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Crowd Logistics: A Survey of Successful Applications and Implementation Potential in Northern Italy

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Abstract: Nowadays, last-mile logistics represents the least efficient stage of supply chains, covering up to 28% of the total delivery cost and causing significant environmental emissions. In the last few years, a wide range of collaborative economy business models has emerged across the globe, rapidly changing the way services were traditionally provided and consumed. Crowd logistics (CL) is a new strategy for supporting fast shipping services, entrusting the management of the last-mile delivery to the crowd, i.e., normal people, who agree to deliver goods to customers located along the route they have to travel, using their own transport means, in exchange for a small reward. Most existing studies have focused on evaluating the opportunities and challenges provided by CL through theoretical analysis and literature reviews, while others have proposed models for designing such emerging distribution networks. However, papers analyzing real successful applications of CL worldwide are lacking, despite being in high demand. This study attempted to fill this gap by providing, at first, an overview of real CL applications around the globe to set the stage for future successful implementations. Then, the implementation potential of CL in northern Italy was assessed through a structured questionnaire delivered to a panel of 214 people from the Alma Mater Studiorum University of Bologna (Italy) to map the feasibility of a crowd-based system in this area. The results revealed that about 91% of the interviewees were interested in using this emerging delivery system, while the remaining respondents showed some concern about the protection of their privacy and the safeguarding of the goods during transport. A relevant percentage of the interviewees were available to join the system as occasional drivers (ODs), with a compensation policy preference for a fixed fee per delivery rather than a variable reward based on the extra distance traveled to deliver the goods.

Keywords: last-mile delivery; crowd logistics; e-commerce; parcel delivery; social crowd

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1. Introduction

In recent years, the growing use of e-commerce channels and the need to make ordered goods available in ever shorter times have required the urgent rethinking of parcel delivery systems, especially in urban areas [1–5]. Nowadays, this trend is much more marked due to the outbreak of the COVID-19 pandemic. In fact, unlike ever before, e-commerce safely provides goods to customers during periods of severe lockdowns and restrictions to protect people's health. As a result, the use of e-commerce increased in 2021, with a turnover growth of 12%, and growth rates have continued their increasing trend in 2022 [6]. Pushed by the e-commerce explosion, urban traffic is increasing dramatically. Several initiatives have been undertaken by the European Commission as part of the so-called Green Deal, which has the overall aim of making the European Union (EU) climate neutral by 2050. Sustainable mobility is among its policy areas, with the aim of increasing the adoption of sustainable and alternative fuels in road, maritime, and air transport and fixing the emission standards for combustion-engine vehicles. It also plans to implement smart traffic-management systems and applications and modify traditional freight delivery methods, with the preferred pathways being land or water. However, efficient and effective

solutions need to be implemented in the short/midterm to optimize urban parcel delivery systems. One of the most promising strategies, which has spread in recent years, is represented by the concept of crowd sourcing. The literature states that this concept can be categorized into three different types: crowdfunding, crowd innovation, and crowd logistics [7,8]. Crowd logistics (CL), also known as crowd delivery, uses idle resources to perform last-mile deliveries instead of traditional delivery companies [9]. People involved in this process belong to the "crowd", i.e., they are normal people, non-professional drivers, commuters, and travelers, coordinated by information technology (IT) systems and willing to share some of their time to deliver goods to customers for a small fee. CL partners can reach customer destinations by slightly modifying their traditional route or by simply walking or cycling, in this way avoiding traffic congestion. As stated by a wide range of studies [10–14], the parcels containing the goods are delivered by logistics couriers to specific transfer points and then transferred to the final customer destinations by crowd partners. Among the benefits conferred by adopting this strategy is the ease of recruiting potential CL partners, as the working area is local and the resources needed are traditionally owned by ordinary people. In addition, this strategy is able to overcome the ping-pong delivery problem [15]. However, one of the barriers is that the partners may encounter limitations in terms of delivery distance or capacity due to the use of non-standard delivery equipment, e.g., normal cars and bikes. A large number of studies are available in the current literature assessing the opportunities and challenges provided by CL through theoretical analysis and literature reviews, while an emerging parallel stream attempts to develop original models for designing such distribution networks. However, papers analyzing real successful implementation cases of CL worldwide are lacking, despite being in high demand. This study tried to fill this gap by presenting an overview of real CL applications around the globe, taking stock of the current situation and looking forward to future successful implementations. Then, the implementation potential of CL in northern Italy was assessed through a structured questionnaire delivered to a panel of 214 people from the Alma Mater Studiorum University of Bologna (Italy) to map the feasibility of a crowd-based system in this area.

The remainder of the paper is organized as follows. Section 2 reviews the relevant literature on this topic. Section 3 presents the most relevant real-world applications of CL, while Section 4 describes the structure and the most significant results of the questionnaire conducted in the Alma Mater Studiorum University of Bologna (Italy). Finally, Section 5 concludes the paper and presents future opportunities for research.

2. Literature Review

Sustainability in logistics and supply chains is a hot topic in the recent literature, explored by a large number of studies [16–19]. Concerning the best way to manage the transport of goods, the concept of CL for last-mile deliveries has gained even more attention from both academics and practitioners because of the increasing number of active home delivery services. It has arisen as an effective answer to the increasing customer expectations for faster, personalized, and cost-reduced delivery, joining advanced technology and sharing and collaboration trends [8,20]. Carbone et al. [8] presented a segmented analysis classifying crowd solutions based on the four types of service offered. In addition, they introduced six theoretical propositions for the future development of CL. Mladenow et al. [21] used a scoring method to examine how companies may evaluate CL alternatives in terms of the ways in which the social crowd can be integrated within logistics processes. In the above paper, the authors discussed the potential benefits and challenges of CL, as well as its opportunities and barriers from both a business and an individual perspective. Buldeo Rai et al. [22] analyzed a set of 42 papers and interviewed 11 logistics practitioners to capture the state of CL practice. In detail, the authors identified 18 key characteristics of CL and assessed whether they affected the economy, society, and/or the environment, adopting a triple bottom line perspective. The results showed that all the characteristics influenced economic sustainability, while 11 characteristics also affected

social and/or environmental sustainability. Buldeo Rai et al. [23] investigated which types of CL initiatives received the most support among the stakeholders involved in sustainability projects to guarantee faster and more flexible deliveries. The authors applied a multi-methodological approach based on a systematic literature review, semistructured interviews, and a multiactor multicriteria analysis (MAMCA). The main findings of this study indicated that the stakeholders' perceptions diverged significantly, which should be taken into account by practitioners and policy makers. Frehe et al. [24], through an assessment of the nature and characteristics of CL business models, proposed a new concept for the sustainable implementation of CL. The authors used the design science process to develop this new business model using data from expert interviews involving 13 companies. The main result of the paper was the identification of four relevant steps that companies should follow to implement sustainable CL. Rai et al. [13] performed an analysis to gain insights into CL's environmental impact and the involved stakeholders through two main methods, i.e., an impact analysis using data from a CL platform in Belgium, and an analysis of stakeholder support for CL using a multiactor multicriteria approach. The results mainly highlighted that the current platform led to a higher external transport cost and environmental impact compared to a traditional parcel delivery system. Thus, a crucial role in improving the impact of CL needs to be performed by the platform provider, who can adjust the platform's operation and incentivization to steer efficient vehicle use. Rześny-Cieplińska and Szmelter-Jarosz [25] assessed CL solutions from the perspective of the needs of different stakeholders, with the aim of adjusting the business model and market offer of other providers to the needs of different groups of stakeholders. The analytic hierarchy process (AHP) was applied to develop the proposed evaluation tool for CL initiatives. The evaluation criteria, i.e., the needs of particular groups of respondents, were derived from document-based data analysis, and the primary data for the model were derived from information supplied by service providers. Szmelter-Jarosz and Rześny-Cieplińska [26] also presented an assessment of the priorities of different urban logistics stakeholders for launching CL solutions within a city area. The purpose of this study was to analyze the priorities of several stakeholders in relation to the introduction of CL solutions within a city area. The results allowed the authors to define the demand characteristics of CL solutions by identifying the areas that are crucial for particular groups of stakeholders. Huang et al. [27] adopted the push–pull–mooring (PPM) theory to build a model to explain the factors influencing crowd workers' participative behavior. The results showed that monetary rewards and trust may positively impact the willingness of crowd workers to continue participating in CL, while work enjoyment from previous work and entry barriers for work have a significant negative impact. Trust plays an intermediate role between monetary incentives and crowd workers' willingness to continue participating. Using the organization information processing theory, Zhang et al. [28] explored the process through which the informative support of CL platforms affects logistics performance. After collecting data from about 300 respondents from two CL companies, the authors proposed and empirically tested the theoretical framework. The main results indicated that a platform's informative support improves logistics performance through two mediators, i.e., logistics resources–demand matching and logistics agility. Alharbi et al. [29] explored how CL meets the new economic and environmental challenges in the rapidly emerging economy of Saudi Arabia. The authors used semistructured interviews to analyze CL from the perspectives of multiple stakeholders, focusing on its implementation, benefits to different stakeholders, and limitations.

On the other hand, an emerging research stream is focused on the development of models and quantitative techniques for designing such distribution networks. In this field, Kafle et al. [2] proposed a crowd-based system for parcel relay and delivery in urban areas, considering pedestrians and cyclists as crowd-logistics partners. The partners express their availability by submitting bids to the truck carrier. The problem was formulated as a mixed nonlinear mathematical model that minimizes the sum of the truck operating cost, the payment to the involved crowd partners, and the penalty cost for serving customers outside

their desired time window. Huang and Ardiansyah [9] explored the planning of a last-mile delivery system in which crowd partners support the management of the deliveries from transfer point nodes to the final customer destinations. The problem was formulated as a mixed-integer programming model to minimize the global cost due to delivery trucks and crowdsources, i.e., the main carrier fleet costs, fixed usage costs, and variable costs of the crowd partners. The main results of this study showed that well-planned crowdsourcing integration can take advantage of the flexibility and cost benefit of crowdsourcing for last-mile deliveries. Wang et al. [10] developed an innovative mobile crowd-tasking model using citizen workers to perform the last-mile delivery of goods. The model was formulated as a network min-cost flow problem, and a wide set of pruning techniques were proposed to reduce the network size. Then, the model was tested and validated using Singapore and Beijing datasets, proving that the solution could support real-time delivery optimization. Akeb et al. [30] developed the idea of encouraging people living in the same neighborhood to collect and deliver parcels to the final customer when that person is away from home during the delivery, to avoid the additional costs of delivery failure. Then, final customers receive a notification and contact their neighbor via a mobile app to schedule the parcel delivery. The model adopted circle packing to estimate the number of neighbors needed, as well as the number of parcels they would have to manage and the corresponding reward, and it was applied to the context of the urban area of Paris, obtaining encouraging results. Some studies have considered the concept of CL as a vehicle routing problem with occasional drivers (VRPOD) [27–31]. Archetti et al. [31] considered a CL system in which the company aimed to perform the deliveries at the minimum cost, factoring in the cost of using their own vehicles and drivers as well as the compensation for occasional drivers (ODs). The authors solved the model by using a commercial solver for optimization and heuristic procedures, producing solutions with small errors. Macrina et al. [32] proposed a VRPOD model considering time windows for both customers and ODs and the possibility of ODs making multiple deliveries. Feng et al. [33] presented a VRPOD variant named the vehicle routing problem with heterogeneous capacity, time window, and ODs (VRPHTO), considering the capacity heterogeneity and the time window of vehicles. The authors solved the model by developing a novel evolutionary multitasking algorithm to optimize multiple VRPHTO problems simultaneously. Archetti et al. [34] expanded their previous study by considering customer requests known in advance of the planning of the distribution or arriving online during the distribution process. Finally, Martín-Santamaría et al. [35] developed a VRPOD model to minimize the total cost of performing deliveries using both vehicles belonging to the company and ODs executing the last-mile deliveries. The authors tested the model using the iterated local search algorithm, finding that it was able to outperform the state-of-the-art approaches in terms of quality.

This literature analysis highlighted the existence of a large number of studies analyzing the main characteristics of CL as well as the main benefits and barriers of its implementation; however, the literature lacks contributions presenting the most relevant CL implementations around the globe. Considering this background, we tried to fill this gap by presenting an overview of existing successful implementation cases of CL. Then, the implementation potential of CL in northern Italy was assessed through a structured questionnaire delivered to a panel of 214 people from the Alma Mater Studiorum University of Bologna (Italy) to map the feasibility of a crowd-based system. Section 3 presents the existing real-world implementation cases of CL.

3. A Critical Survey of Crowd-Logistics Implementation Solutions

The aim of this section was to present and discuss the main existing and successful applications of CL initiatives to determine the most commonly involved sectors and the main geographical areas in which they are implemented. The analysis allowed us to organize the contributions according to the type of shipment. Following this system, Section 3.1 describes applications involving the transport of people, Section 3.2 the transport

of goods, and Section 3.3 the integrated transport of people and goods. Finally, Section 3.4 is devoted to the discussion of the main findings.

3.1. Transport of People

Uber and Lyft, founded in 2009 and 2012, respectively, are among the most relevant examples of CL solutions for the transport of people, already widespread in many cities all over the world [36,37]. Both platforms offer iOS and Android apps to their customers. However, while many services exist allowing customers to book a licensed taxi, the logic behind Uber and Lyft is different, since they have a panel of private drivers belonging to the crowd. Such drivers offer different types of cars and services and, depending on the number of people needing a ride and the type of vehicle required, the user can select the preferred ride through the mobile app. Lyft has fewer service options than Uber, but its services cover everything the average user will need when requesting a ride. A standard Lyft has a seat for the user and up to three friends, while Lyft Plus provides a more expensive ride for up to six passengers. Both companies also offer car-pooling services, i.e., UberPOOL and Lyft Line, which offer the user a cheaper ride if she/he shares the car with another passenger. UberX is the company's most affordable option, followed by UberXL, which is an inexpensive service for larger groups of people. UberSELECT is a service that represents "the next step towards luxury", followed by UberBLACK, which offers the user a ride with a registered professional driver in livery in a black luxury car. Finally, UberSUV is characterized by the highest fares, providing a luxurious vehicle that has space for the user and for a group of his/her friends. In some cities, Uber also offers UberLUX, with high-end cars, and UberASSIST, for the elderly and people with disabilities, who need extra assistance or a vehicle that can accommodate a wheelchair.

3.2. Transport of Goods

Concerning the transport of goods, two main service streams can be offered, i.e., door-to-door and shop-to-door. Roadie Inc. is an example of an American crowdsourced delivery platform provider of door-to-door delivery services whereby travelers, e.g., drivers and bikers, collect and deliver items to shippers [38]. The company calls its crowdsourced model "on the way" delivery, matching crowd drivers with deliveries that are directed along the routes they plan to travel. Roadie's app works by connecting drivers with senders, businesses, or consumers who have items that need to be delivered. A sender creates a delivery on Roadie's web app or via its API. Drivers then review the deliveries in their area on their mobile app and may choose to advertise their availability to take on individual or multiple deliveries along the same route. The deliveries are then assigned to drivers by the Roadie's algorithm. According to the company, this model encourages drivers to choose deliveries that fit their planned schedules and routes.

Crowdsourced store-to-door delivery services mainly focus on the B2C market. As an example, the e-tailer Zalando relies on Trunkrs to offer same-day deliveries for its customers in some European cities. Trunkrs uses both crowdsourced delivery and traditional courier services. This allows the company to guarantee trust and reliability for its customers, i.e., the e-tailers. In detail, Trunkrs is a parcel delivery company seeking to meet the growing need for affordable same-day deliveries through a crowdsourced-based parcel delivery community. The uniqueness of the commercial proposal lies in the way in which the company uses a network of qualified commuter drivers from the crowd to carry out deliveries from the city boundaries to the customers locations. Regarding the logic behind Trunkrs, a professional driver picks up the parcels and transports them to an intermediate hub. Then, Trunkrs commuter drivers provide the last-mile transport from these hubs to the customers' homes, with remuneration for each package delivered [39]. Walmart Inc. is exploring another innovative form of crowdsourced store-to-door delivery service in which the customers present in the stores, i.e., the crowd, may fulfill the delivery of items purchased by its online customers [40]. Walmart Inc. is the world's largest retail chain with 11,847 stores and clubs in 27 countries. Ninety percent of the inhabitants of the USA

use Walmart Inc. services, because its shops are widespread in all cities. However, in recent years, the company has become sensitive to the topic of CL, because it is aware that in-store shopping can be very expensive for customers who have limited available time and presents other inconveniences such as busy parking, long checkout lines, and empty shelves. Because of all these factors, in September 2017, Walmart Inc. acquired Parcel, a technology-based, same-day and last-mile delivery company in Brooklyn. In 2018, Walmart Inc. started offering crowdsourcing delivery services to customers using drivers' private vehicles, under the brand "Spark", which is now active in more than 600 cities and 50 states. Further popular store-to-door delivery initiatives can be found in the grocery and food industry, e.g., restaurants, where the platform provider not only arranges the delivery service, but also allows its customers to select the retailer or restaurant they prefer. As an example, Instacart is an American company providing same-day grocery delivery in the USA and Canada for food products purchased in grocery stores selected by the customers [41]. The service allows customers to order groceries from participating retailers, and the physical shopping is performed by personal shoppers from the crowd. In this way, the orders are processed and delivered by the personal shopper within the time period indicated by the customer, who can pay with a personal credit or debit card, Google Pay, or Apple Pay; then, the customer is asked to tip the personal shopper. Retailers participating to Instacart's network program price individual items on the Instacart marketplace, which are usually similar to in-store prices. This is similar to meal delivery services, such as GrubHub Inc., UberEats, Foodora GmbH, and Amazon Flex, whereby crowd couriers, e.g., drivers or motorcyclists, pick up a meal at the customer's selected restaurant and deliver it to the customer's home. The Just Eat Takeaway group was born during the COVID-19 pandemic. In April 2020, the Dutch company Takeaway decided to acquire its English competitor Just Eat at a cost of about EUR 7 billion. They were able to jointly offer their services to around 155,000 restaurants in more than 23 countries around the world, with a strong focus on the European continent. Then, in June 2020, the group bought Grubhub Inc. at a cost of USD 7.3 billion, marking the birth of one of the largest home service groups in the world [42]. Uber Eats is Uber's delivery service, which is dedicated to food home delivery and active in over 45 countries around the world. Regarding the rates charged by Uber Eats, for each order placed, in addition to the cost of the food, a booking fee and some additional taxes must be paid. Such fees are included in the total cost of the order and are set by the restaurants. This means that the costs offered by restaurants on Uber Eats may vary from the costs charged by the same restaurant if the customer decides to eat there physically. The total order cost does not include tips for couriers, which are not mandatory, but each user can voluntarily decide to leave a cash tip on the delivery or add it later, up to 30 days after the delivery, through their personal account [43]. Foodora GmbH is a German meal delivery company that offers dishes from over 9000 restaurants in various countries [44]. Until summer 2018, Foodora GmbH was active in 10 countries on a global scale, i.e., Germany, Austria, France, Italy, the Netherlands, Sweden, Norway, Finland, Canada, and Australia. In August 2018, it decided to close its activities in Italy, France, the Netherlands, and Australia. Through the company's website or the mobile application, customers are able to track the restaurants near them, place an order, and pay online. The order is prepared by the restaurant and delivered to the customer within as little as 30 min by ODs. The company offers both B2B and B2C services. The Amazon crowdsourced delivery platform, Amazon Flex, introduced in 2015, performs deliveries for Amazon, e.g., Amazon Fresh, Prime Now, and Amazon Restaurants [45]. Through this system, ordinary people can deliver packages or groceries. Amazon Flex is currently present in more than 50 cities and continues to grow. Amazon pays normal people, i.e., the crowd, to travel to their facilities, collect packages, and deliver them to customers. They are usually directed to locations near them to pick up packages, which must then be delivered to customers. The Amazon Flex app is a mobile app provided by Amazon that makes being a Flex delivery agent efficient. The Flex app is used by all the crowd delivery drivers to set up their schedules, load packages, and provide guidance on delivery destinations. Drivers

can also view all their earnings and payment data and set their bank deposit preferences. According to official data reported on the Amazon Flex website, drivers can earn USD 18–25/h for delivering packages and up to USD 25/h by using a larger car, allowing them to deliver more packages.

3.3. Integrated Transport of People and Goods

Nowadays, the integrated transport of goods and people plays an important role in efficient and reliable delivery services, as people and goods can share infrastructure for part of their journey, especially within a city. This is made possible by exploiting, for example, the spare capacity available in public transport, e.g., subways, buses, and taxis, in urban areas for the movement of goods. Relevant examples of freight and passenger transport integration include not only the sharing of transport infrastructure, but also the sharing of infrastructure for the temporary storage of goods, for example the placement of lockers in bus or metro stations, train stations, and parking lots. Hitch Technologies is a relevant example of an American company devoted to the transportation of both people and goods following a crowd-shipping model [46]. Regarding the transport of people, the Hitch service offers up to five departures per day with pick-up and drop-off locations near to the users. The Hitch Premium service, for an additional cost, offers up to ten departures per day with a door-to-door experience. On the other hand, concerning the transport of goods, Hitch offers same-day delivery services and allows the user to schedule the delivery up to sixty days in advance, meeting the driver at a nearby, predetermined location. Another successful implementation case is PostBus Courier, a DHL service integrating parcel transport and passenger service into its long-distance intercity bus network [47]. At first, in 2015, the service was offered between Berlin and Hamburg, especially for urgent same-day shipments for both B2C and B2B customers. PostBus was the first long-distance bus travel provider in Germany to also offer parcel transport in addition to the traditional passenger service. PostBus Courier is a new same-day delivery option that provides customers with the ability to use their own intercity bus network to ship particularly urgent items. The PostBus Courier service is designed to be easy to use for customers, who first print and fill in the shipping documents and then take them along with their packages to the PostBus Courier service point at the main bus station in Berlin or Hamburg. The recipients personally collect the items on the same day at the arrival destination.

3.4. Discussion

The analysis presented in Section 3 highlighted the existence of a still limited number of CL implementation cases, which are summarized in Table 1.

Most of the existing applications are related to American companies, i.e., 75%, while the remaining 25% are from Europe. This implies that, even though some of the presented applications, e.g., UberEats, have now been implemented in Europe, the European continent is still at an early stage of CL implementation, despite exhibiting high potential for such services. Moreover, most of the above applications cover the transport of goods, with a particular focus on food delivery. It should be highlighted that most of the presented applications involve people joining the CL system as their main occupation. Applications based on the sporadic involvement of people from the crowd, who offer their contribution before or at the end of their working day, are lacking, though this should be the essence of CL.

Given the existence of a small number of applications in Europe and the potential economic and environmental benefits that can derive from CL, Section 4 aimed to explore the implementation potential of crowd-based networks in northern Italy, considering as a case study the urban context of the city of Bologna.

Table 1. CL implementation cases.

Case	Transport Focus	Origin
Uber (San Francisco, CA, USA)	People	USA
Lyft (San Francisco, CA, USA)	People	USA
Roadie Inc. (Atlanta, GA, USA)	General goods	USA
Trunkrs (Nieuwegein, The Netherlands)	General goods	Europe
Walmart Inc. (Bentonville, AR, USA)	General goods	USA
Instacart (San Francisco, CA, USA)	Food products	USA, Canada
Grobhub (Chicago, IL, USA)	Food products	USA
UberEats (San Francisco, CA, USA)	Food products	USA
Foodora GmbH (Stockholm, Sweden)	Food products	Europe
Amazon Flex (Seattle, WA, USA)	General goods	USA
Hitch Technologies (Austin, TX, USA)	People and Goods	USA
PostBus Courier (Bonn, Germany)	People and Goods	Europe

4. Implementation Potential of Crowd Logistics in Northern Italy: The Reference Case of the City of Bologna

Despite the high level of innovation and the potential economic and environmental savings that would result from the adoption of CL systems, their success is strongly affected by the way in which they are managed and executed [3]. The characteristics of the urban context also play a relevant role in the successful implementation of CL initiatives. Indeed, urban contexts equipped with infrastructure such as efficient bus systems, metro systems, and cycle paths, are certainly more suitable for this purpose.

Indeed, several authors [16,31] have highlighted certain critical issues regarding both compensation policies and crowd management. Since the feasibility of implementing CL is strongly affected by the characteristics of each urban area, a structured questionnaire was developed and proposed in this study to explore the feasibility of implementing such a system in the context of northern Italy and to ascertain the general perceptions and opinions regarding CL. A sample of 214 people from the Alma Mater Studiorum University of Bologna (Italy) was involved in the analysis. According to the existing literature, in cases of CL implementation, ODs typically include university students, retirees, and freelancers [22]. This theory is supported by the fact that these categories of people, because of their job flexibility and spare time, are able to manage deliveries in several time slots, compared to full-time workers who are subject to rigid office hours. These considerations justified the choice, in this study, to focus our analysis on a class of university students, who in a CL scenario can act as both customers/users and ODs. To determine the sample size, according to statistics and adopting standard values, the population of Bologna (Italy), i.e., 391,810 inhabitants in 2022 [48], was considered the universe, including both potential users/customers and ODs, applying a confidence level of 95% and a confidence interval of 7%. By applying statistics formulations [49], the resulting minimum sample size was determined to be 196. The final selected sample size was 214, covering the whole class to which we decided to deliver the questionnaire. When designing the questionnaire, the guidelines recommended by [50] were followed. In detail, according to these guidelines, a standardized questionnaire is written and administered so that all participants are asked precisely the same questions in an identical format and responses are recorded in a uniform manner. In addition, to avoid bias, the interviewees responded to the questionnaire anonymously, all starting at the same time, and without the possibility of communication. Great attention was paid to the formulation of the questions, which were in the mother tongue of the participants (Italian), and great care was taken concerning the lexical aspect, so that the meaning of the questions was completely clear to the interviewees.

The urban area of the city of Bologna was considered a suitable context for the implementation of such a system, due to the presence of proper infrastructure and the high number of university students living in the city, who are always looking for occasional jobs to save money. Moreover, the reference case of the city of Bologna can be considered as representative of the whole of northern Italy, since it is a medium-sized city located at

the center of an urban area of over one million inhabitants, characterized by a structured and well-known university system with about 81,931 enrolled University students, and equipped with efficient transport networks and infrastructure. The first relevant characteristic of the urban area of the metropolitan city of Bologna is the wide spread of limited traffic zones (LTZs), covering a relevant area of the city. In fact, more than 50% of the area of Bologna falls within the LTZs, as shown in Figure 1.

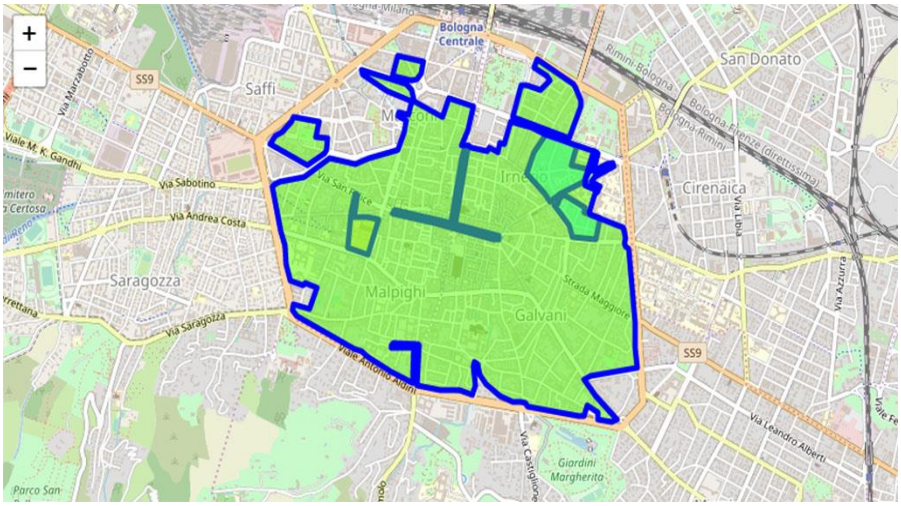

Figure 1. LTZs of the city of Bologna.

The wide spread of LTZs leads to heavy restrictions on the circulation of particular types of vehicles in these areas. However, despite such limitations, at the moment, commercial vehicles, including those used for the delivery of goods to customers, can still access the LTZs, regardless of their power supply.

The consequences of both private and commercial vehicles on urban traffic in terms of noise and pollution are evident. Moreover, considering that Bologna is an historical city, the urban centre is characterized by old narrow streets, which make the circulation of delivery vans difficult. To solve these issues, at least in the most central and ancient areas of the city, in the recent years the institutions have pressed for a progressive reduction in the number of vehicles admitted into the LTZs. Thus, we can foresee that in the next few years, in the urban area of Bologna, vehicles with internal combustion engines will be replaced by more eco-sustainable and lighter vehicles. For these reasons, a progressive change in last-mile urban logistics, from the traditional model involving heavy vehicles powered by diesel to a more innovative model based on low-emission vehicles that is able to fully exploit the high potential of the crowd of people willing to make quick deliveries for a small fee, is a concrete response to this new trend, which is widespread in many other parts of the world. A further element characterizing the city of Bologna, representing an important factor supporting the introduction of a CL-based system, is the presence of automatic lockers in the city center (Figure 2).

In the city center, almost twenty Amazon lockers are available, and more than 90 are available in the entire area of Bologna. Considering the suitability of Bologna as a context for the implementation of CL, a questionnaire was designed (presented in Section 4.1) to analyze people's perceptions and opinions concerning the possible implementation of this innovative system.

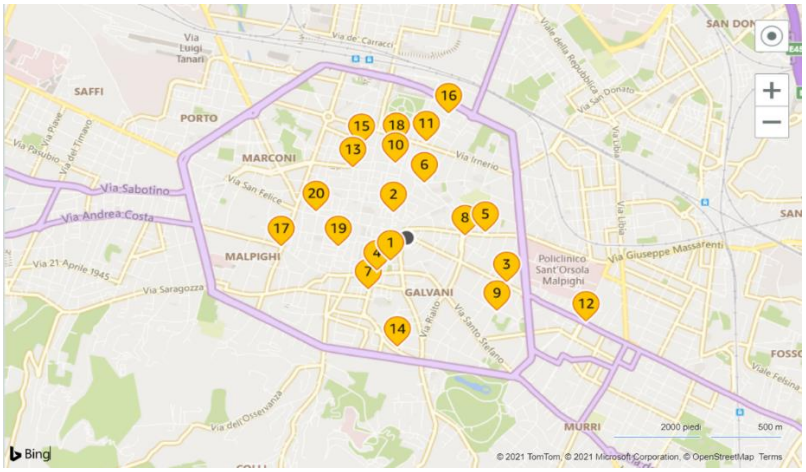

Figure 2. Map of the Amazon lockers in the city center of Bologna, indicated from 1 to 20.

4.1. Questionnaire General Structure and Main Results

The questionnaire consisted of twenty-eight questions organized into five sections. In the first section, the level of knowledge concerning the existence of CL services was assessed. In the second section, shopping and transfer habits and user perceptions about traditional and crowd delivery in terms of reliability, safety, flexibility, good traceability, environmental sustainability, and delivery speed were analyzed. The third section analyzed the likelihood of using the CL service, examining relevant drivers such as the cost, safety, and attention to environmental sustainability. The fourth section assessed people's willingness to join the service as ODs, evaluating factors such as the maximum accepted deviation from the original route in terms of time and distance. In the last section, socio-demographic questions were presented to the questionnaire participants, in case the interviewees wished to provide further comments not previously highlighted. The questions included in the questionnaire are detailed in Appendix A. Below, a summary of the main characteristics of the interviewees is presented (Table 2), and the main results are discussed.

The city of residence refers to the tax residence, while the domicile was within the metropolitan area of the city of Bologna for all the participants. This item was included in the questionnaire because the area of origin, e.g., small/medium city, big city, suburbs, or urban center, could affect people's perceptions about the possibility of implementing a CL system.

The main results of the analysis highlighted that 80.4% of the interviewees were sensitive to the topic of environmental sustainability. However, only 5.4% indicated that they used "sharing economy" services, e.g., BlaBlaCar and AirBnB, strictly for environmental reasons, while 85% were more interested in economic savings. On the other hand, as shown in Figure 3, based on responses to the question "If a crowd-based service was available in your city, which factors would make you prefer choosing this method rather than the traditional one?", it appeared that the main factors encouraging the transition toward the use of new shipping methods were a lower environmental impact (60.2%), lower service cost (50.5%), and shorter delivery time (27%). The ability of CL to achieve such goals has been proven by many quantitative studies in the current literature [27–31].

Table 2. Characteristics of the interviewees involved in the analysis.

		Number	Pecentage
Gender	Male	120	56.10%
	Female	94	43.90%
Age	<16	0	-
	16–20	2	0.90%
	21–26	189	88.30%
	27–35	20	9.30%
	36–45	1	0.50%
	46–55	2	0.90%
	56–65	0	-
	>65	0	-
Employment status	Unemployed	10	4.70%
	Student	131	61.20%
	Worker	73	34.10%
City of residence	Small/medium city—urban center	92	43.00%
	Small/medium city—suburbs	77	36.00%
	Big city—urban center	33	15.40%
	Big city—suburbs	12	5.60%

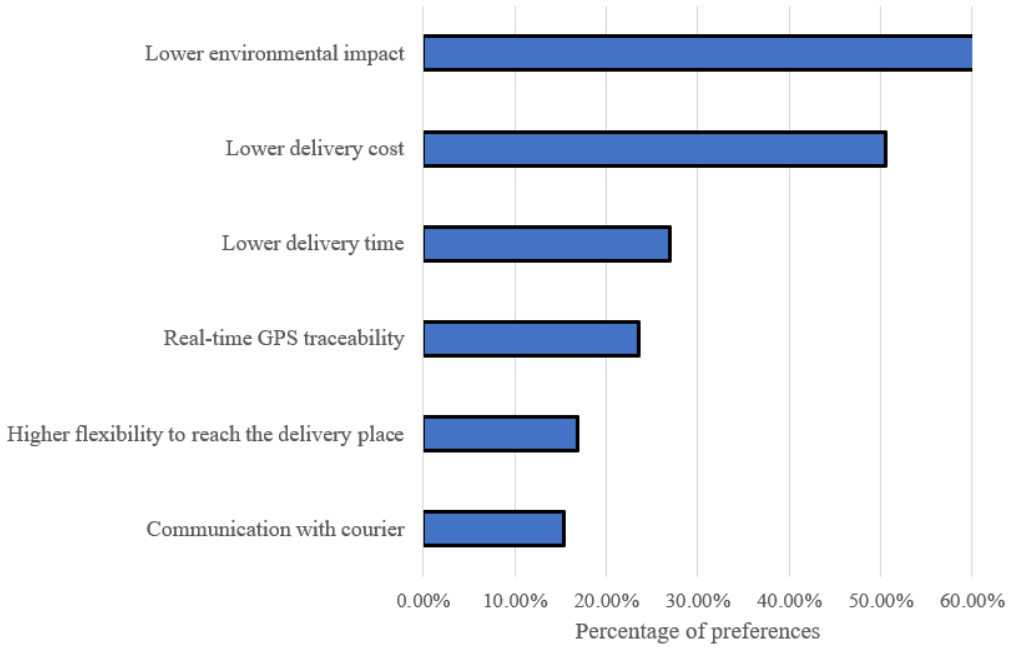

Figure 3. Factors encouraging the use of CL systems.

The results showed that people interested in CL were sensitive to the topic of environmental sustainability, even though they were significantly guided by economic advantages. On the other hand, people willing to join the system as ODs were motivated by economic benefits, i.e., remuneration, as shown in Figure 4. Of the interviewees, 47% would prefer a fixed fee per delivery rather than variable compensation based on the extra kilometers traveled compared to the original route or the time needed to finalize the delivery. This propensity arose because if an OD were asked to perform a delivery to a location very close by, a fixed remuneration would entice the OD to accept. On the other hand, in such a scenario, the offer of a variable fee would be unattractive, and therefore an impediment to the implementation of CL, since, in the case of deliveries very close to the OD, the variable

compensation would be very low. Moreover, only 1.2% of the interviewees would join the OD team free of charge, driven by a pure sense of community.

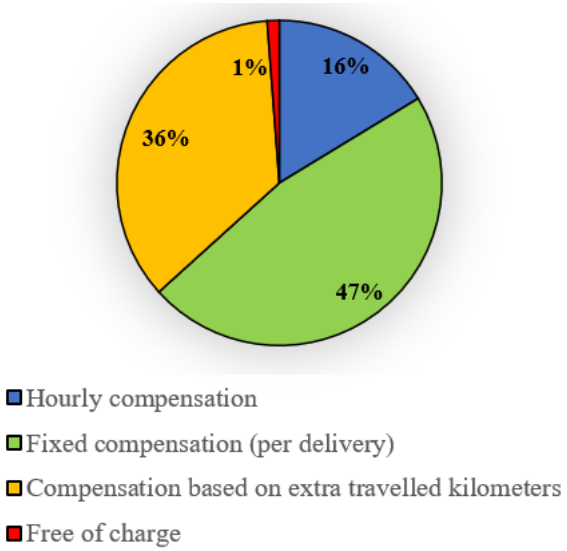

Figure 4. Interviewees' preferences in terms of compensation policies.

Overall, 91.6% of the interviewees expressed the desire to use this emerging delivery system. The remaining 8.4% showed some concern about the protection of their privacy and the safeguarding of the goods during transport. These concerns were also expressed by 78.6% of interviewees who said they would use the service. However, 83.7% of the respondents would have more trust in the delivery service if it were implemented and managed by a company expert in the field of shipping and delivery. On the other hand, it is interesting to highlight that 55.5% of the respondents who would not use the CL service, i.e., 8.4% of the total sample, would still be interested in joining the system as an OD. According to our analysis of the data, it would be useful to pursue partnerships with logistics and delivery companies that are experienced CL systems, e.g., DHL, for the implementation of such a platform to encourage user participation and mitigate the above-mentioned concerns. These companies, thanks to their know-how in the field and their solid reputation, could guarantee high-quality standards.

Furthermore, by comparing the data on the interviewees' perceptions of the two different delivery methods, it emerged that traditional couriers were considered more reliable in guaranteeing high standards regarding the protection of customer privacy, goods security, and order traceability. On the other hand, deliveries through the crowd were perceived as more flexible and environmentally sustainable. The delivery speed was not a decisive factor in the choice between the two delivery policies. Of the interviewees, 77.6% were available to perform occasional deliveries, while 23.4% would perform deliveries even in the absence of a route to travel. This last option would favor the growth of users of the platform, generating more flexibility but undermining the environmental benefits, because the presence of a higher number of delivery vehicles in the urban network roads would increase the risk of traffic jams and cause longer delivery times. However, among the users willing to join the system as ODs, the maximum accepted deviation from the original route was around 10 min in terms of extra time and 4 km in terms of extra distance. The most preferable time slot for deliveries was from 4 pm to 12 am, when people usually return home once they have finished their work, study, or social activities. A relevant recommendation from the interviewees was the necessity of a feedback system to evaluate the ODs in terms of the quality of the provided service. This feature would increase customer confidence, as they could decide in advance whether or not to accept the delivery by a specific OD. In addition, this would help the company to maintain high-quality standards.

4.2. Discussion, Implications, and Limitations of the Study

To be effective, CL requires a strong commitment among the various actors involved in the process, i.e., traditional transporters (logistics service providers (LSPs)); ODs; and final customers. A key issue to manage is the development of solid software platforms connecting the various players in the chain, allowing, in real time, the effective management of the process to guarantee an effective information flow from downstream to upstream, i.e., from the demands of the final customers up to the decisions regarding the delivery by the traditional carriers in the various intermediate lockers and the subsequent collection by the ODs. The final goal is to establish a sustainable system, in accordance with the principles of the triple bottom line (TBL), for all the actors involved, and specifically for the ODs, who need to make the shortest possible detours to deliver the goods. As emerged from the results of the analysis conducted in this study, a fundamental factor for the success of CL is the presence of strong trust in the ODs; therefore, it is advisable that the whole process is managed by existing shipping companies, with a solid reputation behind them, in order to encourage customers' trust the ODs and, in this way, increase the use of this emerging last-mile delivery system. In addition to these factors, the installation of hardware infrastructure, i.e., intermediate lockers, acting as intermediate warehouses for the storage of goods and as a decoupling point between the traditional delivery and the CL system, is also fundamental, and both fixed and dynamic locations (e.g., buses and trains) should be exploited. The social impact of CL also concerns the health benefits that accompany soft transportation modes, e.g., biking and walking. In a Finnish pilot project, the ODs who used bikes stated that they participated in the pilot for the sake of exercise. Moreover, CL initiatives promoting the use of soft modes instead of traditional modes, e.g., trucks, vans, and cars, enhance the health benefits for the whole community.

This study was focused on the urban area of the city of Bologna (Italy). Managers and practitioners can use the preliminary results of this study as a basis to plan future services in this area. Hence, this study paves the way for increasing the awareness, understanding, and knowledge of the opportunities and risks of CL. Concerning the challenges and risks, despite the potential benefits that stem from the implementation of CL, relevant challenges still exist for its successful implementation in terms of security, safety, and privacy. In fact, as for traditional deliveries, a product delivered through CL is exposed to risks of damage, loss, and deterioration [51]. In addition, confidential documents may be uploaded by ODs by mistake, or critical information may be provided incorrectly. Hence, the challenges to be faced include the proper distribution of responsibilities and privacy issues. Furthermore, proper software architectures and technologies need to be developed and implemented to efficiently manage real-time CL networks from the perspectives of both ODs and final customers. Of the main technologies enabling CL, mobile devices, digital payment infrastructure, location services, verified user profiles and online reviews, and communication application programming interfaces and platform-specific algorithms are among the most relevant [52]. In particular, mobile apps are a widely adopted shopping and transaction interface, representing a great share of e-commerce transactions across the world. Digital payments will continue to be a catalyst for digital innovation in the future and may significantly impact the evolution of CL over the next few decades. Location services are enabled by the combination of mobile phone GPS sensors; software operating-system-level location services; and mapping apps, e.g., Google and Apple Maps. In fact, the global availability of personal mobile devices that include location capabilities offers new possibilities for the implementation of CL. Concerning the topic of verified user profiles and online reviews, the technologies behind identity verification services are constantly evolving, balancing security and user experience. These are basic pillars of any online marketplace, as they establish trust and transparency across a distributed network of service providers and buyers. Finally, advanced algorithms need to be developed able to create matches between riders and drivers according to predefined metrics (time, distance, etc.); rank services by price; and rate the services, etc.

Among the limitations of this study, it is worth mentioning that we focused on the city of Bologna, which is a context characterized by a prominent university with a large number of students, who would be among the main parties interested in engaging in such a service. Furthermore, the study was focused on the university context; therefore, it would be advisable to extend the sample to other actors belonging to other contexts to evaluate the feasibility of this solution.

5. Conclusions and Further Research

In recent years, driven by the boom in e-commerce, crowd logistics (CL) has arisen as an alternative last-mile delivery system, especially in urban areas, aiming at reducing the cost of services and the related environmental emissions, with positive effects on pollution and urban traffic. Most existing studies have focused on assessing the opportunities and challenges provided by CL through theoretical analysis and literature reviews, while others have proposed models for designing such distribution networks. However, papers analyzing real successful applications of CL worldwide are lacking, despite being highly necessary. To fill this gap, we first presented an overview of real implementation cases of CL around the globe. The analysis revealed the existence of successful implementation cases dealing with the separate or integrated transport of people and goods. The transport of goods covered most of the reference cases, with a particular focus on the food sector.

Then, the implementation potential of CL in northern Italy was assessed through a structured questionnaire delivered to a panel of 214 people from the Alma Mater Studiorum University of Bologna to map the feasibility of a CL system. The urban area of the city of Bologna was considered a suitable context for the implementation of such a system, due to the presence of proper infrastructure and the high number of university students living in the city, who are always looking for occasional jobs to save money. The analysis revealed that about 91% of the interviewees were interested in using this emerging delivery system, while the remaining portion showed some concern about the protection of their privacy and the safeguarding of the goods during transport compared to traditional services. A relevant percentage of the interviewees were available to join the system as occasional drivers (ODs), with a compensation policy preference for a fixed fee per delivery rather than a variable reward based on the extra distance traveled to deliver the goods. The analysis of the literature and the main findings from our study revealed that, to be effective, CL requires a strong commitment among the various actors involved in the process, i.e., traditional transporters (logistics service providers (LSPs)); ODs; and final customers. To this end, solid software platform architectures need to be developed to connect in real time the various actors involved in the process and to manage the information flow from the demands of the final customers up to the decisions regarding the delivery by the traditional carriers in the various intermediate lockers and the subsequent collection by the ODs. A further critical success factor for CL is the presence of strong trust in the ODs to avoid concerns about the safety and protection of goods. Finally, the installation of intermediate lockers, acting as intermediate warehouses for the storage of goods and as a decoupling point between the traditional delivery and the CL system, is also fundamental, and both fixed and dynamic locations (e.g., buses and trains) should be exploited.

This study aimed to provide a roadmap for assessing the feasibility of implementing an emerging CL system in the context of northern Italy. The positive feedback from the questionnaire paves the way for future advancements, including the conceptual design of a crowd-based logistic system. In this phase, quantitative methods will be developed to design and manage CL networks, with the aim of jointly optimizing the economic and environmental benefits.

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Appendix A

Table A1. List of questions included in the questionnaire.

Questions
1. How sensitive are you to the issue of environmental sustainability? 2. Have you ever used "sharing economy" services, e.g., AirBnB, BlaBlaCar, etc.? 3. What was the main reason you choose to use them? 4. Have you ever heard about crowdshipping or crowd logistics? 5. Have you ever used a crowdshipping-based service? 6. In case of positive answer to question 5, what are, based on your experience, the positive and negative elements of this service? 7. On average, how many online orders do you place per year? 8. How well do you think traditional shipping methods meet the following issues (in a range from 1 to 5)? 9. How well do you think crowdshipping methods meet the following issues (in a range from 1 to 5)? ✓ Availability ✓ Safety ✓ Flexibility ✓ Traceability ✓ Environmental sustainability ✓ Delivery speed 10. How do you usually travel from home to work/school? 11. Would you be willing to use a crowdshipping service for the delivery of goods? 12. What are the reasons that make you skeptic in using this emerging service system? 13. For which product category would you prefer using delivery in crowdshipping? 14. If a crowd-based service was available in your city, which factors would make you prefere choosing this method rather than the traditional one? 15. Are you uncertain about delivery in crowdshipping? 16. Would you be more confident in crowdshipping if it was managed by a company already active in the shipping sector, e.g., DHL, UPS, etc.? 17. Would you be interested in delivery insurance, e.g., in case of damage or loss of parcel? 18. Would you be interested in joining the system as occasional driver (OD) in exchange for a fee? Please motivate your answer. 19. Indicate how much, among *"no interest"*, *"few interest"* and *"interest"*, the following factors are relevant to make you joining the system as OD: ✓ Remuneration ✓ Time availability ✓ Product responsability 20. What are the time slots in which you would be most available to make deliveries? 21. What is the maximum deviation, in terms of time, compared to your traditional route, you would accept to perform a delivery? 22. What is the maximum deviation, in terms of distance, compared to your traditional route, you would be willing to make for a delivery? 23. What remuneration method would you prefer for the service offered as an OD? 24. Please indicate your gender 25. Please indicate your age 26. Please indicate your employment status 27. In which city do you live? 28. Please write any observations/concerns you would like to express about crowdshipping.

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