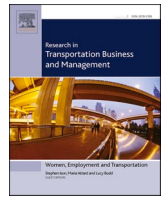




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Green Crowdshipping: Critical factors from a business perspective

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ABSTRACT

Crowdshipping implies involving nonprofessional operators in transporting goods. While its financial benefits are easy to grasp, its environmental implications much depend on the transportation mode used and whether trips are dedicated or non-dedicated. One way of greening crowdshipping services is to use public transportation (less polluting) as a mode of transportation and commuters as bringers (non-dedicated trips). This, in fact, allows minimizing both pollution and congestion at the same time. While conceptually interesting and theoretically self-evident this is practically difficult to implement and much under-studied. A literature review and in-depth interviews are the methods used in sequence to tackle the issue discussed above. The added value this paper produces is a confirmation of already existing research foci, an extension of the research agenda thanks to the investigation of adjacent research fields (passenger and freight urban integration), an enlargement of the critical factors thanks to the practical knowledge deriving from crowdshipping operators.

1. Introduction

Increased traffic in town and city centres has resulted in long-lasting congestion, causing many adverse consequences in terms of delays and pollution (Marcucci, Gatta, & Le Pira, 2023). Transport impact is felt on a continental scale, producing climate change and global warming, increased health problems, bottlenecks in the logistics chain, etc. Many are the reasons explaining this increase in movements in cities (Giglio & De Maio, 2022). One being the steep rise in urban population, inducing an increase in goods' demand in inner cities. Moreover, changing urban freight business' models (e.g., instant deliveries) and steep e-commerce growth, have produced a significant increase in home deliveries (Gatta, Marcucci, & Le Pira, 2023). COVID-19 has clearly made evident to everybody the critical role urban freight deliveries play in ensuring city vitality. In fact, even in a dramatic period where almost all passenger movement was halted to prevent spreading the contagion, still goods transportation was not only allowed but grew due to the higher demand of home deliveries by all the people that felt uncomfortable going to the shops/supermarket ((Maltese et al. 2021).

In addition, customers are becoming more demanding in terms of delivery speed and overall delivery quality. This puts incremental pressure on logistic operators since they are faced with smaller, more frequent and more expensive and difficult-to-perform delivery tasks (Lozzi et al., 2022). Increasing demand for goods in cities centres, and

technological changes produce both opportunities and challenges with respect to urban freight delivery planning and execution. These changes imply more single deliveries within the city, generating higher negative external effects such as congestion, greater emissions, and pollution, thus hindering cities' liveability. The Green Paper on Urban Mobility suggest that "Urban freight distribution could be better integrated within local policy-making and institutional settings. Passenger transport is usually supervised by a competent administrative body while freight transport distribution is normally a task for the private sector. Local authorities need to consider all urban logistics related to passenger and freight transport together as a single logistics system" (European Commission, p. 7, 2007). In addition, it mentions that, from a stakeholder point of view, any urban mobility policy must jointly account for both passenger and freight-transport-related issues.

The combination of urban freight transport and passenger transport (UFT + PAXT), also known as Cargo-Hitching (Van Duin et al. 2019) represents one of the solutions to improve mobility in cities, especially when integrated within local policy-making and appropriate institutional settings. This integration may also play a role in promoting efficient and reliable delivery services (Le Pira et al., 2021). In fact, people and goods typically share the same infrastructure for, at least, part of their journey, especially when travelling within a city. However, they constitute different transport environments, specifically when it comes to research. The attention scholars jointly pay to both these two

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perspectives is increasing with a focus on the conception and development of transportation systems functionally integrating passenger and freight flows from the outset. Unfortunately, examples of successful solutions implemented at this scale are still limited (Cruz-Daraviña et al., 2021).

Many companies are testing different solutions to reduce last-mile delivery costs while also trying to safeguard customers fidelity and satisfaction (Pourrahmani & Jaller, 2021b). Combining passenger and freight flows can create lucrative business opportunities for companies since similar transportation needs can be satisfied using fewer vehicles and drivers. Crowdshipping (Cs), by combining these ideas, provides a potentially viable solution to both. Although preliminary evidence suggests that Cs might become widely accepted and used, nevertheless its large-scale adoption does not necessarily imply sustainability and efficiency per se since many are the factors that could hinder its potential. Detailed, accurate and reliable information about its actual functioning, performance, impact, economic efficiency, and public awareness is still lacking (Ermagun, Shamshiripour, & Stathopoulos, 2020). This is particularly true when Cs foresees the inclusion of bringers using public transport (PT) as a mode of transport. This specific Cs type has been defined green crowdshipping (GCs) (Gatta et al., 2019). As it turns out, relevant research has already been conducted investigating Cs in several contexts and using different methodologies and perspectives. However, most of the research carried out focuses exclusively on understanding: its environmental impacts, the economic benefits for companies' delivery-type acceptance for consumers (i.e., professional shipping the goods) and as availability-to-work as crowdshippers. The transportation mode effectively used is not explicitly considered. One might think that Cs companies have yet to discover the optimal way to reach the masses and, most importantly, to find a market opportunity that GCs might satisfy. This paper scrutinizes what are the critical factors that needed to be addressed to transform a GCs, into a profitable endeavour, thus adopting a business model perspective. More specifically, the paper focuses on the research questions listed below:

1. Which are the main critical factors, from an academic perspective, we need to address to deploy GCs?
2. Which are the main critical factors, from a business model perspective, we need to address to deploy GCs in practice?

With this in mind, first of all, the paper compiles a list of critical factors then it validates it and, finally, expands it. In fact, some critical factors have not been addressed yet by literature or have only been marginally addressed. Promoting environmental as well as financially viable GCs is not an easy since it involves different entities (bringers, customers, platform operators, public bodies) that need to cooperate while being characterized by heterogeneous and, sometimes, contrasting objectives. These considerations can cast doubts on how a GCs can be organised successfully in the market.

This paper adopts a combined methodology integrating a two-step literature review with in-depth interviews. The first literature review step investigates GCs and the second examines Cs types as well as different literature segments focusing on UFT + PAXT. Looking at these two separate, yet adjacent research fields, provide us with precious suggestions to figure out what are the critical factors to be addressed to promote GCs. Lastly, via in-depth-interviews, the paper provides a privileged expert evaluation of the critical factors the two literature reviews have produced. Particularly valuable to this end are the in-depth-interviews performed with currently active Cs companies. This last step is crucial not only for a validation of the issues emerging from the combined literature review activities but also for providing a reliable, valuable, and critical analysis, from a business perspective, of all the critical factors to be addressed when developing/deploying such an innovative business model in practice.

The remainder of the paper unfolds as follows. Section 2 presents the methodology used while 3 reports the two-step literature review,

including first (3.1) the review of the GCs literature, and, step 2 (3.2), reviews the Cs segment (3.2.1) and UFT + PAXT (3.2.2). Section 4 presents the results obtained through the three in-depth interviews performed, highlighting the critical factors validated for each of the companies, as well as the comparative analysis of all these factors with the ones listed in the two-step literature review. Section 5 concludes by providing suggestions for future research.

2. Methodology

This paper adopts a methodological approach resting on two phases (Fig. 1). The first consists of a literature review, where a total of 82 papers were considered. This first phase review process was carried out in two steps. The first step searched for papers focusing on GCs, where only 11 papers were obtained. The results obtained were not sufficient to perform a full-fledged analysis of the critical factors from a business model perspective. The search was thus expanded in two adjacent areas: the first focusing on the Cs service itself and the second on the system used to produce a GCs service. Thus, the second step included papers on Cs as well as those UFT + PAXT. The analysis performed allowed creating a preliminary list of critical factors that one should investigate when approaching GCs, Cs and UFT + PAXT. These two separate, yet adjacent research fields can provide us with precious suggestions to figure out what are the critical factors to be addressed to promote GCs. The investigation produced a reasoned list of critical factors, mentioned in selected literature fields.

Since the GCs literature is still in its infancy, all the factors listed as critical in the other services were not necessarily studied from a GCs perspective. This weakness encountered in the literature surveyed constitutes the basis and motivation of the second phase, where three in-depth interviews with active Cs companies were carried out in Norway, Brazil, and Italy. According to Holguín-Veras, Sánchez-Díaz, and Browne (2016) in-depth interviews can be used to gain general knowledge both about the constraints faced by the various agents involved in supply chains and the factors they evaluate when deciding. This allowed: acquiring an exhaustive list of critical factors, integrating those that emerged from the literature review, implicitly validating the critical factors extracted from the different literature review processes. The in-depth interviews also provided additional information on how these issues should be approached and investigated in a real business model setting. Furthermore, they provided valuable insights on new factors (not emerged from the literature review process) that should be considered when implementing a GCs business model in practice.

All the in-depth interviews were performed according to the processes described in Boyce and Neale (2006). Three employees from Company X, based in Norway, where selected to participate in the process: the General Director, the Routing Manager, and the Cs Manager. We started of interviewing Company X since it participated in a European project in which the Authors where also involved. The interviews were conducted in the same day, first separately, each employee was asked questions about their activities, their view of the service performed, main difficulties and opportunities. The interviews lasted, on average, 50 min. Afterward, the Authors asked each interviewee to evaluate the list all the critical factors emerged from the literature review process, based on their experience. The second part of the interview took place with all interviewees jointly participating to a micro-Delphi study. In fact, the three single evaluations were discussed in order to reach a final mutually accepted lists of critical factors. This discussion was also useful since it allowed adding new critical factors from a business point of view. Furthermore, the participants contributed to individuating four focus areas, clustering the factors. This first set of interviews were conducted in January 2023.

Thanks to a valuable suggestion received in the first round of reviews, from both Referees, we extended the number of in-depth interviews with two additional active Cs companies: Company Y, based in Brazil and Company Z, based in Italy. As for Company X, the interviews

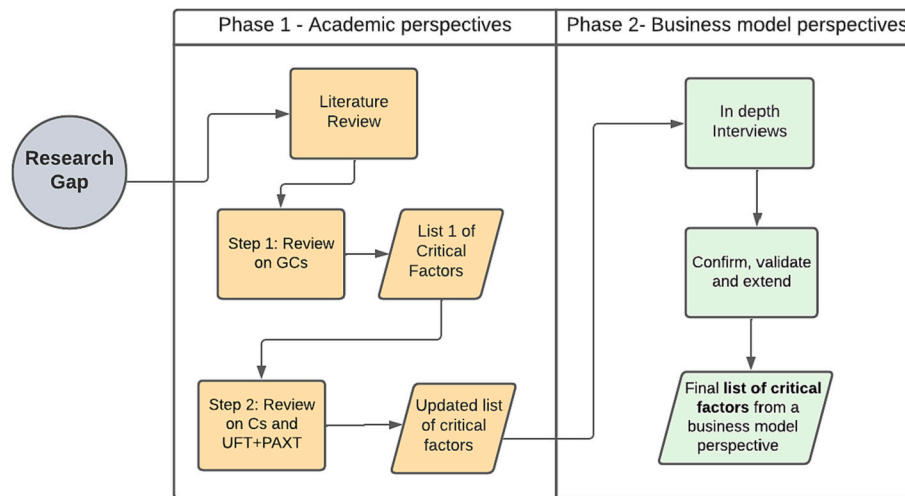


Fig. 1. Methodological phases.

conducted with the two additional companies were useful in acquiring different business-specific views and increased the trustworthiness of the validation process.¹ Company Y and Z were interviewed partially due to the Authors' personal contact with them and, more importantly, since they replied positively to the interview invitation. Fig. 2 below reports a synthetic comparative description of the main characteristics of the companies interviewed.

3. Literature review

The literature review was divided into two steps. The first focused on papers dealing with GCs, while the second includes papers addressing Cs and UFT + PAXT. The articles were found using Google Scholar and ScienceDirect (Scopus). Table 1 reports the paper selection criteria.

Figure 3 illustrates the three main areas, GCs, Cs and UFT + PAXT and the respective number of papers reviewed. Additionally, the figure reports the keywords used to search the databases.

3.1. Step 1 - green Crowdshipping

The critical issue for a Cs business, as for any other business, is ensuring financial sustainability, which mostly depends on the crowd's vehicle choice, path/type of trip (dedicated or non-dedicated). Gatta, Marucci, Nigro, Patella, and Serafini (2018) evaluate GCs service based on the use of the city mass transit network. They assume customers/crowdshippers pick-up/drop-off (PUDO) goods in automated parcel lockers located either inside transit stations or in their surroundings. They consider the integration of PT and Cs services from a supply perspective. The financial sustainability of the proposed system rests upon the provision of public incentives constitutes the main conclusion of the paper. The same idea was proposed by Serafini et al. (2018), who studied the willingness of commuters to act as crowdshippers. The paper investigates the case of last-mile delivery in a business-to-consumers (B2C) e-commerce context where pick-up/delivery is core. In particular, it focuses on Cs services potentially performed via the PT network (metro). They assume passengers can act as potential crowdshippers performing non-dedicated trips.

Fessler et al. (2022) analysed the supply side, measuring users' preferences for a PT-based Cs service when they carry parcels along on their ride. The Authors used a stated choice experiment asking respondents to indicate whether they would be willing to bring a parcel

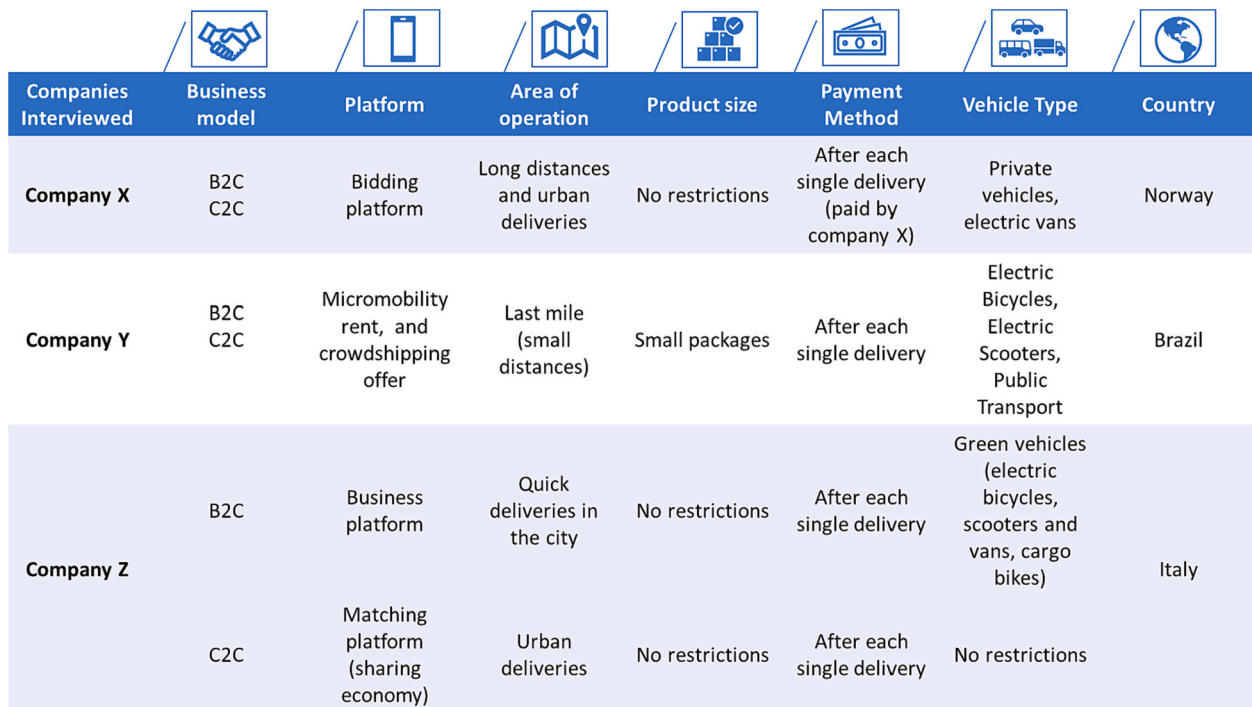
along on their ride while varying the number of parcels, size, weight, compensation for the service and the required extra time needed to perform the delivery. The utility of acting as a crowdshipper is positively associated with compensation (typically a monetary one) provided, while negatively associated with the additional time used for performing the delivery task and the weight/size and number of parcels to be delivered.

Gatta et al. (2019) estimate the willingness to act as a crowdshipper (supply) and to buy goods using a Cs service (demand) to get goods delivered/picked up in the last mile B2C e-commerce situation. Galkin et al. (2019) develop a model to simulate interaction between the operation of a freight tram and a car in a docking station. The research investigates the use of urban PT to perform freight deliveries. Galkin et al. (2021) explore the congestion of urban passenger transport in historical Bratislava considering the introduction of a crowdsourcing service. The study suggest using Cs in off-peak periods. The Authors affirm that monitoring PT flows in the urban core, helps identifying travellers' distribution thus allows understanding the preferred time window to use when deploying a Cs during the day. Lastly, Giuffrida et al. (2021) present a GIS-based approach to evaluate the spatial feasibility of Cs services using PT or active modes in the context of a university community. Results indicate that student flows can be easily coupled with available transit lines, thus making a sustainable Cs service possible.

Fostering stakeholder collaboration in practice is fundamental for GCs. In fact, according to Buldeo Rai et al. (2017), the main stakeholders in a Cs business consist of receivers collecting the goods, commissioners sending them, logistics service providers (LSP) executing the delivery, platform providers matching all parties and, finally, the crowd. The platform posts the delivery service requests (with the desired delivery characteristics -e.g., receiver, bringer, etc.-). Depending on the platform, commissioner and receiver can be the same person. Bruzzone, Cavallaro, and Nocera (2021) mention two other stakeholder categories, namely local policymakers, and residents. With Pimentel and Alvelos (2018) including also city collective passenger transport companies. Therefore, to sum up, the key stakeholders that are involved and should be coordinated in a GCs are:

- City logistics operators': Involved in the pre-delivery and consolidation of the parcels.
- Commissioners (i.e., retailers): selling the products.
- Crowd: commuters performing the deliveries.
- Local authorities: responsible for policymaking and coordination.
- Passenger transport companies: responsible for the PT system.
- Platform providers: Cs companies responsible for matchmaking.

¹ These interviews also followed the proposed method by Boyce and Neale (2006) and were conducted in August 2023, online due to budget limitations.



Companies Interviewed	Business model	Platform	Area of operation	Product size	Payment Method	Vehicle Type	Country
Company X	B2C C2C	Bidding platform	Long distances and urban deliveries	No restrictions	After each single delivery (paid by company X)	Private vehicles, electric vans	Norway
Company Y	B2C C2C	Micromobility rent, and crowdshipping offer	Last mile (small distances)	Small packages	After each single delivery	Electric Bicycles, Electric Scooters, Public Transport	Brazil
Company Z	B2C	Business platform	Quick deliveries in the city	No restrictions	After each single delivery	Green vehicles (electric bicycles, scooters and vans, cargo bikes)	Italy
	C2C	Matching platform (sharing economy)	Urban deliveries	No restrictions	After each single delivery	No restrictions	

Fig. 2. Comparison of companies interviewed.

Table 1
Paper selection criteria.

Items	Description
Database	Google Scholar and ScienceDirect (Scopus)
Document type	Peer-reviewed journal articles OR conference papers
Inclusion Criteria	Published in English AND full text availability
Time Interval	01/01/2014–21/09/2023

- Receivers (consumers): buy and accept the delivery.
- Urban population (i.e., users): using the PT system.

To conclude, one can safely assert that papers considering GCs in an urban freight setting are limited indicating that this research niche is still new. Therefore, in Table 2 all the critical items, from a GCs perspective, are listed, with a succinct description, and the Authors of the various articles.

3.2. Step 2

3.2.1. Crowdshipping

A crowdsourced system implies a customer/business (crowdsourcee) using an ICT platform (crowdsourcer) to place a request for a delivery service to be fulfilled by one of the possibly many independent agents (crowd) registered in the platform. Buldeo Rai et al. (2017) define Cs as “an information connectivity enabled marketplace concept that matches supply and demand for logistics services with an undefined and external crowd that has the free capacity with regards to time and/or space, participates voluntarily and is compensated accordingly”. Punel and Stathopoulos (2017) consider Cs as “a goods delivery service that is outsourced to occasional carriers drawn from the public of private travellers and is coordinated by a technical platform to achieve benefits for the involved stakeholders”. The present study adopts these two definitions of Cs as a starting basis.

Cs requires the use of spare capacity of vehicles on journeys that are already taking place so to facilitate delivery operations while minimizing their impact. Le et al. (2019) categorizes/studies on Cs business models according to the following market pillars: supply, demand, and

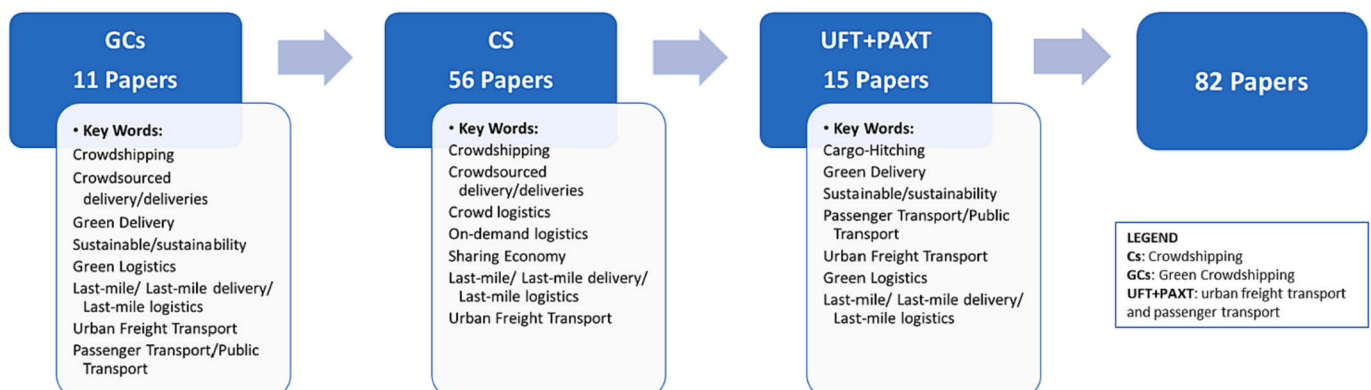


Fig. 3. Overview of papers analysed in the two-step literature review per the main subject.

Table 2
Critical factors of a GCs system from the related literature review.

Critical Factors	Description	Authors
Availability/reliability of public transport	Access to and state of the stations, connection between transport modes, headway, condition of the vehicles	Fessler et al. (2022); Fessler, Klockner, and Haustein (2023); Buldeo Rai et al. (2017)
Collaboration dependent	Full collaboration between agents is necessary, especially between platforms. This system adds a new layer of complexity since the Cs company is also participating.	Buldeo Rai et al. (2017); Fessler et al. (2023)
Consolidation	Consolidation and organization of the parcels to optimize the delivery	Buldeo Rai et al. (2017); Fessler et al. (2023)
Coordination of Stakeholders	Coordination of the involved stakeholders	Buldeo Rai et al. (2017); Fessler et al. (2023)
Crowd motivation (WTD)	Commuters' willingness to act as a crowdshipper. In this system also their willingness of using PT	Buldeo Rai et al. (2017); Fessler et al. (2023)
Delivery cost and time	Cost per delivery and lead time to perform the delivery (next day, same day)	Gatta et al. (2019); Serafini et al. (2018); Gatta et al. (2018); Ermagun and Stathopoulos (2018)
Detour	Amount of extra Km or time that a commuter is willing to take from its original path to perform delivery. In addition, the possible interchange between modes (e.g., metro + bus)	Stakeholder's understanding of the environment, the impacts of human behaviours on it, and the importance of its protection
Environmental Awareness		Buldeo Rai et al. (2017); Fessler et al. (2023); Galkin et al. (2021)
Geographical scale	Concentration of urban population and commercial activity	; Buldeo Rai et al. (2017); Castiglione et al. (2022); Galkin et al. (2021); Ghaderi et al. (2022a); Ermagun and Stathopoulos (2018)
Legal issues	Policies: labour rules, data protection	Buldeo Rai et al. (2017); Castiglione et al. (2022)
Location/presence of urban facilities - parcel lockers	Location of the facilities that simplify the delivery process, like parcel lockers. In this case, they need to be closer to PT stations (e.g., inside a metro station)	Ghaderi et al. (2022a); Giuffrida et al. (2021); Karakikes and Nathanael (2022); Serafini et al. (2018)
Marketing	Activities related to the promotion of the service: incentives to use, enhance the social network of users, propaganda	Buldeo Rai et al. (2017); Gatta et al. (2018); Fessler et al. (2023)
Parcel size	Dimension of the parcels to be delivered (weight, width, length). In the case of a crowdshipper using PT, there are some limitations on this item.	Castiglione et al. (2022); Ghaderi et al. (2022a); Karakikes and Nathanael (2022); Zhang, Cheah, and Courcoubetis (2022)
Reliability of the crowdshipper	Level of trust of the crowdshipper, often represented by a rating (stars or points)	Buldeo Rai et al. (2017); Gatta et al. (2018)
Reliability of the service/company	Level of trust of the Cs' platform, PT service or even the combined platform.	Buldeo Rai et al. (2017); Gatta et al. (2018)
Remuneration	Price paid per delivery, mode of payment	Buldeo Rai et al. (2017); Castiglione et al. (2022);

Table 2 (continued)

Critical Factors	Description	Authors
Road safety	Safety to perform the delivery	Serafini et al. (2018); Zhang et al. (2022); Fessler et al. (2023)
Synchronization/ digital connection of platforms	Condition of the Cs platform, where the assignments are made and where the tracking of the parcel can be done.	Castiglione et al. (2022)
Type of trip - dedicated or non-dedicated	User choice of the route when making the delivery – combining a delivery with a commute.	Buldeo Rai et al. (2017)
Type of vehicle	The vehicle used for the delivery: PT by bus, tram, train, metro.	Ghaderi et al. (2022b); Giuffrida et al. (2021); Fessler et al. (2023); Buldeo Rai et al. (2017); Fessler et al. (2022)
User acceptance (WTA)	Consumers that are willing to accept products via a Cs service	Castiglione et al. (2022); Buldeo Rai et al. (2017); Fessler et al. (2023)

platform/operation. A large segment of the literature focuses on one of the three aspects of Cs. It first emerged in the US but there are now several platforms all over the world offering these services (Carbone et al., 2017; Punel & Stathopoulos, 2017). All these service providers rely on the crowd as their key stakeholders (Buldeo Rai et al., 2017), where the crowd usually consist of students ((Marcucci et al., 2017)), taxi drivers (Chen & Pan, 2016), book readers ((Paloheimo et al., 2016)), retailers, friends, and acquaintances (Devari, Nikolaev, & He, 2017) or migrants as new entrants/players who are looking for a way to earn a living in a new country. Trip duration is important for the drivers (Bathke & Münch, 2023; Sampaio et al., 2019), as well as for the remuneration (Bathke & Münch, 2023). According to Le and Ukkusuri (2019), Cs growth mostly depends on governmental policies.

When commuters are available to take a detour on their way from/to work/study they are likely to have specific preferences and one assumes they will only want to spend a short time delivering parcels (Arvidsson et al., 2016). This is why Cs is predominantly viewed as a delivery option in the last-mile delivery segment. Transporting the goods is relatively simple before they reach consolidation centres. Only when parcels depart from such places, heading towards different customer-selected destinations, the delivery process becomes much more complex. This is particularly true for Cs. Ballare and Lin (2020) point out that Cs can only succeed if micro hubs, or other types of urban facilities, are conveniently located and crowd members reside within a densely populated area of the city. The efficiency of a Cs service is strictly dependent on the number of potential crowdshippers living close to where the service is to be offered. Maintaining motivation among crowdshippers is also a daunting task (Frehe, Mehmman, & Teuteberg, 2017). One of the reasons why people are not always willing to work in this market segment is its managerial immaturity, technology, and lawfulness (Guo, Wang, & Yan, 2019). If one has access to many crowdshippers, Cs deliveries can most likely be performed asking for small detours. This implies a reduction in Km driven compared to depot-supported deliveries performed by professionals. However, the jury is still out concerning the density and availability of drivers needed to ensure a sufficiently high coverage. Carbone et al. (2017) assert that, on a big scale, delivery delays, loss, and damage, as well as traffic accidents represent critical problems, which might negatively impact trust between crowdshippers and platforms. Samad, Ganguly, and Das (2023) offers valuable insights about the factors that are currently hindering CL development and how the facilitating aspects can be explored to ensure further development of CL.

A successful Cs company must consider different aspects when developing its strategic plan. Among the most relevant issues one should

acknowledge the following: the partnership that it establishes (cooperation), the users that commit to it (marketing), and the area where the company operates (geographic scale). The latter is highly influential on the company's financial profitability and environmental sustainability. In addition to the scale at which a Cs company operates, the composition of the transport fleet also plays an important role when considering environmental sustainability. This raises the question of how many crowdshippers actually use environmentally friendly transportation modes (e.g., public transportation and emission-free vehicles).

The overall effect of Cs could and should be measured from an economic, societal, and environmental perspectives (Miller, Nie, & Stathopoulos, 2017; Samad et al., 2023; Wang et al., 2016). Much emphasis has been placed on Cs environmental impact as cities are gradually aiming for emission free standards (EU fit for 55²). However, the literature suggests that three factors determine whether a Cs produces a positive or negative impact on the environment (Buldeo Rai, Verlinde, & Macharis, 2018). The crowd's transport behavior (Karakikes & Nathanaïl, 2022) is the *first critical element* to consider, since reducing kilometres driven implies lower CO2 emissions, travel levels, and resource use (Marcucci et al., 2017). Whether the crowd performs a dedicated delivery or takes a package along a trip that had already been planned and would have taken place independently of the package being transported or not has a substantial role in determining the final impact of a Cs shipment (Wang et al., 2016). The *second critical element* has to do with parcels size since it can affect not only the willingness of a crowdshipper to accept a delivery (Le & Ukkusuri, 2019; Marcucci et al., 2017) but also their transport mode choice when it (Castiglione et al., 2022; Ghaderi et al., 2022a), which represents the *final critical factor* to consider (Buldeo Rai et al., 2017; Buldeo Rai, Verlinde, & Macharis, 2021). Clean fuel or electric vehicles represent possible alternatives, but one could also consider using bicycles (Wicaksono, Lin, & Tavasszy, 2021) and PT (Galkin et al., 2021; Gatta et al., 2018; Giuffrida et al., 2021; Serafini et al., 2018).

Table 3 reports the list of critical factors that should be investigated when implementing a Cs delivery service, according to the literature reviewed, a succinct description, and the Authors of the various articles.

3.2.2. Integrating urban freight transport and passenger transport

Cargo hitching mainly aims to “design networks and related planning and scheduling policies to enable efficient and reliable delivery of each parcel” (TKI Dinalog, 2020). This integration already takes place in long-haul transportation (i.e., airlines and rail) where both cargo and people are moved using the same resources (Le et al., 2019; Le & Ukkusuri, 2019). However, when attempting to develop this integration at an urban scale, effective coordination and synchronization becomes challenging. This is mostly due to the fact that the two systems are usually organised, planned, and handled by different entities according to dissimilar procedural and functional techniques. Therefore, research investigating their potential integration can provide relevant cues and might well contribute to potentially reduce transport externalities and improve logistic reliability and efficiency (Le Pira et al., 2021). Cavallaro and Nocera (2021) performed a concept-centric literature review on UFT + PAXT. The Authors report that there are three ways for integrating the two systems: sharing road capacities, sharing PT services, and sharing consolidation facilities. Nevertheless, they highlight that this integration is not very common in urban areas due to several technical and political issues explaining the low number of concrete implementations. In addition, they affirm that the improvement of both forms of transport can only be accomplished when improving their performances through a shared approach. The integration is illustrated by Sampaio et al. (2019) who assert that coordination and synchronization are challenging issues in such environments. Additionally, they

Table 3

Critical factors of a Cs system from the related literature review.

Critical Factors	Description	Authors
Availability/reliability of PT (PT)	Connection between transport modes, headway, condition of the vehicles	Buldeo Rai et al. (2017)
Consolidation	Consolidation and organization of the parcels to optimize the delivery	Sampaio et al. (2019); Ni et al. (2019)
Coordination of Stakeholders	Coordination of the involved stakeholders	Ghaderi et al. (2022a); Le et al. (2019); Devari et al. (2017) Buldeo Rai et al. (2017); Miller et al. (2017); Le et al. (2019); Buldeo Rai et al. (2021); Allahviranloo and Baghestani (2019); Gdowska, Viana, and Pedroso (2018)
Crowd motivation (WTD)	Commuters' willingness to act as a crowdshipper	Buldeo Rai et al. (2021); Allahviranloo and Baghestani (2019); Gdowska, Viana, and Pedroso (2018)
Delivery cost and time	Cost per delivery and lead time to perform the delivery (next day, same day)	Buldeo Rai et al. (2021); Punel and Stathopoulos (2017); Ciobotaru and Chankov (2021); Buldeo Rai et al. (2017); Ermagun et al. (2020)
Detour	Amount of extra Km or time that a commuter is willing to take from its original path to perform a delivery	Chen and Pan (2016); Cheng et al. (2022); Chen and Chankov (2017); Marcucci et al. (2017); Le et al. (2019); Miller et al. (2017); Wu et al. (2022); Simoni et al. (2019)
Environmental Awareness	Stakeholder's understanding of the environment, the impacts of human behaviours on it, and the importance of its protection	Buldeo Rai et al. (2017); Buldeo Rai et al. (2018); Buldeo Rai et al. (2021); Caspersen & Navrud (2021); Macrina et al. (2020)
Environmental Impacts (–)	Negative impacts such as: pollution, noise, congestion	Simoni et al. (2019)
Environmental Impacts (+)	Positive impacts as: less pollution, less congestion	Buldeo Rai et al. (2017); Pourrahmani and Jaller (2021a); Upadhyay et al. (2020)
Failed deliveries	Failed deliveries and the problem with returning the package	Behrend et al. (2019); Pourrahmani and Jaller (2021a)
Geographical conditions	Concentration of the urban population and commercial activity	Buldeo Rai et al. (2017); Ermagun et al. (2020); Pourrahmani & Jaller (2021a); Sampaio et al., (2019)
Legal issues	Labour rules, data protection	Buldeo Rai et al. (2017); Le et al. (2019); Le & Ukkusuri (2019); Marcucci et al. (2017); Wang et al. (2016); Ni et al. (2019)
Loading/Unloading	The process of picking up the parcel and the delivery to the final destination.	Pourrahmani and Jaller (2021a); Kourouniotti et al. (2021)
Location/presence of urban facilities – parcel lockers	Location of the facilities supporting the delivery process, like parcel lockers	Buldeo Rai et al. (2017); Ghaderi et al. (2022a); Serafini et al. (2018); Castillo et al. (2018)
Market size/conditions	supply/demand ratio, population characteristics, market conditions	Shen and Lin (2020); Saglietto (2021); Chen & Chankov (2017); Giglio & De Maio (2022); Miller et al. (2017); Pourrahmani & Jaller, (2021a); Punel & Stathopoulos (2017); Serafini et al. (2018);

(continued on next page)

² <https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55-the-eu-plan-for-a-green-transition/>

Table 3 (continued)

Critical Factors	Description	Authors
		Alnaggar, Gzara, & Bookbinder (2021)
Marketing	Activities related to the promotion of the service: incentives to use, enhance the social network of users, propaganda	Devari et al. (2017); Le et al. (2019); Punel & Stathopoulos (2017)
Parcel size	Dimension of the parcels to be delivered (weight, width, length)	Boysen, Emde, and Schwerdfeger (2022); Devari et al. (2017); Le & Ukkusuri (2019); Punel and Stathopoulos (2017); Marcucci et al. (2017)
Reliability of the crowdshipper	Level of trust of the crowdshipper, often represented by a rating (stars or points)	Buldeo Rai et al. (2017); Marcucci et al. (2017); Devari et al. (2017); Dahle et al. (2019)
Reliability of the service/company	Level of trust in the platform	Buldeo Rai et al. (2017); Punel et al. (2019); Punel, Ermagun, and Stathopoulos (2018); Punel and Stathopoulos (2017); Serafini et al. (2018); Frehe et al. (2017); Pourrahmani and Jaller (2021a); Neudoerfer, Mladenow, and Straus (2021)
Remuneration	Price paid per delivery, mode of payment	Serafini et al. (2018); Marcucci et al. (2017); Pourrahmani & Jaller, (2021a); Punel et al., (2018)
Road safety	Safety to perform the delivery	Pourrahmani and Jaller (2021a)
Synchronization/digital connection of platforms	Condition of the Cs platform, where the assignments are made and where the tracking of the parcel can be done.	Ciobotaru and Chankov (2021); Carbone et al. (2017); Frehe et al. (2017); Giglio & De Maio (2022); Le et al. (2019); Saglietto (2021)
Type of trip – dedicated or non-dedicated	User's route choice when making the delivery – combining a delivery with a commute.	Ciobotaru and Chankov (2021); Frehe et al. (2017); Giglio & De Maio (2022); Le & Ukkusuri (2019); Saglietto (2021); Arslan et al. (2019)
Type of vehicle	Private car, PT, micromobility	Buldeo Rai et al. (2017); Paloheimo et al. (2016); Mourad, Puchinger, and Van Woensel (2021); Castillo et al. (2021)
User acceptance (WTA)	Consumers that are willing to accept products via a Cs service	Buldeo Rai et al. (2018); Behrend and Meisel (2018); Sampaio et al. (2019); Giglio and De Maio (2022);

underline the substantial uncertainty due to long-term viability caused by a limited understanding of viable business models in this realm.

Arvidsson et al. (2016) synthesize the main first and last mile issue in freight and passenger transport. They explore possible synergies between shared resources (e.g., time, space, and vehicle). The Authors conclude that integrating passenger and freight transport is promising when confronted with last-mile problems. However, this requires institutional and business levels integration for both freight and passenger transport service provision. Some studies investigate cases integrating PT with urban freight transport. Examples include: the Cargo Hitching project in the Netherlands (Van Duin et al., 2019) and the Sprout project in Padova (Italy) (Xenou et al., 2022). Both these projects aim using available PT capacity for freight and parcel transport. Van Duin et al. (2019) indicate that the social benefit of the Dutch project were

significant in attracting customers to use shared systems and the bus resulted the preferred transport mode. In addition, one can consider offering also parcel PUDO and home delivery services thus greatly improving customer service quality.

Other studies also investigated the sharing of PT services (Fessler et al., 2022) including buses and subways (Fatnassi, Chaouachi, & Klibi, 2015), buses and boats (Bruzzone et al., 2021), subways and trams (Pietrzak, Pietrzak, & Montwill, 2021; Zhou & Zhang, 2019), mobility on demand (Romano Alho et al., 2021) and PT (Galkin et al., 2019; Pimentel & Alvelos, 2018). All these studies reached similar conclusions. The integration of the two systems can be very efficient due to fewer km driven by freight vehicles and lower emissions from an environmental point of view. Despite this, most of the results are highly co-dependent on good system integration and influenced by normative/regulatory innovation which is reported as the most difficult to achieve. In addition, some of the systems were only tested in pilot/experimental scenarios/conditions where operators are confronted with reduced freight volumes, limited freight pickup/delivery locations and a lower elasticity of travel demand, which is not always the case in big cities.

One example of the discussion reported above is the shared PT network in Brussels relying on a cargo tram (Strale, 2014). The conclusions reached ascribe the limited development of the project to the difficulties that, among others, include urban goods consolidation, divergent demand of urban economic actors regarding freight services, poor knowledge about urban freight flows and the strong competition with passenger services on light rail networks. Hence, only small scale or private initiatives seem capable of surviving in this daunting context. The integration of different transport solutions within a comprehensive and competitive framework is required for promoting the success of this system. Rougès and Montreuil (2014) underline the importance of considering the crowdsourced delivery service not as an isolated industry segment that provides solutions to specific needs, but rather as an alternative solution to build an interconnected system. Cavallaro and Nocera (2021) also mention that the effects of transport policies on the development of integrated passenger–freight schemes are still defective, and a more rigorous examination of the available policies and transport measures is necessary and will, most likely, prove beneficial. One constraint, not fully considered in the literature, relates to urban product delivery representing one of the emerging bottlenecks e-commerce is facing. This is mostly due to high volumes, package fragmentation, and high last-mile delivery costs. All these characteristics taken together render the UFT + PAXT paradigm difficult to implement in practice. Table 4 reports the *main critical items* cited in the extended literature research affecting the implementation of UFT + PAXT.

Many companies are testing alternative strategies to reduce last-mile delivery costs while, at the same time, trying not to jeopardize the relationship with their customers. Combining passenger and freight flows can create attractive business opportunities for these companies since similar transportation needs can be met with fewer vehicles and drivers. One way for combining both ideas is to develop a GCs.

4. Critical factors for a green crowdshipping business model

In what follows we report the main results emerging from three in-depth interviews conducted with companies located in Brazil, Italy, and Norway. These interviews allowed us both to integrate the critical factors from a managerial perspective when trying to implement a GCs service within the list emerging from the academic literature review as well as to validate them.

4.1. In-depth interview 1 – Company X

Company X currently performs Cs services in Norway, using its own matching platform, allowing senders to connect with different bringers with spare capacity, while using any type of vehicles they find suitable. Payments and communications between senders and crowdshippers are

Table 4
Critical factors to UFT + PAXT system from the related literature review.

Critical Factors	Description	Authors
Accessibility/location of stations of public transport	Access to and state of the stations (buses, metro, tram, train)	Romano Alho et al. (2021); Arvidsson et al. (2016); Bruzzone et al. (2021); Fatnassi et al. (2015)
Availability/reliability of public transport	Connection between transport modes, headway, condition of the vehicles	Bruzzone et al. (2021); Le Pira et al. (2021); Elbert and Rentschler (2021); Cavallaro and Nocera (2021)
Collaboration dependent	To have a functional system, a full collaboration between the agents is necessary, especially between platforms.	Arvidsson et al. (2016); Bruzzone et al. (2021); Le Pira et al. (2021); Dai, Jia, and Liu (2020)
Consolidation	Consolidation and organization of the parcels to optimize the delivery	Bruzzone et al. (2021); Cavallaro and Nocera (2021)
Coordination of Stakeholders	Coordination of the involved stakeholders: mindset shift, integration of operations, public and private initiatives	Arvidsson et al. (2016); Bruzzone et al. (2021); Elbert and Rentschler (2021); Le Pira et al. (2021); Pimentel and Alvelos (2018); Van Duin et al. (2019); Dai et al. (2020)
Legal issues	Labour rules, data protection, transit policies	Bruzzone et al. (2021); Cavallaro and Nocera (2021); Elbert and Rentschler (2021); Le Pira et al. (2021)
Loading/Unloading	The process of picking up the parcel and the delivery to the final destination. This also involves the loading/unloading of the vehicle when the spare capacity of a PAXT is used. This process cannot hinder users and systems timetables (to maintain the quality of the service)	Bruzzone et al. (2021); Elbert and Rentschler (2021); Strale (2014)
Location/presence of urban facilities - parcel lockers	Location of the facilities that facilitate the delivery process, like parcel lockers, especially closer to the stations of PT	Arvidsson et al. (2016); Bruzzone et al. (2021); Strale (2014); Vajihi and Ricci (2021); Cavallaro and Nocera (2021)
Marketing	Activities related to promotion of the service: incentives to use, enhance the social network of users, propaganda	Bruzzone et al. (2021); Elbert and Rentschler (2021); Van Duin et al. (2019)
Parcel size	Dimension of the parcels to be delivered (weight, width, length)	Le Pira et al. (2021)
Reliability of the service/company	Level of trust of the system as a whole	Romano Alho et al. (2021); Le Pira et al. (2021)
Synchronization/digital connection of platforms	Condition of the service platform, where the assignments are made and where the tracking of the parcel can be done by both consumers and logistic operators'	Cavallaro and Nocera (2021); Elbert and Rentschler (2021)
Type of vehicle	Vehicle used for the delivery: private car, PT, micro mobility, tram, train, metro	Arvidsson et al. (2016); Bruzzone et al. (2021); Vajihi and Ricci (2021); Dai et al. (2020)
User acceptance (WTA)	Consumers that are willing to accept products via a combined service	Pimentel and Alvelos (2018)

all handled in the platform. The products shipped using Company X are insured and the company retains a fee for each completed delivery. Currently, the platform is open to all, including business wanting to send packages, but the lions share is C2C (consumer-to-consumer).

The in-depth interview started off using the list of critical factors per subject as reference. While some factors were removed from the list since they were not perceived as relevant from a business perspective, others were grouped since they were perceived as similar. A relevant discussion emerged between the participants concerning the subdivision of the critical factors and allowed clarifying and detailing the analysis. This helped grouping themes by the level of similarity (thematical grouping). The four emerging thematic areas are:

- *Behavioural factors*: related to or affected by the willingness of stakeholders partaking in Cs. Some can be influenced by how the company chooses to operate and to incentivize users (e.g., detour, vehicle type and trip type).
- *Contextual factors*: not directly under company direct control that should, nevertheless, be considered when starting a new business.
- *Service factors*: within the responsibility of the platform (service provider), representing a strategic choice about how the company decides to operate.
- *Technical factors*: related to business model issues that are both the company's responsibility as well as dependent on other service providers' behavior when choosing whether to cooperate or not (e.g., MaaS platforms as an example).

Table 5 illustrates the validated list of critical factors. Originally it included 39 critical factors in total. However, after the first validation/brainstorming with the interviewees, the list was restricted to 25. These items, aggregated due to substantial conceptual overlap, are:

- Availability/reliability of public transport: combining the “capacity of public transport” and “reliability of public transport”.
- Delivery cost and time: combining “delivery cost”, “delivery time” and “flexibility”.
- Legal issues: combined “workforce” and “policies”.
- Marketing: “Social network (connections)”, “Incentives” and “marketing”.
- Reliability of the service/company: “Level of Service”, “Tracking of the “parcel”, “Reliability of the company”.
- Synchronization/digital connection of platforms: “Synchronization/digital connection” and “Digital platform”.

Table 5
List of critical factors according to Company X.

BEHAVIOR	CONTEXT	SERVICE	TECHNICAL
Crowd motivation (WTD)	Geographical conditions	Delivery cost and time	Collaboration dependent
Detour	Legal issues	Marketing	Location/presence of urban facilities - parcel lockers and Hubs
Environmental Awareness	Market size/ conditions	Reliability of the service/ company	Synchronization/ digital connection of platforms
Reliability of the crowdshipper	Road safety	Remuneration	Failed deliveries
User acceptance (WTA)	Availability/ reliability of public transport	Parcel size	Loading/Unloading
Type of trip - dedicated or non-dedicated	Accessibility/ location of stations of PT	Market Strategy	Consolidation
Coordination of Stakeholders		Delivery Location	
Type of vehicle			

The bold text relates to the new item added by Company X

Three items were excluded from the final list due to lack of association and relevance from a business perspective. They are negative environmental impacts, positive environmental impacts, and reduced freight movements in cities. Removing these items does not mean they are not important but, rather, suggests they are linked to other critical factors the company can act upon. A good example is “Type of vehicle”. The choice of the company with respect to the type of vehicle used (electrical or fuel) will affect the environmental impact.

One last input emerging from Company X in-depth interview is the inclusion of 2 items to the final list that surfaced as equally important and relevant from a company perspective considering the implementation of GCs business. The first emerging item is the **market strategy** the company adopts. In other words, should the service be deployed within a business to business (B2B), C2C, B2C or even consumer to business (C2B) market? It is important to note that Company’s X General Director stated that “This strategy will show how the company will present itself in the market”. The Routing Manager provided us with a similar a consideration when he stated that: “The market strategy directly influences items like the type of parcel, marketing, vehicle used and the type of parcel tracking/insurance offered for in the delivery”. This nuance was not found in the literature review, since the studies reviewed focus on analysing already existing system or, alternatively, the behavioural implications a given system might have rather than totally new initiatives. This has been neglected by academic research while considered crucial from a business perspective.

Another important item that emerged from the in-depth interview, is the **final delivery location**. With a steep e-commerce rise, last-mile delivery solutions are becoming more and more relevant. Among these one should recall manned and un-manned PUDO points and home delivery. This was reinforced by the Crowdshipper Manager that asserted “The final destination of the parcel affects the whole system, especially with respect to the motivation of the crowd. When the final delivery is a parcel locker, the detour can be substantially shorter if conveniently located”. The interviewees also mentioned that a substantial problem with a Cs delivery is represented by the failed delivery that implies an additional layer of complexity.

4.2. In-depth interview - company Y

Company Y is a Brazilian-based startup operating a dockless e-mobility sharing system. The company offers e-scooters and e-bike services as options for micro mobility displacements, all via a mobile app. To increase visibility and rentability, more recently the business included a delivery module in the app by allowing micro mobility users to also act as crowdshippers. The system offers the delivery for those who are taking a trip using the app and are available for delivery when a shipper has a delivery to be carried out in the app coverage area..

The interviewee is the Director of Operation and Expansion, dealing with the delivery segment. First, he illustrated the overall context within which the company operates. This was followed by a discussion of the main difficulties encountered in the last-mile segment. The original business model focused on renting micro mobility assets but, in pursuit of profitability, Company Y expanded its' market to an adjacent segment targeting Delivery + Mobility/Sharing + Sponsorship. According to the Director of Operation and Expansion: “The delivery pillar helps to oxygenate and monetize the system, being one of our main sources of profitability”. The prices of the shared vehicles fluctuates during the day and is mostly driven by high and low demand for specific activities (e.g., work/school, delivery, food delivery, leisure).

The critical factors in Table 5 were presented and further discussed. The objective was to further validate the critical factors list. The intent is to ensure that the results obtained are considered relevant from different Companies' perspectives. The discussion confirmed that all the items in Table 5 are critical, and moreover, according to the interviewee “if one of these items is not working properly, or is not duly considered, the system will simply blow up.”. Additionally, new items emerged as critical,

important, and needing additional investigation. In the CONTEXT area, the Director of Operation and Expansion mentioned how the **city infrastructure** can influence the services and, more specifically, the vehicle used to perform the deliveries. This includes, among others: type of pavement, presence of bike lanes, and sidewalk’s structure. In the SERVICE area, the need for an **Intermodal mix (fleet)** was mentioned as relevant. The Manager affirmed that “having a different fleet available for the crowdshipper can help expanding the deliveries in all seasons and weathers”. Lastly in the TECHNICAL area, it was added the importance of a **tracking of vehicles and crowdshippers** since this is crucial to guarantee the safety of the delivery. Table 6 contains the final list from Company Y.

4.3. In-depth interview 3 - company Z

Company Z is currently offering two types of services in major Italian cities: a business platform (express deliveries) and a private platform (sharing economy). Each service is run separately using a self-developed own app.

The first service offered is the supply and demand matching of transport services (C2C) that private individuals upload in the sharing economy platform with no size, type, and vehicle-used restrictions. The major difference with respect to the other companies interviewed is that all the negotiations and payment are arranged between senders and receivers given the platform only marches matching supply and demand only. This implies that, currently, the company does not retain any fee for supply and demand matching.

The second service relies on a business B2C and B2B- dedicated platform allowing companies to get their packages delivered in a fully (zero CO₂ emissions) sustainable fashion. Currently, the Company Z can't affirm to be a full-fledged GCs platform since the crowd can de facto transport the products using any available mode/vehicle.

We interviewed the CEO of the company, responsible for managing operations and future innovative projects. The interview, using the same format as the other two, allowed us getting a clear vision of the company and its services along with the main difficulties characterising the platform. The CEO stressed that the company still has not found a path to follow for the Cs platform to grow and increase the number of daily deliveries. In his opinion “Cs services are still not known to most people thus it is inherently difficult to expand the service to a larger population”. These considerations induced the company to explore different ways of

Table 6
List of critical factors according to company Y.

BEHAVIOR	CONTEXT	SERVICE	TECHNICAL
Crowd motivation (WTD)	Geographical conditions	Delivery cost and time	Collaboration dependent
Detour	Legal issues	Marketing	Location/presence of urban facilities - parcel lockers and Hubs
Environmental Awareness	Market size/ conditions	Reliability of the service/ company	Synchronization/ digital connection of platforms
Reliability of the crowdshipper	Road safety	Remuneration	Failed deliveries
User acceptance (WTA)	Availability/ reliability of public transport	Parcel size	Loading/Unloading
Type of trip - dedicated or non-dedicated	Accessibility/ location of stations of PT	Market Strategy	Consolidation
Coordination of Stakeholders	City Infrastructure	Delivery Location	Tracking of vehicles and crowdshippers
Type of vehicle		Intermodal mix - fleet	

The bold text relates to the new item added by Company Y.

expanding the green deliveries concept. This was pursued by creating a dedicated business platform which today represents the only income generating source of the company, that also offers their business clients the possibility to use the private platform making it clear it is their ultimate choice to use it or continue using the business one. According to the CEO, some of the businesses started with good intentions of using the crowdshippers, but *“when you talk about the possible delays inherent to using crowdshippers, the companies get scared and opt to go with the professional drivers. One specific food company in the past, decided to use only the sharing economy platform, but they also asked for crowdshippers to have a regular work contract and be insured”*. Therefore, the intrinsic uncertainty characterising this service type makes it less attractive from a business-oriented perspective.

Another important input emerged from the interview. The company planned to integrate their Cs platform with local PT systems and micromobility companies in the cities where they operate. These partnerships can attract more commuters to act as crowdshippers, and, as affirmed by the interviewee, *“this could provide a greener way of transporting items and people within cities.”*

Lastly, we presented the CEO with the list of critical factors, adding the extra items cited by company X and Y, for validation and discussion purposes. Some of the items were not considered as important from Company Z's perspective, mainly due to their current business model characteristics. Additionally, no new items were added to the final list. More in detail the items not considered relevant are:

- *“Reliability of the crowdshipper”* since *“Today we don't offer the possibility for the clients to track neither their parcel nor the crowdshipper. This is mainly a crowdshippers' choice given they don't like and do not want to be traced. This was never perceived as problematic by the costumers.”*
- *“Type of trip - dedicated or non-dedicated”* given *“This issue never emerged when discussing with our customers since we do not take care of the delivery itself.”*
- *“Intermodal mix – fleet”* for this item, similar considerations as for the previous one apply.

The final list for Company Z is presented in [Table 7](#) below.

4.4. Final list of critical factors: Results implications and discussion

[Table 8](#) contains the critical factors final list from a business model perspective. It has been validated by three different companies and provides useful insights concerning the overlooked issues that needs

Table 7
List of critical factors according to company Z.

BEHAVIOR	CONTEXT	SERVICE	TECHNICAL
Crowd motivation (WTD)	Geographical conditions	Delivery cost and time	Collaboration dependent
Detour	Legal issues	Marketing	Location/presence of urban facilities - parcel lockers and Hubs
Environmental Awareness	Market size/ conditions	Reliability of the service/ company	Synchronization/ digital connection of platforms
User acceptance (WTA)	Road safety	Remuneration	Consolidation
Coordination of Stakeholders	Availability/ reliability of public transport City Infrastructure	Parcel size	Failed deliveries
		Market Strategy	Loading/Unloading
		Delivery Location	

additional investigations. This table includes all the items derived from the literature review plus those considered relevant by at least one of the Companies interviewed. The heat map describes the number of papers that mentioned each factor and pinpoints the most influential (i.e., most cited) ones in the literature. A not applicable (N/A) label indicates that the specific item is not pertinent to the specific subject considered.

Freight transport has often been overlooked when considering urban mobility and transport planning. This is partly due to a general lack of knowledge and data regarding freight activities and stakeholders (Le Pira et al., 2023). Passenger transport demand is correlated with and dependent on, among other things, urban development (land use, city planning, zoning), ageing of society, economy, and pandemics. Le Pira et al. (2021) underline the relationship between passenger transport demand for certain activity types such as work commutes and goods transport demand. Smart working can reduce passenger transport demand but can also increase the demand for shopping trips and/or home deliveries.³ This can both represent an opportunity for promoting UFT distribution using passenger transport as well as a threat since it much depend on availability and service reliability. This requires a high level of synchronization that is still non-existent in most cities.

Ermagun et al. (2020) mention the 5 D's that can enhance the use of a Cs service: Density, Diversity, Design, Distance to Transit, and Destination Accessibility. Thus, a densely populated area, characterized by several transport links, PUDO points availability and accessibility with an online platform connecting stakeholders, represents a good setting for the service to thrive. These circumstances will induce more people to act as crowdshippers and stimulates trust among consumers to increase so that parcel tracking could become possible. This might well increase the GCs market share, given the actual market size, as well as the overall urban delivery market size or both.

Several important service characteristics should be analysed and discussed when exploring the context within which the proposed GCs can actually thrive. The first, and probably most important, is parcel size. A high efficiency level increase can be expected for small/medium items (between 0,1 and 5 kg), due to the minimal effort a commuter needs to make when transporting them. Although the market opportunity for small items is very limited due to the harsh competition in this market (large courier companies), the accessibility level crowdshippers can provide might still prove profitable, since they can quickly deliver more compared to what a single van can do for a single delivery.

One other important technical benefit achievable is lower service prices and, sometimes, higher service quality. The “problem” with this type of service is that not always logistic companies can guarantee a high service quality, especially with short delivery time window (please refer to the considerations expressed by the General Manager of Company Z), but since crowdshippers will, most likely, use PT thus be less susceptible to congestion, this may prove not be the case. But then again, the remaining problem is how can companies cope with delivery unpredictability – how to recruit and retain trustable crowdshippers or how can one render the service more transparent? Workforce-related legal issues and data sharing are prominent when dealing with integrated platforms. Some studies mention that public and easy to access crowdshipper-related evaluations with respect to their past deliveries greatly enhances consumers' trust and increase their willingness to pay for the service.

Behavioural, technical and market analysis (economic assessment) is also crucial since stakeholder behavior and reactions much depend on the specific business model. Therefore, understanding consumers' needs and expectations is vital. Buldeo Rai et al. (2021) report that frequent e-shoppers, with a high sense of community, preferring home delivery and having a positive attitude towards innovations and sustainability constitutes the most interested consumer profile with respect to partaking in a crowdsourced last mile delivery service. Remuneration plays an

³ This is particular true for e-groceries.

Table 8
Final list of critical factors for a GCs business model per area and research field.

Critical factors per area	GCs	UFT+PAXT	Cs
	Number of Papers		
BEHAVIOR			
Crowd motivation (WTD)	2	N/A	5
Detour	2	0	7
Environmental Awareness	2	0	3
Reliability of the crowdshipper	1	N/A	4
User acceptance (WTA)	2	1	6
Type of trip - dedicated or non-dedicated	4	N/A	2
Coordination of Stakeholders	1	6	2
Type of vehicle	2	3	2
CONTEXT			
Geographical conditions	4	N/A	4
Legal issues	2	4	9
Market size/conditions	0	0	9
Road safety	1	N/A	1
Availability/reliability of public transport	6	3	1
Accessibility/location of stations of PT	0	3	N/A
City Infrastructure	0	0	0
SERVICE			
Delivery cost and time	4	0	4
Marketing	4	6	3
Reliability of the service/company	2	2	14
Remuneration	5	N/A	7
Parcel size	4	1	2
Market Strategy	0	0	0
Final delivery location	0	0	0
Intermodal mix - fleet	0	0	0
TECHNICAL			
Collaboration dependent	2	3	0
Location/presence of urban facilities - parcel lockers	5	4	4
Synchronization/digital connection of platforms	1	3	8
Failed deliveries	0	N/A	1
Loading/Unloading	0	3	1
Consolidation	1	1	1
Tracking of vehicles and crowdshippers	0	0	0

important role too affecting crowdshippers' performance (Bathke & Münch, 2023). Rougès and Montreuil (2014) illustrate five revenue-sharing models: fixed price, negotiated prices, financial and matching fees, resale margin, and membership. A combination of fixed and negotiated price represents the most appropriate revenue model for GCs since it both guarantees a minimum revenue for the crowdshipper (based on the distance, number of parcels and detour) while allowing crowdshippers and parcel owners to negotiate among themselves.

PUDOs density can play an important role in promoting UFT system efficiency. One could, in principle share space between UFT and PT considering vehicles, networks, and facilities. PUDOs in metro stations constitute a good example of shared facilities. When commuters, using PT act as crowdshippers, locating PUDOs close to PT terminals will improve service quality thanks to better parcel accessibility and, at the same time, augment their willingness to act as crowdshippers thanks to shorter detours.

An important choice a Cs platform might consider taking is promoting the synchronization of crowdshippers, commuters, consumers, PT services with company's logistic activities. An online platform could not only track crowdshippers in real-time but also provide on-time notifications and offer one-to-one direct contact opportunities between commuters-crowdshippers and final customers as well as with PT providers (timetables, routes, real-time bus/metro positioning and unforeseen events communications -accidents, strikes, weather anomalies,

etc.).

One should underline the key role that local policymakers can play when promoting policies allowing commuters to carry goods on PT, facilitating the operation of parcel lockers in public facilities and, no less important, investing in PT quality improvements in cities.

5. Conclusions

UFT + PAXT is considered a promising solution for last-mile distribution via parcel consolidation and shared asset use (vehicles, network, and facilities). ALICE's Roadmap towards zero emissions logistics 2050 (ALICE, 2019) suggests Cs can be helpful in this respect by "recruiting citizens to serve as couriers using their private vehicles to pick up and drop off parcels along routes they are taking anyway", or by using PT such as "underground freight trains during non-operating hours or even combining freight and PT in a way that does not affect current schedules".

This integration generates an additional level of complexity when combined with Cs service. In fact, one has to deal with and overcome all the problems due to transforming commuters into crowdshippers that are carrying parcels along their ride. This paper focuses on making GCs sustainable and effective in practice. More specifically, the paper investigates what are the critical factors that one needs to address in order to transform a GCs service, into a profitable endeavour. The critical

factor list was compiled by conducting a two-step literature review for GCs (first) and Cs and UFT + PAXT (later). The first phase produced a preliminary list of critical factors that were subsequently validated and, finally, expanded via in-depth interviews with three different Cs companies. This final list, adopting a business perspective, includes the main critical factors to be investigated with the aim of supporting a company either in the transition towards a GCs model or when initiating one from scratch.

The main Cs services advantage almost all papers analysed mention is the possibility of transforming the last-mile distribution of goods into a sustainable task. However, this sustainability hinges on several factors, such as the: type of vehicle chosen, type of trip (dedicated or non-dedicated), and detour one has to make to perform the delivery. Additionally, one should also consider Cs service dependency on commuters' behavior and their willingness to act as a crowdshipper.

Furthermore, when pondering on GCs, the paper underlines the need for a platform to favour the synchronization of the whole system and to provide extra information to consumers thus enhancing their perceived sense of control over their parcel. This might take place by informing them about who is transporting it thus increasing their service trust. Lastly, one should not forget the role the local government might play by promulgating accommodating policies favouring service production by investing in PT.

Further research and future efforts should be directed towards the identification of common guidelines and strategies for legal and operational acknowledgement of passengers and freight transport integration having in mind a Physical Internet perspective for cities where UFT + PAXT will be fully synchronized. All the critical factors should also be evaluated from different perspectives, including that of companies who are already producing GCs services or are considering a transition towards this market offer. Moreover, it would be interesting to investigate if the items listed are context-specific or intrinsically critical.

In closing we suggest future research should investigate possible ways of bridging the gap between academic research and real-life implementations so to provide a clear and reliable research agenda.

Author statement

The authors confirm contribution to the paper as follows: Study conception and design: Nascimento, Marcucci, Gatta; data collection: Nascimento; Methodology: Nascimento; analysis and interpretation of results: Nascimento, Marcucci, Gatta; Draft manuscript preparation: Nascimento, Marcucci, Gatta. All authors reviewed the results and approved the final version of the manuscript.

Declaration of Competing Interest

The Authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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