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Master Degree Thesis

Case Study: Assessment of the possibility of adoption and impact of blockchain, IoT and Drones technology in the different types of last-mile delivery.

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1. Introduction

1.1. Abstract

The world is facing a new technological revolution, where vast amount of data is being collected, processed and analyzed, and is the companies' duty to take advantage in the new technology to improve value process, develop new strategies and ease the decision-making.

Logistics, supply chain and specifically the last-mile can be highly influenced by this new information technologies, rather than a choice, the correct usage of data has become a task to remain competitive in the market, especially for the last-mile, which is the part of the supply chain that entails higher cost.

The last-mile transportation problem has been always a key part in the supply chain management of business, and several models, technologies and practices has been developed to mitigate its impact on total cost. But as each company is different, each face a different type of last-mile problem, with different characteristics, and therefore different solutions are needed.

The purpose of the study is to deepen and enrich the knowledge on the relation and impact that new technologies, such as IoT, blockchain and unmanned vehicles (drones) might have on last-mile logistics.

This thesis will evaluate the possible impacts that new upcoming technologies, might have on the most important operative characteristics of last-mile, and which types of business will be more likely to adopt the studied technologies in the future.

The analysis will be made through the construction of a case study regarding two innovative start-ups and a third party logistics aiming to use innovative technologies to change the last-mile and the supply chain.

Keywords: Last mile logistics, supply chain, Delivery alternatives, time window, environmental impact, blockchain, IoT, drones, unmanned vehicles.

1.2. Last-mile characteristics

Last mile is a concept used in supply chain management and transportation logistics to describe the movement of people or goods from a transportation hub to a destination, or a final user home.

This last leg of the supply chain is often less efficient, comprising up to 28% of the total cost to move goods. This has become known as the "last mile problem." This thesis will focus primarily on the 'last mile' of freight movement within the Central Business District. The 'last mile' within the Central Business District is characterized by final products being delivered in low volumes and at high frequencies, therefore, it generally has the greatest number of trip ends.(Allen 2011).

When delivering goods in Central Business Districts (CBD) different factors such as: local regulations (time or type of vehicle restriction), different possible routes to arrive at destination, order of deliveries, customer availability, traffic, and many more, have to be considered trying to maximize benefit for all the stake holders involved.

Planning takes a very important role on last-mile management, but should be aid with innovative technologies or business models that could help to overcome all the issues related with the last mile without compromising, and when possible increasing, the efficiency of the delivery process.

Companies and countries are already developing projects to test and study different technologies, the main cases.

For example The synchronized last-mile logistics (de Souza et al. 2014) concept seeks to address, through coordinated collaboration, several challenges that hinder reliability, cost efficiency, effective resource planning, scheduling and utilization; and increasingly, sustainability objectives. Synchronized last mile emphasizes multi-party collaboration to extend and optimize the respective parties' resource portfolios and to reinforce their own market position.

Or the innovative model of containers (Dell'Amico and Hadjidimitriou 2012) that consist in the introduction of two different vehicle types with the aim to optimize the distribution by lowering the transportation costs. Reduces Km traveled in urban area, reduce congestion and pollution because a van can have full electric traction.

And one of the most recent in Germany The Smart City Logistik (SCL) project (Schau et al. 2017), where dynamic information systems are added to the cabin of the EV to provided drivers with real time information.

As mentioned before, the last mile problem varies depending on the type of business, customers and products, and a solution might not work in all cases, therefore become important to have some insights of which of the new technologies might have a significant impact on city logistics and will be adopted by business as new standards.

Recent trends in the supply chain management are moving towards a competitions of supply chains and no more a competition between singles companies, that's why information technologies are beginning to play such a critical role, it is important to build competitive supply chain. To achieve this goal, Information in supply chains is one of the most valuable resources for manufacturers and carriers. (Nakasumi 2017)

1.3. Objectives and scope of work

The main objective of the thesis is to evaluate the possible impacts that new upcoming technologies, might have on the different business models of last-mile, which firms will be more likely to adopt in the future.

First a review of the literature will be conducted to gain insights on the most recent project, trends, technologies and factors that affects the last-mile.

Secondly a set of Key success factors and characteristics that affect the performance of the last mile will be defined, together with the different business models of last-mile.

A set of technologies will be selected, and a first assessment will be developed on hoy the selected technologies can affect each of the business models of the last mile, depending on the impact on the key success factors for companies.

For each technology, a case study applications from the industry will be presented, with a twofold goal. First, a real-life application validates, the choice of the selected technology for this study; second, it enables us to evaluate directly the potential effects that the technology, might have on the last mile logistics.

In this study only technologies that can cope with limited travel ranges will be evaluated. Due to, the fact that until 2020, and beyond, batteries will not be able to guarantee driving ranges close to what can be achieved today with traditional gasoline-driven engines, as least if a viable weight to power ratio must be the goal (Schau et al. 2017). As well as other information system technologies.

Finally, a set of interviews to field experts will be conducted to analyze and gather their opinion regarding the impact each of the proposed technologies might have on the near future of the last-mile industry. By joining the results of the interviews and the information found on literature a case study will be constructed, the study might help to guide future projects and research, focusing only some technologies on specific types of business, in which impact will be greater, and firms will more likely adopt the technology and provide guidelines for future research and projects.

2. Literature Review

2.1. Last-Mile definition

Last mile is a term used in supply chain management to describe the movement of people and goods from a distribution center or hub to a final destination (home, locker, reception box).

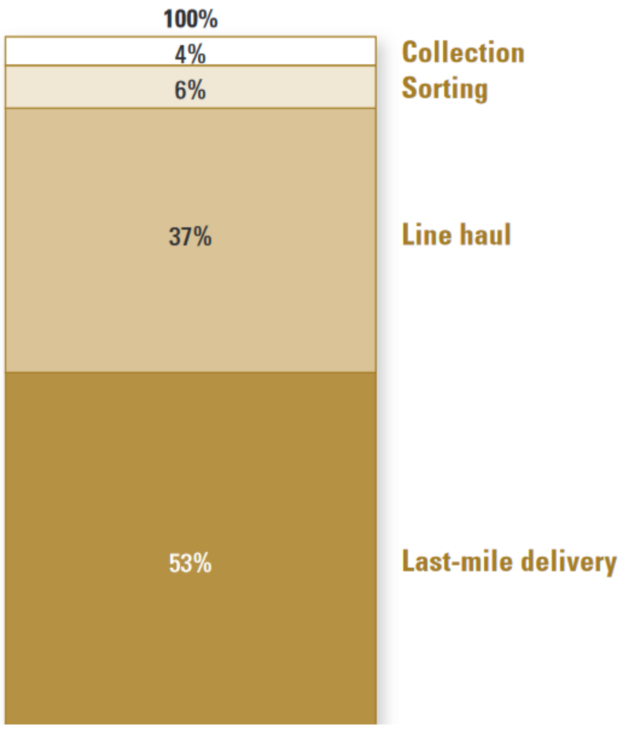
The last mile problem can also include the challenge of making deliveries in urban areas. Deliveries to retail stores, restaurants, and other merchants in a central business district often contribute to congestion and safety problems. (Scott and Anderka 2009).

The focus of last mile logistics is to deliver items to the end user as fast as possible. Last mile logistics has become a popular area of interest for retailers' due to the growing demand for fully integrated omnichannel[1] retailing, which have forced retailers to evaluate current transportation network capabilities and make investment on technologies to improve this problem. (datex corporation 2015)

Last-mile delivery, and the problems associated with it, have always been present on the industry. The largest issue, lies in the cost of transporting individualized shipments to distinct, often unreliable final destinations due to constantly changing routes.

Transporting goods via freight rail networks and container ships is often the most efficient and cost-effective manner of shipping(Kumar and Saurav 2015). The last stage of the supply chain, where goods move from a supplier to a customer is known as the "last mile." The Council of Supply Chain Management Professionals estimates that as much as 28% of all transportation costs occur in the last mile (Goodman, 2005). In exhibit 1 is shown the proportion of cost per parcel taken by the last-mile delivery.

Exhibit 1: Cost structure per parcel



Source: (Goh, Gan, and Chen 2011)

[1] Omnichannel is a cross-channel business model that companies use to improve their customer experience.

Exhibit 1 confirms that the last-mile problem, is indeed a problem to care about, and to invest and use all possible technologies to reduce the cost impact.

The last-mil problem, considers also the environmental impact, as mentioned (Arvidsson and Pazirandeh 2017) by a large share of cost, congestion, and emission in cities is attributed to light goods vehicles like carrier vans distributing to the last mile. The aim of many policy agendas is to reach cleaner cities with less disturbance from the distribution vehicles.

The last-mile considers many variables, and the different management of these variables determines the impact that the issues mentioned above, might have on the company's process. Those variables can be either technical aspects or operative decisions that might vary depending on the type of last-mile faced.

Due to the different variables and issues related to last miles, different typologies have been studied by scholars depending on a specific setting of the problem. For instance, the Urban Last Mile Logistics (ULML), which covers all the distribution in urban areas, mostly with home deliveries, is created due to the rise in online shopping, creating a new huge challenge, in which, companies have to meet the customer requirements, but also needs to consider the characteristics of goods themselves. ULML accounts for a large proportion of the whole logistics cost due to the city traffic situation, the vehicles used, the labor cost (Zhang and Lee 2016)

As IT technologies and e-business continues to grow, the last-mile has become more challenging, with more demanding consumers. E-commerce sales are expected to reach $1.35 billion by 2018, an increase of 28.8% from 2013 (datex corporation 2015).

. These statistics covers a different product types such as, entertainment, food, health & beauty, electronics, etc.

Increasing customer requirements decrease flexibility of delivery. In urban areas, traffic infrastructure is often used to its maximum capacity, resulting in traffic jams. City logistics service providers compete against other road user for the scarce traffic space, which cannot be extended unlimitedly. Defiance of varying infrastructure utilization may lead to lower service quality, higher pollution and higher realization costs of delivery (Ehmke and Mattfeld 2012).

The most common delivery type in the last mile is the Attended Home Delivery (AHD), but this mode lacks flexibility, which means customers have to be waiting at home during certain time periods (Zhang and Lee 2016). Therefore it can still be improved, and is where new Information Technologies can play an important role.

The rise of information and communication technologies (ICT) is bringing new challenges and opportunities to city logistics policies and especially to last-mile delivery process. Smartphones represent the integration of several advanced technologies and are becoming a very powerful tool, which is already available, but not sufficiently exploited.(Letnik, Mencinger, and Bozicnik 2017) That's why it became important to evaluate the possible impact of new information technologies on the last mile to provide guidelines for future research and projects.

2.2. Last-Mile Operative characteristics

According to (Adam Robinson 2017) on his study for, the main metrics and KPI used in the last mile are the following:

Exhibit 2: Main KPI's of the Last-Mile

N	Last Mile Metric	Category
1	On-Time Deliveries	Time
2	Number of Stops	
3	Average Service Time	
4	Cost Per Item, Per Mile, and Per Vehicle	Cost
5	Fuel Consumption Rates	Efficiency
6	Last Mile Vehicle Capacity Used Versus Available	
7	Planned Versus Actual Mileage	
8	Driver Hours In-Motion and Stationary	
9	Customer Complaints	
10	Order Accuracy	
11	Damage Claims	

Source: Own composition -(Adam Robinson 2017)

The KPI and metrics reported on exhibit 2 can be grouped into three main categories, Time, efficiency and cost, which are the most important indicators for any last-mile delivery company, but those three items usually have tradeoff associated to them, and is important to identify which of these can be important factor for technology adoption.

For instance, delivery speed increases, time will reduce, which is good, but efficiency of the last-mile might be subject to decreases.

Improving efficiency has been the focus of much of the academic work on the last-mile (Boyer, Prud, and Chung 2009), which is important since an e-business that can deliver the goods and services at a reasonable cost will have an advantage against slower providers and carriers.

Problems associated with the last-mile are likely to have high supply chain costs (Gevaers, Van De Voorde, and Vanelslander 2011), pollution and city congestion can be reduced by improving efficiency of this stage.

Based on a review of literature, (Winkenbach and Janjevic 2017) highlight five main variables, that are commonly used to characterize last-mile delivery models for e-commerce distribution

- Place of order preparation
- Governance of distribution operations

- Product exchange points.
- Intermediate transshipment.
- Delivery lead time.

Each of those main variables can be related to operative characteristics of the last-mile. Some of these characteristics were proposed as key elements for the last mile by (Gevaers, Van De Voorde, and Vanelslander 2011).

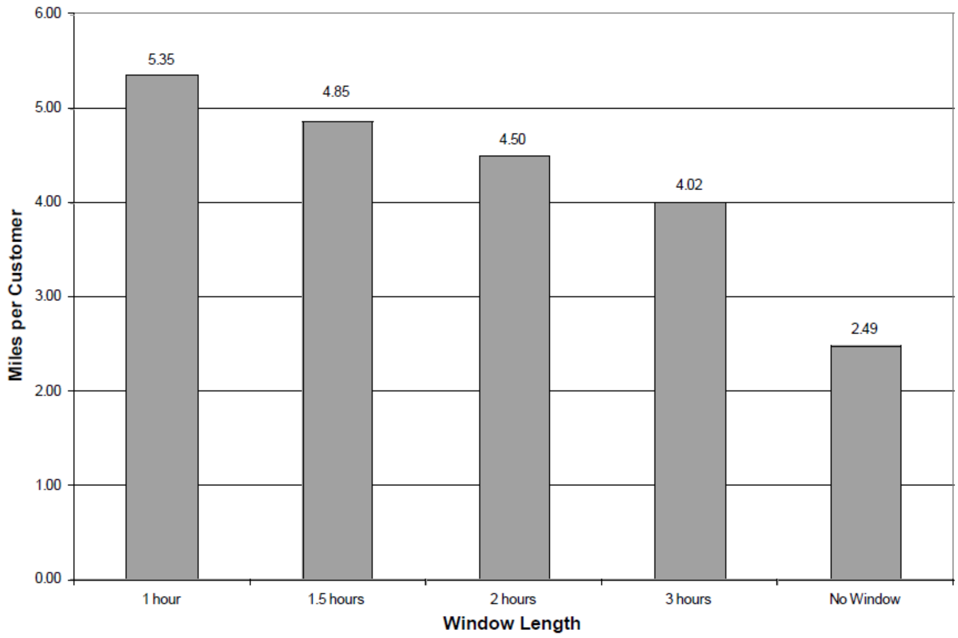
These were selected because each of them was previously studied and plays a critical role in decision making and impact directly on efficiency of the last-mile and environmental impact. Therefore, it’s important to measure the impact of possible disruptive technologies to assess whether this technology will improve overall efficiency or not.

- **Time window:** A time window refers to the span of time in which events (deliveries in this case) might occur.

  Depending on the type of delivery in some cases exist a time window constrain. Occurs when is agreed that delivery (usually at home), will take place in a specific time frame. Delivery window length is important to customers, who want shorter delivery windows, and companies that aim for longer windows that increase efficiency. (Boyer, Prud, and Chung 2009).

  As shown in Exhibit 3, the shorter lengths we have more miles per costumer to deliver, therefore more cost.

Exhibit 3: Effects of Delivery Window Length



Source: (Boyer, Prud, and Chung 2009)

For this variable is important to consider not only the length, of the window but also the moment in time, because is not the same to have the possibility of delivering for one hour when is potentially less traffic or having the same one hour at the moment when streets full of vehicles.

Time window constrains are also related to consumer density and lead to decision such as “In areas where demand is very low, delivery may only be offered on selected days of the week” (Boyer, Hult, and Frohlich 2003)”

- **Route planning:** The routing of vehicles for effective service delivery is an area of critical importance to logistics organizations, and specially in list-mile delivery, combined with other factors such as time windows, it becomes a really challenging problem (Boyer, Prud, and Chung 2009). Any improvements on how the route is calculated or update can mean costs savings for the company.

  Reliable vehicle routing in urban areas requires the consideration of information about:

  - Traffic states.
  - Recurring congestion

  Recurring congestion in city traffic can be provided by time-dependent travel times. In contrast to average travel times or distances, time-dependent travel times allow for the anticipation of typical phenomena in urban traffic and hence result in more reliable delivery tours. Thus, consumer promises can be realized faster and more efficiently. (Ehmke and Mattfeld 2012)

  Three possible outcomes of this variable are considered for the scope of the study:

  - <u>Static</u>: Route is previously defined by some computational tool but is unable to change while deliveries are being made.
  - <u>Dynamic</u>: The designed route previously designs changes depending on the events occurring during the deliveries.
  - <u>None</u>: No computational tool used to aid the route design.

- **Reception mode:** It’s important to evaluate the services provided by the company to make deliveries, these services include, delivery box, collection points, parcel lockers, etc. Implementation of this services can reduce the number of not-at-home deliveries, for expensive goods a signature is no longer needed, because they are secured and can only be retrieved by costumers, can become a collection point for many costumers, therefore the amounts of travels is reduced, decreasing cost (fuel, labor, time) and environmental impact.

  In principle, the delivery can be “attended”, when a signature is needed when receiving the goods or items. Or it can be “unattended” meaning that there is no need of personal receiving. Attended delivery is more secure, but without a previously agreed time window, is possible that nobody is at home at the moment of delivery. (Agatz et al. 2008)

  This variable has four possible values:

  - <u>Locker</u>: If the delivery is left on a parcel locker or box waiting for the customer to retire it at any time.
  - <u>Store</u>: If the costumer customer can go to a pick-up location, could either be a super market, or a store, or a post office. This solution can release customers from time constraints and compensate the inflexibility of Home attended delivery and provide a satisfactory delivery, but requires an investment in

infrastructure and association with key partners such as local stores and markets. (Zhang and Lee 2016)

- Home Attended: Package arrives at the client's home and a signature is needed when receiving the goods. Lacks flexibility, which means customers have to be waiting at home during certain time periods. (Zhang and Lee 2016)
- Home unattended: Arrives to the client's home but there is no need for personal receiving.

- **Length of lead time:** Time between the order and the actual delivery. This characteristic is related with efficiency and the ability of the business to respond to market.

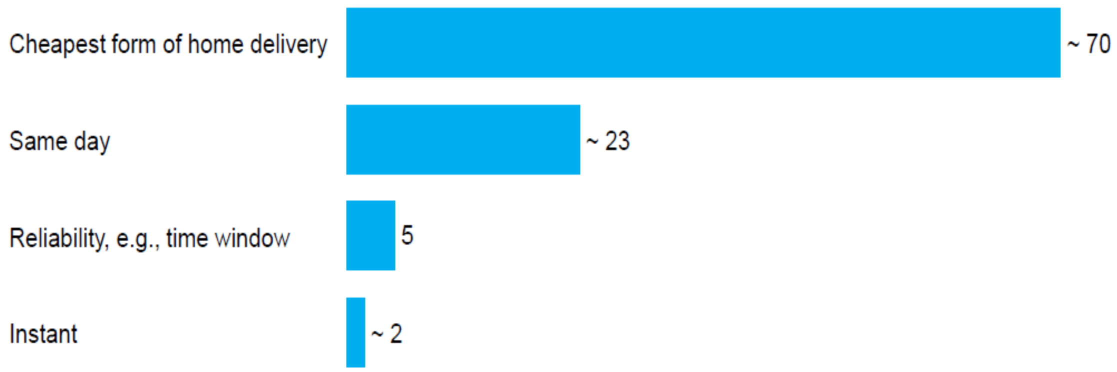
This variable also accounts for other sub-variables directly related to warehousing, such as the place of order preparation, generally shortened if products are held locally and the time and operations need to prepare order, and improvement in this area is translated into an improvement in lead time. (Winkenbach and Janjevic 2017).

The possible values of this variable depend on how long the delivery takes to arrive to the clients after the order is placed, for the purpose of the study, the next time intervals where considered:

- Arrives the same day
- Arrives the next day
- Arrives after 2 or 3 days
- Takes more than 3 days

If one considers the fact that most consumers still chose the cheapest delivery option (Exhibit 4) regarding of the time that will take to arrive, can be sensible to not analyze so many intervals as proposed, but a study made by McKinsey&Company in 2016 on how the parcel delivery might be the future of the last-mile problem, states that Same-day or instant delivery will grow to 20 to 25 in the following years.

Exhibit 4: Share of consumers choosing different delivery options



Source: (Joerss et al. 2016) McKinsey&Company

- **Type of vehicle:** In some cases, an intermediary transshipment is made in the urban area, therefore, two transport stages can be defined, a feeder stage and a last-mile stage. If no intermediary transshipment is made, these two terms refer to the same transport stage (Winkenbach and Janjevic 2017). This variable considers only the vehicle used for last-mile transport, with the following options:
    - Trucks/LCVs
    - Personal vehicles
    - Cargo cycle/bicycle
    - walker/trolley

2.3. Last-Mile Business Models and typologies

In the literature, it is possible to find different types of last miles depending how deliveries are made, or how orders are managed, there are general classifications that can comprehend more sub types of last mile and more specific ones.

- The first main type of last mile is the Urban Last Mile Logistics (ULML), which has to meet the customer requirements, but also needs to consider the characteristics of goods themselves. Accounts for a large proportion of the whole logistics cost due to the city traffic situation, the vehicles used, the labor cost, etc. (Zhang and Lee 2016)

  Urban Last Mile Logistics (ULML) has been taking an increasingly important role alongside the development of e-commerce, this type of last-mile is characterized for two main delivery types (reception modes): (Zhang and Lee 2016)

    - Home Delivery
    - Shared Reception Box(locker, box, stores)

But as mentioned, under this category of last mile is possible to find other typologies.

- **The typology of Boyer, Frohlich & Hult (2005)** is used in some academic papers and articles. This typology divides the last-mile into four sub-types:
    - semi-extended supply chains
    - decoupled supply chains
    - full extended supply chains
    - Centralized supply chains

  This typology is compiled using a matrix format with two variables: order fulfillment and delivery type (exhibit 5)

    - <u>Direct Delivery:</u> Delivery is made directly to the costumers
    - <u>Indirect Delivery:</u> Delivery is made to some intermediate locations or companies before arriving to the costumer

- Stored Based: Orders and processed and delivery from local stores
- Distribution center: Orders and processed and delivery from main distribution centers

Exhibit 5: Typologies of last-mile regarding order fulfillment and delivery mode

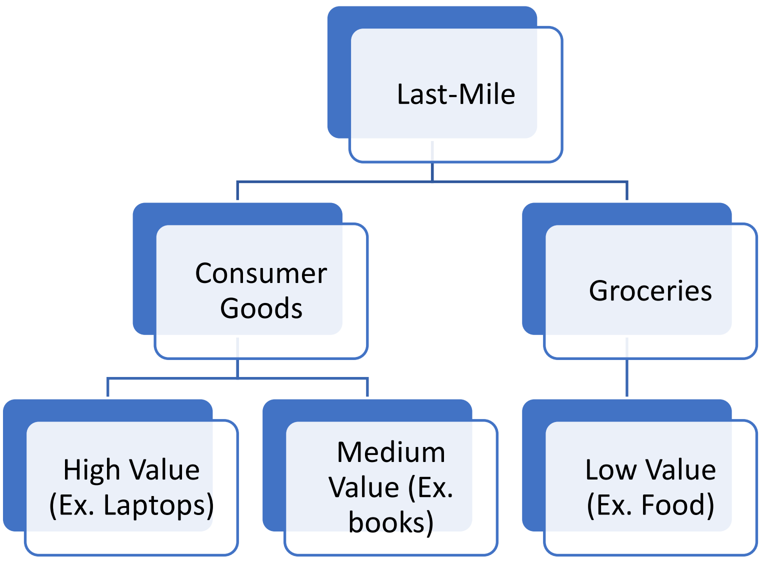
		Order Fulfillment	
		Store Based	**Distribution Center**
Delivery	**Indirect**	Semi-Extended supply chain	Decoupled supply chain
	Direct	Fully extended supply chain	Centralized extended supply chain

Source: Own - Boyer, Frohlich & Hult (2005)

- **Typologies of last-mile depending on product type:** Another typology can be made by subdividing all product flows into three value-based flows:
  - high-value / durable products (such as laptops)
  - Durable goods of medium value (such as DVDs and books), and finally
  - Low value goods (such as groceries or daily consumer goods).

On exhibit 6 is possible to see how the sub flows are categorized according to the relevance of the various sub characteristics or proxy variables.

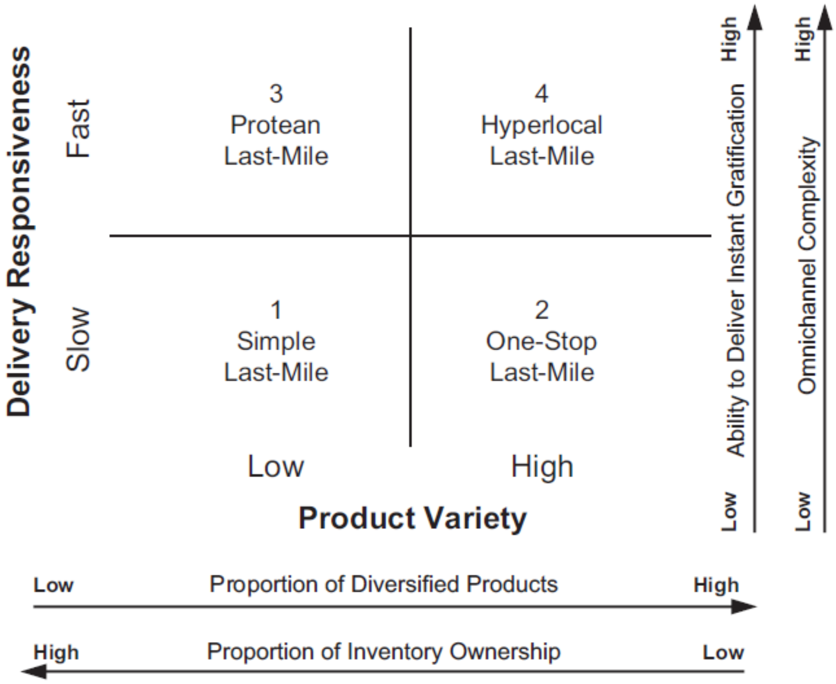
Exhibit 6: Typologies of last-mile depending on product type



Source: (Boyer, Prud, and Chung 2009)

- **The SHOP Model:** is another typology of last-mile distribution, in which, as showed in, exhibit 7, the delivery responsiveness is compared with the offered product variety, is a new last-mile typology proposed in the paper named “Last-Mile Supply Network Distribution in Omnichannel Retailing: A Configuration-Based Typology” written by Stanley Frederick W. T. Lim of the University of Cambridge, the typology is defined by analyzing four possible scenarios for which different business strategies must applied.

Exhibit 7: Typologies of last-mile regarding product variety and delivery responsiveness



Source: “Last-Mile Supply Network Distribution in Omnichannel Retailing: A Configuration-Based Typology” Stanley Frederick W. T.

The proportion of diversified products offered by retailer’s increases and inventory ownership decreases as retailers move along the horizontal axis from low product variety to high product variety. (Lim et al. 2016)

On the vertical axis, retailers moving from slow to fast delivery responsiveness will show greater ability to serve customers with higher immediacy. Delivery responsiveness is a function of how far in advance customers must place their orders in order to receive them prior to the time they are needed. (Lim et al. 2016)

In literature there also different models within the same last-mile type, for instance, (Lierow, Janssen, and D ’incà 2015) In their study on the new frontier for e-commerce, proposed different models for one day delivery, the three models that companies aiming to have one day delivery are:

- **The Courier Network Model:** The business model is based on local fulfillment and superior dispatch software fully integrated into retailers’ existing technology. Retailers can dispatch from point-of-sale through a fleet of local couriers, which usually deliver within two hours, or within a specified one-hour window scheduled by the customer.

This model provides the opportunity for all retail stores in each urban area to become meaningful same-day market players; it is also quick to implement.

The main disadvantage of this model is the need for a real-time overview of inventories across all stores and, also is important to remark that is not all that scalable for lower-cost delivery options. (Lierow, Janssen, and D ’incà 2015)

- **The DIY model**: Large grocery retailers tend to invest in their own delivery fleets, since 3PLs may not have the type of vehicles needed, such as refrigerated trucks. Benefits include end-to-end control of processes (quality, branding, etc.) and the flexibility to adjust to changing customer requirements.

  Disadvantages are that it’s an expensive model, requiring substantial volume to keep down costs, and may be a complex activity to take on outside of a retailer’s core competence. (Lierow, Janssen, and D ’incà 2015)

- **The parcel carrier model:** Several parcel carriers are piloting same-day solutions, with the goal of making delivery more cost efficient, which bundle pick-up and delivery and provide integrated routing. DHL, for example, is offering an evening delivery wave in several German cities where customers can choose a two-hour time slot in the evening for delivery (6–8 PM or 8–10 PM). While currently volumes are small, we expect this model to win mid-term over the courier-based model due to it scalability, cost advantages, and synergy with the existing asset base (delivery vans). This model does require moving beyond a classic hub-and-spoke network and more flexibility in pickup and delivery management.

  With same-day poised to become a de facto standard for retailers of any stripe that want to serve metro areas, careful consideration will be needed as to which delivery model to pursue, and in what timeframe. Smaller multi-channel retailers can get a head start by setting up a courier-based solution right now. This option is particularly attractive if the retailer has a broad network of stores and IT that enables integration with one of the major courier brokers. For most companies, couriers can serve as a bridge until parcel/postal carriers roll out same-day offers. When demand rises, we expect parcel/postal will scale best. The DIY model, from our perspective, will only continue to make sense for very large e-tailers, such as Amazon. (Lierow, Janssen, and D ’incà 2015)

Apart from types of last mile regarding different choices of operative characteristics, the development of technological innovations opens the door for new business models, which are also a way of differentiating different last-mile process.

Following the work done by the united states postal service and the university of Stanford (Hau L et al. 2016), the last-mile delivery business models that either exist today or may be developed in the future, from the perspective of the party arranging for delivery are:

- **Seller-arranged delivery:** The first business model in the last mile, consist in a delivery that is completely arranged by the seller of the goods or service. In this case, after the order is placed, the seller would outsource delivery to a logistic provider that uses its own fleet (UPS, DHL, FedEx, GLS, or local couriers).

A seller may also do the delivery by themselves if they have a network to ship orders. Amazon, the leader using this approach, started employing its own trailer fleet in December 2015 to complement deliveries by partners. (Hau L et al. 2016)

- **Intermediary-arranged delivery**: In this case the delivery is not arrange nether by the costumer or the seller, buts instead an intermediary offer a website or a smartphone application for customers to order goods from various merchants. Once the customer places an order, the intermediary shops for items at local stores and delivers them at a scheduled time, enabling more same-day service. Some intermediaries focus on categories such as groceries or restaurant food (e.g., FoodOra, UberEATS, Rappy). Others deliver a wide variety of products (e.g., Google Express). (Hau L et al. 2016)

  Algorithms for pricing, matching tasks with deliverers, and route optimization, as well as analytics for demand forecast and service rating, enable efficiency and better customer service, and all are performed by the intermediate company, that can benefit from economies of scale. (Hau L et al. 2016)

- **Buyer-arranged pickup:** The final case, covers the opposite to the first one. In the former the costumer let the seller arrange the delivery, and doesn't have the possibility to select specific logistic providers, in this case the costumer must wait the time spent by the seller, and in some cases this time could be high due to the big amount of orders that the seller have. (Hau L et al. 2016)

  To speed up delivery and eliminate shipping costs, consumers may prefer to pick up an online order at the store or arrange collection and delivery with a different firm, such as, crowdsourcing firms that offer peer-to-peer delivery to identify a driver who will go to the store (or to other location) to collect the items and deliver them to the customer. (Hau L et al. 2016)

2.4. Technology adoption model in transportation/supply chain/last-mile

Technology and data are critical factors for all the industries, and the transportation industry is not the exception. From studies, can be seen that technology plays a huge role in the day-to-day operations of freight traffic.

For companies handling larger or routine commercial loads, data is crucial for capacity planning and balancing of loads across vehicles. Technology can also have a role in the vehicles itself, potentially allowing drivers to accept or reject collections, update manifests and query locations.(Bates, Knowles, and Friday 2017).

Supply chains are driven by the customer, and the goal is not only to improve the material flows of a small group of selected suppliers but rather to satisfy the entire supply chain and specially the final consumer (Asare, Brashear-Alejandro, and Kang 2016).

Although the value of B2B technologies has been widely accepted in supply chains, companies are struggling to get their supply chain partners to adopt these technologies, and large numbers of these complex and expensive systems have failed (Asare, Brashear-Alejandro, and Kang 2016).

For instance, while 95 per cent of Fortune 1000 firms implemented EDI[2], only 2 per cent of the remaining US businesses did so even though the largest firms had been aggressively encouraging the adoption of EDI. (Asare, Brashear-Alejandro, and Kang 2016).

The previous example is an indicator that, even though big companies have adopted B2B technologies, very few of them are satisfied with the state of their inter-firm systems, suggesting that substantial barriers exist regarding the adoption and performance of their supply chain technologies.

Studies suggest that IT managers can influence assimilation through their actions, it is unclear which practices and structures can be implemented to facilitate the assimilation of enterprise platforms.(de Mattos and Laurindo 2017) Therefore a more sophisticated adoption model is needed.

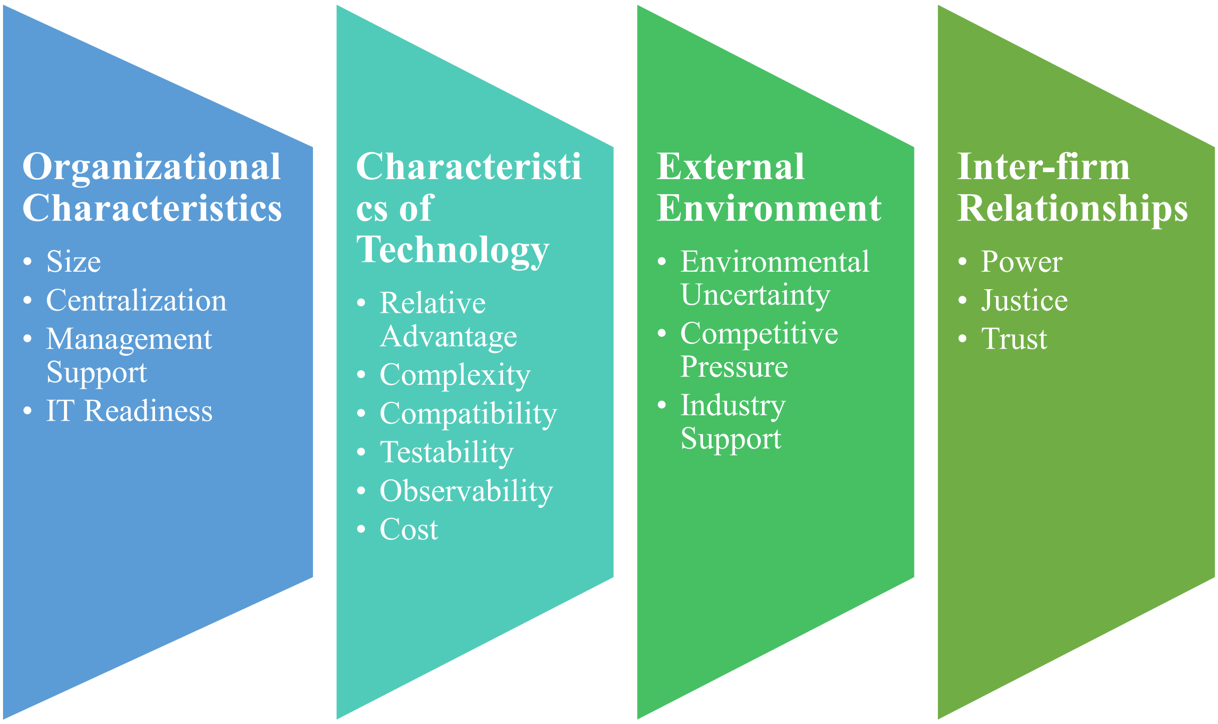
The technology adoption model proposed by (Asare, Brashear-Alejandro, and Kang 2016), states that "perceived usefulness" and "perceived ease of use" are primary determinants of an individual user's attitude toward using technology. According to the model, if individuals perceive a technology to be useful and easy to use, they are likely to have a positive attitude toward the technology and to adopt it.

The Technology adoption for supply chain (TASC) framework, identifies four key determinants of the adoption of inter-firm technologies with their corresponding sub variables (Exhibit 8)

1. Characteristics of technology;
2. Organizational factors;
3. External factors.
4. Inter-firm relationships.

[2] Electronic data interchange (EDI) is the concept of businesses communicating electronically certain information that was traditionally communicated on paper. The two classic examples of such information are purchase orders and invoices

Exhibit 8: TASC Variables



Source: Own Composition - (Asare, Brashear-Alejandro, and Kang 2016)

2.5. Possible disruptive Technologies in the Last-Mile

In this section, it's discussed how the main technological innovations work, what are their potential advantages and limitations and their potential applications in the last-mile business model.

The technologies were chosen by the amount of literature research and applications for each of them, for each technology some case studies and pilots projects are provided to validate the choosing of the technology as a possible industry disruptor.

After a literature review of the technologies, the discussion will be made according to the following topics:

- A summary on how does technology work and its main drivers
- General or global advantages of the technology, either for the last-mil or the global logistics process.
- Possible applications of the technology in the logistic transportation process and real case studies
- Limitations or barriers that might affect the adoption of the technology in the last-mile.

2.5.1. Internet of things

- **Technology overview**

The Internet of Things (IoT) is a recent communication paradigm, in which objects of everyday life, such as, home appliances, surveillance cameras, monitoring sensors, displays, vehicles, and so on, will be equipped with microcontrollers, transceivers for digital communication, and suitable protocol stacks that will make them able to communicate with other devices and with users, becoming an integral part of the Internet by enabling easy access and interaction.(Zanella et al. 2014)

Devices are connected using a set of different technologies, including:

- Wireless local (e.g., Bluetooth, RFID, Wi-Fi)
- Mesh network
- Wide area connections (e.g., 3G, LTE)
- Wired connections

It is predicted that by 2020, the number of IoT devices will grow to 26 billion units, therefore becomes a trend not to ignored, and becomes important to consider it uses in the last-mile industry.

It´s expected that connected devices will produce new types of data. The Internet of Things will help business gain efficiency, improve operations and increase clients' satisfaction. (An Introduction to the Internet of Things (IoT) 2013)

Devices can come from a variety of manufacturers, due to this fact, integrating these devices into a single software system becomes a challenging task. One approach (one of the most used) of achieving such interoperability is to use a Service Oriented Architecture (SOA)-based middleware. In SOA, the capabilities of the devices such as sensing or performing are regarded as services. A SOA-based middleware system may utilize single devices as atomic services or multiple devices as a composite service. (Zanella et al. 2014)

Devices with sensors are connected to a platform, which integrates data from different objects (devices), and applies analytics to get the most valuable information. IoT platforms can detect exactly what information is useful for all the actors in the system.

- **Advantages of the technology**

As mentioned before the benefits and applications of the IoT can change from one industry to another one, but in general terms, according to the research done by "Lopez Research" on generalities of IoT (An Introduction to the Internet of Things (IoT) 2013), the three main general advantages are control, communication and cost savings

- **Control**

  The use of IoT applications, like Radio Frequency Identification (RFID), in several ports in the United States ensures transparency in logistics and helps in efforts to counter terrorism.

- **Communication**

  If we take the case of a last mile courier, all the actors like fleet managers, drivers, retailers and costumers should be able to exchange information in a faster way, allowing them to serve more efficiently under the planed conditions, but also to respond in a better way to unexpected changes

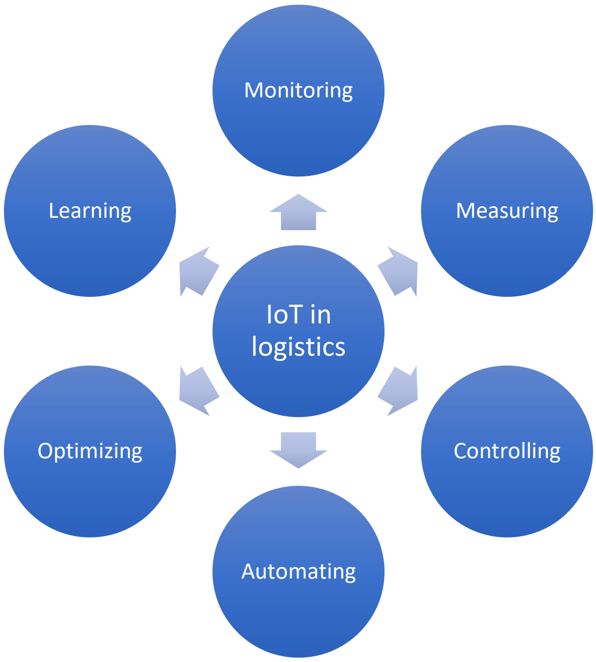
- **Cost Savings**

  IoT technologies for the last mile can helps to reduce costs, and open opportunities to generate more revenue. Couriers can use the IoT, in areas such as vehicle and package tracking, warehouse storage monitoring and vehicle state, by analyzing these areas with accurate data generated the company might spot unused resources or opportunities to improve the process

Regarding the applications of logistic, the 3 main drivers mention above can be subdivided into 6 key areas (Exhibit 9) in which IoT will have great impact, as proposed by (Macaulay, Buckalew, and Chung 2015) in their study regarding IoT applications for logistics:

- Monitor the status of assets, parcels, and people in real time throughout the entire value chain.
- Measure how assets are performing, and change what they are currently doing (and what they will do next).
- Automate business processes to eliminate manual interventions, improve quality and predictability, and reduce costs.
- Optimize how people, systems, and assets work together, and coordinate their activities.
- Apply analytics to the entire logistic chain to identify wider improvement opportunities and best practices.

Exhibit 9: IoT enabled Capabilities



Source: Own composition - (Macaulay, Buckalew, and Chung 2015)

- <u>**Possible real cases applications**</u>

As mentioned in previous sections, the last-mile is a stage of the supply chain that is highly dependent on labor, with logistics providers facing new challenges, due to the number of delivery points is growing and more sophisticated demands from costumers.

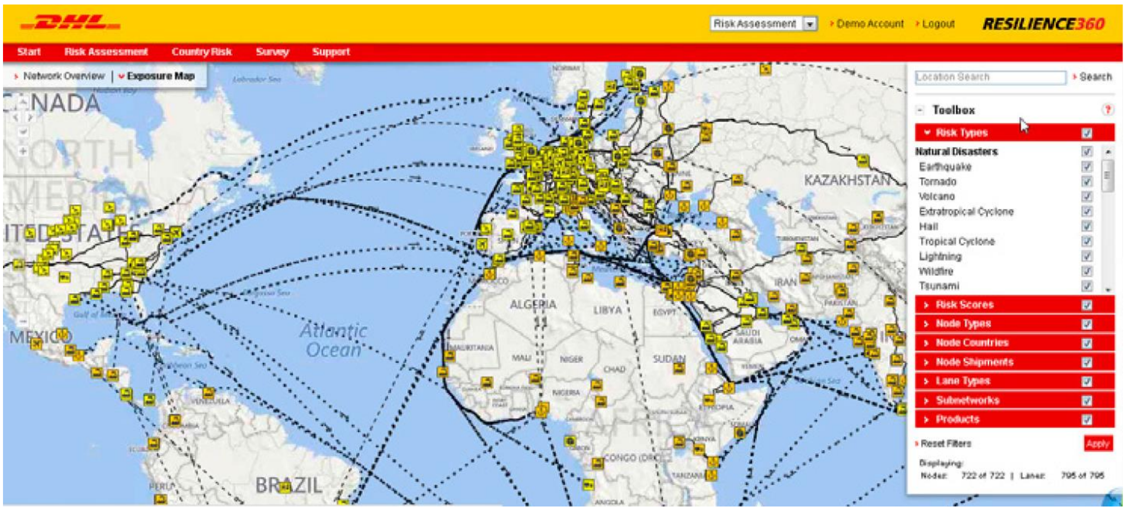
It becomes important to find creative and cost-effective solutions for the last-mile stage, that provide value for the end customer and operational efficiency for the logistics provider. The main case studies of IoT in the last mile, connect the logistics provider with the end recipient and easy the transfer of data, now some main applications of IoT are presented:

- **Application 1: End-to-end supply chain risk management with DHL Resilience360.**

Supply chain risk or vulnerability has emerged as a key challenge to supply chain management (SCM). SCRM is a field of escalating importance which aims to develop approaches to the identification, assessment, analysis and treatment of vulnerable areas and risks in supply chains(Wang, Tiwari, and Chen 2017)

DHL developed an IoT solution called "Resilience360" for supply chain risk management, which provides a multi-tiered visualization of the end-to-end supply chain, including as well last-mile stages.

Exhibit 10: DHL Resilience360 Solution Software



Source: (Macaulay, Buckalew, and Chung 2015)

Any disruptions on a global scale are checked for their effects on key parts of the supply chain; if they entail a strong risk, appropriate mitigation strategies are done automatically. In the future, the tool could integrate all the data transmitted from assets and respond(Macaulay, Buckalew, and Chung 2015), for instance:

- When a truck carrying urgent cargo is about to break down or when a warehouse has been flooded from a storm.
- Move a shipment from air freight to road freight to compensate for an airline strike.
- Adjust city routes due to streets closure of traffic accidents.

All the previous actions can only be completed by a reliable data transmission system incorporating IoT device on the assets of the company. Managing threats such as port strikes, airport closures, and highway closures may not seem like an obvious application at first glance, but analytical capabilities are becoming sophisticated enough not only to predict them, but increasingly to respond.(Macaulay, Buckalew, and Chung 2015)

- **Application 2: Flexible Delivery Address:**

As explained in the previous section, when defining the key variables in the last-mile, the reception mode showed up to be critical in the overall performance of the last-mile, traditional solutions to reduce the number of not-at-home deliveries, are locker and store pickups, which also reduces the amounts of travel by introducing common collection points. (Agatz et al. 2008)

But this still not a complete solution, and still there is a share of consumers that prefer a type of delivery without them going somewhere to pick it up

As a solution to this issue, another IoT possible application in the last-mile appears, having a flexible delivery address.

Many experiments have been conducted to provide more flexible delivery, but one of the key issues has been in matching real-time delivery to the given addresses and time slots in a cost-effective manner for the logistics provider.

With IoT-enabled solutions, tagged parcels offer more visibility to the recipient on when their parcel is expected to arrive and whether a change in address is required — for example, if they are at work. If a delivery is planned during the day, a customer could change the address to that of a neighbor who is home or at a workplace in the vicinity. If it is unclear what a recipient's schedule will be, smarthome products with proximity sensors could sense if the recipient is at home and communicate to the delivery person ahead of time if a delivery is possible. A flexible delivery address service could also be initiated by the logistics provider.(Macaulay, Buckalew, and Chung 2015)

Applying predictive analytics to the recipient's historical mobile device location data (with the recipient's opt-in to the service), the provider could request confirmation of the expected delivery window and location.

- **Limitations of IoT in adoption in last-mile**

According to by (Macaulay, Buckalew, and Chung 2015) is the right moment to leverage logistics with IoT technology, the rising needs of the logistic process match with the features that technology is pushing to the market, as shown in exhibit 11.

Exhibit 11: Convergence of Technology and Logistics Trends

Technology Push	Need for logistic solutions
Mobile computing growing steadily with more mobile phones expected in 2020 than people in the world	High need for transparency and integrity control (right products, at the right time, place, quantity, condition and at the right cost) along the supply chain
Due to the consumerization of IT, sensor technology has become more mature and affordable to be used for industry purposes in logistics	End consumers are asking for detailed shipment tracking to have transparency in real time
With the move towards 5G, wireless communication will reach a new level of maturity connecting everything anytime	Business customers are asking for integrity control especially for sensitive goods
Cloud computing and big data technologies will enable new data-based services	Logistics companies need transparency of networks and assets being used for ongoing optimization of efficiency and network utilization

Source: Own composition - (Macaulay, Buckalew, and Chung 2015)

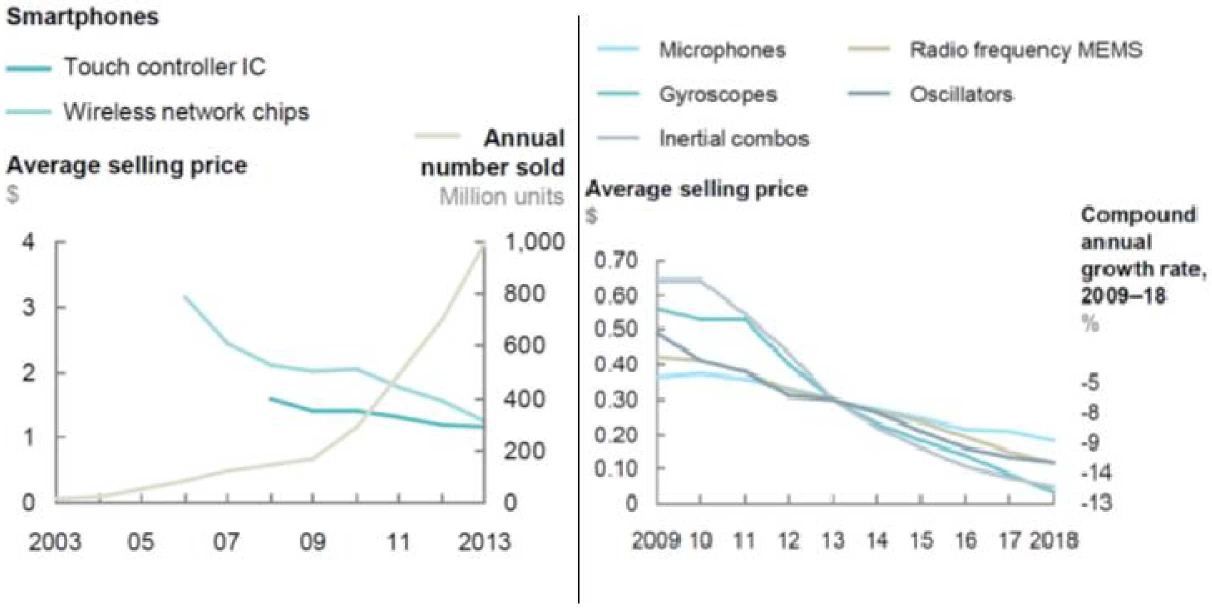
Despite of this, there still some limitations regarding the possible adoption of IoT in logistics and especially in the last-mile.

IoT depends on connectivity and positive networks externalities, the most people uses it, more powerful applications will be. According to (Manyika et al. 2015), to achieve the full potential of the Internet of Things by 2025, technical progress is required in three areas:

- **Improvements in basic infrastructure elements**: The manufacturing cost of the main components must continue to decrease in order to make IoT applications cost-effective. Today many applications are technically feasible, but the high cost of components makes implementation impractical.

  However, there is a trend in cost decrease in MEMS[3], which indicates that somewhere in the future, IoT products can be cost-effective solutions. For example, the cost of semiconductors on a per-transistor basis has fallen by 50 percent in the past three years, while the cost of MEMS sensors has decreased by 35 percent (Exhibit 12).

Exhibit 12: Customer Demand/Price correlation and MEMS Cost change trough years (normalized)



Source: (Manyika et al. 2015)

- **Improvements in software and data analytics:** The real value of IoT applications comes from analyzing vast amounts of data and making decisions based on those data.

  Today, analytics software has not progressed to the point where it can be easily applied in every case—one reason that so much of the data that is collected goes unused. The hard work of developing and tuning these algorithms for the peculiarities of specific use cases is largely still undone, and the skills and capabilities to do this work remain in short supply (Manyika et al. 2015). This might represent a big barrier in the full adoption of IoT technologies, especially in the last-mile context, where applications need to be highly reliable.

- **Technological solutions for interoperability:** As mentioned before, vast amount of data are needed for IoT to deliver quality results, therefore interoperability between different devices and products is needed, mains barriers to interoperability, include the lack of common software interfaces, standard data formats, and common connectivity protocols. One possible way to overcome these barriers is by creating common technology standards, to ease interpretability among products and companies.

[3] Microelectromechanical systems

These three elements correspond to the main barriers that IoT might face if goals are not achieved.

2.5.2. Drones

- **How does the technology works and main issues**

Drones can be simply defined as an unmanned aerial vehicle (UAV), without a human pilot aboard, which development has been improved over the last two decades mainly due to the military applications. This speed growing has given the ability to UAVs not only to support dangerous military missions where pilot operations can be risky but also to be integrated into civil activities. In the group of civil activities is possible to consider personal use for recreation, videos, photos and business use such as last-mile deliveries (Troudi et al. 2017)

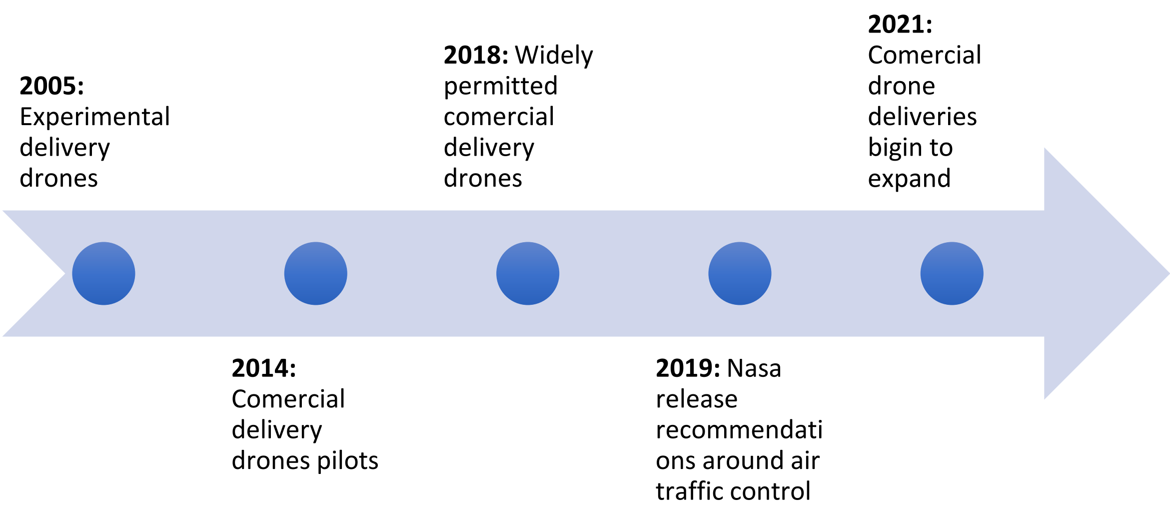
Examples of logistic carriers investing in this technology are:

- DHL with PaketKopter
- Amazon with Amazon PrimeAir
- Google with Project Wing
- GeoPoste with Geodrone.
- Dominos Pizza

Hybrid drones, equipped with propellers and wings, can take off and/or land like a copter and can glide like a plane. This design increases the drone's range for deliveries. Some are designed to lower deliveries on a line, while others are designed to land (Hau L et al. 2016)

Over the past 3 years, the distribution of parcels by drone has attracted a great deal of media attention. Although the use of un-manned autonomous vehicles (UAVs) is tightly constrained by aviation regulations in most developed countries, companies such as Amazon, Google and Matternet are experimenting with this form of aerial logistics. Drones are already being used to deliver medical products in developing countries where surface transport infrastructure is poor and to remote communities in developed countries (Mckinnon 2016)

Exhibit 13: Timeline of drone development



Source: Own composition

In exhibit 13, is shown a timeline with the most important milestones already achieved and predicted in drone delivery, the timeline was constructed with information form the study on disruptive technologies made by Stanford University (Hau L et al. 2016) and the study on drone perception made by the magazine Business Intelligence (Meola 2017).

In 2005 the Companies such as Amazon, Google, UPS, DHL, and others start to test the first drone prototypes for efficient delivery, although the technology was not diffused as was not as famous as today, but was not until 2014 when DHL launched its first commercial drone delivery for the German island of Juist in 2014, and Flirtey ran the first legal drone delivery for bottled water, food, and a first-aid kit in the United States on July 17, 2015. In 2015 Amazon received FAA[4]approval for research and development for drone delivery in 2015, and is estimated that in 2018 around 7,500 commercial drones will obtain permits to operate.

The NASA, plans to release recommendations on air traffic regulations and is expected that by 2021 drones' delivery are widely used and standardized. As CEO of Amazon Jeff Bezos said: "One day seeing Amazon drones will be as common as seeing a mail truck".

The flight time of a drone depend on its weight, and weight of the cargo, and the energy stored in its battery. When optimizing deliveries, a model in which the energy consumption is considered as a function of total weight, can be used to compare the energy consumed by alternative routes and types of drones. (Dorling et al. 2017).

The capability of drones to deliver parcels has been proven in numerous trials, main cases and characteristics are:

- The optocopter developed by Amazon's 'Prime Air' division can carry packages weighing up to 2.3 kg a maximum distance of 16 km and then return empty.

This payload limit may seem relatively low, though as four out of five of Amazon's online orders are for products weighing less than 2.3 kg, the potential could exist for a substantial switch from van to drone delivery. Such a switch would be driven by a desire to accelerate the last mile delivery and gain a transit time advantage over retailers using more conventional, surface-based transport modes. (Mckinnon 2016).

The previous theories, can be interpreted as a sign that, rather than replacing standard delivery methods, drones can be used for urgent deliveries in areas that are geo-graphically difficult to access, suggesting more of a rural than urban role for them.

- **Advantages of the technology**

Drones are not constrained by road infrastructure and congestion, they can deliver packages faster than a car/truck from a close-by storage location. Furthermore, drones can traverse difficult terrain, take a much shorter route. Similarly, drones can easily fly over water or rural areas with poor infrastructure to deliver a package. (Hau L et al. 2016).

One of the main advantages of drones is related to emergency deliveries of medication and other urgently needed items and deliveries to remote locations, in which the time is more important and urgent than the cost.

Some examples are DHL's delivery service to the island of Juist, Matternet running drone deliveries of medical supplies and specimens in collaboration with Swiss WorldCargo and Swiss Post.

[4] Federal Aviation Administration

Chinese retailer JD.com, looking for ways to reach consumers in the country's vast rural interior, started testing drone deliveries to the remote countryside, similar to what is done by the Italian startup Flying basket in the Bolzano region.

Given the previous observations, drones can provide a cost advantage solutions due the fact that this kind of deliveries to remote locations represent an expensive component of standard delivery networks, and they may also require a non-standard infrastructure tailored to regional specifics. (Hau L et al. 2016).

- **Limitations of Drones adoption in last-mile**

The main limitations in drones adoption are related with the inability to cope with current logistics trade off and the security issues and regulations, the main barriers in drones adoption according to (Mckinnon 2016) are:

- **Product Availability vs Inventory Cost:** One of the main trade off in logistics is offering a 100% product availability and the high cost that having huge inventory entails, therefore companies try to balance these to variables, one way of doing so is by creating large distribution center and taking advantage of the square root law (Maister, 1976), which states that, by centralizing the demand and the inventory, companies will reduce the total amount of inventory required to maintain a given level of product availability.

  Usually companies using the mentioned above model, serve areas within hundreds of kilometers, which hardly can cooperate with the limited range of drone deliveries, which suggest the drone solution is not feasible

  Therefore, online retailers would have to develop a new network of local stockholding points, involving alliances with local retailers with the required storage capacity available.

- **Cargo capacity of drones' vs vans**: Drones can only carry one package at the time, been this a main limitation compared to vans which can carry several packages in the same shipment, the high drone–van substitution ratio would also be reflected in much higher costs per parcel-km.

  When considering also the additional inventory and property costs, drone delivery is likely to prove an expensive option. Premium rates that would have to be charged to cover operation cost might restrict aerial delivery to a market segment of wealthier consumers.

- **Reception facilities for drones:** Most of the actual advertisement of drone deliveries are made, showing the drone that gracefully and peacefully lands on the front garden of a house or in an open space, but, this is harder than it seems.

  To solve this issue, it might be necessary to install 'landing stations', to minimize the risk of damage and injury. This creates a new issue regarding if a householder would have to receive drone deliveries to justify an investment in such a facility, and lead to think that few households are be prepared to invest in drone landing pads. Due to the extra cost it will entail.

- **Security an integrity:** The main risk can be divided into two categories, the former one been the risk to the drone and the company itself and the later been the risk to the people and pedestrians. Risk to the drone include:

  - Drones might crash due to bad weather

- Interception of drones and theft of the cargo
- Vandalism and use of drones as targets for shooting practice

These risks could be minimized by suspending deliveries during periods of stormy weather and restricting their movements to safer neighborhoods and routes, though at the expense of reliability and market coverage.

Risks to the public include:

- Malfunctioning drones crashing onto people and property
- hacking of drone control systems and drone hijacking for malicious

2.5.3. Block Chain

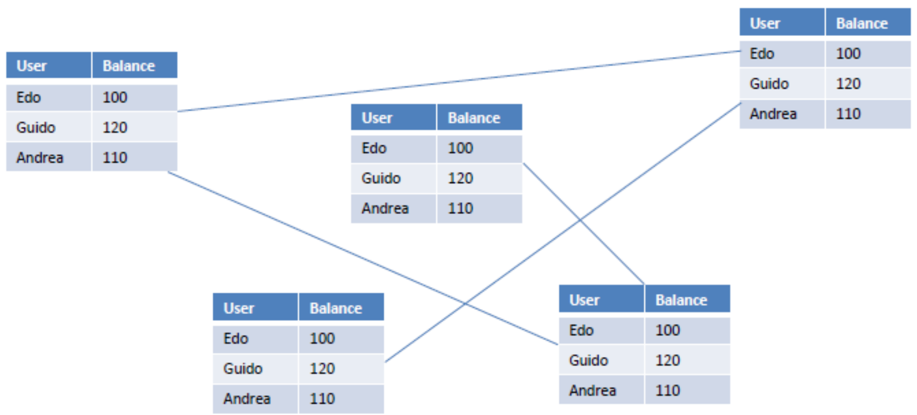
- **<u>How does it work</u>**

Historically, when it comes to assets transactions, people and businesses have relied on intermediaries like banks or governments to ensure trust and certainty. Distributed ledger technologies (mainly Blockchain) are aiming to disrupt this paradigm and allow individuals to perform transactions without an intermediate.

A distributed ledger can be defined as a commonly agreed, replicated (repeated), shared, and synchronized digital set of transactions geographically spread across multiple places (cities, countries, sites, institutions). In order to work properly a block network is required as well as hash algorithms, to ensure replication of transactions across the network is done correctly.

Blockchain is a type of distributed ledger or decentralized database that keeps records of digital transactions (Exhibit 14). Rather than having a central administrator like a traditional database, (think banks, governments & accountants), a distributed ledger has a network of replicated databases, synchronized via the internet and visible to anyone within the network. Blockchain networks can be private with restricted membership similar to an intranet, or public, like the Internet, accessible to any person in the world.

Exhibit 14: Blockchain graphic representation



Source: Distributed Ledger Technologies Seminar – Instituto superiore Mario Boella, Politecnico di Torino-26/07/2017

Many believe Blockchain will be as impactful as the Internet. Originally built as the infrastructure underlying Bitcoin, now many researchers and companies see the different applications of Blockchain technology that beyond currencies and financial markets. Blockchain technology can influence artificial intelligence, computers and technology in general. (Kakavand, Kost De Sevres, and Chilton 2017)

It is important to consider the technical concepts of blockchain to understand all the possible variations the technology might have, with respect to regulation, security, performance and privacy. Blockchain is not a single solution applied to a single technology or field, instead, is a there are a variety of different technologies based on Blockchain that were developed to solve various problems. Thus, for different needs there are different available technologies. (Kakavand, Kost De Sevres, and Chilton 2017)

Some of the main characteristics of Blockchain are:

- Transactions in one node trigger a corresponding variation in the ledger of every node.
- All transactions are linked to each other.
- Inputs must equalize outputs.
- There is a sender and a recipient
- Transactions must be made by the sender and it has to be verified that the sender has the right balance of assets to execute the transaction.

Identity verification is made with the public key to certify that transaction was made with the corresponding private key.

Asset verification is made not by the usual account balance, but is made by calculating all the past transactions, no date is stored but instead are continuously calculated.

Fundamental technical concepts of Blockchain technology are the following according to (Kakavand, Kost De Sevres, and Chilton 2017) and to the information gathered on the Distributed Ledger Technologies Seminar made in *Instituto superiore Mario Boella, Politecnico di Torino* on 26/07/2017

- **Node**: Any computer connected to the Blockchain network, with the special software that maintains a Blockchain, is called a node. Nodes receive and submit transactions.
- **Network**: All nodes that run Blockchain software to communicate with each other create the blockchain network
- **Smart contract:** Smart contracts are computer protocols that facilitate, verify and enforce the negotiation or performance of a contract.

  To develop a smart contract, the terms are coded and uploaded to the Blockchain network, producing a decentralized smart contract that does not rely on a third party for recordkeeping or enforcement.

  Contractual clauses are automatically executed when pre-programed conditions are satisfied.

  In a more general context smart contracts can be programmed to execute a number of actions based on pre-defined rules and conditions, for example the timing of transaction execution or a response when a variable arrives to a determinate value

- **Transaction Validation:** All transactions are cryptographically validated by the nodes on the Blockchain network. Invalid transactions are ignored.
- **Block:** It is a group of transactions collected by nodes. To be valid blocks must be formed according to pre-determined set of rules: They must not exceed a maximum size in bytes, contain more than a maximum number of transactions, and must reference to the most recent valid block.
- **Consensus:** It is an agreement of all nodes in the Blockchain. To enable distributed system operation, multiple processes cooperate with each other. Faults in such systems can occur anywhere, which is why they use consensus protocols.

- **<u>Advantages of the technology</u>**

Blockchain technologies have been widely studies, and even though its main purpose is to financial applications, this technology is accepted also to disrupt many other industries, such as in this specific case, logistics and transportation.

As a digital payment framework, blockchain has some advantages over existing electronic frameworks for data sharing and securing such as: (Pradip, Seo Yeon, and Jong Hyuk 2017)

- **Transparency:** All blockchain network exchanges are cleared in the blockchain, which means a total, verifiable and unchanging record of any action exists.
- **No risk of fraud:** When sent and deleted, a blockchain exchange cannot be canceled by the sender.
- **Low or no exchange costs:** The organization of the blockchain network is sponsored by the procedure of creation of the treasury. Thus, exchanges on the blockchain network can be sent for a small or no exchange fee. Also, there is no cost to get to the blockchain network.
- **Transactions almost instantaneous:** Exchanges of blockchain networks immediately register. Affirmation and compensation for these exchanges can occur in minutes to more than 60 minutes. In traditional payment systems, compensation takes much longer.
- **Network security:** The blockchain network itself is exceptionally secure thanks to the use of cryptographic and decentralized blockchain conventions. Individuals in general of the private key sets used to provide adequate security against the danger of a wild constraint hack or the inadvertent appearance of two clients producing a similar private key. Moreover, there is no single goal, combined with disappointment, which limits the vulnerability of the blockchain network to downtime and piracy.

These characteristics are related with the characteristics of the last-mile mentioned in the previous section, and could be translated into a more secure environment protecting client's information and less operation lead times due to shorter verification.

- **<u>Possible applications</u>**

In this section, some applications of the blockchain technology in logistics and last-mile delivery are presented.

- **Application 1: Logistics and transportation solution built on IBM Blockchain and Watson IoT**

  AOS is a Colombian company specializing in providing business solutions. The company is developing a solution built on IBM Blockchain and Watson IoT on the IBM Cloud, to increase efficiency in the logistics and transport industry in Colombia.

  Traditionally, supply chain transactions, in all its phases, are completed manually, creating delays and a higher risk for recording error, which can cause differences between what was recorded and what was loaded. By digitizing this process using blockchain and IoT, the relevant information is captured directly from the sensors placed on the trucks, and entered onto the blockchain, creating a single, shared repository that all authorized participants can access and which can only be altered with consensus from all parties.

  The solution is built with IBM Blockchain and IBM Watson, can be used to track the status of trucks and their goods, the solution records the handling of transactions and information on cargoes to create greater transparency in the delivery process

  With the solution, once the truck leaves the distribution point, an automatic message is sent to the customer, informing them about the load, weight and estimated time of arrival. If part of the delivery is returned, the invoicing can be automated depending on the actual load delivered. Also, through the sensors located on the trucks, an information repository is generated using IoT and blockchain, which tracks all the exchanges, stops and transactions made by each truck and its respective load, from the distribution point to the final customer. This heightened level of transparency can help increase accountability between shippers and their customers, promoting the flow of business.

  The new solution also integrates a designed monitor, connected to the internet, to show what is happening with the trucks. For instance, captures the input and output weight to define available capacity as well as in which silo and which person will carry the load; and that data is also correlated to external information, such as weather, humidity, temperature and driver's data, to estimate delivery time to customers.

  One of the biggest challenges in the logistics and transportation industry is the protection of its assets and cargoes, as the correct monitoring and tracking of all transactions involving such charges (Jorge Vergara, IBM Colombia CTO). This is as well, an important feature of the last-mile and the same principle might be applied, which might lead to innovative new solutions for the last-mile distribution with the same basis as the one just explained.

- **Application 2: Port of Antwerp(Belgium) Tests Blockchain Software System**

  Europe's second largest container port, Antwerp, is introducing a blockchain pilot which can release containers faster as well as more securely and efficiently. Technology will affect in many processes which involve:

  - Shippers
  - Carriers
  - Terminals
  - Forwarders
  - Drivers

According to the Port of Antwerp, getting a container from point A to point B often involves more than 30 parties and 200 interactions. Given that many of these transactions are still carried out by e-mail, phone and fax, paperwork accounts for up to half of the cost of container transport.

A Belgian software startup, called T-Mining, has developed a solution for a specific data handling problem at the Port of Antwerp: when a container arrives today, it is collected from the terminal in Antwerp by a truck, who is in possession of a PIN code. The PIN code is transmitted through a few parties, creating the risk of theft or fraud.

The risk of fraud in the previously described process can be similar to the system for real estate transactions, reason why a blockchain solution initially intended for real transactions can be applied.

By using blockchain protocols are used for the transfer of data, no intermediary is required. With the blockchain platform the right truck driver is given clearance to collect a particular container, without any possibility of the process being intercepted, it uses a distributed network, so that the transaction is accepted only when there is consensus among all participating parties, excluding any attempts at fraud or undesired manipulations

A pilot project is currently running in the port of Antwerp with a limited number of parties.

- **<u>Limitations for the adoption of blockchain in the last-mile</u>**

  Blockchain solutions for the shipping industry will start by competing among them and with existing technologies, but if every customer and shipper has to work with multiple different blockchains, which don't interoperate they will, quite reasonably, resist and the overall efficiency will be reduced. According to Charles Brett, business analyst and consultant, in the following years is expected to:

  - Show that blockchain technology can deliver
  - Demonstrate that multiple, incompatible blockchains might fail and instead of achieving cost reduction and competitive advantage, will have the opposite effect.
  - Open the debate about what 'hybrid-blockchain' means and how it might work

3. Methodology

Research needs to be designed and guided by a plan to make it follow the objective. The most significant decision is the choice of research approach, since the research design determines how the information will be obtained.

The methodological approach of this thesis is the case study. The aim is to evaluate different innovative delivery alternatives, taking into account different factors like cost, time consumed, order quantity and current state of the technology. The final objective is to find out how logistics and last-mile performance would be affected by these innovative solutions.

After explaining all the relevant information found in literature in the previous section is important to explain the methodology used for the development of this case study.

A last-mile typology will provide a theoretical framework trough which data are structured, and results are drawn, in order to have a clearer perspective of advantages, disadvantages and the impact each of the analyzed technologies will have on the last mile.

The typology of last-mile distribution is generated by fitting the ones existing in the literature with the purpose of this work. In particular, the typology includes the operative characteristics and business model types that are more affected by the selected technologies

Then, interviews with directors of two start-ups that are innovating on the field of last-mile and logistics are conducted and the case study will focus on explaining the experience of these two companies and how their experience might be generalized to the industry.

A final interview with a 3PL company was conducted to gather insights on how the technology impacts companies, to have and opinion from a different stakeholder (not only entrepreneurs) and to validate if the two case studies analyzed are, in fact, applicable to the current needs of the industry.

Interviews were recorded, transcribed and coded. The aim of the coding process is to structure the data according to the objective of the thesis, which is twofold. First, to confirm, refute or expand the literature on the main barriers and advantages of the selected technologies in terms of last-mile application. Second, to explore the potential impact of such technologies on the last-mile. To this end, data from the interviews are triangulate with existing literature and categorized based on the theoretical framework depicting the last-mile typologies.

Afterwards, an analysis of the findings is performed, to adress the main barriers and advantages of main technologies

Then, the impact of the technologies on each type of last-mile, following the theoretical framework, is assessed

Finally, the thesis will present an estimate about the future development of these two logistics solutions (comprehending three main technologies), and possible business modalities.

3.1. Theoretical Framework

As mentioned on of the objectives of this thesis is to assess the impact of the technologies on each type of last-mile, the approach on how the matrix will be constructed is show in exhibit 15, by combining and relating findings on literature and interviews, regarding different key operative characteristics of the last mile and the different technologies characteristics, advantage and barriers a final verdict on the impact of each technology in each type of last mile can be assessed.

Exhibit 15: Work framework on constructing final matrix

	Op Characteristic 1	Op Characteristic 2	Op Characteristic 3
Tech 1	x	x	x
Tech 2	x	x	x
Tech 3	x	x	x

	Op Characteristic 1	Op Characteristic 2	Op Characteristic 3
Type 1	y	y	y
Type 2	y	y	y
Type 3	y	y	y
Type 4	y	y	y

	Tech 1	Tech 2	Tech 3
Type 1	x+y	x+y	x+y
Type 2	x+y	x+y	x+y
Type 3	x+y	x+y	x+y
Type 4	x+y	x+y	x+y

Source: Own composition

All the typologies presented in the literature review can be used to devise business strategies or possible targets to improve efficiency of the last mile, but most of couriers' companies belong to more than one of these classifications, due to the diversity of the market and the need to serve it,

For instance, given that nowadays postal couriers and delivery companies, often a wider range of types of shipment, the same company can cover all types of products categories mentioned in the first category proposed in the earlier section, and companies can be in some or all the segments of products, therefore, a classification by product type might not be good enough.

The study focusses on technology adoption, and given that all technologies can improve globally the last-mile, the adoption of a technology might make that a company currently in one category of last-mile, will start to operate in another, therefore to remain in the scope of this work is better to analyze the effects of possible new technologies for the most common business models used in the last-mile, related to how the business is managed and develop and not by the current performance and responsiveness, the idea of the technology is to improve those items.

Due to the existing trend of companies of having price discrimination strategies, where you can pay higher prices for faster deliveries, or pay less for regular services, also the categories mentioned in the second classification proposed can be all contained within the same company and will not be accurate to evaluate the effect of technologies for each of those types, because they are comprised in the same company offer.

Therefore, the business models classification proposed in the study conducted by the United States Postal Service(USPS) and the University of Stanford (Hau L et al. 2016), where the typology of last-mile is based on who arranged the delivery, is going to be used as the framework to evaluate the advantages and disadvantages of each technology and define for which business models' technologies can be more effective, but it will be discriminated in each type rather than value of the product, the size and weight. Elements of the typology defined by Boyer, Frohlich & Hult (2005) will also be taken into account:

- **Type 1:** Seller-arranged delivery, wide range of products sizes, and either direct or indirect delivery, with distribution centers
- **Type 2:** Intermediary-arranged delivery, wide range of products sizes, direct delivery.
- **Type 3:** Buyer-arranged pickup, wide range of product sizes, direct or indirect delivery with stores based distribution
- **Type 4:** Any kind of arrangements for pickup and delivery but only small products

Evaluation of the selected technologies will be made considering these four types of last-mile.

3.2. Case Study Development

3.2.1. Sampling

3.2.1.1. AOS

AOS is a Colombian company specializing in providing business solutions, currently they are collaborating to create a solution to enhance efficiency in the logistics and transport industry, built on IBM Blockchain and Watson IoT on the IBM Cloud.

They have been working on robotics and automation for 7 years, and know their new challenge is to bring process automation and control to the cloud.

AOS is one of the few cases of companies implementing blockchain solutions to solve the last-mile problem, because as stated before this technology is usually associated with financial applications, reason why AOS becomes an interesting study subject whose expertise will give clear data to the research.

Blockchain is an open source program, big enterprises such as Microsoft and IBM are starting to develop more intuitive solutions for the use of the technology that usually come with an associated cost, even though blockchain is an open source code, the implementation and user interface are costly. Reason why for AOS the most important resources are their technical know-how.

The interview was conducted to Ricardo Buitrago, director of innovation of AOS Company.

3.2.1.2. FlyingBasket

The second interview of this study was made to Moritz Moroder, Accountable Manager of FlyingBasket.

Flying basket is a startup that becomes an interesting study subject, due to its researching and development of innovative ways of making shipment and deliveries in hard to reach locations in the mountains of the Bolzano region in Italy, the idea was born from the necessity to serve the market niche at a lower cost.

At the moment, for those locations, deliveries are made on specific dates by a helicopter that aggregate most of the demand, but still an expensive service, due to maintenance cost of the helicopter (and cost of the helicopter itself), pilot wage and fuel.

Is important to clarify FlyingBasket is not a carrier company, their focus is the development of an innovative drone (multicopter) with real live applications, to test their product they decided to serve this market, but is not their main purpose, and might therefore shift to different market in order to find more applications for their product, which is its main asset along with the know-how of members.

The vehicle(drone) is entirely design by FlyingBasket, some components are bought and other are complete develop by them, manufacture is developed in partner with providers, the need to entirely develop most of the drone, is due to the fact that current market standards are not enough for the needs there are trying to serve.

Company is aiming on developing an autonomous multicopter with weight 50kg that can carry a package up to 100kg, current drones are far away from these measures. Previous fact completely changes the business model and industry standards in which drone cargo capacity was very limited.

3.2.1.3. TDM Transports (3PL)

With the 53% of global transport operations and 40% of warehouse operations carried by 3PL (Langley and Capgemini Consulting 2017), it was important to conduct an interview to a 3PL company to know their opinion on possible technologies to be adopted in the last mile

TDM transport is a third party logistic provider that offers service of warehouse and transportation in south America with main base in Colombia, the interview was conducted to Juan Esteban Calle, the operations research director of TDM Transportes,

TDM is not directly performing a technology implementation in the last-mile, but is important to interview them as a mean for gathering information on the real industry of how useful technologies can be applied

TDM Transportes is a logistic company, that offers transportation and warehouse services, the main activities performed by the company are:

- National Distribution
- Bulk cargo transport Solid
- Transportation of Liquids
- Transport of Dangerous Goods
- Extra-large cargo transport
- Consolidation and Deconsolidation of cargo
- Transportation of Imports and Exports

The company main focus is on how to improve the internal supply chain of the company, which is focused on long distance deliveries and in last-mile logistics to deliver to the end costumers.

TDM is characterized for being a company constantly innovating and adding new technologies to provide value to their customers. Within the main technologies implemented by them is possible to highlight:

- Software for loading trucks, which tells how to position the merchandise inside to take advantage of the space and improve the vehicle usage.
- Satellite tracking systems for vehicles and a platform for our customer service team to monitor the status of the cargo.
- Software for demand forecasts to dimension the fleet and know how many resources are needed and how much have to be invested in extra capacity, the software processes all the information and help the company to make better decisions.

TDM is currently working on a mobile application for the drivers, so they can report the status of their shipments, such as arrival, upload, download, start and end of travel, emergency stops etc., also so they can report any news or unexpected situations and ask for extra money, when needed, to deal with emergencies, and have a general traceability of the transport process.

The TDM efforts on adopting new technologies, complies with the results on the 2017 21st Annual Third-Party Logistics Study, in (Langley and Capgemini Consulting 2017), are shown the most important technologies for 3PL in order to remain competitive, the percentage shown in the figure are the answers to the question: “which information technologies, systems or tools must a 3PL have to serve a customer successfully”.

All the previous facts and the necessity of interviewing also TDM comes from the fact that is important to have opinion from different stakeholders and not only the entrepreneurs made of TDM an important study subject for the study.

3.2.2. Data Collection

3.2.2.1. Questionnaire

After explaining to the interviewees the objectives and scope of the study, the following questions (Exhibit 16), were made, is important that interviews were conducted as a conversation, therefore the order of the question might vary or in some cases when a question was made the interviewee answered in an extensive way, providing answer to following question that were no longer necessary to be made.

Exhibit 16: Interview Questions

Question
1. How the startup/idea was born
2. Description of the service/product
3. Advantages of the technology and added value proposition
3.1. Which key resources and activities are needed for your business model? Do they provide significant competitive advantage?
4. Business model and barriers of the service
4.1. What are the main issues that your company faced/is facing/will face? (Intervene with some of the barriers retrieved from literature, e.g. safety concerns, capability of the matching algorithm, installed base)
4.2. Witch are the main clients and users, who pay for the service
4.3. Is the service expensive to develop? Is it necessary to build them in an exclusive way or could they be developed in partnership?
4.4. Who are your key partners? How do they help you overcome the existing problems?
4.5. Critical mass(diffusion) to profit

3.2.2.2. Data Summary

The data for the developing of the case study and the analysis was partially shown in the literature review section, in exhibit 17, is a summary of all data sources used in the analysis and conclusions.

Exhibit 17: data Summary

Data inventory		
Data Type	**Quantity**	**Original Data Source**
Scientific and academic Articles	50 articles PDF Format	Academic Data Base
Company research and publications	7 Documents PDF format	Company Website
Interviews	1st interview duration is 22min 2nd interview 16min 3rd interview 31min	Skype Call, experts found trough company website contacts.

3.2.3. Data Analysis

First, a detailed description of the technology application in terms of performance, usability and main advantages is depicted by means of interviews and company publications.

Then, triangulation between the data retrieved from the interview and the literature review on the technologies will be performed in order to provide a first viewpoint on the potential impact of new technologies on the last-mile, and their uptake with potential advantages and disadvantages

Finally, a proposal on the types of last-mile that are most affected by the technologies is developed by integrating the findings from the triangulation with the theoretical framework.

As a path for achieving this final goal before making final relationship, a matrix relating findings to each operative characteristic previously defined is performed.

4. Results

In this section the main results of the analysis of the Interviews performed to the field experts and the findings of literature are presented and at the end in section 4.4 a summary of the results is presented structuring the information in a matrix relating the main advantages and barriers each technology present and how can barriers be overcome.

4.1. IoT

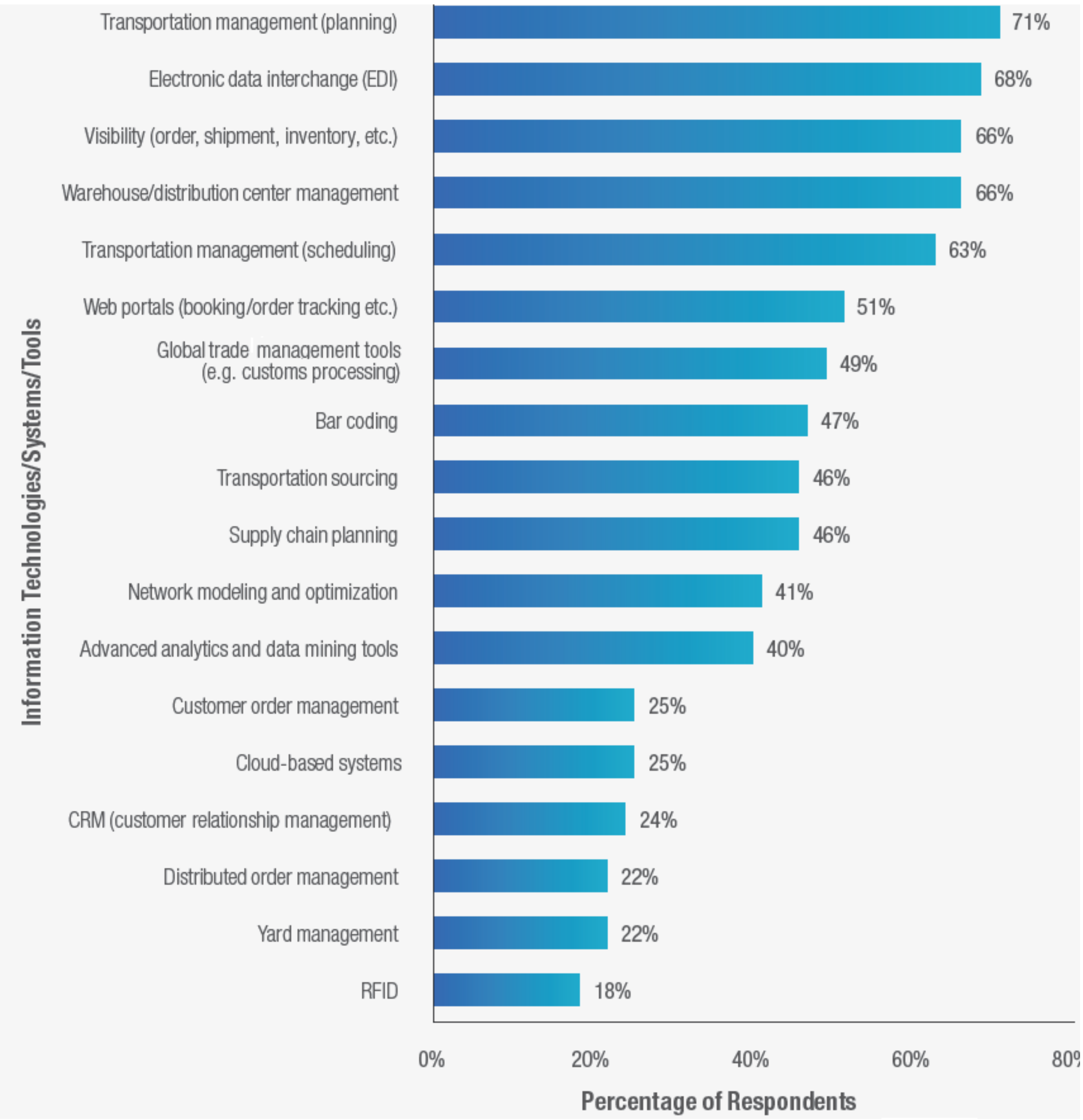
According to the research done by "Lopez Research" on generalities of IoT (An Introduction to the Internet of Things (IoT) 2013), the three main general advantages are control, communication and cost savings, making IoT a desirable technology to be correctly implemented and used by companies

The 2017 21st Annual Third-Party Logistics Study, made a list of the needed IT-Based Capabilities by 3PLs (Exhibit 18)

The technologies shown in exhibit 18 are all highly related to IoT, because they provide advance analytics, process optimization and ease supply chain planning, therefore the result of the report can be a good indicator that the studied technologies might in fact be adopted in the near future.

Apply analytics to the entire logistic chain to identify wider improvement opportunities and best practices for the business is key to success on the last-mile industry and in logistics in general (An Introduction to the Internet of Things (IoT) 2013). IoT solutions, like the ones presented by AOS can give complete analytics' calculations and process KPI allow to a better decision-making process, by knowing exactly which part of the process needs to be improved.

Exhibit 18: Needed IT-Based Capabilities by 3PLs

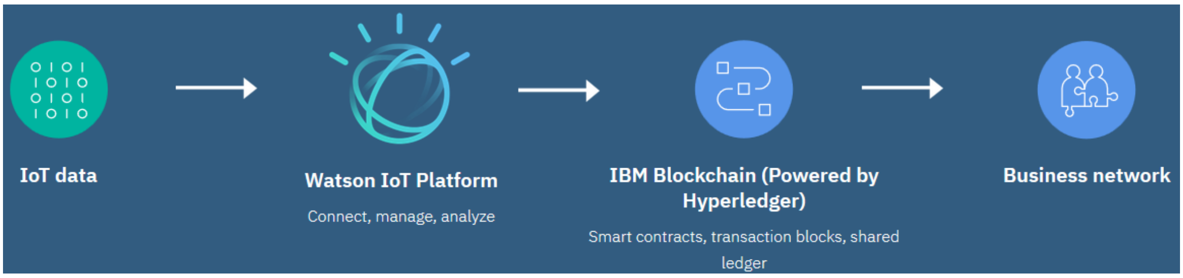


Source: (Langley and Capgemini Consulting 2017)

One of the main limitations of IoT is the fact that software and data analytics have to be correctly processed (Manyika et al. 2015), This is usually not an easy task and the full potential of the technology might be loosed in the process.

Previous limitation can be overcome using a similar approach as the one AOS used, by making a partnership with important software companies (like IBM) is possible to implement the IoT-Watson platform (Exhibit 19), a built-in capability that allows users to add selected IoT data to private blockchain ledgers that can be included in shared transactions and therefore process data in a more efficient way.

Exhibit 19: IBM IoT-Watson platform structure



Source: (IBM Research Centre 2017)

For an IoT based solution, and in general for information technology applications in the supply chain, according to TDM interview, the main barrier is the coordination among members of the Supply Chain, the same barrier apply also to blockchain and was explained in the literature review.

For instance, TDM operation is carried out 50% with own vehicles and 50% with third-party vehicles, which are contacted to make shipments when all the fleet is occupied, the main barrier and the challenge is to implement this application in the third party drivers, and in the integration of the whole process, since them are another company, is difficult to integrate operations, and traceability becomes much more difficult.

It will be difficult to convince third parties to report everything in a new application they do not know and are not used to manage.

The topic of alignment remains relevant, and shippers and 3PLs agreed on the importance of openness, transparency and effective communication to overall success. Among respondents, 44% of shippers and 86% of 3PL providers agree that collaborating with other companies, even competitors, to achieve logistics cost and service improvements holds value. (Langley and Capgemini Consulting 2017)

For a technology to be adopted it has to allow to know the current and exact status of each resource and help to schedule the operation more effectively and for many more days, for instance, the company currently schedule for one or two days in advance, which is not optimal.

In the warehouse, the company doesn't know exactly how long warehouse take to load or unload a truck, or how long the merchandise lasts in the warehouse, although, the issues is trying to be solved with the implementation of SAP WMS to have a better management and control of the time and information.

A solution of this kind will also have a lot of application in the last mile to know the current status and combine it with routing systems.

4.2. UAV – Drones Technology

The growth in drone technology research and investment has given the ability to UAVs not only to support dangerous military missions where pilot operations can be risky but also to be integrated into civil activities. In the group of civil activities is possible to consider personal use for recreation, videos, photos and business use such as last-mile deliveries (Troudi et al. 2017).

Opening the market to companies such as flying basket aiming to bring drone technology to the last mile deliveries, knowing that Hybrid drones, equipped with propellers and wings, can take off and/or land like a copter and can glide like a plane. This design increases the drone’s range for deliveries. Some are designed to lower deliveries on a line, while others are designed to land (Hau L et al. 2016)

Is exactly in the cost of the service where the company focus its main value proposition, by eliminating the costs (and weight) related to the helicopter, and using an UAV multicopter (Exhibit 20), that won’t carry unnecessary weight and will still be able to arrive to the hard to reach locations at lower cost and faster.

Exhibit 20: Multicopter Drone

Source: (Heutger and Kuckel 2014)

The size of the market is an important variable to consider when thinking on implementing a drone delivery based solution, for the case of FlyingBasket the complete market niche comprehends around 250 costumers, which can aggregate demand, FlyingBasket estimates that by capturing at least 25 of these customers the project becomes economically feasible, is important that companies in the future perform a similar analysis based on size of the market.

Aside from the economic feasibility, the value proposition of flying basket is aligned with the results find on literature for which, one of the main advantages of drones is related to emergency deliveries of medication and other urgently needed items and deliveries to remote locations, in which the time is more important and urgent than the cost. (Hau L et al. 2016)

In order to succeed, companies should generate strategic alliance with supplier, for instance, FlyingBasket aim to generate strategic alliance with food companies to ease the flow of materials and speed deliveries.

Current main barriers are related to legal issues and regulations, which are mostly vague and uncompleted, for instance, in Italy for operating drones heavier than 25kg, a license is required, but such a license doesn't exist yet. Is expected that next year most of the regulation will be aligned and therefore the technology will take off.

Amazon, one of the main big players in delivery drones prototypes and shipments has stated that currently the two main requirements for an order to be eligible for drone delivery are (Keeney 2015):

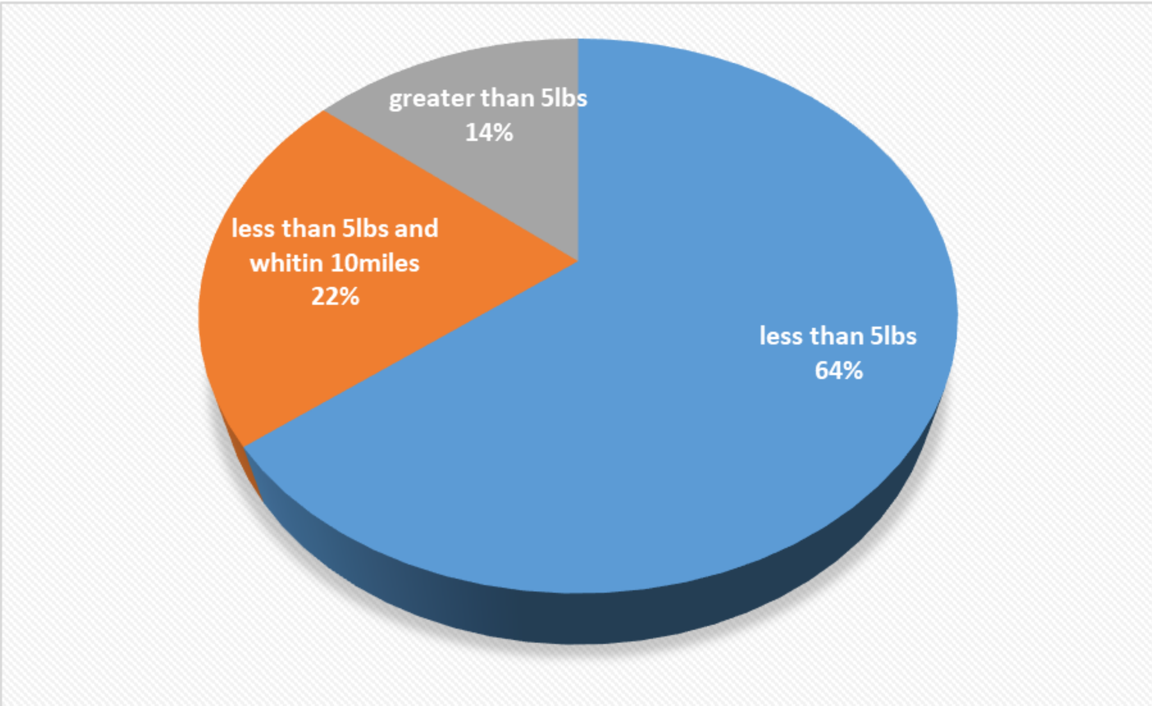
- Packages must weigh fewer than five pounds
- The delivery distance must be within ten miles of Amazon's facilities.

This payload limit may seem relatively low, though as four out of five of Amazon's online orders are for products weighing less than 2.3 kg, the potential could exist for a substantial switch from van to drone delivery. Such a switch would be driven by a desire to accelerate the last mile delivery and gain a transit time advantage over retailers using more conventional, surface-based transport modes. (Mckinnon 2016).

In exhibit 21 there is the percentage of total amazon deliveries that are currently eligible for drone delivery, the FlyingBasket prototype could carry a higher percentage of this deliveries, due to the higher carrying capacity, and therefore depending on the type of drones known barriers can be overcome.

In July 2014 it was revealed Amazon was working on its 8th and 9th drone prototypes, some that could fly 50 miles per hour and carry 2,26kg packages, and had applied to the FAA regulations.

Exhibit 21: Total Amazon deliveries by weight



Source: Own composition - (Keeney 2015)

Other important barrier proposed in the literature analysis was the issues regarding security and accidents in the, this concern can be neglected by FlyingBasket, by making deliveries in the mountains most of the setbacks, are overcome, making it a feasible solution without having to cope with city problems, such as pedestrians, kids playing outside the house, landing platforms, etc.

The tradeoff between product availability vs inventory cost, explained in the previous section, where offering a 100% product availability entails a high cost related to a huge inventory, does not apply to FlyingBasket, because their demand is concentrated in the same area, therefore there is no need of multiple warehouse to cover the entire area, as in cities where customers are not in the same place.

Having the demand concentrated in the same place is one of the main reason to consider that the proposal made by the company is a good one, because does not violate logistic principles.

The second barrier exposed was that drones can only carry one package at the time, been this a main limitation compared to vans which can carry several packages in the same shipment. Being able to carry up to 100kg in the same shipment, this is no longer an issue.

Regarding drones, Mr. Calle (TDM Transport) thinks that the main challenge is in terms of regulations and legal issues, once all those issues are solved, drones will be very used since it will solve many problems of logistics at a lower cost.

For the case of drones able to carry up to 100kg, such as the one flying basket is developing, there is not a big usability with deliveries to regular persons or in the field of electronic commerce but mostly in the B2B field.

For instance, all the big super markets chains are opening small centers within the city, the model used is to have a distribution center and then make deliveries to all their branches, sometimes there is not enough product to fill a van or a truck because most shipments are done daily because is food and have to be fresh, but not of much quantity, and vans have to leave half carried or lees, the company see this in current operation

With a drone that can load up to 100kg could consolidate the load with different smaller products and make shipments faster to each branch in a faster and cheaper way. By applying this model the barrier that each house would need to have its own platform for landing will be overcome, because everything remains in the entire network of the business.

Another possible application would be for example with dangerous substances that cannot be transported by road, the solution to transport this type of material could be this drone that allows to load up to 100kg.

It is also important to consider the security issue, which would happen with having a 100kg package flying over us, this could be a possible problem of this new design.

The biggest constraint, however, in current commercial drones operations is battery life and the relation to the weight carried, which create a vicious cycle where, the bigger the payload, the bigger the lift requirement. The bigger the lift requirement, the bigger the battery that is needed. The bigger the battery, the bigger the total cargo and lift requirement. This is an issue that FlyingBasket hope to solve with their new design.

It can be interpreted as a sign that, rather than replacing standard delivery methods, drones can be used for urgent deliveries in areas that are geo-graphically difficult to accesses, suggesting more of a rural than urban role for them.

FlyingBasket value proposition is sustained by various articles, exposing that, rural delivery by UAV is attractive not only in emergency applications because low-volume remote locations represent a costly part of standard networks. Furthermore, they typically require a non-standard infrastructure tailored to regional specifics (Heutger and Kuckel 2014)

4.3. Blockchain

As seen on the previous section, Blockchain is a relatively new technology, which traditionally has been used for traceability of value assets, and most of the applications are related to the financial sector.

The main reason why blockchain can be applied to logistics, is the fact, that value assets are not just money, but also assets that are been physically transported. The solution search to provide information about the state and the traceability of the transported assets.

A possible logistic solution is the platform used by AOS, which translates the data from connected devices into the blockchain format. The platform filters device events and sends only the data that is required to satisfy the contract. All business partners can access and supply IoT data in a decentralized fashion and can verify each transaction. Data is not collected, stored, or managed centrally. (Kshetri 2017)

As mentioned, supply chain transactions, in all its phases, when completed manually, can create delays and a higher risk for recording error, which can cause differences between what was recorded and what was loaded. By digitizing this process using blockchain and IoT, the relevant information is captured directly from the sensors placed on the trucks, and entered onto the blockchain, creating a single, shared repository that all authorized participants can access and which can only be altered with consensus from all parties

Main advantage AOS solution, will provide are:

- Companies with high production rates, would be able to prioritize projects by knowing exactly when resources will arrive instead of waiting for important goods.
- Complete information on the precedence of goods and the security issues related to it, which can be validated thanks to the blockchain technology.
- Information about changes in the history of the assets.
- Avoiding human mistakes, even though the information reading in an IoT process, is automated, reports creation still manual, and subject to human error, by adding a Blockchain network to this IoT interface we avoid human mistakes and unwanted changes, thanks to the unmodifiable characteristic of blockchain, to the variables of interest.
- Geolocalize vehicles
- Real time measures related with the state of the cargo and control mechanisms to protect the goods, such as weather changes and temperature regulators
- Alerts generation and execution of smart contracts when needed.

The users for this type of solution can be all supply chain actors. But to define costumers, is important to analyze who profits the most from the service, which are transportation companies that want to provide security to end users and manufacturing companies.

Manufacturing companies, as well, might consider buying the service to have full control of the states of their products once they leave the plant, for example car companies.

The main limitations for the adoption of the technology found on literature was that multiple, incompatible blockchain might fail and instead of achieving cost reduction and competitive advantage, will have the opposite effect. In the case of AOS, been their solution, blockchain network will not overlap, and they will be related to logistic networks itself.

Mr Calle states that “Currently all the traceability of resources is done only for security issues, but this information is not enough to make a better planning of the operation, it would be very useful for us, if we could have a platform that would allow us a total traceability of our resources to be able to foresee any eventuality, plan more effectively and have greater control of our resources”.

The previous request is exactly the blockchain solution proposed by AOS, it might let us to thinks that in fact, the solution can be feasible and adopted for transportation companies as expressed in previous section.

4.4. Impact of the technology in the cases of the study

On previous sections the main advantages and disadvantages of the technologies studied were explained, now on exhibits 22, 23 and 24, will be shown how the subjects of the case study deal with these issues, and a summary of the interviews and triangulations results is presented

Exhibit 22: How FlyingBasket respond to the Advantages and limitations of UAV

		References	**What is FlyingBasket doing to profit from the advantage or to overcome the barrier**
	Main advantages found on literature		
Unmanned aerial vehicle (Drone)	Not constrained by road infrastructure and congestion	(Hau L et al. 2016),	This advantage of drone technology is not fully exploit in the case of study, due to the fact that flying basket delivers in mountains area where there is no roads or traffic
	Emergency deliveries of medication and other needed items	(Mckinnon 2016) (Hau L et al. 2016),	Exactly the kind of service aimed, monthly or weekly deliveries of supplies, food and medications
	Main limitations found on literature		
	Product Availability vs Inventory Cost	(Mckinnon 2016)	Is not an e-commerce platform, therefore demand can be planned in advance, in order to have low inventory, receiving products and ship them immediately by partnership with food suppliers
	Cargo capacity of drones’ vs vans	(Dorling et al. 2017) (Mckinnon 2016)	New drone design that can carry up to 100kg
	Reception facilities for drones	(Mckinnon 2016)	As deliveries are made in not populated areas, the infrastructure needed is lees, and deliveries can arrange to be in specific points, besides there is no risk of harming people due to the small population on these areas
	Security an integrity	(Mckinnon 2016)	

Regarding drones, the technology still more development and regulation, but a good way to overcome main limitations is by getting away of the urban areas, as mentioned before, drones rather than substitute current delivery methods are going to complement and provide better solutions, with higher efficiency in specific cases.

For all cases, for low populated areas, drones are more feasible that in populated areas.

The issue regarding the cargo capacity of the drone, might work for FlyingBasket but it cannot be replicated to the industry, common delivery drones are not able to carry up to 100kg, this consist on a special asset of the company, if such vehicles become widely common on the market, then drones can be considered as a replacement for vans in some cases, but for now is not possible.

Drones solution might work for e-commerce platforms such as amazon where most of their deliveries weight less than 2kg, and therefore high loading capacities are not needed but battery life and flight time still an important issue to be considered.

For bigger drones, such as the one studied that is able to carry up to 100kg, the solution might be adopted in the B2B environment for specific types of products that need to be delivery daily from a main warehouse to smaller locations inside the city solving the issue of dedicated infrastructure in each house. The goods can be consolidated inside the drones and save the cost of shipping half way loaded vans.

IoT can be considered as a bridge supporting other technologies, IoT by itself is a broad concept that can be applied to different situations and technologies, like in these case to drones and blockchain, IoT by itself cannot deliver packages, but it can monitor, measure and optimize the last-mile process

The way AOS uses IoT can be extend to the industry, because main advantages are being considered and used and main limitations are either overcome or accepted.

IoT can be bring grate advantages to last-mile logistics thanks to the amount of collected data, that will be available for decisions, making logistics carriers more reactive to changes. The technology can support other technologies such as drones, blockchain, parcel lockers and many other applications that involved data analytics.

Exhibit 23: How AOS respond to the Advantages and limitations of IoT

		References	What is AOS doing to profit from the advantage or to overcome the barrier
	Main advantages found on literature		
IoT	Monitor the status of assets	(An Introduction to the Internet of Things (IoT) 2013) (Macaulay, Buckalew, and Chung 2015)	It's the main value proposition of AOS products, by monitoring the state of assets when transported by truck
	Measure how assets are performing, and change what they are currently doing (and what they will do next).	(An Introduction to the Internet of Things (IoT) 2013) (Macaulay, Buckalew, and Chung 2015)	Installing sensors on Trucks in order to measure external variables, such as temperature, and execute automated control actions if needed, such as rising or decreasing temperature, also predictions can be made regarding exact time of arrival
	Automate business processes to eliminate manual interventions, improve quality and predictability, and reduce costs.	(An Introduction to the Internet of Things (IoT) 2013) (Macaulay, Buckalew, and Chung 2015)	
	Optimize how people, systems, and assets work together, and coordinate their activities.	(An Introduction to the Internet of Things (IoT) 2013) (Macaulay, Buckalew, and Chung 2015)	Reports and variables states are reported automatically, avoiding possibility of human errors when reporting information
	Apply analytics to the entire logistic chain to identify wider improvement opportunities and best practices.	(An Introduction to the Internet of Things (IoT) 2013) (Macaulay, Buckalew, and Chung 2015)	Complete analytics' calculations and process KPI allow to a better decision-making process, by knowing exactly which part of the process needs to be improved
	Main limitations found on literature		
IoT	Improvements in basic infrastructure elements	(Macaulay, Buckalew, and Chung 2015) (Manyika et al. 2015)	
	software and data analytics:	(Manyika et al. 2015)	By partnering with IBM, the company can use pre-built user interface to better develop the solution and take greater advantage of the technology, analyzing more data
	solutions for interoperability	(Manyika et al. 2015)	AOS is developing and external device that communicate with the sensors, and the blockchain, allowing interoperability of different IoT devices

Exhibit 24: How AOS respond to the Advantages and limitations of blockchain

		References	What is AOS doing to profit from the advantage or to overcome the barrier
	Main advantages found on literature		
BlockChain	Transparency:	(Pradip, Seo Yeon, and Jong Hyuk 2017)	All the state of assets is recorded in the blockchain, therefore all the agents (carriers, manufacturing company, retailer, etc.) can see the state in real time
	No risk of fraud:	(Pradip, Seo Yeon, and Jong Hyuk 2017)	All the transactions or changes to assets states are approved before entering the blockchain, therefore false transactions regarding stat4es of assets transported are no longer a risk
	Low or no exchange costs:	(Pradip, Seo Yeon, and Jong Hyuk 2017)	DOES NOT APPLY TO THE CASE
	Network security:	(Pradip, Seo Yeon, and Jong Hyuk 2017)	Network recording state of assets cannot be hacked
	Main limitations found on literature		
BlockChain	Show that blockchain technology can deliver	Charles Brett Consultant Study	Developing a blockchain solution in a sector(logistics) different to the financial, by solving problems in the logistic supply chain related to responsibility, precedence of goods, maintenance and safe transportation and avoiding delays of production due to uncertainty arrival of supplies
	Multiple, incompatible blockchain might fail	Charles Brett Consultant Study	
	Know-how and user interface	(Pradip, Seo Yeon, and Jong Hyuk 2017)	By partnering with IBM, the company can use pre-built user interface to better develop the solution and take greater advantage of the technology, saving developing time

Source: Own composition

5. Implications and discussions

5.1. Relation between operative characteristics and studied technologies

Following the theoretical framework proposed in section 3, the next step is to relate each technology with the main operative characteristics discussed in this study.

In the thesis it has been analyzed how IoT, blockchain or drones can influence logistic and last mile, now in exhibit 25 a summary of all the topics discussed above is presented, relating possible impacts of the technologies in the man operative characteristics described on chapter 2

The relation is build thanks to the interviews and the literature review, it's considered how the advantages and disadvantage of each technology can cooperate with each key operative characteristic.

Exhibit 25: Technology relations with Last mile operative characteristics

	How technology impacts each Operative Characteristic		
Last-mile Op Characteristics	**Blockchain/IoT**	**Drones**	**Reference**
Time window	The importance of creating different time slot or windows is due mainly to the availability of costumer for pick up and the state of road and traffic in that specific time. Thanks to IoT will be possible to predict if the costumer will be at home or not, with instant communication thanks to the collected data	The importance of creating different time slot or windows is due mainly to the availability of costumer for pick up and the state of road and traffic in that specific time. Drone technology traffic problems are no longer an issue and therefore current time slot for companies might be more flexible	(Agatz et al. 2008) (Boyer, Prud, and Chung 2009) and Interviews
Route Planning	Route can dynamically change depending on the transmitted costumer state and availability, customers can report if they are not at home and carrier will immediately update route By making the route available in the blockchain network will make easy to assess responsibilities, traceability will be more accurate	New routes can be considered, since physical road constrains is eliminated, although will be important to consider upcoming regulations regarding the transit area of drones	(Ehmke and Mattfeld 2012) (Dorling et al. 2017) (Agatz et al. 2008) and Interviews

Length of lead time	Shorter lead time will be achieved in several ways depending on in which point the technology is implemented: At the moment of order preparation, picking time can be shortened by adding IoT connected labels to each package. In the transportation phase, the costumer might also receive earlier the package due to the improvements on the route planning, carriers wont wasted time on arriving to locations where there is no one to deliver.	One of the reasons drones can eventually succeed on last-mile because they can achieve 30 minutes(or less) time window deliveries, by avoiding all traffic-related influences. A reduction on delivery time translates into a reduction of global lead time - **Value of fast delivery:** Consumers are more likely to re-acquire the service if the experience was satisfactory, by giving them a faster delivery with drone technology is likely to gain more customers leveraging on the innovate delivery service	(Brar, Rabbat, and Runcie George 2015) (Heutger and Kuckel 2014) (IBM Research Centre 2017) and Interviews
Type of vehicles	**X**	Environmentally friendly vehicles that are not subject to human driving	(Brar, Rabbat, and Runcie George 2015) (Dorling et al. 2017) and Interviews
Security	More security to the customer in terms of the state of the good received and traceability of the product, in case of damage will be possible to determine exactly in which point the package was damaged.	Current states of drones does not implies an upgrade on actual security issues. But instead entails a big risk, of package damage or harm to pedestrians, is important to consider the security aspect before considering adoption of drones technology, because even if is economically feasible it will not be adopted if is not secure	(Feng Tian 2017) and Interviews

Source: Own composition

5.2. Relationship between types of last mile and operative characteristics

The third step of the analysis explained in the theoretical framework is defining the relationship of each type of last-mile with the different operative characteristic chosen as key success factors to evaluate technology impact on the last mile

The relationship is made with the findings on literature and the opinions of the experts gathered in the interviews

Type 1: Seller-arranged delivery, wide range of products sizes, and either direct delivery, with distribution centers

As previously explained in this type of last mile, the costumer let the seller arrange the delivery, and doesn't have the possibility to select specific logistic providers, in this case the costumer must wait the time spent by the seller, and in some cases this time could be high due to the big amount of orders that the seller have.

After the order is placed, the seller would outsource delivery to a logistic provider that uses its own fleet. A seller may also do the delivery by themselves if they have a network to ship orders. Delivery is made directly to the costumers.

- **Time window** is a critical issue, as seller is arranging It must respect costumer schedule.
- **the lead time** is shorter than in other cases because the seller have all demand information and is ready to process orders, might also profits from economies of scales and will arrange shipments and deliveries in the most cost efficient way.
- **The type of Vehicles** used will likely be the industry standard used by most 3PL. unlikely to find innovative vehicles since seller and 3PL use great volumes, is risky to test new transport means. In the long term, when vehicles are proved to be cost efficiency companies might adapt the solutions
- **The Route Planning** becomes a critical factor, the importance of information technologies is very high in this type of last mile since consumer wants to pay as less as possible by giving the seller control over shipment and delivery.
- **Security** is also a critical issue, guarantee by the seller, it must be taken into account that the security risk for new technologies, supporting previous point on delaying adoption until is safer and legislation are clear.

Type 2: Intermediary-arranged delivery, wide range of products sizes, direct delivery.

In this type of last-mile the delivery is not arrange nether by the costumer or the seller, buts instead an intermediary company usually through a website or an application, in which customers can request and order goods from various merchants. Once the customer places an order, the intermediary shops for items at local stores and delivers them at a scheduled time, same-day service is very important in this typology because customer might consider getting the good on its own if the delivery time is high.

Delivery is made to some intermediate locations or companies before arriving to the costumer

- **Time window** is a critical issue, the task of the intermediate party is to speed up the process and be faster that the regular acquisition to the seller. The value and profits of the intermediate party are especially on respect strict time windows and perform, as much as possible, same day delivery.

- **Length of lead time** Critical factor for the same reason mentioned above, the added value of this companies lies on having shorter lead times and making deliveries faster that when directly contacting the seller.
- **Route planning** should be the more important a critical characteristic of companies operating on this sector of last mile, as mentioned costumer will not use the service if is faster for them to get them, the value of the service relays on been faster and more comfortable than the normal purchase and deliver process. Algorithms for pricing, matching tasks with deliverers, and route optimization, as well as analytics for demand forecast and service rating, enable efficiency and better customer service, and all are performed by the intermediate company, that can benefit from economies of scale.
- **Type of vehicle** in this typology are light and fast vehicles such as minivans and bicycles are used, there is room for alternative vehicles such as drones or other type of aerial vehicles, as long as are faster/cost efficient solutions the company will try them to take advantage of emerging competitors
- **Security** Critical issue, it has to be guarantee by the intermediate party, is very important to protect the goods, given that are not own products but instead products already acquired and possibly paid products by someone else.

Type 3: Buyer-arranged pickup, wide range of product sizes, direct or indirect delivery with store based distribution

To speed up delivery and eliminate shipping costs, consumers may prefer to pick up an online order at the store or arrange the delivery with a different firm, and hire a driver who will go to the agreed place to collect the items and deliver them to the customer. Delivery is made directly to the costumers

- For this type of last mile, the **Time window planning** is not a big issue because is the buyer that is going to pick up the product and therefore does not create an extra constrain on the delivery. Is in this type of last mile where lockers and pick up store points start to appear and be useful for both costumer and company.
- **The Length of lead time** is similar to other types on the business side, but then the time in which the costumer receives the product will depend on buyer's readiness to collect products.
- **Route Planning** Critical factor, the importance of information technologies is very high in this type of last mile since buyer wants to pay as less as possible to extract as much value as possible from the product.
- **Security** Is a critical issue, guarantee by the seller, it has to be taken into account that the security risk for new technologies, supporting previous point on delaying adoption until is safer and legislation are clear.

Type 4: Any kind of arrangements for pickup and delivery but only small products

For this type of last-mile, all different combinations of previous factors are considered, for instance delivery is made directly to the costumers or through some intermediate locations or companies before arriving to the costumer. But the key factor is the products size refers only to small products

- **Time window** is a critical issue, the costumer and city schedules have both to be respected

- For this typology is important to consider economies of scale, are most product might be small size, e-commerce platforms this can be achieve through and active and efficient route planning
- **The type of vehicle** will be very different, drones, bicycles and other specialized vehicles with low cost and low cargo capacity may emerge. Is in this type where alternative vehicles are more likely to be adopted.
- **Security** is critical, is always harder to keep track and control smaller products

5.3. For which types of last mile, each technology might have greater impact

Before starting the assessment of the impact of each technology in the different types of last-mile is important to keep in mind that IoT is a very broad technology, and its applications are as unlimited as the creativity of humans, therefore is fair to consider IoT as a transversal technology that works for all the 4 types of last mile and that can cooperate and complement the other technologies.

Advantages and disadvantages of IoT are strictly related whit the kind of device or application developed not with the technology itself, that, instead can be considered as a bridge or platform for constant and correct data transmission from things (trucks, boxes, lockers, vans, drones, persons, packages, etc) connected to the internet

Internet of things will allow the last mile to have more information and correctly interpret these data from consumers, this facts and all the other implications of IoT explained in previous sections lead to think that the technology is very likely to be adopted (as it have been so far) because of the high impact the technology can have in all the operative characteristics and overcome current barriers as explained in the literature review and results sections.

In Type 1 of last-mile as delivery is managed by the seller, the seller will manage great amounts of data and IoT solutions based on big data will be very useful to fulfill costumer needs and remain competitive against other sellers.

In Type 2 of last-mile, the impact IoT can have is higher than for any other types, because in this typology, the competitive advantage of companies relies on the algorithms for routes and delivery planning, as well as pricing, they are not selling the products and the profits comes from efficient and effective delivery operations, IoT solutions to enhance this algorithm are needed, resulting on a high possibility of adoption.

In Type 3 of last-mile buyers arrange deliveries, as is done by individuals and IoT solutions are based on a network of devices or user sharing data to achieve grate results, for this type of last mile impact is a bit lower than in other types. But this does not mean technology will not be adopted, just that solutions are not going to be implemented by individuals but instead for larger companies such as parcel locker companies or stores offering pick up. New companies might arise to offer this type of solutions to the group of individuals arranging deliveries.

For Type 4, the type of solution will affect the possibility of adoption, but in any case, product size is not a critical variable for IoT, because the spectrum of applications is broad, therefore the same arguments valid for type 1, 2 and 3 are valid for this category as well.

Keeping previous analysis in mind, Blockchain and Unmanned aerial vehicles (Drones) are the two technologies remaining to be assed in this case study.

To evaluate the impact of each technology, three levels of possibility of adoption are defined, high, medium and low, each level is assigned according the previously explained relationship between the variables and the technologies, as well as the opinions and information gathered in the literature review and the interviews with field experts.

Exhibit 26: Adoption possibility of each technology in the types of last-mile

Types of last mile	Main technologies of the case study	
	Blockchain	**UAV**
Type 1	**<u>High:</u>** The main barrier of blockchain is related to the implementation cost, for small companies or single buyers there is no sense on making the investment of building a network, but in this type of last mile the seller arranges the delivery, usually the seller is a large company willing to invest in reduce cost and offer a better service, a shorter lead time will be translated in a competitive advantage against rivals, and therefore will find profit on the implementation of this type of technologies. Blockchain can also have a high impact on this type of last mile thanks to the transparency it brings to the process, giving security to the customer in terms of the state of the good received and traceability of the product, in case of damage will be possible to determine exactly in which point the package was damaged Companies might start choosing this kind of solutions to add value to consumers, if network is big enough the development effort is worth.	**<u>Medium:</u>** On the previous section the different advantages of the use of aerial vehicle for deliveries were explained, and is a trend going stronger each day, but for type 1 of last mile the possibility of adoption is Medium, due to the fact that still a complicated task, and seller with low IT capabilities will not be able to adopt the technology, even though it might be useful most of the players will wait to see if there is real advantage and if the technology is really feasible So even if the advantages brought to this type of last mile are considerable the previous fact reduces the possibility of adoption.
Type 2	**<u>Low:</u>** The main advantage of blockchain is the capacity of integrating all the information in the same network, but at the same time, as explained in previous sections, this is also an important barrier, because integration activities are hard, and it’s even harder when dealing with different companies as in this case of this type of last mile. There is low possibility of adopting known blockchain solutions because the	**<u>High:</u>** The time and cost are the critical success factors for this type of last mile, is the aspect companies in this type of last mile will use to earn market share. Costumer will not use the service if is faster for them to get them directly at the store, the value of the service relays on been faster and more comfortable than the normal purchase and deliver process.

	effort will be very high and not all companies might be willing to cooperate and share data, the intermediate company will likely opt for other type of solutions that require less integration with the vendor.	This facts bring high possibility of adoption to UAV or Drones to delivery products faster using alternatives routes.
Type 3	**Medium:** As the buyer is the one arranging the delivery it will be of great importance to offer security to the in terms of the state of the good received and traceability of the product, in case of damage will be possible to determine exactly in which point the package was damaged. This kind of security can be offered with a Blockchain network. Even if security is a critical factor, it will be hard and maybe not well rewarded to implement a solution of this kind because the network is very wide and complex, also arise the issue of who should implement the solution, the sellers or the pickup locations companies?	**Low:** Is very unlike to have persons using own drones to pick up goods, because the cost of a single drone for few deliveries is high. Drone solution can be feasible while taking advantage of having a fleet of drones and performing lots of deliveries a day, but when the buyer of customer have to pick up goods is not a very feasible solution Also the security of goods is not guarantee by any company.
Type 4	**Low:** If products size is small, products might be low value, therefore implementing a Blockchain solution for security and traceability of assets would not be profitable, other cheaper tracking methods are available, such as IoT Solutions or current carriers tracking information systems. In case delivery is made to a delivery point or regardless who arrange it a blockchain solution is unlike to be adopted, due the complexity blockchain solutions have and the constrains related to the process explained in previous sections.	**High:** In this type of last mile is a critical issue, the costumer and city schedules have both to be respected. The majority of last mile deliveries weight less than 5 pounds, therefore this is a clear insight that drones will be very useful in the last mile once all regulations are sorted Drones will bring faster and more efficient ways of delivery single packages to costumers in urban areas.

Source: Own composition

6. Conclusions

The last mile is the stage of the supply chain that entails higher cost, and is where companies and research are trying to invest more to figure out new innovative solutions, one of the most important trend in the future of last mile is that companies must accept and adopt the new consumer demands. (Langley and Capgemini Consulting 2017)

The growth on technology usage in logistics is a good indicator that newest information technologies such as IoT, Blockchain and drones might be implemented if this help 3PL to achieve competitive advantage.

Home deliveries, same day deliveries, time windows, alternative pick up locations, stores in public transport stations, just-in-time deliveries and real time tracking are no longer value added service but instead the new standard that majority of costumers except, this is the reason why new technologies and solutions have a great opportunity of being tested and adopted due to the industry accelerated evolution.

A second important trend is the requirement for zero emission vehicles, especially in densely populated areas, is expected that usual vehicles such as Vans and trucks will be electric. This issue also invite companies to test new transportation vehicles such as unmanned air vehicles, like delivery drones.

Many research agreed that UAV will succeed on the last-mile both for traditional retailers (Like Wallmart) and big internet retailers.

For traditional retailers with a nearby local presence, deliveries will become faster and more convenient.

For the large internet retailers like Amazon, it will need to build out warehouses close to where people live in order to compete on speed that the traditional brick and mortar will have.

It will make the deliveries happen faster and at more economical prices therefore helping fuel the adoption of the drones for lightweight deliveries.

This will create a supporting ecosystem and a surrounding industry which will be able to create value for everyone and make the end consumer's life better. The first adopters will likely win as they will be able to learn faster, iterate and establish their brand names as the cheaper and faster companies to deliver packages. Examples of some companies that are ahead in this space are Amazon and Walmart, which are already testing the drones and are ahead of the game. This will be a great boost for them in the long run and enable them to stay competitive and earn new customers given the cost, convenience and speed of delivery.(Brar, Rabbat, and Runcie George 2015).

To meet all the new demand requirements is expected that new transport planning and scheduling systems will be developed using big data to forecast delivery routes, using real time traffic information and availability of unloading zones (Walther Ploos van Amstel 2017)

Also, the capabilities for dynamic planning will include pick-ups of goods and integration with planning of sorting and loading processes. The planning buckets will be in seconds, no longer in minutes.

Previous facts and the need for managing big data, open a new set of possibilities for IoT technologies that will allow the correct processing of information, companies will have to train themselves in the usage of this technologies, because as mentioned in some years it will not be innovation solutions but the industry standard.

The objective of this case study was to assess the impact of three innovative technologies in the last-mile distribution, and determine, according to interviews to field experts and a deep literature review, the level of impact each technology might have.

A theoretical framework was developed with the aim to structure the results and classify the impact of each technology in different typologies of last mile each of them having different parameters and environment that might affect the adoption or the impact a technology might have on the industry.

A case study with innovative companies was conducted, in order to gather results from the industry and triangulate them with the information found on the literature, in order to have a more accurate verdict when assessing the level of impact.

For Blockchain was found that the main impact will be in ensuring supply chain security, it also makes it possible to contain an IoT security breach in a targeted way after discovery of the breach. Blockchain can facilitate handling and dealing with crisis situations such as product recalls due to security vulnerabilities. (Kshetri 2017)

Blockchain's public availability means that it is possible to trace back every product to the origin of the raw materials, and transactions can be linked to identify users. Sharing data such as machine loads, sales previsions and inventory positions has proven to improve the fulfil rate and the product cycle time, and to decrease order fluctuations. (Nakasumi 2017)

IoT solutions open endless possibilities, and instead of being considered as a separated technology it should be considered as a platform or a bridge to support other technologies such as drones and blockchain.

The cities will play a major role on aiding technology adoption, by having reliable city data and provide those to delivery companies.

The main barrier found in the study for all the technologies studied is the fact that stabilization of the process and coordination in the supply chain is needed, A good sing that this issue is improving is the fact that the satisfaction with 3PL IT capabilities has increased very significantly from 27% in 2002 to 65% in 2016, according to (Langley and Capgemini Consulting 2017). This positive trend opens the door to further and more complex implementations of technologies such as blockchain and drones.

Results show that the technology that might have a higher impact is Internet of Things due to the current status of implementation and the versatility when implementing, as well as the number of different applications and solution that might be based on IoT

As a following study it will be interesting to analyze at a more quantitative level the cost and feasibility of adopting these technologies in the defined typology of last mile to have clear insight of how much companies will be willing to invest.

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Appendix 1 - Transcript of Interview with Mooritz Moroder Founder of FlyingBasket

Q1: How the startup/idea was born

Flying basket is a startup that becomes an interesting study subject, due to its researching and development of innovative ways of making shipment and deliveries in hard to reach locations in the mountains of the Bolzano region in Italy, the idea was born from the necessity to serve the market niche at a lower cost.

Q2: Description of the service/product

FlyingBasket is not a carrier company, their focus is the development of an innovative drone (multicopter) with real live applications, to test their product they decided to serve this market, but is not their main purpose, and might therefore shift to different market in order to find more applications for their product, which is its main asset along with the know-how of members.

Company is aiming on developing an autonomous multicopter with weight 50kg that can carry a package up to 100kg, current drones are far away from these measures.

Q3: Advantages of the technology and added value proposition

At the moment, for those locations, deliveries are made on specific dates by a helicopter that aggregate most of the demand, but still an expensive service, due to maintenance cost of the helicopter (and cost of the helicopter itself), pilot wage and fuel. Is there were we add value to our consumer, by overcoming the issues and problems related with deliveries to difficult locations.

Is exactly in the cost of the service where the company focus its main value proposition, by eliminating the costs (and weight) related to the helicopter, and using an UAV multicopter (Exhibit 17), that won't carry unnecessary weight and will still be able to arrive to the hard to reach locations at lower cost and faster.

Q4: What are the main issues that your company faced/is facing/will face?

Current main barriers are related to legal issues and regulations, which are mostly vague and uncompleted, for instance, in Italy for operating drones heavier than 25kg, a license is required, but such a license doesn't exist yet. Is expected that next year most of the regulation will be aligned and therefore the technology will take off.

Q5: Is the service expensive to develop? Is it necessary to build them in an exclusive way or could they be developed in partnership?

The vehicle is entirely design by FlyingBasket, some components are bought and other are complete develop by them, manufacture is developed in partner with providers, the need to entirely develop most of the drone, is due to the fact that current market standards are not enough for the needs there are trying to serve.

Q6: Who are your key partners? How do they help you overcome the existing problems?

In order to succeed, FlyingBasket aim to generate strategic alliance with food companies to ease the flow of materials and speed deliveries.

Q7: Critical mass (diffusion) to profit

The complete market niche comprehends around 250 costumers, which can aggregate demand, FlyingBasket estimates that by capturing at least 25 of these customers the project becomes economically feasible.

Appendix 2 - Transcript of Interview with Ricardo Buitrago AOS director

Q1: Any comments about technology

Blockchain is a relatively new technology, traditionally it has been used for traceability of value assets, and even though Blockchain is an open source program, big enterprises such as Microsoft and IBM are starting to develop more intuitive solutions for the use of the technology that usually come with an associated cost, which is high for normal companies, and that's why only banks are willing to pay for it.

Assets Value are not just money, that's why it can be used for other assets been physically transported, and it start to make sense using the technology when member of the network are interested in the state and the traceability of the assets, especially for companies with high production rates, in order to prioritize projects by knowing exactly when were they arrive.

Other important uses is the precedence of goods and the security issues related to it, which can be validated thanks to the blockchain technology.

In some cases, the report of variable in IoT process, even though is an automated process (such as sensors reading), reports creation is still manual, and subject to human error, by adding a Blockchain network to this IoT interface we avoid human mistakes and unwanted changes to the variables of interest, whit all the change history in the assets.

We were working on robotics and automation for 7 years, but becomes really interesting to bring all this automation to the cloud. Blockchain has to be carefully use, and not in every case is feasible, it makes sense to use the technology, when client have some of the issues mentioned above, that can be solved by the implementation of it.

We are creating a customizable service, for the logistic transport sector, to geolocalize vehicles and have real time measures related with the state of the cargo and control mechanisms to protect the goods, such as weather changes and temperature regulators, to detect alerts and execute smart contracts when needed, this product will be on sale by December the 1st, and will allow us to have information, alerts and geolocalize.

Q2: You were talking that implementing a blockchain solution is costly, and make sense to use it when dealing with value assets, for type other assets still an economically feasible solution?

IBM, advantage is that interface is already built, is already o the cloud and methodologies area already made, is not starting from zero, but you are able to save time in the development phase, and is back up by a reliable company such as IBM

Pure Blockchain make sense for every asset type and business with the needs explained before, and been open source its free, the real cost is in the expertise in the development of a usable solution and the time it takes, which not many companies are able to implement.

Q3: How the idea was born

We are IBM partner for a long time, and we invest a lot on innovation and R&D. This year we had the opportunity to assist to a bootcamp made in London, were we learn about the technology and understand the real applications, especially on the financial sector, and possible uses and where is better to use it.

That was where the idea was born, when we return to Colombia we talk to BM and they liked the idea and we start working on it.

Where are planning also to develop an own device, wirelessly connected to the devices, to read in real time all the information from the sensors in the vehicle, and start to exploit the main feature of blockchain technology, which is that all members of the network have access to the same information in real time, and can understand and see all the information related to cargo status, with the history and from a reliable source.

For Example: Lets imagine a truck that have cargo sensitive to temperature, for instance food, so the goods arrive to the company, then they pass to warehouse and the to a new shipment point, when the goods were open it where damage, so the discussion start, since when are products damage?

Thanks to blockchain and by control points, all members of the blockchain, will have unaltered information of the state of the shipment and can detect exactly what happen and where happen.

Q4: Which are your main customers, transportation companies or manufacturing enterprises?

In theory the most accurate solution will be that all members of the supply chain pay for the service together, but in practice this is hard, therefore we need to ask ourselves who profits the most from the service, which are transportation companies that want to provide security to end users and manufacturing companies.

But also, some manufacturing companies might consider buying the service to have full control of the states of their products once they leave the plant, for example car companies.

Q5: Which technology might have greater impact in the logistics and last mile, between IoT, drones and blockchain?

The first IOT, secondly Drones and lastly Blockchain.

Appendix 3 - Transcript of Interview with Juan Esteban Calle TDM research director

Q1: Good morning, what is your current position and occupation in the company?

Good morning Carlos, In this moment I'm working as the operation research director, in my department we think, design and implement new ways to improve our operations and our costumer's. Also we focus on how to improve the internal supply chain of the company, which is focused on long distance deliveries, but we deal with the last-mile as well to deliver to the end costumers.

Q2: Which are the main Information technologies that, so far, your company has implemented?

Within the main technologies implemented by us, we have one for loading trucks, which tells us how to position the merchandise inside to take advantage of the space and improve the vehicle usage. We also have satellite tracking systems for vehicles and a platform for our customer service team to monitor the status of the cargo.

With respect to IoT, we are currently working on a mobile application for our drivers, so they can report the status of their shipment, such as arrival, upload, download, start and end of travel, emergency stops etc., also so they can report any news or unexpected situations and ask for extra money, when needed to deal with emergencies, and have a general traceability of the transport process.

We develop demand forecasts to dimension the fleet and really know how many resources we need and how much we have to invest, for this we use software that processes all this information and allows us to make better decisions

Q3: What will be the main barrier on the adoption of this new mobile application based on IoT that you just mentioned?

Our operation is carried out 50% with our own vehicles and 50% with third-party vehicles, which we contact to make shipments when all our vehicles are occupied, the main barrier and the challenge is to implement this application in the third party drivers, and in the integration of the whole process, since them are another company, is difficult to integrate our operations, and traceability becomes much more difficult. It will be difficult to convince third parties to report everything in a new application they do not know and are not used to manage.

Q4: Any other important challenge to overcome in your current operations?

The main challenge is to control the timing and the accuracy of the information in the warehouse, we do not know exactly how long our warehouses take to load or unload a truck, or how long the merchandise lasts in the warehouse, and we currently implement SAP WMS to have a better management and control of the time and information.

For us is a priority to have a control center for all our resources, currently they are:

- Driver
- Vehicle
- Trailer

We would like to have technologies that allows us to know the current and exact status of each resource and be able to schedule the operation more effectively for many more days, we currently schedule for one or two days in advance, this solution will also have a lot of application in the last mile to know the current status and combine it with routing systems.

Q5: I am currently evaluating the impact of drones in the last mile, a technology that in recent years has had a lot of publicity and research and experts mention that it can be a disruptive technology, what is your opinion on the subject.

Well, one knows that there is a great challenge in terms of regulations and legal issues, but I think that once all those issues are solved and regulations currently defined, it will be very used since it will solve many problems of logistics at a lower cost.

Q6: One of the cases that I am analyzing on my thesis, is a Startup developing a drone that has the innovation of being able to carry packages of a maximum of 100kg, you think that this could be useful and that it would have a big market in the last mile?

For me yes, not so much with deliveries to regular persons or in the field of electronic commerce but mostly in the B2B field.

For me the great utility would be for all the big chains that are opening small centers within the city, for example the majority supermarkets, have a distribution center and they make deliveries to all their branches, sometimes there is not enough product to fill a van or a truck because most shipments are done daily because is food, but not of much quantity, with a drone that can load up to 100kg could consolidate the load with different smaller products and make shipments faster to each branch.

Another possible application would be for example with dangerous substances that cannot be transported by road, the solution to transport this type of material could be this drone that allows to load up to 100kg.

It is also important to consider the security issue, which would happen with having a 100kg package flying over us, this could be a possible problem of this new design

Q7: What other technology would they like to implement in the future that they believe can solve their problems?

Currently all the traceability of resources is done only for security issues, but this information is not enough to make a better planning of the operation, it would be very useful for us, if we could have a platform that would allow us a total traceability of our resources to be able to foresee any eventuality, plan more effectively and have greater control of our resources.