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Research paper

Exploring Logistics-as-a-Service to integrate the consumer into urban freight

Joris Beckers [a,*], Ivan Cardenas [b], Michela Le Pira [c], Jia Zhang [a]

[a] Department of Transport and Regional Economics, University of Antwerp, Prinsstraat 13, 2000, Antwerpen, Belgium
[b] Division of Service Management and Logistics, Chalmers University of Technology, Chalmersplatsen 4, 41296, Gothenburg, Sweden
[c] Department of Civil Engineering and Architecture, University of Catania, Via Santa Sofia 64, 95123, Catania, Italy

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ABSTRACT

E-commerce established the consumer as a freight actor. This new reality in the e-commerce supply chain holds economic, social, and environmental opportunities. First, logistics service providers can capitalize on the willingness to pay of consumers with tailored logistics services. Second, consumers can be confronted with the correct costs of delivery options, raising awareness and influencing their choices' sustainability. Third, policymakers can steer the consumer directly, nudging their behaviour to reach urban freight policy objectives. Until now, the lack of interaction between the logistics service provider and the consumer prevented exploiting these opportunities. In this paper, we look at passenger transport, specifically the concept of Mobility-as-a-Service (MaaS), for inspiration on how to integrate the consumer into the logistics market. We propose conceptualizations for a Logistics-as-a-Service (LaaS) platform with different levels of integration and discuss the role of various stakeholders. We conclude with a suite of research questions that deserve attention to develop further the LaaS idea and its proof of concept for consumer logistics.

1. Introduction

Online shopping caused a seismic shift in the organization of the retail and logistics sectors. The retail landscape has gone from a relatively linear to a complex integrated system of consumers, logistics service providers (LSP), and retailers. Three trends within this changing landscape define the amount of freight destined for households as a result of online shopping (Beckers et al., 2022). First, the plethora of choices in terms of products and retailers resulting from the digitalization of retail catalogues, on the one hand, and their position as the endpoint of the last-mile, on the other, have elevated the role of the consumer. Consumers now constitute the demand for last-mile logistics services. This demand for services can range from requirements on place and time of delivery to more complex services such as returns, bundling of shipments, time windows, and others. Second, retailer diversification causes the disintegration of retail operations, resulting in a shift of responsibilities from the shipper to the LSP. Third, LSPs face fragmentation in time and space. The intricacy of the last-mile, with drop ratios of close to one parcel per stop, results in many vehicle kilometres. As a result, the last-mile has become the most complex, expensive, and polluting leg of the supply chain (Cárdenas, Beckers, & Vanelslander, 2017; Taniguchi & Kakimoto, 2004).

In addition, a large share of these operations take place in constrained urban environments, and local policymakers are increasingly imposing restrictive measures such as zero-emission zones or circulation plans to get a grip on urban freight activities and mitigate externalities such as congestion, pollution and conflicts for public space (Holguín-Veras et al., 2020; Letnik et al., 2020). In this competitive environment, LSPs are adopting various strategies and technologies to improve the economic model of their last-mile delivery process (Mangiaracina et al., 2019; Winkenbach & Janjevic, 2017). New players like Amazon Logistics and on-demand delivery services have emerged to cater to last-mile services (Cardenas, 2017). Yet, the uptake of green vehicles, technological solutions, or tailored services in urban freight is slow. Most solutions are restricted to consolidation efforts but face recurrent issues regarding mistrust among LSPs to collaborate (Carvalho et al., 2020). One can find the reason for this inertia in how the logistics market is organized. The customer of the LSP is the shipper, not the receiver. Hence, the shipper sets the service level requirements. But in the fight for the online consumer, the race to the bottom between online retailers is reflected in the competitive logistics market where LSPs aggressively compete for volumes, and costs are squeezed to the maximum, hurting

* Corresponding author.
E-mail address: joris.beckers@uantwerpen.be (J. Beckers).

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the service levels (Allen et al., 2018). In such a market, the LSP lacks interest in complying with specific customer requirements, even though research demonstrates the willingness of some consumers to pay for tailored logistics services (Hagen & Scheel-Kopeinig, 2021; Nguyen et al., 2019). As a result, the number of failed deliveries remains significant, and alternatives, such as collection-and-delivery points (CDP), often remain only a backup solution (Vakulenko et al., 2017). In Belgium, for example, the proliferation of CDPs resulting from a lack of integration among LSPs jeopardizes their usage (Beckers & Verhetsel, 2021). Hence, aligning LSPs with consumers' expectations towards a user-centric approach seems vital to advance last-mile delivery (de Araújo et al., 2020; Kiba-Janiak et al., 2021).

Consumers have become an essential stakeholder in freight transport, which current logistics systems thus do not reflect. We see three ways in which the integration of consumers is vital to advance last-mile deliveries. First, from an economic point of view, a better understanding of consumers leads to better logistics. On the one hand, LSPs can supply the services for which consumers are willing to pay (Nguyen et al., 2019). Hence, consumers gain access to services that otherwise will remain unexplored. On the other hand, the LSP can exploit this understanding to optimize their operations, for example, by decreasing failed deliveries or increasing the fill rate. Second, a direct interaction between consumers and LSPs allows contrasting consumers with their own decisions and their impacts on costs (external and private) that are not captured in the current market structure. Contrasting consumers should help raise their awareness of actual logistics costs, which has proven to increase the sustainability of their delivery choices (Kiba-Janiak et al., 2022). In doing so, the integration of consumers should contribute to a more fair allocation of costs. Third, if a mechanism exists to contrast consumers with their decisions, it could be used to incentivize the choice of sustainable delivery alternatives from the consumers' side. Such a platform can be a tool for policymakers to align delivery practices with policy objectives. Hence, they can tempt consumers to choose greener alternatives or the same delivery place and time for different shipments, realizing consumer-driven consolidation. This consumer-centric logistics opens new ways for efficiency gains, which have only been explored from the side of the LSP. Rimmer and Kam (2018) coined the term consumer logistics for such a consumer-centric logistics organization.

A consumer-centric approach is not new. Several industries have taken significant steps into more user-centric trends, such as servitization. The critical element of servitization is offering a pool of service attributes that each user can customize, moving away from standardized products and services. Servitization takes advantage of digital technologies integrating different suppliers into seamless platforms where users do not care about specific suppliers but the platform's service.

To further explore the improvement of the last-mile through the consumer, this paper discusses the following research question: How to integrate the consumer in the last-mile? We answer this research question by looking at passenger mobility. There, the concept of Mobility-as-a-Service (MaaS) gained much traction as it holds the potential for more sustainable transport through servitization. We study the value of MaaS for freight using the framework of Jittrapirom et al. (2017) and propose various levels of integration by using the five levels of Sochor et al. (2018). Both frameworks are well-established articles in the MaaS literature. In doing so, we develop the concept of Logistics-as-a-Service and draw hypothetical scenarios for integrating consumers in the last-mile. This conceptualization should (i) inspire academics to start exploring the value of improving urban freight via the consumer or receiver; (ii) convince retailers and logistics service providers to better connect to consumers for the organization of the last-mile, and (iii) help local authorities when piloting such logistics innovations, as is currently happening within the Horizon Europe Framework.[1]

[1] See e.g. the Horizon Europe GREEN-LOG project: https://greenlog-project.eu/.

This paper is structured as follows: in the next section, we provide an overview of the current evolution of the last-mile toward consumer logistics, making a case for the integration of the consumer. In section 3, we put forward our conceptualization of this integration based on a comparison with passenger transport. Finally, we draw avenues for further research to test and improve our conceptualization.

2. Literature review – towards consumer-centric logistics

The elevated role of the consumer, the disintegration of retail operations, and fragmentation in the logistics sector fuel the number of household freight deliveries (Beckers et al., 2022). Home deliveries' economic and environmental impacts are severe, and their advent spurred the research on last-mile logistics (Olsson et al., 2019). We mentioned that the changing roles within the supply chain result in fragmentation at the strategic level, but operational fragmentation impacts the sustainability of the last-mile even more. First, national post operators, integrators, parcel carriers, and last-mile specialists take a share of the parcel volume (Cárdenas, Dewulf, et al., 2017). Second, they do it with trucks, vans, bikes, and other emerging distribution technology. Given that the combination of choices by the shipper and the LSP defines an order's last-mile characteristics, a proliferation of household freight flows occurred. Demand-side factors worsen this supply-induced proliferation. As many residential addresses are empty during business hours, failed deliveries occur (Song et al., 2009). Failed deliveries imply a significant logistics cost, even if the parcel is rerouted to a collection-and-delivery point (Mangiaracina et al., 2019). Next to failed deliveries, the possibility of returns bares even more implications. While they pose an additional trip for the carrier, reverse logistics are also more costly for retailers than forward flows because they are exception-driven, requiring inspections and lacking consolidation opportunities (Robertson et al., 2020). However, the free return policy is difficult to abandon because when retailers offer free returns, customers are more likely to shop and shop more (Janakiraman et al., 2016).

The proliferation of household freight flows jeopardizes the sustainability promise of e-commerce. For example, Jaller and Pahwa (2020) calculate that online retail can reduce vehicle kilometres travelled (VKT) by up to 88% without considering failed deliveries or returns. In another example, Buldeo Rai et al. (2019) calculate a decrease of 50% in CO2 emissions due to lower VKT for the online shopper versus a traditional shopper (with a failed delivery rate of 0.3%). In both assessments, however, the authors assume the online activity to be equivalent to in-store activity in terms of basket size. In this case, equivalent means that (i) the e-shopping cart should have at least the same size as all purchases of the shopping trip together and (ii) all items from the purchase should come from the same origin, which is not the reality, especially when purchasing on online platforms such as Amazon.

There is a need for collaboration among the different stakeholders to decrease the ongoing fragmentation. Although shippers bare a significant responsibility, e-commerce companies and policymakers look at LSPs to reduce the carbon footprint of deliveries (Velazquez & Chankov, 2019). Allen et al. (2017) also address LSPs and call for improved operational collaboration to combine shipments to given geographical locations, increasing vehicle loads, improving drop density, and reducing the number of vehicles entering the city. In addition, however, the authors advise businesses to work together in procurement and tackle proliferation at the point of purchase. Also Pahwa and Jaller (2022), when calculating the costs of different last-mile strategies for e-commerce, highlight the importance of households as the new endpoint in the supply chain to consolidate demand to mitigate some of the complexities that cause fragmentation. Consolidation is not the only potential benefit of consumer connectivity. While sketching the ideal supply chain in a society configured by consumption, Kam and Rimmer (2022) consider digital interaction with the consumer fundamental to allow for *demand sensing*. Combining data from various sources should help mitigate volatile market conditions and has given rise to exploring new delivery methods. In a review of 56 articles on consumer logistics, Wang et al. (2022) conclude that, on the pathway to better-integrated retail and logistics systems, "*logistics operators can provide consumers with technological tools that can help them manage their logistical activities independently*".

A good understanding of the consumer has thus potential to decrease fragmentation and contribute to better sustainability of the e-commerce last-mile. Understanding the consumer means delivering at home when the consumer is present or – if they are open to the idea – getting the parcel to the preferred CDP. However, the logistics preferences of the consumer are – much like personal mobility behaviour - heterogeneous and often depend on socio-economic characteristics (Hood et al., 2020). Hence, LSPs should tailor their services to this variation (Gruntkowski & Martinez, 2022; Maltese et al., 2021). In the COVID-19 context, for example, cautious shoppers preferred parcel lockers over home deliveries for safety reasons (Wang et al., 2021). Besides reducing failed deliveries, interaction with the consumer is becoming part of the last-mile service offering. Although the exact quantification of online shopping value remains food for research (Huré et al., 2017; Picot--Coupey et al., 2021), it should be clear that the logistics process now also influences consumers' channel choice (Inoue & Hashimoto, 2022; Marcucci et al., 2021). There is a willingness to pay for delivery services (Gomes & Lopes, 2022; Hagen et al.; Nguyen et al., 2019). Yet, negative delivery experiences (e.g., delays) impact future shopping decisions (Gruntkowski et al., 2022; Mehlawat et al., 2021). Also, similar to the appreciation of shortened communication channels in the trend to purchase local products (Pollák et al., 2022), LSPs are expected to provide accurate information on delivery locations and time windows (Jun et al., 2022). In return, consumer-centric KPIs found their way into the design of logistics strategies and operations (Sandoval et al., 2022). As a result, integrating the consumer in the logistics process not only holds the potential for improved efficiency but using receivers' information to update business models and delivery services could also help LSPs to increase their competitive advantage.

However, there are not only economic incentives to explore integrating consumers. Marketing research extensively studied the positive impact of awareness on sustainable consumer behaviour (see, e.g., Kostadinova, 2016; Van de Velde et al., 2010). Indeed, in the e-commerce context, consumers informed about last-mile deliveries' environmental and social impacts tend to choose more sustainable delivery alternatives (Agatz et al., 2020; Buldeo Rai et al., 2021; Ignat & Chankov, 2020). Although these studies demonstrated the value of labels or the option to share your environmental consciousness on social media, price remains a deciding factor when selecting a delivery option (Kiba-Janiak et al., 2022; Nogueira et al., 2021). In this context, price differentiation to nudge consumers towards sustainable choices makes sense from a policy perspective (Caspersen et al., 2022; Chen & Wang, 2018). As such, Barcelona attempts to steer consumers towards pick-up services by taxing home deliveries.

Yet, communication between shipper and/or LSP on the one hand, and consumer on the other remains underdeveloped (Gomes et al., 2022; Pollák et al., 2021; Wang et al., 2022). In the following section, we derive inspiration from MaaS to draw a potential framework for such communication. We call this framework conveniently *Logistics-as-a-Service (LaaS)*. In section 4, we discuss the potential impacts of the LaaS. The framework was developed within the Horizon Europe GREEN-LOG project (https://greenlog-project.eu/). Multiple discussions were held with four last-mile specialists, three cities, and three sector representatives in Belgium. These discussions served to design the Flanders pilot of GREEN-LOG, which is about testing the LaaS concept in Gent, Mechelen, and Leuven.

3. Defining LaaS for consumer logistics

Considering these evolutions, integrating the consumer in the last-mile and tailoring deliveries to individual needs seem thus paramount. As the introduction mentions, we draw inspiration from passenger mobility to conceptualize integrating the consumer. The mobility sector underwent a similar trend of fragmentation, with disruptive technologies enabling new mobility on-demand transport services (Shaheen & Cohen, 2021). These transport services constitute a new framework for public transport, one that abandons the one-solution-for-all for mobility services tailored to individual requirements. In this context, Mobility-as-a-Service originated from the hypothesis that better transport services could reduce car dependency in our society and contribute to a more sustainable transport system (Ambrosino et al., 2016; Utriainen & Pöllänen, 2018). MaaS aims to integrate a wide range of (new and old) mobility services and provides consumers with on-demand customized solutions, luring them away from private car use (Hietanen, 2014). MaaS has considerable potential to change transport systems; however, it is still not a fully-fledged reality. Several open issues are mainly related to regulatory barriers and the need to standardize data and investments (Cruz & Sarmento, 2020; Polydoropoulou et al., 2020). Besides, following the user-centric approach, some authors propose its extension to services other than transport, towards smart cities and the concept of "City as a Service" (Clohessy et al., 2014), or by linking it to a broader package of services (Hensher & Hietanen, 2022; Le Pira et al., 2023).

Integration, personalization, and digitalization are fundamental for the MaaS concept, but Jittrapirom et al. (2017) detail these main components in nine characteristics by summarizing the emergent literature (see Table 1). The *integration* of transport modes is fundamental to the concept, as the goal is to turn the proliferation of mobility services into a sustainable and convenient alternative for private car ownership. The level of integration, however, varies significantly. Sochor et al. (2018) provide a widely-used scale related to the extent of integration by linking each level to the number of services offered (see Table 2). MaaS systems of Level 0 exhibit no integration. Level 1 implies the integration of information (e.g., route planning). Level 2 includes booking and payment, while Level 3 adds subscription packages combining different modes. Finally, Level 4 implies the full integration of societal goals. A MaaS system reaches the highest level of integration when it reduces private car ownership and contributes to a more sustainable transport system. Jittrapirom et al. (2017) split the *personalized* characteristic into demand orientation (user-centric), personalization (uniqueness in the offer), and customization (tailoring is possible by the consumer). All three components refer to the possibility of the user having personalized mobility from different perspectives. Finally, the *digital* characteristic links demand and supply without a physical marketplace and the flow of information.

While we know the barriers limiting its uptake and discuss those further in this manuscript, we see strong analogies between mobility and logistics. We believe that the idea of servitization, which underlies the MaaS concept, promises to integrate the consumer better into the last-mile system. Although logistics is already a service, the consumer has minimal access to the attributes of such service as the current focus of the last-mile sector remains on the transport service itself and not on the whole logistics service to the final consumer. Early trials of LaaS applications appear (e.g., UberFreight), and the academic literature is starting to conceptualize the idea. Initially, few studies considered including freight actors in MaaS platforms as an option to improve the business model (König et al., 2016; Pangbourne et al., 2018). In another study, Monios and Bergqvist (2020) see the freight equivalent of MaaS as a reorganization of the transport system characterized by (i) the shift from ownership to leasing and (ii) enabling the value of information technology (IT) in planning and managing the system as a whole. Their proposal considers, like MaaS, digitalization as key for the modal shift of transport and integration among carriers through vehicle pooling. However, responsibilities are centralized, putting the entire transport system in the hands of a network operator who optimizes the system. Such centralization ignores the vital third component of MaaS systems:

Table 1
Conceptualization of a Logistics-as-a-Service system in comparison with MaaS.

	Characteristic	MaaS (Jittrapirom et al., 2017)	LaaS
1	Integration of transport offer	One of the goals is to increase the use of alternatives for the car. Multimodal offer, e.g., integrating public transport, ride-sharing, micro-mobility	The underpinnings of LaaS is a platform that integrates the consumer into the delivery system. To reach any of the three objectives (i.e., better service, awareness, or incentivization), various providers should offer different logistics solutions.
2	Multiple actors	Interactions between users, suppliers of transport services, and platform owner	We see four main actors that need a role in the Laas. • Consumer: demands specific last-mile logistics services to deliver its orders. • Shipper: demands specific last-mile logistics services for the shipment of its sales. • LSP: provides logistics services. They can differentiate the cost of delivery alternatives. • Local authority: regulates the players and potentially steers the market interactions by imposing restrictions and economic incentives.
3	One platform	One access point for all services: planning, booking, ticketing, etc.	The fewer platforms, the more efficient the LaaS will be in reaching its goals because (i) more actors will be interacting, leading to the availability of more and different services; (ii) there will only be one (or a few) places where data on orders and shipments (e.g., origin, destination, volume) will be centralized; (iii) one go-to platform has higher chances to attract users from all stakeholder categories.
4	Tariff option	Bundle or pay-as-you-go	Including tariff options are necessary to differentiate the pricing of delivery alternatives for two reasons: • Servitization: consumers should be able to choose from different services, as there is a willingness to pay. • Incentivization and awareness: confronting consumers with the correct price should increase awareness. Dynamic pricing also allows for incentivization. Together, awareness and incentivization lead to fairer prices.
5	Use of technologies	Combine smartphone with GPS, e-ticketing, database management …	Technologies are a requirement for data-sharing and collaboration that guarantee (i) the protection of the interests of individual companies and (ii) legal liability related to the delivery of the parcel.
6	Registration requirements	Subscription is necessary; this facilitates personalization	Subscription is needed for two reasons. First, linking the LaaS profile to online purchases (i.e., on a website) enables the transition from order to delivery via the LaaS. Second, the subscription would allow demand sensing, facilitating the personalization and customization points below.
7	Demand orientation	The proposed solutions should satisfy the requirements of the user.	This characteristic constitutes the fundament of LaaS: integrating the consumer into the logistics system. The LaaS allows for better services, fairer compensation, and an increase in the uptake of delivery alternatives by giving more control to the consumer, who is the actual origin of the transport demand.
8	Personalization	The proposed solution should be based on the characteristics of the user	Through the knowledge of the consumer's characteristics and dynamic pricing, a LaaS can offer tailored delivery solutions. Hence, LSPs can use forecasting techniques to propose alternatives for which they expect the highest efficiency, the fairest compensation, the least CO2 emissions, etc.
9	Customization	The user should be able to customize the proposed solution	The integration of the consumer not only implies tailored offers but also interaction. The consumer should be able to choose or customize the proposed solution. On the one hand, this increases the information for the LSPs, improving future offers. On the other hand, it allows for extreme flexibility from the consumer's side, which aligns with the on-demand trend in society.

personalization. Le Pira et al. (2021) leave more room for heterogeneity in the transport systems while conceptualizing their MaaS for Passengers and Freight (MaaS4PaF). In their model, every individual working within a mobility provider or a MaaS user performing a trip can become a carrier by taking freight while travelling. When looking in detail, however, the MaaS4PaF adopts mainly the passenger transport perspective. It focuses more on the potential carriers and their role in the deliveries while neglecting the decision power of the receiver of the goods. In contrast, we perceive the LaaS as a freight-only system at this stage. Consumers are individuals or households that place an order which requires delivery. In the most simple case, LSPs make the

Table 2
Integration levels for LaaS in comparison with MaaS.

Integration level	MaaS (Sochor et al., 2018)	LaaS
Level 0	No integration. Single, separate services	No integration. Merely information channel from a single LSP towards the consumer.
Level 1	Integration of information. Multimodal travel planner, price info	Tracking information on parcels by different LSPs. Information on delivery alternatives.
Level 2	Integration of booking & payment. Single trip – find, book, and pay	Option for the consumer to pay for the selected service. Considers every online order individually.
Level 3	Integration of the service offer. Bundling/ subscription, contracts, etc.	App bundles all freight to the consumer and thus allows for consolidating different shipments in the last-mile. This level requires shared contracts and responsibilities.
Level 4	Integration of societal goals. Policy, incentives, etc.	LaaS guides the broader organization of urban freight, e.g., with micro consolidation hubs. This way, it results in the reduction of the societal and environmental impact of urban freight. Policy regulations define the possible service offerings.

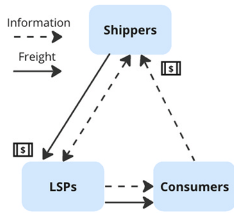
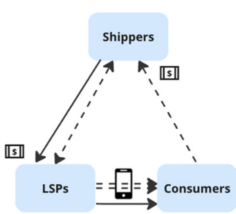
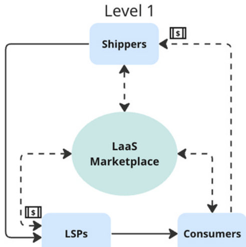
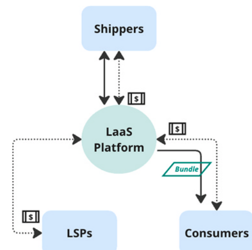
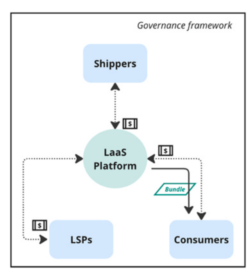
deliveries.

In Table 1, we describe the characteristics of LaaS. First, the overall goal of introducing a LaaS system is integrating the consumer into the last-mile system. As mentioned, a system that incorporates the consumer should lead to (i) better logistics services; (ii) more awareness and fairer pricing; (iii) options for incentivization. The strategy to achieve these objectives is thus integrating the consumer into logistics processes. In Table 2, we will discuss the different levels of integration. Second, interaction should occur between the consumer, the LSP, and the shipper. The government can regulate so that the market functions in line with the policy objectives, such as internalizing all societal costs. The regulation can come in different ways, ranging from the guarantee that social and environmental standards are upheld to, for example, posing restrictions on fill rates or vehicles. Third, the platform should allow matching supply and demand, payment, tracking, and other options. These functionalities can only happen when a central platform combines all different data sources in a central location. Having only one platform is also a requirement to combat the ongoing fragmentation, not only in terms of deliveries but also in policies. Because urban freight policy is primarily a local responsibility, regulations can change from city to city, further complicating the delivery process. Fourth, different tariff options are necessary for two reasons. On the one hand, it facilitates the shift towards servitization. Consumers should be able to register for a bundle similar to existing bundles, such as Amazon Prime, which might include additional membership benefits. In this case, the consumer can, for example, register for an expensive bundle that includes deliveries anywhere, any time, or a cheaper alternative within a personal parcel locker. On the other hand, the tariff option allows organizing a fairer pricing system for last-mile deliveries. Fifth, establishing a framework for secure data exchanges between the stakeholders is fundamental. Logistics data should allow the tracking of the parcel, while personal location sharing could improve the hit rate. In addition, including GIS layers is necessary to provide the options in different locations correctly. Sixth, registration is required to link the order to its delivery (e.g., connecting the information on the online store to the LSP). Also, the LaaS requires registration for legal issues and allows for demand orientation, personalization, and customization. Delivery profiles would also help set up a reward scheme to incentivize more sustainable deliveries (e.g., extra credits when combining shipments with neighbours). Seventh, demand orientation is fundamental. The LaaS is about improving the sustainability of the system through the demand. Eight, the options the consumer can choose should be based on their characteristics. Far-fetched integration of the various steps in the consumption journey is necessary. The combination of purchase characteristics (e.g., return frequency, known by the shipper) and delivery characteristics (e.g., favourite CDP, known by the LSP) allows for more efficient distribution planning. In addition, linking shippers' and LSPs information on users would uncover mismatches between orders and shipments. Finally, the consumer should receive different options and be able to customize the final solution. Customization is also necessary to generate awareness.

Table 2 displays the different levels of integration for the LaaS system. As in the original publication by Sochor et al. (2018), the levels are more nominal than ordinal, implying that a LaaS system can be level 3 while lacking the characteristics of level 1. Considering the levels of integration, level 0 would be a simple information display. In the current last-mile sector, however, an app displaying accurate tracking is far from ubiquitous. A level 1 LaaS allows for more than only displaying information. To be successful, information from as many LSPs as possible should be available in one application, although for any potential interaction, such as changing the delivery location, the receiver will be forwarded to the LSPs's website. It, however, already requires a great deal of integration, as information about all shipments towards a particular consumer should find their way to the LaaS. This integration would require a unique identifier per consumer. At this level of integration, information still comes from the LSP. A LaaS of level 2 would include the selection and payment of services. At this point, the LaaS becomes an actual marketplace. There is communication between the LSP and the consumer. LSPs should be able to vie for all shipments going to consumers of which they know the delivery preferences. The online store needs to integrate with the LaaS to enable the connection between LSP and consumer, as the shipper has to put the information about the order in the LaaS. In this marketplace, transactions occur between shipper and LSP, and between LSP and receiver. The former relates to the selection of the LSP for the delivery. The latter entails changing the service level of the delivery, potentially for an additional cost that the consumer pays to the LSP over the platform. Every shipment related to an online order remains, however, treated individually. In level 3, the LaaS includes additional functionalities that allow the consumer to select and pay a LSP for the delivery, enabling the system to reach the envisioned objectives outlined in this manuscript. There is now complete, two-way responsibility between receiver and LSP, as the retailer just sends the order information to the LaaS. It demands a juridical framework to manage the transfer of obligations. Finally, policymakers should use the LaaS system to organize urban freight to achieve societal goals. By posing restrictions and regulations on the potential of services offered or by including an immediate calculation of a tax for polluting choices, governments can set the condition for freight in the city (see, e.g., Anand et al., 2021).

Finally, in Table 3, we conceptualize how these different integration levels would look for the e-commerce delivery system. As mentioned, this conceptualization emerged after discussions with various stakeholders from the logistics sector and governmental actors. Level 0 is the traditional organization without direct communication between consumer and LSP. Consumers pay the shipper, who pays a LSP to deliver the goods. Feedback only occurs between LSP and shipper, as the latter requests delivery information. In level 1, interaction starts to happen between consumers and LSP. For example, the LSP considers the preferred delivery time of the consumers. Ideally, communication with all the LSPs occurs in the same app. In level 2, the shipper provides information directly to the LaaS marketplace. LSPs can then vie for the consumer's selection to deliver the parcel. This situation resembles crowd-shipping platforms but has two structural differences. First, all LSPs on the market compete for all deliveries. Second, the consumer has the final say on how the delivery occurs and can, for example, select a greener delivery. Level 3 goes one step further as, in this case, the consumer selects the shipment for an ordered parcel. Hence, the only

Table 3
LaaS conceptualization.

Schematic overview	Integration	Operational mode
 Level 0	• Little to no integration	• Information flow: (i) Consumer initiates shipment on websites and potentially selects predefined delivery options; (ii) The shipper selects the LSP and passes delivery information; (iii) The LSP reports shipping information to the shipper and consumer. • Financial flow: When placing an order, the consumer pays the shipper for goods and transport. The shipper pays the LSP. • Freight flow: (I) Goods are transferred directly from shipper to LSP; (ii) The LSP delivers to the consumer.
 Level 1	• Information of different LSPs is centralized in one information platform. A unique consumer identified for the consumer is required.	• Information flow: same as level 0, but for different LSPs. • Financial flow: same as level 0 •Freight flows: same as level 0
 Level 2	• LSPs can subscribe on the marketplace and vie for the delivery of orders. • LSPs can update the delivery based on direct interaction with the receiver. • Logistics information is partially integrated into the LaaS marketplace (because the initial request is not made on LaaS).	• Information flow: (i) The receiver initiates a shipment on the website and potentially selects predefined delivery options; (ii) The shipper enters the delivery order on the LaaS marketplace; (iii) LSPs propose delivery solutions for a specific price; (iv) The shipper decides upon the LSP; (v) The consumer could change delivery parameters in contact with the LSP. • Financial flows: (i) The consumer pays the shipper for the goods and transport when placing an order; (ii) The shipper pays the LSP on the LaaS; (iii) The receiver potentially pays the selected LSP for better services. • Freight flows: same as level 0
 Level 3	• Consumers are fully initiating the delivery/High level of personalization • Higher level of interactions between LSPs and consumers (because there is communication over the decision-making process now) • Logistics information is integrated into the LaaS platform • Open logistics infrastructure is required	• Information flow: (i) the consumer initiates the shipment on the online store; (ii) the shipper enters delivery information on the LaaS platform; (iii) the consumer selects delivery solution from the LSP. • Financial flows: (i) Consumer pays the shipper for the goods when placing the order; (ii) The consumer pays the LSP for the delivery on the LaaS platform. • Freight flows: (i) Shippers send goods to open warehouses (e.g., urban distribution center); (ii) The LSP delivers to the consumer.
 Level 4	•Integration of governmental stakeholders steering the system for sustainable purposes • Dynamic pricing + incentives to promote green and sustainable options/ service bundles for consumers • Consolidation of shipments to consumers	• Information flow: same as level 3, steered by algorithms fed by policy objectives. • Financial flows: same as level 3. • Freight flows: same as level 3

financial transaction for the LSP is with the consumer. At this point the consumer can bundle freight deliveries coming to them. We indicate this change as moving from a LaaS marketplace to a LaaS platform as a tool. Finally, in the fourth level, the LaaS fits within a broader governance framework towards sustainable transport. Hence, incentivization can be used to steer the receiver in specific directions, or LSPs can only take certain orders depending on sustainability targets.

4. Discussion and conclusions

The concept of MaaS holds many opportunities for improving our transport system in all its facets (Alyavina et al., 2022; Becker et al., 2020). Yet, different pilot projects laid out some key barriers that have prevented a successful MaaS implementation, such as required technical investments (Polydoropoulou et al., 2020). IT integration should, however, not be impossible. In general, MaaS can provide higher convenience to users by enabling different alternatives and increasing their utility by using multiple mobility services. For transport providers, it provides a mechanism where specific user segments can be addressed with differentiated services at different prices, therefore better-capturing users' willingness to pay and maximizing their profits.

In this paper, we consider that there are similar issues within the context of logistics. We conceptualize LaaS as a framework to connect logistics service providers, shippers, and consumers that can answer questions surrounding the integration of different last-mile distribution schemes, as mentioned by Lim et al. (2018). In LaaS, last-mile logistics users (i.e., consumers) can improve their convenience by accessing specific and customized logistics services in the last-mile. Logistics service providers in the last-mile can provide consumer-centric services and better capture a willingness to pay that we consider unexplored. Simultaneously, the LaaS can contribute to a more sustainable last-mile in two ways. On the one hand, given that greater awareness of transport impacts leads to more sustainable choices (Agatz et al., 2020; Ignat et al., 2020; Kiba-Janiak et al., 2022), consumers confronted with the logistics decision should become more conscious of the consequences, indirectly improving the system's sustainability. On the other hand, policymakers can incentivize greener alternatives and regulate options that create externalities such as congestion and pollution. By doing so, the LaaS contributes directly to the improved sustainability of the last-mile.

However, a couple of critical issues remain to be studied. First, increased personalization and a more diverse set of services potentially lead to only more fragmentation in the last-mile, further increasing externalities. In earlier work, Manerba et al. (2018) showed an increased environmental impact of 400% when consumers can select a 2-h time window for deliveries. The LaaS is, however, not merely about providing endless opportunities. In analogy to passenger transport, these opportunities should be accompanied by a system that creates awareness and results in a higher consumer surplus due to increased convenience and the ability to satisfy preferences that otherwise will remain unexplored (Di Dio et al., 2020; Whittle et al., 2019). Thus, although consumers seem ready to pay for certain services (Ma, 2017), the first path of further research is to determine the willingness to pay of consumers for the LaaS-services. Given that LaaS is about providing convenience, discrete choice analyses of consumer demand and social cost-benefit studies of different scenarios could bring light to this matter. Simulation could then take help to estimate impacts of a LaaS concept on KPIs such as vehicle kilometers travelled and CO2 emissions.

Second, a LaaS of level 3 or 4 requires an open logistics infrastructure. Current studies on this topic, for example, on urban consolidation centers or shared pick-up points, have already highlighted the issues related to the sharing of logistics infrastructure, such as a lack of data integration (Beckers et al., 2021; Lindkvist & Melander, 2022). Nonetheless, different trends keep pushing for it. As such, there is a growing interest in the physical internet, which implies an open, connected, and standardized logistics system, improving the capability, efficiency, resilience, and sustainability of distributing goods (Montreuil et al., 2012). Yet, the integration that the LaaS can provide, on different levels, could be used to use dynamic price mechanisms to improve home delivery efficiency, better manage parcel lockers' capacity, allow a better connection between crowd shippers and other carriers, and other innovations. Hence, the LaaS could provide the IT backbone for the physical internet in the last-mile.

Third, questions remain surrounding governance, the public sector's role, and the actual effect on transport justice for older generations and the less well-off (Butler et al., 2021; Pangbourne et al., 2020). Because of the high political costs, the transport sector has been historically approached via indirect or *second-best* policies (Blauwens et al., 2014). LaaS allows policymakers to align freight practices with policy objectives, such as external cost internalization, by charging the user accordingly with the services consumed. Policymakers can allocate incentives and levies to favour specific mobility solutions that provide higher welfare, contrasting the consumer with the costs of their decisions. However, this needs to be tested in real-life. Potentially, policymakers should take a leading role as, similar to MaaS implementations, it is unclear who should take the first step, what gain-sharing models could be effective among the different stakeholders, and which juridical frameworks would be appropriate. Trust issues exist among companies and between companies and consumers, yet they should not be insurmountable. Again, the evolutions in passenger transport can serve as examples. However, we invite scholars from the field of city logistics to collaborate with other study areas to tackle these issues, such as transport law. It will be more difficult to generate sufficient levels of trust when one existing market player takes the initiative. Hence, we believe the potential lies with a third party or the local government. The role of the government within this story requires further research, as they seem to hold the key for a transition of the urban freight sector with the potential to steer logistics according to policy objectives. A configuration where all last-mile operations run through one platform eases the creation of a local level playing field, as checks for efficiency or regulations could be implemented quickly. However, logistics is only slowly gaining governmental attention, so a leading role in such an innovative step seems too early.

Besides these three barriers, we also identify two opportunities in addition to the ones outlined in this paper. First, we introduced the LaaS system within the context of e-commerce deliveries. This choice is because e-commerce is the exponent of the on-demand economy. Yet the delivery of online orders only makes up 5–10% of the urban freight market, but we see similar trends also occurring in the other freight flows (Beckers & Cárdenas, 2023). For example, short in space in dense urban environments, construction firms fragment the supply of construction material on an *ad-hoc* basis. As a result, wholesalers started with bike deliveries of construction materials. But also, restaurants and bars have an infrequent demand during busy evenings that could be supplied by a LaaS system, and with the expensive real estate, store owners and supermarkets are downsizing retail floor space to the minimum, relying on swift on-demand supply. These on-demand characteristics of other urban freight flows allow expanding the LaaS concept. Hence, we should not talk only about consumers but about receivers. Opening up the LaaS concept to other flows would increase the potential benefits for LSPs (i.e., as the market enlarges) and policymakers, as they could then align the other freight flows with the policy objectives.

Second, different from the earlier work by Le Pira et al. (2021), we conceive the LaaS as a freight-only system at this stage. Limiting to freight is because we focus on improving the logistics service to the consumer. The proposed levels of integration already require significant innovations in the somewhat static last-mile market. Hence we refrained from adding even more complexity. Nonetheless, if a logistics marketplace exists, it should be easy for individual crowdshippers to join that market. Moreover, due to the impacts of urban transport on cities in terms of emissions, safety, congestion, and space, passenger and freight flows will have to converge in the future city. As such Cavallaro and Nocera (2023) propose not only convergence in flows (e.g. parcels in the public transport vehicle), but also in infrastructure (pick-up points at the public transport stop) and find reductions in transport externalities through simulation. However, what role the LaaS can play in this evolution remains to be studied. In conclusion, the start- and endpoint of the last-mile, i.e., the consumer, holds enormous but unexplored potential. Thus, we call for considering the IT-driven integration of the receiver, which we here term the LaaS. The cities of Ghent, Leuven, and Mechelen will test this concept in the Flanders pilot of the Hozion Europe GREEN-LOG project. This pilot will uncover barriers to a LaaS implementation and objectively evaluate its impacts. These learnings will be invaluable for further exploring the consumer's potential for sustainable urban freight.

CRediT authorship contribution statement

Joris Beckers: Conceptualization, Investigation, Writing – review & editing, Writing – original draft. **Ivan Cardenas:** Conceptualization, Investigation, Writing – review & editing. **Michela Le Pira:** Conceptualization, Writing – review & editing. **Jia Zhang:** Investigation.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Jia Zhang reports financial support was provided by Horizon Europe. Co-author Michela Le Pira is co-editor of the special issue.

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