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Crowdsourcing Logistics in e-commerce B2C: a model to evaluate costs in different scenarios

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Abstract

Consumers in ecommerce have become much more demanding in terms of fast delivery, having high costs implications on merchants. Among the possible strategies that can be implemented to provide fast shipping services, there is crowdsourcing logistics. Crowdsourcing logistics is defined as the outsourcing of logistics services to a mass of actors.

In this dissertation, first, a literature analysis was carried out to understand the existing body of knowledge. The overall subject of crowdsourcing delivery is not deeply analysed in scientific literature, so far. The first finding of was the lack of any significant number of papers on crowdsourcing logistics, because of the novelty of this theme. Due to the scarcity of scientific literature and in order to have a better understanding of the industry, an analysis of the business models of all firms operating in the crowdsourcing logistics has been done. They were classified in a taxonomy that examines them on eight attributes. Two main clusters have been identified, the so-called B2C and P2P companies. Then an analytical model was developed, idea behind it is to understand the advantages of shipping through a crowdsourcing platform compared to other fast delivery providers. The model was built to consist of riders that can deliver with several vehicles in different service levels and it was applied in Milan. The output of the model is the cost of a crowdsourced delivery, which can be compared to other express courier fares, and unviability rate of the crowd, which measure the amount of non-eligible riders in the crowd. The model showed that the crowd delivery is 60% cheaper than normal couriers in one-hour delivery and in the two-hour one crowdsourcing is 50% less expensive. The model was then tested in a sensitivity analysis to evaluate its capability of adapt to different scenarios. The algorithm was run with crowd made by only one type of vehicle. The best vehicle in terms of performance is the motorbike. The worst performer was delivery on foot. The model was then used to simulate the food delivery service in two districts of Milan and it predicted the behaviour of food delivery companies in those areas. The contributions of this dissertation to crowdsourcing logistics research can be summarized into two points. First, it provides a classification framework that allows the analysis of crowd shipping companies' business model in a simple and effective way. Second, and most importantly, the development of the model. This model is a tool that allows any company to decide whether to ship with crowdsourcing logistics or not, simply through a delivery fare comparison. The strength of the algorithm is its flexibility towards different kinds of crowds, parcels' weights and service levels, potentially opening its application to several industries.

Abstract

Nell'ambito dell'e-commerce i consumatori stanno diventato sempre più esigenti in termini di spedizioni rapide, tutto ciò ha delle implicazioni di costo non indifferenti sui merchant. Tra le possibili strategie che possono essere implementate per risolvere questo problema c'è il crowdsourcing logistics. Il crowdsourcing logistics è definito come l'esternalizzazione delle attività logistiche a una massa di attori. All'inizio una analisi della letteratura è stata redatta per comprendere lo stato dell'arte della letteratura scientifica su questo argomento. L'argomento in generale non è molto trattato dagli accademici, infatti il primo risultato è stato proprio la mancanza di articoli scientifici su questo tema. A causa di questa scarsità di fonti accademiche su cui basare la ricerca, è stata fatta un'analisi approfondita dei business model delle aziende che operano in questo settore. Queste sono state classificate in una tassonomia attraverso otto attributi. Due cluster principali sono stati individuati, le così dette aziende P2P e B2C. L'idea che sta alla base del modello è di comprendere i vantaggi dell'utilizzo del crowdsourcing logistics paragonato ai vettori tradizionali nelle spedizioni rapide. Il modello è stato costruito in modo tale da poter operare con differenti tipologie di fattorini che consegnano con diversi veicoli in vari livelli di servizio. Il modello è stato poi applicato alla città di Milano. Gli output dell'algoritmo sono il costo di una spedizione in crowdsourcing e il livello di indisponibilità del crowd, che misura il numero di fattorini non idonei alla consegna. Il modello ha dimostrato come una consegna in un'ora fatta in crowdsourcing sia più conveniente del 60% rispetto ai vettori tradizionali e come in due ore sia il 50% meno costosa. Il modello è stato poi testato in una analisi di sensitività per verificare la sua capacità di adattarsi a diversi scenari. L'algoritmo è stato eseguito con diverse tipologie di crowd fatte da fattorini con un solo tipo di mezzo. Il motorino è risultato il mezzo più performante, mentre le consegne a piedi sono le peggiori in termini di prestazioni. Il modello è stato poi applicato al settore della consegna di cibo a domicilio in due quartieri di Milano e i risultati ottenuti hanno previsto correttamente il comportamento delle aziende in quelle zone della città. I contributi di questa tesi alla ricerca sul crowdsourcing delivery possono essere riassunti in due punti. Primo, questo studio fornisce un framework di classificazione che permette di analizzare le aziende che operano in questo settore in maniera semplice ed efficace. Secondo, e maggiormente importante, lo sviluppo del modello, che è visto come uno strumento per le imprese a supporto della decisione di spedire o meno attraverso il crowdsourcing logistics, mediante una comparazione delle tariffe. La forza di questo algoritmo è nella sua flessibilità di adattarsi a diverse tipologie di crowd, diversi pesi di pacchi e diversi livelli di servizio, aprendo le sue possibilità di applicazione a diversi settori.

Executive Summary

The spread of ecommerce over the last years has radically changed the customer shopping experience and behaviour. Consumers have become much more demanding in terms of service level. One-day, same-day, two-hour, and one-hour deliveries are currently popular among merchants, but these delivery methods have increasing costs implications. Among the possible strategies that can be implemented to provide fast shipping, there is crowdsourcing logistics. Crowdsourcing is the act of company of externalize to a crowd of people a task that previously was carried out internally. This practise is currently used in several industries across various business activities. More specifically, crowdsourcing logistics is defined as the outsourcing of logistics services to a mass of actors, whereby the coordination is supported by a technical infrastructure with the aim of providing benefits for all stake - and share-holders.

This dissertation investigates the characteristics of crowdsourcing logistics industry, identifying the main actors operating in this business and how they execute this activity. Furthermore, the main objective is to understand if it is convenient to apply this kind of solution by a merchant. In order to achieve those results, an analytical model will be developed to estimate the costs and the benefits arising from the application of such an initiative. The research objectives can be summarized into three main research questions:

1. What is the status quo of the scientific literature regarding crowdsourcing logistics?
2. Which are the business models that characterise the crowdsourcing logistics industry?
3. When is it convenient to use crowdsourcing logistics versus normal couriers?

First, a literature analysis was carried out to understand the existing body of knowledge and to identify gaps in the scientific publications. The overall subject of crowdsourcing delivery is currently popular and discussed in many blogs and website. However, crowdsourcing delivery is not deeply analysed by scientific literature and academic research.

The literature analysis has two objectives: first, to identify papers within crowdsourcing related literature discussing its application in last mile delivery, and second, within ecommerce scientific articles, the possibility of finding this solution, among the options to deliver parcels. The first finding of this research was the lack of any significant number of papers and academic essays on crowdsourcing logistics, due to the novelty of this theme. Further support was that even among the few papers collected from scientific journals, there is a lacks any kind of predominance of one type of research method over another. There are business cases, simulations and

theoretical frameworks, but what is missing is an overall scheme that allows the comprehension of the entire business. Considering the papers which addressed the last mile delivery, crowd shipping is listed as one of the possible innovations that could have a positive impact on future logistics development, but none of these expands deep into details of the benefits that its application could have.

Due to the overall scarcity of scientific literature to base the research on, and in order to have a deeper and clearer understanding of the industry, an analysis on all the possible ways to carry out crowdsourcing logistics has been completed. This research involved the study of the business models of all firms and initiatives that are currently operating in crowd shipping business. At the date of the research, 35 companies have been found active in this field and they were classified in a taxonomy that examines them on eight attributes: target, origin, destination, firm type, crowd, industry, fare and time frame. Two main clusters have been identified, the so-called B2C and P2P. The former is consists of companies that offer crowdsourced delivery services to ecommerce merchants, usually operating in urban areas with fast shipping services. The latter are platforms where two people, peers, are connected and one can ship items for the other in exchange of money. All of the details of the delivery are bargained between the two peers. This industry is very dynamic and, a part from few exceptions, it consists mainly of start-ups. Consequently, some companies operating last year have already disappeared and new firms will arise in the near future.

Between the two methods of crowdsourcing logistics, the better fit with ecommerce is the B2C cluster. These companies could be, even, considered ecommerce enablers for those offline firms that can rely on them to ship their product on demand and at a convenient rate, so they can start selling online.

The idea behind the model starts from here: understanding the advantages of shipping through a crowdsourcing platform compared to other fast delivery providers. The model has been developed with the aim to be as general as possible to broaden its use across different companies operating in several industries (e.g. fashion, grocery, food delivery). The first step was to understand how the process is carried out and which fundamental variables are to be entered in the model. The variables that are required to set up the model were identified as: receiver's location, riders' location, parcel weight, riders' vehicle and service level required. The model was built to consist of riders that can deliver on foot, by bike, by motorbike and by car. For sake of simplicity, three possible service levels were set: one-hour, two-hour and same-day delivery. The riders' wage consisted of a fixed amount, given once the delivery is accomplished, and a flexible amount, related to the amount of time that the platform estimates is needed to ship the parcel. The flexible amount compensation varies according to the service

level required: 6€ per hour for one-hour delivery, 4€/h for the two-hour one and 2 €/h for the same-day shipping.
The model was applied in the city of Milan. The algorithm was developed in such a way that it approximates the values inserted for the origin and destination to some locations contained in its data set, in this case 100 addresses were put inside.
The output of the model is the cost of a crowdsourced delivery, which can be compared to other express courier fares, and unviability rate of the crowd, which measure the amount of non-eligible riders in the crowd. A rider is defined as non-eligible when he is available to deliver but due to its position or transportation means he is unable to accomplish that delivery with respect to the service level required. The monitoring of this indicator is important, where high values of can quickly lead to dissatisfaction within the crowd of riders whereas they may choose to not return to the platform, negatively affecting the overall platform performances.
The model was set with specific data distribution of vehicles, parcel weights, and service levels. The outcome obtained for average cost in the model initialization was 7.80 € for the fastest delivery, 6.50 € for the two-hour time frame and 5.04 € for the same-day shipment. When it is compared to traditional logistics: in the fastest service level, the crowd delivery is 60% cheaper than normal couriers and in the two-hour one crowdsourcing is still less expensive at 50%. The difference narrows with the same day delivery, but crowd shipping is still more convenient at 40% less than traditional shipping.
The model was then tested in a sensitivity analysis to evaluate its capability of adapt to different scenarios. The algorithm was run with different vehicles' crowds, inputted with the aim of understanding how the different vehicles perform. The best vehicle in terms of time and consequently in cost is the motorbike, which guaranteed the best results in all the service levels even in terms of the unavailability rate. The worst performer was delivery on foot. This shipping mode does not satisfy the one-hour and the two-hour delivery, but only the same-day one.
The model was then used to simulate the food delivery service in Milan, currently done by start-ups like Foodora and Deliveroo. Crowds of motorbikes, bikes, and mix of both were tested with a parcel weight of less than 5 kg. The service levels used were one-hour and two-hour delivery, plus an extra one of 45 minutes to better reproduce this kind of service. Again, the best performers were the motorbikes. However, even bikes allowed delivery within in those time frames, but with higher costs. The results obtained in terms of prices were higher compared to food delivery start-ups for two main reasons: the wage of the riders is higher in this case and the delivery is thought

to happen in all the city of Milan, not limited to restricted areas like those companies currently do.
In order to better replicate the food delivery industry, another variation was done. This time, the model dataset was changed with more restricted databases related to two districts in Milan, Municipality 1 and Municipality 7. The choice of those two municipalities was taken because in Municipality 1 most of the delivery start-ups were operative there, while in Municipality 7 none of them were found active at research time.
The model was fed with data configuration similar to the previous food delivery cases and with three new types of service levels, 60 minutes, 45 minutes and 30 minutes. The model was able to exactly predict the real facts. Indeed, in Municipality 1 the costs were almost the same to the benchmark values for food delivery and the unavailability rate equal to zero. While in Municipality 7, the crowd was not able to satisfy the 30-minutes service level and the 45-minute one had only 50% of the crowd available, looking at the fares they were 30% higher than the benchmark value; those two results explain that, due to the low profitability, those companies do not operate in this area.
Finally, the model was set with a growing number of people in the crowd to see if the actual cost of delivery decreases as the amount of possible drivers' increases. This scenario was tested at all service levels and with all methods of transportation. A general conclusion from this scenario is that the two dimensions are negatively correlated, but the cost decreases less than what was theoretically predicted. While there is an increase of 80% in the dimension of the crowd, the costs reduce only at 1%, so it is almost constant in the model. The cause of this can be found in the way the model is built; the driver's origin and the customer's address are approximated to one of the 100 selected locations in the data set and, consequently, the degree of error and the precision of the model is affected by that proxy.
The contributions of this dissertation to crowdsourcing logistics research can be summarized into two conclusions. First, it provides a classification framework that allows the analysis of crowd shipping companies' business model in a simple and effective way. Second, and most importantly, the development of the model. This model is a tool which allows any company to decide whether to ship with crowdsourcing logistics or not, simply through a delivery fare comparison. The strength of the algorithm is its flexibility towards different kinds of crowds, parcels' weights and service levels, potentially opening its application to several industries.

Introduction: Crowdsourcing

The term crowdsourcing was coined for the first time by Jeff Howe and Mark Robison in an article appeared in June 2016 on Wired magazine. Their definition is as follows:

"Simply defined, crowdsourcing represents the act of a company or institution taking a function once performed by employees and outsourcing it to an undefined (and generally large) network of people in the form of an open call. This can take the form of peer-production (when the job is performed collaboratively), but is also often undertaken by sole individuals. The crucial prerequisite is the use of the open call format and the large network of potential labourer"(Howe 2006)

So as they say crowdsourcing consist in externalize one or more activities that were done into the company boundaries to an external entity, which in this case is an undefined group of people that are willing to share their knowledge and skills in order to satisfy the firms' needs. All this is possible thanks to the Internet that is the mean through which this could happen.

From an etymological analysis, the name is made by two words crowd and sourcing. The former, crowd, refers to the group of people that want to take part to the initiatives, and the latter, sourcing, is related to a number of procurement practices, aimed at finding, evaluating and engaging suppliers for acquiring goods and services. (Estellés-Arolas & González-Ladrón-de-Guevara 2012)

Following this first main definition a lot experiments and activities can be defined as crowdsourcing, but anyway among scholars there are some doubts about which activities can be considered crowdsourcing or not. Starting from this grey area Estellés-Arolas & González-Ladrón-de-Guevara (2012) decided to analyse several crowdsourcing definition in order to find a common ground upon which basic characteristics could be extract to describe any crowdsourcing initiative.

In their literature analysis they found three main elements: the crowd, the initiator and the process. A further division is made from those resulting in eight characteristics dived into three macro subjects:

About the crowd:

a) who forms it
b) what it has to do
c) what it gets on return

About the initiator

d) who it is
e) what it gets in return from the work of the crowd

About the process:

f) the type of process it is
g) the type of call used
h) the medium used

All these characteristics were researched in papers and the results were several definitions per each one, which all combine will give a general delineation of crowdsourcing.

The *crowd* is defined a group of individuals, which can have different size, heterogeneity and knowledge depending on the requirements of the crowdsourced task. This crowd is supposed to carry out the resolution of a problem through their voluntary contribution of effort, money, skills, knowledge and experience. With *problem* it is defined every situation given by the initiator of the crowdsourcing activity. The *return* that the crowd get for the task, once it accomplished, is generally defined as satisfaction, which can be economic, social recognition, self-esteem and development of individual ability, those categories are not mutually exclusive.

The *initiator* of the crowdsourcing process, that can be define even crowdsourcer, is an entity that wants to carry out the initiative with the help of a crowd of contributors. The nature of the crowdsourcer can vary from a company to a non-profit organization, from an institution to an individual. Of course the initiator requests the help of the crowd to gain something in return. The achievement that the crowdsourcer has back is the solution to the problem he asked a solution to crowd with a call. The crowd by answering to the call and accomplishing the task request delivers the solution to the issue for which it was called to action.

Regarding the process, crowdsourcing can be defined both as an outsourcing process or a problem solving process. Crowdsourcing can be the business model of an organization, the production process or a strategic model. This practise can be implemented just in some occasions to foster up the innovation or the client integration process. However, all those different process have as a common point the fact that crowdsourcing is an online process. The Internet is the medium used to spread the call among the participants; many authors stressed the importance of the Internet for crowdsourcing.

The call is the way by which all the potential participants are brought together. This call can be totally open, so anyone who is interested can participate; it can be limited to a community of selected people with specific knowledge and expertise; and, finally, the call can be a combination of the those two, so the call is open but it is addressed to a selected pool of people. Integrating all those information gathered the authors, Estellés-Arolas and González-Ladrón-de-Guevara, obtained a more compreshive and general defintion of crowdsoucing:

"Crowdsourcing is a type of participative online activity in which an individual, an institution, a non-profit organization, or company proposes to a group of individuals of varying knowledge, heterogeneity, and number, via a flexible open call, the voluntary undertaking of a task.
The undertaking of the task, of variable complexity and modularity, and in which the crowd should participate bringing their work, money, knowledge and/or experience, always entails mutual benefit. The user will receive the satisfaction of a given type of need, be it economic, social recognition, self-esteem, or the development of individual skills, while the crowdsourcer will obtain and utilize to their advantage what the user has brought to the venture, whose form will depend on the type of activity undertaken." (Estellés-Arolas & González-Ladrón-de-Guevara 2012)

Crowdsourcing is even discussed by Brabham (2008) in his studies. He sees crowdsourcing as " a problem solving model that can be generalized, applied to a variety of industries to solve both mundane and highly complex tasks"(Brabham 2008). What it is in important is to attract a "motivated crowd" from which the answer to the task can be harvested in ways that provides solutions, which are higher in quality and in quantity. The first question asked, in his papers, is how it is possible that this crowd can provide a help to company problems in a better way that the company itself. The answer is the so-called Crowd Wisdom theorized by Surowiecki (2005) in the book *The Wisdom of Crowds,* ha states that under certain circumstances groups can be really intelligent, even more then the smartest individual in the team. Groups have this propriety called emergence: their wisdom does not come from averaging solution or proposal, but combining them. The right environment for all of these to happen is the web. The Internet provides the perfect infrastructure that is capable of aggregating "millions of independent ideas in the way markets and intelligent voting system do". The web eases the exchange of independent and diverse opinions in a decentralized way; it is the aggregator of this diversity of thoughts.
As it was defined, crowdsourcing can be similar to a commonly used practise among companies, especially in software development, the open source production. This kind of initiative allows the test of the fundamental features of a product to the ones who are willing to suggest an improvement to it. This is made possible by sequential releases of the product that includes step by step the several suggestions proposed. Open source development is mainly used for software and the main actors of those

initiatives are hobbyists, which give for free their help and share their knowledge because they are the first users of those services. When a practise like that is applied to a usual product, human beings are not that likely to give their talent and knowledge for free to help the construction of something that is going to generate profit for the firm. As said by Braham “Crowdsourcing, [...], overcomes these limitations in the open source model by providing a clear format for compensating contributors” (Brabham 2008). Crowdsourcing is a hybrid model that merges the democracy of open source in a profitable way to do business. Those companies harvest solutions from the crowd and they have the potential to maximize returns on those solutions.

As it has been stated crowdsourcing takes the best aspects from the open source philosophy, but anyways it has its drawbacks. One of them is the negative impact that this practise can have on the labour pool or the crowd. Let’s take the example of Threadless. This is a website firm that crowdsource designs for t-shirt through a continuous online competition. Anyone enrolled user in the website is granted with the possibility to vote for designs or to submit their own proposal by downloading the template from the website. The voting time range is two weeks long and after that the most voted t-shirts are produced ad made available for sale. The winners receive a prize: US$ 1,500 in cash, a gift card of US$ 500 to be used on the website. If this reward is compared to the amount of money the company makes out of them and the average wage of professional clothing designers, the payback is really low. Crowdsourcing companies make profits exploiting the crowd skills. On a micro-level crowdsourcing is having a negative impact on the job markets and ruining careers, but on a macro-level it is reconnecting workers and involving consumers in the design process.

Crowdsourcing, as it was defined so far, can be a strong mean in the hands of companies and they can apply it in several ways and take different benefits from it. Vukovic in Crowdsourcing for Enterprises provides a general taxonomy of the way by which companies applies crowdsourcing and gives a framework of the process and the required features that a crowdsourcing platform has to have.

The taxonomy proposed has two main classification dimensions: the crowdsourcing function and the crowdsourcing mode. Starting from the first one, the crowdsourcing function means “the part of the product and/or service lifecycle that is being outsourced” (Vukovic 2009) and it can take one of this different forms:

- Design process: the company benefits from the innovation, inventiveness and creativity of the masses. This can happen by receiving designs from the crowd or asking to people to evaluate proposal by people feedbacks on the platform. Good examples of those are Thereadless, already mentioned above, and IStockPhoto, a photograph digital marketplace.

- Product development and testing: this is quite similar to open source and those systems gather scalable workforce and expertise matching. It is mostly used in software development, like PeoplePerHour and Mob4Hire.
- Marketing and sales: many companies used crowdsourcing in those functions to benefit from crowd analytics. Examples are PeerToPatent, which opens the patent examination process involving community reviewers to analyse the patent applications. Marketocracy identifies best investors and monitor their trading activity.
- Support: supporting function to the business can be crowdsourced leveraging so called community information system, on-line help system that are like online forums but with social networking capabilities. A good example here is Amazon Mechanical Truck, which provides a marketplace for micro tasks like content creation, testing, and development. Another example is Askville, again from Amazon, which is a social community site, where users answer questions about a topic in a gaming environment earing reputation on specific subjects.

The other dimension of the categorization is the crowdsourcing mode which says if the request is made like an offer, where jobbers has to bid to obtain the task, so it like a marketplace; or if there is a competition and the winning submission is chosen.

The result of this bi-dimensional taxonomy is the following matrix in which companies can be put according to their business model:

	Crowdsourcing Function			
Crowdsourcing Mode	Design and Innovation	Development and Testing	Marketing and Sales	Support
Competition	Threadless	PeoplePerHour	Marketocracy	Askville
Marketplace	IStockPhoto	Mob4Hire	PeerToPatent	Amazon Mechanical Turk

Table 1 Crowdsourcing initiatives' taxonomy

Among those several application of crowdsourcing what they have in common are the different stages of delivering the crowdsourcing request, those four phases characterise in general a crowdsourcing initiative and they determine its success.

1. *Registration and specification*: the first stage of the process is the moment in which providers and requestors enrol in the platform. What is important here is the identity verification and the validation of users' skills. The requestor has to

post the task, it intends to crowdsource with all the needed specifications and the start and the end date.

2. *Initialize crowdsourcing contest*: the second phase starts when the platform advertises on the website the request among the providers both in a marketplace or competition call. Here the providers' discovery occurs and there can be the possibility to form up virtual team in order to improve the request.
3. *Carry out crowdsourcing request*: the platform is like a broker between the requestors and the providers, once the connection between them is established, the platform has to guarantee the provider all what he needs to undertake the request.
4. *Complete the crowdsourcing request*: once the jobber has completed the request, he has to submit it to the platform and after the requestor has to validate the results according to different criteria, this step can be automatic through the use of algorithms or made by humans. Once confirmed the completion of the request, the platform gives the award for the task accomplished and usually both actors, requestor and jobber, are requested to give a feedback about the experience.

A crowdsourcing platform properly works only if all those four requirements are guaranteed.

Crowdsourcing can be seen, finally, as an important mean from which companies can gain a lot from the crowd in terms of innovation or workforce that they want to externalise. Crowdsourcing was applied in several industries and across several business activities. In the product innovation and in the co-creations of the offer companies often involves the crowd, good examples can be My Starbucks Idea, where Starbucks customer can propose their own coffee based drink, or Lego, which opened a request on its website asking customers to suggest their ideas about Lego sets to be produced and commercialized. Crowdfounding is a successful application of crowdsourcing in the capital raising market. Among the several start-ups that populate this business, the most famous one, is Kickstater, where people can post on the platform their creative projects and they ask for being founded by other people, since the website was opened 12 million people backed a project and almost 115 thousand project were successfully financed. Another interesting example is Waze, which is one the most successful crowd powered start-up. This app works thanks to users' reports on traffic jams and through the monitoring of their speed he app suggest them then best way to reach a destination. Waze was bought by Google in 2013 for 1.15 billion dollars.

As those examples report crowdsourcing can be applied and exploit in several different industries. Among them, there is even the delivery service, companies are used to outsource this service to external providers like logistics couriers, but thanks to the spread of Internet this industry can be crowdsourced and both company and the crowd can benefit from it.

The objective of this research is to understand and analyse how crowdsourcing logistics is carried out and which benefits companies can gather from it, particularly the ones operating in B2C ecommerce where delivery expenses have a great impact especially in the last mile delivery.

The research will be structured as follow:

1. **Literature review and gap analysis**: the first step will be a research of papers in academic literature to understand the existing body of knowledge about this topic and evaluate which parts of the topic are not covered by scholars.
2. **Taxonomy of existing companies**: being a new industry an analysis of all the actors involved leads to a better and deeper understanding of the characteristics of this business.
3. **Model development**: understood all the previous steps, the development of a model lets acknowledge the benefits of such a practise can have on different stakeholders of the process

The main goal of the dissertation will be answering to the following research questions:

RQ1: “*What is the status quo of the scientific literature regarding crowdsourcing logistics?*”

RQ2: “*Which are the business models that characterise the crowdsourcing logistics industry?*”

RQ3: “*When is it convenient to use crowdsourcing logistics versus normal couriers?*”

Literature Analysis

Introduction

The literature review has as a general objective the research and the analysis of scientific papers regarding crowdsourcing logistics and its application in the last mile delivery.

Scope of analysis

The research is carried out to examine the scientific literature related to crowdsourcing logistics and its application in the ecommerce, especially in the last mile delivery. The ultimate scope is to have a general overview on scientific research about this theme and understand the existing body of knowledge, identifying the possible gaps and predicting which could be the future research direction of this subject.

In order to have a more comprehensive and deeper understanding of the theme, the search has been expanded from crowdsourcing logistics even to the last mile logistics characteristics. By doing this there are two main objectives: on one hand, the aim will be to understand if in the academic research regarding crowd shipping there will be any reference to its application in the last mile delivery or in ecommerce; on the other hand, looking for last mile delivery related articles, test if any mention is made about crowd shipping especially in those paper regarding innovation and new way to solve criticalities of home delivery. To sum up in a main research question:

RQ1: "*What is the status quo of the scientific literature regarding crowdsourcing logistics?*"

Methodology

The literature review was developed following the methodology applied in Mangiaracina et al. (2015) and Perego et al. (2010). A three-step process was applied (figure 1). In the first phase several papers were collected and selected, the second stage was analysing all the scientific articles with a consequential reduction of some of the papers, which did not match specific requirements. Finally, the last phase is related to gaps identification and future research directions.

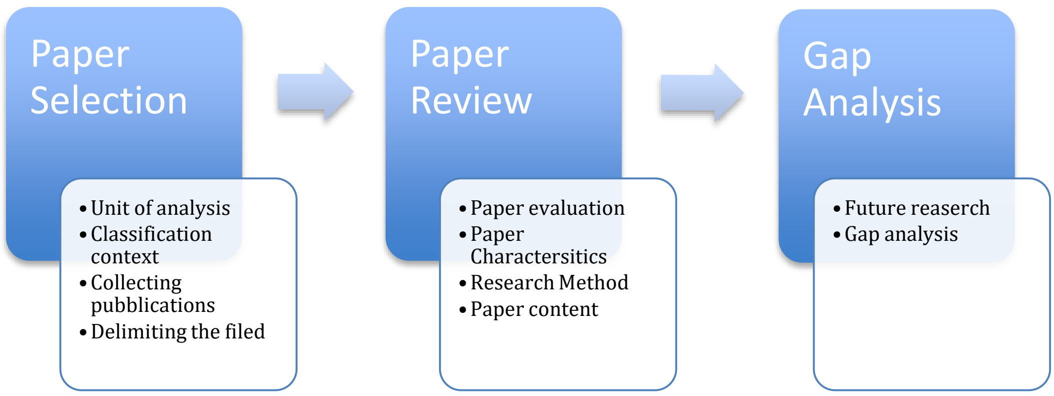


Figure 1 Literature Analysis flow chart

Phase 1: Paper selection

This first phase is made by different stages according to the literature analysis of Srivastava (2007) in Mangiaracina et al. (2015).

- *Defining the unit of analysis*: the unit of analysis is the single research paper published on scientific journal or in proceedings of international meetings.
- *Classification context*: the first thing to be define is the context in which this literature review is carried out, in this case the application of crowdsourcing logistics in ecommerce delivery, focusing mainly on the last stage of the shipment, the last mile delivery where the box is delivered to the customer house.
- *Collecting publications*: A search by keyword was conducted using library databases (e.g. Scopus, Science Direct, etc), search engines like Google Scholar and the Politecnico di Milano library system Biblio.Polimi. The search has been done both in the abstract and in the paper main body using keywords and strings varying them with synonyms to be sure not exclude any resource.

  For crowdsourcing logistics, the looked up terms were "Crowdsourcing logistics", "Crowd shipping", "Crowd delivery", "Crowd logistics" and "Social delivery".

  For the last mile delivery, the looked up words were "Ecommerce delivery", "Ecommerce shipment", "Ecommerce Logistics", "Last mile logistics" and "Last mile delivery". This method let the analysis of the most relevant papers and several conference proceedings published in management and logistics journals.

The most relevant sources are:

- Transportation Science
- Environmental Science & Technology
- International Journal of Physical Distribution & Logistics Management
- Journal of Cleaner Production
- Innovation and Strategies for Logistics and Supply chains
- IEEE Transaction on Engineering Management
- Journal of Business logistics
- European Transport
- Asia Pacific Journal of Marketing and Logistics
- Transportation Research

- *Delimiting the field*: during the examination some of the papers found were taken away because of they were not published on a scientific journal or peer reviewed. For crowd sourcing logistics no time limitation was applied, being this subject relatively new; regarding the last mile logistics paper from the last 12 years were taken into account, with some exceptions.

In the end 32 papers published in the last 12 years have been selected and deeply examined and analysed.

Phase 2: Paper Review

The paper reviews started with a careful reading of all the contribution found, they were summarised and the main topics highlighted. After this deeper analysis a further selection were needed because some of the papers were not marching exactly the research field, they were not published in a peer reviewed scientific journal or simply not relevant to the overall discussion.

Different review method used in literature review publications were examined (Perego et al. 2010; Mangiaracina et al. 2015). Following the aim of having a general overview of state-of-art analysis of scientific literature, the selected contributions were classified according to:

- Main characteristics such as authors, publication year, journal title
- The research method used: here five main methodologies were identified and they can be divided in qualitative and quantitative approaches:
  - Case Study: a real case is described and analysed in the paper.
  - Survey: a questionnaire is the base from which the paper is written and developed.

    - Framework: in the paper information are collected, classified and generalized.
    - Simulation: starting from real database some calculation and computation are done in order to obtain a result.
    - Analytical Model: in the paper there is the development of a mathematical model starting from theoretical or empirical data.
- Their content: all the paper listed were deeply analysed as described before, therefore macro themes were identified and the different articles are classified according to them. In the following sections both from crowdsourcing logistics and last mile delivery the macro themes will be stated and explained.

In table 1 the papers analysed are presented following the classification scheme presented before:

Table 2 Scientific papers' classification

N	Authors	Year	Title	Source	Methodology	Focus
1	Punakivi, YrjoÈlaÈ, HolmstroÈm	2001	Solving the last mile issue: reception box or delivery box?	International Journal of Physical Distribution & Logistics Management	Simulation	Last Mile Delivery
2	René	2003	Distribution Strategies for Online Retailers	IEEE Transactions on Engineering Management	Survey	General
3	Boyer, Frohlich, Hult	2004	Chapter 8: Supply Chain Design - How to Bridge the Last Mile	Extending the Supply Chain	Framework	General, Last Mile Delivery
4	Cho, Ozment, Sink	2007	Logistics capability, logistics outsourcing and firm performance in an e-commerce market	International Journal of Physical Distribution & Logistics Management	Framework	General, Last Mile Delivery
5	Boyer, Prud'homme, Chung	2009	The last mile challenge: evaluating the effects of consumer density and delivery window pattern	Journal of Business Logistics	Simulation	General, Last Mile Delivery
6	Yu, Xiu-yan	2010	Study of Physical Distribution of B2C ecommerce model	International Forum on Information Technology and Applications	Framework	General, Last Mile Delivery
7	Fenie, Sparks, McKinnon	2010	Retail logistics in the UK: past, present and future	International Journal of Retail & Distribution Management	Survey	General
8	Greasley, Assi	2011	Improving "last mile" delivery performance to retailers in hub and spoke distribution systems	Journal of Manufacturing Technology Management	Case Study	Last Mile Delivery
9	Chen, Chang, Hsu, Yang	2011	Understanding the relationship between service convenience and customer satisfaction in home delivery by Kano model	Asia Pacific Journal of Marketing and Logistics	Analytical Model	General

N	Authors	Year	Title	Source	Methodology	Focus
10	Yao, Zang	2011	Pricing for Shipping Services of Online Retailers: Analytical and Empirical Approaches	Proceedings of the 44th Hawaii International Conference of System Science	Analytical Model	General
11	Suh, Smith, Linhoff	2012	Leveraging Socially Networked Mobile ICT Platforms for Last-Mile Delivery Problem	Environmental Science & Technology	Simulation	Last Mile Delivery, Crowdsourcing Logistics
12	Ghezzi, Mangiarancina, Perego	2012	Shaping the E-Commerce Logistics Strategy: a Decision Framework	International Journal of Engineering Business Management	Framework	General, Last Mile Delivery
13	Gonzalez, Ambrosini, Routhier	2012	New trends on urban goods movement: Modelling and simulation of e-commerce distribution	European Transport	Analytical Model	General
14	Vanelslander, Deketele, Van Hove	2013	Commonly used e-commerce supply chains for fast moving consumer goods: comparison and suggestions for improvement	International Journal of Logistics Research and Application	Analytical Model	General, Last Mile Delivery
15	Gevaersa,Van de Voordea, Vanelslandera	2014	Cost Modelling and Simulation of Last-mile Characteristics in an Innovative B2C Supply Chain Environment with Implications on Urban Areas and Cities	8th international conference on city logistics	Simulation	Last Mile Delivery
16	Wang, Zhan, Ruan, Zhang	2014	How to choose "Last Mile" delivery modes for e-fulfilment	Mathematical Problems in Engineering	Analytical Model	Last Mile Delivery
17	Rougès, Montreuil	2014	Crowdsourcing delivery: new interconnected business models to reinvent delivery	1st international physical internet conference	Framework	Crowdsourcing Logistics

N	Authors	Year	Title	Source	Methodology	Focus
18	Chen, Zhang, Han, Sha	2014	TaxiExp: A Novel Framework for City-wide Package Express Shipping via Taxi Crowdsourcing	ResearchGate - Conference Paper	Simulation	Crowdsourcing Logistics
19	Mladenow, Bauer, Strauss	2015	Crowdsourcing in Logistics: Concepts and Applications Using the Social Crowd	ICPS - International Conference Proceedings Series	Framework	Crowdsourcing Logistics
20	Pan, Chen, Zhong	2015	A solution to collect e-commerce reverse flow in metropolitan areas	HAL	Simulation	Crowdsourcing Logistics
21	Mehmannn, Frehe, Teuteberg	2015	Crowd Logistics - A literature review and maturity model	Innovation and Strategies for Logistics and Supply chains	Mixed	Crowdsourcing Logistics
22	Chen, Pan	2015	Using the crowd of taxis to last mile delivery in e-commerce: a methodological research	HAL	Analytical Model	Crowdsourcing Logistics
23	Slabinac	2015	Innovative solution for a last mile delivery: an European experience	15th international scientific conference Business Logistics in Modern Management	Framework	Last Mile Delivery
24	Sakia, Marei, Blanquart	2015	Innovations in e-grocery and logistics solutions for cities	The 9th International Conference on City Logistics,	Framework	Last Mile Delivery
25	Paloheimo, Lettenmeier, Waris	2015	Transport reduction by crowdsourced deliveries - a library case in Finland	Journal of Cleaner Production	Case Study	Crowdsourcing Logistics
26	Cohen	2015	Sharing cities and sustainable consumption and production: towards an integrated framework	Journal of Cleaner Production	Framework	Crowdsourcing Logistics

N	Authors	Year	Title	Source	Methodology	Focus
27	Carbone, Rouquet, Roussat	2015	"Carried away by the crowd": what types of logistics characterise collaborative consumption	1st International Workshop on Sharing Economy, At Utrecht, Netherland	Survey	Crowdsourcing Logistics
28	Arslan, Agatz, Kroom, Zuidwijk	2016	Crowdsourced delivery - a pickup and delivery problem with ad-hoc drivers	Thesis	Simulation	Crowdsourcing Logistics
29	Savelsbergh, Woensel	2016	City Logistics: Challenges and Opportunities	Transportation Science	Framework	General, Last Mile Delivery
30	Weinelt	2016	World Economic Forum White Paper Digital Transformation of Industries: Logistics	World Economic Forum	Framework	General, Crowdsourcing Logistics
31	Wang, Zhan, Liu, Shen, Lee	2016	Towards enhancing the last mile delivery: An effective crowd-tasking model with scalable solutions	Transportation research	Analytical Model	Crowdsourcing Logistics

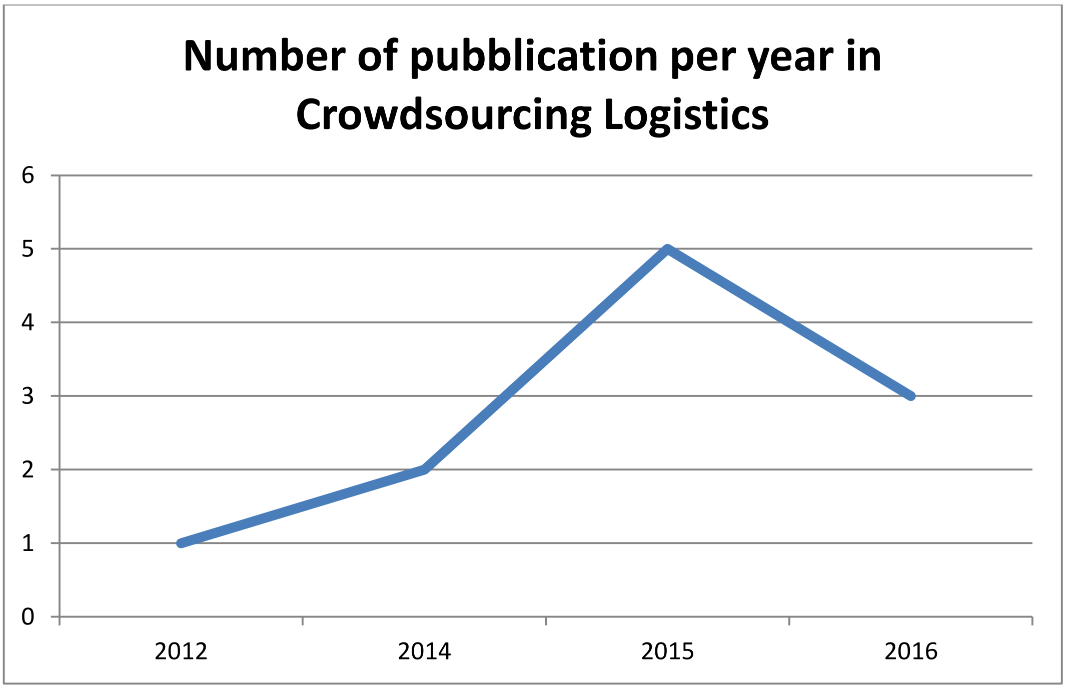
Summary of review and discussion

The discussion is split between the two main subjects of this review, the crowdsourcing logistics and the last mile delivery. The chapter will be divided as follow: for the two topics all the papers found will de analysed according to the publication year, the research method, and finally the topic addressed. Only in the end the two topics will be jointed again in the final discussion of the results.

Crowdsourcing logistics

The research leaded to find only 13 papers about crowdsourcing logistics (CL), even if the research was made among the papers published in the last decade. The low number of publications is a recurring matter stated by almost every author in their paper (Mehmann et al. 2015; Carbone et al. 2015a; Rougès & Montreuil 2014). Indeed crowdsourcing logistics is relatively new business and “still in its infancy […][with] few high quality studies” (Mehmann et al. 2015).

Looking at the **publication year** we see how these theme is new to academics research, indeed the first article was published in 2012 (Suh et al. 2012), before no articles were found, then there is peak during last year, 2015, where 62% of the papers were published. Anyway how it can be seen from the Graph 1 there is growing number of publication about this topic, the value is for 2016 considered only the first semester of the year, when this research is written.



Graph 1 Number of publications per year in crowdsourcing logistics

The second classification axis is the **research method** used in the different articles, the papers were divided according to the categories defined before. Results are shown in table 2.

Research Method	**Number**	**Percentage (%)**
Framework	5	38%
Simulation	4	31%
Analytical Model	2	15%
Case Study	1	8%
Mixed	1	8%
Total	13	100%

Table 3 Research method used in crowdsourcing logistics papers

The most used method in the sample is the framework 38%, followed immediately by the simulation at 31% and the analytical model at 15%. There is only one literature review about crowdsourcing logistics that is listed as mixed method because in the same paper even a maturity model, a framework, is developed. There is low number of case studies in academic research whereas it is plenty of articles and essays in specialised press, mass media and blogs, this testifies, again, the novelty of the theme (Carbone et al. 2015a).

The last classification dimension is the **topic** on which the papers focus on, several macro subjects have been identified and the articles were classified according to them:

- General: the paper is about the overall characteristics of the business and it gives a qualitative description of it.
- Economical impact: in the essay the economical advantages of crowdsourcing logistics are stressed showing how the solution can lead to costs saving for whom implement it.
- Environmental impact: as for many other example of crowdsourcing experiences even crowdsourcing logistics leads to a better usage of the natural resource and a consequent reduction of CO2 emissions. If this green aspect is addressed in the article, it will be classified under this topic.
- Social impact: this last aspect is related to fact that crowdsourcing platforms can have a positive impact on people life in terms of extra earnings or other intangible benefits.

In the following table 4 all the subjects are listed with associated the paper in which they are discussed, some papers will appear in more than one topic because those articles treat more than one in a relevant way or the solution discussed has impacts on those two areas.

Table 4 Crowdsourcing logistics paper classified by methodology and main topics addressed

Authors	Title	Method	Main topics			
			General	Economical advantage	Environmental Advantage	Social advantage
Suh, Smith, Linhoff	Leveraging Socially Networked Mobile ICT Platforms for Last-Mile Delivery Problem	Simulation		X	X	
Rougès, Montreuil	Crowdsourcing delivery: new interconnected business models to reinvent delivery	Framework		X	X	
Chen, Zhang, Han, Sha	TaxiExp: A Novel Framework for City-wide Package Express Shipping via Taxi Crowdsourcing	Simulation		X		
Mladenow, Bauer, Strauss	Crowdsourcing in Logistics: Concepts and Applications Using the Social Crowd	Framework		X	X	
Pan, Chen, Zhong	A solution to collect e-commerce reverse flow in metropolitan areas	Simulation		X	X	X
Mehmann, Frehe, Teuteberg	Crowd Logistics - A literature review and maturity model	Mixed	X			

Authors	Title	Method	Main topics			
			General	Economical advantage	Environmental Advantage	Social advantage
Chen, Pan	Using the crowd of taxis to last mile delivery in e-commerce: a methodological research	Analytical Model		X		
Paloheimo, Lettenmeier, Waris	Transport reduction by crowdsourced deliveries - a library case in Finland	Case Study		X	X	X
Cohen	Sharing cities and sustainable consumption and production: towards an integrated framework	Framework	X			
Carbone, Rouquet, Roussat	"Carried away by the crowd": what types of logistics characterise collaborative consumption	Survey	X			
Arslan, Agatz, Kroom, Zuidwijk	Crowdsourced delivery - a pickup and delivery problem with ad-hoc drivers	Simulation		X	X	
Weinelt	World Economic Forum White Paper Digital Transformation of Industries: Logistics	Framework	X			
Wang, Zhan, Liu, Shen, Lee	Towards enhancing the last mile delivery: An effective crowd-tasking model with scalable solutions	Analytical Model		X	X	X

The table provides as interesting summary of the topics discussed in scientific literature regarding crowdsourcing logistics.

The main addressed subjects are the ones regarding economical impacts (40%) and environmental effects (27%) of this practise implementation.

The positive economical impact is demonstrated in those paper through simulations and analytical models, showing as for same day delivery or real time (on demand) delivery crowdsourcing can lead to a lower cost for the shipping company and then a lower price face by final consumer (Suh et al. 2012; Chen et al. 2014). In Wang et al. (2016) a large-scale mobile crowd tasking model is developed and tasted with Singapore and Beijing dataset about buses and taxis. The results of this study show an improvement in city logistics by applying crowd delivery.

Another mainstream subject is the environmental sustainability of crowdsourcing logistics. The main result of applying crowd delivery is in a reduction of the overall number of vehicles in the cities' streets and an exploitation of the idle spaces in people cars, those leading to a reduction in travel distances and consequently in lower carbon emissions. Authors of two papers even evaluate the reduced amount of CO2 emission. In one case the decrease in carbon emission is estimated at 94% for deliveries in an urban environment and 82% in a suburban one (Suh et al. 2012); in the library case study developed by Paloheimo et al. (2015) the trail results in a saving 149 km and a consequent reduction of material footprint of 55 per cent and air consumption of 60 per cent (Paloheimo et al. 2015).

The low number "general" papers about crowdsourcing logistics can be another consequence of the novelty of this industry. Researchers write about simulations and frameworks focuses only on some aspects of this industry without trying to give an overall and complete view of it, even because some aspect of it has still to be observed. Mahmann tried to infer a definition of crowdsourcing logistics adapting ideas from crowdsourcing, crowdfounding and crowd-working in the field of logistics. This definition is:

"Crowd Logistics designates the outsourcing of logistics services to a mass of actors, whereby the coordination is supported by a technical infrastructure.
The aim of Crowd Logistics is to achieve economic benefits for all stake- and shareholders" (Mehmann et al. 2015)

Another important contribution is a crowd logistics research agenda, which shows how in this filed academic research is still at its first stages, and a maturity model, which is developed in order to evaluate crowd-shipping experiments. In Rougès (2014) and

Carbone et al. (2015) there are two attempts to develop a general framework to better classify and understand different ways to carry out crowdsourcing logistics. After the analysis of several dimensions Rougès identify a typology of five business model: Courier, Intendant, Intra-urban, National, Social delivery. Carbone et al. develop a matrix with type of logistics management, which can be centralized or decentralized, on one axis, and the role played by logistics on the other; the result is four types of logistics as can be seen in the picture named: Peer-to-peer logistics, Business logistics, Crowd-party logistics and Crowd-driven logistics. (Carbone et al. 2015b)

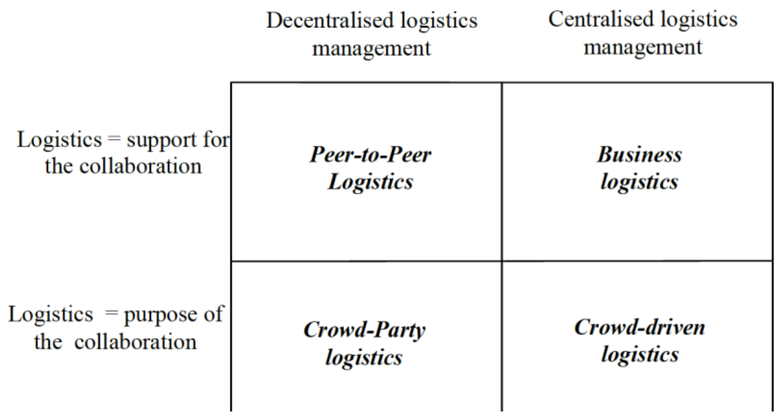


Figure 2 Crowdsourcing logistics matrix

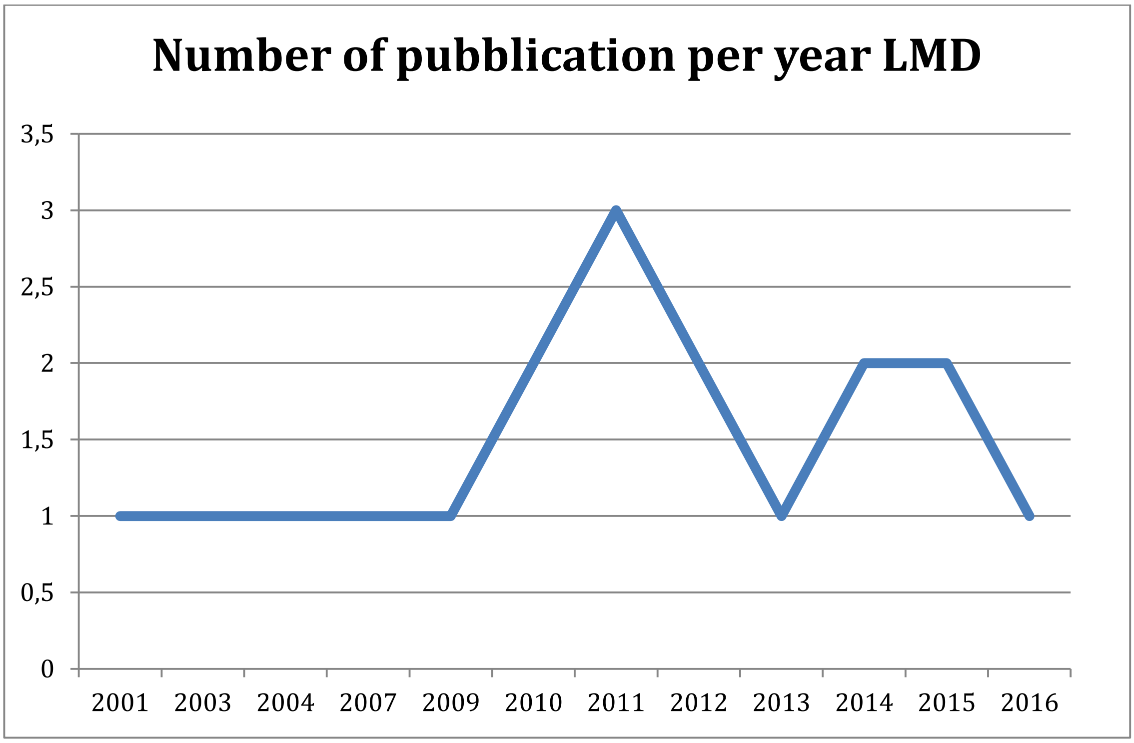
A recurring subject among those articles is related to one of the main pillars of the crowdsourcing, the crowd. Some of the papers found developed simulation and analytical models on existing network like the taxis (Chen et al. 2014; Pan et al. 2015; Chen & Pan 2015), ad-hoc drivers dedicated to the platform (Arslan et al. 2016) and normal people, defined in several ways and all of them connected to the network to get in touch with the platform (Suh et al. 2012; Paloheimo et al. 2014; Wang et al. 2016).

Referring to the overall research another important aspect is the correlation between crowdsourcing logistics and the last mile delivery. Among this 13 papers found regarding the crowdsourcing logistics the 23% of them deals with even with last mile delivery. In those paper crowdsourcing logistics is presented as a possible solution for last mile shipment (Wang et al. 2016; Chen & Pan 2015; Suh et al. 2012).

Last mile Delivery

The research leaded to find 18 papers about last mile delivery and ecommerce more in general. The paper selection was again made among recent publications dated since 2001. Compared to crowdsourcing this theme is not that recent and thus the total amount of papers is bigger. The aim here was not to have comprehensive literature review about this subject but to look for possible solution to the so-called last mile delivery problem and some innovations that could have help in solving it.

Considering the publication year, as it can be seen, those publications are equal distributed from 2001 to 2016, with a peak in 2011.



Graph 2: Number of publication per year of last mile delivery

Looking at the methodology applied in developing those papers in table 5, a different distribution can be seen from the crowdsourcing logistics ones. Most of the papers are frameworks (50%) and analytical models (28%). Those two research methods are connected probably to a longer lifetime of ecommerce that lead to a better understanding of the theme. Consequently, there is a more structured theoretical knowledge about this theme and this is testified by the frameworks, and a better aim to develop solutions that deeply analyses the issues related to it. Here even a survey can be found, research method that was not present among crowdsourcing logistics papers

Research Method	Number	Percentage (%)
Framework	9	50%
Analytical Model	5	28%
Simulation	3	17%
Survey	1	6%
Total	18	100%

Table 5 Research method used in last mile delivery papers

Regarding the topic addressed by the papers, three macro areas where identify to group up the different papers and to give an easier understanding of their content. The tree main subjects are:

- Criticalities: this macro theme regards all the issues related to the last mile and home delivery of ecommerce parcels
- Efficiency: this subject is related to all those papers that highlight the impact of different variables on the
- Innovation: in this segment are put all those papers that deal with the possible actual or futuristic innovation that will change the last mile delivery problem

Table 6 Last mile delivery papers classified by methodology and main topics addressed

Authors	Title	Method	Topic		
			Criticality	Efficiency	Innovation
Punakivi, YrjoÈlaÈ, HolmstroÈm	Solving the last mile issue: reception box or delivery box?	Simulation	X	X	
René	Distribution Strategies for Online Retailers	Survey	X		
Boyer, Frohlich, Hult	Chapter 8: Supply Chain Design - How to Bridge the Last Mile	Framework	X	X	
Cho, Ozment, Sink	Logistics capability, logistics outsourcing and firm performance in an e-commerce market	Framework	X	X	
Boyer, Prud’homme, Chung	The last mile challenge: evaluating the effects of consumer density and delivery window pattern	Simulation	X	X	

Authors	Title	Method	Topic		
			Criticality	Efficiency	Innovation
Yu, Xiu-yan	Study of Physical Distribution of B2C ecommerce model	Framework	X		
Fenie, Sparks, McKinnon	Retail logistics in the UK: past, present and future	Survey	X		
Greasley, Assi	Improving "last mile" delivery performance to retailers in hub and spoke distribution systems	Case Study		X	
Chen, Chang, Hsu, Yang	Understanding the relationship between service convenience and customer satisfaction in home delivery by Kano model	Analytical Model		X	
Yao, Zang	Pricing for Shipping Services of Online Retailers: Analytical and Empirical Approaches	Analytical Model	X	X	
Ghezzi, Mangiarancina, Perego	Shaping the E-Commerce Logistics Strategy: a Decision Framework	Framework	X	X	
Gonzalez, Ambrosini, Routhier	New trends on urban goods movement: Modelling and simulation of e-commerce distribution	Analytical Model		X	
Vanelslander, Deketele, Van Hove	Commonly used e-commerce supply chains for fast moving consumer goods: comparison and suggestions for improvement	Analytical Model	X	X	

Authors	Title	Method	Topic		
			Criticality	Efficiency	Innovation
Gevaersa,Van de Voordea, Vanelslandera	Cost Modelling and Simulation of Last-mile Characteristics in an Innovative B2C Supply Chain Environment with Implications on Urban Areas and Cities	Simulation		X	
Wang, Zhan, Ruan, Zhang	How to choose "Last Mile" delivery modes for e-fulfilment	Analytical Model	X	X	
Slabinac	Innovative solution for a last mile delivery: an European experience	Framework			X
Sakia, Marei, Blanquart	Innovations in e-grocery and logistics solutions for cities	Framework	X		X
Savelsbergh, Woensel	City Logistics: Challenges and Opportunities	Framework	X	X	X

An overall learning from this table is that papers dealing with criticalities and efficiency are the same number in the sample of scientific contributions and most of the times those two subjects are discussed in the same paper. This shows how those two streams are both really relevant and correlated in the scholars' studies. The innovation cluster is smaller compared to the others only three relevant articles were found about this subject.

Starting from **Criticalities**, this macro category is related to all the issues, problems, and then expenses that an online merchant has to face when it has to ship a parcel. The main difference with offline logistics compared to ecommerce one is the "small distribution volume and distribution of high frequency" (Gu & Geng 2010) and this affects in certain way all the development and the choices that has to be made in developing the supply chain for ecommerce. The first decision that merchants or logistics couriers have to make is to go for an attended or unattended home delivery. In the first case the consumer has to present at the moment of the box arrival for several reason(Campbell & Savelsbergh 2006), the latter happens where there is no one at home waiting for the shipment. Another important aspect is the “desire for speed”, e-tailers are offering more and more faster delivery solution within a day or even in one or two hours and clients are likely to pay more for their deliveries in order to have their shipments sooner(Savelsbergh et al. 2016). This of course implies supply chain complexity in order to guarantee this higher service level. Supply chain configuration is even another theme discusses among the scholars. In Vanelslander et al. 2013 there is an interesting comparison among different configurations of supply chains differentiating among parcels’ delivery for only-online pure players and brick and mortar delivery, and discussing where shipping activities can be outsourced or not. Ghezzi et al. 2012 identify the relationship between logistics staregies and logisitcs problems in the ecommerce of physical goods. The factors affecting the logistics problems can be product or service related. In the first case the drivers are value density, product range and obsolescence risk, in the second one the variables are the order cycle times, the returns and the punctuality. Those issues have different relevance according to the industry and the typology of the merchant, and they have an impact of the logistics strategy implemented by the company. Relationship between customer service, internal organizational complexity, and existence of a traditional distribution channel are argued by de Koster (2014). Again a comparison between best practises in term of dedicated or share channels is made to understand which configuration those actors have. In case of traditional companies selling online, it usually exploits its existing offline network and assets, like point of sales, to deliver parcel even for the ecommerce and online players ship directly from the delivery warehouse to the final consumers’ houses.

The security problem that could arise in unattended delivery is solved by Punakivi et al. 2001 with their proposal to use secured delivery box or costumer specific reception box, which are respectly owned by the merchant or the clients. This solution tries to cut down the high expensies related to the attended home delivery storing the prodcuts in a safe packaing. A further research is made by Wang at al. (2014) starting from the Pulakivi et al. (2001) contribute comparing its solution with attended home delivery and collection and delivery points.

The second macro theme of **efficiency** is strictly related to the criticalities; indeed, in order to be efficient and profitable merchants have to overcome the criticalities of this industry and here are proposed some possible solutions to achieve this goal. Considering the supply chain design there are studies that suggest separating retails (on-line orders) and non-retails deliveries (point of sales replenishment), having them different specifications and consumers' needs, in spite of a higher driver and fuel cost. (Greasley et al. 2012). More recent publications state as using the offline existing network can be an advantage for e-tailers, which can duplicate the function of their point of sales using them as distribution centres closer to final consumers. (Savelsbergh et al. 2016). Chen et al. (2011) reflect in their paper about which are the those attractive service elements that better satisfiy consumer needs in home delivery in order not to waste company resourcing in investing in unappreciated services.

In Ghezzi et al. (2012) a picture of the Italian ecommerce environment is drawn and according to the different level of logistics problems and strategies. Here different types of actors in ecommerce are associates to the level of logistics complexity they face and which strategy they apply to solve it: complete online sellers can have both supplier full managed inventory or consignment inventory, online clubs use mostly supplier managed inventory and traditional sellers managed all their inventories but facing higher logistics problems compared to the others.

A recurring subject in those articles is the relationship between customer density and cost per delivery in the last mile shipment made by a company, which directly deliver to the final consumer. This topic has been discussed by Boyer et al. (2009) providing the function that relates those two variables. Consumer density is defined as the number of consumers in the delivery area and, then, the stops that have to be made by the deliver. Greater customer density in a given area increases the efficiency for the delivery in that place, the curve has a negative quadratic component as it can be seen in the graph. (Boyer et al. 2009)

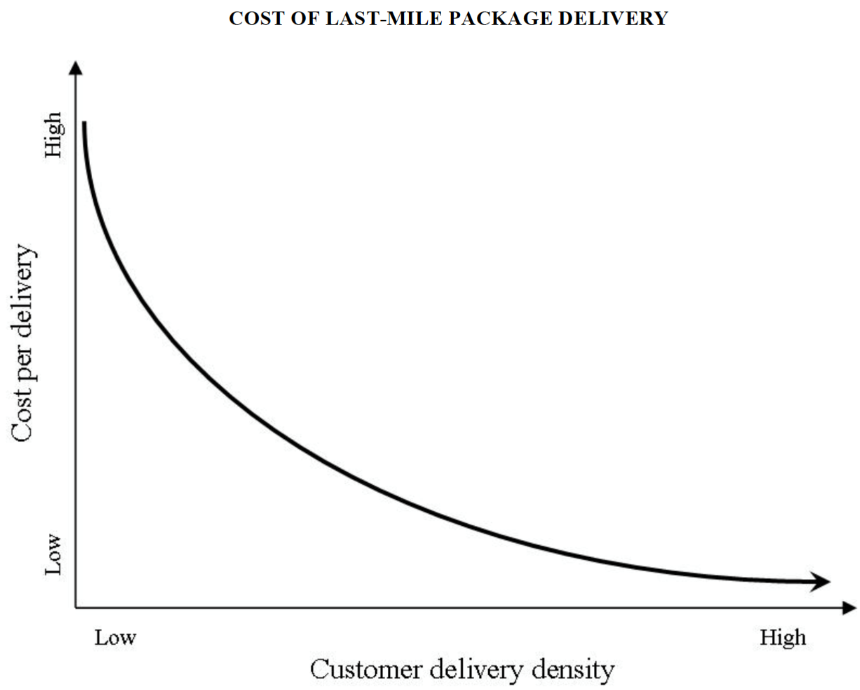


Figure 3 Cost per delivery and customer delivery density distribution

Considering the high impact that last mile delivery has between 30% and 50% according to the probability of failure at the first time (Vanelslander et al. 2013; Boyer et al. 2009), some scholars discuss even the possibility to outsource this activity, but logistics outsourcing and firm performances were not found to be positively correlated. Strong logistics capabilities are related to good performances in an ecommerce environment; companies that outsourced logistics do not have better performance than non-outsourcing ones, furthermore the formers perform poorly compare to the latter in terms of gross and net profit margins. (Cho et al. 2008)

The **innovation** group of papers is low in the entire sample, only the 11%. Between the innovation articles two perspectives can be identified: the first one is related to the innovation achieved so far and the second one is projected to the future, in these papers possible futuristic scenarios are evaluated according to the recent trends in logistics and more specifically in last mile delivery.

In the grocery industry according to Saskia et al. 2016 several innovative actions are taking place in Germany and in France and those solutions are listed and compared. Among the different examples provided, *Bounduelle* case is interesting; it managed to dis-intermediate the channel to deliver branded fresh food directly to consumer house, or *Kochhaus.de*, a German company that sells food in combination with recipes, the consumer chooses one of them and all the ingredients are provided. Another main trend highlighted by this article is that the fresh food delivery is becoming more and more popular among delivery operators, even with chilled lockers (Saskia et al. 2016).

Other research focuses on more innovative solution in a future perspective, for instance Slabinac (2015) makes a list of possible innovative and futuristic delivery vehicles that in the future can bridge the last mile delivery. Here follows the list with the most important ones:

- <u>Bikes</u> will have an important role in the future, they are agile in traffic and environmentally friendly, possible further developments of this vehicle are electric bikes with big bagged holder that allows to bundle the delivery of several parcels.
- <u>Small electric vehicles</u> like V-Feather or Deliver, the former one is made by modules for carrying different types of goods, the latter has a very large load capacity.
- <u>Delivery drones</u> automatically piloted aerial vehicles.
- <u>Self-driving road vehicles</u> like small robots that can carry one single parcel to the final receiver with controlled delivery path, temperature and handling modes.

- Capsules to be used in underground transport pipeline system, that can be even used for freight transportation

All those innovative vehicles can be developed and applied in next years, some of them in a closer time, like the drones, some other in a longer time frame. Most of the problems here arise from regulations that could restrict their applications. Among those futurist solutions, even crowdsourcing logistics is quoted, it is seen as a new approach with some practicability and reliability issues, but it is seen as a way to reduce shipping cost while enabling same day delivery (Slabinac 2015).

Crowdshipping is analysed even by Savelsbergh (2016), who exposes the experience of Wal-Mart in making its own customers delivers of other clients' orders where they live in the same neighbourhood. In the same paper even collaborative way of doing business like sharing logistics infrastructures with competitors is analysed. Looking at the future crowd shipping is seen as a " fertile environment to study delivery routing problems"(Savelsbergh & Woensel 2016).

Conclusions and Identified Gaps

The literature review discussed had as main objective the understanding the state of art of crowd shipping in academic research. The 32 papers were analysed in order to pursue this aim. The results of the research show how crowdsourcing logistics is still a new subject to scholars and the few number of papers available testifies this. Anyway this theme is getting its momentum; it can be assumed that the growing number of publications in the recent years shows as the interest in this subject is increasing.

Looking at the papers about crowdsourcing, what it is missing is a general framework that can describe this industry and this should be the future objective for researchers in order to better and deeper understand this them. Crowdsourcing logistics as a solution for the last mile problem is a subject that is not really popular in the articles analysed. Academics theoretically see it as a possible solution or an improvement to this issue, but what have not been found are a rich and complete literature and a high number of practical application studies.

There is not any kind of predominance of one type of research method over the other; simulations and analytical models are the most used among the scholars. Regarding the themes, the economical and environmental advantages are most discussed ones and the results are inferred by mathematical simulation over already existing data from other fields. There are no surveys or researches based on real data collected exclusively in this field. In only two cases there are attempts to organise this business into a classification, but the final result is not clear and complete, especially because the pace of change in this industry is high, so the examples brought by the authors are not actual anymore.

In the last mile delivery field, crowd shipping is seen and listed among the possible innovative remedies, which could be implemented in the future, with other transportations innovation that will reshape the home delivery landscape in the following years. One main gap is the lack of any simulation or analytical model that can practically show the improvement that crowd shipping could bring in last mile delivery in terms of lower costs for the merchants.

To sum up it is clear how this subject is still at first stages in academic research. This is firstly testified by the scarcity of scientific papers regarding this subject. Furthermore, among the published articles, the theme is not the main focus of the papers, and, when it is, the methodologies applied are mainly simulations or analytical model. Few general frameworks that deeply explain crowdsourcing logistics and gives detailed analysis of its peculiarities, advantages and disadvantages, are found.

Future research should be focus on finding the right way to implement crowd shipping in the last mile delivery, but before all the aspects of this business have to be discussed and analysed, both the advantages and the possible drawbacks and risk that could arise from the application of such a practise. A deeper understanding could come from systematic studies upon real business cases, which are already discussed in publications for general public in books and blogs, but not in the scientific literature.

Crowdsourcing Logistics Taxonomy

The literature analysis presented identified crowdsourcing logistics as field that is not very discussed among scholars in academic papers or journals articles. In order to have a better understanding of crowdsourcing logistics industry the research will continue with a classification of the different players operating in this industry with a detailed analysis of their business model.

Taxonomy development

The development of taxonomy is a way to organize knowledge in a field of interest. Indeed "the classification of objects helps researchers and practitioners understand and analyze complex domains" (Nickerson et al. 2012).For instance the taxonomy made by Linnaean or Maslow respectively in the natural world and in social science.

Taxonomies can be defined as "*classification systems that categorize phenomena into mutually exclusive and exhaustive sets with a series of discrete decision rules*."(Doty & Glick 1994). They are useful when little is known about a topic, or the knowledge regarding it is not well organized in a meaningful way (Strode 2016). Baily (1994) states that taxonomies can organize information into discrete categories with unique names and description, and they can be organized in lists, hierarchy or matrix.

According to Nickerson et al. (2013), researchers have to follow an method for taxonomy development. The first step is to identify a meta-characteristic, which is "the most comprehensive characteristic that will serve as the basis for the choice of characteristics in the taxonomy" and "all the categories should be a logical consequence of this meta-characteristics". (Nickerson et al. 2012).

Taxonomies can be developed by using a inductive (determining dimensions and characteristics from empirical observations), deductive (deriving dimensions and characteristics from theory or conceptualization) or intuitive approach (ad hoc, based on the researcher's perceptions) (Nickerson et al. 2010 in Rosselet 2013).

The development of the taxonomy will be helpful to answer to this research questions:

RQ2: "*Which are the business models that characterise the crowdsourcing logistics industry?*"

Methodology

The purpose of the taxonomy is to understand how different firms operate in crowdsourcing logistics and provides a general overview of the industry. Thus the objects of the classificiation here are the companies operating in this field with the aim of understanding their business model.

The main axes of classification were deducted combing the different approaches proposed in Nickerson et al. (2012). Crowdsourcing logistics is related to several subjects such as crowdsourcing, logistics, last mile delivery and ecommerce.

Starting from other crowdsourcing taxonomies (Rouse 2010; Rosselet 2013; Haas et al. 2014; Rougès & Montreuil 2014;) some recurrent dimensions can be found and applied even in this case. Some others are characteristics of the last mile delivery and logistics, and, finally other attributes were deduced during the companies' analysis. Below all the dimensions that will be use to classy actors are presented and described.

The Crowd

The first dimension is the crowd, it refers to the group of individuals that are asked to undertake the task(Estellés-Arolas & González-Ladrón-de-Guevara 2012). This element is present in most crowdsourcing taxonomy (Rosselet 2013; Geiger et al. 2011).

The crowd in the crowd shipping case, can be made by **everyone** – a generic mass of individuals (Estellés-Arolas & González-Ladrón-de-Guevara 2012) -, or it can be subject to context-specific reason (Geiger et al. 2011), like being **travelers** or a **company customer**.

Geiger et al. (2011) state that there can be a pre-selection of the contributors who have to demonstrate certain skills before taking part to the task, consequently the crowd restricted to **skilled contributors** (Zwass 2010) like professional carriers or taxi drivers (Chen & Pan 2015), for instance Uber and Lyft drivers.

Fare

Another important characteristic of crowdsourcing platforms are the forms of motivation (Rouse 2010); those incentives are crucial for providers' involvement (Leimeister et al. 2009) and they determine how contributors gets paid and get compensated for their work (Geiger et al. 2011). Rouse (2010) classifies motivations into token compensation (small monetary prize) and market compensation. Geiger et al. (2011) diversify between fixed and success based remuneration, considering if the objective is achieved or not. In the crowdsourcing logistics case, all the firms analysed provides remuneration for their workers, who can be paid in two main ways: a **fixed price**, for standardized delivery request, and a **bargained** one, according to the customization of the deliveries (Rougès & Montreuil 2014). The fix price rate can be further divided in two groups: if the estimation of the fare is made on time spent to make the delivery (**hourly based**) or if the number of shipment done by the deliveryman (**parcel based**).

Target

This dimension is related to the final target of the platform, which entity can benefit from the service offered by the crowd. The classes identified here are two and they are mutually exclusive. Rougès (2014) named this dimension the "offer pole" and he finds two main groups: B2C and P2P. The **B2C** (Business to customers) is the segment made by merchants that want to make crowd shipping option available on their website and then ship in this way the orders made on their website.

The **P2P** side of the offer has as objective "matching people who want to send packages with people who accept to go […] (in a specific location) or already going there" (Rougès & Montreuil 2014).

Origin

This classification axis has been induced by the research made on firms' business model. The origin is defined as the starting point of the crowdsourced delivery; this is the location where the deliveryman has to go to pick up the delivery he is in charge of. This element is strictly related to the target dimension, indeed the two delivery classes, having different scopes, start from different points.

In the B2C case the origin is a node in the merchant supply chain. The distribution channel for an online retailer can have different configurations, it can be distribution from existing stores, from distribution centers, that are dedicated only to supply online customers or in common with convectional stores warehouses, and hybrid structures (De Koster 2003).For the sake of simplicity, only two categories will be considered the **distribution center (DC)**, which is usually dedicated, and the **retailer point fo sale (POS)**.

The P2P category has a single starting point for the delivery and this is the **peer location**. This location can be the home of the peer or specific place defined in the interaction of the two actors.

Destination

Another classification criterion relevant to differentiate different crowd shipping initiatives is the delivery destination. De Koster (2003) states that ecommerce retailers can ship goods in different areas, the delivery can be on regional, national or global scale. Crowdsourced delivery can be offered at three geographical scales according to Rougès & Montreuil (2014): intra-urban, interurban and global service. Starting from those assumptions and looking at the empirical data collected on firms' business model, this criterion can assume three possible values: **urban** destination, the sender and the receiver are in the same city; **national** destination, the box is carried for distance that is within a country; and **international** destination, the sender and the receiver are in two different nations and the object is carried usually by a traveller.

Time Frame

The time is an important component on the delivery service. Many scholars argued about delivery windows and other solution to solve the problem of high expensive delivery cost in the last mile. (Boyer et al. 2009). At the same time on the clients side there is this desire for speed, " In recent years, many e-tailers have started to offer their customers a same day delivery option, sometimes even […] 1-hour and 2-hour delivery" (Savelsbergh et al. 2016). The so-called time frame category can be seen as the delivery lead-time and this has to meet consumers' expectations. The time lapses offered by the firms are: **one hour**, **two hours**, **same day** and **chosen by the consumer**, where the two parties in the transaction come with an agreement on the delivery time.

Firm type

The crowdsourcing logistics industry has been observed to be made by different kind of companies. There are new born **start-ups** specialized in this field(Rougès & Montreuil 2014), **traditional retailers** that are trying to solve the last mile delivery problems with crowdsourcing(Savelsbergh et al. 2016), and established online companies, like Amazon and Uber, from now called **dotcom**.

Industry

The last dimension is the industry in which the company operates. All firms are logistics vectors who delivery parcels (**generic**), but some of them are specifically dedicated to some industry, like **grocery** or **retail**.

Table 7 summarises all the different variables explained so far.

Variable	Attributes	Variable	Attributes
Firm Type	Start-up	**Destination**	Urban
	Traditional		National
	Dotcom		International
Origin	Retailer POS	**Time frame**	Chosen by consumer
	Peer		Fast delivery
	Warehouse		One hour
Crowd	Everyone		Two hours
	Travellers		Same day
	Customers	**Target**	B2C
	Uber, Lyft drivers		P2P
Fare	Bargained	**Industry**	Grocery
	Parcel based		Not specific
	Hourly based		Retail

Table 7 Variables and attributes in the proposed crowdsourcing delivery taxonomy

Results

Starting from the dimensions listed and explained before, the classification criteria were applied to a set of 33 companies operating in this business. The companies were found on the Internet by searching for "crowdsourcing delivery firms" or "crowd shipping start-ups" and other combinations of those strings. The business model of each firm was deeply analysed by using the company website (homepage, FAQs, YouTube videos) and online press articles related to them and to crowd shipping in general.

The first step of the empirical analysis was to put in a table all the firms found and list and organize all their characteristics according to the variables discussed before.

Therefore, selecting a hierarchy among the variables a classification tree has been developed. This tool lets a more visual and easier comprehension of all the data gathered. Starting from the target, going down with the origin, the destination, the time frame, the industry, the crowd, and, finally, the fare. All firms found in the research were classified and divided, they can be found in the last leaves of every branches, following the path from the top to the bottom all the main characteristics for each company can be seen. If two companies are found in the same "leaf", it means that they operate in the same way according to the classification criteria identified.

Table 8 Crowdsourcing logistics companies' taxonomy

Company	Firm Type	Country	Target	Origin	Destination	Time frame	Industry	Crowd	Fare
AmazonFlex	Dotcom	USA	B2C	Distribution Center	Urban area	One hour/Two hours/Same day	Ecommerce	Everyone	Hourly based,
Barnacle	Startup	USA	P2P	Peer	National	Chosen by consumer	Generic	Everyone	Parcel based
Beequick	Startup	China	B2C	Retailer POS	Urban area	One hour	Grocery	Everyone	Hourly based
Bitstip	Startup	Indonesia	P2P	Peer	International	Chosen by consumer	Generic	Everyone	Bargained
Dada (JD Daojia)	Startup	China	B2C	Retailer POS	Urban area	Same Day	Generic	Everyone	Parcel based
Deliv	Startup	USA	B2C	Retailer POS	Urban area	Same day	Retail	Everyone	Parcel based
DeliveryFolks	Startup	UK	P2P	Peer	National	Chosen by consumer	Generic	Everyone	Bargained
MyWays	Traditional	Sweden	B2C	Distribution Center	National	Chosen by consumer	Generic	Everyone	Parcel based (points)
Entrusters	Startup	Argentina	P2P	Peer	International	Chosen by consumer	Generic	Everyone: Travellers	Bargained
Friendshippr	Startup	USA, Dubai	P2P	Peer	International	Chosen by consumer	Generic	Everyone	Bargained (even for free)
Hitch	Startup	USA	P2P	Peer	Urban area	Chosen by consumer	Generic	Everyone: Travellers	Parcel based
Honestbee	Startup	HK	B2C	Retailer POS	Urban area	One hour/Same day	Grocery	Everyone	Hourly based

Company	Firm Type	Country	Target	Origin	Destination	Time frame	Industry	Crowd	Fare
iCarry	Startup	Italy	P2P	Peer	Urban area	Same day/Chosen by the consumer	Generic	Everyone	Bargained
Instacart	Startup	USA	B2C	Retailer POS	Urban area	One hour/Same day	Grocery	Everyone	Parcel based
Jib.li	Startup	France	P2P	Peer	International	Chosen by consumer	Generic	Everyone: Travellers	Bargained
Kanga	Startup	USA	P2P	Peer	Urban area	Chosen by consumer	Generic	Everyone	Parcel based
Kanga	Startup	USA	B2C	Retailer POS	Urban area	Same day	Generic	Everyone	Parcel based
Lalamove	Startup	Singapore	P2P	Peer	Urban area	Same day	Generic	Everyone	Bargained
Meemeep	Startup	Australia	P2P	Peer	National	Chosen by consumer	Generic	Everyone	Parcel based
Meemeep	Startup	Australia	B2C	Retailer POS	Urban area	Chosen by consumer	Generic	Everyone	Parcel based
Nimber	Startup	UK, USA	P2P	Peer	National	Chosen by consumer	Generic	Everyone	Bargained
NinjaVan	Startup	Singapore Malaysia	B2C	Distributio n Center	Urban area	Same day	Generic	Everyone	Hourly Based
Packmule	Startup	Czech Republic	P2P	Peer	International	Chosen by consumer	Generic	Everyone: Travelers	Bargained
PiggieBee	Startup	Belgium	P2P	Peer	International	Chosen by consumer	Generic	Everyone: Travelers	Bargained
Postmates	Startup	USA	B2C	Retailer POS	Urban area	One hour or less	Generic	Everyone	Hourly based
Renren Kuaidi	Startup	China	B2C	Retailer POS	Urban area	With 2 hours	Generic	Everyone	Parcel based

Company	Firm Type	Country	Target	Origin	Destination	Time frame	Industry	Crowd	Fare
Rideship	Startup	USA	P2P	Peer	National	Chosen by consumer	Generic	Everyone	Bargained
Roadie	Startup	USA	P2P	Peer	National	Chosen by consumer	Generic	Everyone	Parcel based
Shipizy	Startup	Portugal	P2P	Peer	International	Chosen by consumer	Generic	Everyone: Travelers	Bargained
Taskrabbit	Startup	USA	P2P	Peer	Urban area	Chosen by consumer	Generic	Everyone	Hourly based
TocTocBox	Startup	Italy	P2P	Peer	National	Chosen by consumer	Generic	Everyone	Parcel based
UberRush	Dotcom	USA	B2C	Retailer POS	Urban area	Fast delivery; Chosen by consumer	Retail, restaurant,	Restricted: Uber Drivers	Pay as an Uber route
Wallmart	Tradition al	USA	B2C	Retailer POS	Urban area	Same day	Grocery	Everyone: Wallmart customers	Parcel based
Wallmart	Tradition al	USA	B2C	Retailer POS	Urban area	Same day	Grocery	Restricted: Uber, Lyft drivers	Pay as an Uber route
Zipments	Startup	USA	B2C	Retailer POS	Urban area	Same day	Retail, restaurant	Restricted: Professional	Parcel based

Classification Tree

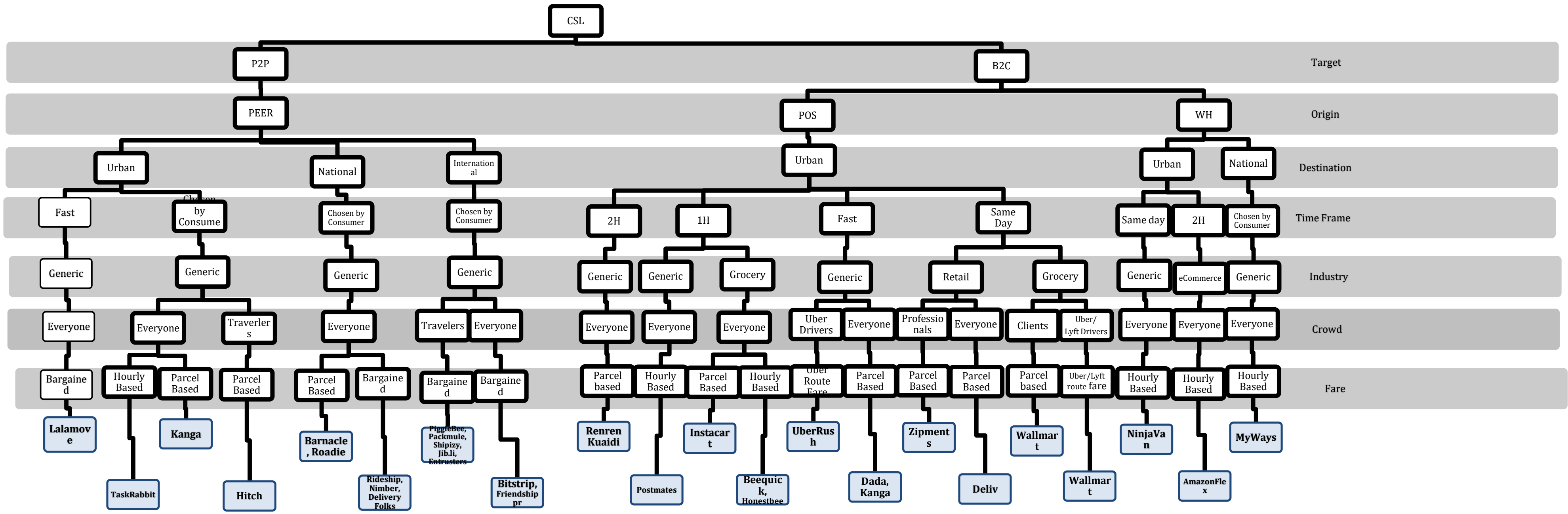


Figure 4 Classification tree of crowdsourcing logistics companies

Observations

Looking at the sample of 35 companies analysed a deeper analysis can be made. The first main division in the sample is made based on the target; the two offered services are both part of crowd shipping, still being different the recipient of the offer, they have particular characteristics in the two cases. In the following paragraphs those two clusters will be analysed and discussed.

B2C

The B2C segment is made by 16 companies, Wal-Mart is considered twice because it tried to use crowd delivery in two different ways. Those firms are mostly start-ups born in this industry (11), but there are even traditional companies (3) (Wal-Mart, DHL), and, as previously defined, dotcoms (2) (Amazon, Uber), that try to use the crowd in the last mile delivery. The origin of the delivery can be the Point of Sale (POS) or a Distribution Centre (DC), respectively in 13 and 3 cases. Those start-ups that delivery directly from the shop of the merchant can be seen as **ecommerce enablers** for those companies: they allow those firms to enlarge they potential customer base thanks to displaying on the website their offer and delivery through their service.

Looking at the destination and the time frame of deliveries in almost all the case (15 out of 16) the shipment is made in an urban environment and in fast time, one hour (5), or at least during the same working day (9). The industry in which those companies operate most is grocery (5), follow by retail (4), but still the majority of them are not industry specific serving different of firms (7). The crowd related dimensions are the crowd type and the fare that is paid to the workers. In the most of the cases everyone can deliver the parcel (12), some companies offer professionals drivers or deliverymen (3) and one uses his consumers as logistics vectors. The monetary incentive given to the crowd is principally parcel based (9), still few companies pay on an hourly based (4) and in the Uber or Lyft drivers case, the compensation is the same of a standard route.

Variable	Attributes	#	Variable	Attributes	#
Origin	Retailer POS	13	**Time frame**	Same day	9
	Warehouse	3		One hour	5
Destination	Urban	15		Two hours	1
	National	1		Chosen by Consumer	1
Firm Type	Startup	11	**Industry**	Not specific	7
	Traditional	3		Grocery	5
	Dotcom	2		Retail	4
Crowd	Everyone	12	**Fare**	Parcel based	9
	Skilled	3		Hourly based	4
	Customers	1		Uber/Lyft Route	2

Table 9 Results of taxonomy in B2C segment

The B2C business model in crowdsourcing logistics can be exemplify as follow. The actors involved in the transaction are four: the customer, the merchant, the crowdsourcing logistics platform and the delivery man. They are put on the horizontal lanes. The interactions between them are represented in the flowchart, the blue blocks states for the information flow, the orange ones the logistic flow and the green one the money flow.

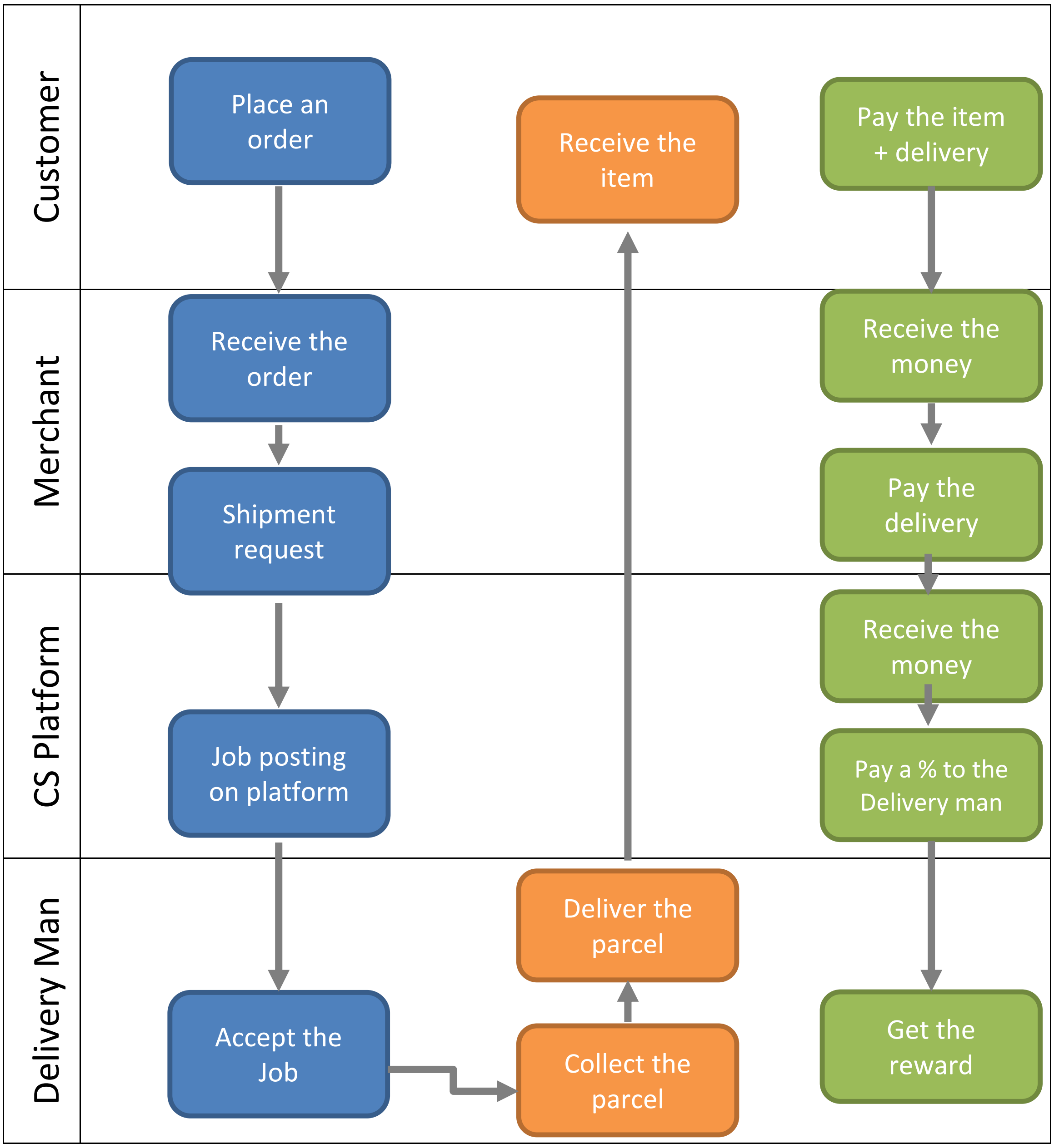


Figure 5 Crowdsourcing logistics B2C flow chart

The process begins when a customer purchase something on the merchant website, when the seller receives the order he can decide to ship it through a crowdsourcing logistics platform, to which he sends a shipment request. After that, on the crowdsourcing platform an open call to all its member is posted, all the potential jobbers are reached by SMS, notification or email. Among all the possible workers one accepts the delivery job. After the approval of the platform, the new delivery man has to go to the local warehouse or the merchant's point of sale to collect the parcel he is in charge of deliver. Consequently, he brings the package to the final consumer. Completed the delivery, the money flow starts and it goes backwards from the final consumer to the deliveryman, through different steps: the customer corresponds the money for the product and delivery to the merchant; this one pays the crowdsourcing platform for the shipment service, the platform takes a percentage of the delivery fare corresponded by the merchant, and finally the delivery man gets paid the amount he accepted the job for. The jobber's wage can be parcel based or hourly based, proportional to the time he need for the delivery.

P2P

The P2P side of the offer is greater than the B2C one with 19 companies, which are all start-ups. In this case the firm is an intermediary between two individuals: the person who need to send something and another one who wants to make some money by carrying it.

The origin point is the peer; the place can be the peer's house or another location agreed between the two actors. The shipment final destination can be within an urban area (5), at a national (7) or international (7) scale according to the different firms.

The delivery time frame can be decided between the two parties in the majority of cases (17), but in the urban area two companies guarantee the same day delivery.

There is no industry specificity for those companies; no one of them is specific for a certain business. The crowd of carriers is made by everyone, potentially any person can deliver by enrolling on these platforms. Some companies are addressed specifically to travellers (6), who decide to publish their itinerary and accept possible shipping requests. Looking at the money that those people can make, in most of the cases the transportation fare is bargained between the two peers (12), in some other the firm gives a price based on the parcel (6), and finally only one pays on an hourly base.

Variable	Attributes	#	Industry	Generic	19
Origin	Peer	19	**Firm Type**	Startup	11
Destination	International	7	**Fare**	Bargained	12
	National	7		Parcel based	6
	Urban	5		Hourly based	1
Crowd	Everyone	13	**Time frame**	Chosen by Consumer	17
	Travelers	6		Same Day	2

Table 10 Results of taxonomy in P2P segment

The P2P business model in the crowdsourcing logistics is described in the following chart. The actors involved are four: the sender, the crowdsourcing logistics platform, the deliveryman and the receiver. They are put on the horizontal lanes. The interactions between them are represented in the flowchart, the blue blocks states for the information flow, the orange ones the logistic flow and the green one the money flow.

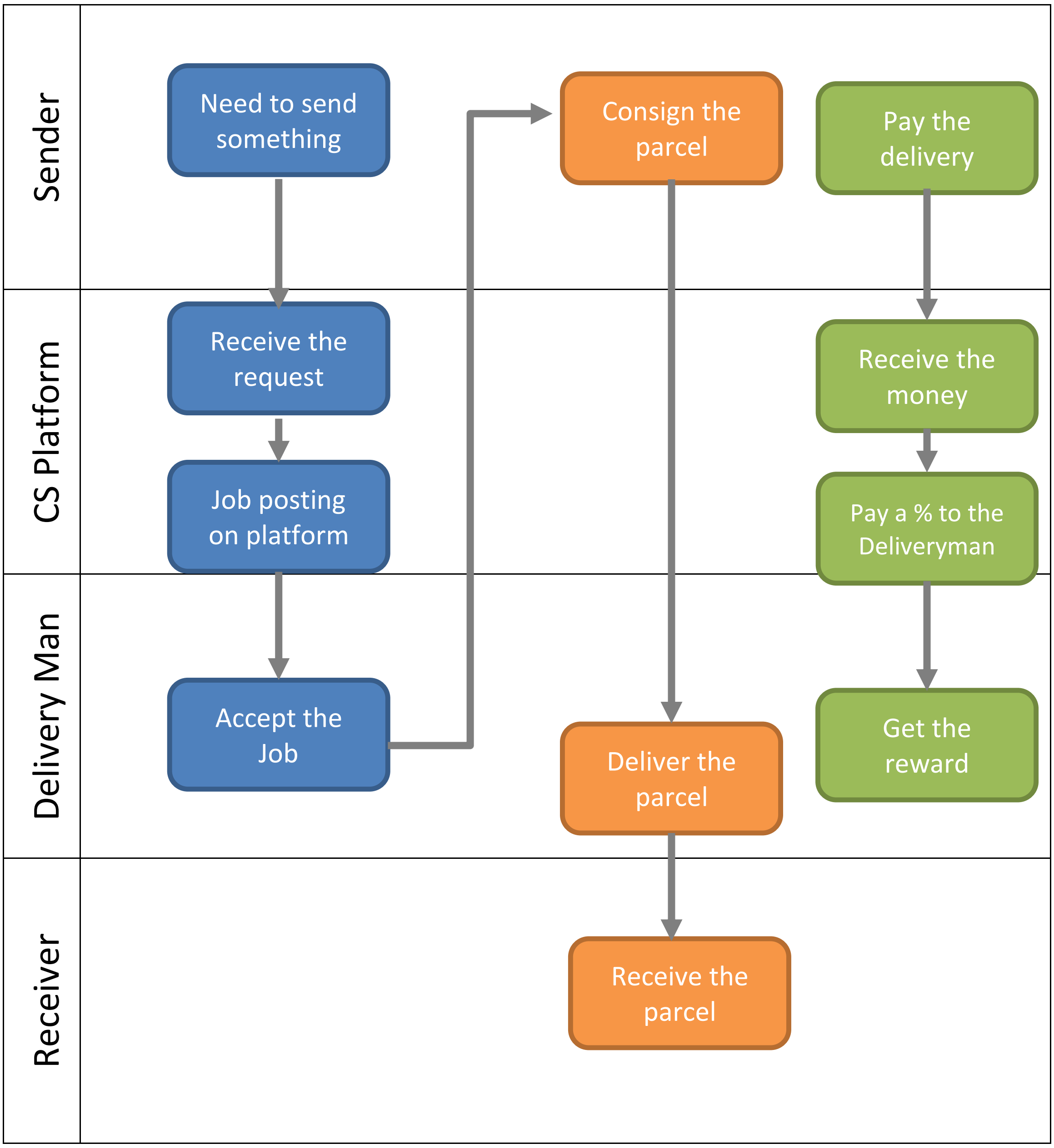


Figure 6 Crowdsourcing logistics P2P flow chart

The P2P process starts when a person needs to send something and he cannot deliver it by himself. So he accesses a crowdsourcing logistics platform and posts a request of shipment, which may contain the information about item he wants to ship, the time frame and the destination. Otherwise he can start looking among trips posted on the platform by other people, mostly travels that publish their itinerary seeking for some parcels to deliver on their way. In one of those two ways a match can be found. When the two peers get in touch they discuss and agree about the time, the destination, the pickup point, and they bargain about the fare that one have to give to the other. The price can be suggested by the platform taking into account the expenses the deliveryman has to face. The money flow goes from the requester to the shipper, passing by the platform that usually charges a fee for the service provided.

Conclusions

The development of the taxonomy starting from the research made on different companies' business models resulted in a better understanding of crowdsourcing logistics industry. All the information gathered was divided and organized following specific classification criteria like the target, the crowd, the origin, the destination, the industry and so on.

The first main result is the classification tree, which gives a structured overview of the crowd shipping industry. The most popular way to do crowdsourcing logistics is the so-called P2P, where two pairs, the sender and carrier, agree about almost all the aspects of the delivery of an item, this type of shipments occurs even on broad distances like national and international scale.

The second big cluster is made by the B2C, the firms that make this segment can be identified as ecommerce enablers, because they guarantee the access to the ecommerce to merchant that otherwise would have to pay higher fees to normal courier compared to the lower commission crowdsourcing logistics firms required. Almost all of these players deliver in an urban area in with very fast shipping service, at maximum in the same day.

Model development

As so far discussed crowd shipping can be considered a good solution to last mile delivery issue, moreover the crowdsourcing logistics reduce the initial cost that a company has to face in order to became an e-tailer, indeed offering delivery services at a lower price and offering a fast service make the offer of any merchant more appealing to the final consumer, to whom are usually charged of high speed delivery expenses.

The result of the taxonomy gives an overview of the two main ways to carry out crowdsourcing logistics. At the actual moment the industry is more crowded by the P2P solution. This offer side is mainly made by start-ups and it is really dynamic. Here the main objective of those companies is to facilitate goods exchange between people, who can live close or even on opposite places of the globe, by getting them in touch through their platforms.

On the other hand, the B2C side of the offer has fewer applications, but those are again start-ups or well establish firms, that try this alternative way to deliver their parcels. The B2C star-ups can be seen as ecommerce enablers because they let offline companies become on line sellers thanks to display and logistics services offered by them. Among the well establish firms as it can be seen in tree shown before we have different trials: Wal-Mart, that tries to use its customers as last mile delivers, Amazon, which experiments crowd shipping in big cities, like New York, to carried out fast deliveries coming from Prime and Prime Now programs, and UberRush, which takes advantage of its drivers' network making them deliver parcels coming from point of sales nearby.

Starting from those examples, the main aim of this research is to evaluate the possible effects of the use of crowdsourcing logistics in the last mile delivery. Considering the industry at the current status the solution that better fits the requirements is the B2C side of the business. In order to understand if it is convenient or not applying the crowdsourcing delivery it is necessary to develop a model. This model has to compare on different dimensions the usual logistics and the crowdsourced one.

Objective and methodology

The model which is going to be develop is thought as a tool for a merchant that has to make a decision on which type of delivery service use for the shipment of its own parcels sold on its ecommerce website. The main objectives of the model can be sum up in this research question

RQ3: "When is it convenient to use crowdsourcing logistics versus normal couriers?"

In order to answer to this question same assumptions as to be taken and the two possible delivery solutions in the last mile has to be analyzed and compared to assert which one is the most convenient and in which occasions.

The model is going to be developed using an analytical approach and the hypothesis taken will be clearly defined with the aim of making it reliable and applicable in a real contest.

In the development phase three different stages has been followed: the first one is a general description of the delivery process in the two alternatives considered; the second phase shows the model and the evaluation of the costs that are going to be faced by the merchant in the two solutions and in the last stage the model is applied to carry out a sensitivity analysis.

In the first phase information form the literature were taken to build a flow chart that will represent the different phases of the delivery process. The crowdsourcing logistics solution proposed will be analyzed following the framework introduced in the taxonomy part.

During the development of the model some information were taken by all the research developed so far in this dissertation, and most of them were supposed starting from comparison from industry standard, here again the novelty of these affects the availability of the data.

The output of this phase is a model, is an estimation of the cost that a merchant should face if he would go for a crowdsourcing logistics and a sustainability measure for the crowd itself.

In the last phase the model is applied with different configurations of input data with the objective to evaluate in the different case scenarios how the model performs and if the results obtained are reasonable and they can be attribute to a real case.

Process analysis

The last mile delivery process will be modeled in two ways the traditional and the crowdsourced one. In this model the only focus of the analysis will be only the shipping phase. In the scenario choosen the delivery is not carried out internally by the company, but it is outsourced to an external provider of logistics services. The typology of delivery considered in this scenario is the express one, this request has usually to be satisfied in one or two hour, or at maximum in the same working day it was demanded by the merchant. In some ways this kind of service is similar to the pony express offer or to delivery offered by food delivery startups (like Foodora, Deliveroo and Justeat).

The shipping process carried out by a traditional courrier starts with the request by the merchant to ship a parcel on its benhalf. The relationship between those two actors is usually formilized in a contract, but there can be even spot requests from the e-tailer, especially in those industries where the demand forecast is not enough accurated.

The main activity taken into account starts from the collection of the order in the merchant local warehouse and its shipment to the final comsumer. This kind of service is simple from a manageral view point, being it externalized, but it can be expensive for the merchant especially if the transaction is spot.

The crowdsourcing logistics process is rather more complicated compared to the other option. As previusly explained in the taxonomy paragraph the process can be modelized as follow. The merchant receives an order and he accesses a crowdsourcing logistics platform, to which he sends a shipment request. Afterwards the crowdsourcing platform post a call to all its member. Among all the workers that could accepts the delivery job, the ones with the lower cost, which means the ones which have to do the shortest path to from their actual position to the local warehouse and from ther to the final comsumer address, are seleced and to them is shown the shipping request. Once one of them accept the offer and, after the approval of the platform, the delivery man has to go to the local warehouse to collect the parcel, he is in charge of deliver, and he brings the package to the final consumer according to the service level he was given to accomplish the task.

In the model, the place where the crowdsourcing logistics will be tested is the city of Milan, Italy. This metropolitan city is good choice to implement this kind of initiative: it is considerd a global city (to be developed). Milan has been the place where differnt similar initiavite were tested:

- it was the fist city were UberPop was launched in Italy in May 2014 and afterwards it was blocked by the court. In November 2016 a new service was launch , the so called UberEats, that delivers food from restaurant to consumers home (Ansa, 2014)

- There are lot of food delivery startups like Foodora, Deliveroo, Piazzabo and Justeat. (YouMark, 2016)
- Milan is the first italian city where Amazon Prime Now was launched in Italy and in 46 sourronding towns. This kind of service allows people to reiecive a selcetion of 20 thousands product direclty at their houses with an express delivery. The customer can choose the delivery time of one hour, two hours or in a seleceted time window in the same or following day. (Biagio, 2015)

According to offer in Milan there is the demand for this type of fast delivery service, that can ship both ready meals or even other type of prodcuts bought on internet by the people.

In model the crowdsourcing initiative that is goign to be used to be compared with the traditional couriers can be fully descrived by the following table applying the framwork developed in the taxonomy paragraph:

Variable	**Attribute**
Origin	Local Warehouse, Point of sale
Destination	Urban
Crowd	Everyone
Time Frame	One hour, two hours, same day
Industry	Generic
Fare	Mixed (parcel and hourly based)
Transportation means	Foot, Bike, Motorbike, Car

Table 11 Characteristics of Crowdsourcing logistics initiative used in the model

The crowdsourcing initiaive chosen for this model has a crowd that can be made potentially by everyone living in Milan, they have to enroll on a platform and they can deliver parcels. The starting point of the shipment is the local warehose or a point of sale of a merchant and the final destionation is within an urban area, the city of Milan. The delivery can be accomplish by the riders using differnt kinds of trasportation means, that they own and they have to specify which one they use everytime they log in and they become availabele to ship, they can deliver on foot, by bike, by motorbike and by car. In order to be as much general as possible and for the sake of semplicity the initiative is not industry specific, but general, so riders can deliver whatever parcel from whatever merchant. Finally the rider remunarition is given on an huorly base, starting from the time they accept the job till the monent which they deliver the order. The wage is mixed parcel and hourly based and a fraction of it is taken by the platform for the intermediary role it did, this percentage is equal to 10%.

Some issues can arise from the application of this model, especially in the starting phase, indeed this initiative is crowd dependant, if the number of people is too small and consiquently the company is not able to deliver the box, so it has to rely on a backup solution, or the delivery cost is not the lowest that theoretically can be achived.

In the next flow chart the two processes described so far are compared, the blue arrows represent the steps made in a crowdsourcing logistics inititive and the red ones the traditional logistics process.

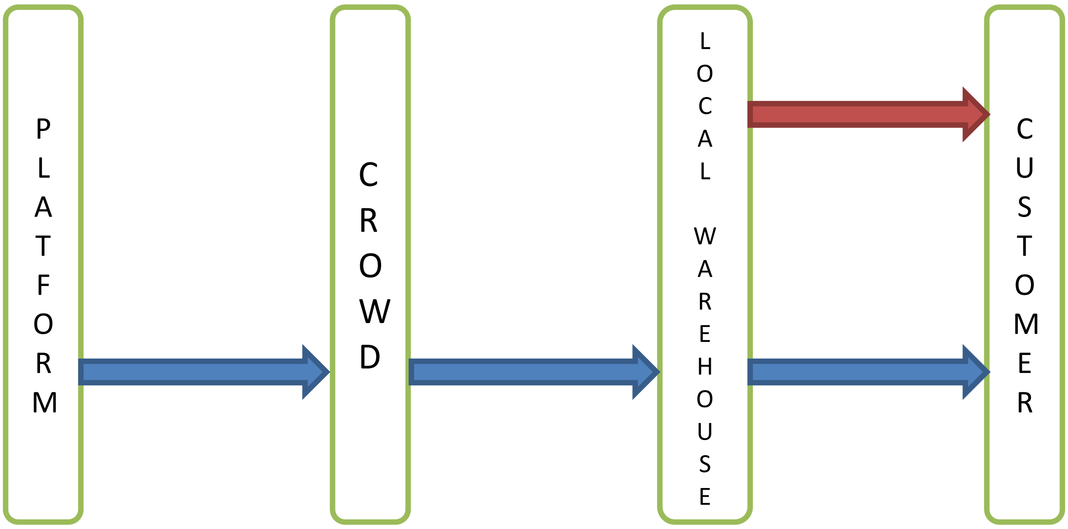


Figure 7 Crowd shipping and traditional delivery process map

The model

The architecture of the model develop is shown in the following schem. The structure is made by four main building blocks:

- The Input data, the variables that are needed to start the model and the ones are put inside at the beginning by the user;
- Environment data, those information are all the constants and the values considered in the building process of the model;
- The Algorithm, this is the the set of all the operations to be performed in order to obtain the results;
- The Output data, those are the outcomes of the model computations on the input data given in input.

All those section will be deeply and fully explain in the following paragraphs.

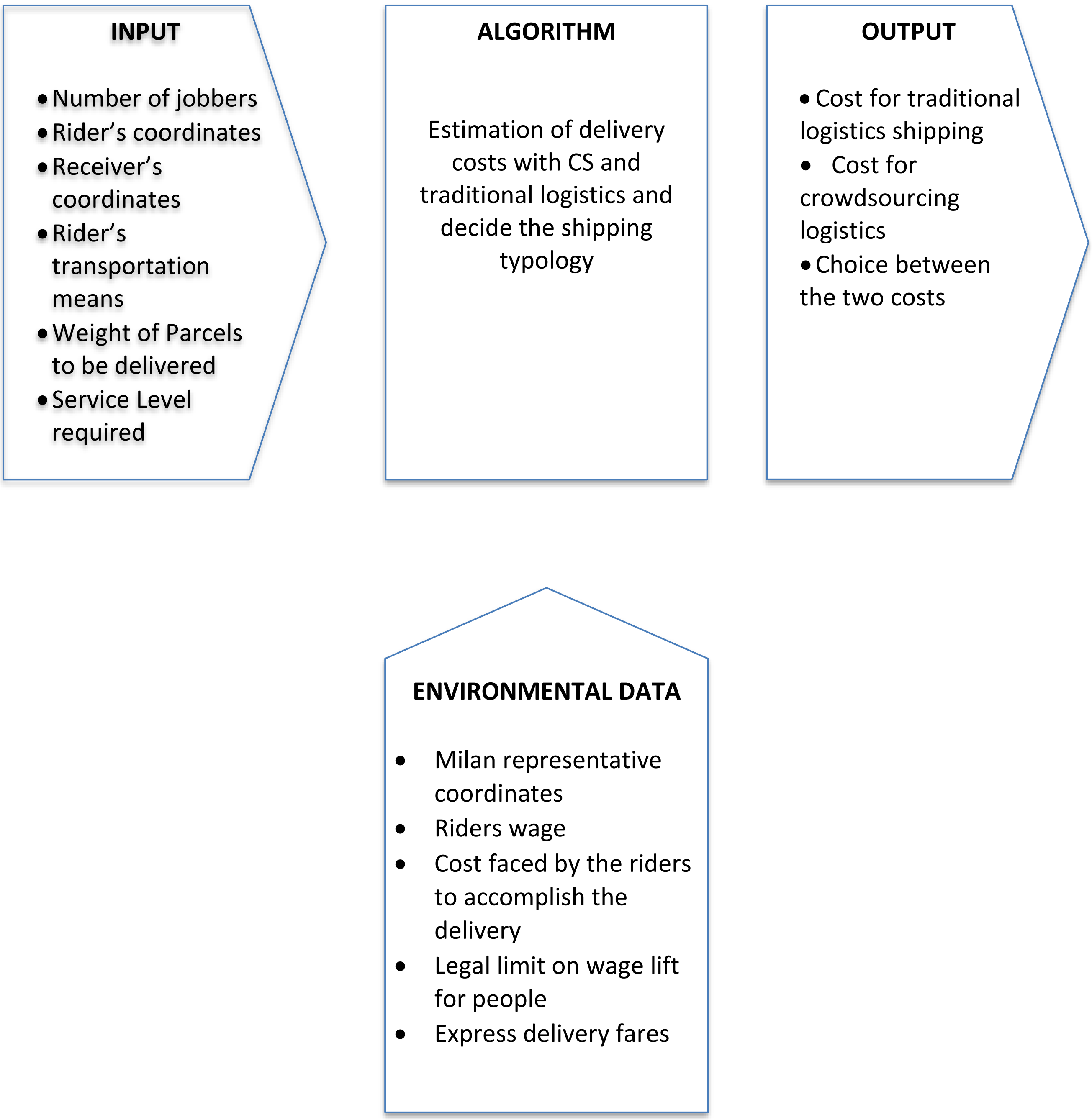


Figure 8 Model structure

Input Data

The input data are made by six types of data. All those information are necessary in order to make the model work properly and consequently to have reliable results in output.

Those six groups are:

- *Number of Jobber*: the dimension of the crowd is a fundamental variable to have a successful application of the crowdsourcing. Bigger is the number of people that make the crowd , highest is the possibility to have a parcel delivered and delivered at the lowest cost teoretically achivable. The model will be run per each available rider in the moment which the shipping request is pubblished on the platform and those ones that have the lowest cost could become riders for that specific parcels.
- *Rider's coordinates*: the location of the riders in terms of geographical coordinates is needed to starts the algorithm and it is request in order to evaluate if the rider can satisfy the delivery demand according to the service level request by the consumer. This is the starting point of the crowd shipping service. In real application this information is automatically decteced by the geolocalization of the smartphone on which the rider opened the app to make itself available and visible in the platform.
- *Receiver's coordinates*: this location is the final destination to reach, the ending point of the crowdsourcing delivery service. This information is usually owned by the merchant, that, having received the invoice for the order by the final receiver, in the customer profile has the address where to ship the items he bought on its website. The delivery address has to be converted into geographical coordinates to be put into the model and to make it work properly.
- *Riders' transportation means*: when a rider enroll for the first time on the platform he is requested to list all the possible transportation means he owns and he can use to carry out the delivery and, the first time, he has to demonstrate that he has the permission to drive those vehicles, for instance by giving the driving license number. Anytime he makes himself available for shipping he has to mark which kind of transportation mean he can use in that moment. The algorithm needs in input this information because by using different vehicles, riders can achieve different performances in terms of times, so they can be assigned different deliveries. The four vehicles that are allowed on the platform are: Foot, Bike, Motorbike and Car.

- *Weight of parcels to be delivered*: this information is related to the type of parcel that the rider can deliver. The chioce of not limiting the industry of this crowdsourcing initiative taken for sake of general applicability of it, forced the introduction of this data in the model because of the limit of weight lifting that legally and physically a man or a woman can handle. For instance if this initiative was limited to the food delivery industry, this costrain and conseqeuntly this information would not be relevant being all the parcels that the riders have to deliver below the legal upper limit, that will be discussed in the environmental data paragraph. This information has to be communicated in kilograms to the platfom by the merchant when makes the delivery request.
- *Service Level required*: this information is again communicated to the platform by the merchant. The crowdshpping logistics is usually applied in the fast delivery cases, so at maximum the parcel has to be delivered by the end of day that the order was made. This data is required by the model in order to screen all the possible drivers according to their real possibility to sastisfy this service level. The three possible service levels to be given in input: one hour, very fast delivery, two hours, express delivery, and same day delivery. Anyway the model can adapted to other service levels if it is required by the merchant.

Environmental data

The environmental data are those data that has to be taken as given or they are the hypotesis on which the model has been built. They can be due to some specific rules and laws of logistics industry. This part is diveved into five main groups that relate to the drivers and Milan, the city where thre model is applied:

- *The rider's wage*: this variable is a fundamental one because it has the duty to balance demand and offer, for sake of semplicity this model is not able to descriminate in order to redistribute offer to adapt it to the demand peak, like uber does with surge pricing (The Economist , 2014). The riders' wage is a very tricky point and it has been subject of protest of some food delivery companies' employee recently, like Foodora riders (Coccorese, 2016). This level is again really important because upon it is base the economical soustenability of the model itself. On one hand the wage has to be competitive when its compare to other company espress delivery fare, on the other the wage has to cover the costs that the rider faces when he carries out the shippiment. The driver pay is made by a fixed part that is given to the rider when he accomplished the delivery and a flexible part that it is propotional to the distance, consequently to the time the rider needed to deliver. The flexible part is different according to the type of the delivery the rider does, this to make the fastest delivery more appealing to riders. This part is estimated by the platform, or the model, with the data it has. If the delivery will be in one hour, the salary will be 6 € per hour, if the shipment will be in two hour, it will be 4 € per hour, and finally if the delivery will occur in the same day the wage will be 2 € per hour. In the latter case the wage is evaluated based on the time the rider would need if he delivers the parcel in the moment he accept the delivery, then it is up to him decide when and how deliver the parcel, but at maximum in the same day.

Service Level	**Fix part**	**Flexible part**
1h	3€	6 €/h
2h	3€	4 €/h
Same Day	3€	2 €/h

Table 12 Riders' wage structure

- *Cost faced by the rider*: this expense is estimanted to evaluate if the pay given to the rider actually covers the costs that he has to face when he makes the delivery. The data to evaluate this cost are take from the ACI, Automobile Club d'Italia. In this cost estimation are included both the expenses proportional to fuel, the car usage and mantainance, and the fixed ones related to the insurance and taxes.
- *Milan representative coordinates*: Milan was ideally represented in the model with 100 couples of coordinates; to which will be approximate the input and the output value of the model. The process of choice and initialization of the algorithm will be explained in the following paragraphs.
- *Legal weight lifitng limit*: riders have to carry around the city several parcels and as already said for sake of generality of the model no industry was chosen, so there can be the possibility for them to bring different sizes and weights of parcels in their delivery path. Italian law on safety at work does not clarify specific levels of load for safe manual material handling (Punto Sicuro, 2010). The correct application of D.Lgs.81/2008 law suggests the assumption of a load of 25 and 20 kg as reference values for male and female adult and healthy workers. Still if it is considered that in the crowd shipping case the weight has to be hold by rider itself, at least in two cases out of four, on foot and by bike, a maximum weight of 15 kg has been set. This threshold is considered the maximum one under which a worker can carry out its job without incurring in any risk for his own health, this limit is taken even by other crowdsourcing

delivery providers, like UberEats (Uber , 2016). In the model taken the maximum threshold as given, a further division was made according to the transportation mean used by the rider. In the following table the ranges are shown:

	Foot	**Bike**	**Motorbike**	**Car**
Maximum parcel weight	5 kg	10 kg	10kg	15kg

Table 13 Parcel weight constrains

The values in the table are the maximum ones that can be carried with that vehicle, which means that a parcel that weights 5 kg can be delivered by all the transportation means, rather than one of 8 kg that cannot be shipped on foot, but by all the others vehicles.

- *Express Courier delivery fares*: this external data is really important because they are the benchmark with which the results from the algorithm evaluating the cost of crowd shipping are compared. In order to have some significant and reliable data a research among possible competitor in this fast delivery field has been carried out. The actors that can compete with this kind of initiative are pony express service providers and, for some aspects, food delivery start-ups. In the following tables the results of such research are shown.

Cost per deliver (€/delivery)	**1h**	**2h**	**Same Day**
Delivery Agency	10.00	10.00	10.00
Eagle Group	8.00	8.00	8.00
Go Bike Express	15.00	10.00	-
Jet Post	20.00	20.00	-
Shadow	18.00	18.00	-
Spedireweb	15.98	6.98	-
Moto Express	20.00	10.00	-
My Milano City	20.00	10.00	-
SuperVelox	16.00	10.00	-
Work in Progress	20.00	15.00	-
Zebre	-	20.00	-

Bici Couriers	15.00	10.00	7.00
GBM	10.00	8.00	8.00
Pony Zero	20.00	20.00	8.00
Security Courier	15.00	8.00	-
Urban Bike Messengers	20.00	15.00	9.00
Triclò	-	18.00	-
Smile and Bike	20.00	15.00	9.00
MilanBike	20.00	10.00	-
Willy Express	20.00	15.00	-
Average	**16.834**	**12.89**	**8.43**

Table 14 Fast delivery comperitors' fares

In this first table different pony express providers' tariffs are shown and in the last row an average of the cost is computed. As can be seen the average cost for one-hour delivery is at € 16.83, the price decreases for the two-hour delivery to € 12.89 and finally for the same-day delivery is € 8.43.

Food Delivery Startups	**Delivery Time**	**PRICE (€/delivery)**
Cantina Express	30 min (average)	-
Cosa Ordino	ND	ND
Deliveroo	32 min (average)	2.50
Foodinho	30 min (average)	Free
Foodora	45 min (average)	2.90
My Food	Within 1 hour, in a specified time window	6.00
Night Food	20/40 min	Free
Taxi Bar	Within 1 hour	ND
Teledrink	10/25 min	Free
Winelivery	30 min (average)	Free
YouEat	ND	4.00 -7.00
Bacchetteforchette	Within 1 hour	ND
Buon Appetito Milano	Within 1 hour	7.00
Average	**40 min**	**5.00**

Table 15 Food delivery start-ups' fares

The second table shows the tariffs of other potential competitors, the start-ups operating in the food delivery industry. That kind of companies could even ship other items instead of meals from restaurant. As it can be noticed the average cost in lower than pony express companies still in same case the two services are comparable, but what has to be noticed here is that, those company only operates in specific areas of Milan, not in the entire metropolitan city.

The model algorithm

In this part all the computations made by the model in order to obtain the the outputs to be compared will be explained. In the overall model some hypotesis were taken in order to simply the model and they are the following:

- The time of picking, handling and consolidation are not considered in the in the model, the rider, when he arrives at the warehouse, finds the order ready to be shipped and no waiting time at the werehouse are considered, so there is queue he has to do in order to collect the parcel to deliver.
- Each rider deliver one parcel from the werehouse to the final deistination and no failure is considered in the shipping process. Both for the driver and for the final consumer to receive the parcel. Once a rider accepted the delivery, he is thought to complete without any take down in the middle of the process. From the receiver point of view, the customer is supposed to be home or in the destiantion address waiting for the delivery, the possiblity for the delivery man not to find someone that took the parcel is equal to zero.

Building the model

The first step in the building process of the model was to find the data to feed the model with. As show in the scorecard of the input, the first kind of data to define are the coordinates both for the rider position and for the destination. The development of a model that could take as input any kind of couple of coordinates both for the start and the ending point of the delivery was too high, so again for the sake of semplicity 100 possibile coordinate couples were taken as represantative of the city of Milan. Those 100 addresses were selected in all Milan, the city of Milan is divided into 9 municipalities, those position were selected in those areas. In the municipalities with higher population density more addresses were taken, because there are more possiblities that some one make an order or that a driver is located in those spots. In the map the 100 destinations can be seen and, even from a visual point of view, it can be seen as they are well distributed in all the city surface.

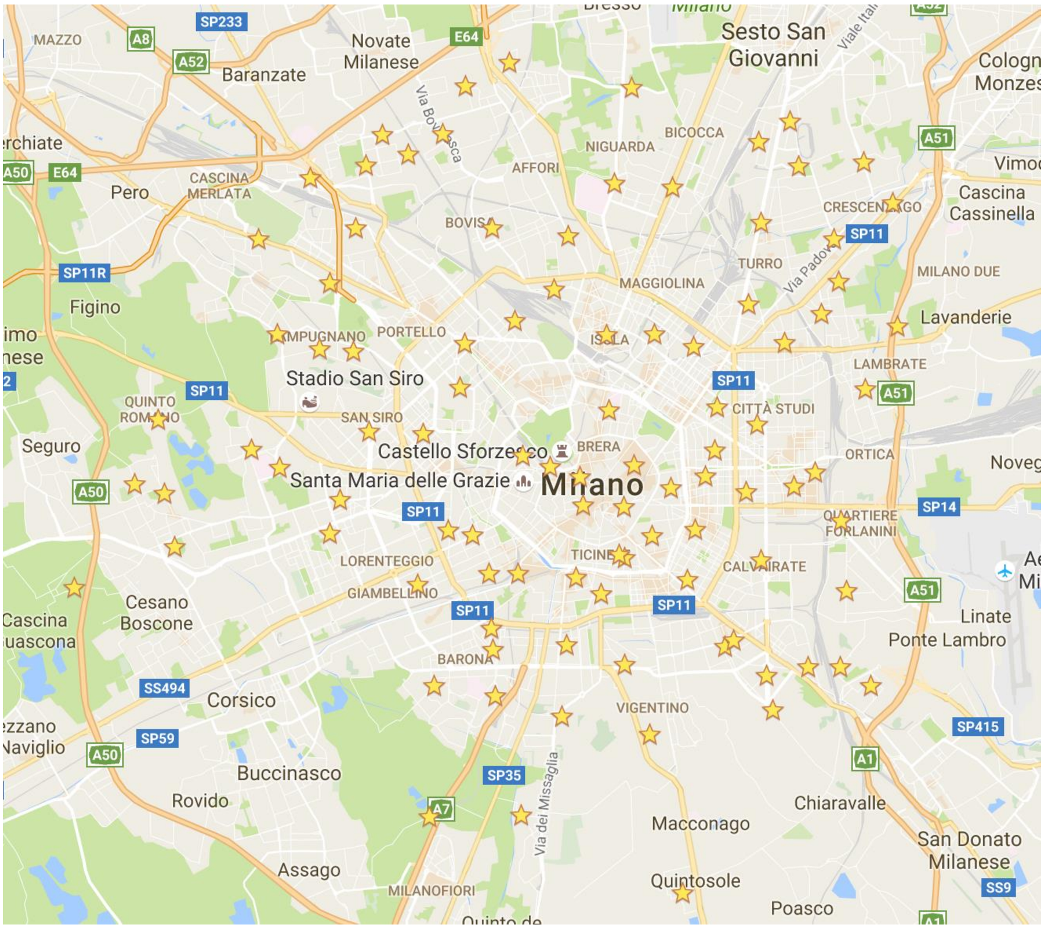


Figure 9: 100 locations in Milan

Pizzale Luigi Cadorna 9 20123 Milano	Via Giuseppe Palanti 4, 20142 Milano
Via Edmondo De Amicis 15, 20123 Milano	Via Giulio Cesare Gabussi 1, 20141 Milano
Via Quadronno 7, 20122 Milano	Via Achille Faraboli 14, 20142 Milano
Via della Commenda 13, 20122 Milano	Via Quintosole 20, 20141 Milano
Via Conservatorio 30, 20122 Milano	Via San Dionigi 80, 20139 Milano
Via Marina 5, 20121 Milano	Via Bernardino Verro 48, 20141 Milano
Via della Moscova 40, 20121 Milano	Via Tortona 27, 20144 Milano
Via Montenapoleone 20, 20121 Milano	Via Barona 45, 20142 Milano
Via Larga 8,20122 Milano	Via San Paolino 6, 20142 Milano
Via Manfredo Camperio 9, 20123 Milano	Via Santander 9, 20143 Milano
Via San Maurilio 11 Milano	Via Vincenzo Foppa 28, 20144 Milano
Via Venti Settembre, 20123 Milano	Via Giorgio Washinton 80, 20146 Milano
Piazza della Repubblica 10, 20121Milano	Via Giambellino 49, 20146 Milano
Via Pietro Crespi 16, 20127 Milano	Via Gattinara 94, 20142 Milano
Via Melchiorre Gioia 137, 20125 Milano	Via Pietro Filargo 16, 20143 Milano

Viale Monza 152, 20127 Milano	Via Valenza 5, 20144 Milano
Via Padova 191, 20127 Milano	Via delle Azalee 1, 20147 Milano
Via Platone 17, 20128 Milano	Via Caldera 129, 20153 Milano
Via Adriano 263, 20128 Milano	Via San Giusto 85, 20147 Milano
Via Roberto Tremelloni 20, 20128 Milano	Via delle Forze Armate 62, 20147 Milano
Via Fortezza 1, 20126 Milano	Via Muggiano 25, 20152 Milano
Via Soperga 5, 20124 Milano	Via ippodromo 7, 20151 Milano
Via Palmanova 209, 20132 Milano	Via Domenichino16, 20149 Milano
Via Tolmezzo 15, 20132 Milano	Via Valesia 96, 20152 Milano
Via Riccardo Pitteri 100, 20134 Milano	Via Francesco Raimondo 56, 20152 Milano
Via Lomellina 25, 20133 Milano	Via Quinto Romano 47, 20153 Milano
Via Mecedonia Meloni 17,20129 Milano	Via Carlo Marx 7, 20153 Milano
Via Modena Gustavo 8, 20129 Milano	Via Alcide de Gasperi 10, 20151 Milano
Via Francesco Redi 21, 20129 Milano	Via Gallarate 313, 20151 Milano
Via Plinio 70, 20129 Milano	Via Angelo Brunetti 15, 20156 Milano
Via Accademia 40, 20131 Milano	Via Michele Lessona 10, 20157 Milano
Via Crescenzago 110, 20132 Milano	Via Renato Simoni 10, 20157 Milano
Via Canelli 17, 20134 Milano	Viale Dullio 22, 20145 Milano
Via Pannonia 9, 20133 Milano	Via Giorgio Stepheson 74, 20157 Milano
Via Andrea Maffei 6, 20135 Milano	Via Eugenio Montale 9, 20151 Milano
Via Lazzaro Papi 7, 20135 Milano	Via Francesco Goya 36, 20148 Milano
Via Maria Montessori 10, 20138 Milano	Corso Sempione 100,20154 Milano
Via Salomone Oreste 73, 20138 Milano	Via Carlo Amoretti 12, 20157 Milano
Via Marcona 77, 20129 Milano	Viale Mar Jonio 3, 20148 Milano
Via degli Etruschi 5, 20137 Milano	Viale Vincenzo Lancetti 33, 20158 Milano
Via Brenta 18, 20139 Milano	Via Graziano 3, 20162 Milano
Viale Omero 12, 20139 Milano	Via Bovisasca 84, 20161 Milano
Via Carlo Bancompagni 67, 20139 Milano	Via Senigaglia 60, 20161 Milano
Via San Venerio 51, 20138 Milano	Viale Fulvio Testi 7133, 20125 Milano
Via Giacomo Manzu 4, 20138 Milano	Via Carlo Imbonati 61, 20158 Milano
Via Bianca di Savoia 6, 20122 Milano	Via del Regno Italico 1445, 20162 Milano
Via Pietro Custodi 3, 20136 Milano	Via Pietro Borsieri 24, 20159 Milano
Via Leopoldo Sabbatini 8, 20136 Milano	Via Stilicone 14, 20154 Milano
Via Mincio 5, 20139 Milano	Via Giovanni Durando 18, 20158 Milano
Via Ruggero Borghi 7, 20141 Milano	Via Salemi 21, 20161 Milano

Table 16 100 locations' addresses

Once all the addresses were selected, another fundamental position to define in the warehouse one. This position could have been between the data to put in input in the model, but to keep the model as much general as possible it was chosen to operate in a different way. The aim in developing this model is that to be a tool that a company can used to estimate if and when to use use crowdshipping, consequently, working on a single warehouse position can be seen as restrective.
The idea was then to taken 10 possible position of 10 possible warehouses in the city of Milan, those locations now on will be called **warehouse position** but nothing excludes that those locations can be 10 point of sale of a firm that decided to crowdsource the delivery expoliting the already existing network of shops in Milan, or they can be 10 possible restaurant of a chain, that wants to deliver at its customers' homes food by using crowdshipping.

Starting from those assumption 10 possible warehouses were selected and in the following table their addresses can be found.

Warehouse	**Address**
Warehouse 1	Via Andrea Appiani 15, 20121, Milano
Warehouse 2	Via Ponte Nuovo 53, 20128 Miano
Warehouse 3	Via Raffaele Rubattino 95, 20134 Milano
Warehouse 4	Via Terruliano 94, 20137, Milano
Warehouse 5	Via Giuseppe Ripamonti 440, 20141 Milano
Warehouse 6	via degli Inganni 87.20147 Milano
Warehouse 7	Via Pessano 11, 20151 Milano
Warehouse 8	Via Angelo Brunetti 17, 20156 Milano
Warehouse 9	Via George Sand 4, 20161 Milano
Warehouse 10	Via San Vigilio 33, 20142 Milano

Table 17: Possible warehouses' addresses

The map shows visually their location

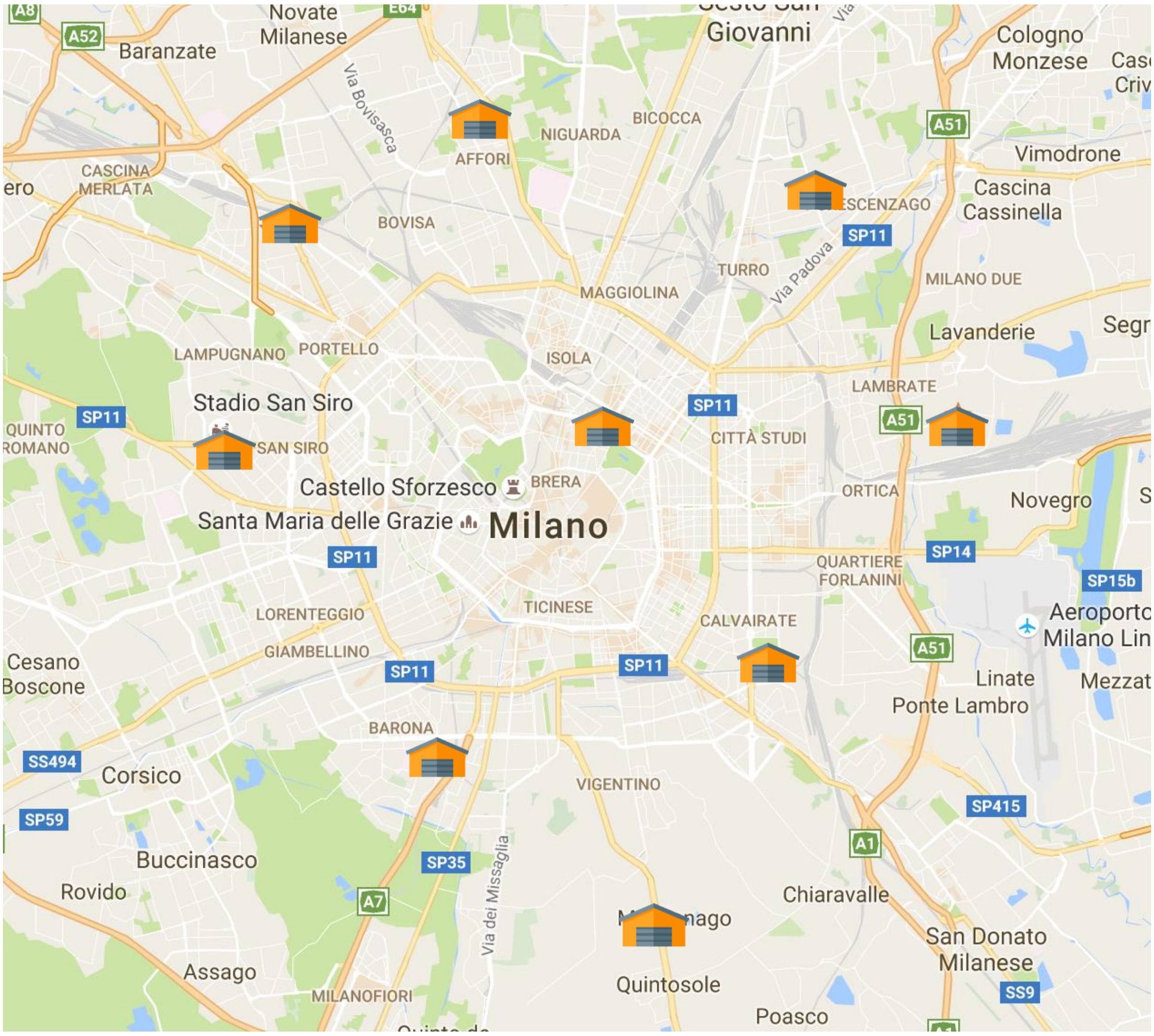


Figure 10 Possible warehouses locations

The following step once identified the start and the ending points, the 100 destinations, and the position of the 10 possible warehouses, was to evaluate the average time needed to go from one point to another.

All the position found were combined together to obtain 10,000 different paths that can be done by a rider. If the origins are going to be called O and the destinations D, there O1D1 to O1D100, O2D1 to O2D100 till O100D100.

For each of those 10,000 paths the time need to go from the origin to the warehouse and form the warehouse to the final destination were evaluated for every of the 10 warehouses selected before. Finally, an average of the ten path were computed, so basically what was obtain is an average time from an origin to a destination passing through a warehouse that can be positioned in ten different spots.

For instance, let's consider the path O1D1 the time need to go from O1 to the first warehouse and from this warehouse to D1 is estimated, the time needed to go from

O1 to warehouse 2 and from warehouse 2 to O1 is calculated, this for all ten warehouses, and, in the end, an average of the 10 time frames obtained is assessed.
In the end an overall average was computed and this last calculation can be a good proxy that give an idea of which kind of service level can be achieved by the crowd. All those calculations were done through a Google Map and the time was evaluated for all the transportation means that are considered in the model, with some exceptions.
For motorbike and foot the data were exactly taken as they are, the difficulty was to evaluate the effect of traffic in the model, because Google Maps gives only a rough estimation of the street congestion. So the time for the car without traffic were selected for the motorbike, which ideally does not face the traffic on its path. For walking again, the time was taken as fair from the Google Maps proxy. Regarding the bike, the time estimation was made starting from the distance made in the walking case and it was divided by the average speed of bike, which is 15 km/h. For the car the traffic effect on the speed was considered to have an effect on the time need equal to 1,5 the time without any traffic. All that information about the time for each vehicle are put into a database that will be called **model dataset**. All the computations do by the model will have source of information this model dataset.
In the following table the average, the maximum and the minimum time estimated through this simulation can be found.

Time (min)	**Average Time**	**Maximum Time**	**Minimum Time**
Foot	186	293	141
Bike	58	98	44
Motorbike	41	49	35
Car	88	147	65

Table 18 Average, maximum and minimum times per each transportation means

From this table some main callouts can be taken, for sure motorbike will be the vehicle that will allow satisfying in every cases all the service level of the model, considering only the time constrain. The foot will be the most problematic one because in terms of performance is the slowest one. Three out of four transportation means on average allow the two hours delivery, which can be a good proxy for the fast delivery services demand.

The model algorithm

Once defined the raw data on which to base the model and stored them in the model dataset, the computational part has to be developed. In this section all the

computations that are at the base of the algorithm are explained and shown to give an overall idea of the algorithm structure.
The first two values that are inserted into the model are the rider position and the destination address. Those two information, in order to be read by the algorithm, has to be translated into geographical coordinates, indeed the input format of those two variable are two numbers with eight decimal position. Once the model receives those data, it has to estimate the time need to go from the origin to the warehouse and then to the final address. The model has to rely on the data that ware given in the building phase, so once the two pair of coordinates are given to the model it estimates which is the closest position to this address among the 100 locations put as building data in the model dataset. In order to evaluate the closets position, the algorithm goes through all the locations and it calculates the distance between them and the input value. The distance is estimated with the following formula:

$$d = \sqrt{(x_1 - x_n)^2 + (y_1 - y_n)^2} * (69) * (1609)$$

where $x_1$and x_n are the longitudes of respectively the input data and the n know value in the model, the $y_1$and y_n are the values for latitudes, 69 is the factor converting geographic coordinates into miles and 1609 is factor converting miles into km. Then the couple of the input data and a building data with the lowest distance are selected and to this position is associated an acronym. If the position is the rider one, it will be called origin and to it an O will be associated; if the position is a customer address, it will be called destination and a D will be associated to that. On the side to the letter the number of the most similar position in the dataset will be put. Then the two data will be marge in a path, which for instance can be identified like "O42D73", because the rider position is close to "Viale Omero 12, 20139 Milano" and the customer home is near by "Via Domenichino 16, 20149 Milano". Once the path is inserted in the model, in the model dataset average time for each vehicle expected in the model. The first step of the algorithm is done when it gives the best proxy to the actual path with one in the model data set.
The second steps of the algorithm is about the discussed constrains related to parcel weight, the transportation means and the service level required by the merchant. Some of them are mutually dependant like the weight and the transportation mean as show in the environmental data part. So a sequence of control check are introduced in model in order to guarantee that the limits and constrains are respected, every time those boundaries are not respected the result of the model is null. For instance if the box to be delivered weights more than 10 kg and the only riders available are the one on foot, this type of crowd cannot be used to accomplish this task. In more structured

way the following flow charts show the control systems implemented in the model. The following figure 11 gives an idea of the sequential checks made by the algorithm.

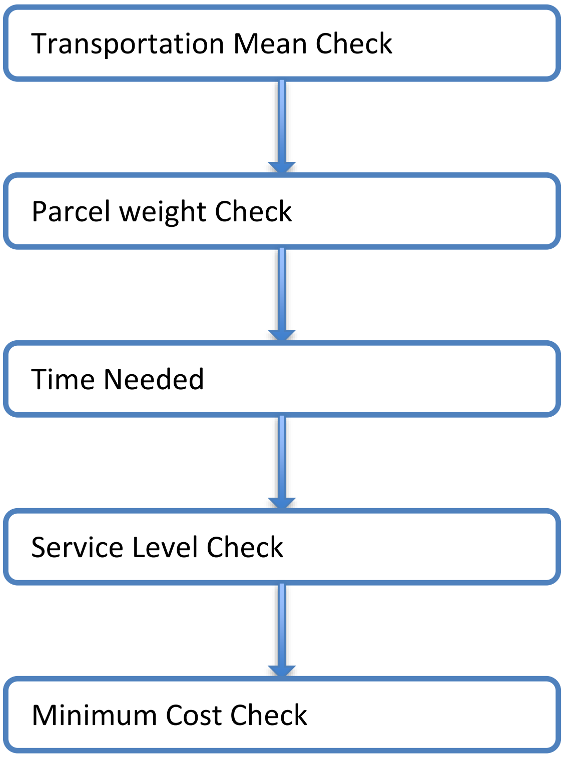


Figure 11 Model's algorithm control checks

The first check done by the algorithm is if the string in input for the transportation mean is equal to the ones accepted and recognized by the model: foot, bike, motorbike and car. The second check is performed is the one about the parcel weight in general terms, if a parcel weights more 15 kg the crowd shipping will be automatically excluded, for all the weights below this threshold restrictions are applied considering the vehicle available for the rider in that exactly time, using the ranges stated before. If the parcel respects this constrain passes to the next step which is the time needed estimation, with the procedure shown before the time from the rider's position to the final destination, passing by the possible warehouse, is calculated. If the time range obtained before is below the service level required by the merchant in input, the control process proceeds to next stage, otherwise the result is null.

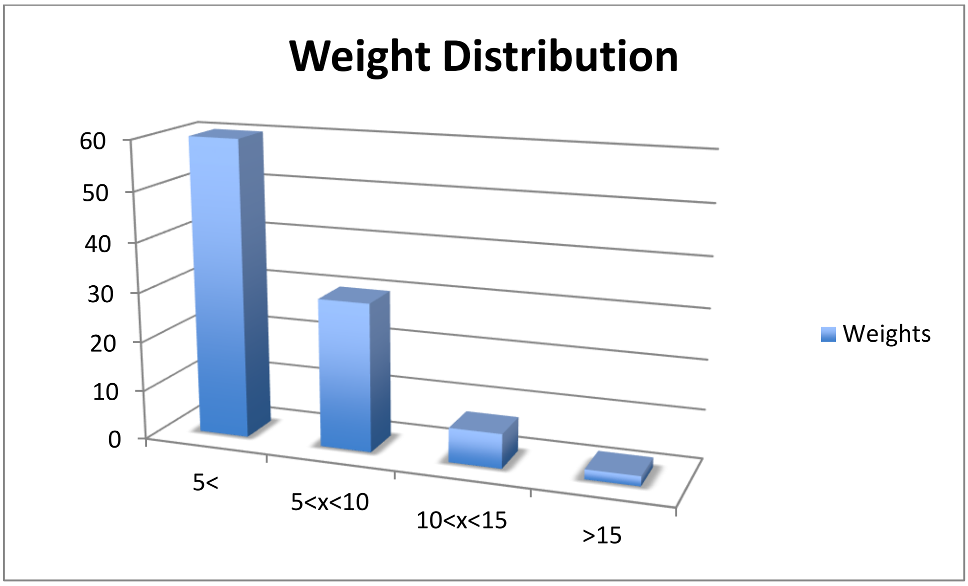
The last step is the rider fare calculation and it is compared with all the others fares estimated, if this is lower than the ones already obtained this option is taken as valid and this rider is one of the candidate in the crowd to deliver the parcel.

The algorithm applying the formula showed in the paragraph before undertakes the rider's fare estimation. The rider's wage is made by a fixed part that will be corresponded to him for accomplishing the delivery and another flexible part proportional to the time he needs to complete the entire path from its position to the warehouse and then to the final consumer address. The amount given for the delivery is always 3 euros and the flexible part depends on the type of the delivery required in input by the merchant according to the service level requested. If the delivery has to be done in one hour the flexible part of the wage will be paid at 6€ per hour, if it is a two-hour delivery at 4€ per hour, and finally if it is a same day delivery at 2€ per hour. Especially in the last case the rider salary will be evaluated for the time that would be needed by the rider to accomplish the delivery in the exact moment he accepts the job.

Model initialisation

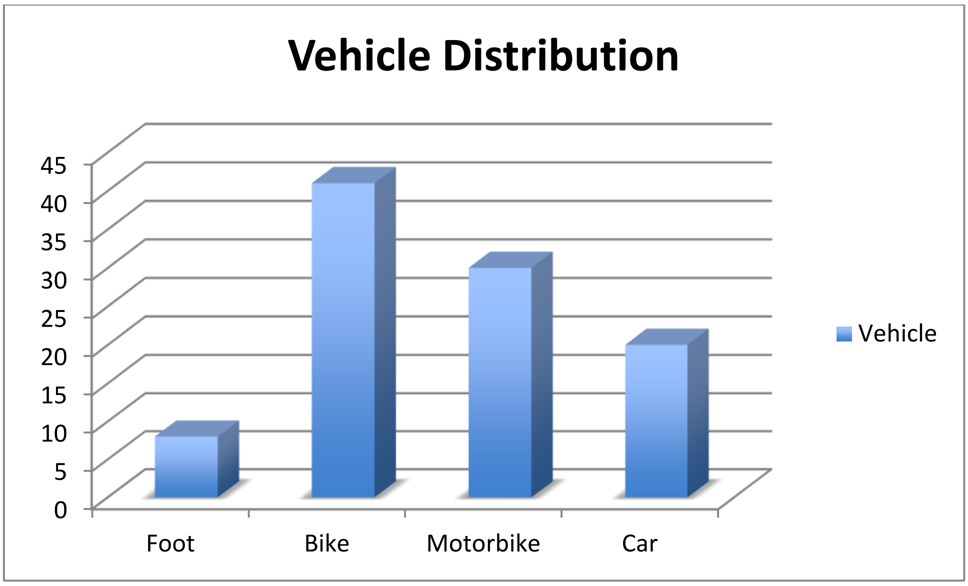
Once defined the data, on which to base the model, and all the computations, that make the algorithm. The model has to be tested in order to see if it works and to understand if the results it gives back are reliable and they make sense.

So a first trial was made putting as input values for parcel weight distribution, vehicle distribution and testing all the three kinds of service level. These following distributions related to the parcel weight and the vehicles distribution are shown in the graphs.



Graph 3: Weight distribution in the model initialization

As can be seen from the first graph one of the assumption used in the initialization of the model was that most of the parcel are thought to be light, 60% of them under 5 kg and another 30% under 10 kg, this is due to the fact mostly an order made on the web are a single order item or two no more (Gu & Geng, 2010)



Graph 4 Vehicle distribution in model initialization

The second graph shows the distribution of the vehicles assumed in this first phase of the model that has those values: 40% bikes, 30% motorbike, 20% cars and 10 % foot.
As final destination 100 random addresses were selected and approximated to the values inside in the model database. Per each of those destinations 100 possible drivers were estimated to be available to accomplish the delivery among them the cheapest one was selected, so the result of this calculation is 100 possible costs for 100 destinations. The model has been run for free times considering all those input values, each one for a service level. The running time of the model to evaluate the out is 20 minutes per 10100 computations and the calculation of the outputs.

Output data

The outputs of the model are two values: the **average cost** of a crowdsourced delivery and the **unavailability rate** of the crowd.
For each destination several drivers are evaluated, among the ones who can satisfy the model constrains and, consequently, accomplish the delivery on time, an average cost is estimated. The overall average price for the crowdsourcing initiative is obtained by calculating the average among the delivery cost per each destination.
The second result is the unavailability rate. This value represents not available riders in the crowd, in the sense that those riders even if they were willing to accept the job, due to several reasons, like their position, the parcel weight, and the transportation mean, they are not eligible to accomplish the delivery in respect with the service level. The rate is obtained as the ratio between the number of not eligible drivers over the total number of drivers in the crowd per each destination and, in order to have an overall idea of the crowd shipping initiative, an average of all destination unavailability rates is estimated. This number has to be as lower as possible because it affects the

crowd. If the unavailability rate is high it means that there are a lot possible riders that are willing to deliver, but they cannot. If this value is kept high for long periods those people will be discourage to log in and being available to deliver because they are willing to deliver a parcel and earn, but they cannot. The overall effect is a reduction of the people in the crowd that will affect the crowd capability to guarantee the service. Finally high values of this data are not compliance with the definition of crowdsourcing delivery, which states that this kind of practise has to beneficial for all its stake and shareholders. The following data are the ones obtained in the model initiation, now on they will be called the base case scenario to which others will be compared.

Service Level	Avg cost (€/delivery)	Max cost (€/delivery)	Pony express (€/delivery)	UR (%)
1h	7.797	8.904	16.83	42.85%
2h	6.535	9.518	12.89	18.29%
Same Day	5.041	9.844	8.43	11.42%

Table 19: Result of model initialization

Those data obtained in output has to be compared with fast delivery provides fares. Taken as benchmark the pony express providers, the crowd shipping fares are dramatically low compared to them in terms of average values. In the one-hour and two-hour delivery, the differences are the highest. In the fastest service level, one-hour, the crowd delivery is 60% cheaper than the traditional couriers, and in the two-hour service level crowdsourcing is 50% less expensive. The difference becomes narrower with the same day delivery, but crowd shipping is still more convenient, at 40% less than traditional shipping.

Considering the crowd shipping fares' maximum values, that are the highest prices in all the 10,000 delivery cases, if they are compared again with traditional fares, it can be seen as crowd shipping is again cheaper than the traditional couriers, and, of course, the difference is narrower than the one made with average values. In the one-hour case crowdsourcing is 47% more convenient, in the two hours 26%. In the same day delivery pony express are more convenient than crowd shipping if that is compared to the maximum level, indeed the traditional logistics providers are 14% cheaper than the crowd.

Another interesting data is the unavailability rate; it can be noticed as this value decreases as the service level required by the merchant becomes less restrictive. This is actually a big limit of the crowd shipping in this base scenario; especially in the one-hour case where 43% of the rivers cannot deliver, this can actually be for the riders a deterrent to apply in the crowd-shipping platform.

Sensitivity Analysis

Once the model was tested and the results were evaluated as good and fair, some sensitivity analyses have been carried out in order to understand the model's robustness and its capability to predict real events with good a grade of approximation.
In the following paragraphs some business cases will be presented and explained in detail, all of them are variations of the three base scenarios shown before in the model initialization. Some predictions are made according to theory and results obtained discussed to understand the ability of the model to follow and describe real events.

Number of drivers

The number of riders in the base case scenario was put as 100 in order to have a good sample of possible deliverymen that can accomplish the shipping. The first variation will be decreasing the number of possible drivers per each delivery and see which impact this variation has on the final cost faced by the merchant and on the unavailability rate.
From a theoretical point of view smaller is the crowd higher should be the final cost, because the possibility to choose the cheapest rider in a smaller amount of people is lower, and, in order to guarantee the delivery service, the merchant is forced to choose the cheaper among the ones available. So it is forecasted that the cost and the number of drivers are negatively correlated. Considering the unavailability rate, it may decrease, because increasing the amount of drivers higher becomes the denominator of the ratio, but it may even stay constant if the number of non-eligible riders grows with the same pace of the overall number of people.

Case 1.1

In this case the effect of the number of people in the crowd are analysed to see the impact in the fastest service level offered by the platform. The model has been run for 4 times with a growing number of available riders.

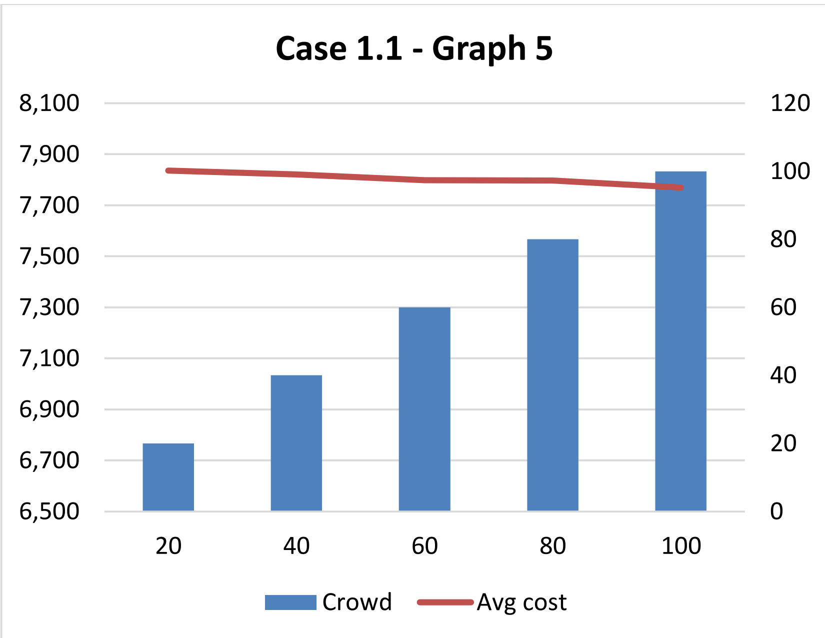
	Service Level	Crowd	Vehicle	Parcel Weight
Case 1.1	1h	20	Base	Base
	1h	40	Base	Base
	1h	60	Base	Base
	1h	80	Base	Base

Table 20 Case 1.1

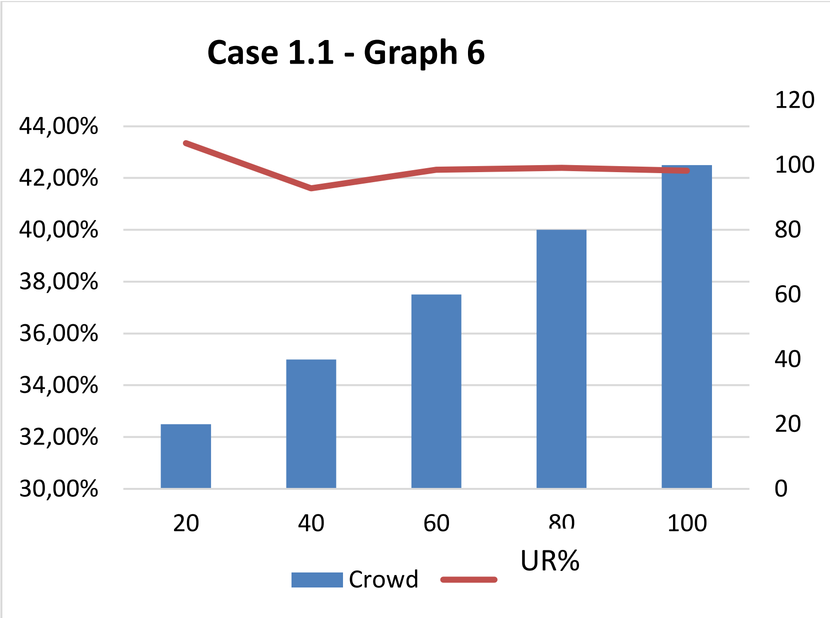
The following result has been obtained:

Crowd	Avg cost (€)	UR (%)
20	7,836	43,35%
40	7,820	41,60%
60	7,799	42,32%
80	7,798	42,40%
100	7,770	42,28%

Table 21 Results Case 1.1



Graph 5 Average cost behaviour increasing the number of people in the crowd Case 1.1



Graph 6 Unavailability rate behaviour increasing the number of people in the crowd Case 1.1

Graph 5 and Graph 6 respectively shows how the average cost and unavailability rate vary when the number of riders in the crowd increase.

Case 1.2

The case 1.2 evaluates the effect of the number of people in the crowd in the two-hour time frame. The model has been run for 4 times with a growing number of riders available.

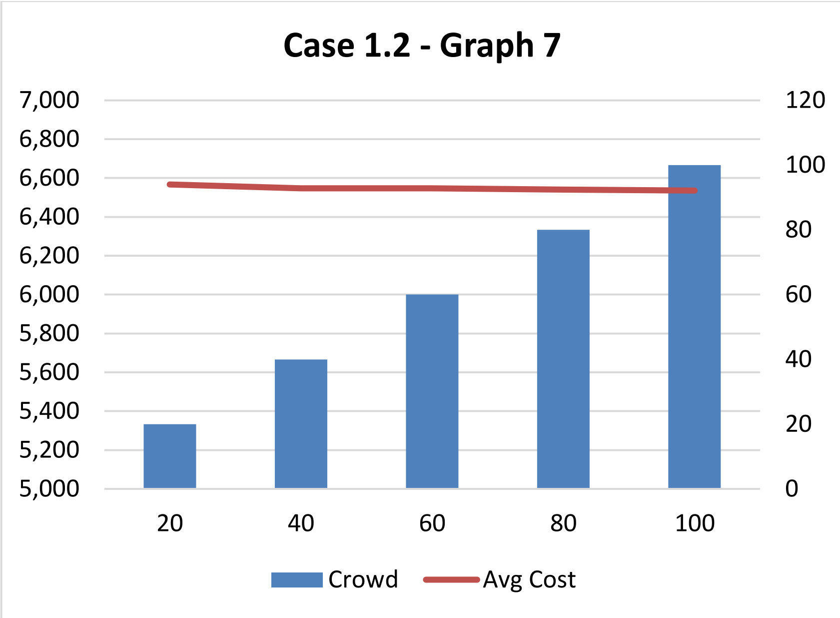
	Service Level	Crowd	Vehicle	Parcel Weight
Case 1.2	2h	20	Base	Base
	2h	40	Base	Base
	2h	60	Base	Base
	2h	80	Base	Base

Table 22 Case 1.2

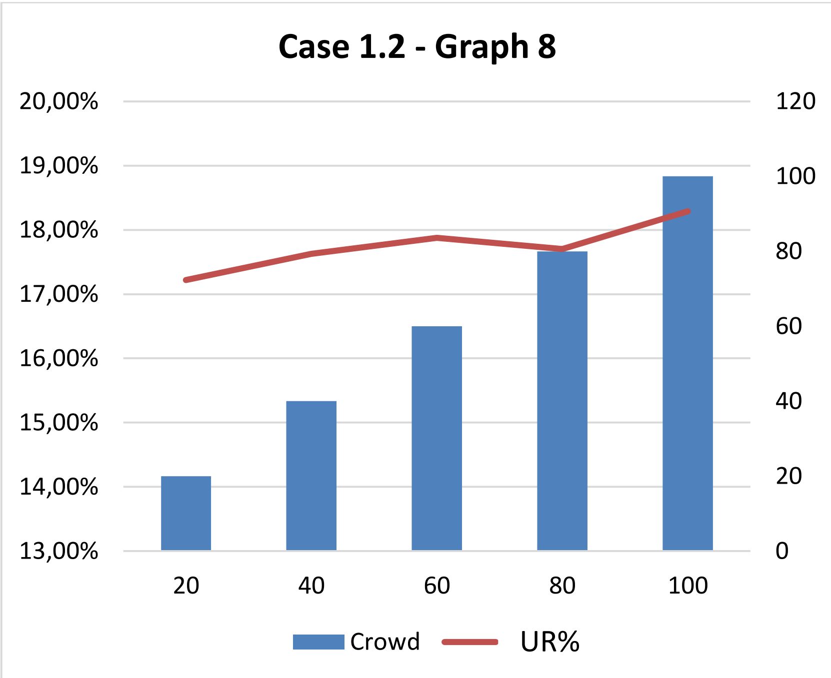
The following result has been obtained:

Crowd	Avg cost (€)	UR (%)
20	6,566	17,22%
40	6,548	17,63%
60	6,548	17,88%
80	6,541	17,70%
100	6,535	18,29%

Table 23 Results Case 1.2



Graph 7 Average cost behaviour increasing the number of people in the crowd Case 1.2



Graph 8 Unavailability rate behaviour increasing the number of people in the crowd Case 1.1

Graph 1 and Graph 2 respectively shows how the average cost and unavailability rate vary when the number of riders in the crowd increase.

Case1.3

In the end in case 1.3 evaluates the effect of the number of people in the crowd in the same day delivery case. The model has been run for 4 times with a growing number of riders available.

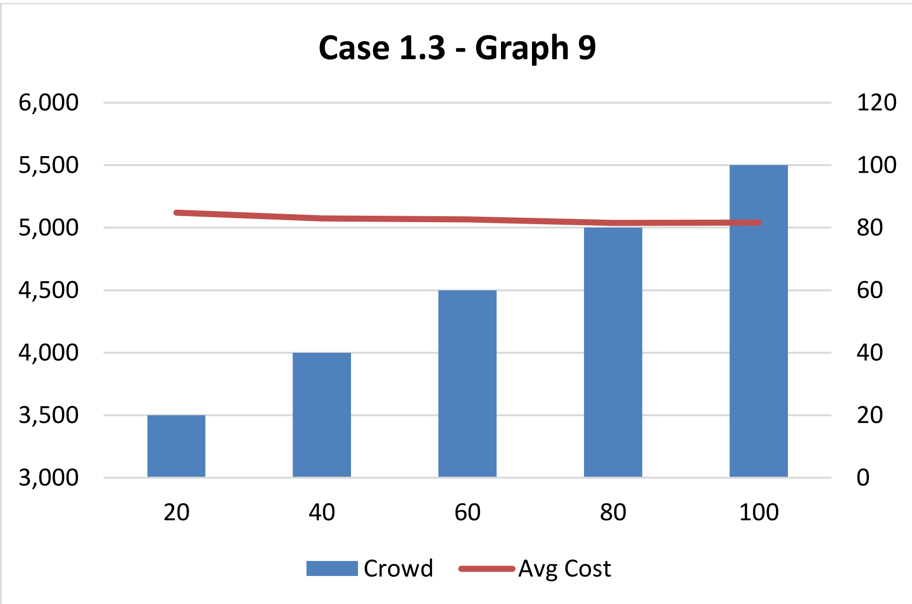
	Service Level	Crowd	Vehicle	Parcel Weight
Case 1.3	Same Day	20	Base	Base
	Same Day	40	Base	Base
	Same Day	60	Base	Base
	Same Day	80	Base	Base

Table 24 Case 1.3

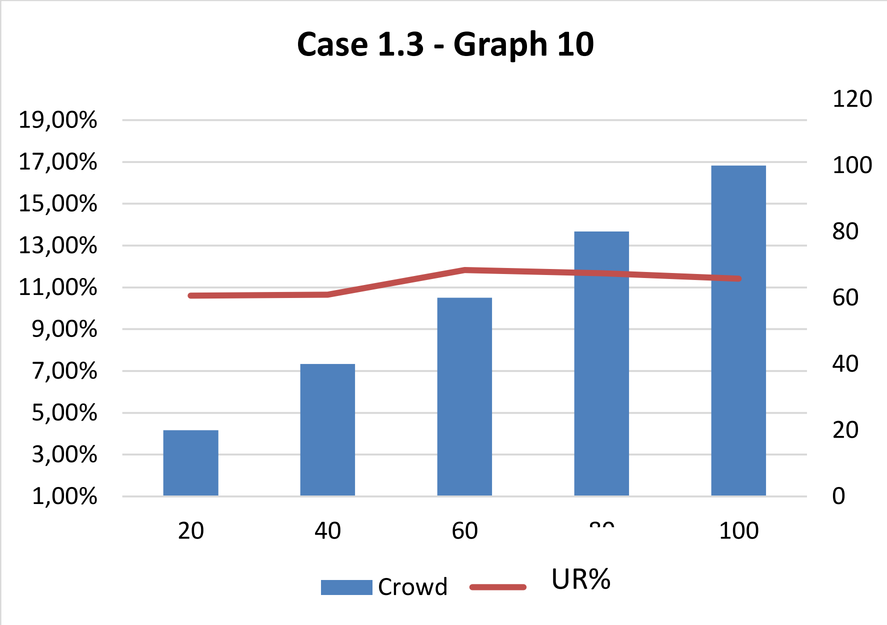
The following result has been obtained:

Crowd	Avg cost (€)	UR (%)
20	5,128	10,60%
40	5,109	10,65%
60	5,103	11,83%
80	5,099	11,68%
100	5,092	11,42%

Table 25 Results Case 1.3



Graph 9 Average cost behaviour increasing the number of people in the crowd Case 1.3



Graph 10 Unavailability rate behaviour increasing the number of people in the crowd Case 1.3

Graph 9 and Graph 10 respectively shows how the average cost and unavailability rate vary when the number of riders in the crowd increase.

As shown in all the previous graphs it can be seen as the costs per delivery decreases when the number of riders increases. The reduction is absolute terms is small: in the one-hour case is € 0.066, in the two-hour € 0.031 and finally in the same day is €0.029. If the cost reduction is compared to the percentage of the increase of number of riders it can be seen as, while the crowd grows of the 80%, the fares decrease of 0.85% in the one-hour case, 0.48% in the two-hours service level and of 1.85% for the same-day delivery. If the crowd increases to 200 or 300 people, the reduction is still slight, still around 1% in the one-hour delivery case.
Looking at the unavailability rate it can be noticed as it remains almost constant around 43% per one-hour delivery, at 18% in the two-hour one and 11% in the same day shipping, this is maybe related to the fact that the number of people grows at the same pace of the number of drivers that are available but not eligible to carry the delivery due to some constrains.
From a theoretical point of view this reduction probably was expected to be higher. This kind of sensitivity test may show an overall limit of the algorithm. As previously explained the model is based on 100 locations to which the algorithm approximates all the addresses put in input, the low sensitivity of the price to the increase of people in the crowd can be based on this limit. Probably if more address were put in the model data set, a more precise evaluation of the cost could be done and consequently higher variation could be seen in the results.

Vehicle Mix

Another interesting variation that will be made is about the type of vehicles used by the drivers. As stated the transportation mean is related to the rider performances due to its connection with other constrains in the model, like the time and the parcel weight. In the base case scenario, the vehicles were put in input according to an imposed mix in which different transportation means have different distributions. The first trial will be try different types of crowds made only by one type of transportation mean and then looking at the performance, then a good mix of two or more vehicles will be tested to see if it can give some improvements.

Case 2.1

The case 2.1 is the one made by a walking only crowd with all the other entire variables equal to the base case scenario. Again the model was run three times with the three service levels of the model.

	Service Level	Crowd	Vehicle	Parcel Weight
Case 2.1	1h	100	Foot Only	Base
	2h	100	Foot Only	Base
	Same Day	100	Foot Only	Base

Table 26 Case 2.1

Case 2.2

Case 2.2 is characterized by having only bikers as possible delivery man cycling to meet all the service level required.

	Service Level	Crowd	Vehicle	Parcel Weight
Case 2.2	1h	100	Bike Only	Base
	2h	100	Bike Only	Base
	Same Day	100	Bike Only	Base

Table 27 Case 2.2

Case 2.3

The crowd in case 2.3 is made only by motorbike riders and it is tested with three possible service level

	Service Level	Crowd	Vehicle	Parcel Weight
Case 2.3	1h	100	Motorbike Only	Base
	2h	100	Motorbike Only	Base
	Same Day	100	Motorbike Only	Base

Table 28 Case 2.3

Case 2.4

In case 2.4 the only vehicle available for the riders is the car.

	Service Level	Crowd	Vehicle	Parcel Weight
Case 2.4	1h	100	Car Only	Base
	2h	100	Car Only	Base
	Same Day	100	Car Only	Base

Table 29 Case 2.4

Results

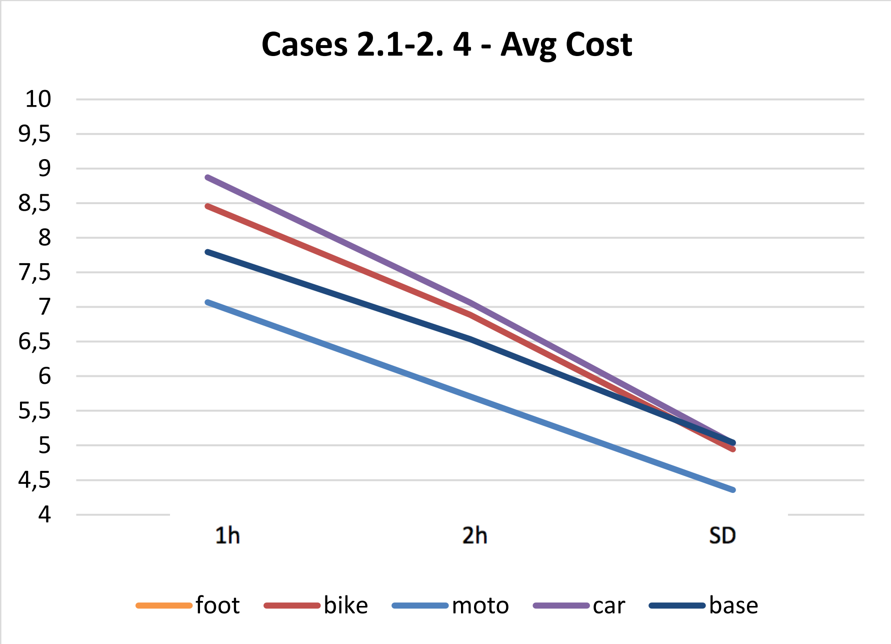
The following tables and graphs show the result obtained in the case from 2.1 to 2.4 and they are compared with the base case scenario.

Avg Cost (€)	1h	2h	Same Day
Case 2.1	-	-	9,812
Case 2.2	8,457	6,889	4,944
Case 2.3	7,066	5,710	4,356
Case 2.4	8,870	7,066	5,033
Case Base	7,797	6,535	5,041

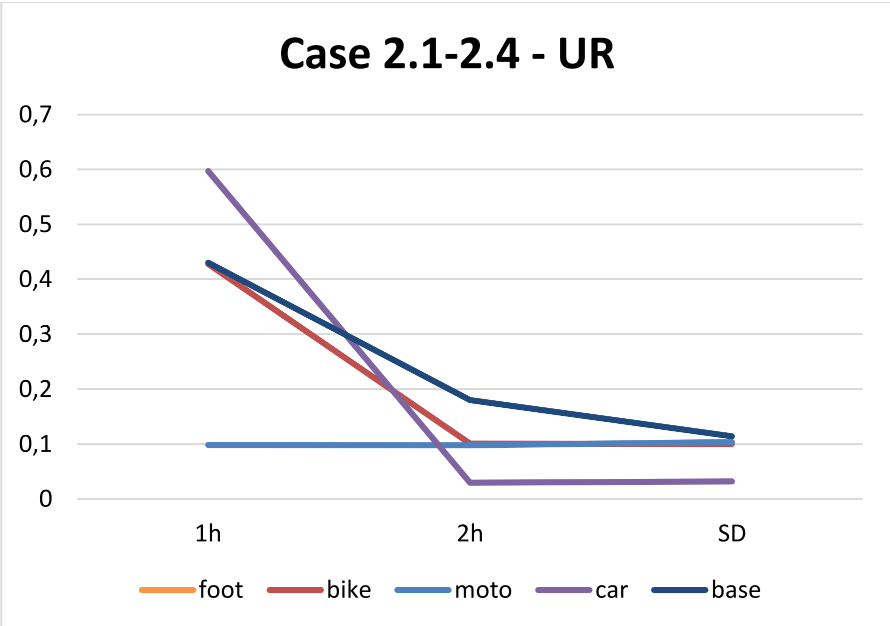
Table 30 Results Case 2 average cost

UR (%)	1h	2h	Same Day
Case 2.1	100,00%	100,00%	39,39%
Case 2.2	42,82%	10,08%	10,02%
Case 2.3	9,87%	9,79%	10,39%
Case 2.4	59,69%	2,98%	3,18%
Case Base	43,00%	18,00%	11,42%

Table 31 Results Case 2 unavailability rate



Graph 11 Average cost for Case 2.1-2.4



Graph 12 Unavailability rate for Case2.1-2.4

The first thing that can be noticed is that for Case 2.1, the foot only one, there is no cost for the 1h and the 2h delivery because those two service levels are not satisfied by this type of crowd being their averages performance over 60 minutes of time. Consequently, the unavailability ratio is at 100% for both, because all the walking riders cannot meet the requirements for that delivery.

The best case is definitely the Case 2.3, the motorbike one, which has the lowest cost per delivery for all the three service levels, and the lowest unavailability rate, for almost all the delivery times. The second best solution is the bike one with still good prices in terms of delivery fare for all the shipping time. What it is interesting to notice is that a two-hour delivery done by car cost exactly the same of one carried by motorbike in an hour. Consequently, for sure, the most efficient crowd to use in terms of time and cost from the merchant point of view is definitely one made by motorbikes, especially in the very fast (one-hour) and fast delivery (two-hour). From a crowd perspective the unavailability rate does not have its lowest values with the motorbike, but with the car in the two-hour delivery and in the same day shipping. The values of respectively 2.98% and 3.18% show how only a very small part of the crowd is not eligible to accomplish deliveries in Case 2.4. The reasons behind those results are found in the transportation mean itself, which allows good performances in terms of time, even if traffic is considered in the model, and the upward limit that is put on the parcel weight transported, usually at 10 kg, here is move up to 15 kg because the items can be stocked in the car and the riders do not have to carried it on shoulders or by hands.

If the results of one-vehicle type cases are compared to base case scenario, it can be noticed as in terms of average cost a mixed model is preferable to the almost all the others cases, except for the motorbike. Considering, instead, the unavailability rate in the mixed model is higher compared the one-type vehicle crowd especially in the fastest delivery times, this is due to the effects of walkers and car drivers, who cannot meet those types of requests.

Considering the output obtained in terms of costs and of unavailability rate the best outcome were in the bike and motorbike cases (Case 2.2 and Case 2.3), therefore a new mix of 50% bike and 50% motorbike is going to be test to see if there some other improvement in the performances.

	Service Level	Crowd	Vehicle	Parcel Weight
Case 2.5	1h	100	50% Car – 50% Bike	Base
	2h	100	50% Car – 50% Bike	Base
	Same Day	100	50% Car – 50% Bike	Base

Table 32 Case 2.5

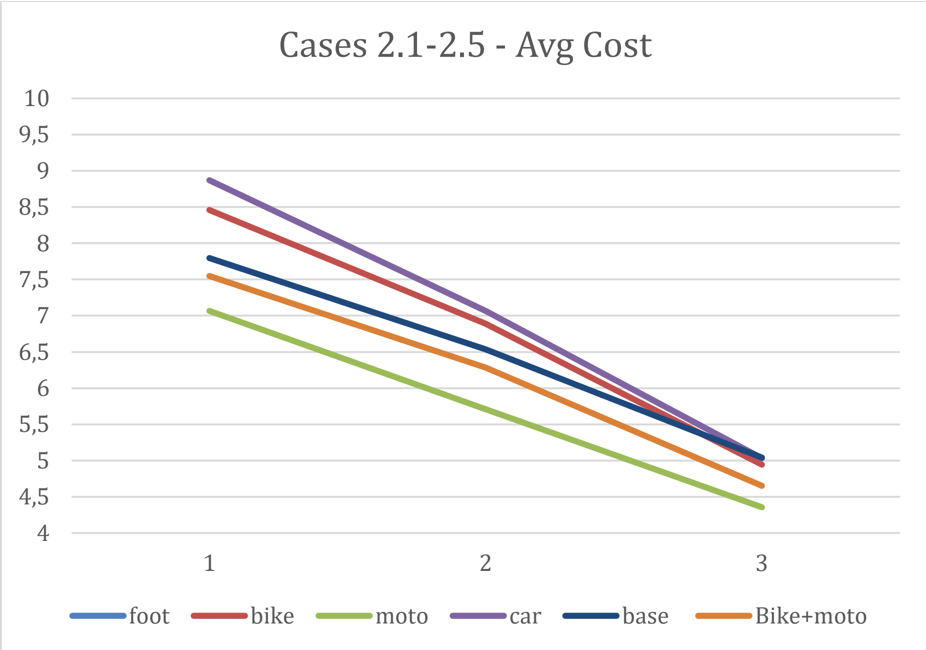
After running the model for three times, those are the outcomes:

Avg Cost (€)	1h	2h	Same Day
Case 2.5	7,548	6,286	4,650
Case Base	7,797	6,535	5,041

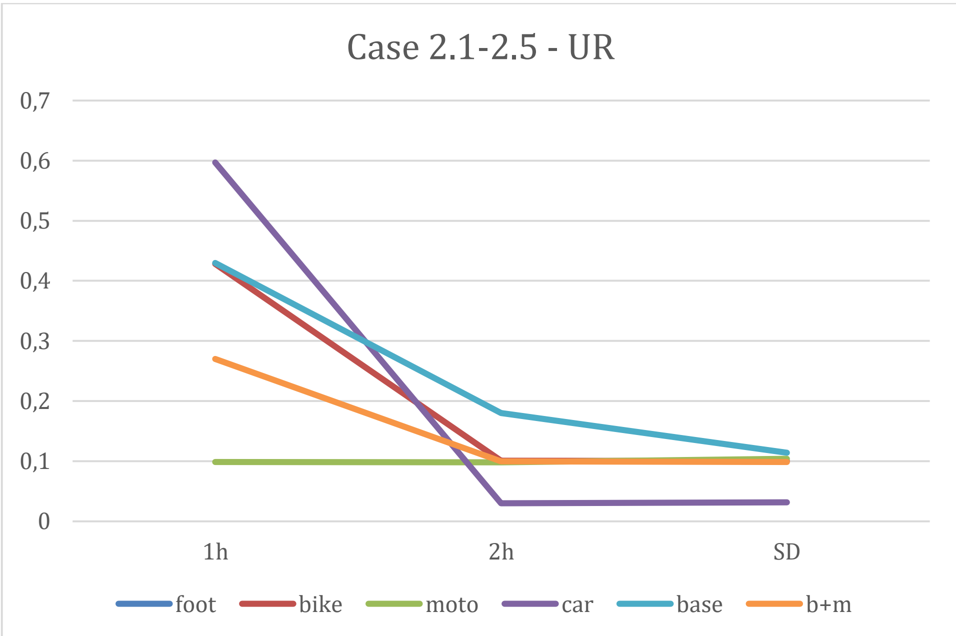
Table 33 Results Case 2.5 average cost

UR (%)	1h	2h	Same Day
Case 2.5	27,01%	9,97%	9,86%
Case Base	43,00%	18,00%	11,42%

Table 34 Results Case 2.5 unavailability rate



Graph 13 Average cost for Case 2.1-2.5



Graph 14 Unavailability rate for Case 2.1-2.5

The results obtained in the case 2.5 are compared with base case scenario in the tables and in the graphs with all the other cases discussed in the vehicle mix. This new combination of transportation means, as forecasted, is an improvement if it is compared to base case scenario, of which the two best performers were taken. The difference in terms of cost increases with the enlargement of the delivery time frame, from -3%, Case 2.5 vs base, to -8.4%. Looking at the UR, it can be noticed, as there is an improvement of 20 bsp in the one-hour delivery and 9 bsp in the two-hours one, then the performances are closer in the same-day shipment.

The comparison of the new vehicle mix with all the other cases shows that the motorbikes only always exceeds it in terms of costs, while in the UR motorbike and motorbike+ bike are aligned, but still in this case car only scenario wins.

Food Delivery

As previously discussed a very interesting industry, where potentially crowdsourcing can be applied, is the food delivery, which has seen recently a growing number of actors. Those companies, right now, do not operate in crowdsourcing logistics, but they way of choosing the best rider to assign to him the shipping is really similar to crowdsourcing logistics. Indeed, the delivery cost optimization is one of their objectives in order to increase profitability. Their business model is built on very fast delivery, usually 30 minutes, accomplished by bikers or motorbike riders. Looking at the model dataset this performance cannot be achieved by any type of vehicle; the lowest average time is 35 minutes with motorbikes, for all the other transportation means the averages are higher. The closest performance achievable in the model data set is 45 min with motorbikes, which is going to be test in the following cases.

In order to understand if the algorithm can describe and predict those firms' business model four cases were set as input in the model. All those cases, to better describe food delivery business have peculiar characteristics: all the parcels are under 5 kg; the crowds consist of bikes, motorbikes or mix of them; the service level inputted are always one hour with an exception of one put at 45 minutes.

Case 3.1

Case 3.1	**Service Level**	**Crowd**	**Vehicle**	**Parcel Weight**
	1h	100	Bike Only	<5kg

Table 35 Case 3.1

Case 3.2

Case 3.2	**Service Level**	**Crowd**	**Vehicle**	**Parcel Weight**
	1h	100	Motorbike Only	<5kg

Table 36 Case 3.2

Case 3.3

In this case, in order to make more attractive to the riders the 45 min long delivery, the wage for this super express delivery has been increased. The rider's salary, and then the merchant cost, will be evaluated as 3€ per delivery, fixed part, plus 6.5€ per hour for the flexible part.

Case 3.3	Service Level	Crowd	Vehicle	Parcel Weight
	45 min	100	Motorbike Only	<5kg

Table 37 Case 3.3

Case 3.4

Case 3.4	Service Level	Crowd	Vehicle	Parcel Weight
	1h	100	50% Bike 50% Moto	<5kg

Table 38 Case 3.4

Results

The results of the model calculation are shown in the following table

	Avg Cost (€)	UR (%)
Case 3.1	8.453	36,49%
Case 3.2	7.067	0,01%
Case 3.3	7.400	50,96%
Case 3.4	7.557	18,42%
Case base (1h)	7.797	43,30%

Table 39 Results Case 3

The first learning that can be taken from those data is that all the values are higher compared to the benchmark ones in the real food delivery cases; this is due to two main reasons. First, the offer of this kind of delivery providers is limited to same part of Milan, while the model is set on the entire city surface. So being the availability of the service restricted to some areas the distance that has to be covered by the rider is smaller and consequently the cost is too. Moreover, the average wage of the deliver in the model is higher compared to the one of the existing competitor. The algorithm gives 3€ per delivery plus a flexible part related to the time that the rider need to reach the destination, while Foodora pays 2.70€ per delivery and secondary sources say that with Deliveroo riders can earn up to 7€ per hour.

Looking at the results, the best performers are, again, the motorbike riders, with the lowest cost and an UR rate at zero per cent. Comparing the one-hour delivery and the 45-minutes one it can be seen as the difference in terms of price is low, even if in the

45-minutes shipping the rider is paid more, but in terms of UR the values are really different the target of 45 minutes' delivery cannot be satisfied but half of the crowd. The case 3.1 compared to the others has a higher cost at the same performance level of case 3.2, another time the mix solution is interesting because its cost is not that high and this solution is flexible according to the distance of the delivery, for instance in the short range bicycles can be used for the delivery and in the long one motorbikes can be deployed.

With the aim to better simulate the way in which these companies operate the model can be reset with input data that are more similar to the food delivery start-ups business. As previously said the overall cost resulted in the case 3.1-3.4 is higher to the benchmark levels because those companies deliver only in specific areas of Milan. In deeper analysis, these firms require the user to insert the destination address on the website as first things. Then, an algorithm shows only the restaurants that are close enough to allow the fast delivery, in 30-45 minutes, and, consequently, the shipments made are not too expensive. Starting from this, the model dataset, the database connected to the model where all the origin and destination addresses are stocked, has been changed.

The city of Milan is divided into nine municipalities and two of them were chosen to test the model, Municipality 1, the city centre, and municipality 7, Baggio, De Angeli and San Siro area. The new datasets, with which the model will be used now on, contain only addresses that are into those areas, so the cost estimations and the unavailability rate will be specific for the area the dataset is about.

The choice of this two districts were not casual, indeed in the former the two start-ups chosen as benchmark are active, in the latter they do not deliver any kind of meal. The activeness/inactiveness was proved by inputting all the addresses inside in the two new datasets in these companies' websites.

For Municipality 1, 114 possible paths were put and evaluated in different service levels; for Municipality 7, 121 possible tracks were inserted and then tested. As for the other food delivery cases the parcel weight is estimated to be less than 5 kg and the crowds considered are made only by the motorbikes riders, bikers or a mix of them.

The service levels considered are three and they are specific for these cases in order to better reflect the real offer of those companies. There are three time frames 60 minutes, 45 minutes and 30 minutes; for the different service levels incremental wages are given to the riders. In the one-hour delivery they are paid as before, 3€ fixed plus 6€/hour for the time needed to the delivery, in the 45-minutes delivery, again 3€ fixed plus 6.5€/hour and, finally in the 30-minutes one, 3€ fixed plus 7€/hour; in this way

the merchant is charged the highest for the fastest delivery and the riders are more likely to accept a fast shipping rather than another one.
From a theoretical point of view, the model is forecasted to give the following results: on one hand, for Municipality 1, low shipping fares and low unavailability rate for all the service levels, on the other hand, high shipping prices that should not make profitable for those companies to deliver in this area, or the impossibility for the drivers to accomplish the shipping in respect with the time frame required.

Case 4.1

	Service Level	**Parcel Weight**	**Vehicle**
Case 4.1	60 min	<5kg	Moto
			Bike
			50% moto -50% bike
	45 min	<5kg	Moto
			Bike
			50% moto -50% bike
	30 min	<5kg	Moto
			Bike
			50% moto -50% bike

Table 40 Case 4.1

The inputs summarized in table 40 have been used both for Municipality 1 and 7 to test the hypothesis taken before. After running the model with all the 144 and 121 tracks available in those districts the following results have been obtained.

Municipality 1	**Service Level**					
	60 min		45 min		30 min	
Motorbike	€ 5.279	0%	€ 5.468	0%	€ 5.420	0%
Bike	€ 4.545	0%	€ 4.674	0%	€ 4.803	0%
50% motorbike - 50% bike	€ 4.926	0%	€ 5.028	0%	€ 5.071	10,40%

Table 41 Municipality 1 results

Municipality 7	**Service Level**					
	60 min		45 min		30 min	
Motorbike	€ 7.200	0%	€ 8.217	42%	-	100%
Bike	€ 7.654	0%	€ 7.440	46%	-	100%
50% motorbike - 50% bike	€ 7.419	0%	€ 7.515	44%	-	100%

Table 42 Municipality 7 results

The results shown in previous tables 41 and 42 are divided per municipality, per each service levels and per each vehicle two value are given, the first one is the shipping fare arising from the model simulation and the second one is the unavailability rate.
Looking at the outputs for Municipality one, it can be noticed as almost all the service level are guaranteed with 0% of unavailability rate, except for the mixed vehicle crowd in 30 minutes. Those values testify that is feasible to having a lot of riders because they do not have to wait too long to get a shipping. Very good results are the ones about the fares. Overall the prices are low, both compared to the based case scenario and the previous food delivery case. Comparing the fares with the start-ups taken as benchmark in this case (5 €/delivery), the outputs are really similar and sometimes even smaller, even if the riders' wage choice that was taken at the begging. In order to be fair with the deliverymen this higher salary is given to them. Anyway, even with those higher pays the model is sustainable for the companies and the results confirms that those companies deliver in municipality 1.
Considering the data for Municipality 7, another scenario is given. The first thing that can be noticed is the total unavailability of all drivers to deliver in 30 minutes. In this area it is not possible for any vehicle to accomplish a delivery in half an hour. The 45-minutes service level can be satisfied only by 44% on average people in the crowd and the one-hour delivery does not have those issues. Looking at the fares per delivery the values are higher than the ones in the other municipality considered and they are almost the double of all the other prices. Compared to the benchmark (5 €/delivery), they are on average 33% higher. Those outputs both in terms of delivery fares and unavailability rates shows how it is not profitable for a company to deliver in this area and even they can make some profit, it is not possible to unsure the 30-minute delivery which is a standard for the food delivery start-ups. Another time the model describes correctly the fact that the food delivery start-ups are not active in this area because they would face too much high expense.

Rider Convenience

So far it has been discussed how crowd shipping is more convenient for the merchant because it cost less than the traditional express couriers and in some way this convenience is seen even by the final consumer that can receive his purchase at a lower shipping rate. Anyway there is another fundamental actor, who is the rider. The rider is the jobber that delivers the parcel to the final consumer. Higher is the number of the riders in the crowd better are the performance in terms of cost and delivery time. An interesting perspective to take is the rider convenience. In the crowdsourcing model presented the rider faces all the costs related to the delivery. The platform, indeed, does not provide any kind of vehicle or maintenance to the drivers; it is only an intermediary to provide delivers and all the expenses related to that are on the rider shoulders.

The aim of this paragraph is to understand if it is convenient for the rider accomplish a delivery or not, the data will be taken from the model and the cost will be estimated thanks to ACI, Automobile Club d'Italia.

First of all, the prices for deliveries that results from the model executions are the one that are charged on the merchant, but they are not the one given to the riders. In fact, the platform to self-sustain itself withdraw a commission on every delivery accomplished by the driver as a facilitator fee. This commission is a percentage of the final delivery price; in this case it will be put at 10%.

The cost faced by the rider can be estimated only for the motorbike and for the car. For the walking case, the deliveryman does not have any kind of cost, beside the time he decides to invest in the delivery. Considering the bike beside the initial purchase of the bike and some maintenance the biker does not have great expenses. For the motorbike and the car the costs increases: the gasoline, the taxes paid on the ownership of a vehicle and the annual maintenance of the transportation mean. The objective here is not to have a detailed list of all those expenses, but the value from ACI will be taken a good estimation for the costs based on the kilometres done with the vehicle.

	Cost (€/km)
Motorbike	0.108
Car	0.198

Table 43 Cost per Km faced by the driver

The two values showed in the table are estimation made on ACI website, the expenses consider both the proportional and not proportional costs related to the use of the

vehicle. Different cars and motorbikes were selected and an average value was estimated.
Two cases were selected to make the evaluation of the riders' profit, the case 2.3 and the case 2.4. In those situations, there are respectively only motorbike and only car in the crowd.
In the following tables the computations needed to obtain the profit per delivery are shown: the first value to subtract is the platform fee, put at 10%, then the riders' expenses evaluated with the cost stated in the previous table.

Case 2.3	**Merchant fee (€)**	**Platform fee (€)**	**Rider expenses (€)**	**Profit per delivery (€/del)**
1h	7.066	0.707	1.355	5.004
2h	5.710	0.571	1.355	3.784
Same Day	4.356	0.436	1.356	2.564

Table 44 Rider's profit Case 2.3

Case 2.4	**Merchant fee (€)**	**Platform fee (€)**	**Rider expenses (€)**	**Profit per delivery (€/del)**
1h	8.870	0.887	4,314	4,410
2h	7.066	0.707	3,818	3,756
Same Day	5.033	0.503	3,259	3,206

Table 45 Rider's profit Case 2.4

The results show how the highest profit can be achieved with motorbike in the express delivery of one hour. This result is reasonable because in this situation the wage is the higher compared to the others, the time is the shorter, consequently the space covered, and being smaller the space lower are the expenses related to it. The lower profits are the ones in the same day delivery both for motorbike and car, but in those cases the degree of freedom for the rider is higher and he can try to optimize the deliveries during the same day and by doing so he can earn more money.

Conclusion

The sensitivity analysis presented is useful to estimate how good the model is in predicting the real events that it tries to describe. In absolute terms the model can be considered good, it gives a good proxy of reality and its results vary according to the several scenarios put into it. The best configuration in terms of delivery cost and unavailability rate are the ones in which the crowd is made only by motorbikes or the mixed ones where there are always a good percentage of motorbike rider. The worst ones in terms of performances are the walking crowd, which strive to achieve the more demanding service levels. The model can be even used to explain domains similar to the ecommerce shipping like the food delivery industry, here the actual actors offer a service similar to it, but the area in which they operate is restricted to some areas of Milan, they do not cover the entire city, this is why the result of the model are not close to their tariff. Restricting the model data set to specific districts within the city, the model predicted correctly where it is profitable or not for a company to deliver ready meals. The two municipalities has been chosen to test the model and to see if it can explain the start-ups' choice to ship or not in same areas. This result is important to demonstrate how flexible is the model algorithm and to prove its real capability to describe and predict some business choices made by active actors in this business. Simply by changing the input values the model can be applied to different business cases and give a trustful description of them.

One drawback of this model that the sensitivity analysis highlighted was the incapability of the algorithm to measure changes when the number of drivers increases, this is due to the dimension of the model data set, which is broad, but not broad enough to be sensitive to this kind of changes.

Last, the evaluation of the convenience for the rider, gives an idea of how this solution can be sustainable not only for the merchant or for the platform but even for the crowd itself. Looking at the results, the riders do not earn a lot of money and probably they will not be able to live out of this work, but compared to the competitors the pay is higher and fair.

General Conclusion

The research has been set from the begging to answer to three research questions, one related to literature review, one about the way of doing crowd shipping and the last one about the convenience of crowdsourcing logistics.

The literature analysis carried out in scientific papers about crowdsourcing logistics highlighted how this theme is new to scholars and how the existing body of literature is made by very few papers. Anyway the increasing number of papers in the recent period shows as this subject is having hype in scholars' interest. There is not any kind of predominance of one type of methodology over another; simulations and mathematical models are the most used among the scholars. What it is missing is a general framework that can describe this business and this should be the future objective for researchers in order to better and deeper understand this theme.

Scientific research future agenda on this topic has to be focus mainly on finding the best way to implement and put in practise crowdsourcing logistics in the last mile delivery, but first the aspects of this business have to be argued and analysed, both the pros and the cons and risk that could arise from the application of such a practise. A deeper understanding could come from systematic studies upon real initiatives and business cases, which are already discussed in publications for general public in books and blogs, but not yet in the scientific literature.

Starting from this overall scarcity of scientific literature to base the research on, in order to have a deeper understanding of the industry, an analysis on all the possible ways to do crowdsourcing logistics has been done. The result of this practical analysis is the development of classification or taxonomy of the firms' business model that operates in this industry. The classification variables, chosen from crowdsourcing literature and from practical experience, allowed analysing completely in detail the business models of those firms. Those classification dimensions are eight and they are: target, origin, destination, firm type, crowd, industry, fare and time frame. It was possible to identify two clusters within the 35 companies analysed, the B2C and the P2P side of the offer. The B2C cluster is made by start-ups and initiatives put in place but big players in ecommerce. They ship in short times and always in urban areas. The P2P is made only by start-ups. These new firms are platforms that meet demand and offer for shipping especially in long distances, usually all the aspects of transaction are decided among the two peers. At the research time the bigger cluster was the P2P, but looking and the dynamicity with which this industry is evolving the environment could change really fast.

For future research should be interesting to study how this industry will evolve and reshape in time and understand which ones of the two business models will have more success.
Regarding the application of crowdsourcing in ecommerce for sure the best one is the B2C side of the offer, so starting from its characteristics the model to evaluate the effects on the last mile delivery was built. As explained in the previous paragraph the model was built with the aim to applicable in several industries.
The results obtained with the model show an improvement in terms of costs face by the merchant if it goes for the crowdsourcing delivery instead of the traditional logistics. Indeed, for the one-hour delivery the average cost is 7.80 € per delivery, 6.50€ for the two-hour shipments and 5.04€ for the same-day. If those results are compared with the traditional couriers' fares they are cheaper respectively of 60%, 50%, and 40%. The just shown results are for mixed vehicle approache, where all the transportation means inserted in the model were inputted in the simulation (foot, bike, motorbike and car). Better performances can be achieved with motorbikes only and bikes only crowds. The best vehicle in terms of cost is the motorbike that guarantees the best results in all the service levels even in terms of unavailability rate.
The cost for a one-hour delivery is 7.06€, 5.71€ for the two-hour and 4.36€ for the same-day. The worse performer is the delivery on foot, this shipping mode does not satisfy the one-hour and the two-hour delivery time, but only the same day one at 9.81€ per delivery which is even 14% higher than the average of traditional couriers.
The model, then, was use to simulate the food delivery service in Milan, actually done by start-ups like Foodora and Deliveroo; crowd of motorbikes, bikes and mix of them were tested with a parcel weight under 5 kg and with the usual service of one and two hours, plus an extra one of 45 minutes to better simulate this kind of service.
The results obtained were higher in terms of prices compared to food delivery companies for two main reasons: the wage of the riders is higher in this case and the delivery is thought to happen in all the city not only in restricted areas like those companies do.
In order to better simulate the food delivery business, a last variation was done. This time the model dataset was changed with more restricted databases related to two municipalities in Milan. The choice of those two municipality, the fist and seventh, was done because in Municipality 1 most of the delivery start-ups operate, while in Municipality 7 none of them is active right now. The model was fed with data configuration similar to the previous food delivery cases and with three types of service level, 60 minutes, 45 minutes and 30 minutes. This last one is a standard for food delivery and it was not possible to achieve before operating on an entire city

scale. The computations were done by the algorithm and the results confirmed the hypothesis taken at the beginning. For Municipality 1 all the service levels were available and at cost which was almost the same of the benchmark value. Regarding Municipality 7 the 30-minute service level resulted to be unavailable for all vehicles considered and the 45-minute one was unavailable for almost 50%of the crowd. Looking at the fares the results are 33% higher than the average in food delivery. Those two factors show it is not possible and profitable to deliver in this area indeed those companies do not operate in this district.

Finally, the model was set with a growing number of people in the crowd to see if the actual costs of delivery get down increasing the amount of possible drivers. This scenario was tested in all the service levels and with all the types of transportation means. An overall learning from that is the cost decreases but less that actually is predicted to do. It is correct to say that the two dimensions are negatively correlated, but while there is an increase of 80% in the dimension of the crowd, the cost reduces only at 1%, so in the model it is almost constant. The cause of this can be found in the way the model is built; the driver's origin and the customer's address are approximated to one of the 100 selected locations in the data set and, consequently, the degree of error and the precision of the model is affected by that proxy.

Looking at future research there is some room for improvement in the model presented in this dissertation. First of all, by increasing the number of locations inserted in the data set, the model can have a better precision in predicting real events, so a more realistic estimation in terms of time, cost and unavailability rate can be done. For a greater improvement the model can automatically connect to Google Maps to evaluate the time for each transportation mean. Another interesting deployment can be in allowing other way of carry parcels for instance by using public transportation services, that can make the walking solution more suitable even for the more restrictive service levels. Some other new features could be added like a mechanism of surge pricing, that can make the pay of the riders more flexible and shape it in order to redistribute in time and in space the crowd.

In the end this model is an attempt to study and analyse this emerging business of crowdsourcing logistics to understand which are the possible benefits that can arise from its application in the ecommerce. This industry, as already stated several time, is still in the first phases and it will probably see a lot of changes and developments in the next years, it has a lot of potential in terms of offering cheap delivery services in the last mile and to be one of the factors that will facilitate and foster even more the diffusion of ecommerce.

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