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Exploring the feasibility of Mobility as a Service (MaaS) for integrated passenger and freight transport through a Delphi survey

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Abstract

This paper presents the first results of a Delphi survey aimed at eliciting experts' opinions on possible scenarios of integration between passenger and freight transport enabled by a Mobility as a Service (MaaS) platform. Combining freight shipments with passenger trips is a promising addition to the MaaS business model that could help to reduce the number of freight vehicles and contribute to a more efficient use of passenger transport services and modes. The research objective of this paper is therefore to explore the feasibility of an extended version of MaaS including freight, called "MaaS for Passenger and Freight" (MaaS4PaF). Passenger and freight transport experts were asked to express their opinions with respect to the potential market penetration, business ecosystem, and implementation of this concept. Results allow to elaborate on opportunities and barriers, especially related to uncertain business models and the multitude of actors involved, and propose a research agenda to further investigate the feasibility and potential of MaaS for passenger and freight transport integration.

Keywords: mobility on-demand; last-mile logistics; urban freight transport; digital platforms.

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1. Introduction

"Integration" and "sharing" have emerged as key features of the sustainable transport concept. They imply combining and sharing transport modes and services to satisfy different transport demands while optimizing vehicle use, limited space and resources. The concept of "Mobility as a Service" (MaaS) goes in this direction. MaaS can be considered as a user-oriented integrator of transport services enabling searching, booking, payment and ticketing through a single digital platform for door-to-door customized trips (Le Pira et al., 2021). Public transport (PT) is seen as the backbone of MaaS, complemented by Mobility on Demand (MoD) services (Wong et al., 2018). MaaS has been introduced in 2014 by Sampo Hietanen and, since then, it caught the attention of many scholars, professionals and policy-makers (from the first seminal works of Kamargianni et al., 2016 or Jittapirom et al., 2017, to the most recent works of Hensher and colleagues, e.g. Hensher et al., 2023). It is a promising concept, and it can be a game-changer for the future of transport, especially if it results in sustainable travel behaviours (Alyavina et al., 2024). However, it has also raised some doubts about its feasibility and its potential to effectively contribute to the reduction of private car ownership and use, transport-related emissions, and social exclusion (Storme et al. 2020; Hörcher and Graham, 2020; Pangbourne et al., 2018).

Different applications have been proposed and tested in the last ten years, especially at the urban level. As an example, the Italian Ministry of Transport is currently funding MaaS pilots in different Italian cities and aims at creating an open platform for mobility data with the idea that the National Government should act both as a regulator and an enabler. The most well-known case of MaaS is Whim, operating first in Finland and then in other countries. However, recent news about Whim bankruptcy point to the need to find sustainable business models for MaaS[†]. Hensher and Hietanen (2023) propose a new multi-service concept based on MaaS, i.e. "Mobility as a Feature" (MaaF), where passenger mobility is only one of the services that are proposed to users. Going in this direction, one solution related to MaaS with the potential to increase its attractiveness and reduce transport-related emissions is the integration of freight and passenger transport. However, MaaS is usually only focused on passenger transport, while freight transport has a huge impact on city sustainability as well. Moreover, freight transport has been rapidly changing, both due to technological innovations with new business models, like on-demand logistics platforms, and to an unprecedented rise of fragmented fast deliveries, mostly due to e-commerce purchases (Tavasszy, 2020). In this regard, the idea of a consumer-centric integrated logistics has been explored by Beckers et al. (2023), proposing the concept of "Logistics as a Service" (LaaS), as a way to integrate customers in urban freight and make them more conscious of the negative impacts of e-commerce deliveries.

Passenger and freight integration has been a widely investigated topic in the very last years. There are two ways of fostering integration, i.e. by involving users in the delivery, or via co-modality, i.e. the joint use of the same transport service or facility (Elbert and Rentschler, 2022). The idea of delivering goods via the crowd (i.e. crowdshipping) is a fascinating one, especially when delivery trips are non-dedicated (Marcucci et al., 2017). The possibility of using the spare capacity of public transport via cargo hitching or sharing a delivery ride by using new MoD solutions has also been explored (van Duin et al., 2019; Li et al., 2022; Fehn et al., 2023). Some caveats refer to business model uncertainty, unclear responsibilities, and roles of the different actors, as well as the need to match different transport demand in real time. Besides, a more comprehensive framework of passenger and freight integration is required (Cavallaro and Nocera, 2022). In this respect, the MaaS framework could represent a solution for a fully-fledged implementation of passenger and freight integration.

This paper contributes to the debate around MaaS and its potential for sustainable mobility by proposing an extended concept that combines passenger with freight transport, called "MaaS for Passenger and Freight" (MaaS4PaF). MaaS4PaF has been first conceptualized by Le Pira et al. (2021) who performed a systematic exploration of conceptual service models through which integration might take place. Based on this conceptualization, this paper aims to perform a validation of MaaS4PaF with experts, by involving them via a Delphi survey. In this respect, since the MaaS4PaF concept has never been explored before, it becomes necessary to investigate its potential feasibility and attractiveness from an expert point of view.

[†] https://sifted.eu/articles/maas-whim-bankrupt-news

The remainder of the paper is organized as follows. Section 2 describes the MaaS4PaF concept; section 3 introduces the survey; section 4 discusses the results; section 5 concludes the paper with future research directions.

2. The MaaS4PaF concept

A conceptual framework is needed to systematically explore passenger and freight integration in MaaS. Fig. 1 presents the MaaS4PaF ecosystem. It is based on the integration of the MaaS and logistics ecosystems (Le Pira et al., 2021). It basically consists of a MaaS operator (i.e. the MaaS platform) that provides the matching of users requiring a trip ("MaaS pax users") with transport operators and services ("pax transport operators"), as in MaaS applications. The novelty is represented both by the presence of users requiring a freight delivery (shippers) and freight transport operators who can perform deliveries. Besides, in this configuration every MaaS actor can become a carrier while doing his/her daily transport activities. The matching between the demand and supply is done via the digital platform and can consist of an integrated passenger and freight trip. It could be performed by passengers performing their trips and/or by passenger transport operators sharing their spare vehicle capacity to perform the delivery and/or by freight transport operators who have spare capacity. A multimodal trip involving different MaaS actors is thus possible as in the traditional MaaS scheme. Cities with a good transport system are ideal for MaaS4PaF since there would be more options to match passenger and freight trips.

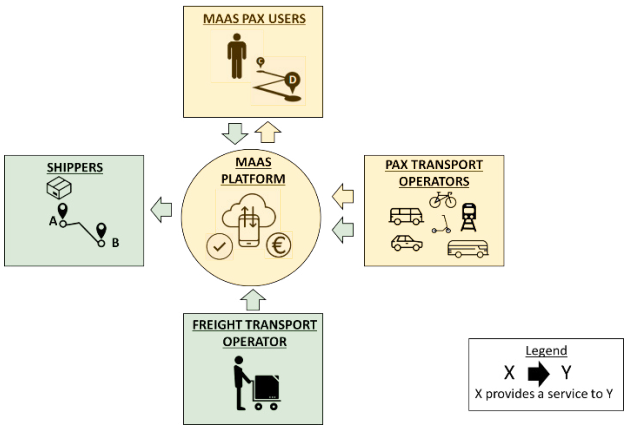

Fig. 1. MaaS4PaF ecosystem (based on Le Pira et al., 2021).

The MaaS4PaF proposition is based on an identification of possible service combinations that could perform the integrated passenger and freight service, for multiple delivery networks and logistics segments. In particular, different MaaS4PaF service configurations can exist, based on three logistics chains: (1) one-step chain: only one MaaS carrier is responsible for the door-to-door delivery. This excludes PT; (2) two-step chain: the MaaS platform evaluates possible combinations of trips, and requests MaaS carriers for their availability to perform a leg of the delivery. As above, this type of solution excludes unaccompanied transport via PT; (3) multi-step chain: many MaaS carriers could be involved in the delivery. Part of the delivery can be unaccompanied.

Different combinations (e.g. a delivery performed by a passenger using the metro and a freight transport operator) can be explored with respect to the size of the freight (e.g. cyclists cannot carry large items) and the required delivery time (e.g. for instant delivery, a multi-step Maas delivery would be unfeasible). Therefore, there are a bunch of solutions in which all MaaS carriers can be involved in (e.g. small parcels delivered in multi-step chains), and others that are more suitable for some categories (e.g. large freight instant deliveries can be performed only by freight transport operators). This also implies different levels of integration between passenger and freight transport, from full integration (e.g. deliveries performed by passengers in combination with PT) to no integration at all (deliveries performed by freight transport operators only). Based on these considerations, one can identify different service models that can be driven by passengers, passenger transport operators, or freight transport operators, according to the logistics segments. The conclusion is that there are more integration possibilities with

passenger and passenger transport operators' involvement for parcel – both instant and time-definite – deliveries, but some barriers apply to transport operators, like PT operators, mainly due to regulatory issues that could hamper MaaS4PaF implementation. Besides, one should address other issues like responsibility, privacy and remuneration. More details of this analysis can be found in Le Pira et al. (2021). In general, this conceptualization may oversimplify reality and needs to be validated. To this end, experts have been involved in a survey to assess MaaS4PaF and its feasibility. The next section presents the survey.

3. The survey

An online survey has been set up to elicit expert opinions on possible scenarios of integration between passenger and freight transport enabled by a MaaS platform. The survey is conceived as a Delphi survey, with experts involved in multiple rounds of anonymous interactions, with the possibility to change their opinions based on the average ones so to reach a consensus in the panel (Dalkey and Helmer, 1963).

The questionnaire for the first round consisted of two main parts. The first part aimed at setting the context, by asking (1) participant-related information, i.e. the stakeholder category and the country where they live, and (2) questions related to the level of confidence and general opinions on MaaS, last-mile logistics innovations (LMLI), and passenger and freight (PaF) transport integration. All answers are on a 1-5 scale from "very low" to "very much" for questions regarding confidence, and from "fully disagree" to "fully agree" for questions regarding the level of agreement with sentences related to MaaS, LMLI, and PaF integration (e.g. please state your level of agreement with the following sentence: "The integration of passenger and freight transport is a promising concept for future transport scenarios oriented towards transport efficiency and sustainability").

The second part aimed at collecting experts' opinions with respect to MaaS4PaF and its feasibility. A description of the concept has been provided to experts. Then, they were asked to express their opinion on the expected period of full market penetration of (a) MaaS (passengers only and with full MaaS functionality), (b) digital logistics platforms (only freight), and (c) MaaS for passenger and freight integration, on a 1-5 scale from "already available" to "never". The next questions aimed at determining experts' opinions related to MaaS4PaF ecosystem and the actors that should be involved, distinguishing among (1) MaaS4PaF operators, (2) actors that can have an active role in MaaS4PaF implementation (i.e. in the service provision), and (3) other stakeholders that can have an influence on MaaS4PaF implementation, but that are not required for its operation. The last questions were focused on different service configurations based on the three logistics chains explained in section 2. Experts were asked to indicate the feasibility of different logistics chains (general feasibility, independently on the logistics segment) on a 1-5 scale, and the most suited actor(s) to act as carriers among passengers, passenger transport operators and freight transport operators. A final open-ended question aimed at identifying (three) main barriers that could hamper MaaS4PaF implementation. In general, experts were asked to provide a brief comment to their answers to aid interpretation.

4. Results and discussion

The first round of the survey was launched in April 2022 until June 2022. Different social media were used to disseminate it and involve potential participants from different backgrounds, including researchers, transport operators, public authorities, city logistics stakeholders, industry and technology, and data providers. Contact lists from projects and associations were also used. Other participants were identified based on the research group contacts. 83 answers were collected and none of them was excluded from the analysis. This number is considered acceptable for a Delphi study, aimed at involving an expert panel, to enable consensus to be achieved. Most of the sample is composed by academics (73%), and the rest belongs to the categories public authority (11%), transport experts/consultants (7%), technology and data providers (4%), passenger transport operators (2%) with only 1% is from the industry and freight sectors (freight operators). We believe that the disproportion towards academics and researchers is due both to the contacts from the research group involved in the study (coming from Academia), and to the higher interest of researchers towards innovative concepts. Regarding the geographical distribution of the panel, 71% of respondents comes from Europe, 17% from America, 9% from Asia, 1% from Australia and there is no one from Africa. Within the panel, there is higher confidence with the concepts of MaaS and LMLI, and less with PaF integration. This is also reflected in the agreement on the potential of MaaS and LMLI to improve transport

systems towards sustainability. These answers reflect the novelty of the PaF integration topic, and the fact that most of the experts involved have specific competence on passenger or freight transport.

MaaS and digital logistics platforms are expected to reach a full market penetration sooner than MaaS4PaF, as reflected in Fig. 2. In particular, for the majority of respondents MaaS4PaF is expected to be implemented after 2030, while some of them answered "never". Among the motivations for this answer, concerns about the complexity of mixing passenger with freight transport in MaaS emerged.

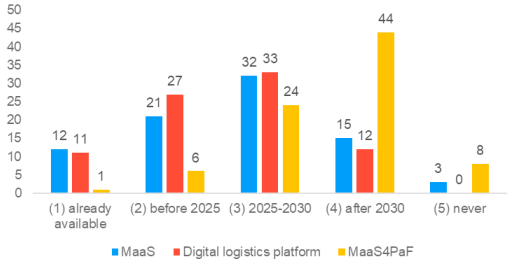

Fig. 2. Expected period of market penetration of innovative concepts.

When it comes to the MaaS4PaF ecosystem, answers are moderately scattered (see Fig. 3). Fig. 3a and 3b show potential MaaS4PaF operators (more answers possible) and the preferred MaaS4PaF operator (only one answer). PT companies are the first ranked among potential MaaS4PaF operators, followed by Transportation Network Companies (TNC), logistics service providers, and shared mobility operators (more than 50% of experts indicated them). However, TNC are considered the preferred MaaS4PaF operators, followed by PT companies, service integrators and public authorities (Fig 3b). This result is consistent with the debate around MaaS where there are different schemes and business models (Polydoropoulou et al., 2020). In this respect, it emerges that MaaS4PaF could be operated by a public entity (i.e. by a public authority or a public transport company), as well as the private sector (TNC, logistics service providers, shared mobility operators or logistics operators). In any case, public authorities are perceived as the most important actors who can have an active role in MaaS4PaF implementation, followed by logistics service providers (Fig. 3c). Finally, other important stakeholders that can have an interest in MaaS4PaF are industry and commerce associations, followed by investors and shareholders (Fig. 3d).

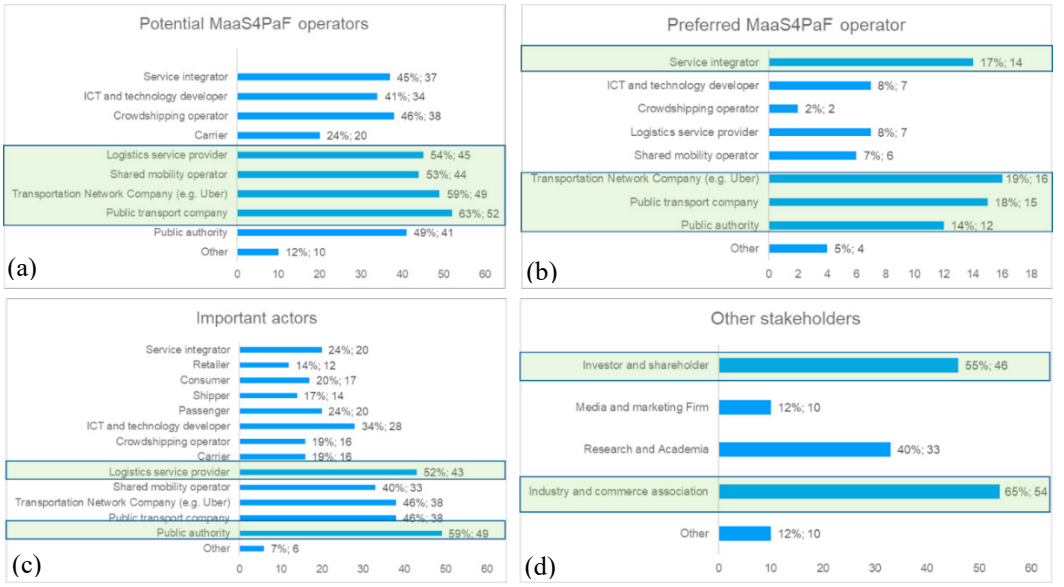

Fig. 3. (a) Promising MaaS4PaF operators (more than one answer possible); (b) Preferred MaaS4PaF operator (only one answer); (c) Important actors (three choices); (d) Other stakeholders (maximum two choices).

In terms of feasibility of MaaS4PaF service configurations, Fig. 4a shows that the one-step chain, involving a single MaaS carrier, is considered the most feasible scenario. This result is quite expected, since it would be more complicated to involve multiple carriers in a multi-step chain, especially for fast deliveries. However, the two-step chain, excluding unaccompanied deliveries via PT, is also considered feasible.

Freight transport operators are considered the most suited to act as MaaS carriers, in particular when it comes to multi-step deliveries (Fig. 4b). However, passenger transport operators are also considered well suited to perform the deliveries, in particular for two-step and multi-step processes, while passengers are considered the least appropriate.

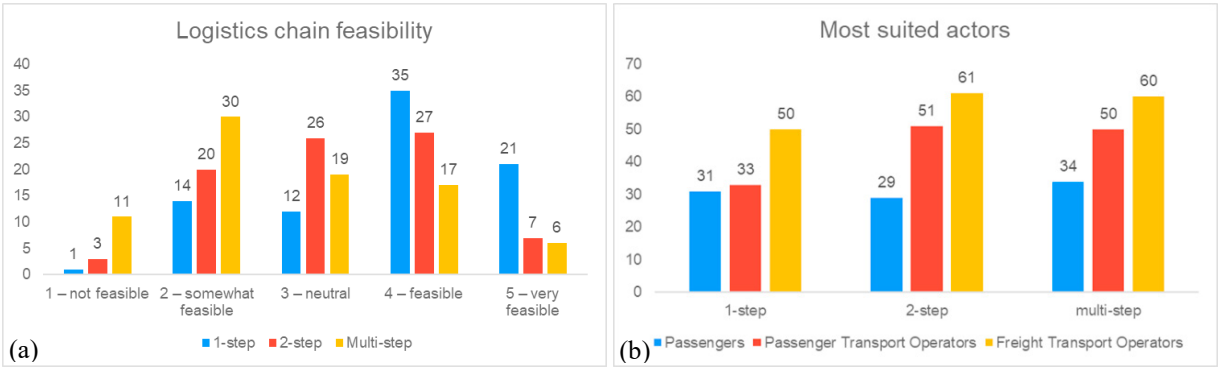

Fig. 4. (a) Logistics chain feasibility; (b) Most suited actor per logistics chain (more than one answer possible for 2-step and multi-step).

According to the majority of experts involved, it seems that a MaaS4Paf service model with a fundamental role of freight transport operators would be more feasible when compared to other service models led by passengers or passenger transport operators. This result is not in line with the idea of integrating passenger and freight transport, while it resembles the idea of integrating MaaS with digital logistics platforms, i.e. a MaaS with a higher service offer (see Hensher and Hietanen, 2023). This can be ascribed to higher difficulties and barriers that would be encountered when involving non-freight operators (passengers or passenger transport operators) in freight delivery.

In this regard, several barriers that could hamper MaaS4PaF implementation were identified by experts. They were grouped into 12 groups as reported in table 1. There is a good level of agreement among experts regarding the main barriers, which relates to stakeholders and their role (reported by 42 experts), uncertainties in the business model (reported by 34 experts), need of behavioural and cultural change (reported by 30 experts), issues of technical feasibility and lack of regulation (reported by 18 experts). These answers are consistent with the previous ones related to market penetration and potential actors involved in MaaS4PaF implementation, and shows that, even if it is considered an interesting concept, there can be some obstacles to its implementation in the near future.

We can reasonably conclude that results from the first round are quite satisfactory in terms of level of agreement among experts. To have some metrics, we evaluated the coefficient of variation of replies based on a 1-5 Likert scale (Fig. 2 and Fig. 4a), resulting less than 0.5, testifying a good degree of consensus (von der Gracht, 2012).

5. Conclusion

MaaS is a user-oriented service concept providing door-to-door mobility solutions for people. It is a promising and widely investigated concept that could change the future of mobility in our cities towards sustainability. However, there are many open issues and barriers preventing its full implementation. One potential solution to increase the attractiveness of MaaS, while also reducing the negative impacts of transport, is to combine passenger transport with freight shipments under the MaaS framework. This paper explores the feasibility of the concept of MaaS for Passengers and Freight (MaaS4PaF), first introduced by Le Pira et al. (2021), by performing a Delphi survey involving experts. The results from the first round are analysed in this work, providing interesting insights.

In general, the experts involved in the survey showed a general interest towards the concept of MaaS4PaF and considered it to be feasible in the future (horizon 2030 and beyond). There is also a high level of agreement among respondents, particularly on the important role of passenger transport operators and public authorities in MaaS4PaF

implementation. Private operators both from passenger and freight sides are also considered important actors and suitable to operate a MaaS4PaF system. In terms of feasibility, according to the experts, freight transport operators should continue to have a central role in the deliveries, due to the complexity of involving passengers and passenger transport operators in multi-step deliveries. This could hamper MaaS4PaF potential to integrate passenger and freight trips and therefore reduce the negative impacts of transport. Besides, several barriers were identified by experts, among which the multitude of stakeholders involved, and uncertainties related to the business model.

Results show that including freight into MaaS can be a feasible solution, but more effort is needed for a full integration between passenger and freight transport. This is also linked to MaaS maturity level, which is not very high, and the debate around its role which is lively (Hensher and Hietanen, 2023). In terms of limitations and future research, even if a satisfactory level of consensus was reached by the panel, a further step of the Delphi survey could help to refine judgments and ask more specific questions related to the feasibility of MaaS4PaF for different logistics segments. Besides, since the sample was mainly composed by Academics, involving other stakeholders could help to perform a more comprehensive analysis. Future research should also be based on developing business models for MaaS4PaF and testing them to derive practical and policy suggestions for its actual implementation.

Table 1. MaaS4PaF barriers based on expert answers (number of comments associated with each barrier reported in bracket).

Barriers	Main answers
Behaviour and culture (30)	*status quo bias; familiarity with concepts; different cultures in passenger and freight transport; passenger mentality; adoption of the service; adaptiveness of consumers; availability of passenger to accompany freights; lack of public understanding on the concept; lack of awareness; customer entrusting; passenger resilience due to bad/low advertising; industry willingness; fear of losing market by giving up their current operation; reluctance to be first to adopt new technologies*
Business model (34)	*unclear added value causing hesitation at demand side; business model profitability; financial feasibility and investor interest; payment requirement; competition from regular freight options; low value freight chain that limits interest (high value freight will never be mixed); economic management (costs, ticketing, tariffs); slow investment; investment needs; payment between Lsp, Maas, Public Transport Enterprise; sharing the added costs and/or the possible benefits or cost savings among actors; unclear quantification of benefits*
Data management (12)	*data security; data standardization; data sharing issues; limited willingness to share info and clients*
Lack of regulation (18)	*legal difficulties not enabling ticketing solutions; legal framework; regulatory issues (workforce, responsibilities, insurance); legal and administrative barriers such as insurance, GDPR, revenue sharing models, etc.; absence of legal and regulatory environment for shared economy*
MaaS-related barriers (6)	*Market penetration of MaaS passenger-only; car ownership*
Privacy concerns (2)	*privacy issues*
Security concerns (5)	*security issues; insurance issues; security and trust; guaranteeing security and safety of delivery*
Service quality (13)	*quality of service; strict time windows; efficiency; service reliability; shippers need reliability, consistency, and control above all, which will be difficult or impossible to provide; MaaS cannot provide consistent capacity; Scheduling uncertainty*
Stakeholder roles (42)	*trust among stakeholders; governance; lack of willingness to collaborate among operators (e.g., competitiveness); getting all the transport operators on side; relationships; industry competitive stance; service silos; political/ local government will; cooperation of private and public sector; conflict of interests between stakeholders; coordination of multiple stakeholders; challenges in aligning interests of competing stakeholders - equity in moving people vs business imperative of moving freight; leadership; unsolved struggles among actors; unwillingness of freight operators to share and potentially reduce profits; liability; uncertainties in distribution of roles and responsibilities*
System complexity (14)	*hyper specialization; complexity of the system; high integration complexity; combination of freight and passenger would lead to new unreliability sources (unreliability is better managed when transport loads are passenger or freight exclusively); global dynamics; there may be conflicts in service optimization between passenger and freight*
Technical feasibility (18)	*not suited vehicles; modular vehicles that are difficult to reconfigure; payment; sometimes it can be uncomfortable to share the space with some goods (odor, volume, hazards, etc); difficulty for online coordination; coordination; integration; end-to-end services; matching; consolidation (different operators, where would the transshipment be done?); there may be a fundamental spatial and temporal mismatch between passenger and freight trips*

Barriers	Main answers
Technology gap (10)	*effective communication; requires a significant physical and software infrastructure; technological harmonization (e.g. electronic tags identifying parcels); digitalization level still low; tech security; lack of unified app and backend systems; systems operability*

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