Innovative crowdshipping model for e-commerce deliveries

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Abstract

Cities have faced a rapidly growing demand for mobility due to the growth of e-commerce activities and the increase of population living in urban areas. It is expected that 68% of the world population will be living in cities by 2050. A substantial increase in parcel delivery has appeared as a major component of e-commerce growth, and this has become a challenge in the operations of logistics providers that are in charge of the management of the last mile delivery and home delivery services. To mitigate some of the challenges of e-commerce, a term crowdshipping has been introduced to address some of the issues in urban areas. Crowdshipping can be described as the utilization of spare loading capacity on already existing transportation flows.

An online-based survey with an SPS approach was conducted with the participation of 54 university students for the collection of necessary data for the creation and proposition of an innovative crowdshipping model for e-commerce deliveries. Additionally, the identification, analysis, and discussion of different crowdshipping models were studied in the thesis by means of an extensive literature review.

The combination of an extensive literature review and the collected data from the online-based survey have successfully assisted for the creation and suggestion of an innovative crowdshipping model which focuses on e-commerce deliveries. The establishment of a University-based Hub with the participation of crowdsourced student's has been suggested as a potential solution to cope with the demand of e-commerce deliveries.

The proposed innovative crowdshipping model has appeared to be a potential solution to improve the last mile delivery and capable to supply the demand of e-commerce deliveries. It was concluded that crowdshipping was recognized as a novel concept. Therefore, research for the further development of the introduced concept and the proposed crowdshipping model was recommended.

Keywords/tags (subjects)
Crowdshipping, Crowdsourcing, Last-mile delivery, E-commerce, Sustainability

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1. Introduction

Cities are facing a fast-rising demand for mobility associated with the megatrend of e-commerce, an increase of the world population, and the constant mass movement of people to urban areas. Today, 55% of the world´s population lives in urban areas, a proportion that is expected to increase to 68% by 2050 (United Nations 2018). Moreover, the environmental impact that urban mobility provokes accounts for 40% of all CO_2 emissions of road transport and up to 70% of the other pollutants from transport (European Commission 2015).

It is known that freight transportation plays a key role in the economic development of the cities, but, at the same time, it threatens their inhabitability due to increased road congestions, environmental impacts, and energy consumption (Simoni, Marcucci, Gatta & Claudel 2019). Additionally, it increases noise pollution, transportation costs, and the risk of road accidents (Priester, Miramontes & Wulfhorst 2014).

E-commerce creates many challenges for transport planners and logistics companies that are in charge of the management of the last mile delivery and home delivery services. One of the major outcomes of the e-commerce growth is the substantial increase in parcel delivery (McKinsey & Company 2016) and the growth in the number of single parcels (Rougès & Mantreuil 2014), which may lead to a low utilization rate of the fleet (Chen & Chankov 2017).

'Last-mile' refers to the last leg of goods' movement from the last upstream distribution center, consolidation point, or local warehouse to the final destination (Xiao, Wang, Lenzer & Sun 2017). As a share of the total costs of shipping, last-mile delivery costs are substantial comprising 53% overall (Dolan 2018). The crucial challenges for last-mile delivery are closely related to cost and speed, meaning faster shipping at a lower cost. From an online customer point of view, delivery time is a major concern when it comes to immediate needs (Chen, Zhang, Wang, Ma, Han & Sha 2014).

The environmental impact of e-commerce has been drawing attention in the public´s eye, and the challenges of the last mile delivery have led to the necessity to develop new and effective solutions. Solutions that might contribute to the improvement of the environmental sustainability of the last mile delivery are fundamental due to the

substantial increase of e-commerce related to trips and urbanization (Allen, Piecyk, Piotrowska, Mcleod, Cherrett, Nguyen, Bektas, Bates, Friday, Wise & Austwick 2017).

As an attempt to mitigate some of the challenges created by e-commerce in the last mile delivery, a term introduced as ¨*crowdshipping*¨ has emerged as a potential option to address some of the problems in urban areas. Buldeo and colleagues (2017) referred to *crowdshipping* as the usage of the spare loading capacity on already existing transportation flows. It targets the crowd as potential actors that voluntarily accept to perform delivery tasks based on their original itineraries and flows.

The growing interest in shared practices of passenger and freight transportation indicates that a significant opportunity for improving city competitiveness could be found in combining both (Buldeo, Verlinde, Merckx & Macharis 2017). From the perspective of logistics companies, this solution seems to be promising for improving efficiency and meeting the growing demand for faster and cheaper home deliveries (Simoni, Marcucci, Gatta & Claudel 2019). Following this approach, costs can be reduced due to a better use of spare capacity, and a potential reduction of delivery trips can be achieved (Miller 2017). In addition, crowdshipping, in practice, can provide a more flexible and cheaper on-demand workforce.

This paper discusses a variety of implemented and suggested crowdshipping models. One of the objectives was to identify the benefits of crowdshipping and the related sustainability issues by analyzing the different approaches, strategies, and features that the presented crowdshipping models have. The study results on the creation of a new and innovative crowdshipping model which intends to supply the demand of e-commerce deliveries in one region specifically (Jyväskylä, Finland). However, the proposed model can be studied and developed further, which provides the possibility of enlargement of the coverage area in the future. The proposed model takes into consideration the participation of university students (potential crowdshippers) and requires the establishment of a parcel hub located at a selected university (JAMK University of Applied Sciences). To analyze the reliability and optimality of the suggested crowdshipping model, an online-based survey has to be constructed and carried out. The details of the survey have to be clarified with the continuation of the study regarding the other existing crowdsourcing models.

1.1.   Main objective and research questions

The aim of the current study is to develop an innovative crowdshipping model for e-commerce deliveries. The aim is to be reached by answering the following research questions:

1. How the presented crowdshipping models intend to balance the supply and demand?
2. What makes a crowdshipping model sustainable?
3. What repercussions does crowdshipping have on stakeholders and in urban areas?
4. Which kind of university students-based crowdshipping model would work in Jyväskylä (considering students willingness, capabilities, and limitations to participate as crowdshippers)?

The above-mentioned questions intend to be answered with the completion of the tasks below.

1. The analysis of the present situation of e-commerce and the selected crowdshipping models is required.
2. Discussion of the overview concerning the existing and suggested crowdshipping models is needed.
3. An impact of crowdshipping models on e-commerce demand are to be determined.
4. A survey regarding the proposed innovative crowdshipping model has to be carried out.

Because the main aim of the thesis is to develop an innovative crowdshipping model for e-commerce deliveries, the title of the thesis is being presented as *Innovative crowdshipping model for e-commerce deliveries.*

1.2. Thesis structure

The remaining part of this study is structured as follows: Chapter 2 introduces various *crowdshipping* models that intend to mitigate some of the problems of the last-mile delivery. It also describes the sustainability and benefits of crowdshipping in practice. Chapter 3 defines the methodology utilized for the data acquisition in relation to existing crowdshipping models and describes the methods utilized for the proposition of an innovative crowdshipping model. Chapter 4 presents the results from the distributed online survey, and describes the potential of the analyzed and proposed crowdshipping models as an option to supply the demand of the e-commerce. Chapter 5 suggests an innovative crowdshipping model for e-commerce deliveries and answers the main research questions of this study. Consequently, Chapter 6 concludes the thesis work and suggests further research on the proposed crowdshipping model.

2. Literature review

2.1. Crowdshipping and its relation to e-commerce

The author must clearly explain the significance of the concepts which are mainly utilized throughout this work. Therefore, optimal definitions concerning both crowdshipping and e-commerce are described below.

Crowd shipping is an innovative delivery model that could, at least in principle, stimulate a better use of the currently unexploited transport capacity, which might result in reducing transport cost emissions (Bubner, Helbig & Jeske 2014). However, crowdshipping is also referred to as crowd logistics, crowdsourced delivery, cargo hitching, or collaborative logistics that uses the free capacity available in various transport modes to perform deliveries (Buldeo, Verlinde, Merckx & Macharis 2017). Nevertheless, crowdshipping is a shared mobility service and implies delivering goods by using the crowd (McKinnon 2016).

Similarly, e-commerce, also known as electronic commerce or internet commerce, refers to the buying and selling of goods or services using the internet, and the transfer of money and data to execute these transactions (Shopify 2020). The term of e-commerce can be mainly categorized in different groups as shown below:

1. Business to Consumer (B2C)
2. Business to Business (B2B)
3. Consumer to Consumer (C2C)
4. Consumer to Business (C2B)

Due to the constant growth of global e-commerce operations and sales in the past years as shown in Figure 2, many challenges and difficulties have emerged with it, affecting mainly the profitability of the transportation companies and logistics providers in charge of managing the last mile and home delivery services. Subsequently, this increases competition between service providers, has an environmental impact, creates unnecessary expenses for failed deliveries, and tends to make matters concerning reverse logistics more challenging.

The above can be directly linked to customers´ demands since they now expect faster and free shipping and competitive prices for their deliveries. As a result, consumers begin to value time over reliability. Figure 1 describes a cycle that identifies possible consequences for logistics providers due to the increase of e-commerce activities.
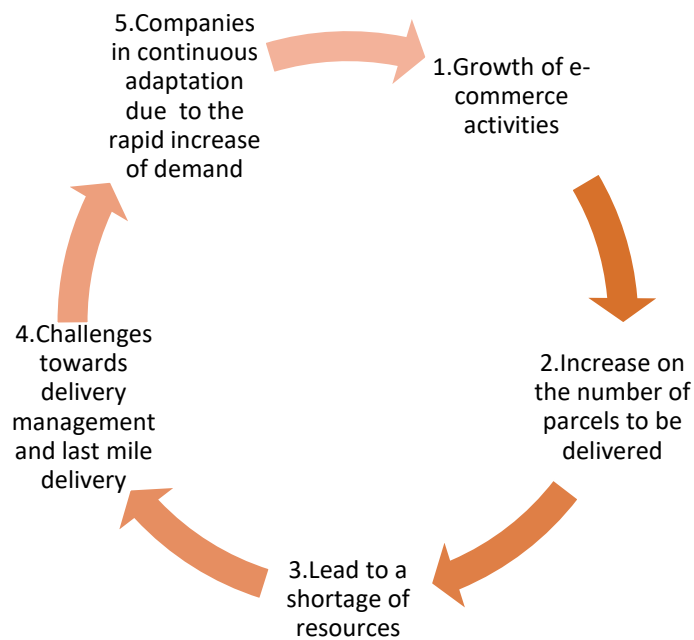
Figure 1. Consequences of increase of e-commerce activities for logistics providers.

One of the reasons why the industry of e-commerce has recorded a considerably high increase in sales is the high density of urban areas, which eases logistical challenges that online companies face when offering a service. At the same time, brands have improved their online capabilities, which makes them more accessible and reachable. However, e-commerce might appear to be the most convenient way at least from the customer's point of view since it is faster, and easier to purchase items. Depending on the product, it can be customized and tailor-made, and e-commerce industry makes it attainable. E-commerce as a service could be used 24/7 and

365 days a year offering the opportunity to perform transactions regardless of place and time.

Retail e-commerce has been rapidly increasing its sales in the past years, and it is expected to grow considerably in the upcoming years as shown in Figure 2.

Retail e-commerce sales worldwide from 2014 to 2023
(in billion U.S. dollars)
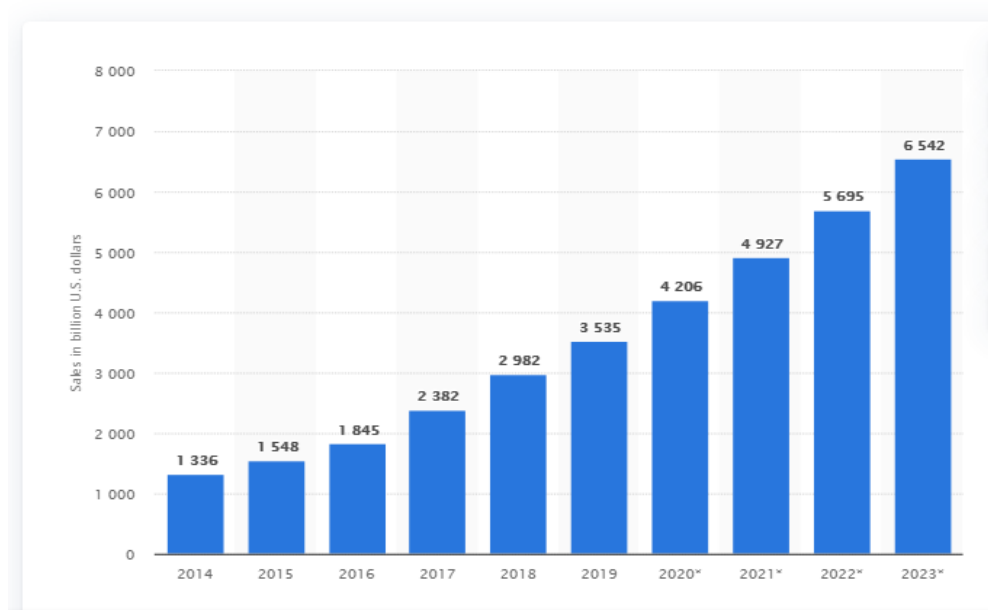
Figure 2. Global retail e-commerce sales from 2014 to 2023 in billion U.S. dollars (Clement 2020).

Figure 2 indicates a gradual increase in sales regarding the global retail e-commerce from 2014 to 2023. Sales in 2019 reached 3535 billion dollars representing a growth of 18% in comparison with the previous year 2018. However, it has been forecasted that for the year 2020, e-commerce sales will be worth 4206 billion U.S. dollars constituting a rise of 19% from the year 2019.

2.2. Crowdshipping models

This chapter presents suggested delivery methods and practices. The purpose is to give a clear insight into how the logistics industry can mitigate the current problem regarding parcel delivery and how the traditional deliveries have been replaced by different models of new services. In other words - *"How can crowdshipping provide feasible and effective solutions and adapt to the needs of urban areas?"*

2.2.1. Packing circle model

One of the most challenging issues surrounding urban logistics is the parcel delivery. Due to the constant growth of e-commerce worldwide, this industry has faced a rapid increase in operations in the recent years as shown above in Figure 2. A significant number of house parcel deliveries have been returned since the customer (consignee) has not been at the agreed point of delivery. Unattended parcels may require multiple attempts for delivery, and this situation has become a significant issue among logistics companies (Wang, Zhang, Liu, Shen & Lee 2016). Therefore, special methods and actions have been suggested to meet the customers' demands and improve their satisfaction.

It is considered that urban entities and highly dense cities are in the priority in comparison to rural areas. That is why delivering to urban online shoppers should be the main concern (Durand, Mahjoub & Senkel 2013). Besides, deliveries have to be performed promptly along with the location accuracy.

Urban logistics is the final stage for delivering parcels to customers living in urban areas. The studies focused on urban logistics could be classified into two main categories: *last mile and city logistics* (Rose, Mollenkopf, Autry & Bell 2016).

1) Last-mile delivery: Mainly focused on costs associated with delivering to end customers.
2) City Logistics: Focused on the characteristics of the urban area that influence the efficiency of logistics.

Due to the increase of e-commerce worldwide, more operations are performed. The number of operations, in its turn, creates more complexity in the supply chain concerning environmental and economic aspects. It is important to mention that there is also a controversy from the customers´ point of view and their needs. While the majority of the customers prefer their parcels to be delivered quickly and at a smaller cost, the other part of the customers care about sustainability and the environment. However, sometimes one can observe the third group of customers who have a combined view on logistics operations.

According to the study by Akeb, Moncef, and Durand (2018), the idea of encouraging the citizens from the same neighborhood (neighbor-relays) to collect and deliver parcels to the final consumer has been presented. This approach is valid when the actual consignee is away from home during the planned time of delivery. To fulfill the above, transparent and reliable communication between the final customer and neighbor-relays must take place. If such has been carried out successfully, the delivery is referred to as completed according to the plan – the item has been delivered on time at the right place without any additional or overhead costs.

If the above solution is implemented, it might be attractive for both neighbor-relays and transporters. Since neighbor relays receive an incentive or income, the transporters will benefit from the reduction in cost.

A model based on circle packaging has been suggested to find a solution to all those deliveries that have failed at the first delivery attempt. Akeb and colleagues (2018) have proposed a model that is economically effective since it avoids parcel delivery failures and provides a reward to the citizen in charge of the last-mile delivery.

Some researchers have suggested solutions to meet the customers' demand, maximize capacity, and minimize travel distance as well as time and costs. A vast number of models, such as VRP (Vehicle Routing Problem) and many other studies use heuristics and metaheuristics. These approaches could be observed, for instance, in ant colony optimization (Yu & Yang 2011) and local search (Zhong & Cole 2005).

Packing problems are usually utilized in combinatorial optimization and operations research. The presented model focuses on covering one geographical area (for exam-

ple, District 12 of Paris) by a set of pieces (citizens) to optimize the given item or object (parcel). The current model, which is meant to be used in urban areas, has been adapted through packing circles to a two-dimensional area to control the distribution of the neighbor-relays and their potential customers. The described model intends to allocate one neighbor-relay at the center of a circle with a calculated radius so that neighbor relay will be in charge of managing all the deliveries inside its given circle. (Akeb et al. 2018.)

Figure 3 shows a description of the main idea of presented model.
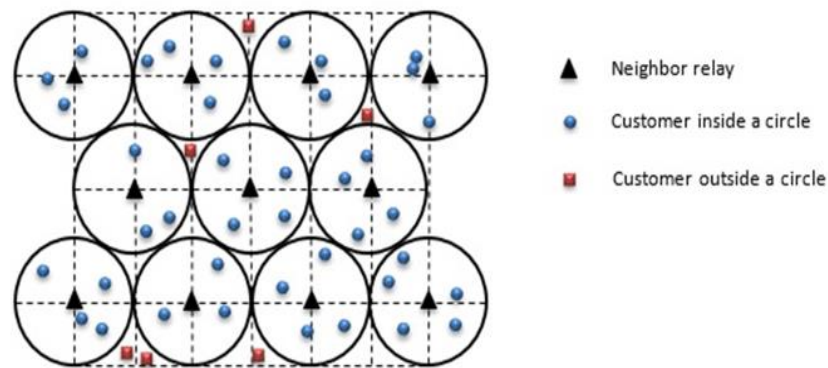
Fig. 2. Circles associated with neighbor relays.

Figure 3. Circles associated with neighbor relays. (Akeb et al. 2018.)

The packing circle model will help to determine the number of neighbor-relays that will be needed to reach the final customers in a geographical position. For this problem, the maximum distance between one neighbor relay and its possible customers is utilized. The maximum distance is shown as the corresponding radius of the circle, and the second variable is the population density (number of possible customers/delivery addresses).

The objective of this packing circle model is to analyze the implementation of a collaborative solution for parcel delivery in urban areas (ibid.). The results presented are based on the information collected from District 12 in Paris - a highly dense city.

2.2.2. Minimum cost flow model

The minimum cost flow model focuses on the improvement of the last-mile delivery and efficiency throughout the whole supply chain. Wang, Zhang, Liu, Shen, Lee (2016), have proposed a crowd-delivery model, in which a vast number of pop-stations are distributed along the city, and they have a large number of workers who are ready to accept delivery tasks from the previously mentioned pop-stations to deliver parcels to the final customer's address.

The idea behind this model is that the logistics companies have a task to focus only on delivering the parcels to the pop-stations based on customer's final addresses. A pop-station is the location point to which the parcels are delivered by the transportation companies and consolidated. After the parcel has been delivered to the so-called pop-station, a worker in the area must be assigned to deliver this item to the final consignee. It is important to mention that the delivery of the parcels needs to be completed in the same sequence in which the orders have been assigned for the delivery. Moreover, customers who are waiting for their item will have a chance to check the status of the shipment with a specific tracking number.

Figure 4 provides a clear description of the presented crowd-delivery model which intends to assist in the last mile delivery. Subsequently, Figure 5 gives a representation of the presented model.
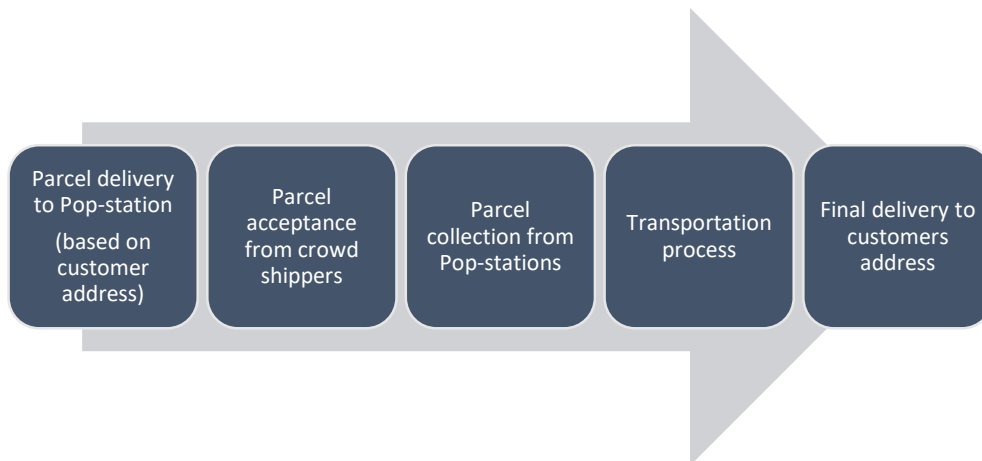
Figure 4. Description of the model
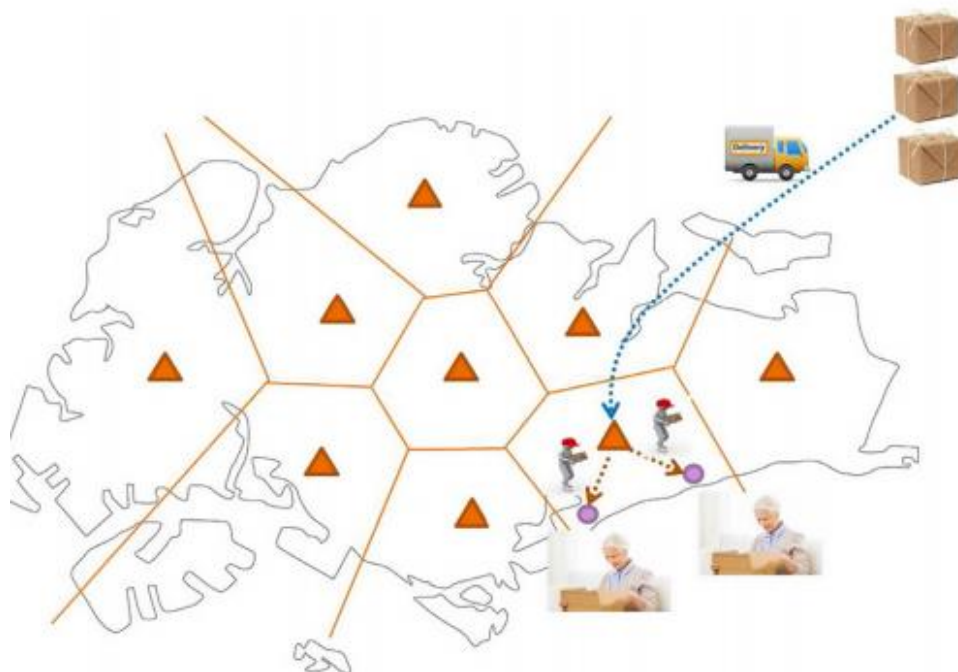
Figure 5. Crowdsourcing for the last-mile delivery. (Wang et al. 2016.)

All the assumptions and calculations are based on the minimum cost flow model. The problem has been proposed with the optimization of the crowd-delivery model as the minimum cost flow model because each parcel is assigned to one worker at most and a certain cost. The model in the discussion is a fundamental problem in the network flow domain (Ahuja, Magnanti & Orlin 1993). The model explains the way to supply the demand nodes from the supply nodes by a flow at a lower cost (Wang,

Zhang, Liu, Shen, Lee 2016). This approach might help significantly to balance supply and demand.

Moreover, the research group has also examined pruning strategies to find a solution when the model has many pop-stations and delivery addresses, in other words, numerous variables. The following pruning strategies have been used to reduce costs.

- Rule 1: Cost-based pruning
- Rule 2: Capacity-based pruning
- Rule 3: Frequency-based pruning

2.2.3. Public transport-based crowdshipping for B2C

Gatta, Marcucci, Nigro, and Simone (2019) have estimated, based on an extensive SP (Stated Preference) survey, the willingness to act as a crowdshipper (supply-side) and the willingness to acquire a crowdshipping service (demand-side). Their focus was mainly on picking up and deliver goods in the last-mile B2C (Business to customer) situation.

The suggested solution, which took place in Rome, was based on the use of automated parcel lockers located either inside or in the surroundings of metro stations. For this research two multinomial logic models were utilized intending to estimate the disposition to act as a crowdshipper and to acquire the service.

Figure 6 represents the variables utilized for calculating the demand and supply sides. The results of the given model are reported in Appendix 1 and Appendix 2. As it is shown in the sample, the number of times the model can give the right choice of the users is equal to 59.9% concerning the demand-side and 62% regarding the supply-side.

MNL1 demand-side model:

$$V_A = \beta_1 * \text{Shipping Fees}_A + \beta_2 * \text{Shipping Times}_A$$

$$+ \beta_3 * \text{Parcel Tracking}_A + \beta_4 * \text{Delivery Planning}_A \, V_B$$

$$= \beta_1 * \text{Shipping Fees}_B + \beta_2 * \text{Shipping Times}_B$$

$$+ \beta_3 * \text{Parcel Tracking}_B + \beta_4 * \text{Delivery Planning}_B \, V_{no \; choice}$$

$$= \beta_5 {}^* \text{Age} + \text{ASC}$$

$$(1)$$

MNL2 supply-side model:

$$V_A = \beta_1 * \text{Location of APL}_A + \beta_2 * \text{Remuneration}_A$$

$$+ \beta_3 * \text{Delivery booking}_A + \beta_4 * \text{Bank Credit Mode}_A \, V_B$$

$$= \beta_1 * \text{Location of APL}_B + \beta_2 * \text{Remuneration}_B$$

$$+ \beta_3 * \text{Delivery booking}_B + \beta_4 * \text{Bank Credit Mode}_B \, V_{no \; choice}$$

$$= \beta_5 {}^* \text{Age} + \text{ASC}$$

$$(2)$$

Figure 6. Demand and supply model. (Gatta et al. 2019.)

One of the main reasons for the research of these solutions was for the possible implementation of the proposed model. The conducted study from Gatta and colleagues (2019), aims to test the conditions in which crowdshippers would provide a service and the conditions in which a customer will acquire the service.

Moreover, the researchers in charge of this model investigated possible delivery scenarios performed by non-professional shippers in comparison to the traditional shipping options and evaluated them from a service user´s point of view. (ibid.)

Possible scenarios have been presented aiming to measure the willingness to act as crowdshipper and the willingness to adopt the service. The results based on four different scenarios are shown in Table 1.

Table 1. Possible scenarios. (Gatta et al. 2019.)

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Demand-side simulation				
Shipping fees (with respect to current national shipping companies)	Lower	Typical	Lower	Typical
Shipping times (with respect to current national shipping companies)	Typical	Typical	Typical	Typical
Parcel tracking	Available	Available	Available	Available
Delivery date and Time schedule flexibility	Yes	Yes	No	No
Probability of adopting a crowdshipping service	*66.1%*	*59.7%*	*16.4%*	*12.4%*
Supply-side simulation				
Location of APL	Inside metro stations	Inside metro stations	Outside metro stations/adjacent buildings	Outside metro stations/adjacent buildings
Remuneration	3 €/delivery	1 €/delivery	3 €/delivery	1 €/delivery
Delivery booking	Off-line booking	Off-line booking	Off-line booking	Off-line booking
Bank crediting modes	Single delivery	Single delivery	Single delivery	Single delivery
Probability to act as a crowdshipper	*84.6%*	*54.8%*	*46.0%*	*12.8%*

The comparison of the demand and the supply results and the scenario analysis with different service options gave a comforting preliminary result since the estimated number of potential crowdshippers in Rome was higher than those who would satisfy the potential demand. (ibid.)

2.2.4. Same-day delivery with crowdshipping and store fulfillment

Ming, Qing, Xuan, and Hampanur (2019), have developed a problem that considers daily operations with same-day delivery (SDD) using crowdshipping and store fulfillment (CSF; the full term is SDD-CSF). The research aims to minimize the last-mile delivery gap between local stores and customers.

SDD allows the customers to receive their online purchased order within a couple of hours while the SDD-CSF problem tends to deal with the hourly and daily operation of same-day delivery with store fulfillment. (ibid.)

SDD-CSF model is mainly focused on supply chain operations by taking into consideration the order assignment into a specific store and options for the last-mile delivery. Figure 7 illustrates the SDD-CSF scheme.
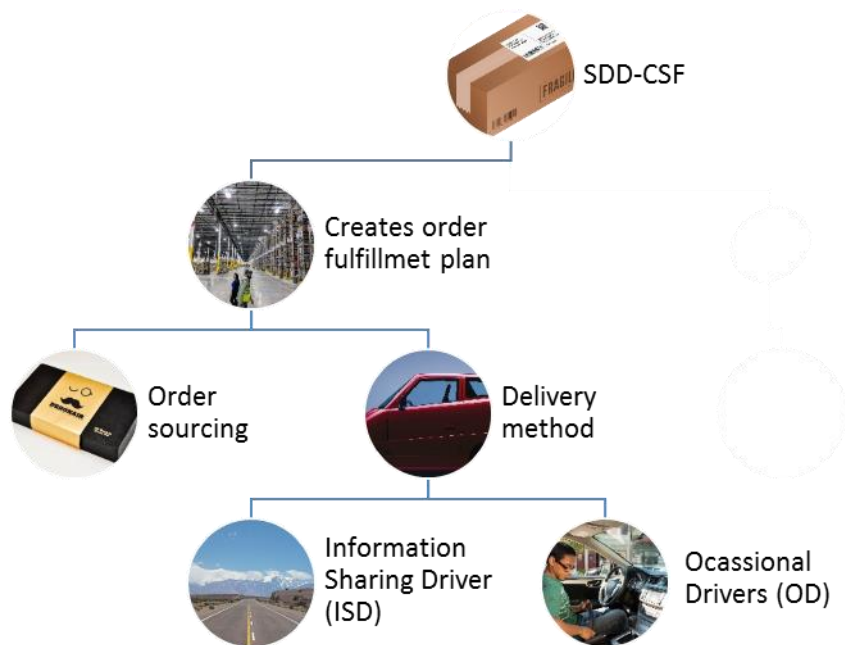
Figure 7. SDD-CSF scheme. (Ming et al. 2019.)

The adopted method presents an order fulfillment plan for both order sourcing and for the selected method of delivery seeking to minimize costs for order completion. The purpose of SDD-CSF is to create an optimal fulfillment plan for sourcing local online orders from nearby retailing stores. (ibid.)

The suggested model contemplates physical stores to fulfill online orders. This selection of having an actual store has the advantage of shortening the last-mile delivery distances and making the service more accessible and versatile. However, this selection introduces challenges for the successful delivery operation concerning order consolidation, order assignment, and delivery methods. (ibid.)

Regarding the delivery methods, Ming and colleagues (2019) have included two different methods for the potential crowdsourced shippers. *While Information Sharing Drivers (ISD)* has been created for those drivers that are willing to share their future trip with retailers, *Occasional Drivers (OD)* are random customers already located at the store that are willing to deliver a package. (ibid.)

A dynamic programming model has been suggested for the order fulfillment by utilizing a rolling horizon framework which later has been mathematically approximated

into a mixed-integer linear programming model. The model takes into consideration both current received and predicted orders intending to take an order assignment decision. (ibid.)

Three methods with the common goal of achieving economies of scale in order fulfillment have been proposed. These models are listed below:

- Rolling horizon framework to gather the orders
- Estimation and calibration of future demand
- Integration of crowdshipping as an option for delivery options.

The proposed SSD-CSF model aims, as mentioned before, to reduce the order fulfillment costs by forecasting transportation resources and by leveraging the forecast of future customer orders. Such an approach might result in the reduction of future expected costs. It intends to balance the demand and the existing resources.

Ming and colleagues (2019) have adopted five different smoothing frequency strategies to show how demand forecast output can have a positively correlated influence on the results of the suggested SDD-CSF method.

To finalize, it is important to mention that for the developed SDD-CSF model the rolling horizon structure enables the creation of a feedback control system. This system copes with the inaccurate forecast of future demand.

Nevertheless, SDD-CSF achieved sufficient results in comparison with other solutions such as global optimal since it can optimize the order fulfillment for different sizes of customer demand.

2.2.5. Crowd of taxis to last mile delivery in e-commerce

According to the research performed by Chen and Pan (2015), a methodological approach of applying a crowdsourcing solution focused on the last mile delivery which might be used in the e-commerce environment has been suggested. The proposed solution is based on the utilization of fleet of taxis in the city, road network, and self-pickup facilities (described as 24/7 shops in the city). The presented model has acquired the name of the "*TaxiCrowdShipping*" System.

The main objective of the proposed model is to find the optimal delivery path which can minimize the total delivery time for the package request. Once the optimal path has been determined, the system will schedule and assign the package to the next coming taxi directing the same destination.

Therefore, the current Taxi Crowdshipping system relies on a two-phase decision model as shown below in figure 8.

For a better understanding, the summarization of the mentioned model is presented below.

1. A package delivery request is generated.
2. Passenger real-time order request (going to the same destination as a package) is created.
3. The package is then assigned to the taxi which has accepted the delivery task.
4. The combination of the services could be performed – delivery of the package and passenger transportation. It is important to mention that the passenger is not the owner of the package.

Therefore, the current TaxiCrowdshipping system relies on a two-phase decision model as shown below in figure 8.
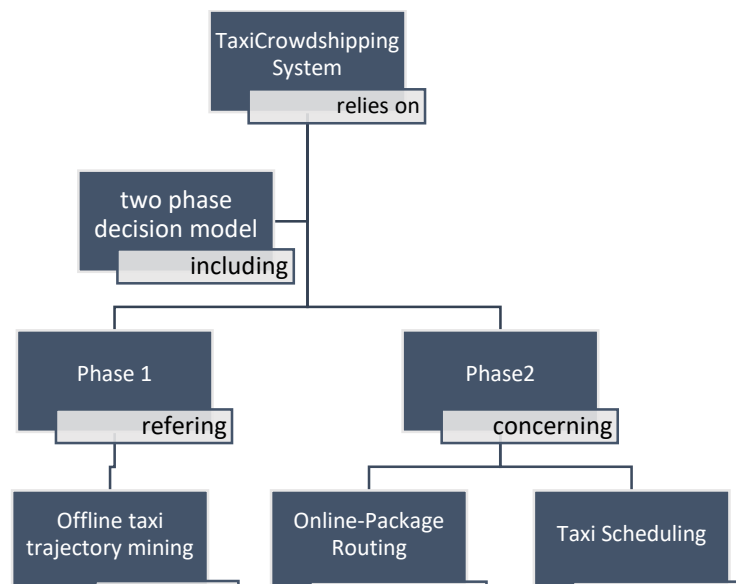
Figure 8. Two-phase decision model applied to the TaxiCrowdShipping System. (Chen et al. 2015.)

As mentioned above, the model comprises the two-phase decision problem. Thus, an explanation of these phases is expressively described below.

Phase 1

Offline Trajectory Mining estimates the direct package delivery time from one pick up station to another by performing a single hitchhiking ride. The time-cost takes into consideration the time-cost for waiting on the hitchhiking ride (frequency of taxi rides) and the time spend on driving on the roads. (ibid.)

Phase 2

Online-package routing and taxi scheduling assist to schedule the specific taxis to help to deliver the packages with the determined optimal path, based on the real-time coming taxi ordering request.

Two steps were proposed to complete the task. The first one aiming to find an optimal pickup station sequence (applying the shortest path finding algorithm) and the second one concerning the scheduling of available taxis.

All in all, the proposed system combines the transportation of both passengers and assigned packages. This solution can be featured as economic and eco-friendly since it decreases the labor costs and energy consumption as well as CO_2 emissions. (ibid.)

2.2.6. Package express shipping via TaxiCrowdShipping

Chen, Zhang, Wang, Ma, Han, and Sha (2014) have proposed the model of having packages by taking hitchhiking rides with existing taxis that are transporting people. The model has merged as an attempt to achieve environmentally friendly and economical express shipping by the usage of taxi crowdshipping.

The main idea of the model is described as follows.

1. Specific package needs to be delivered from point **A** to point **B;**
2. Fortunately, there is a passenger close to the point **A** who is making a real-time taxi order request (passenger is located at point **C**) intending to go to point **D;**
3. If the driver (taxi 1) accepts the request, the package will be assigned to the driver (taxi 1);
4. The driver (taxi 1) will pick up the package at the point **A** before picking up a passenger at point **C;**
5. Transportation process will take place;
6. After the passenger has been dropped at location **D,** the driver will proceed to leave the package in the safe boxes located at point **D;**

7. The next taxi (taxi 2) located near point **D** will pick up the package from the safe boxes and will then perform the similar process that the taxi 1 to bring closer the package to its final destination;
8. The process keeps running until the package has arrived at its final destination.

The suggested model has been described in a two-phase framework as shown in Figure 9.
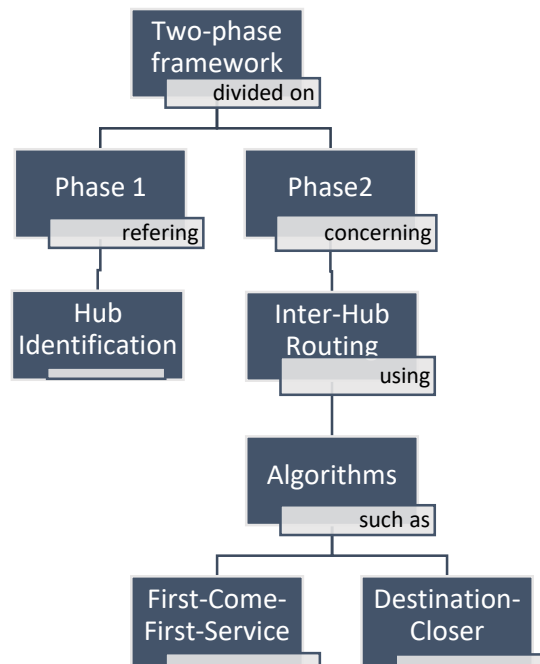
Figure 9. Two-phase framework for TaxiCrowdShipping Problem Solving. (Chen et al. 2014.)

Hub identification tends to identify influential people in social networks to rank the influence of certain road segments in the road network. An entropy-based algorithm has been adapted to rank different road segments. (ibid.)

The possible Hubs need to cover special requirements such as: Popular locations in which both taxis and passengers can be found, secondly from the selected Hub many different places can be reached, and third proper distribution along the city to assure efficiency.

Inter-Hub Routing enables us to ship packages between selected origins and destinations by scheduling taxis which answer to taxi order requests and, at the same time, participating in the package delivery task.

The Inter-Hub Routing can be completed by the usage of two algorithms as shown in Figure 9. The First-Come-First-Service (FCFS) and Destination-Closer. Regarding the FCFS, each package will be assigned to the first taxi that will pick up a passenger at the same road segment. Concerning the Destination-Closer algorithm, it will assign the package to the closest taxi which will be in charge of heading to the nearer hub based on the final destination. (ibid.)

The usage of taxi crowdsourcing for package delivery can provide several advantages concerning shortening delivery times. The fact that taxi drivers know the traffic situation in the city provides the opportunity for them to identify shorter routes. Additionally, taxis are being identified as the main mode of transport for this model can positively result in the provision of a high number of taxis for delivery tasks. Last but not least, it brings economic and environmental benefits by the leverage of existing taxis on the street.

2.2.7. Online Crowdsourced Delivery for On-Demand Food

According to Zhao, Zhou, Jiang, Xia, and Li (2019) an online crowdsourced delivery (OCD) approach for on-Demand food has been proposed. This solution can be performed by the implementation of an online dynamic framework compromising order collection, solution generation, and sequential delivery. The main idea is to provide a service for On-demand food delivery by the usage of crowdsourced riders in charge of picking and delivering the requested food orders.

At the same, the usage of a hybrid metaheuristic solution process in charge of integrating both Tabu search approaches and adaptive large neighborhood search has been utilized to assign food delivery tasks. (ibid.)

The stakeholders for the proposed OCD are catering businesses, customers, and couriers (shown as crowdsourced riders).

The OCD cycle is described in Figure 10.
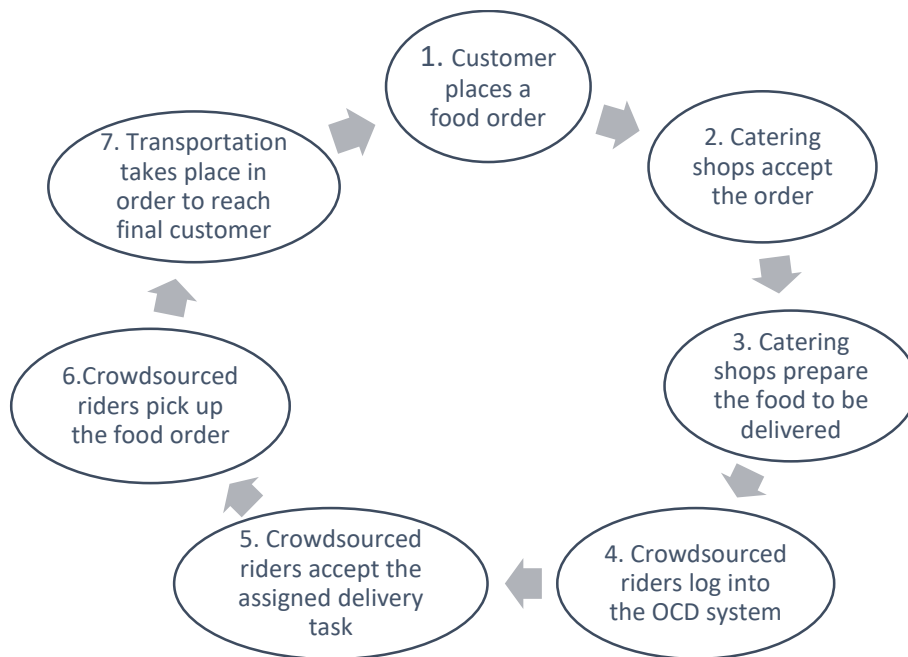
Figure 10. OCD cycle. (Zhao et al. 2019.)

A proposed model can be performed by the utilization of a dynamic framework which takes into consideration the following factors for its completion.

- Order collection - Information collection process for both crowdsourced riders and customers
- Solution Generation - Process for the task allocation to active riders
- Sequential delivery- Personalized delivery sequence each rider will receive assigned described visits to reach customers.

OCD solution provides a clear explanation of two concepts used throughout the research concerning task allocation and urban logistics.

Two different approaches have been suggested focusing on task allocation to have a better understanding and usage of the spatial crowdshipping. The first approach is a pull mode that is in charge of publishing and collecting tasks on the platform. The second one is the push model where the tasks are assigned to maximize the system´s

overall goal. However, it is important to mention that the push mode´s solution has to be divided into two categories: task matching and task scheduling.

Urban logistics refers to the management of collections and deliveries of goods and parcels so that the demand is fulfilled. (ibid.)

The main features of the OCD model are described in Figure 11.
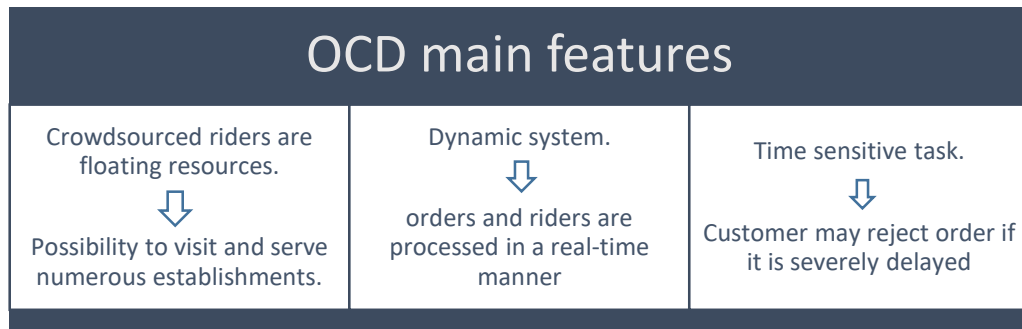
Figure 11. OCD main features. (Zhao et al. 2019.)

The main goal of the OCD model is to assign customer orders to crowdsourced riders and simultaneously design delivery routes (including pick-ups, travel, and delivery sequence).

2.2.8.   Dynamic crowdshipping model

Allahviranloo and Baghestani (2019) have proposed the utilization of a dynamic optimization model. To study the transactions of pick-up/delivery activities between two groups in a Peer to Peer (P2P) crowdshipping model - carriers and requesters. The dynamic model has been developed using a rolling horizon framework which aims to find the best matches between carriers and requesters within a certain timeframe.

Allahviranloo and colleagues (2019) determined that the presented model is based on the value of time in which requesters set maximum willingness to pay for their parcels to be picked up and delivered, and the carriers make an offer depending on the changes that need to be made to their original itinerary. For the current model the price of performing a task is based on the value of time.

The process of the presented crowdshipping model can be described as follows.

1. Requester submits pick-up/delivery tasks to be carried out by carriers in the system. Requesters set maximum willingness to pay for the task based on the value of time savings
2. Carriers will then select the most desirable and favorable tasks based on their original itinerary
3. All carriers evaluate the tasks and offer the price for performance of each task (price is based on carrier's original activity schedule)
4. The offers made by carriers are compared to the requester's maximum willingness to pay for the required task
5. After this has been done, its carrier´s decision whether to accept the task or not;
6. Carrier selects the task which has the maximum benefit among the feasible tasks offered. Requesters will select the carriers depending on the price
7. The model assigns the best match between carriers and requesters. The matching order is defined as carrier first and requester second.

To maximize the number of matches generated by this model, an incentive or subsidy can be used. This would transform the model into a bi-level optimization model. The bi-level optimization model is described in Figure 12.
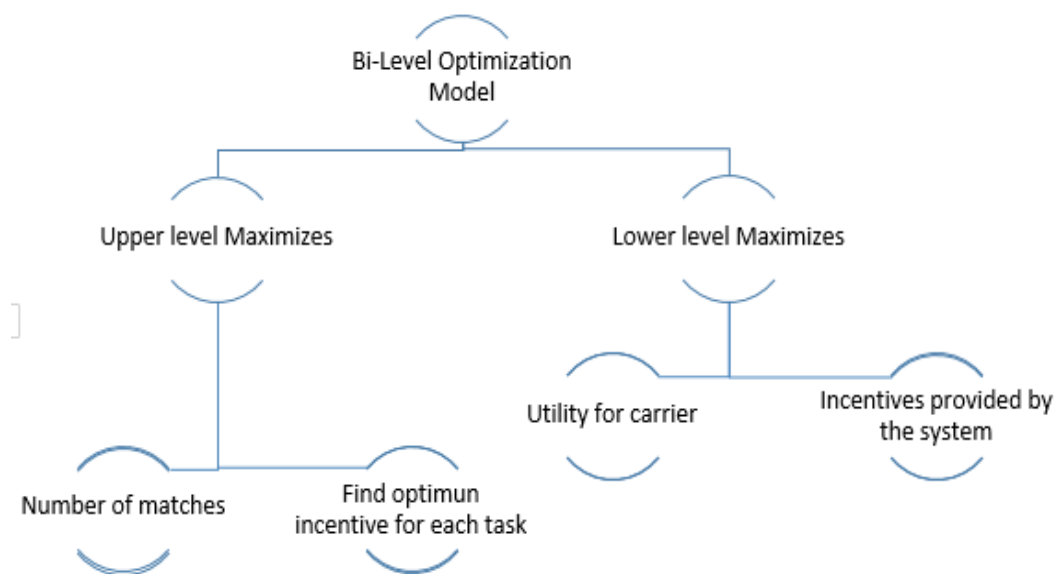
Figure 12. Bi-level optimization model. (Allahviranloo et al. 2019.)

The presented dynamic crowdshipping model intends to maximize the utility for both carriers and requesters. At the same time, it identifies the optimal task transaction between carriers and requesters.

2.3.   Crowdshipping sustainability

Freight transportation plays a fundamental role in the economic development of the cities. However, it also threatens the inhabitability of it (Simoni, Marcucci, Gatta & Claudel 2019). Freight transportation in cities can generate negative environmental and social impacts. Environmental repercussions can include fuel consumption depending by the mode of transport utilized, energy consumption, greenhouse gas emissions, air pollution, etc. Social impacts, concerning noise pollution, traffic congestion, and at a certain point, it can affect safety on the road.

The rise of the world´s population, growth of urban areas, and the constant increase of e-commerce activities, they all have created a vast number of challenges. Challenges mainly affecting the logistics industry that is in charge to cope with the door to door services. The current door to door service is changing considerably the way deliveries are being carried out.

Therefore, sustainable city logistics solutions are required to address this problem in urban areas (Russo & Comi 2012). Different crowdshipping models have emerged to cope with the challenges and issues surrounding the logistics industry.

The following chapter intends to describe the sustainability that crowdshipping has as a potential option to solve various logistical issues. It is important to start by defining *sustainability* and its factors*. "Sustainable development is a development that meets the needs of the present, without compromising the ability of future generations to meet their own needs."* (European Commission 2016). Three issues can be implied to reach a joint of harmonization - economic growth, protection of environmental resources, and social equity (Zito & Salvo 2011).

Macharis and Kin (2017) have proposed a classification called the 4 A's of sustainable city distribution as shown in Figure 13.
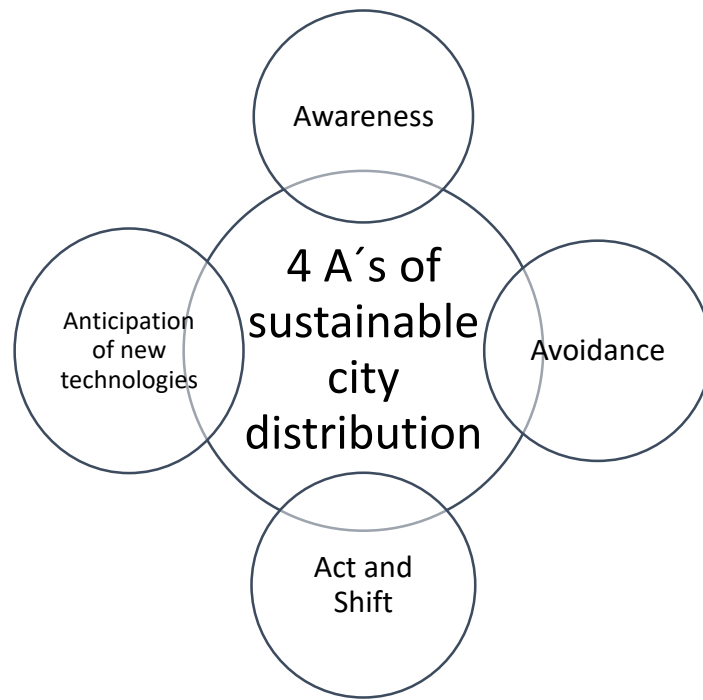
Figure 13. 4 A´s of sustainable city distribution. (Macharis et al.2017.)

All the previously-mentioned concepts are explained below.

Awareness: Bringing about awareness to the citizens of the challenges that last mile transportation and home delivery cause in the city. Additionally, being aware of the consequences of e-commerce and the number of parcels that need to be delivered, and realizing the environmental impact and the repercussions in their quality of life. All this information and facts can change customer's decision making whether to purchase something or not. *Avoidance:* To encourage citizens to make use of the free capacity on their intended trips so that the usage of unnecessary vans that pollute the air will be avoided. Nevertheless, the number of failed deliveries can be reduced by the flexibility and interconnect ability that citizens have. *Act and Shift*: Opportunity to choose the number of parcels, time, and trajectory is possible for the crowd. Crowd can decide how the parcel will be delivered - by public transportation, bicycle, and on foot. *Anticipation of new technologies:* It refers to exploiting the potential offered by mobile applications, navigation tools, and geo-localization, taking advantage of the digitalization and its possibilities.

2.3.1. Economical sustainability

Buldeo, Verlinde, Merchx, and Macharis (2017) have mentioned that all the characteristics that define a certain crowd logistics concept determine the business model and, thus, impact on its economic sustainability. Additionally, it has been established that any business model is dependent on generating sufficient partnerships (presented as cooperation) and users (presented as marketing), in an area that matches the geographical scale in which the proposed concept intends to operate.

Crowdshipping can be seen as an asset-light activity since the different platforms and models does not have ownership of any vehicle fleets and permanent employees. Crowdshipping can also be identified as flexible activity regarding operations. Operations which can significantly decrease costs.

Designing an effective cost model for crowdshipping activities is a major challenge for the ones involved in the development and implementation process. The design is being determined based on crowd characteristics, such as transport flows, motivation, and model choice (Archetti, Savelsbergh & Speranza 2016). Seven characteristics have been identified which are important from an economic perspective: receiver (user) and commissioner (crowd participant) identity, revenue model, platform role and strategy, cooperation, and marketing. (Buldeo et al. 2017.)

A sustainable business model depends on well-designed revenue and cost structures (Savelsbergh & Van Woensel 2016). It has been suggested that a suitable revenue model should take into consideration additional costs such as insurance, training, routing instructions, GPS devices, and software development (Mladenow, Bauer & Strauss 2016).

To reach a sustainable concept, it requires to achieve a great performance in terms of service level. Concerning crowd logistics concepts: time, platform organization, and efficiency must be the priority to achieve a desired level of service. A successful business model, therefore, requires a large database of individuals to cope with the presented demand.

Some of the limitations of crowdshipping models are that models only support point to point deliveries, meaning that it creates a less flexible delivery network since

crowdshipping is only possible if the delivery actor (crowd shipper) passes through the starting point and the parcel final delivery address (Rougès & Montreuil 2014).

2.3.2. Social sustainability

The platform transparency and the implementation of a trust generating mechanism are two characteristics that balance economic and social considerations. Besides, crowd logistics platforms users share valuable data such as their locations and addresses, so that privacy appears to be a critical challenge (Rougès & Montreuil 2014).

Therefore, to guarantee safety and security to the users is necessary to build credibility and trust. The European Commission embraces crowd logistics platforms to comply with the applicable legal framework on the protection of personal data (European Commission 2016).

Schreieck, Pflügler, Dehner, Vaidya, Bönisch, Wiesche, and Krcmar (2016), have proposed seven principles addressing the respect of privacy. Principles are listed below in Figure 14.

Principles to respect privacy	Proactive not reactive
	Privacy as the default
	Privacy embedded into design
	Full functionality
	End-to-End security
	Visibility and transparency
	Respect for users privacy

Figure 14. Principles to respect privacy. (Schreieck et al. 2016.)

Crowd shipping has faced several issues ensuring the development and assurance of trust on customers, one of the key questions that crowdshipping platform designers should asked themselves is: *How to create and assure trust in the user?*

Many businesses and crowdshipping companies have implemented rigorous selection processes for couriers. Moreover, the majority of the companies involved in crowdshipping have developed feedback systems to evaluate the courier's performance by providing star ratings and sharing comments. Nevertheless, companies are encouraging direct contact between requesters and couriers for instance through telephone or email. (Rougès et al. 2014.)

Concerning the crowd, some aspects have been identified to provide clear examples of the implications that crowd logistics models can generate. Although the main idea of the crowd logistics models is meant for the voluntary participation of the crowd, some crowd logistics initiatives use a casual workforce of self-employed drivers that have been criticized for exploitative practices (McKinnon 2016).

It is also important to mention that the crowd can be exposed to financial insecurities, lacking social protection, isolation, stress, high competition, and uncertainties due to short-term schedules (De Groen & Maselli 2016). Underpayment and lack of optimal working conditions can prove that some business models are unsustainable from the social point of view. Special actions and improvements should be taken to make the business models more appealing and favorable for the crowd.

One of the social impacts that can make crowd logistics a socially sustainable practice is related to the mode of transport used to perform the task. It can lead to a positive effect on the crowd's health since some deliveries are meant to be performed by the usage of bicycles or performed on foot.

2.3.3. Environmental sustainability

Crowd logistics has been positively related to the reduction of traffic, CO_2 emissions, and resources, by the usage of extra capacity and by exploiting existing transportation flows. The mode of transport chosen by the crowd is fundamental for the overall sustainability of crowdsourced deliveries. (Simoni et al. 2019.)

However, the fact that parcels in most of the presented crowdshipping models are handled individually can limit the sustainability of the introduced concept. Special adjustments in future models can be performed in which the crowdshipper can accept and deliver more than one parcel as long as is sustainable and the presented circumstances are convenient.

2.4.   Crowdshipping benefits in stakeholders

Throughout this chapter crowdshipping benefits from different perspectives are de-
scribed. The following benefits from numerous crowdshipping models have been
identified and discussed with the proceeding of the current chapter.

2.4.1. Customers Benefits

The utilization of crowdshipping services can benefit the customer from different an-
gles when placing an order from retailers. Figure 15 mentions some of the benefits
that crowdshipping can offer its customers.

Figure 15. Benefits of crowdshipping for customers

When customers make use of the crowdshipping services, they can directly benefit
from their advantages as shown in Figure 15. First of all, a customer can benefit from
the speed of the service, a fast delivery can be achieved if the task (delivery) is ac-
cepted and performed immediately (if the carrier is available).

Rougès and Montreuil (2014) have mentioned that the power of crowdsourcing is supposed to create a huge pool of carriers. If a significant number of couriers are achieved, the probability of having one available courier can be significantly high. Secondly customers can benefit from the so-called ¨personalization of delivery¨ since every parcel will be managed individually. Following this, the opportunity to have communication between customer and carrier can be achieved. Nevertheless, personalization provides the customer with the opportunity of arranging the delivery by rescheduling the time in case the first agreed schedule is not suitable and convenient to the customer.

Crowdshipping can provide consumers access to a more extensive range of products (Botsman 2014). This applies to the cases when the seller is not selling online or has no delivery service or when products are sold in foreign places and are not available for sale online. Besides, it is also considerably relatable to situations when the goods to be delivered are unique, oversized, or fragile and not accepted by traditional couriers. (Rougès et al. 2014.)

The price can be one of the key points for the acquisition of crowdshipping services since low prices are considered as a selling point. It has been discovered that certain crowdshipping companies offer the same prices for same-day delivery as for standard shipping. Crowdshipping can offer competitive prices for the users and retailers. Last but not least, most of the crowdshipping models include the option to track in real-time parcels which provides the up-to-date information on the status and location of the item.

2.4.2. Retailer benefits

One of the main stakeholders involved in the crowdshipping business are the potential retailers that are willing to participate such as departmental stores, restaurants, warehouse retailers, etc. Retailers might benefit from crowdshipping because their items or products are being distributed by the crowd and they do not need to invest on equipment for distribution. Some of the benefits for retailers are shown in Figure 16.
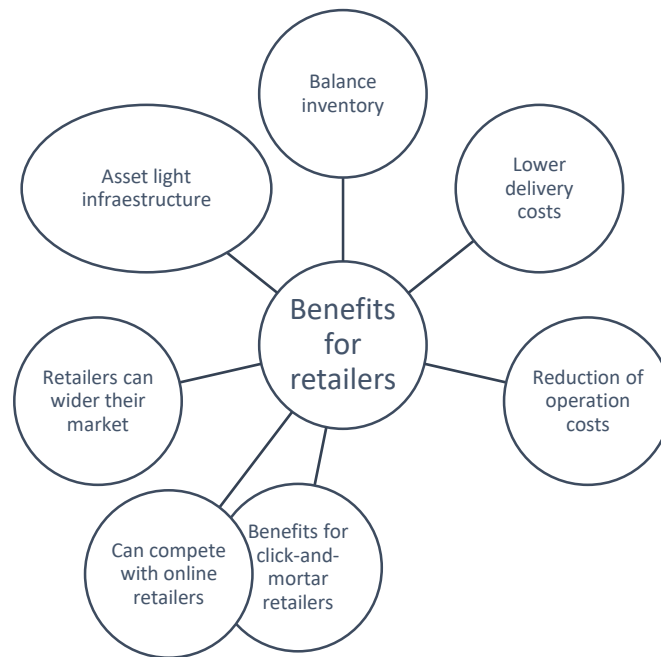
Figure 16. Benefits for retailers

Retailers can benefit from the reduction of operational and delivery costs because the last-mile delivery will be carried and performed by crowdshipping services. However, businesses can benefit from crowdshipping since it has the potential to reach a larger area (Mcinerney 2013; Rogers 2013; Jennings 2013; Mladenow 2019; Bauer 2019; Strauss 2019). Click-and-mortar retailers can compete more aggressively with online retailers (Rougès et al. 2014).

Click-and-mortar retailers can also reduce the need to stock balance inventory amongst retail stores (Tompkins & Loftis 2014). Moreover, retailers and businesses that acquire crowdshipping services can take advantage from this service since it appears to be asset-light for them, meaning that investment to fleet expansion, HR, and maintenance facilities for the utilized equipment is not necessary.

2.4.3. Social and environmental benefits

The utilization of crowdshipping models can decrease traffic jams and minimize the environmental footprints of traditional delivery tasks. One of the main principles of crowdshipping is the utilization of free loading capacity on predetermined trips. That

is why the number of cars or delivery vans can to be reduced. At the same time, the actors in charge of the delivery and society, in general, can be benefit from the promotion of alternative modes of transport such as bicycles and different public transportation systems.

All the presented crowdshipping models intend to contribute to the wealth of the actors that are in charge of delivering the parcels by generating and receiving incentives on different forms such as monetary compensation, discounts, rewards, etc.

One of the special features of crowdshipping that can benefit directly to the participants (crowd shippers) is the flexible working hours that the models offer since they are supposed to voluntarily decide when to carry out a task based on their availability and original itineraries.

Figure 17 represents the benefits of crow shipping for the society.
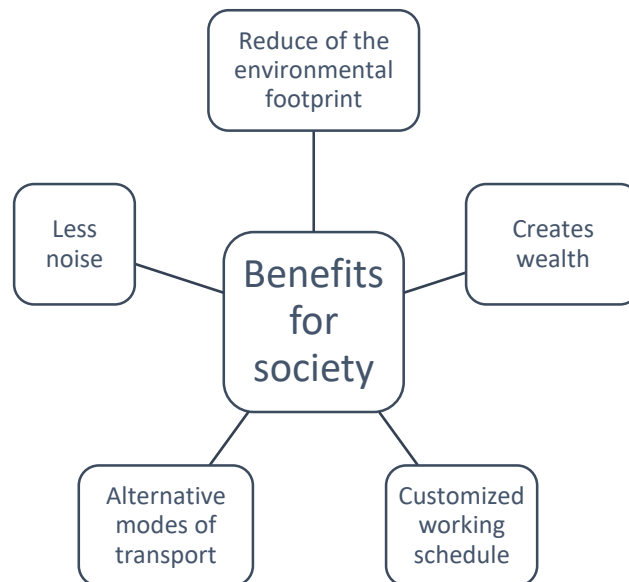
Figure 17. Gains for society

Regarding the environmental matters, crowdshipping can provide a better use of spare loading capacity on existing flows to perform deliveries. This concept leads to

the maximization of logistics efficiency. The efficient use of loading capacity can help to decrease the number of delivery vans around the city. This practice can assist in the reduction of traffic congestions and carbon emissions in urban areas.

Environmental benefits are, in principle, directly proportional to the saved distances. Extensive and more frequent transport abatement would yield higher environmental benefits. (Paloheimo et al. 2016.)

3. Methodology

As stated in the introduction (Chapter 1), with the aim of creating and suggesting a novel and an innovative crowdshipping model for e-commerce deliveries, an online-based survey has been proposed and distributed among the selected target group (university students), to gather important data that can assist on the further development of the proposed model.

The methodology used in this research is obtained from the approach of Stated Preferences Surveys (SPS), to acquire data which can be used for the design and development of an innovative crowdshipping model for e-commerce deliveries in Jyväskylä, Finland. SPS has been identified as an effective method for data collection and as an essential tool for modelling utility functions to represent traveler decisions when facing different travel alternatives (Cascajo, Garcia-Martinez & Monzon 2017). The SPS method serves as an important tool that assists for taking forecasting decisions by presenting to the respondents´ different questions with their possible choices in hypothetical situations. The above could be achieved by giving a set of conditions.

SPS approach has been applied in this thesis, and it has been adapted into an online-based survey to identify the willingness of university students to participate as potential crowdshippers. Additionally, the online-based survey aimed to measure the willingness of university students to accept a crowdshipping service (relates to demand-side). The SPS has been structured as an online-based survey that aims to evaluate the acceptability of crowdshipping and measures the willingness to participate in a crowdshipping model. The online-based survey intended to collect data from the potential participants (university students) concerning their travel conditions and limitations.

For the simultaneous and remote collection of data, an online-based survey was created using Google forms. To clarify, the survey has been divided into two segments: *Segment 1 - Student willingness to act as crowdshipper* - to gain a better understanding of the various factors and limitations that would play a key role in the possible implementation of the proposed crowdshipping model. *Segment 2* aims to measure

the *willingness to accept the crowdshipping service* (receiver) from the student's perspective.

The scope of the survey was considered to be set for a group of university students greater than 50 participants to have a sufficient amount of collected responses to provide a thorough analysis. The survey has been designed to gather information regarding university students, their travel behavior, conditions and capabilities. The proposed model intends to include the participation of university students from all study fields for the further development of the model. Therefore, the importance of focusing on this group on specific.

When the scope of the survey was established, a target group of 54 university students has been achieved. The number of achieved participants was recognized as favorable for the survey conduction and completion. However, the number of registered responses belong in its totality to university students and does not include any other secondary groups' responses.

The chosen participants for the survey are university students that are currently enrolled in different fields of studies from the business, technology, education, tourism, medicine and social sciences departments belonging to both universities and universities of applied sciences in Finland and from member countries of the European Union. The online-based survey has been intentionally distributed among students from different fields of studies with the mere purpose to draw concrete conclusions about the possibility of university students to act as crowdshippers and to accept the service regardless of their background, nationality and field of studies. The only requirement for the participation on the online survey was set to be enrolled as a university student.

The main necessity for the acquisition of responses from this group in specific is directly related with the intention of focusing on university students as potential crowdshippers; by having responses from university students belonging to different studies fields we can measure the overall willingness to participate as crowdshippers and to accept the service. The inclusion of university students from different study fields can be beneficial for the further implementation of a crowdshipping model

since the potential number of participants is higher in comparison with the approach of just focusing on the participation of one study field in specific.

The online-based survey was distributed among the participants from May 3rd through May 10th 2020. It has been recognized, from the selected pool of university students, that the majority of them are currently enrolled at universities in Finland. The idea of acquiring the majority of respondents, from this country in specific, relays on the fact that the proposed model approaches its implementation in the city of Jyväskylä, Finland. However, the survey also includes student responses from different countries within the European Union. A convenient sampling strategy has been adopted and all the participants had access to the survey using social media channels.

To provide a clearer representation of the main intention of the distributed online-based survey, and to mention the group that has participated in the survey the following Figure 18 has been constructed.
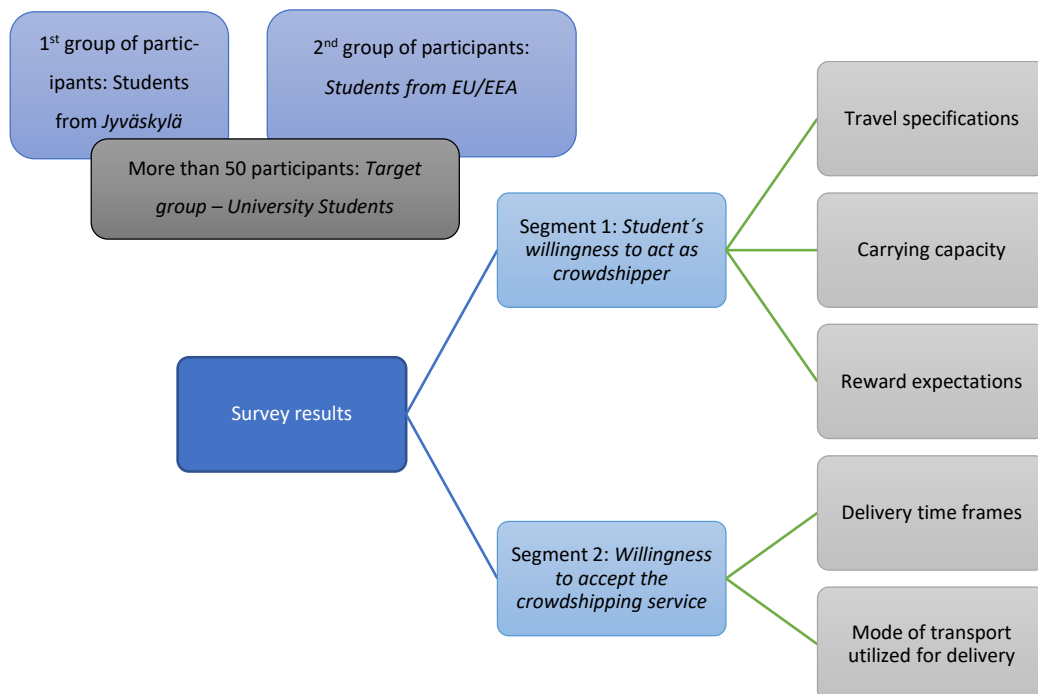
Figure 18. SPS approach overview with the regard to achieve the main goal.

The following section precisely explains how the survey has been executed. For the survey design two different segments in the online-survey have been presented to the participants. The two presented segments in the online-based survey are described below.

Segment 1

The objective of Segment 1 is to collect data regarding university students' consent to perform delivery tasks by acting as crowdshippers. The study aims to compile data based on students´ travel conditions and personal itineraries. The questions have been introduced to the participants by the hypothetical situation of them acting as a crowdshipper.

Information such as eagerness to share their student addresses and disposition to act as crowdshippers are to be identified with the help of the online-based survey. One of the sections in the Segment 1, concerns *travel specifications* which intends to gather information regarding the mode of transport utilized for university purposes (to arrive and depart). The survey also investigates student's maximum willingness to deviate from their permanent addresses to deliver a package and maximum carrying capacity by taking into consideration their daily mode of transport. To make the situation of carrying capacity more realistic the use of actual box sizes is presented to the participants, the different boxes provided in the online-based survey are based on DHL standardized measures as shown in Appendix 4.

From the supply side (student´s perspective), the online-based survey intended to measure the reward expectation (in euros) for successfully completion of a delivery task. Likewise, it also aimed to identify the most convenient delivery time based on the student's itinerary.

Segment 2

Segment 2 addresses the demand side of the online-based survey. This part of the survey is presented with the hypothetical situation of university students acting as customers that expect to receive a package. The demand side explores the consent

to accept the service by realizing that the actors in charge of the delivery are university students. Additionally, the online-based survey intends to recognize how important it is for the customer the mode of transport utilized and aims to spot the most optimal times for receiving a package. All the above-mentioned data is to be identified from the university student perspective. It's important to highlight that the responses concerning the demand side (segment 2) of the survey belong to the same students that participated on the supply side (segment 1) and no secondary groups of people were included nor requested.

The further research of the segment 2 is being suggested to have a more extensive and varied sample, in which the inclusion of different groups of people on different life situation is being recommended.

To provide a more illustrative description of the process which has been performed for the completion of the online-based survey Figure 19 is being presented.
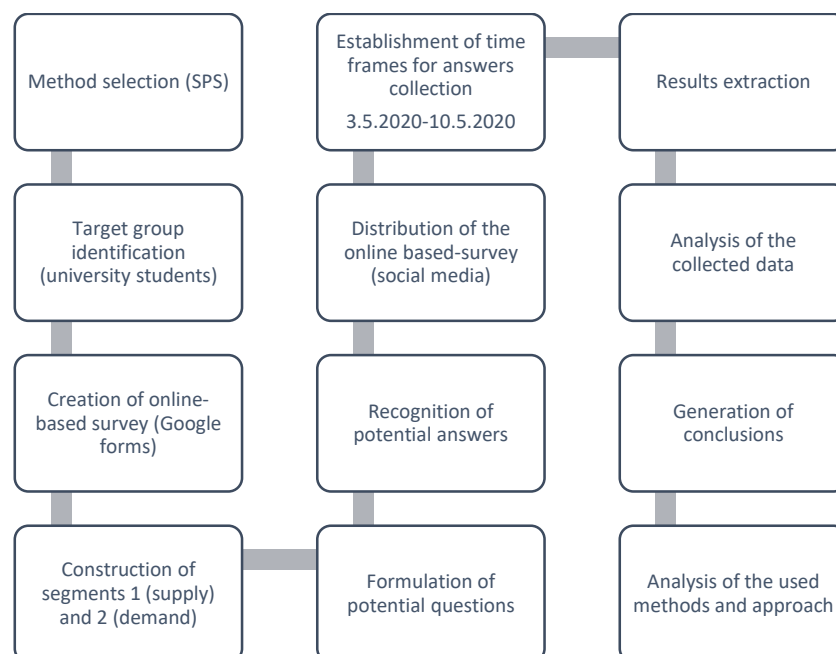
Figure 19. Process for survey creation

The second research method applied to this thesis included desk research, based on the review of an extensive body of literature on the already existing data regarding *crowdshipping*. The analysis of the secondary data for this research was as an attempt to answer the main research questions. Literature for this research was found by the utilization of online databases, such as Elsevier, Research Gate, MDPI, LEEE Xplore, SpringerOpen, and some other publications. All these sources considerably assisted in the acquisition of valuable data related to the research topic. Numerous keywords were used for the selection and identification of potential data such as Crowdshipping, Crowdsourced delivery, City logistics, Crowd logistics, and Crowdsourcing deliveries.

Due to the novelty of the topic, the data-mining strategy where reliable and critical articles and other types of publications were utilized, including governmental ones, journals, research papers, case studies, online databases, and official statements. For the analysis and description of different crowdshipping business models, and for the study of sustainability regarding the crowdshipping models, articles from a vast number of databases were examined. However, most of the research studies were based in Europe while the rest were frequently found in the regions of Asia and America.

The combination of an extensive literature review and the congregated survey results have assisted for the completion of well-designed responses, concerning the potential of crowdshipping models to supply the demand of e-commerce. Additionally, these two methods contribute for the analysis of crowdshipping sustainability and its repercussions on urban areas. The collected data from both literature review and the distributed survey has been analyzed by the identification of the most important features and approaches that the presented models have in relation to the potential of their business to possibly supply the demand in an e-commerce environment.

However, the distributed online survey considerably aided for the creation and proposition for an innovative crowdshipping model for e-commerce deliveries, which has targeted university students as the main actors to perform the delivery tasks. The survey has recognized participants' capabilities and limitations throughout the process of parcel delivery and has contributed for the identification of special features.

This information can ease the design and further development of the proposed model. The collected data from the online-based survey was analyzed with descriptive statistics and graphical analysis, to present a quantitative sample description and to measure the tendencies and preferences from the selected respondents, towards the possible participation in a crowdshipping model.

4. Results

4.1. Survey results

The survey results are based on 54 student responses. The survey has intentionally targeted university students from Finland and students from countries in the European Union. One of the main objectives of the survey is to examine the university students' willingness to act as a crowdshipper based on their travel conditions and the disposition to acquire the service all of this from university students own perspective. The results are presented in two fragments: Fragment 1 - regarding the supply side (willingness to act as crowdshipper) and Fragment 2 - concerning the demand side (willingness to accept the service).

4.1.1. Supply side

The students were firstly introduced to the supply side questions by the assumption of *"Imagine you are a student that is performing a delivery service"* in a hypothetical situation. The distributed questions in the supply side have been constructed with the purpose of collecting useful data that can help for the creation and development of an innovative crowdshipping model. Five questions have been created and distributed to the participant university students and are being mentioned as follows.

Based on the first question from the supply side – *"Are you willing to participate in a delivery service, and share your current address?"* - The results are described below.

On average 4 out of 5 students are willing to participate as crowdshippers, to perform a delivery task and to share their addresses for task delivery assignment purposes. However, the remaining 20% of the participants refuse to participate in the service. The reasons were not requested, but the fact that they have been asked to share their address might appear as a limitation.

The survey has controlled the information provided to the university student to intentionally avoid sharing model features. If the model is further developed and im-

plemented the university students will be informed that sharing their addresses rep-resents a valuable data for the system but mainly for the model overall success. The data in the system intends to achieve the most optimal task allocation by registering student's addresses. The address shared is meant only for service purposes, and it will not be shared with any third parties to ensure student/customer privacy and se-curity.

Secondly, to identify the most utilized mode of transport among the participants, the following question was presented:" Which *mode of transport do you use to come to university and return?"* The results are presented in Figure 20.
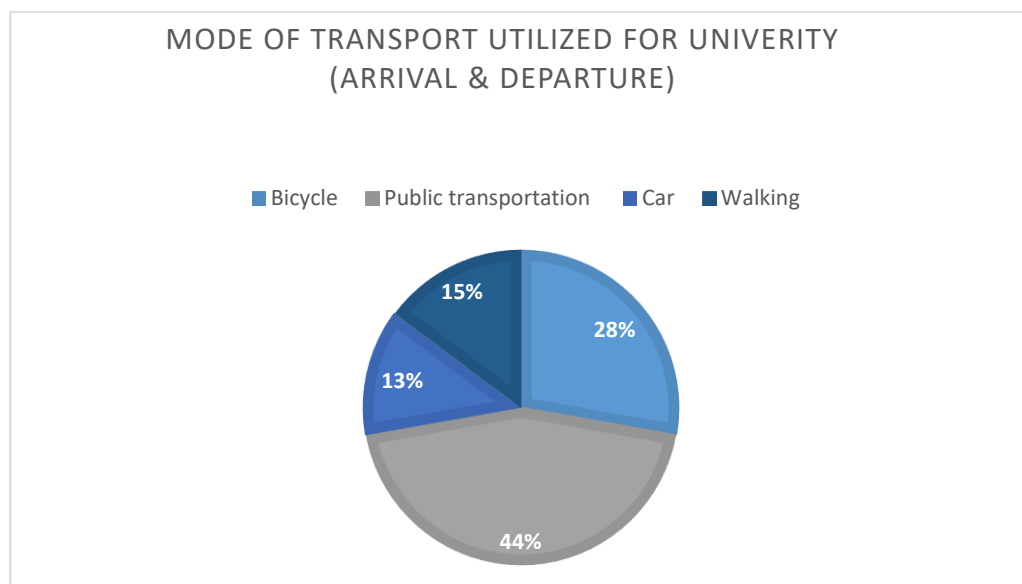
Figure 20. Mode of transport utilized for university purposes

Figure 18 illustrates that public transportation (buses, trains, trams, etc.) play a sig-nificant role as a transport service provider among the university students. It repre-sented 44% of student responses. The fact that public transportation is highly used

among the students can lead to the conclusion that students utilize in the majority default trips, meaning that they make use of existing transportation flows. The least utilized mode of transport among the participants corresponds to the usage of cars for university purposes with just 13% of responses. However, the usage of bicycles takes a significant place for university students' mobility since 1 student out of 4 utilizes this mode of transportation for university purposes.

Consequently, the survey has introduced the question: *"How far are you willing to deviate from your home address to deliver a package to the final customer?"* The bar chart below shows the percentage of students concerning the maximum deviation willingness (results are presented in meters). Responses can be observed in Figure 21.
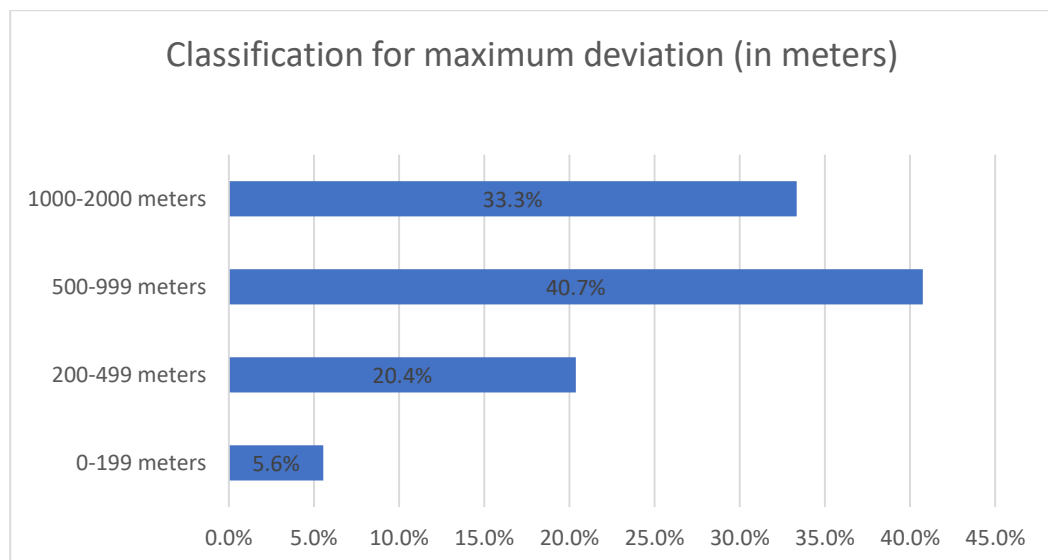
Figure 21. Classification for maximum deviation (in meters)

The given answers are based on students' responses regarding their current mode of transport. Figure 19 shows that 40.7% of respondents are eager to deviate from 500 to 999 meters to deliver a package. The results achieved can assist as a reference for the further development for a maximum deviation value which can help for a more

convenient task allocation (based on student and customer addresses). However, the second-highest value corresponds to the distance of 1000-2000 meters with a 33.3% of acceptance. This result may ease the parcel delivery task allocation since it provides a wider ratio of coverage. The minimum distance provided to the participants relates to 0-199 meters appearing to be the most preferable among participants. Nevertheless, 5.6% will not travel more than 199 meters. Anyways, the collected data has led to a positive conclusion since students are eager to deviate a considerable long distance from their addresses to deliver a package.

Following the sequence of the survey, the next question was generated:" Based *on your main mode of transport, what package are you able to carry and deliver?"* The results are illustrated in Figure 22.
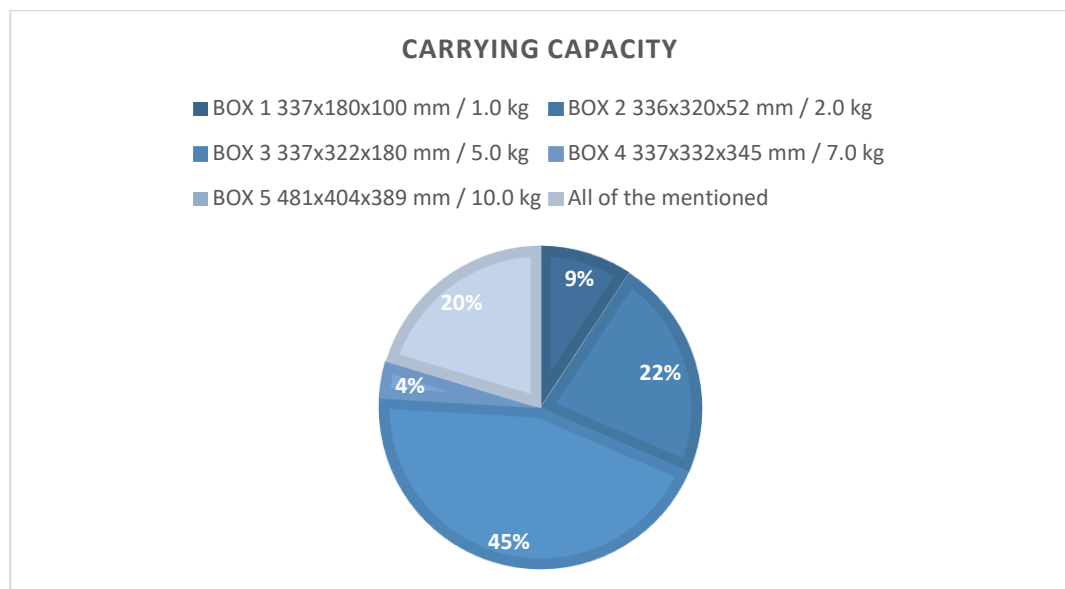
Figure 22. Carrying capacity

Based on the DHL standardized box sizes as shown in Appendix 4, various boxes with their measures have been presented to the students. However, for Box 4 and 5 the weights have been alternated to 7.0 kg and 10.0 kg respectively. This has been intentionally changed by the mere assumption that university students are not able to

carry a package of 15-20 kilograms for a long period of time. However, the utilization of cars can be exempted from this statement. Figure 20 shows that the respondents have chosen the Box 3 (337x322x180 mm) representing 45% of the total sample responses which account for the majority of respondents. It can also be identified that 1 out of 5 students are willing to carry all of the given options. Some assumptions were considered for a better analysis concerning the carrying capacity. For this question in specific, the majority of the students have chosen the Box 3, it is being assumed that students are additionally able to carry Box 1 and 2 since the measures and weights are settled to be smaller than the Box 3.

To conclude the supply section, the following question was distributed among students:" How *much are you expecting to receive for delivering a package in your neighborhood?"* A condition was established for this question since the students were requested to share their answers in euros. Figure 23, provides a clear distribution of the monetary expectations based on an individual delivery.
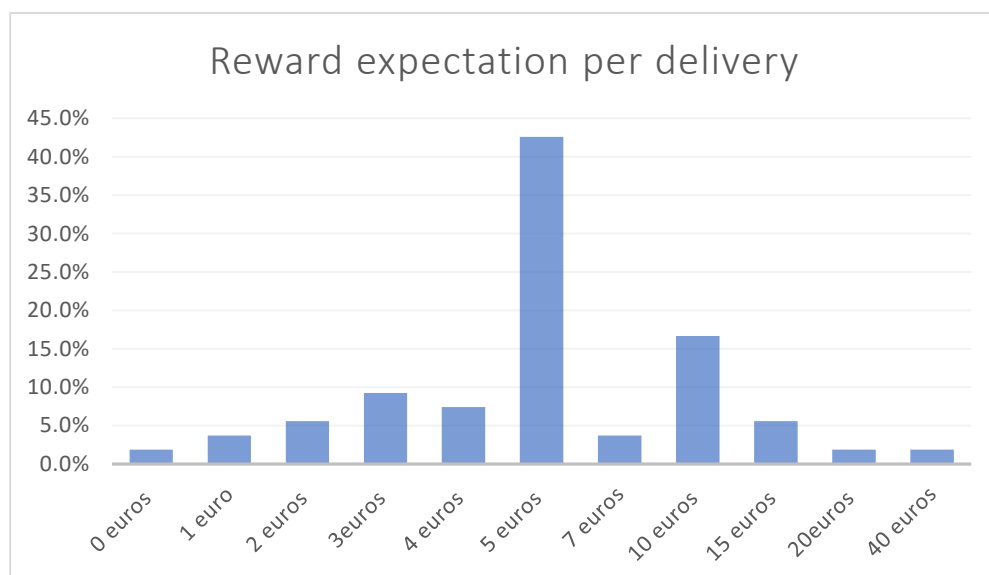
Figure 23. Reward expectation per delivery

Figure 23 presents a clear distribution of student's monetary expectation based on the successful performance of a delivery task. The results can be identified as unexpected since the survey has not provided any monetary value options. However, the majority of the participants, accounting to 42.6% of the total sample, suggested 5 euros to be the most convenient reward. A possible risk for the analysis was identified since the survey has taken into consideration responses from students who are not setting a minimum and maximum value. This could have been influential for the formulation of a conclusion. Regarding this question, the majority of the participants have suggested one amount in specific, and a common value among university students has been identified (5 euros).

4.1.2. Demand-side

The participants have been introduced to the demand side by the hypothetical situation of *"Imagine you are the customer and for this situation in specific you are waiting to receive a package"*.

Three questions were generated to identify and analyze participants´ responses that might contribute to the design and implementation of the *University-based Hub with the participation of crowdsourced students' for on-demand deliveries.* To measure university student's disposition to accept a delivery service the following questions have been formulated.

The first question that was presented to the university students in the demand side is described as follows. *"Are you willing to accept a package that is meant to be delivered by your neighbor/student instead than by a professional carrier?"* The results are described below.

The majority of the respondents 53.7% have selected that the fact that students are acting as crowdshippers is not an important factor, and they have agreed to accept the package. Additionally, 44.4% agree to accept the delivery by knowing in pre hand that students are in charge of the delivery. The remaining responses contributed to 1.9% that are not willing to accept the package in the given conditions.

To identify the importance of the mode of transport utilized by the students, from the customer's point of view (university student's perspective), the next question was formulated. *"In terms of security and safety, how important the delivery transport mode is for you?"* The results can be found in Figure 24.
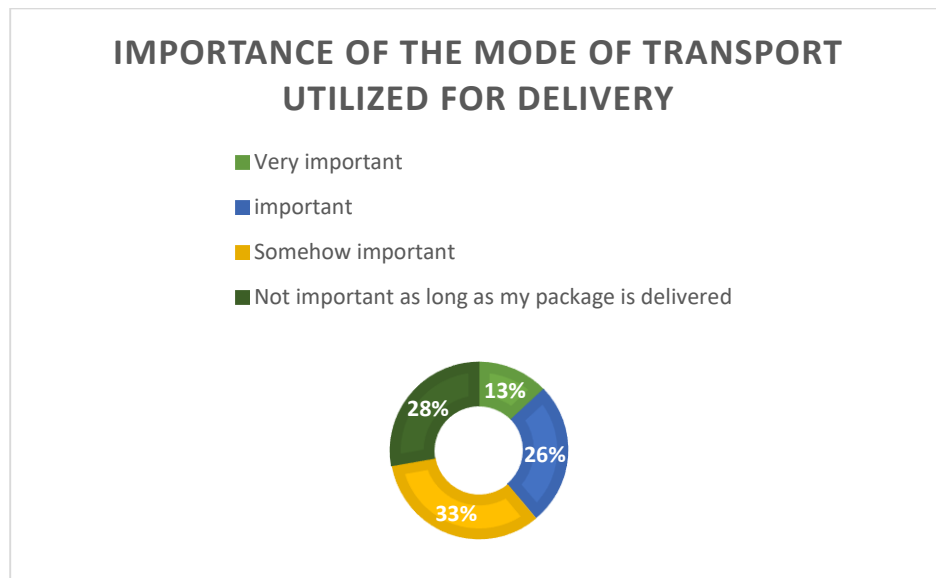
Figure 24. Importance of the mode of transport utilized for delivery purposes

Based on the results of the previous question, the respondents in the majority have agreed that the mode of transport is "*somehow important"* in the delivery process with a 33% of the total responses. Nevertheless, it can be identified that customers (students' perspective) do not consider the utilized mode of transport as a crucial factor which can influence on the acceptance of the service as long as the package is successfully delivered. The overall results confirm that the utilized mode of transport for performing a delivery is not a major concern for the participants.

For the last part of this section, two questions have been formulated and distributed among the participants. The first one from the supply side *" What is the most convenient time for you to deliver a package (supply side)?",* and the second one from the demand side *" What is the most convenient time for you to receive a package (demand side*

The mentioned questions have been intentionally generated as an attempt to measure if the responses from the supply side will be able to cover the demand side, all of this by registering and analyzing convenient delivery time frames. The responses from both questions are described in Figure 25.
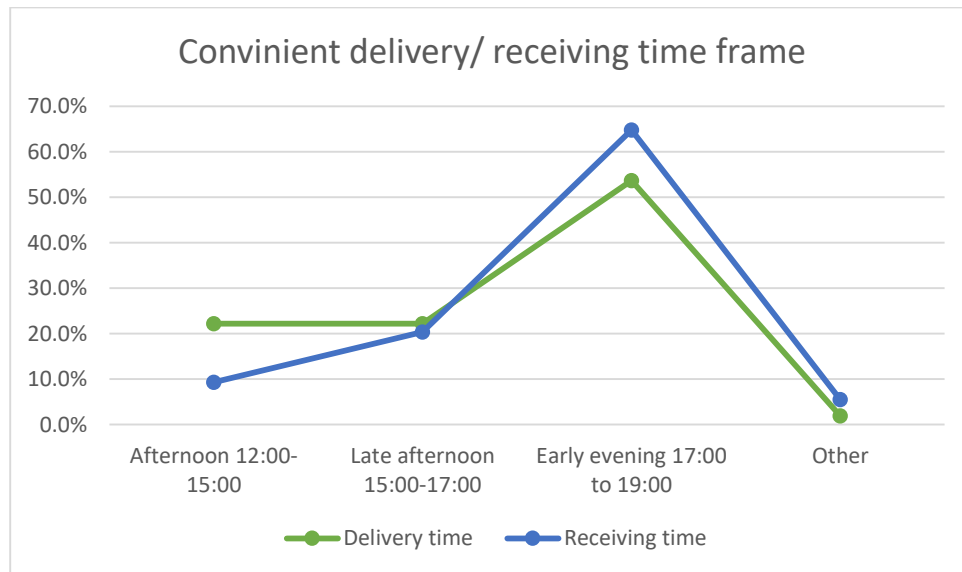
Figure 25. Convenient delivery/receiving times

It can be recognized that in certain time frames the supply side can reach and overpass the demand side in the part of the day presented as *Afternoon 12:00-15:00* as shown in Figure 25. However, in the *early evening of 17:00-19:00* the demand side is slightly higher than the supply side. The fact that *early evening 17:00-19:00* was the most convenient time for parcel deliveries and acceptances can lead to the conclusion that this is the most favorable time for customers that are expecting a package since it represents to 64.8% of the total responses. Nevertheless, the *early evening 17:00-19:00* contributes to 53.7% of the responses from the supply side. The given results led to the identification of a possible shortage of resources to perform deliveries for this part of the day.

All in all, the accumulated responses from students have led to positive conclusions about the disposition to act as crowdshipper.

4.2. Survey conclusions

From the supply side favorable and positive responses were collected which led to valuable conclusions. All in all, 4 out of 5 of the participants (university students) are willing to act as crowdshippers for delivery purposes and to share their addresses. Additionally, 44.4% of the respondents are utilizing existing transportation flows with regards to the usage of public transportation (buses, trains, trams, etc.). It has been identified that the majority of the respondents are eager to deviate between 500 and 999 meters from their addresses to deliver a package. The chosen deviation distance (500-999 meters) is assumed to be favorable one since it can assist for a more adequate and convenient task allocation.

One of the major challenges lays on the maximum carrying capacity that university students are willing to take/carry based on their mode of transport. Surprisingly, 44.4% has decided to carry a box with the following measures 337x322x180 and with a maximum weight of 5.0 kilograms. Concerning the rewards expectation the results were unforeseen since 2 out of 5 the university students agreed to receive 5 euros per successful delivery.

However, the demand side has provided useful information for the further development of the model. Five out of ten participants do not show any concern about the situation when a university student/neighbor is in charge of the delivery of their package. The remaining participants agreed to accept the package without any hesitation. Regarding the mode of transport utilized for deliveries did not appear to be a major concern for customers (university student's perspective). Also, it has been identified that the most convenient time for delivery and accepting a package lies between 17:00 and 19:00.

The given results may lead to the assistance for the further development of the suggested model. Special features are to be identified, but the respondents have already contributed with useful information concerning their travel behavior, conditions, and

limitations. Further research for the segment 2 (demand side) is being recommended.

To provide a clearer representation of the compiled survey results the following table has been constructed. Table 2 mentions each of the questions which have been provided to the participating university students with their respective answers. Additionally, Appendix 3 provides a more extent representation of the distributed questions with all the collected answers.

Table 2. Online-based survey results

Supply side	
Questions	Majority of responses in percentage
Are you willing to participate in a delivery service, and share your current address?	Yes 80%
Which mode of transport do you use to come to university and return?	Public Transport 44%
How far are you willing to deviate from your home address to deliver a package to the final customer?	500-999 meters 40.7%
Based on your main mode of transport, what package are you able to carry and deliver?	Box 3 (337x322x180 mm) 45%
How much are you expecting to receive for delivering a package in your neighborhood?	5 euros 42.6%
Demand side	
Questions	Majority of responses in percentage
Are you willing to accept a package that is meant to be delivered by your neighbor/student instead than by a professional carrier?"	Yes 98.1%
In terms of security and safety, how important the delivery transport mode is for you?	Somehow important 33%
Combined	
What is the most convenient time for you to deliver a package (supply side)	17:00-19:00 53.7%
What is the most convenient time for you to deliver a package (demand side	17:00-19:00 64.8%

4.3. Analysis of presented crowdshipping models

This section has been constructed primarily to analyze the presented crowdshipping models, and to identify different model capabilities of supplying the demand by offering their services with its own strategies and approaches. Additionally, this section identifies models limitations and describes a way to possible cope with the increase of demand.

4.3.1. Packing circle

The proposed parcel delivery model from Akeb and colleagues (2018) based on the packing circle approach intends to determine the number of neighbor-relays needed, and the number of parcels to be delivered in an urban area.

Regarding the packing circle, some suggestions could be already given. The packing circle model has utilized circles for the selected geographical area as shown in Figure 3. One can observe that some customers do not enter in the coverage range of the neighbor-relays. Therefore, the selection of another figure for the area coverage is being suggested (in the initial model the figure of the covered area is a circle) such as rectangles, triangles, or squares might help to create a wider area for deliveries and cover in the totality the selected area.

However, the model has been primarily adopted into a two-dimensional area. This might limit the information accuracy received by the neighbor-relays for the further delivery plan. One suggestion is to adopt the model into a three-dimensional area which is adjusted better to reality because urban cities might be found with a vast number of high buildings and unoccupied areas.

If an increase of demand is observed for this model in specific, the two most suitable solutions might be applied as follows. Firstly to increment the number of neighbor relays (supply) to deliver all the parcels (demand). Secondly to keep the same amount of neighbor relays (supply), but adjusting the coverage area per neighbor-relay to deliver all the parcels (demand). It can be concluded that the packing circle model could be a potential option for crowdshipping. However, some adjustments and changes need to be performed to guarantee that all parcels are delivered, and in case of an increase of demand that the neighbor-relays will be capable of fulfilling it.

4.3.2. Cost flow model

As previously mentioned, Wang, Zhang, Liu, Shen, Lee (2016) have proposed a cost flow model aiming to improve the last-mile delivery and efficiency throughout a whole supply chain. The model suggests the implementation of numerous pop-stations in the city to consolidate the orders based on the customers 'addresses, to finally be delivered by the crowdshippers. The cost flow model presented can be a suitable option to deal with the increase of demand due to the constant growth of e-commerce. The current model contributes to the efficiently organized distribution of the parcels at the minimum cost.

The model explains a way to supply the demand nodes from the supply nodes by a flow at a lower cost. This can be achieved by the establishment of the so-called pop-stations and the utilization of crowdshipping participants.

However, the presented model needs to consider some aspects to reach the main goal of improving the last mile delivery and efficiency in the supply chain. Firstly to assure that the parcel will be delivered to the most optimal pop-station, on the contrary, it will not reach the main goal. The second aspect that can be considered is that the amount of the number of crowdshipping participants (supply side) should increase accordingly so that the demand will be satisfied.

4.3.3. Public transport-based crowdshipping model

The studied model from Gatta, Marcucci, Nigro, and Simone (2019) aims to estimate the willingness to act as crowdshipper and to acquire the service as a user. The suggested solution, applied in Rome, describes the implementation of automated parcel lockers placed inside or in the surroundings of metro stations. The automated lockers contain the parcels intended to be delivered by the crowdshippers.

The survey conducted by Gatta and colleagues (2019) suggested a variety of possible scenarios under different circumstances in which crowdshipping workers and service users will either perform or acquire a service. At the same time, the survey has shown the results in which the majority of the participants are willing to join the community of crowdshipping. The higher percentage of willingness from crowdshippers makes it convenient to cover the demand since the number of workers is more

than enough to complete this task. However, the main idea is to identify under which factors the workers will accept the tasks and which ones will make the user participate. Some of the factors which were considered are presented in Figure 26.
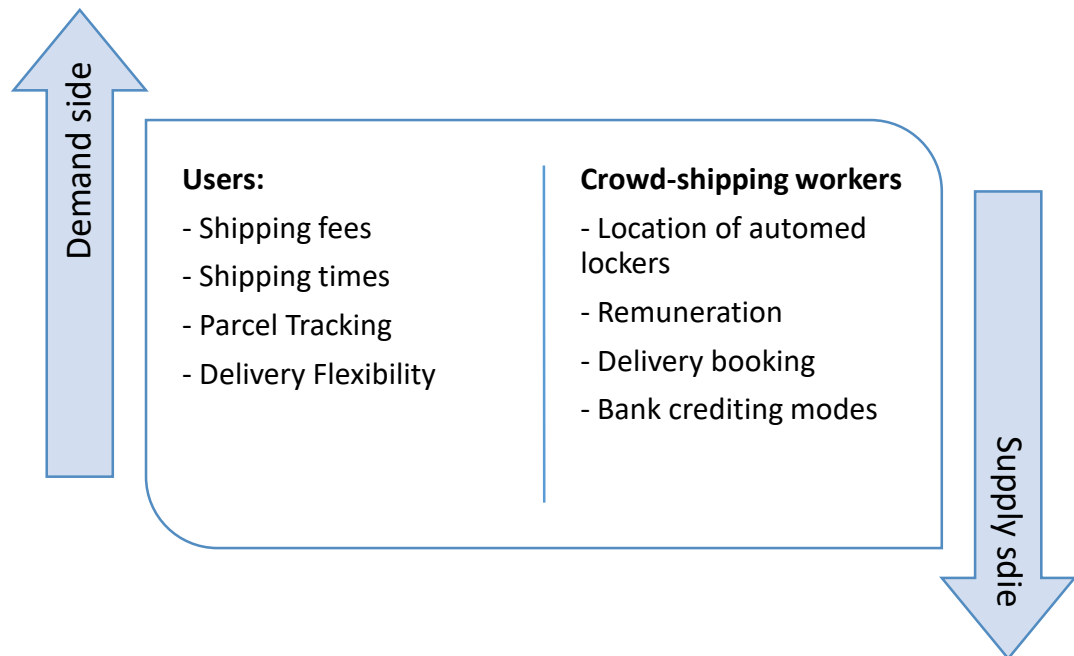
Figure 26. Factors affecting willingness to accept a task and acquire a service. (Gatta et al. 2019.)

If the scenarios are favorable for the crowdshipper and for the service users, its being assumed that there will be a high percentage of willingness to participate in both. One may conclude that one of the man approaches to gather participants for crowdshipping is to offer favorable scenarios and conditions for both participants. Firstly to the workers (supply side) since they will be in charge of providing the service, and, secondly, for the users (demand-side) that will also acquire the service if it is convenient. To sum up, the scenarios may affect directly the willingness to participate which, in turn, has a straight effect on the capacity to supply the demand.

4.3.4.   Same-day delivery with crowdshipping and store fulfillment

Ming, Qing, Xuan, and Hampanur (2019) have proposed the SDD-CSF model with the purpose of minimizing the last-mile delivery gap between local stores and customers.

The SDD-CSF model takes into consideration the order assignment for a specific store and the delivery method in the last-mile.

One special feature of the SDD-CSF model is that it takes into account the currently received orders but it also predicts future orders so that the most convenient solution for the order assignment is found. By the utilization of this special feature the model intends to balance the demand (both current and predicted) with the existing resources available for its delivery.

Ming and colleagues (2019) stated that the SDD-CSF can definitely assist for balancing the supply and the demand since the model is capable to cope with current and future orders. This approach can be implemented for a better distribution of the items aiming to be delivered on the same day as stipulated before.

4.3.5. Crowdsourcing taxis for package deliveries

Two models with the same idea of using taxis to deliver packages have been suggested (Chen, 2015; Pan, 2015; Chen, 14; Zhang, 2014; Wang, 2014; Ma,2014; Han, 2014; Sha, 2014). The main idea behind these models is to match package delivery orders with real-time taxi orders which are made by passengers. The presented models aim to find the optimal paths and the optimal stations close to the final destination of the package (customers´ address). It is important to mention that both of the models tend to leverage the existing taxis on the streets to avoid extra labor costs, emissions, etc.

The main reason for the analysis of both models is to have a clear understanding of how can these systems cope with the increase of parcel delivery demand.

After analyzing the capabilities of the taxi usage for deliveries, it can be concluded that taxis can assist in covering part of the demand for e-commerce due to the high number of taxis that can be utilized to perform deliveries around the world.

However, some constraints can be identified in the model. Firstly the package might require multiple handling times makes the process risky and unreliable. Secondly, the number of taxis that can handle a package is unknown, and the last constraint identified relies on the fact that taxis can just deliver one package per trip since one package will be assigned to one taxi at a time.

It is important to mention that even if the taxis participate in the crowdshipping service, the proposed models do not intend to affect their service level of transporting passengers. The main service for the taxis is to transport the passengers but not the parcels. However, the explained-above taxi models can appear to be a solution and potential option for crowdsourced delivery.

4.3.6. Online Crowdsourced Delivery (OCD)

According to Zhao, Zhou, Jiang, Xia, and Li (2019), this particular model presents a solution to satisfy real-time food orders. Based on the implementation of an online dynamic framework the model can function. The suggested online dynamic framework, as mentioned before, is in charge to collect information from both crowdsourced riders and customers. The model allocates tasks to the available riders (pick-up/delivery) and personalizes riders´ delivery sequence for the assigned tasks.

The suggested model intends to provide its service for On-demand food delivery by the usage of crowdsourced riders appearing as the main actors. This model focuses on providing service to catering businesses such as restaurants and other food establishments. OCD accumulates several valuable advantages - since the crowdsourced drivers can operate on different establishments, the system processes real-time orders and assigns them to the riders.

However, this model relays on the availability of the riders that have the opportunity to accept or deny the delivery task. The fact that food is the main product transported in this model can provide many challenges, since the whole delivery process for On-demand food relays on speed. This might signify that customers can cancel the order at any time if a considerable delay on delivery is identified. The time frames for delivering food tend to be relatively short as the value is reduced over the time passes. Following this thought, the complexity of the delivery service increases as well.

OCD can definitely assist to supply on-demand food orders by the implementation of the proposed model. It's important to highlight the importance of the riders in this model since the number of potential riders and their availability appear to be the key factor for the overall success of the model.

4.3.7. Dynamic crowdshipping model

The presented model from Allahviranloo and Baghestani (2019) describes the premise that each individual involved in every delivery task, regardless if it is a requester or carrier will reach the maximization of utilities. Therefore, the optimal task allocation between carriers and requesters is being identified. Requesters set the maximum willingness to pay for a task based on the value of time-saving while the carriers evaluate the task based on the original itinerary. (Allahviranloo et al. 2019.)

However, the requester tends to select the courier which is offering the lower price for performing a delivery task. This model, from requester's perspective, might lead to a reduction in operation costs and time, and create the opportunity for them to perform other activities. Unfortunately, it does not necessarily mean that the most optimal carrier and route will be selected. This model can assist in balancing the extra demand that requester can have by offering tasks to potential carriers that are willing to carry out those tasks.

5. Discussion

5.1. Research questions and findings

In this section the research questions that have been formulated are presented with a thorough responses which have led to certain conclusions.

Throughout this research different crowdshipping models were introduced to explain the different strategies and approaches that crowdshipping models utilize to provide parcel delivery services. The objective is to identify and analyze different solutions which in practice can contribute to the improvement of the last-mile delivery process. In regards to the presented models, the main approach of the models is to utilize the crowd as potential actors to perform parcel delivery tasks. It is important to mention that one of the main ideas of crowdshipping is the usage of the crowds´ spare loading capacity on already existing transportation flows.

In this section the research questions that have been previously formulated are presented with their own responses.

5.1.1. How the presented crowdshipping models intend to balance supply and demand?

Different models have been presented throughout this thesis in which various transportation modes, approaches and strategies are being identified. A vast number of solutions have been discussed and all the identified models, at least in principle, intend to balance the supply and demand by providing a delivery service (each one with its features). The majority of the presented and suggested solutions are mentioned below.

Packing circle: Determination of the number of neighbors (crowdshipping actors) needed to deliver all the packages in one geographical area. This can be achieved by the usage of algorithms that consider the density, amount of deliveries and other factors to generate a coverage ratio. The neighbor-relay will be in charge of providing service to all the users within his/her coverage area.

Minimum cost flow model: Establishment of pop-stations in different locations around the city to consolidate parcels. Pop-stations aim to decrease travel distances and to deliver all the requested parcels to the final delivery addresses. The crowd voluntarily decides to accept a task based on their schedule and direction.

Public transport B2C: Implementation of automated parcel lockers in metro stations. The lockers will contain the parcels that are meant to be delivered by the crowd that appears as the main actor. Different scenarios are discussed to identify willingness from the crowd to perform a delivery.

Same day delivery with store fulfillment: Development of a system that will take into consideration current and future orders for a better resource allocation. Establishment of physical stores for order fulfillment has been suggested. Deliveries will be performed by sharing information on existing transportation flows and occasional drivers appearing as crowd volunteers that are intended to travel in the direction of customer addresses.

Taxis for crowdshipping: Usage of taxis that can be matched with package deliveries and with real-time taxi orders from passengers. Two models aim to find the optimal paths and stations that are located close to the final destination for delivery.

Online crowdsourced deliveries: System development for deliveries regarding on-demand food orders. This can be performed by the utilization of available riders (crowd) that will be matched with a delivery task based on their location and availability.

University-based Hub model with the participation of crowdsourced students: this model can assist on the supplement of the demand by offering a wide distribution range. The model takes into consideration delivery actors (mainly university students´) addresses. The online survey has presented positive results concerning students´ willingness to participate as crowdshippers since four out of five students are eager to perform a delivery task. It is assumed that if the number of students that are participating in this model is high, the demand will be covered.

The following table 3 has been constructed to summarize the approach of the presented crowdshipping models.

Table 3. Crowdshipping approaches

How the presented crowdshipping models intend to balance supply and demand?	
Model	*Approach*
Packing circle	- Assignment one specific neighbor relay (delivery actor) into one geographical area to perform deliveries in that area
Minimum cost flow model	- Establishment of pop-station for parcel consolidation (the parcel will be allocated into the pop-stations based on their final delivery address)
Public transport for B2C	- Implementation of automated lockers located in metro stations for its further transportation and final delivery
Same day delivery with store fulfillment	- Development of a system that will take into consideration current and future orders for a better resource allocation and establishment of store for order fulfillment
Crowd of taxis for last mile delivery in e-commerce	- Combination of both passengers and parcel transportation.
Package express shipping via taxi crowdsourcing	- Combination of both passengers and parcel transportation (the package will be delivered to the closest safe box based on the passenger final destination)
Online crowdsourced delivery for on-demand food	- Matching available riders with on-demand food orders to the further transportation and final delivery
Dynamic crowdshipping model	- Matching between carriers and requesters to assign delivery tasks to those carriers which are able to offer their services for delivery
University-based hub (suggested)	- Establishment of a university-based hub for parcel consolidation and assignment (students appearing as the main delivery actors for on-demand deliveries)

All in all, feasible solutions have been suggested. However, the majority of the models agree that for the success of their models a high participation of the crowd is necessary to supply the demand for the requested deliveries. Therefore, having an extensive crowd network appears to be the priority to be able to balance the supply and demand. Offering favorable scenarios, a smooth delivery process, and decent

working conditions are the key factors for the triumph of the different business models. The presented models have proved the capability to supply the demand presented with their strategies and methods. However, crowdshipping has been recognized as a novel concept. Therefore, further research is being suggested to assure that the models can satisfy all the formalities and supply the presented demand.

5.1.2.   What makes crowdshipping sustainable?

Sustainable development can be achieved by reaching the needs of the present without compromising the ability of future generations to meet their needs (European Commission, 2016). To assure sustainability in the implementation of crowdshipping models, economic, environmental, and social repercussions shall be identified and analyzed.

As mentioned before, all the features that define a certain crowdshipping concept will then determine the business model and thus the impact on its economic sustainability (Buldeo, Verlinde, Merckx & Macharis 2017). From the economic perspective crowdshipping can be classified as an asset-light approach since it does not have any fleet ownership and permanent employees, these can considerably reduce operational costs. However, every crowdshipping model is dependent on generating sufficient partnerships and users to satisfy the demand in the area in which it is to operate.

Savelsbergh and Van Woensel (2016) have mentioned that a sustainable business model depends on a well-designed revenue and cost structure. To reach a sustainable model, it will require the assurance of a great performance and a sufficient level of service. Crowdshipping speed, platform organization, and efficiency throughout the service appear to be the key aspects.

Crowd shipping in regards to economic sustainability can face some limitations since most of the models support point-to-point deliveries creating a less flexible network for deliveries. Moreover, for the majority of the business models presented it is assumed that every parcel is transported individually. This might limit the overall sustainability of the introduced concept.

From the social perspective, crowdshipping has faced several challenges as an attempt to assure trust in their customers and privacy has been identified as a priority. However, numerous models have implemented different and rigorous selection processes for potential delivery actors. Additionally, a vast number of feedback systems have been developed to evaluate the delivery actor's performance. Also, the implementation of different communication systems to directly connect customers and couriers is under the development stage. This can upgrade the model and assist the overall improvement of sustainability.

One of the main features of crowdshipping is the voluntary participation from the crowd to perform deliveries. However, some business models in practice have been identified with exploitative actions by self-employed drivers. Crowdshipping in practice have created different issues that mainly affect the crowd. It has also been identified that the crowd is exposed to financial insecurities, high competition, underpayment, and lack of optimal working conditions. These matters can prove that in some cases the business models are unsustainable from the social perspective.

Environmental sustainability of crowdshipping: The reduction of resources and emissions can be identified by the usage of spare capacity on existing transportation flows. In practice, the utilized mode of transport for deliveries plays a key role in the overall sustainability of the crowdshipping concept.

From the proposed model perspective and from the survey collected data, it can be recognized that the presented model could, at least in the design stage, be identified as sustainable. The main idea of the model is to utilize students´ daily transportation flows to perform a delivery task. This can affect directly the environmental sustainability of the model, since already existing transportation flows are being utilized. From the economical perspective, the proposed University-based Hub model is asset-light since the model itself does not intend to own any vehicles. From the social perspective, the majority of the students are voluntarily willing to participate in the model. Additionally, an incentive of 5 euros has been identified as the most preferable one to compensate the student for a successful delivery. However, an optimal and well-designed revenue system is being suggested for the further development of the model.

The following Table 4 has been constructed in order to summarize the sustainability aspects of crowdshipping concept.

Table 4. Sustainability of crowdshipping

What makes crowdshipping sustainable?		
Economic	*Social*	*Environmental*
- An asset-light approach → reduction of operational costs - Speed, platform organization, and efficiency throughout the service → assurance of a great performance and a sufficient level of service	- Implementation of different and rigorous selection processes (communication systems) for potential delivery actors - Voluntary participation from the crowd to perform deliveries	- Usage of spare capacity on existing transportation flows → reduction of resources and emissions
Limitations:	Limitations:	Limitations:
- Dependent on generating sufficient partnerships and users to satisfy the demand - Point-to-point deliveries creating a less flexible network for deliveries	- Assurance of customers´ trust - Privacy assurance - Financial insecurities - High competition - Underpayment - Lack of optimal working conditions	- Each parcel tends to be handled individually which can affect the overall sustainability of crowdshipping models

5.1.3. What repercussions does crowdshipping have on stakeholders and in urban areas?

Some of the repercussions that crowdshipping creates are precisely linked to all the participants throughout the process.

Customers can benefit from the speed of the service; delivery tasks can be accepted and performed immediately. Crowdshipping offers a personalized delivery since, in the majority of the models, every parcel tends to be transported individually. Besides, different business models can offer direct communication between customers and couriers.

One of the main features of crowdshipping is that it provides the option to track your parcel in real-time and allows the option to be notified in case of any inconvenience. Shipping prices appear to impede online shoppers when purchasing online. Crowdshipping appears as a solution to perform delivery services for affordable prices.

Retailers can face a significant reduction in operation and delivery costs by the acquisition of crowdshipping services. Crowdshipping has been identified as an asset-light service for retailers since fleet investments, workforce, and maintenance are not necessary. Retailers can wider their markets by offering their services to a more extensive area. Click-and-mortar businesses can increase their competitiveness by outsourcing their delivery orders.

The implementation of the assorted crowdshipping models can create positive repercussions for urban areas since there is a reduction of delivery vehicles, congestion, carbon emissions, and noise pollution. From society's point of view the further development and implementation of different crowdshipping models can generate wealth among delivery actors since incentives and rewards are granted for a successful delivery. Besides, crowdshipping promotes the usage of spare capacity on existing flows and can recommend the use of clean transportation modes such as bicycles. Also, crowdshipping models might encourage citizens to do extra physical activity by taking bicycles to perform the delivery.

The following table 5 has been created to summarize the repercussions of crowdshipping in stakeholders and urban areas.

Table 5. Crowdshipping repercussions on stakeholders

What repercussions does crowdshipping have on stakeholders and in urban areas?	
Actor	*Benefit*
Customer	- Fast delivery - Personalized delivery options - Notification option (in case of any inconvenience) - Real-time parcel tracking option - Affordable prices - Direct communication
Retailer	- Significant reduction in operation and delivery costs - Fleet investments, workforce, and maintenance are not necessary - Market expansion - Click-and-mortar businesses can increase their competitiveness
Urban areas	- Reduction of delivery vehicles - Reduction of congestion - Less carbon emissions, and noise pollution - Promotes the usage of spare capacity on existing transportation flows - Promotes the use of clean transportation modes such as bicycles
Society	- Generates wealth among delivery actors - Encourages citizens to do extra physical activity

5.1.4. Which kind of university students-based crowdshipping model would work in Jyväskylä?

Based on the presented literature review and the collected data from the distributed online-based survey, a University-based Hub model has been created and is being suggested as a potential option to supplement e-commerce deliveries. The model utilizes crowdsourced university students' as the main delivery actors. This model represents a potential option for crowdshipping which, at least in principle, could work in Jyväskylä, Finland.

The conducted survey has shown that 80% of the university students are willing to participate in a delivery task. The created model, which will be presented in this chapter intends to identify the most optimal actor to perform a delivery task. By taking into consideration the high percentage of task acceptability (80%), and the student's deviation range (500 to 999 meters), it is assumed that a significant high number of students are willing to participate and to deviate a considerable long distance to complete a delivery task. These two described preferences can considerably assist to the optimal task allocation.

The model has been created to reduce operational costs for service providers in charge of delivering packages. The reasons for the proposition of a university to be a hub are for the received parcels to be stored, consolidated and allocated. Last but not least the establishment of a university-based hub intends to avoid unnecessary travel distances for the delivery actors in charge of collecting the parcels. Delivery actors will be rewarded with monetary compensation for a successful delivery. The survey has provided useful information concerning reward expectation since the majority agree on receiving 5 euros for a single delivery.

The online survey results concerning students willingness to participate in crowdshipping is favorable since 80% of the participants are eager to perform a task. It is assumed that if the number of students that are participating in this model is high, the demand for e-commerce deliveries will be fulfilled. It is important to mention that the majority of the delivery trajectories from university to customers address is identified as default since it is assumed that students will return to their addresses after finalizing the day at the university.

Nevertheless, it has been recognized that the model has certain limitations. For instance university students´ willingness to participate in the service and to share their addresses. Additionally, the mode of transport utilized by the student can directly affect the carrying capacity, which is why gathering sufficient data about students and their transportation behavior is highly important. It has been recognized that for the overall success of the proposed model the student's availability and participation disposition appears to be the priority.

In the remaining part of this section the model that has been created and proposed is being presented. Along this section the model proposition, model description, contributions and possible advantages are clearly explained for a better understanding of the current model for e-commerce deliveries.

5.1.4.1.   Model proposition

University-based Hub with the participation of crowdsourced students for e-com-merce deliveries

The proposed model consists of crowdsourcing parcel deliveries to students and staff members from JAMK University of Applied Sciences located in Jyväskylä, Finland. The presented online-based survey has positively contributed for data collection that has assisted for the design and can help for the further development of an innovative crowdshipping model for e-commerce deliveries.

The survey has confirmed that four out of five students are willing to participate in a delivery service, this fact can lead for the recognition of university students as potential delivery actors for this model in specific. The University-based Hub model intends to improve the final step of the process (identified as last-mile delivery) by assigning delivery tasks to students that can voluntarily perform deliveries. Based on the suggested model from Ming and colleagues (2019), the establishment of a fulfillment store to consolidate shipments have been adapted in the proposed model by the creation of a University-based Hub, in which the received parcels will be then consolidated, allocated and picked-up by university students for its further transportation and final delivery.

This model focuses on covering one geographical area (Jyväskylä, Finland) by a set of actors (university students) to improve the last-mile delivery for the given objects (parcels). This area coverage method has been adapted from Akeb, Moncef, and Durand (2018), in which the same approach was utilized in the District 12 of Paris. The current model aims to identify the most optimal actor to perform a delivery task based on both customers and university student's addresses. The parcel will be assigned to the student whose address is the closest one to the package final destination.

The potential delivery actors for this model are students and staff members from JAMK University of Applied Sciences (teachers, assistants, catering employees, cleaning personnel etc.) that are willing to participate in the last-mile delivery.

5.1.4.2. Model description

To provide a visual representation of what does the model intend to perform an illustrative description of the model is shown in Figure 27.
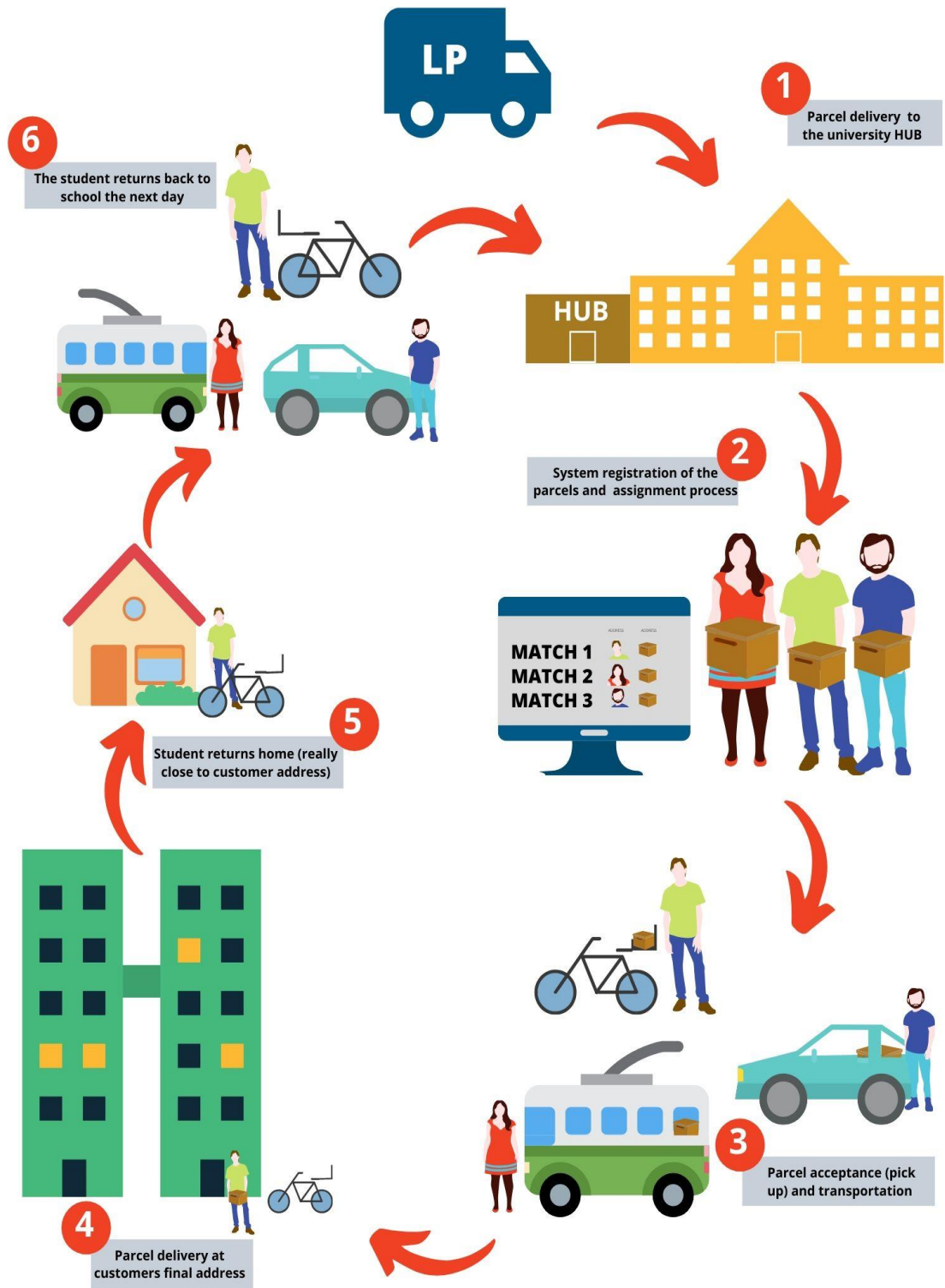

Figure 27. Model illustrative detailed description of the model

Clear explanation of the intended actions for each step of the model are described below.

1. Logistics providers will deliver their parcels (which are meant to be distributed along with the city) to the University Hub (Location in which parcels will be stored and consolidated).
2. The system will receive and register the parcels and their final delivery addresses. Also, the system will compare parcels' final addresses and delivery actors' addresses to assign the best match. The system will then assign the most suitable actor for the delivery. (Actor will decide whether to accept the task or not).
3. If the actor accepts the offer, the parcel pick-up will be arranged at the University-based Hub (Pick-up time is assumed to be when the actor is heading back home after university).
4. Actors will travel to the final customer address by their current mode of transport (mainly by foot, bike, and public transport). Then, the final parcel delivery will take place at customers´ address.
5. If delivery is successful, a monetary incentive will be transferred to the delivery actor, (Is assumed that the delivery actor will return home after the delivery task has been completed).
6. Actor will return to University the next day (Monday-Friday), and the same procedure will be performed again if required and accepted.

The described model intends to allocate at least one actor to one neighborhood in specific (students' neighborhood) to be in charge of delivering parcels to its nearby destinations with their own mode of transport. The survey has identified that public transportation plays a significant role in students daily travel behavior. The fact that public transportation is the most common mode of transport among participants can lead to the conclusion that if the presented model is implemented, the students will continue to exploit already existing transportation flows to deliver a package if requested.

If the above-explained model is implemented, it may be attractive for both logistics providers and university members.

5.1.4.3. Possible contribution for stakeholders

Some possible reasons for the participation in the proposed model are described as follows. For logistics providers the proposed model can assist to decrease operational costs and operational delivery times since the actors (mainly university students´) will be in charge of the last mile delivery. For the delivery actors (university students) it is intended to avoid long travel distance to pick-up a parcel since the parcels will be allocated and consolidated in the University-based Hub.

An incentive will be granted to the delivery actor is the pick-up and delivery are carried out appropriately and are successfully performed. Based on the survey results, the majority of the students have decided that 5 euros is the most appropriate and optimal reward for performing a delivery task (This information can assist for the further development of a reward system).

The final parcel destination might deviate the delivery actors from their own addresses. However, the survey participants in its majority have shown sufficient eagerness to deviate between 500 and 999 meters to deliver a package.

5.1.4.4. Model design

Two problems have been identified as potential options that may assist with the further development of the suggested model. The first problem concerns the so-called clustering problems which are often utilized in different areas for the allocation of distribution centers, public institutions, and data mining. The second identified problem relays on the Travelling Salesman Problem (TSP) approach.

The clustering problem can be adapted to the model by taking into consideration the main actors of the proposed model. If the problem is adjusted to the model, the given information will be described as follows - the given objects (customers) should be grouped into subsets/clusters (university students) so that the subsets are divided. For this problem the k-Means Algorithm is being suggested as an option to solve the problem because it occurs to be a method of vector quantization that is applicable in cluster analysis for data mining. K-Means Algorithm is proposed since it assigns every object (customer) to one cluster (university student) whose center is the closest. The center of the cluster for the proposed model is set to be located at the delivery actors (university students´) addresses. Figure 28 represents the k-Means Algorithm while Figure 29 provides a clear overview of how the presented model intends to assign customers to one actor in specific in the selected area (Jyväskylä, Finland). Appendix 5 sets an example of the usage of clustering problems.

Algorithm 1 k-means algorithm
_____
1: initialize cluster centroids
2: **while** changes occur **do**
3:     assign objects to nearest centroid of a cluster
4:     calculate new centroid
5: **end while**
_____

Figure 28. K-Means Algorithm

● **Start point (University HUB) for pick up**
● **Student addresses**
● **Parcel final delivery address**
— **Default student daily route**
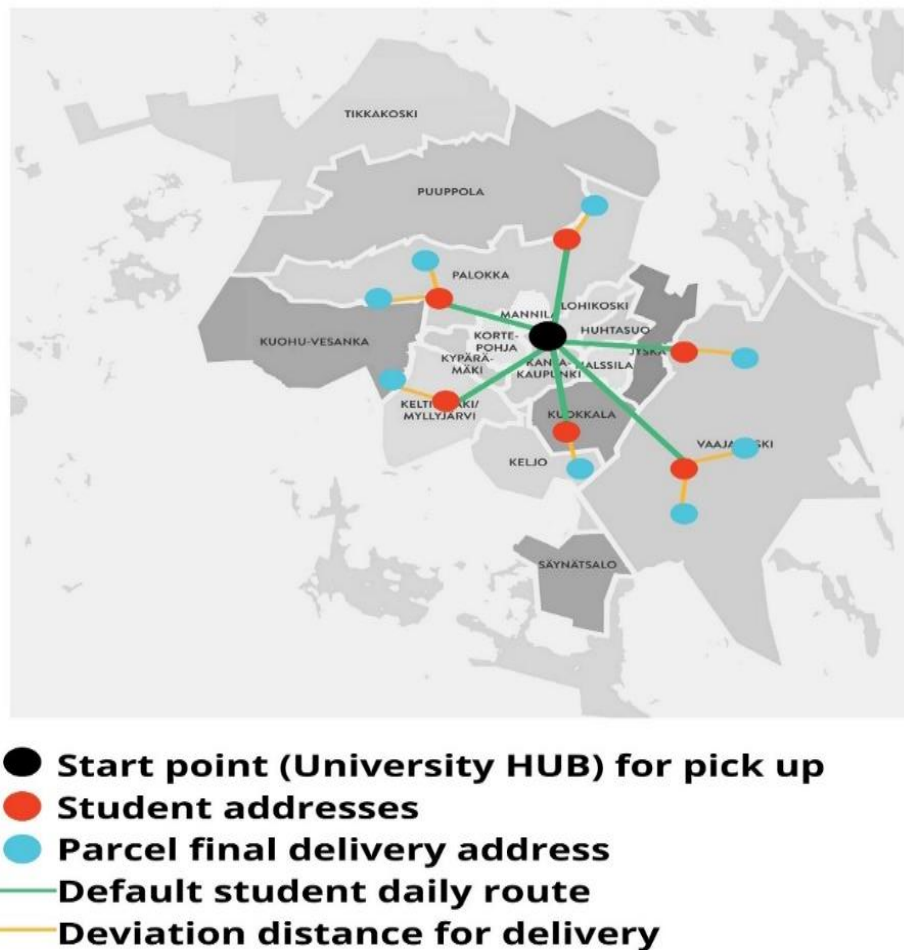— **Deviation distance for delivery**

Figure 29. Model overview (adapted from Jyväskylä.fi website 2020)

Travelling Salesman Problem (TSP) is being suggested as a potential option to serve students who have accepted the delivery of two or more parcels. The problem intends to assist by searching the shortest path. The goal of TSP is to search for the minimum distance that the students need to travel to deliver all the parcels. In TSP each node (location) passes only ones except for the initial point that, also, is set to
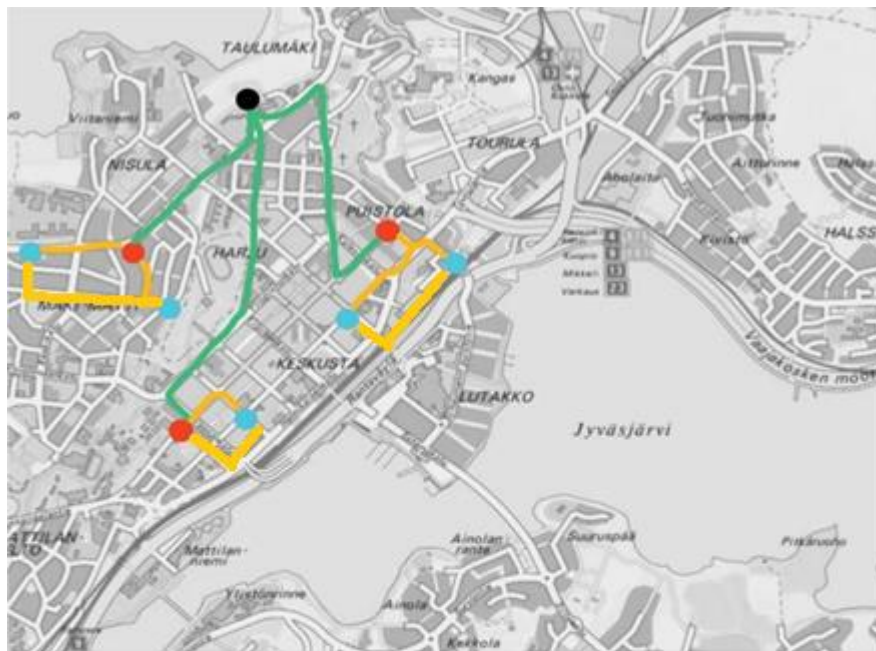
be the final point (student´s address). TSP related to the proposed model is assumed that the student will return to the start (own address) after completing all the requested deliveries. Also, the Nearest Neighbor Heuristic (NNH) algorithm is being presented as a possible solution for this problem. NNH intends to set the movement to the nearest non-visited destination and to repeat the process until the cycle is completed (when the student returns to their address).

Figure 30 presents the Nearest Neighbor algorithm while Figure 31 illustrates the intention of the delivery cycle in the proposed model. Additionally, Appendix 6 provides a clear representation of the nearest neighbor in practice in which Point A is set to be the start and endpoint.

Algorithm 1 NNH algorithm

```
1: select start city s
2: while not all visited do
3:     find closest unvisited city c
4:     label c as visited
5: end while
6: return to city s
```

Figure 30. NNH algorithm

Figure 31. Delivery cycle intention (adapted from Jyväskylä.fi website 2020)

5.1.4.5.   Possible advantages of the current model

Several advantages could be assumed if the proposed model is implemented. These advantages have been assigned to two groups' pick-up and delivery. Assumed advantages are described below.

Pick-up: Flexible times provided to university students for picking-up a parcel are presented (09:00-17:00). Secondly, students do not need to travel outside the university to pick-up the parcel which can ease the process and can make it more flexible. Additionally the fact that the hub will be located at JAMK University of Applied Sciences can give a huge advantage to gather a high number of participant students.

Delivery: The model intends to offer flexible time frames for deliveries. However, it is planned to consider certain time frames, by taking into account that working class groups will finish their jobs between 14:00 and 17:00. It's important to mention that the students that have participated in the survey have selected the early evening from 17:00 to 19:00 as the most convenient time for receiving and delivering a parcel. One of the main features of the proposed model is that most of the travel trajectory is identified as default since it is being assumed that university students are returning back home after the completion of their university day.

However, model limitations are subject for existence. The current model has been identified with limitations, which are presented in Table 6.

Table 6 Model limitations

Model limitations	Possible solutions
Student´s willingness to share their address	- Assuring that the addresses are not being shared and that security and safety are a priority.
Student´s desire to perform deliveries	- Offering attractive rewards; - Making the overall process smooth.
Student´s availability (based on itineraries)	- Selecting feasible and convenient delivery times.
Utilized mode of transport	- Speed appears as a priority. Therefore, the collection of data from existing transportation flows should be a priority to assure successful deliveries.
Student´s maximum carrying capacity	- Assigning congruent parcels to students based on their mode of transport.

5.2. Limitations

This section has been created in order to discuss all the aspects that are not favorable for the proposed model and can affect its performance. Concerning the distributed online-based survey it is being concluded that the segment 1 (students appearing as crowdshippers) appears to provide reliable results since the answers were provided by university students from both Finland and abroad, which are in charge of performing the deliveries and have shown eagerness to participate as crowdshippers. The fact that the participants were from different fields of studies around Finland

and abroad dispense valuable data since the acceptability of participating as crowdshippers has been identified as high can lead to result that it can gather both participants in Finland and from other countries. The unreliable part that has been identified in the pool of university students is that not all of them are university students in Finland so it can affect the acceptance rate of acting as crowdshippers in Finland.

However, the controversial part has been identified in the segment 2 (students acting as receivers) of the distributed online-based survey in which the answers were from the same group of students as in segment 1. The fact that the answers from segment 2 come from the same pool of university students has provided valuable information but not necessarily the most optimal data since we have just included students and no any other secondary group of people. The segment 2 responses have been identified as unreliable for the overall conclusion of the acceptability of the service.

Regarding the validity of the used methods for data collection, the online-based survey appeared to be an efficient tool for gathering responses from university students. The group size of the chosen target group (54 university students) has been recognized as useful for the completion of segment 1 and the results are being identified as reliable and valuable to draw conclusions regarding the willingness of university students to act as crowdshippers.

However, the inclusion of a higher number of participants and a wider survey sample is being suggested to draw more concrete conclusions, since the collected responses from the 54 participant university students appeared to be a valuable sum which assisted for the acquisition of important data, but has not been identified as the most optimal sum. Therefore, the total sum of 54 participants in the distributed online-based survey is being recognized as a limitation.

Segment 2 responses are classified as unreliable since the inclusion of secondary groups for the demand side were not requested nor mentioned. This has affected the overall reliability of the used method and the target group included in the online-based survey did not appear to be the most optimal. It's being suggested the further research of segment 2 to collect responses from different and more varied groups of

people belonging to different classes. The inclusion of middle aged respondents, working class, and elderly is being suggested in order to gather more reliable information concerning the acceptability of this crowdshipping service.

6. Conclusion

One may conclude that the continuous growth of e-commerce activities and the constant increase of urbanization are practices that play a significant role in the economic development of urban areas. However, numerous threats for cities inhabitability have been identified and associated with the increase of e-commerce and urbanization. A substantial increase in single parcel deliveries has been recognized as the main outcome of e-commerce. It is important to mention that the above-mentioned events are expected to keep growing in the following years.

It has been proved that the implementation of sustainable solutions as crowdshipping can considerably assist in the mitigation of some issues that are encountered in the last-mile delivery and might also contribute to the overall improvement of delivery operations. It appears that shared practices of passengers and freight, as well as the utilization of spare loading capacity on existing transportation flows, had grown attention in the past years indicating a significant opportunity for implementing crowdshipping business models in urban areas.

Crowd shipping has been identified as a promising solution since the various business models have proved a great achievement in the overall efficiency of the last-mile delivery with the reduction of travel distances, costs, and trips. The presented models have also proven that they are capable to assist on the supplement of the demand for e-commerce. Crowdshipping, in practice, can provide faster, affordable, and more flexible deliveries. It leads to the conclusion of contemplating crowdshipping as a potential solution for attenuating the issues and challenges that e-commerce generates.

It is concluded that crowdshipping success relays in its majority on the participation of the crowd that appears as the main actor in charge of performing the requested delivery tasks. This concludes the importance of creating convenient delivery scenarios for the crowd as well as of the implementation of a well-designed revenue and cost structure.

It may be inferred that crowdshipping business models provide multiple benefits for the involved stakeholders, which have obtained numerous advantages by either performing or acquiring crowdshipping services. However, the concept of crowdshipping

is relatively new, and further development is required. Therefore, some limitations and inadequacies on the overall sustainability have been addressed as well as the matters which can threaten the overall sustainability of the introduced concept.

Regarding the proposed crowdshipping model and its described features, it allows us to claim that the model appears to be a potential solution as an attempt to improve the last-mile delivery and to positively cope with the presented on-demand deliveries. This can be achieved by the participation of students that can assist in the delivery tasks. The distributed survey has provided valuable data for the future development of the model. Limitations in the model have been identified due to the lack of information that was intended to be complied from the participants in the generated and distributed online survey. Research for the further development and implementation of the proposed model is being suggested and recommended.

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8. Appendices

8.1. Appendix 1

Table 4 MNL2, supply-side model: parameter estimates, fit statistics and validation

	MNL			
	Coeff. (β)	Stand. Error	T-test	P-value
Attributes				
Age	0.0473	0.0111	4.25	0.00
Location of APL[a]				
Inside metro stations	0.5940	0.0706	8.42	0.00
Remuneration[b]				
3 €/delivery	0.4890	0.061	8.02	0.00
Delivery booking[c]				
Real-time booking	0.3350	0.0683	4.90	0.00
Bank credit mode[d]				
Single delivery	0.5330	0.0698	7.64	0.00
"no choice" [ASC]	−3.390	0.483	−7.03	0.00
Model Fit Statistics				
N. of observations (individuals)	627 (209)			
Null log-likelihood	− 688.83			
Final log-likelihood	−489.293			
Likelihood ratio test	399.074			
Rho-square	0.290			
Adjusted rho-square	0.281			
Simulation test				
Sample reconstitution	62%			

[a]base level: "Outside metro stations/adjacent buildings"; [b]base level: "1 €/delivery"; [c]base level: "Off-line booking"; [d]base level: "Every 5 deliveries"

8.2. Appendix 2

Table 3 MNL1, demand-side model: parameter estimates, fit statistics and validation

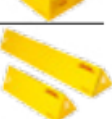|	MNL			
	Coeff. (β)	Stand. Error	T-test	P-value
Attributes				
Age	0.0905	0.0118	7.65	0.00
Shipping fees* [a]				
Lower	0.6750	0.0998	6.76	0.00
Shipping time** [a]				
Lower	0.5870	0.0882	6.65	0.00
Parcel tracking***				
Present	0.6980	0.0946	7.38	0.00
Delivery date and Time schedule flexibility ****				
Yes	0.7860	0.0886	8.87	0.00
"no choice" [ASC]	−5.2300	0.5880	−8.90	0.00
Model Fit Statistics				
N. of observations (individuals)	618 (206)			
Null log-likelihood	− 678.942			
Final log-likelihood	− 469.842			
Likelihood ratio test	418.201			
Rho-square	0.308			
Adjusted rho-square	0.299			
Simulation test				
Sample reconstitution	59.9%			

*base level: "Typical"; **base level: "Typical"; ***base level: "Not available"; ****base level: "No"
[a] with respect to current national shipping companies
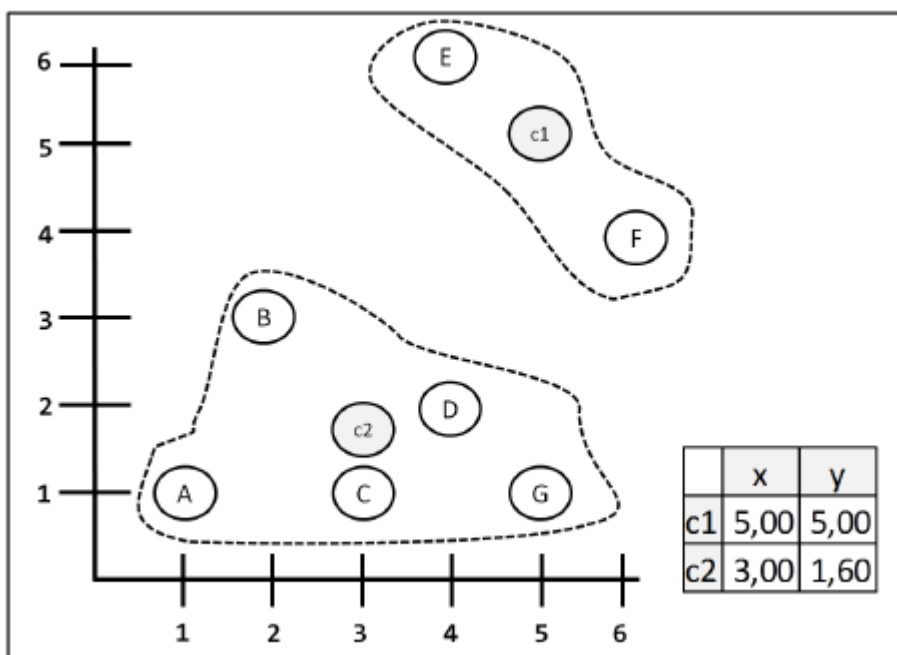
8.3. Appendix 3

Supply side					
Questions	Mayority of responses in percentage	Other responses			
Are you willing to participate in a delivery service, and share your current address?	Yes 80%	No 20%			
Which mode of transport do you use to come to university and return?	Public Transport 44%	Bycicle 28%	Car 13%	Walking 15%	
How far are you willing to deviate from your home address to deliver a package to the final customer?	500-999 meters 40.7%	1000-2000 meters 33.3%	200-499 meters 20.4%	0-199 meters 5.6%	
Based on your main mode of transport, what package are you able to carry and de-liver?	Box 3 (337x322x180 mm) 45%	Box 1 (337x180x100 mm) 9%	Box 2 (336x320x52 mm) 22%	Box 4 (337x332x345 mm) 4%	All of the mentioned 20%
How much are you expecting to receive for delivering a package in your neighbor-hood?	5 euros 42.6%	10 euros 16.7%	3 euros 9.3%	4 euros 7.4%	Remaining answers 24%
Demand side					
Questions	Mayority of responses in percentage	Other responses			
Are you willing to accept a package that is meant to be delivered by your neigh-bor/student instead	Yes 98.1%	No 1.9%			
In terms of security and safety, how important the delivery transport mode is for you?	Somehow important 33%	13%Very important	Important 26%	Not important as far as my oacjage arrives 28%	
Combined					
What is the most convenient time for you to deliver a package (supply side)	17:00-19:00 53.7%	12:00-15:00 22.2%	15:00-17:00 22.2%	Other 1.9%	
What is the most convenient time for you to deliver a package (demand side	17:00-19:00 64.8%	12:00-15:00 9.3%	15:00-17:00 20.4%	Other 5.5%	

8.4. Appendix 4

EXTERNAL PACKING MATERIALS

Boxes				
Box Type	**Weight Limit**	**Size** (mm)	**Bursting Test** (pounds-per-square-inch)	**Edge Crush Test** (pounds-per-square-inch)
Box 2	1 kg	337 x 182 x 100	155	34
Box 3	2 kg	336 x 320 x 52	160	34
Box 4	5 kg	337 x 322 x 180	160	34
Box 5	10 kg	337 x 322 x 345	280	52
Box 6	15 kg	417 x 359 x 369	280	52
Box 7	20 kg	481 x 404 x 389	280	52
Box 8	25 kg	541 x 444 x 409	280	52
Express Tube Tube 3 Tube 4		475 x 155 x 134 976 x 176 x 152		

8.5. Appendix 5

	x	y
c1	5,00	5,00
c2	3,00	1,60

8.6.   Appendix 6