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The Role of Collaboration for Sustainable and Efficient Urban Logistics

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Abstract. The scarcity of resources is one of the main concerns for the present and the future of the environment and society. The "load factor" in logistic transport has a great potential for improvement, especially in the *last-mile* deliveries, as the transport of goods is largely fragmented between several small companies using small vehicles. This paper investigates the potential for collaboration to increase efficiency in urban logistics. Based on an overview of the concepts and initiatives regarding vertical and horizontal collaboration, a research agenda is proposed.

Keywords: Urban logistics, collaboration, sustainability, last-mile.

1 Introduction

Efficient logistic networks have a determinant role in the economic development of countries, regions, and cities. However, in urban areas, freight transport can have very significant negative impacts in terms of traffic, air and sound pollution, and the safety of the citizens.

According to the European Technology Platform ALICE [1], Eurostat surveys estimate that, for long-distances, 24% of vehicles transporting goods in the European Union (EU) are running empty. In comparison, the average loading of the other freight vehicles is 57%, yielding an overall efficiency of 43%. Flow imbalances can explain only half of this loss. The opportunity is estimated as representing 160 billion Euros and a reduction of 1.3% of CO₂ emissions.

Urban areas present a higher potential for improvement. The *last-mile* delivery is, in general, performed through a fragmented market. In Europe, 85% of freight companies dedicated to short distance deliveries have less than 5 employees [2]. They often work as subcontractors for large companies, but integration between services is not always achieved. These small companies perform the deliveries in the urban areas often using small trucks or vans. In this context, features such as the lack of standardization of packages, the deadline for deliveries, that is usually very short, and the difficulty of adapting the routes to multiple destinations can significantly reduce the load factor (the relation between the real and the potential loading weight) [3].

Resource sharing between stakeholders can improve efficiency in the transport of goods, becoming financially attractive to logistics operators, and bringing benefits for

the society and the environment. Despite the increased interest in transport collaboration in the literature, preliminary research suggests a lack of consensus on a *typology* for collaborative logistics in urban areas. This paper is a brief overview of collaboration in urban logistics, more specifically in the *last-mile* delivery, and presents some on-going initiatives in this sector. Moreover, this work seeks to develop a preliminary research agenda for collaboration in logistics, focusing on resource utilization and social impact.

The paper is structured as follows. The next section details the main stakeholders in collaborative transport and their interests. Then, an overview of collaboration in logistics is given, describing its different types, and presenting practical experiences as examples. Afterwards, a research agenda is presented, entailing the research gaps and opportunities in practice. Finally, we provide the conclusions of this preliminary research.

2 Stakeholders in Logistic Collaboration

Assessing the different types of partnerships in collaborative logistics is a necessary step to describe stakeholders and understand their needs. The overall cost of the supply network activities can be reduced through collaborative agreements between urban logistics stakeholders [4]. [5] classify the different stakeholders of urban transport according to the different land-uses, divided into three main categories: generators of transport demand, transport operators, and interface roles. Residents in the city and the main activities that generate trips (economic, leisure, and others) form the first group. The second category represents providers for the transport of goods and passengers. Finally, the last set includes the public authorities and professional bodies, responsible for planning and organizing the urban space. New solutions are dependent on local authorities' decisions, while the other stakeholders react to those choices.

[6] view the carriers, the authorities, the receivers, and the end consumers as the main stakeholders in urban freight. For these direct participants in the logistics chain, the main benefits of collaboration may be an increase in the load factor (and consequently a cost reduction), increased service capacity, reduced delivery time and, ultimately, increased customer satisfaction and improved image for the companies involved.

However, to this group of stakeholders, we need to add the actors indirectly affected by the urban supply chain, such as the city inhabitants, both users or non-users of public or private transport, and the environment. Therefore, our analysis encompasses the sustainability of the operation, adding the social and environmental goals to the economic standpoint. These three perspectives are often described in the literature as the three P's: People, Planet, and Profit, to which recently a fourth dimension was added, Policy [7].

For both public and private transport users, the reduction of trucks and vans naturally has a direct impact on traffic reduction and congestion. Moreover, the traffic reduction of trucks and vans in urban areas may lead to a significant decrease in the

number of accidents involving cyclists and pedestrians. In London, between 2008 and 2012, 53% of cyclist deaths involved heavy goods vehicles [1].

Additionally, the EU has set a target for 2030 of *zero emissions* from logistics operations in the major urban centres. As stated by the European Horizon 2020 innovation programme [8], this target can be achieved through actions that produce new solutions and practices for enhanced collaboration between suppliers, transporters, and public decision-makers in urban regions. The resulting reduction in air and noise pollution would be beneficial to the environment, and thus to citizens in general.

3 Collaboration in Urban Freight Transport

3.1 Vertical and Horizontal Collaboration

To reduce the environmental and social impact of freight transport, regional authorities often implement restricting land-use measures, such as limiting the size of vehicles, reducing parking places, and limiting access to urban centres during specific periods of the day. [9] argue that the negative consequences of these initiatives in terms of efficiency for logistics operators encourage companies to collaborate and share resources, in order to reduce the kilometres driven with empty vehicles. [10] argue that logistic companies look for collaboration as an opportunity to reduce costs, increase productivity, improve customer service, and expand geographical coverage. In the context of supply chain management, [11] states that transport should not be planned only as an operational activity since a collaborative approach can improve the performance of companies. These arguments reinforce the importance of collaboration for the urban logistic stakeholders, and the need to understand the emerging initiatives in the sector.

According to the literature, collaboration in logistics can be *vertical* or *horizontal*. "For vertical collaboration, transport is often organized along modes and service operators. In horizontal collaboration, multiple providers work together in the same section of the transport chain, potentially sharing orders and infrastructure" [12].

Vertical collaboration is part of the essence of logistics, since cooperation between stakeholders will always be necessary, whether at the level of Logistic Service Providers (LSP) complementing their operations (maritime, air and land), or at the level of producers, receivers or final customers, or even between existing platforms and carriers. [11] identifies different relationship degrees in vertical collaboration, that range from pure negotiation on prices to a closer and more integrated relationship composed of joint planning and information systems sharing.

[5] identify three main approaches for vertical collaboration: Efficient Consumer Response (ECR), which promotes automatic procedures to deal with supply chain links; Vendor Management Inventory (VMI), where the supplier is jointly responsible for warehousing; and Shared VMI approaches, with a consortium of producers and/or

grouped distribution stakeholders. [13] argues that although initiatives such as ECR and Collaborative Planning, Forecasting, and Replenishment (CPFR) are well known in terms of logistics, the best results of vertical collaboration arise from broad-based strategic collaboration towards a more partnering approach.

Horizontal collaboration is not new in logistics either. However, technological developments, in terms of Information and Communication Technologies (ICT) and Intelligent Transport Systems (ITS), have fostered the creation of new possibilities of collaboration for companies, therefore stimulating a growing interest by researchers. The first works on horizontal collaboration [9], [14] and [15] were often based on empirical studies, developed from the management and logistics principles available at the time, based on interviews with managers in the area, and also on comparisons with existing alliances in the air and maritime sectors.

We can find features from both horizontal and vertical collaboration in part of the initiatives implemented by enterprises on logistics. Although, by definition, horizontal collaboration initiatives generate more opportunities to harness idle resources. According to [16], collaboration in transport can take different forms and can be developed at different levels: transactional, informational, and decisional. The transactional level is, in general, vertical, and the other levels can be vertical or horizontal. In the next sections, we will further explore some of these alternatives for collaboration.

3.2 Freight Transportation by Customers

As in other fields of society, in recent years, several resource sharing initiatives have emerged in the logistics sector, as forms of the so-called *sharing economy*. Leveraged by the dissemination of internet and mobile technologies, logistics companies are stimulating the participation of citizens as occasional or, sometimes, regular service providers in the supply chain. [17] describe the example of the *pick-up* point networks, where the stores make the products available in a mid-location, such as locker boxes or fuel stations, and the final customers collect the goods themselves, performing the last-mile transportation to their homes or work. In other cases, these customers can make other deliveries in the neighbourhood. These are typical cases of vertical collaboration, in which the last leg of the transportation is not made by trucks or vans, but by the customers. Streetpotr and Task Rabbit are technological ventures in which persons can execute housework tasks to other people, including collecting and delivering goods [18].

Crowdsourcing in the last-mile is based on the same principles, with people being responsible for the final leg in the delivery, but, in this case, the customer takes advantage of a previously planned trip to transport the goods [19]. Crowdsourcing enables more efficient utilization of existing capacity, reduces transportation costs, and builds customer networks and local communities [18]. This type of service can enhance the urban mobility of both people and freight when the delivery route is integrated into an existing journey [20]. Indeed, detours from the planned journey or dedicated trips will most probably increase vehicle circulation in cities, as few packages are loaded on each delivery service. Several start-ups such as Walmart to

go, MyWays from DHL, and Deliv, are investing in business solutions based on benefiting from unused loaded space [21].

3.3 Urban Consolidation Centres

Urban Consolidation Centres (UCCs) are a successful way to reduce the number of large trucks circulating in city centres, quite often with a low load factor. [20] define an urban consolidation centre as "a logistic facility that is situated relatively close to the geographical area that serves the city centre, an entire city, or a specific place for which consolidated deliveries are made". Companies consolidate cargo at UCCs by sharing warehouses, vehicles, human resources, and ICT to reduce trips within cities. Due to these efforts to share goods and infrastructure, UCCs can be analysed from a horizontal or vertical collaboration perspective [10].

[23] lists several examples of joint delivery centres developed in Japan in the last decades, with a particular reference to the project in Yokohama. In this project, 17 companies shared the same UCC (Motomachi) and jointly organized and distributed their products using trucks with the initiative's brand, resulting in a reduction in the number of vehicles from 100 to 29, in the ten days of the project. [24] proposes, for Singapore, a solution of consolidated warehouses and synchronized last-mile, as an alternative to manage the scarcity of resources. Although experiences indicate a positive impact on environmental and social terms, most of these initiatives do not last long [25]. In terms of resource utilization, UCCs increase the load factor in the last-mile, but, on the other hand, they require high investments in infrastructure and ICT. Furthermore, this type of initiative raises costs and delivery times by introducing additional transshipment, often creating a heavy reliance on government subsidies that target social and environmental benefits [26].

3.4 Using Passengers Transport Resources for the Transport of Goods

A well-known collaboration strategy consists in sharing the city's passenger transport infrastructure with the urban logistics network. In many periods of the day, the capacity of urban public transport is under-utilized, thus creating the opportunity to plan the transport of passengers and goods as a single system [6]. [10] presents an overview of the leading research on the use of taxis, buses, and light rail systems to transport both passengers and goods. [27] describe some initiatives of this type, such as the Dabbawala System in India, that uses public trains for the transport of lunch boxes, or the Bussgods Service in Sweden and the Cargo Hitching in the Netherlands, both using bus services to transport parcels. [28] analyse the impact of product distribution through an intercity passenger transport network in Ceará, Brazil.

In similar initiatives, in which passengers and goods share the same infrastructure, logistics providers use the rail structure to transport products [29]. In Dresden, Cargo Tram transports car components to the Volkswagen plant, together with passengers, in the same tram service. Other projects in Zurich, Amsterdam, and Vienna were created based on the German experience.

3.5 Freight Pooling

Horizontal collaboration can be implemented by sharing different tangible and/or intangible assets, alone or in combination [14], such as logistics facilities, skills, and information systems. An example of this type of collaboration occurs when logistic service providers share the freight. In a conventional vertical approach, different operators perform each *distribution leg*, for example, when delivery has road, maritime and last-mile shipments. In this type of collaboration, increasing efficiency may involve better synchronization between partners or a reduction of the total routing cost [30]. Moreover, environmental-friendly initiatives have been launched for the last delivery leg in urban areas, using electric vehicles or bicycles [4], for example.

In another approach, the freight is shared, and each vehicle carries goods from different logistic operators simultaneously. *Freight transport pooling* can be defined "as the use of residual capacities of an already planned vehicle to include more goods" [5]. This type of horizontal collaboration can offer these companies benefits such as a reduction in the transportation costs, an increase of the service levels, handling costs decrease, and brand improvement, among others [31]. Moreover, freight pooling has the purpose of increasing load factors and decrease the number of trucks and vans in urban areas, thus reducing the social and environmental negative impacts of logistics.

Bilateral cooperations are usually based on flexible short-term arrangements, where purchase orders and packages are exchanged promptly to reduce inefficient routes [32]. In multilateral collaborations, agreements or contracts are formalized to define the governance strategy of the partnership, since companies have to control the degree to which structures, information, or purchase orders are shared. For example, in a case where companies are competitors in one market and collaborate in another market, limitations in these sharing schemes would be necessary [10].

For companies to participate in collaboration, there must be a fair distribution of the costs and benefits of the partnership. There is an extensive literature on cost allocation in vertical and horizontal collaboration. Proportional allocation is a simple approach based on the overall volume or weight of the goods. However, more often, these analyses are made using the principles based on game theory [33]. [31] applied the concepts of cooperative game theory in a horizontal collaboration between three companies in Belgium: the partnership improved the efficiency between 10% and 30%, concluding that flexibility, in terms of a time window for deliveries and split of orders, offers better results.

The mistrust between collaboration participants to share orders and information is another potential barrier for the creation of freight poolings. To assure their interests within a collaborative initiative, companies define a limited liability company (LLC) as an impartial entity, responsible for the central management of the alliance [34]. In autocratic alliances, the LLC centralizes decision power; in more participative alliances, the LLC acts as a moderator.

Another issue often studied in horizontal collaborative transport is the method to exchange requests. For this purpose, two main mechanisms can be found in the literature: the capacity exchange price, that defines a fixed rate for extra-capacity available, and auctions, formed by a bidding price-setting problem and a winner determination problem [32].

Companies currently use pooling as an alternative to UCCs, with digital platforms replacing the physical location for the exchange. In a more traditional business model, companies, producers, or receivers can use the internet to simulate, compare, and negotiate the complete supply chain for deliveries. Companies such as MCU Cargo and Transfix act as facilitators, offering platforms where companies can negotiate the freight, seeking for a simpler and faster transport process. Other business models offer logistic providers the opportunity to share the goods and available space on trucks, in a horizontal collaborative perspective. Truckpad and Bizzcargo are examples of this type of platform. UFreight is a mobile platform, in the prototype phase, for freight pooling integrating cargo bikes, where constant updates on requests, compatible with routes and capacities, improve the load factor and avoid empty return trips [35].

4 Research Agenda

While vertical collaboration has already been widely addressed in the literature, horizontal collaboration, and all its opportunities, has only recently become a subject of research. Although vertical collaboration is inherent to the logistics processes and has the potential to improve the performance of those entities involved in the supply chain, in this paper we claim that horizontal collaboration is more promising in creating new business models that emphasize sustainability in logistics and promote the *best use of resources already available*.

This research also indicates that, in some sense, existing business collaborative initiatives outweigh the knowledge accumulated in many years of research. Companies are overcoming the barriers mentioned above, and are investing and developing *new business models* to collaborate. This opens the opportunity to investigate, through studies in the field, how this evolution is taking place, and which may be the drivers for innovative forms of more sustainable collaboration in urban logistics.

The financial perspective in the decision-making processes of logistic partnerships seems to be predominant. Several scientific studies investigate the costs and benefits of partnerships in an exclusively financial way. But the overall aspects of these operations, which impact multiple stakeholders, should also be explicitly considered. This means *social and environmental issues need to be taken into account*, this being, therefore, a topic with great research potential.

Starting with the identification of the main drivers guiding the research agenda in this area, we first propose the *development of a typology* offering a new way of viewing collaboration. Such a contribution is needed since there is no comprehensive classification (typology) of the different forms of collaboration in logistics, accepted by the academic community and capable of synthesizing the existing terminology and concepts and aggregating the various initiatives that exist in the business world. In this context, this paper aims at contributing to the creation of such a typology.

This new perspective should go beyond the traditional categorizations, by emphasizing a better use of resources, and the consequent social and environmental impacts. Such an analysis should allow the assessment of the potential for

optimization of each type of collaboration, its effects on the different stakeholders, and its potential viability as a lasting solution for urban areas.

5 Conclusion

Partially loaded or empty trucks circulating through cities have, for many years, been considered as an intrinsic issue of urban logistics operations. If, in the past, these inefficiencies were somehow tolerated, today's awareness of the limitation and scarcity of resources, coupled with the increasing demand for sustainable operations, creates the right environment for the development of innovative, integrated and more sustainable solutions. In this way, collaboration in logistics emerges as an essential alternative to improve the use of resources.

However, aspects such as the fierce rivalry between companies, whose competitiveness is often based on price, resistance to sharing information, and strict cost-benefit analysis by participants, are obstacles to these new initiatives and often result in failed forms of collaboration. Therefore, the identification of criteria to guide the creation of new business models for companies willing to participate in horizontal collaboration initiatives, possibly triggered by the development of new technologies, will be of interest, not only for these companies but to public authorities that plan and regulate urban mobility.

In order to develop a research agenda for logistics collaboration, which involves the development of a typology for the subject, this paper analysed some critical concepts and components of different types of collaboration, aiming to develop more efficient logistics distribution solutions. The focus was put on the potential of logistic providers to create sustainable alternatives for sharing resources with their customers, with other modes of transport, or among themselves, or for taking advantage of private and public under-utilized infrastructure. This preliminary research agenda should cover the design of a typology on logistics collaboration for urban logistics, the analysis of existing business models for horizontal collaboration, and the mechanisms for a fair distribution of costs and benefits in more sustainable partnerships.

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