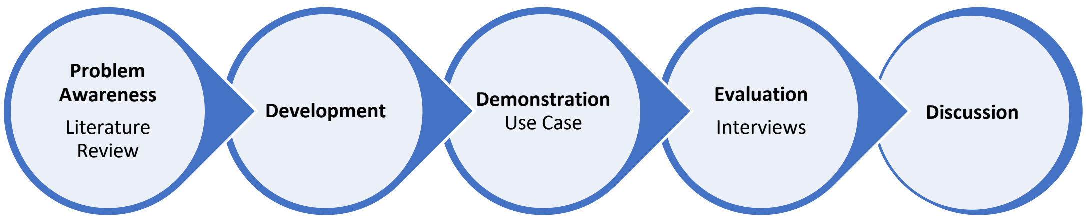
The result is evaluated by the interested parties according to the efficiency of the practical application (Peffers et al., 2007) accordingly to the evaluation methods, appropriate definition of the problem and business requirements. It is essential to align business requirements in order to obtain a solution that performs well in the initial problem (Hevner et al., 2004). Depending on the nature of the problem, evaluation can take many forms as comparison between the artifact's functionality with the solution objectives from Objective's definition and solutions, objective quantitative performance measures comparable to deliveries made and total transportation cost, the results of managerial surveys, client feedback, or simulations. It can also include quantifiable measures of system performance, such as response time or availability. Conceptually, such evaluation can include any appropriate empirical evidence or logical proof (Peffers et al., 2007).

Communication

The final methodology result is the stakeholders' communication, since it is a scientific work, showing the effectiveness of the artifact in the identified problems (Peffers et al., 2007). It is also important to clarify the entire process of building and validating the artifact (Hevner et al., 2004). The communication should be directed to the technological and management concerned parties to gather feedback information to improve the solution, and business and technological information for future implementation.

Research Strategy

According to DSR methodology framework, presented above, the below figure shows how each stage of the research strategy supporting this study was carried out:



In this section it is described the methodology composition and how it will be used in the study and the tasks involved. The study begins with the objectives design and the solution stages definition according to the solution objective, in this case, decision making algorithm responsible for deciding the allocating ad hoc requests to regular flows according to the costs and expected revenue.

In order to solve the proposed problem, the identified activities to be executed encompass:

1. Understand how last mile transportation works inside companies so that it can be establish whether the resources are being used to their fullest capacity and if not, what is the reason behind. This process will identify if there really is a problem and if it is worth it to pursue a valid solution. Create knowledge is the ultimate goal and innovative approaches must arise to change in truth the phenomena that occurs.
2. Draw suitable outcomes that are expected to arise from the last mile problem correction.
3. Create a process to be implemented by logistic companies to stimulate the maximization of resources. This process must comprise an original and practical approach for companies to embrace.
4. Demonstrate that last mile problems have less impact in terms of costs for companies and that their impact its lowered in environment.
5. Set up a comparison with the initial state when objectives where draw and the results observed resulting of the artifact application.
6. Communication of the method effectiveness by participating in scholarly research publication enabling the described artifact to be implemented and used within an appropriate organizational context.

2.2 Expert Interviews

The expert interview is one of the possible ways of retrieving stakeholder's perception without using general surveys, the interviews convenience is that they are able to encourage the discussion of alternative, solutions or even small changes between the implementation team and the subject field experts, collecting applicable insights about how some changes can increase the solution effectiveness and acceptance, since it requires a deeper though compared to surveys(Prasad, 2017). Using this technique, workers can be targeted to providing the best feedback of the artifact (Prasad, 2017).

3 LITERATURE REVIEW

This chapter presents a review on the topics to be studied by synthetizing and assemble a set of themes addressed in the existing literature conducting to a potential support for the research that is being performed. Focus will provide a overall understanding of the enviroment and context on the investigation being conducted.

Moreover, despite last mile being a fairly old subject there is still plenty of literature being directed and a constant dwell on the matter as new techonologies emerge and others just get to be perceived as potential solutions for the problem in study.

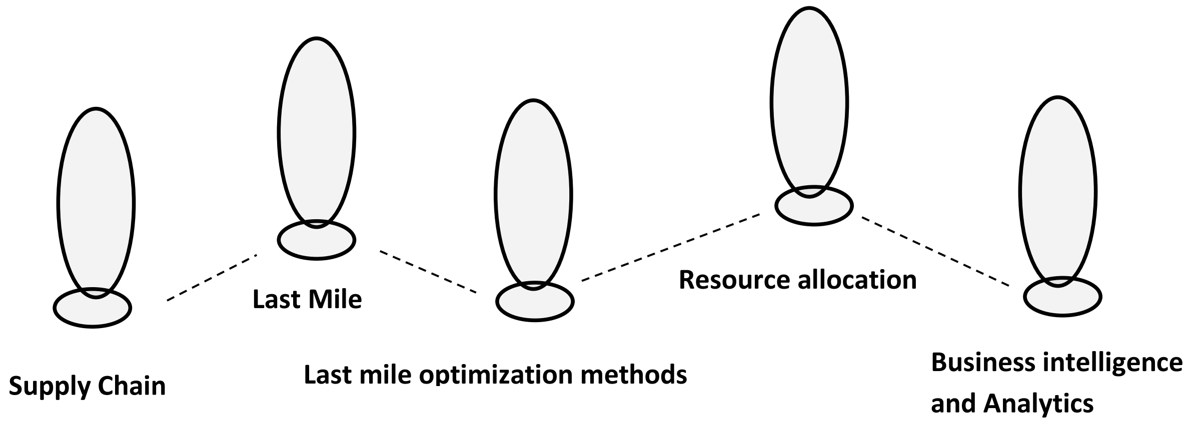


Figure 2 - Literature review subjects

The first part focus on the concept of supply chain giving a context to how did it arise, its importante, the integration of different players and their part at smoothing the problem supply chains have regarding inventories and stock costs. The second part regards to a more specific problem of supply chain that represents a big part of its total costs as mentioned before and that regards to transport. Consequently, it is approached the optimization methods of last mile which constitute some solutions already in use for companies and somehow can provide insights on the method to follow.

Resource allocation is the analysis of the process of other implementations and possible fits for the study in analysis considering the already existing flows and its optimization with ad hoc requests.

3.1 – Supply chain management (SCM)

According to (Forrester, 1958) "Management is on the verge of a major breakthrough in understanding how industrial company success depends on the interactions between the flows of information, materials, money, manpower, and capital equipment. The way these five flows systems interlock to amplify one another and to cause change and fluctuation will form the basis for anticipating the effects of decisions, policies, organizational forms, and investment choices."

SCM are the activities that control financial, information and materials flows coming in and outside of an organization. This flows portrait the natural relations from supplier to manufacturer to wholesaler to retailer to consumer. SCM is all about the planning, implementation and control of the flows of raw materials, inventory and finished goods from their origin point to the consumption point being that all the process of purchasing, manufacturing process and customer delivery is under its scope (Zhu et al., 2008).

The term of Supply chain management increased popularity due to specific drivers such as global sourcing, an emphasis on time and quality-based competition that compel to more effective ways to coordinate the flow of materials into and out of the company. Supply chain management was the enabler to a constantly changing world and increased the performance based on competition combined with rapidly changing technology and economic conditions (Mentzer et al., 2001) but supply chain has considerable confusion around and authors have conceptualize SCM as a form of integrated system between vertical integration and separate identities on one hand, and as a management philosophy on the other hand.

For the paper, will be consider (B Handfield & EL, 1999) definition ''The supply chain encompasses all activities associated with the flow and transformation of goods from raw materials stage (extraction), through to the end user, as well as the associated information flows. Material and information flow both up and down the supply chain. Supply chain management (SCM) is the integration of these activities through improved supply chain relationships to achieve a sustainable competitive advantage''.

Supply chain is more than a one-to-one relationship, instead it is a multi-business relationship in which SCM captures de synergy of this integration leading to a new way of managing relations with integrant members of supply chain (Lambert & Cooper, 2000). These deepened relations between different players are the management result of an overall understanding of the multiple gains of collaboration that can be translated into:

- Lower costs (Houlihan, 1988) in order to provide the necessary level of customer service to a specific segment.
- Supply competitive advantage (Monczka et al., 1998). (Porter, 1985) defines two types of competitive advantage: cost leadership and differentiation.
- Customer satisfaction (Giunipero & Brand, 1996) can be achieved by improving a firm's competitive advantage and profitability through SCM.
- Reduced order cycle therefore a better customer service (Cooper & Ellram, 1993).
- Innovative solutions and synchronism of products, services, and information flows that create additional value to the customer service (Ross, 1998).

Optimization of supply chain's relationship throughout its different activities have lots of benefits being the main one the shortening of response times consisting in the correct articulation between production and product availability that is easily translated in cost reduction and better customer service (Pereira, 2016). Therefore lean production happens as a result of a high interrelation of a lean product plan and a good logistic strategy being that the former plays a significant role on the success of the whole management (Jafari-Eskandari et al., 2009).

3.1 DIFFERENT PARTIES' INTEGRATION PROCESS

A good supply chain management encompasses a series of assumptions that intend to promote gains inside organizations by:

Integrating customers and suppliers acting in unison to respond dynamically to the needs of the end customer. This is only possible if all partners of one's supply chain are able to create an integrated behaviour. (Bowersox & Closs, 1996)

Open sharing information, the performance of different party's gets enhanced due to mutual sharing of inventory levels, forecasts, sales promotion strategies, and marketing strategies reducing the unpredictable factor and consequent costs (Andel, 1997). This information sharing is the willingness to o make strategic and tactical data available to other members of the supply chain (Mentzer et al., 2001).

Mutually sharing risks and rewards is important to establish a long-term focus and cooperation among members of supply chain (Ellram & Cooper, 1990)

Cooperation in which complementary and coordinated activities create synergies trough the joint forces of planning and activities control impacting largely on the Supply chain performance (Ellram & Cooper, 1990). A new product development is natural to emerge along to product portfolio decisions (Drozdowski, 1986). The design and quality control are also part of this so called cooperation (Treleven, 1987).

For the implementation of supply chain to happen, an integration of the processes is imperative to occur from sourcing to manufacturing and to distribution (Ellram & Cooper, 1990) being that there should not be any lag in between capable of destroying the well function of the chain.

3.2 PRIMARY AND SECONDARY ACTIVITIES

Supply chain is an integrant part of business strategy being the foundation for a good running company.

According to (Hines, 1993) consumers have to be taken in consideration in porter's value chain to understand what consumers expect of a given service or product. So, the primary activity is to define customers requirements and needs in a joint value creation with marketing, materials, engineering, quality, R&D and design team. For all these to work out, different firms should be integrated and jointly define "the value required of the product at each stage of its transition from raw material to consumption in each member firms", this pipeline goes from raw material, supplier chain, inbound logistics, operations, outbound logistics customer chain until it gets to the final stage – Consumer.

The secondary activities are meant to facilitate this pipeline integration allowing primary functions to succeed, being that secondary support activities are linked to primary ones thru procurement, technology development, human resource management and firm's infrastructure(or management systems)

3.3 INBOUND AND OUTBOUND LOGISTICS

When talking about inbounds logistics it is being reference the materials management and different interactions between a supplier and a company in which the last is concerned about moving in the necessary materials for an undisruptive production. Outbound logistics regards the movement, storage and processing of an order to a firm's outputs (Ballou, 2004).
An efficient management of this activities requires well bonded links between different parties in the supply chain meaning integration and collaboration are the key to succeed in this operations.(Zhu et al., 2008).

3.4 LAST MILE

Last mile stands for the final haul of a shipment to its final consignee being it a shop, company facilities or a residence. With it carries a lot of externalities such as air pollution, congestion, noise, road damages and traffic incidents resulting in big damages for society (Dablanc et al., 2013). As previously stated last mile is the least improved segment of supply chain (Gevaers et al., 2014) being that throughout the course of the years it has been largely studied although the complexity of the problem grew exponentially with ecommerce boom (*European Comission - A Roadmap for Completing the Single Market for Parcel Delivery*, 2013) due to the amount of nodes to fulfil, thus a big challenge was brought up as the complexity of operations increased with the phenomena called mass customization whereby there's a need for adaptation in order to transport small quantities of the most diverse items. Intangible electronic transactions are part of this last mile problematic along with the growing customers demand for same day delivery (Ko et al., 2020).
There is also the problem with legislation as in the (Fitria, 2013) report, more than 70% of inland transport in Europe was made by road haulage and 67% of it was carried out by domestic hauliers being that only 1% of national transport was performed by foreign carriers in 2012. This type of transport (cabotage) is subject to restrictions and for that reason operators face difficulties in optimizing their operations becoming a problem once one in two vehicles operating domestic transport outside of the country of registration runs empty (*Transport in the European Union*, 2019).

According to (*A Sustentabilidade Dos Transportes Na Cadeia de Abastecimento*, 2009) about Portuguese reality stated that 11% of flows between logistic operators warehouses and distribution centres is made by vehicles with less capacity (12 to 18 Tons) being the average of occupancy of 2% revelling load factor as another problem that needs to be solved up in last mile.
European study (*Load Factors for Freight Transport*, 2010) stated, load factors are generally under 50% and (ALICE & ERTRAC, 2015) affirmed that one of the problems took in consideration was the very low load factors for delivery vehicles in the city.

In 2020 according to (*A Fifth of Road Freight Kilometres by Empty Vehicles*, 2021), overall, around 20% of the kilometres performed by road freight transport in EU was carried out by empty trucks.

There is an urge to have a well-organized transport system due to all costs associated with this new market requirements which require to fulfil multiple nodes quickly in order to satisfy customers' needs. Eighty five percent of short distance truck companies run as subcontractors of big organisations in which integration not always occurs (ALICE & ERTRAC, 2015).

According to (Ergun et al., 2007) shippers and carriers always worked to improve their internal processes focusing on reducing their own costs and increase profitability. As internal processes got improved the next step was a shift to improve cost through the supply chain having big gains while adopting collaborative strategies in which wide system cost control resulted in profit sharing. In what regards empty reposition of trucks, according to the authors, shippers have no idea on the logistic involved to position empty trucks although they are charged in order for carriers to make trucks available. As a solution, there are collaborative transportation networks that aim to unite shippers and carriers in order to have better truck utilizations and reduce logistic cost where one of the tasks involves the identification of more regular routes.

Deliveries effectiveness of B2B in Europe is around 95%, meaning there is not signifying costs related to second attempt deliveries as there is with B2C deliveries (ALICE & ERTRAC, 2015).

In (Cherrett et al., 2012) it is described core goods as essential to activity running of a given company varying accordingly to the type of activity. Deliveries to premises can be scheduled involving planning in advance and regularity or it can be ad hoc meaning deliveries are not foreseeable and for that reason they are unscheduled. According to (Cherrett et al., 2012), in their study, the majority of companies inquired, operate on regular delivery schedule being really few the ones operating on ad hoc only. The respondents receiving a mix would have arrangements for emergency stocks that would be delivered alongside with their regular planned deliveries.

According to (Allen et al., 2008), United Kingdom deliveries from 06:00-12:00 period generate most of urban deliveries what suggests most of this activity is made during morning time.
Back-loading the main logistic providers vehicles refers to the utilization of a delivery vehicle capacity to take items back either the inverse logistics, customer returns or stock cascading to other stores and (Cherrett et al., 2012) refer that this is an activity undertaken by a big part of the companies.

3.5 OPTIMIZATION METHODS

When it comes to literature review, researchers and local stakeholders have explored a range of possibilities to improve urban freight, such as improvement through route algorithms, more efficient and greener haulage alternatives, use of alternative modes, split deliveries, off-peak deliveries, (Dablanc et al., 2013) mid route shipment consolidation, resource to cross-docking, and collaboration between different stakeholders.

Literature review is full of optimization methods to help improve the efficiency of deliveries although despite all this information made available last mile research seems to fail to combine all these solutions by disregarding important key business drivers such as service quality and others like trust between different parties evolved.

The topics above are the ones that stand out the most regarding of their transversal relation.

Literature has shown meaningful insights proposing the following:

(Gevaers et al., 2009) found last-mile can be determined by five main characteristics, are they, security of consumer service, geographical area, market density, type of vehicle fleet and environmental impact which are directly correlated to the costs of delivery when talking about B2C. This 5 characteristics studied in depth revealed several related sub-characteristics.

(Gevaers et al., 2014) built a model in which they based themselves in data from literature review from (Blauwens et al., 2010). The standard function looks for the transportation costs, represented by TC = T x t + D x d + Z where T represents the duration/time of transport, t is the time/hour coefficient, D stands for the distance driven/travel for the transport, d is the distance coefficient and Z are the extra costs not related to distance or time.

Payload	Time coefficient (t)	Distance coefficient (d)
Delivery van 0.5 ton	22.26	0.16
Lorry 5 tons	23.70	0.23
Lorry 8 tons	24.88	0.27
Lorry 20 tons	28.52	0.33
Tractor + semi-trailer 28 tons	29.74	0.37

Table 1 Average costs for road haulage (2011) (Source: (Gevaers et al., 2014)).

(Gevaers et al., 2014) developed the model even further by understanding the variables (Sub-characteristics) that are directly related to the main characteristic's costs influencing last mile. And so the following symbols were created originating the creation of the following model.

STOP	Average number of stops (addresses) per delivery route per driver per day	**cp**	Collection points coefficient
Q	Average quantity of products in the parcel	**ad**	Area density coefficient
w	Time window coefficient	**p**	Pooling[3] of parcels coefficient
r	Reverse logistics coefficient	**v**	Type of vehicles/vans coefficient
lc	Logistics handling cost coefficient	**Ict1/ ict2**	ICT coefficients
ht	Average handling time in the reverse leg of a chain	**pac**	Packaging coefficient
ip	Manned versus unmanned (in person) delivery coefficient	**SHF**	Extra special handling fee that can be added (example: insurance)

Table 2 - Overview of the used independent variables (Gevaers et al., 2014)

The model development by (Gevaers et al., 2014) focus on designing all variables that define transportation costs originating a complete model able to reflect different variables that are key influencers of cost in deliveries. For that, TC is defined having two assumptions of time and distance, the model was developed as follows:

(1) TC defined
(2) Use of real variables to define time and distance coefficient by making two assumptions
(3) Model development

(3.1) Stop coefficient [STOP] – the average number of stops in a route reduces the TC by the number of stops. Function extension: $\frac{TC}{STOP}$

(3.2) Unit coefficient [Q] – the average number of units in a parcel reduces the TC by number of units per parcel. Function extension: $\frac{TC}{Q}$

(3.3) Time window coefficient [w] – Less efficiency is caused by this constraint, causing less parcels to be delivered as ping pong effect may arise. The average number of deliveries decrease as consumer time windows narrow down. This coefficient provides information on the decrease number of deliveries as there's a linear relation between STOPS per route. Function extension: $\frac{STOP}{w}$ with w assuming 1 when no time window and assuming other values accordingly to the window length based on (Boyer et al., 2009).

(3.4) Reverse Logistics Coefficient [r, lc, & ht] – "r" coefficient represents the cost of returning a parcel. It is assumed that the total last mile cost accounts outbound and reverse inbound, extra handling cost and time to inventory the products back. This r coefficient is a dummy variable being it can assume the value 0 or 1.
Function extension - cost per parcel/unit $x\ (1 + r) + \frac{(r*lc*ht)}{Q}$
The inicial part of the function $(1 + r)$ refers to outbound and inbound transportation costs. The second part $(r * lc * ht)$ is about handling costs and putting the goods back in inventory. Of there is no reverse leg r should assume 0, if yes r value should be 1.

(3.5) Manned versus unmanned coefficient [ip] - "ip" coefficient is based on first time hit rate meaning the real number of successful stops are expected to be lower than the average number of stops. This means in the functions STOP coefficient/variable needs to be multiplied by the first time hit rate percentage (ip). The former can assume a value between 0 (FTHR = 0%) and 1 (FTHR = 100%). Parcel drops using collection box kiosk implies a higher FTHR than home deliveries. (Weltevreden, 2008).
Function extension – STOP* ip.

(3.6) Collection points coefficient [cp] – Collection points imply increases on the average number of parcels delivered per drop and on the first time hit rates. Consequently, the number of drops are multiplied by the effect of using collection points. When executing only collection point stops/drops, the ip coefficient should be set on value 1.
Function extension – STOP* cp.

Coefficient	Symbol	Analysis
Collection point	cp	If no => cp = 1 , if yes => cp >= 1

Table 3 - Collection point coefficient (Source: (Gevaers et al., 2014))

(3.7) Density and area coefficient [ad] – Density of deliveries are directly connected to efficiency of transports and influences the real travel distance. Therefore, ad coefficient is the relation between the effect on the increasing/decreasing number of stops(Agatz et al., 2008) of a given region having the same amount of average driven kilometres.
Function extension – STOP* ad.

No of inhabitants per square km	Assumption coefficient ad
0-50	0.5
51-200	0.93
333 (Density/km in Belgium)	1 (Index)
201-400	1.09
401-600	1.24
601-800	1.31
801-1000	1.35
1001-1200	1.38
1201-1500	1.39
> 1500	1.41

Table 4 - Assumed coefficients per density class (Source: (Gevaers et al., 2014))

(3.8) Pooling coefficient [p] – This coefficient indicates on possible cluster effects, how collaboration might be able to cluster and perform a bigger amount of stops compared to the average amount of stops when the driven kilometres per day remain unvaried. This “p” coefficient is influenced by lead time meaning a longer one can influence shippers to pool deliveries for a specific area while a shorter lead time will make this possibility harder to exist.
Function extension: STOP x p.

(3.9) Vehicle type coefficient [v] – The type of vehicle is directly related to the driving cost. The “v” can increase/decrease the distance cost coefficient when comparing the average distance cost coefficient “d”. The “v” coefficient should be based on internal data from interested players.
Function extension: d x v

Vehicle type	Relation
If v = 100%	The vehicle type has the same “d” coefficient than assumed (0,23[10])
If v < 100%	The vehicle type has a lower than market-average operating cost
If v > 100%	The vehicle type has a higher than market-average operating cost

Table 5 - Vehicle type coefficients (Source: (Gevaers et al., 2014))

(3.10) ICT coefficient [ict] - The “ict1” coefficients is the relation between the effect on the increasing/decreasing number of kilometres driven to execute in each region the average amount of stops. The “ict2” coefficients is the relation linking the effect on the increasing/decreasing time needed for performing in a certain region the average amount of stops.
Function extension: D x ict1 or T x ict2

Coefficient	Symbol	Analysis
ICT coefficient on distance	**ict1**	**If ict1 is not 1 => ict2 = 1**
ICT coefficient on time	**ict2**	**If ict2 is not 1 => ict1 = 1**

Table 6 - ict coefficients (Source: (Gevaers et al., 2014))

(3.11) Packaging coefficient [pac] – This coefficient can impact the efficiency of number of stops and the filling of the vehicle. Optimal packaging brings efficiency in the way that can reduce costs due to volume and delivery/stop characteristics.
Function extension: STOP x pac

(3.12) Consumer's environmental awareness (trade-off between time & environment)
This characteristic would impact every

(4) Integration of the different B2C coefficients into the total cost [TC]

Last mile cost per unit shipped $=$

$$\frac{(\mathbf{T}\ x\ \mathbf{ict2})x\ 23.70\ +\ (\mathbf{D}\ x\ \mathbf{ict1})\ \ x\ (0.23\ x\ \mathbf{v})}{[(\frac{\mathbf{STOP}}{w}\ x\ (\mathbf{ip}\ +\ \mathbf{b})\ x\ \mathbf{ad}\ x\ \mathbf{cp}\ x\ \mathbf{Q}\ x\ \mathbf{p}\ x\ \mathbf{pac})}\ x\ (1\ +\ \mathbf{r}) + \frac{(\mathbf{r}\ x\ \mathbf{lc}\ x\ \mathbf{ht})}{\mathbf{Q}} + \frac{\mathbf{SHF}}{\mathbf{Q}}\ x\ (1 + r)$$

Based on interviews the authors were able to have concrete values and create possible scenarios.
From it, some of the conclusions drawn are the following:

- For the reference cost B2C 3.87€
- Delivery cost can almost triple in rural areas vs cities
- Deliveries with time windows have significant higher costs than the ones with no time windows especially when talking about time windows in rural areas.
- Delivery in offices is a manned vs unmanned option being the principle behind scale of economies (higher density), reducing last mile costs in 29%.

(Agatz et al., 2008) organized customer demand by first determining the capacity that could be allocated to a certain cluster in order to minimize costs and secondly used flexible prices needed to maintain a stable customer demand. (Ko et al., 2020) understood that there is a big competitiveness in express service companies and proposes a model to stimulate collaboration and profit of the intervening companies. As an solution to diminish costs, (Khayyat & Awasthi, 2016) suggest that the different agents must interact between themselves and one of the interactions is about a collaborative measure able to look into a Less than truck load (LTL) database and select a truck with a route close to the retailer/intervenient requesting the transport.

(Allen et al., 2017) approached the difficulty in distribution sector that has a lot of competitors and is a very competitive market in the means that there are very low margins and proliferation of new competitors. The low cooperation is the motive behind poor vehicle utilization rates and route overlapping. The solution found by the authors is to create a responsible party for the work equity distribution and allocation through the visualization of collection and delivery schedules of individual carriers within the alliance. In this paper UK domestic parcels distribution generated in 2015 almost 9 billion pounds whereas B2B, B2C and C2X were responsible for 54, 34 and 12% respectively and in September of the year in analysis, 42% of orders dispatched to consumers were sent economy meaning there was no guarantees in lead time, delivery day or time-slot, 30% were next day delivery, 4% had more specific details on when to delivery and 24% were dispatched internationally. This customer requirements do not make easier the problems caused by the fragmentation of transport resulting from the rise of e-commerce (Bergmann et al., 2020). To meet these customer demands, carriers have to perform multi-drop operations and do a mix of pre-planning and ad hoc request during the round considering geographical area and maximum capacity with a round being established by premium deliveries beaconed by a time window.

(Ko et al., 2018) refers companies are already using their optimal routes, and already have their hubs near optimal locations so the next move is to price deliveries according to market density and create a model of collaboration able to increase competitiveness of small companies, as in (ALICE & ERTRAC, 2015) it is reflected that 85% of short distance truck companies in Europe are categorized as very small and usually work as subcontractors of big organisations.
Recognizing last-mile efficiency is not as high as it could and that high costs are a consequence of the hardship to reach target levels of service, meagre order dimension and the broad panoply of widely dispersed addresses (Macioszek, 2018), collaboration need is perceived by companies and (Parise & Henderson, 2005) highlights its benefits of interlinking companies allowing resource sharing to achieve goals. All these can be translated into competitive advantages where sharing is the watchword for risk and knowledge with new opportunities arising. (Ko et al., 2020) suggests small and medium companies to specialize themselves in shipping specific items as it could be heavy weights or cold chain. The main lines of the report synthetize how collaboration can be carried out resorting to market specialization and creation of service clustering without competing, estimating the unit costs accordingly to each market share, how much profit to expect according to different market shares due to density factor and how to make the distribution of profit accordingly to each company contribution. (Gonzalez-Feliu & Salanova, 2012) defines the most common strategies developed to increase efficiency of freight transportation through collaboration. It is stated several different levels of interaction which are transactional collaboration focused on benchmarking and consequent standardization of administrative practices, informational collaboration foreshadows a mutual information exchange of internal data namely stock levels, sales forecasts and delivery dates being that for confidentially reasons and for competition reasons it can preclude collaboration, decisional collaboration works in different plans of logistic and transportation and can be divided in three types in which operational planning is a stage related to the day-to-day operations that don't need much planning into it and impact directly in the coordination of daily activities such as freight transportation or cross docking, tactical planning is the middle-term planning and is responsible for the analysis of some indicators responsible for the good performance of the company, impacting directly on the results, namely sales forecasts, production management, quality control, inventory and shipping, strategic planning consists in the highest collaboration stage and is about long term planning decisions that are not easy to change and any change may be costly, are they facility location, network design and production and finance planning. Information sharing is of an extreme importance according to (Fabbe-Costes, 2007), without it other levels of collaboration could not take place. In short, (Gonzalez-Feliu & Salanova, 2012) defines collaboration any exchange given between companies, its nature can be diverse and can start with simples things like facility sharing, a warehouse, vehicle pooling or freight pooling in which the first one, deliveries are executed by a shared resource – the truck, without mixing freights from the different collaboration agents, the former, the opposite just happens as the objective is to merge the freights. The plans and optimization methods made in group are one way of collaboration, along with logistics and

transportation information providing essential information able to make more reliable previsions and coordinate daily operations.
(Ko et al., 2020) suggests collaboration of small last mile delivery companies should assume a form of non-competitiveness meaning that for each region companies should focus themselves on the handling of a certain classes of goods being big sized/weighted items, regular items, and cold items.

As some problems in last mile are being continuously solved by literature, e-commerce boom brought with it a bigger problem for delivery service. One of the solutions found, crowdshipping, an innovative alternative solution able to make a return on unexploited transport capacity, utilizes crowd based on their daily movements (Gatta et al., 2019). In (Wang et al., 2016) it is proposed to have a considerable number of pop-stations distributed over the city and crowd workers can be part of deliveries by accepting a task via mobile app being the pop up stations and the final consumer in the same Voronoi cell. In this study there are some premises like any parcel should be sent by workers with the minimum additional effort to deliver the goods and any worker is associated with a travel pattern. There are some concerns associated to crowd workers performing parcel deliveries, are they data privacy and confidentiality. - Integrating first-mile pickup and last-mile delivery on shared vehicle routes for efficient urban e-commerce distribution paper

In (Bányai et al., 2018), technology is recognised as a propellant to solve complex operations like first and last mile that include a considerable amount of problems like: facility location, routing, scheduling, design of loading unit building and packaging processes, budgeting, warehousing, and assignment or queuing. Technology is the key aspect of this paper and intends to project a real-life routing schedule based on variables like time windows and loading capacity. An interconnected supply chain proved to have better results than the traditional one. Vehicle reidentification, GPS-based methods, and smartphone-based monitoring are the cooperation enablers being that smart scheduling is something changeable and the best solution for a certain task is real-time optimized and dependent of the captured information from the running processes.

Use of alternative vehicles as transport sector is globally responsible for 20-25% of the emissions of greenhouse gas is one of the alternatives proposed by (Ranieri et al., 2018) that reduces one of the externalities of this sector. They also propose the use of stations in proximity points representing gains due to lower distance travelled by transport means and a higher load factor of transport means. (Ranieri et al., 2018) also suggest the share of resources, infrastructures and transport means to make the last mile delivery in urban areas in comparison to codeshare used by airline companies. (Park et al., 2016) looks over small CEP's (apartment complex) that receives goods from all logistic companies and distributes it over the buildings in the area. The collaborative delivery system increases delivery efficiency in last-mile networks, reduces delivery truck traffic, and prevents access by criminals impersonating delivery service people. In the study they estimate that only 15–19% of the carrier would be interested in the concept event thought the study showed savings in vehicle operation and traffic accidents.

Drones can present themselves as an alternative to road transport. This battery powered vehicles for customer deliveries may contribute for the mitigation of environmental problems such as pollution. This is a limited solution as there are constraints when it comes to distance and flight time and capacity characterized by weight and size.(Chiang et al., 2019). Accordingly, to the authors there is a reduction of 20% for gas emissions and an average reduction of variable costs around 30%.

The “Helper strategy” created by (Lu et al., 2020): It’s a strategy that proposes gains in urban areas since there are a lot of nodes to fulfil. This study proposes the creation of two routes according to the number of packages to dispatch resorting to the use of helpers. The results show that companies saving can account up to 13,34% by decreasing service time even when distance is increasing. This model is dependent of the helper’ and driver’s salary plus the number of nodes to fulfil.

According to (Claudia Archetti et al., 2008) vehicle routing problem with split deliveries (SDVRP), allows customer’s demand to be satisfied by multiple vehicles as opposite to the traditional Vehicle routing problem (VRP) in which a customer can only be visited once, which provided significant cost savings over traditional VRP models being that according to (C. Archetti et al., 2006) cost savings can account up to 50%. There was a reservation regarding the lack of insights into the relation between the characteristics of a specific distribution environment, for example, geographic distribution of customers and demand distribution of customers and the reduction in delivery costs from allowing split deliveries which (Claudia Archetti et al., 2008) decided to approach reaching the conclusion that split deliveries can have considerable benefits but only under certain customer’s demands specific characteristics, more precisely when mean demand is greater than half the vehicle capacity yet less than three quarters of the vehicle capacity and demand variance is relatively small. (Claudia Archetti et al., 2008) also explains the strong relationship between delivery costs reduction and the diminishing in the number of delivery routes arising from allowing split deliveries.

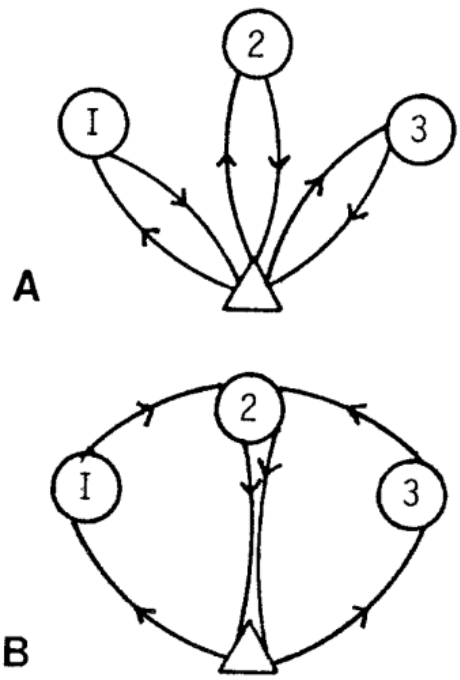


Figure 3 - (A) The VRP solution and (B) the SDVRP solution (Dror & Trudeau, 1989)

Figure 3 represents the gains arising from split deliveries resulting from having two vehicles (B) instead of three (A) representing savings in terms of costs when the distances satisfy first property of triangle inequality in which two routes cannot have more than one split demand point in common and the second property states that split is always optimal according to demand satisfaction where total demand is adjusted to avoid having more than one stop in the same location (Dror & Trudeau, 1990).

(Dror & Trudeau, 1989) explains that an addition of a new route eliminating split delivery might also reduce the total routing cost if the demand split between two routes results in reduced total distance according to different route configurations capable to eliminate the split.

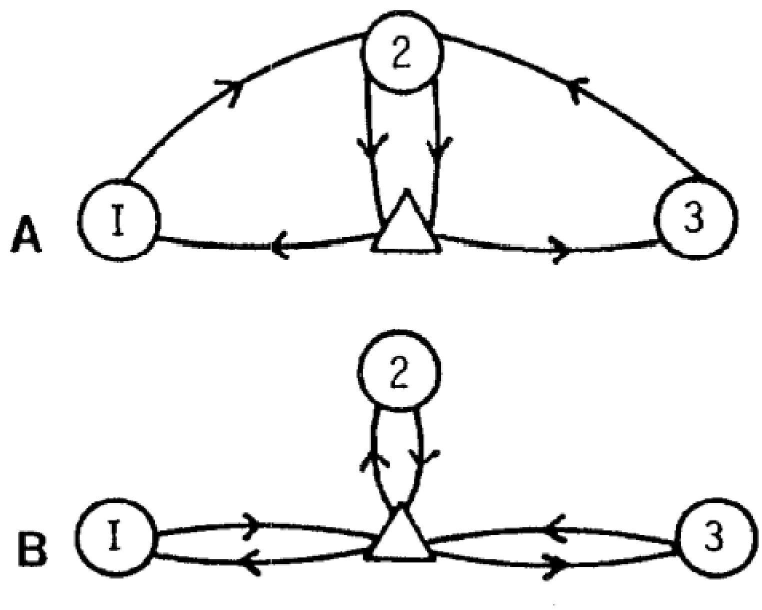


Figure 4 - (A) two routes with one split and (B) three routes and no split (Dror & Trudeau, 1989)

(Cortes & Suzuki, 2020) explored this model by taking advantage of the multiple vehicles that visit the same customer under the VRPSD framework to tranship goods at the customer location. Mid-route shipment consolidation can be a solution to improve vehicles' capacity utilization and bring noticeable cost savings. This cost reduction varied from 1.38% to 4.5% as most of deliveries are performed by LTL and TL carriers.

Cross docking appeared in literature to promote scale economies in transports by consolidate cargo in a certain point allowing to have a more efficient distribution network through the merge of multiple small shipments to full truck loads. The terminals devoted to this activity have incoming deliveries of inbound trucks that are unloaded, sorted and moved across the dock to finally be loaded inside outbound trucks responsible to delivery different sized goods to a final destination resulting in considerable competitive advantages (Boysen & Fliedner, 2010). Cross docking can be a good alternative to point-to-point deliveries as if it is well handled savings can be major as this transhipment points are able to consolidate cargo that has the same destination. Several success cases can be seen in retail chains, mailing companies, automobile companies and less truckload logistic providers (Boysen & Fliedner, 2010). In one hand traditional distribution centres store the goods and eventually ship it fulfilling its four big activities of a Warehouse (goods reception, storage, order picking and shipping) and when we talk of cross docking this approach reduces the two most expensive operations, storage (because of inventory holdings) and order picking (because it is labour intensive) as they eliminate it and everything is synchronized resulting in stocks reduction (Van Belle et al., 2012) but in the other hand this concept needs to be dealt carefully as cross docking can signify double handling which means less efficiency (Boysen & Fliedner, 2010). Cross docking is in line to the concept of a lean supply chain management considering smaller amounts of the most needed stocks to be delivered faster and more frequently (Van Belle et al., 2012).

According to (F. Chen & Song, 2009), benefits from cross docking when compared with traditional distribution centres can be summed up into low inventory and handling costs, less space required, decrease of transportation costs along with centralized processing, shorter lead time (that by itself represents a lot of savings in supply chain), diminishing of overstock, risk, loss or damage of the cargo.

The comparison of cross dock with point to point deliveries are the better use of resources as via shipments consolidation it is possible to have full truckloads, cost reduction when it comes to transportation and labour costs and greater compatibility between shipped quantities and actual demand.

Although cross-docking can represent several benefits for many companies, it may not be the most suitable strategy for every case and (Apte & Viswanathan, 2000) analysed the factors influencing the suitability of cross docking when compared with traditional distribution of small quantities as for full truckloads point-to-point deliveries would fit better. They came out with important factors with product demand rate and unit stock-out cost weighting in the decision making. In that sense, product demand must have its minimum demand stability while warehousing and transportation are more predictable and that's the base for a good supply chain as it avoids several costs. Regarding unit stock-out cost it impacts the resort to cross-docking as it does not rely on warehousing and the risk of running out of stock is considerable as per the fact that low unit stock-out costs benefit of crossdocking and can outgrow the increase of the stock-out costs. The encapsulated information would be translated to the preference in using cross-docking for stable demand products that have a low unit stock-out cost adopting traditional warehousing for the exact opposite case.

As stated by (Van Belle et al., 2012) other constituents can have a part in the best strategy to adopt when it comes to high distance between suppliers and customers as in this case it's possible to make the most of consolidation. Product value, life cycle and demand quantities can benefit from reduction of inventory in high value stocks, shorter life cycles and high demand stocks. Additionally, it is important to ensure that the correct synchronization is possible between inbound and outbound trucks.

Accordingly to (Apte & Viswanathan, 2000) cross docking relies on 4 basic principles so benefits can be seen. Are they, effective handling of physical goods flows consisting in receiving, redistributing and shipping the goods, effective deployment of information technology as each incoming goods should be correctly identified with any relevant information, worthwhile use of FTL shipments that are the ones promoting scale economies intended without falling in inventory traps responsible for cost increasing and the constructive resort to planning and management tools.

Information flows are exceedingly important and for that reason information tools play a leading role when organizing cross docking activities for small packages and big throughput rates, (Apte & Viswanathan, 2000) refers, EDI which is capable of supporting business transactions making it available to all concerned parties with warehouse between them having major emolument being able to plan accordingly to the information given for in-transit and incoming goods. In that way sorting operation, dock assignment and truck fleet operation can be properly planned to avoid extra costs caused by setbacks. Bar-coding provides a unique UPC able to provide associated information from databases to identify the item by simply using an optical scanner. The SCM is used for bulk packaging containing itself several individually packages bar coded promotes efficient inventory data update, warehouse management and transportation activities whereupon a scanner can head unit loads to the correct docks for outbound shipments. This technology should be applied to incoming loads that should be split into different customer orders, generating new labels able to help in warehouse activities like handling and sorting of the products. RFID is a more advanced technology used when bar coding is not an option able to automatically identify and retrieve data ("RFID and IT Challenge.," 2003) used as a more efficient alternative for the goods tracing, visibility of the entire supply chain being a boost for all operational process corresponding to tracking, shipping checkout and counting process which conducts to more detailed information and a up to date inventory flow granting a shortest processing time and diminishing of operation costs (Robert & Steven, 2002). In (Robert & Steven, 2002) journal it is proposed the enhancement of operation by integrating RFID real time data identification and collection to the planning and route optimization of the handling equipment promoting cost effectiveness by making real time decisions on the equipment routing.

It is important to elucidate that not all optimization methods work in different types of business and different solutions will have different impacts according to the business requirements and operating mode.

3.6 RESOURCE ALLOCATION APPROACHES

Since the intention of this project is to build a solution able to promote company's better allocation of their physical resources based on their already existing flows and resource enhancement with ad hoc services, this chapter and topic review will provide a panoply of different approaches for resource allocation.
According to (Heidenberger & Stummer, 1999) there are major techniques and trends for project selection and resource allocation being the more appropriate for resource allocation of new companies/ companies with fewer data available - Simulation, Game Theory and Optimization encompassing mathematical programming techniques and heuristics.

A simulation model theoretically represents reality, imitating existing and real world operation processes to understand decisions impacts that a process has in the real world (Simul8 Corporation, 2019). The change in parameters associated to the model it is possible to test new and existing processes through a sequence of simulations, in order to assess a model sturdiness when required to answer specific situations with a rather low cost (Simul8 Corporation, 2019). The high number of attainable scenarios when using simulation and the difficulty of evaluating results.

Game theory is the analysing strategy of making decision based on interactions with other players. It uses homo economicus assumption – a self-interested, rational seeking for maximum utility of the resources in the outcomes (*Behavioral Economics*, 2019).

According to (Hausken, 2002) in order to game theory to be applied there are three requirements needed:

- At least there have to be two players
- No less than one player must have the opportunity to choose between at least two strategies.
- The advantage to each player depends on the strategies combination chosen by all players.

Optimization is an important tool that focus on finding the most optimal solution to a problem with low computational effort by identifying and mathematically express the objective, the variables and the constraints of the problem.an optimal or near-optimal solution to a problem with low computational effort (*Neos Guide*, 2019).
The model can have one or various objectives that can be optimized, constituting the measures of performance in the system that will get boosted, maximized or minimize according to the objective. The variables represent resource's consumption being that it's a volatile input as they can change during optimization process. The constraints are the functions representing the links between variables and determine the permittable values for the variables (*Neos Guide*, 2019).

3.7 OPTIMIZATION FOR RESOURCE ALLOCATION

In today's global market, manufacturers failing to efficiently allocate and make use of their resources will eventually lose their competitiveness (Chen V & CochranV, 2005). Efficient resource allocation allows optimizing of companies' objectives and a rewarding promotion of business performance and goals achievement.

Optimizations methods are a very broaden and transversal study on the more diverse areas such as engineering, management science and industrial processes (Anjos & Zhang, 2006), optimization for retail shelf space allocation (Yang, 2001), , (A. Lim et al., 2004), it can even be found studies about organs transplantation (Freeman et al., 2002), inventory management (Axsäter, 2003), (Li, 2013), (Ramakrishna et al., 2015), (Bhatnagar & Syam, 2014), (W. Chen & Dong, 2018), (Joines et al., 2006), project management (Hegazy, 1999), resources scheduling and operations planning (Belien, 2006), (Sujono & Lashkari, 2007), job-shop scheduling (Sadeh & Fox, 1996), electricity retail market (Fotouhi Ghazvini et al., 2015), and to solve classical optimization problems related to vehicle routing (Doerner et al., 2008), (Laporte, 1992), location optimization (Dias et al., 2007) and general optimization improvement (Chaharsooghi & Meimand Kermani, 2008).

In (Doerner et al., 2008) it is approached Vehicle routing problem with multiple interdependent time windows in which the relation between perishables cargos and their interdependencies between pickups and deliveries are important to define the possible routes as there is a time span to be fulfilled. The problem is about a red cross challenge to improve blood pickups that have a life span of 5h being the next pickup has to be carefully chosen considering deterioration and travel times. In order to solve this problem a mixed-integer programming model was formulated resorting to the use of heuristic approaches, branch-and-bound solution and computational analysis.

When addressing the milk run problem, (Jafari-Eskandari et al., 2009) developed a mixed integer approach. Having in consideration the problem formulation is NP-Hard it was used a robust optimization approached being that it was used some actual data to compare results with the strategy followed.

3.8 HEURISTIC APPROACHES IN RESOURCE ALLOCATION

The standard approach to an optimization problem begins by designing an objective function, having that it is a non linear and non-differentiable, there are some best-know algorithms, are they "Nelder&Mead: Bunday et alii (1987), by Hooke&Jeeves: Bunday et alii (1987), genetic algorithms (GAs): Goldberg (1989), and evolution strategies (ESs): Rechenberg (1973), Schwefel (1995)" according to (Storn, 1997) which all generate a variation of the parameter vectors and once that happens a decision must be made whether to accept or no the derived parameters. This standard direct search methods use greedy criterion that might be confined to a local minimum escaping to this, by running several vectors simultaneously and having superior parameter configuration helping vectors escaping local minima there is genetic algorithms and evolution strategies from the above mentioned (Storn, 1997).

3.9 BUSINESS INTELLIGENCE AND ANALYTICS

A business process is a sequence of activities with distinct inputs and outputs collectively pursuing a business purpose or policy goal, being that they are crucial to maintain competitiveness of a company (Rodríguez et al., 2007). It is possible to see its importance when software developers want to express from business processes the necessary requirements to build, design and create a software.

According to (*Workflow Management Coalition Terminology & Glossary*, 1999) a workflow is "the automation of a business process, in whole or part, during which documents, information or tasks are passed from one participant to another for action, according to a set of procedural rules". A workflow importance holds on the growing need to solve complex, scientific computational problems, and complex simulation techniques (Talia, 2013). In order to develop scientific applications, high level mechanisms and tools are indispensable for designing and execute complex workflows. A workflow is a defined and repeatable pattern or structured organization of activities designed to achieve a certain transformation of data (Talia, 2013).

The concept of workflow exists since industrialization, in which work activities are separated into well-defined tasks, roles, rules, and procedures that set the compass for most of the work in manufacturing and the office. Typically, business process management is referred as a specification of a process, software that suits and automates a process, or software that supports the coordination and collaboration of people that implement a process (Georgakopoulos et al., 1995).

The robotic process automation (RPA) has the same objectives as a workflow automation of removing manual and repetitive work where the first automation engine appeared in early 1990's (M. Lim, 2018).

Business intelligence (BI) arose from the various decision support applications like online analytical processing (OLAP) , executive information and predictive analysis being that the term business intelligence was coined in the early 1990's as stated in (Watson & Wixom, 2007). Business intelligence is about getting data into an integrated data warehouse and transform it to extract meaningful insights for decision support and create new fields from the records of the different systems. The second activity involving data access and its use to make decisions thus allowing business users and applications to access data from the data warehouse conducting to enterprise reporting, queries, OLAP and predictive analysis (Watson & Wixom, 2007).
According to (Sallam et al., 2011) in Gartner Report, There are thirteen characteristics considered essential for BI platforms being reporting, dashboards, ad hoc query, search-based BI, OLAP, interactive visualization, scorecards, predictive modelling, and data mining considered business intelligence and analytics (H. Chen et al., 2018).

In (Delen & Ram, 2018) it is shown a graphical depiction of business analytics taxonomy developed by INFORMS' and presented below on figure 5. Analytics promotes the achievement of business goals by first answering to questions of what is going on and what happened in a company being this stage called descriptive analytics often called business reporting as most of analytics activities at this level intend to create reports that summarise business activities. Information is often delivered to decision makers mainly in dashboards allowing decision makers to personalize it do address specific situations (Delen & Zolbanin, 2018).

Predictive analytics is second in the three-level analytics hierarchy and the maturity in the previous level allows organizations to move towards predictions and make a new question of what will happen. Prediction essentially is the process of making intelligent/scientific estimates about the future values of some of the available variables influencing an organisation (Delen & Ram, 2018).

Prescriptive analytics is the highest level of the analytics hierarchy. Through the analysis of the previous levels, it is possible to the course of action that is determined resorting to the use of sophisticated mathematical models and so this highest level tries to answer the question of what should be done. Havin this, prescriptive analytics uses optimization, simulation, and heuristics-based decision modelling techniques (Delen & Ram, 2018).

Figure 5 - Taxonomy for analytics by (Delen & Ram, 2018)

Usually companies have some information systems to support the execution of their business processes and common examples can be ERP, CRM or workflow systems which support the creation of event logs that makes the register of the activities performed while executing business processes. In this event logs, process mining allows automated discovery of process models based on information hidden in event logs (De Medeiros et al., 2008), (Van Der Aalst et al., 2011).

Machine learning systems (a.k.a. data mining or predictive analytics) according to (Pedro, 2012) automatically learn programs from data being that it is often a very attractive alternative to manually constructing them. Machine learning algorithms can figure out how to perform important tasks by making generalizations from examples. This is often feasible and cost-effective where the manual way of programming it is not.

There are several opportunities to improve the productivity and increase the automation, using the ability of ML and AI to handle mundane tasks, freeing the employees to deal with more complex challenges, contributing to a profit increase (Fernandez & Aman, 2018)

Deep learning is a machine learning and artificial intelligence paradigm, that builds models with huge data amounts, with neural networks as base. Deep Learning models do not need any instruction to improve, it uses the feedback to adapt the weights to the input parameters. The artificial neurons in conjunction create a deep neural network, with a perceptron as a human brain replica, connected between each other forming a deep neural network, with input nodes, human brain dendrites replica, a decision function and output nodes (human brain axons). (Cockburn et al., 2018)

Big data gained a significant attraction in academia and industry for providing valuable business intelligence and evidence-based decisions. Big data has been a key facilitator for the advancement of the Internet of Vehicles (IoV) in which big data can be leveraged for efficient processing and valuable decisions. Moreover, data acquired from connected vehicles, traffic monitoring, social media feeds, and crowdsourcing can strengthen urban development and management (Arooj et al., 2022).

3.10 EXISTING LAST MILE LOGISTIC FLOWS ANALYSIS

Transition from brick-and-mortar to online shopping and delivery from a sustainable perspective, has its particularities, resulting in different positive and negative factors that are hard to measure due to the different ways to proceed when delivering goods being that the net improvement in the carbon footprint will depend on variables like product type, consumer buying process, urban density, traffic congestion, transportation choices, time windows to fulfil (Chiang et al., 2019). Nowadays this perspective is really important because not only reveals the environmental impact, but it also provides an economic indicator for companies by analysing whether there is a good use of resources looking at every footprint indicator of the different last mile journeys.

Although this footprint indicator in theory may be good, it is not possible to forget that the delivery of one parcel only can negatively influence the footprint due to a higher distance between points of delivery that do not correspond to a regular distribution. For that reason, it is important to study the impact thru the eye of several perspectives such as:

- Carbon footprint/number of parcels
- Carbon footprint/number of kms travelled

Other indicators are necessary if when looking for accuracy and more concrete information regarding efficiency topic leading to the analysis of other important indicators as below:

- Number of parcels CBM/total capacity of the vehicle
- Number of parcels CBM/Total number of kilometres

3.11 MAIN ISSUES, BENEFITS AND DRAWBACKS OF THE CURRENT SOLUTIONS

Information in supply chain is really important as information systems are major enablers able to support supply chain activities. Through demand history, inventory planning is insightful on stock planning throughout time according to inventory rules of stock levels, safety stocks, stock rotation and order quantity. In that way replenishment planning arises from inventory planning and bases itself on the available stocks, expected deliveries and customer contracts which leads to the procurement phase, triggering off two activities, manufacture planning and transport with the first being the resources planning and capacities necessary for the production plan and the second one is related to the transport capacities planning either for deliveries of transport requests.
Information exchange in SCM between different parties involving, supplier, producer and customer generates advantages in the domain of forecast mistakes decrease, joining inventory levels and obsolescence reductions and improvements in service level. This is materialized precisely because of the integration of each party with forecasts, inventories, resources, orders, and distribution shared. At the present times of competitiveness, cooperation between vendor and buyer is crucial to reduce joint inventory costs and response times with economic order quantity (EOQ) and economic production quantity (EPQ) having to be contemplated together as in the past the different standpoints from the buyer and the vendor not always collided on an optimal solution for both parties (Cárdenas-Barrón et al., 2011). Successful experiences have demonstrated that integration of the supply chain significantly influences company's performance and market share (Simchi-Levi et al., 2000) with other papers showing results of improved performance and profitability to all parties involved in supply chain (Weng, 1995).

The main purpose of this study is to improve the status quo of last mile through understanding the power of information that each player upholds and promote collaboration between integral parts of supply chain to encourage the development of synergies capable of revolutionize the industry by creating profitability for a saturated market. Technologies are big propellers behind last mile optimization and in this paper the suggestion made will be in that sense, whereupon the main objective will be to use the resources already in use to:

Create a mixed-integer programming formulation encompassing some mid-objectives:

1. Improvement of utilization rates for regular flows.
2. Ad-hoc exploitation based on maximization of existing flows.
3. Profitability improvement based on combinatorial distance between the several potential ad-hoc pickups, the main cargo flow, the depot and different existing routes.
4. Time window consideration.

These will ultimately guide to the final objective on the decision making of which cargos to pickup to complement the ones that are key business drivers.

4 STRUCTURED METHOD FOR THE OPTIMIZATION OF THE EXISTING LAST MILE LOGISTIC FLOWS

4.1 ASSUMPTIONS

Literature review provided a panoply of techniques used to improve last mile flows which will directly impact the variables influencing the total cost. Cooperation is the driver and focus of this study as it is of a big importance to have Logistic companies to make the most out of their resources and have the appropriate tools to decide which path to follow while running their regular activity, for that it is assumed that:

- There are several variables influencing transportation costs, with its complexity growing when applying optimization techniques.
- Collaborative transportation networks identify transportation needs of the shippers.
- Truck reposition costs can be attenuated by creating collaborative networks.
- Transport companies running at short distance usually are very small companies working under big organizations with integration not always being achieved.
- There are really low load factors for delivery vehicles in the city.
- It is possible to have goods being routed based on a mid-shipment route in order to maximize profits.
- Urban density improvement can be done resorting to collaboration and market segmentation
- There are gains arising from split deliveries when the mean demand follows certain rules and in order to have those gains, mean demand has to be greater than half the vehicle capacity
- Split deliveries have to be well examined has there are route configurations for a given demand that can supplant these gains.
- As in B2C there are several shipments that do not have time windows constraints which makes planning easier, resulting in savings.
- Companies through collaboration can have access to different parcels in need to be shipped in real time.
- Crossdocking can supplant earnings if well combined leading to gains that would not be possible by doing point to point deliveries.
- Machine learning systems automatically learn programs from data by generalizing from the data.
- Machine learning and automation intelligence handle mundane tasks and free employees to deal with more complex tasks.
- Internet of things is one of the sources of big data that can provide an extended understanding of the current situation of an organisation.

4.2 PROPOSAL

The assumptions are important elements able to help in the elaboration of the proposed implementation roadmap for the delivery making process of choosing to deliver one extra parcel according to the routes already defined for the delivery of regular flows.

The framework intends to extend the use of this decision-making algorithm to several ground carriers and work on their competitive advantages able to provide the biggest profit for the company instead of being another one out of many solutions available in the market. This means there is an urge to make use of data available and guide the business through it. Identify some key costs is essential for the posteriori analysis on how to proceed with the acceptance of new service orders and still be competitive about it and generate as much profit possible having in consideration all variables and opportunity cost. This roadmap is the base and the direction for what is needed to run a business and what is avoidable to ground carriers. With this, the target of the algorithm will be the identification of transportation opportunities considering each company's features and goals supporting the decision of monetize existing flows in a way that it really generates profits for the company mainly through the power of collaboration and increase of the truck load factor of cargos with similar pickup and delivery areas or cargos that can be transhipped to follow other regular flows until having their optimal route to reach the final destination.

Below there is the macro vision of the designed artifact:

Figure 6 – Strategy implementation process

4.2.1 IDENTIFY OPPORTUNITIES FOR ALGORITHM ALLOCATION.

The first step in this framework is the understanding of all opportunities in daily activities where it is possible to have better performance results based on this decision-making algorithm in transports allocation.

The importance of this algorithm will depend on the type of business that ground carriers are running being the spot service a big opportunity to improve operations when performing regular service. The success of this goal will depend on how flows are organized in terms of time constrains, contracts and if the performed route will allow new cargo acceptance and if it is a good principle to accept it according to cargos destination and solutions that may exist for that given transport. The quality of the solution that may be found will rely on data availability and which point of the route the order of pickup is given based on real-time information, cooperation between the different players of a supply chain in the same business unit, Business objectives and features.

In short the business process of companies will determine the overall result of the allocation algorithm.

There is also the opportunity to explore certain zone areas where it would be profitable for the company to improve the profitability whether because of the amount of transportation needed around or the proximity to the warehouse that would reduce the spending in first mile.

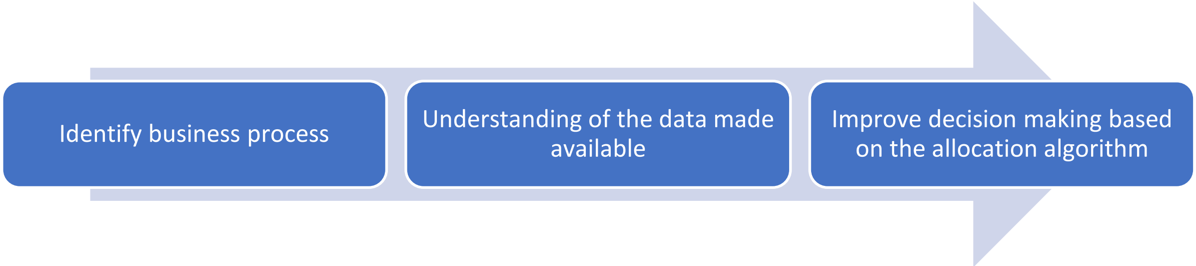


Figure 7 – First step of strategy implementation

The process of information gathering from different companies will happen in the form of a questionnaire to logistic companies' drivers and pricing decision makers being the main objective the understanding around transports organization in terms of regular flows, how much profitability is it possible to have around this specific type of transportation, truck space occupied by regular flows, space exploitation of the truck with regular flows for ad hoc cargo, time windows to fulfil, in-route pickup possibility, how does it work for ad hoc urgent pickups, space optimization with ad-hoc requests even with time constraints. Only through the understanding of the business processes it is possible to attain the goal of maximizing existing delivery flows by looking into opportunities to apply an optimization algorithm if there is indeed the possibility of implementing it with companies willing to integrate themselves with other stakeholders, and if there is no restriction for cargo to follow other path rather than point-to-point delivery. It is important to understand the operational side of companies and how do they organize their work, taking in consideration all the costs and earnings and what is the strategy promoting the optimization of transports on daily activities. It is also important to identify in the questionnaire if there is any strategy implemented in search for the optimization of future flows meaning if there is any planning, sales prospection, or technology being implemented to improve the status quo of delivering and if there is the existence of analytics or data related to quotidian activity since it is inconsequential the implementation of an algorithm without gauging the results and understand whether efforts are working and if it is possible to extract any other meaningful information capable to disclose a business standing. It is also valuable to check for any worker with the knowledge of the data involved and the potential use cases.

According to each level of integration between players of the supply chain, different algorithmic applicability is possible creating infinite possibilities.

The questionnaire incorporates the following questions:

1. Sector identification

Questions: Which sector are you part of? What are the main goals of your sector? What are the main business processes so the sector can achieve the goals? Is there any freedom to make decisions on how to organize work? What is that freedom about?

2. Is there any optimization method in use?
3. To drivers: Is there any specific route or way to do the service to any specific customer? Is there any extra hours payment if there is an extra service to do or you simply got delayed on work?
4. How do you price the transports requests?
5. Do you have more regular or ad hoc services? Is there any proximity of acting areas between each service?
6. Do you usually accept services with your regular flows? How do you price them?
7. Is there any geographically area that has a bigger amount of services? Is there any way to retrieve the area with most services? Is there any information system that allows to have visibility over all transports?
8. Do you need to analyze the output of your work? What is the relevant data analyzed? What are the use cases of the data analyzed? Is there any analysis performed related to pricing? Is there any analysis performed on drivers' conduction? Is there any analysis on the routes chosen? Is there any analysis on the places visited, and amount of cargo transported? Is there any analysis on how to combine cargo according to regular flows? Is there any information on the most popular service areas?
9. Is there any way to retrieve the above business data?
10. Is there anyone in the company performing data analysis?
11. Is there any reason for not performing any type of analysis?
12. What is the technology used that enables the retrieve of the above data?
13. What are the main objectives with the analysis performed?
14. What are the analytical and Technological needs to fulfill the mentioned objectives?
15. Is there any collaboration between other stakeholders, clients or same business units?

The questionnaire intends to reach workers responsible for strategy making, in a way it is possible to understand how companies are managed and uncover situations which would benefit of an optimization.
The answers will be gathered from the different members and comprised in a list, this approach will be a driver to acknowledge not only, how to deal with additional cargo in existing flows but it also will help conceding other facets of the business and provide meaningful insights that can change the course of the study.

Finding a way to promote the process of additional cargo acceptance in existing flows as a walkthrough diagram that any company can use as guide, is proposing a workflow diagram with possible paths and depending on each company's reality. This research will not enter in the details of process implementation, because it would require a detailed investigation under that area and lead to a discussion which would deflect the study objective.

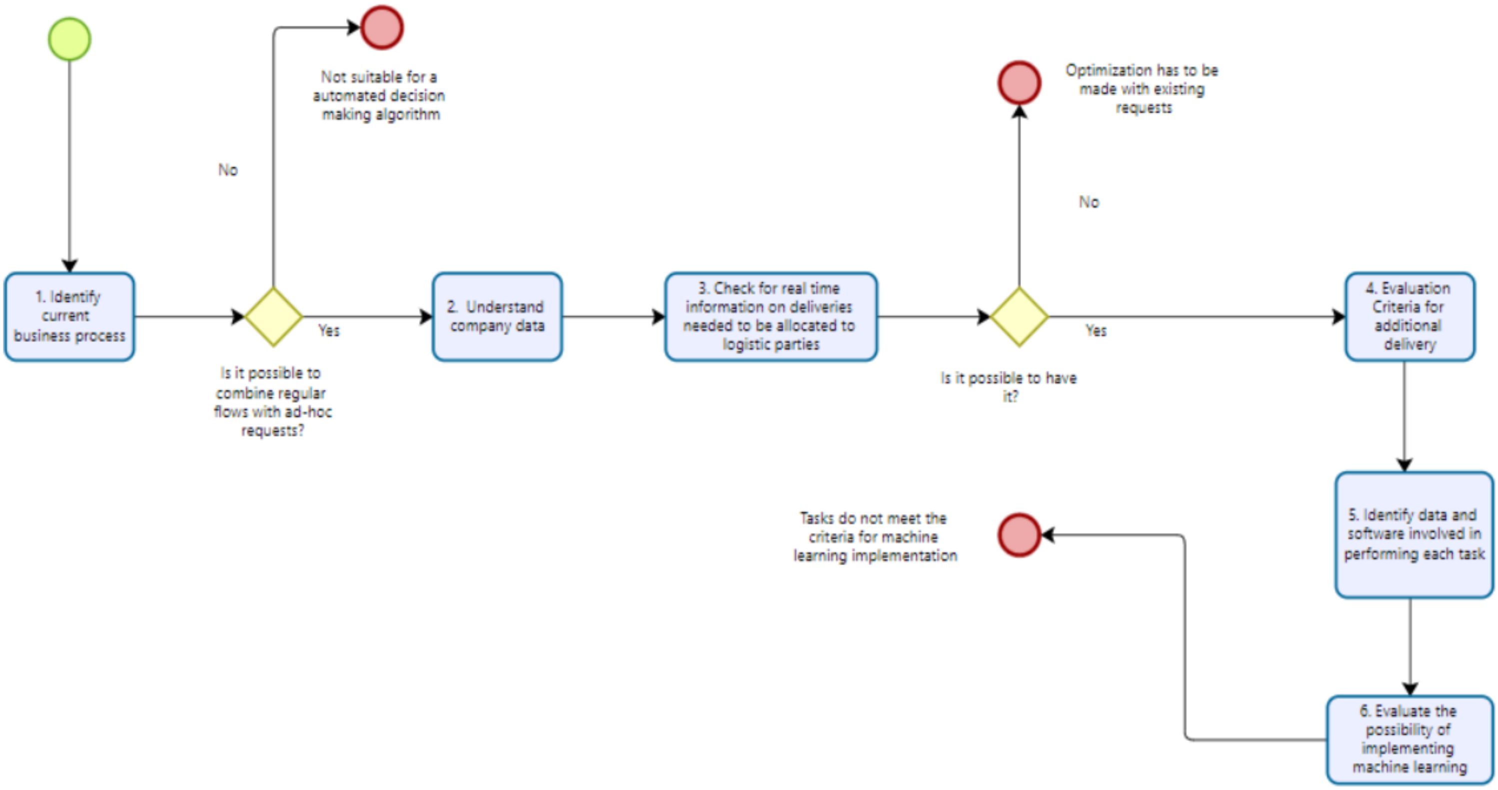


Figure 8 - Walkthrough guidelines diagram.

Below it is clarified each step from the above figure in order to provide an extended explanation of each phase:

- Process ID – Identifies the workflow step.
- Process Name – Identifies the name of the step.
- Description – Describes what is intended with the execution of the step.
- Goal – Defines the objective of the stage.
- Tool – Indicates the tool that assists in the execution of the step.

Process ID	1.
Process Name	Identify Business Processes
Description	Questionnary about companies' existing processes - Understand companies' processes - Identify the departments involved - Understand the importance of processes to the business - Identify any problem that need to be address
Goal	Build a process description

Table 7 - step 1 - Identify business processes

This first step consists in understanding the current state of the companies processes in order to assess the processes quality and evaluate the real need for the implementation of the proposed solution. It automatically identifies the foundations of companies and their focus to achieve goals.

There are several methods to retrieve information, being experts interview the one that will be used. The expected data to be collected is the following:

- Process type
- Purpose – Process scope
- Process Triggers – Identify the triggers that initiate the process.
- Workflow Diagram – Relation between the different activities in the process.
- Tasks and Activities Description – Process activities description along with the roles and responsibilities of the different intervenient.
- Exceptions – List of exceptions to the process.
- Business policies – Unique characteristics that are part of the process but not essential.
- Results – List of outcomes from the performance of the workflow diagram.
- Process finished – Identify what ends the process.
- Metrics – List of process evaluation.

Process ID	2.
Process Name	Understand company's data
Description	Create knowledge from the existing data - Create enviroments of learning to improve efficiency - Extract meaningful insights off the data - Define the molds of the integration of ad-hoc requests with regular flows - Address issues impacting the transports
Goal	Improve efficiencies of the transport

Table 8 - step 2 - Understand company's data

Company's data understanding is important to address some issues impacting the efficiency of already existing transports in a way it is possible to make more conscious and knowledge-based decisions. Unravel hidden patterns and dig in deep on data is of extreme importance for future combinations of transports giving space to implement last-mile optimization solutions.

Process ID	3.
Process Name	Check real time information on deliveries in need to be allocated to logistic parties
Description	Look for potential additional transports to complement existing flows - Ad-hoc exploitation based on maximization of existing flows - Promote gains through collaboration - Encouragement of optimal solutions - Profitability improvement based on combinatorial distance
Goal	Improve truck-load and earnings of the company based on ongoin deliveries activities

Table 9 - Step 3 - Check for real time information on deliveries in need to be allocated to logistic parties

This process intends to improve truck load of already existing routes inside a logistic company by looking for real time transportation necessities able to provide space optimization and improvement by choosing additional parcels to deliver that might be a fit into the already existing routes.

Process ID	4.
Process Name	Evaluation criteria for addional delivery
Description	Understand costs related to an additional delivery based on a regular flow - Define the minimum profit expected from an unexpected delivery - Evaluate the costs for an extra delivery - Verify essential conditions for cargo acceptance besides cost - Explore different combinations to make delivery possible
Goal	Assess and establish a criteria to decide on new parcel acceptance

Table 10 - Step 4 - Evaluation criteria for additional delivery

Transport costs encompass several variables responsible for increasing the total cost and an additional delivery might cloak unexpected costs that must be covered up on the profit margin. The assessment of new deliveries must have in consideration the below aspects shown in the table below

Trucks capacity	Check for trucks capacity taking into account: ○ Parcels' volume ○ Space availability in the pickup moment ○ Space needed during the programmed route
Cargo type	Check the type of cargo to transport. ○ Make sure the additional cargo does not damage the original cargo ○ Identify if the conditions in the truck are favourable for the transport to happen
Distance	The additional distance travelled between potential ad-hoc pickups and deliveries must: ○ Have costs that do not exceed the expected revenue ○ Encompass costs related to distance e.g., fuels ○ Look for optimal solution of combinatorial routes ○ Avoid additional truck reposition costs in the sum of total costs
Density and area (Cluster effect)	Check deliveries density: ○ Check for opportunities to conjugate deliveries in dense areas
Time	The time must be respected in what regards: ○ Time needed to fulfil the route and the additional parcel ○ Time windows of the existing flow ○ Time windows of the new parcel ○ Working hours of the driver
Loading and Unloading conditions	Check for the loading and unloading conditions which: ○ Include not attributing trucks that cannot go through certain streets ○ Proper truck attribution
Legislation	Complying with rules is important in what regards: ○ Being aware of the needs to comply with transportation requirements if not general cargo ○ Truck preparation for the additional cargo ○ Licenses for the cargo to be transported ○ Understand that in some areas loading and unloading is constraint to certain time periods ○ Carros têm de estar preparados para carregar certas mercadorias ○ Acompanhar a legislação até porque as vezes tbm é necessário licenças especiais. ○ Prohibition for trucks to circulate in certain areas

Warehouse capacity	For potential shipments in which the routing will need consolidation/any type of warehouse, it is important to check for: o Warehouse capacity

Table 11 - Decision variables

Trucks capacity is determinant in deciding whether to attach a new parcel in a giving moment or not as no space automatically prevents the additional haulage to happen. Having the space, it is necessary to assess if that space is not necessary during the route later-on.

Check the type of cargo to transport can preclude the transport as it might damage the existing cargo and truck conditions might not be the suitable for a certain cargo e.g., perishable cargo.

Distance is understood as the cost respecting to kilometres travelled that enclose associated costs of wear and tear and fuel.
The best solution for delivery not always is point-to-point routes and combinatorial routes may be considered for the decision of accepting new cargo as improvements in cost can be gained.

Density of deliveries are directly connected to efficiency of transports and influences the real travel distance. Bigger numbers of deliveries within the same area corresponds to bigger earnings as with the same travel distance more deliveries have been made. The more the transports in the same area the less the costs and the blend of several potential shipments can be the turning point to decide positively about one cargo when only accepting the second one in the same area makes it profitable.

Regarding time, it is important to consider the time needed to fulfil a given route and the additional parcel which encompasses the time needed for loading and unloading. As a resource, time, and lack of it, can impact other transportation routes that are more profitable, and a good balance must be imperative to maintain operations working smoothly. It is important to highlight that although time and distance might be related, there are quotidian variables that influence transport that do not have impact on distance e.g., traffic accidents and the risk must be ensure at least partly. Conditions as time windows must be considering on the cargo acceptance process just as the working hours of the driver that cannot be exceeded.

Loading and unloading conditions can get related with time losses as a shipment may not be delivered due to problems in getting bigger trucks into smaller streets that are not prepared to receive them.
The proper truck must be consider to the deliver as some request require platform lift or some other characteristic that must correspond to the delivers needs.

Legislation requests for some additional precautions for some transport and they must be taken in consideration. Moreover, there are some time constrains in certain areas for loading and unloading as well as truck circulation which may cause more problems for an additional cargo acceptance.

Warehouse capacity might be important as some route's profitability lies on the capacity to consolidate the cargo and its transhipment. For that reason, check out warehouse capacity might be needed before allocating a transport.

Process ID	5.
Process Name	Identify data and software involved in performing each task
Description	Understand the tools made available to have more detailed and precise information Identify: - Task executor - Software involved - Data management
Goal	Assess companies' technological resources to implement the best solutions possible

Table 12 - Step 5 - Identify data and software involved in performing each task

Identification of the technological resources made available by companies is important to understand the efficiency of the solutions and the different results that can be obtained according to it.

Process ID	6.
Process Name	Evaluate the possibility of implementing machine learning
Description	Evaluate the need of implementing machine learning to improve results - Understand costs involved - Identify possible gains - Resort to internet of things to improve performance
Goal	Identify patters in data capable to provide cost reductions

Table 13 - Step 6 – Evaluate the need of implementing machine learning

Machine learning is a great tool to improve efficiency and reveal hidden patters on data. Machine learning is important in this study because last mile is a complex subject with a big amount of decision variables and the criteria to find and optimal solution may be improved with variables that cannot be foreseeable in the present moment.

4.2.2 ADJUSTMENT ACCORDING TO THE INTENDED RESULTS

Each company has their unique way of running a business and according to the integration of different stakeholders, it is possible to reach different results and have a better articulation of flows enabling the assembling of better solutions based on truck position, data sharing and route interchange. In the absence of that interconnection, it is possible to have optimization methods that grant companies the best choices possible with the resources they have, allowing appropriate tools to help in the optimization process and how to better pricing and being competitive

The next figure shows the implementation of an adequate algorithm conforming to existing flows and steps needed resorting to the help of the information and conclusions drawn in the previous phase.

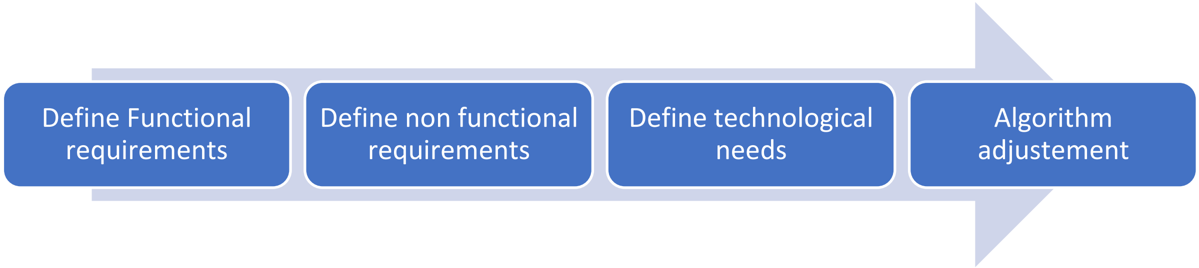


Figure 9 - Second step of strategy implementation

In order to achieve the described goal, some conditions must be met being that they appear in the form of functional and non-functional requirements in which the first represents actions, and how the system works and can do in terms of tasks and services, and the former supports functional requirements describing the properties and maintenance evolved on how software systems should perform and how functionalities are delivered to the end user.

The ongoing state of each logistic company can influence the algorithm implementation according to each company predisposition to integrate themselves with other stakeholders and clients, the amount of existing flows that allow the articulation with ad-hoc requests and the mixing between ad-hoc requests itself in order to monetize the routes and being able to generate the biggest profit possible without having marginal margins for additional pickups but still having better prices than the ones offered by the competition.
Another influence factor on how to apply the algorithm is the current state of the logistic company, considering the current situation of a company in which every movement can represent the sustenance and business continuation and what matter the most is to make the most profit out of each service without having opportunities lost due to the arrangements of not so profitable services resulting in opportunity costs that can be important for companies profitability. It is important to understand where there is the biggest concentration of opportunities geographically speaking and have the trucks around certain areas so that chances of getting good opportunities can happen meaning certain area services should be privileged according to each logistic company situation.

The technological assets are another relevant factor of major importance in producing the best solution possible.

Identification requirements come from the understanding of the objective function that identifies the parameters and information needed to the good function of the decision-maker algorithm.

Tabela 1 - Different types of requirements

Type of requirements	Requirements Types
Functional requirement	• Analysis of organization characteristics • Identification constraints for regular flows to mix with ad-hoc • Systems and technologies that can be use • Strategic vision definition • Business strategy development • Create functional user experience • Algorithm adaptation according to the parameters • Regular flows identification • Regular flow utilization rate • Route systems availability • Collaborative platforms with deliveries in need to be performed • Integration of different parameters that feed the algorithm • Internet of things • Data analytics • Data availability system • Event logs • Workflow systems • Understanding of companies' financial health • Understanding of current companies' strategy • Regular flows service areas • Ad-hoc service areas • Racio ad-hoc services vs Regular flows • Work with supervised model

	• Work with unsupervised model • Determine best model evaluation criteria • Train set of different models (hyperparameter optimization) • Integration with different types of data • Integration with different data sources • Integration with different file formats • Choose best model • Accurate models • Model deployment • Dashboarding results
Non-functional requirement	• Scalability • Formation • Computational power • Easiness of use of the resulting model • Explain ability of allocation algorithm process

The table hand over the general requirements identified in an allocation algorithm implementation, and next some recommendations will be presented according to the common requirements:

- Integration with different types of data: The data retrieval for algorithm feed needs to be made through the transformation and necessary adaptation of different types of data taking the first steps to process all types of data and reach through it the required information to have real time information and make decisions based on it.
- Integration with different data sources: It is essential to have automatizations systems connected with organization data sources which is very important to ensure a smooth integration and updated information.
- Work with supervised model: The business needs and the presented use cases involving allocation algorithm are expected to have different outcomes, so it is necessary to be able to apply a variety of supervised learning models in order to adjust previsions based on errors and reach the intended results.

- Work with unsupervised model: This model is important to understand if there are final results that are not being considered and if the outcomes make sense on the final application.
- Data analytics: Answer to essential questions of what happened to the business, why it happen and what can be done.
- Determine best model evaluation criteria: The step of the deployment of the algorithm is the choice of the best model to implement afterwards.
- Dashboarding results: Produce a report and a dashboard with the obtained results in a way it is possible to access the results of the implementation of the algorithm for the additional delivery

After the identification of the requisites that need to be fulfilled by the allocation algorithm both at technological level needs and business information, it will be important to have platforms able to integrate information and monitor daily activity of the businesses.

4.2.2 Definition and implementation of the roadmap

The implementation roadmap of an allocation algorithm will lay in the several phases:

1. Project Preparation

The first phase of this implementation roadmap has been properly launched, with the project being planned and project milestones defined. The starting point was set when the first drafts of the project scope appeared, defining the thematic and the incidence of the study object with clear lines of what the procedures can be to solve the intended problematic.

1.1. Recognize allocation algorithms implementation needs

The project can only move forward through the understanding on how implementation can occur and concentrating on the preconditions its essential to move on with the plan. A list of requirements gets set with the condition of constant update according to the adequate solution to be implemented.

1.2 Assign resources

Consists in the attribution of resources to fulfil the implementation itself. The nature of resources can be diverse as either technical or personnel resources. This step needs to take in consideration the organization financial state and the already existing resources and consequent adaptation to produce the expected results.

1.3 Set up calendar

Having resources distributed, the methodology can be defined and schedule how all company can adapt the algorithm implementation and rely on its information to make decisions based on knowledge by the algorithm created. This final implementation will severely rely on business resources and integration with other information systems which are essential conditions so the algorithm can work.

1.4 Set a control and monitoring structure

The correct monitoring of the execution of the algorithm has to be constant during the initial phase to understand the overall gains comparing to the previous procedures. Some milestones should be defined to access the progress and keep showing the progress to business directors. It is also needed to have adjustments to the algorithm according to world, and daily situation as small changes that occur can result in massive changes on the end result. This control is very important due to the nature of the sector that is one of the first sector to suffer the influence of small changes.

2. Business Blueprint

It's the second macro phase in which the project requirements are reviewed in order to check if everything is in accordance.

2.1. Review of identified requirements

The second project phase is about the reunion of the different requirements earlier mentioned according to the solution to be build with the resources available and corresponding companies' integration with technological systems.

2.2 Update of requirements definition

If there is any revision on the identified requirements emerging on the probability of arising changes, it is necessary to

After the list of requirements revision, there is the possibility of arising changes in the requirements previously defined, so it is necessary to iterate with the business teams regarding the update of the requirements.

3. Realization

The third macro is focused on the assembling of the intended project, going through the achievement of the proposed project work by checking after all the points identified in the project scope. This step will happen in different variations according to the best solution that can fit businesses in their choices to adopt a better strategy, information based.

4.3 VALIDATION

To validate and assess the usability of the proposed framework, an interview was conducted. Unfortunately, it was only possible to have one interview due to the lack of availability of top directors in this field. The operations Chief of DHL Global Forwarding, Rui Correia was the interviewer and it was able to provide meaningful insights over last-mile deliveries.

The objective of the interview is to understand if the proposed model complies with the real world necessities and to assess the usability of the developed criteria.

To validate the proposed framework, a specialist with a life dedicated to transports operations was selected. The interview was conducted via internet in two distinct days in which recording was authorized but due to technical problems only one recording is available. The first step of the interview was the presentation of the objectives and proposed framework to optimize existing last-mile flows with criteria definition for the pickup of additional cargo to transport.

Throughout the interview more specifically during the additional cargo decision criteria presentation, several questions were made, and suggestions were given:

- Apply Loading and unloading conditions as one of the conditions for cargo acceptance because of the cargo weights or facilities conditions that are not always adapted for the cargo to be received.
- Insights over Legislation and its constraints to be considered.

To the questions:

Q1: Do you consider the proposed framework useful?

The interviewed answer positively as it promotes economies for the truck companies that have regular services for which the transport is already paid but is not completely efficient. As an example, it was mentioned less than truck loads operations in Europe that benefit from groupage.

Q2: Would you consider using the proposed framework?

The interviewed answer positively, having in consideration that the proposed framework is complete and supports decision making in improving already existing transport flows. The criteria set is also complete and approaches all variables necessary to have in consideration for a proper decision-making

4.4 DISCUSSION

The analyse performed regarding utility, viability of implementation and improvements based on the answers from validation phase enabled the artifact evaluation as useful for transports sector.

The participant highlighted that although many small companies are operating in a very competitive market with extremely small fleets under the umbrella of big logistic companies, they do resort to information systems to improve their efficiency and make a stand in the market by improving the decision process based on relevant information that influences the total costs and performance of the entire delivery network. For that reason, this tool would facilitate the work of selection on creating a checklist for carriers to use in order to avoid common traps that incapacitate them from keeping the schedule leading to a poor service, and eventually not complying with the service level agreement or just give a bad image of the company if happening in a regular basis.

During the presentation of the criteria used for additional deliveries to be performed it was suggested by the interviewer, one of the variables to be Loading and unloading of cargo as an improvement to the criteria to be establish as it might be one of the reasons for not delivering the cargo when the clients do not have the conditions to due so or when simply this step cannot be performed because of streets conditions and size of the truck preventing deliveries from happening. This disruption draws attention for the need of having careful planning in this area which in some cases might involve getting smaller trucks for deliveries or even getting special authorizations for the unloading to happen.

Regarding the topic density and area, the interviewer considered it of big importance as it is through optimizing groupage that it is possible to have big gains and having a big cargo density in each area reflects bigger gains for carriers and having in consideration the addition of more than one cargo that can be delivered in a given location is a good way to have better results.

The main concern for the interviewer about the proposed framework is the criteria developed which is useful but involves a detailed information about cargo that might not always be possible to have with the necessary rigor and availability which will work in most of cases, but in others there will be some errors exactly because information made available is not always rigorous as there are last time changes made in the warehouses and production lines that are not correctly transmitted to the logistic department either because of companies' organization or due to the internal management of lean production adoption that does not allow to know final measures and characteristics of the goods to transport. Another influencing factor that might lead to mistakes is the lack of internal knowledge and understanding of cargos characteristics that legally require some rules and additional documentation even for truck transport and not always they are perceived like that.

5 CONCLUSIONS

This chapter is about the conclusions of the developed dissertation work which include limitations and future work. It is the walkthrough revision and understanding of the accomplishment of the proposed objectives. From the feedback possible it is possible to state that the objectives were fulfilled, and the created artifact can be used in every carrier for the implementation of a establish criteria for the acceptance of a new cargo.

5.1 SYNTHESIS OF THE DEVELOPED WORK

This investigation approached many different subjects of this complex matter that is last-mile. From the several last-mile optimization techniques like route optimization, consolidation, and cross-docking to some more broaden resources able to improve efficiency like business intelligence and analytics as well as machine learning. The gathered knowledge set the possibility of defining and implement a framework to support roadmap to the implementation of a criteria for additional cargo flows having in consideration the existing flows.

5.2 LIMITATIONS

The investigation should have had many more experts being interviewed what would influence the framework validation to provide a more broaden validation and more suggestions on how to improve the model. The pandemic reduced the availability of the participants with interviews found to be uninviting by the participants.

The participant of this study did not get in a big level of detail in what regards business processes and all activities associated with it which does not provide big insights on possible improvements in this field. The level of detail regarding cargo criteria might not always be possible, what precludes the correct assessing of additional cargo acceptance criteria.

5.3 FUTURE WORK

Concerning future work, the validation process should be improved benefiting the framework and making it more universal through absorption of knowledge from a larger number of people and from different sizing companies.

Considering the limitations, it would be necessary to establish in the absence of visibility over some criteria variables what to do and decide whether to proceed or not with the acceptance of additional cargo. Some variables should be established as critical e.g., distance/price paid for a given transport and repositioning of the truck as well as time.

It would be beneficial the field application of the study, and different scenarios testing and the resorting to different optimization methods as well as market technologies used to monitor the transports and extract meaningful information that can be helpful when performing last-mile.

Making this investigation available to the academic world through a publication, would also made it more accessible to the public and allow the investigation on the topic.

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