Investment in Greening Last-Mile Logistics: A Case Study

Franco Corti and Alessandro Nava

Abstract Based on growing interest in sustainable solutions in last-mile logistics, one of the most promising investments is the electrification of commercial fleets to decrease the high level of pollution created by urban freight traffic. In this case study, vans that can be driven with a C1 European driving license are considered, mainly used in B2B deliveries to small shops and SMEs in city centres. The purpose of this research is to analyse the reasons behind the choice of switching the last-mile logistic service fleet to electric and its economic and environmental implications and to analyse the main barriers to its implementation. To do so, we use interviews from managers working in a successful Urban Consolidation Center (UCC) in Italy. The Italian energy infrastructure, the cost of electric vans, and the actual insufficient technological development of van batteries are the key issues highlighted in the interviews, but lower operating costs, lower fuel costs, a decrease in negative environmental externalities, possible institutional cooperation and better working conditions for couriers are the main features to consider in the switch to electric.

Keywords ESG · Case study · Last-mile logistics · UCC

1 Introduction

Today almost 56% of the world's population live in cities with an urbanization trend that is expected to continue and reach a point where nearly 7 of 10 people will live in cities by 2050 (The World Bank Group 2022). With more than 80% of

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global GDP generated in cities, urbanization can contribute to sustainable growth through increased productivity and innovation. This rapid growth is also influencing the increasing demand for freight delivery in urban contexts and also the level of e-commerce and traffic (Digiesi et al. 2017). This phenomenon has several consequences, for our purpose, one of the most critical is that 25% of total global Green House Gas (GHG) emissions are related to transportation, 75% of which comes from road transport (IEA 2021). Governments and private organizations are not neglecting the environmental and social consequences of urban transport and so they are trying to develop and implement measures, policies, and incentives to counteract the high level of pollution generated. The problem relates mostly to GHG emissions, but also noise and safety pollution are externalities that must be incorporated into the negative impact on society.

The Fit for 55 programme (European Commission 2021) is a package of measures that have been elaborated to provide policy instructions to support Member States in cutting emissions by at least 55% by 2030. This target is going to be addressed through several initiatives such as an increase in the number of electric vehicles (EVs) or ones powered by alternative fuels. To sustain this measure, the EU's aim is to install charging stations every 60 km on main roads: the purpose is to install them by 2025 for cars and by 2030 for trucks in urban areas too. There are several measures proposed by the EU Commission to contrast pollution relating to manufacturing and restrictions on combustion vehicles by 2035 to a future increase in fuel prices for freight transport.

Focusing on urban freight transportation, as proposed by the Fit for 55 programme, a possible solution could be the electrification of vehicles. In this case, commercial fleets could take advantage of the intrinsic characteristics of EVs to reduce the negative impact with lower GHG and noise emissions, and better conditions both for couriers and the local community. The role of companies that provide services in urban areas is crucial, since they manage the usage and circulation of means of transport to deliver goods to and from their warehouses and places of final delivery, controlling the modality and routing of the whole process (Patella et al. 2021).

Existing literature investigates the impact of last-mile logistics provided with light electric freight vehicles (LEFVs) belonging to N1 category according to EU vehicle classification, as bicycles, tricycles, or small vehicles under 3.5 tonnes (de Oliveira et al. 2017; Lebeau et al. 2013; Schau et al. 2015). In this case, we focus on medium-sized vehicles, which are electric vans belonging to the N2 category, exceeding 3.5 tonnes but not exceeding 12 tonnes, and which can be driven with a C1 European driving license, thus limiting this group to those that do not exceed 7.5 tonnes. It is common to study small-medium-sized parcel deliveries, such as those related to e-commerce deliveries and LEFVs, but larger ones, which are likewise needed by shops and Small-Medium Enterprises (SMEs) located in city centres and delivered through medium-sized vehicles, are often neglected. On the other side, this phenomenon is not so well known because last-mile logistic services have difficulties integrating EVs that do not exceed 7.5 tonnes in their fleets. Therefore, the main purpose of this research is to investigate the reasons that could incentivize companies to convert their fleets to electric beyond existing technical solutions and the purchase cost factor.

2 Related Literature

To have an outlook on this kind of service the starting point is to analyse the related literature on bicycles, tricycles, and LEFVs. The first and one of the most important problems of last-mile logistics is that it is the least efficient stage of the supply chain (Wang et al. 2016). Up to 28% of total delivery costs are imputable to the last mile and it is due to several aspects, starting from the high cost of organization to the extensive amount of time spent accomplishing it, compared to the other steps in the supply chain. Some studies pointed out that these aspects are attributable to different determinants, i.e., a fragmented and uncoordinated service, traffic volume and, finally, Urban Vehicle Access Regulations (UVARs) and Low Emission Zones (LEZs) in city centres and particular areas in the industrial side of the city (Digiesi et al. 2017).

Some authors demonstrated that congestion, lack of loading/unloading parking due to high-density populations, inefficient planning and logistics sprawl lead to longer distances to final receivers, and so increase the negative externalities that the last-mile logistic service produces and the related costs (Coulombel et al. 2018). Congestion is mainly due to the high volume of traffic and the lack of city design (i.e., unloading parking, ancient narrow streets, etc.). At the same time, congestion could be partially solved with the creation of Urban Consolidation Centres (UCC) and mid-delivery points, as illustrated by Janjevic and Winkenbach (2020) and Trott et al. (2021).

The conglomeration of different last-mile logistic services to reduce the total cost of delivery is addressed by literature but it is very difficult to apply because of competition between different operators and clients. However, a possible solution to this issue is to set up a neutral service, which operates on a coopetition scheme to complete the last step of delivery (Zou and Zhao 2010).

Focusing on clients, some researchers pointed out that small stores suffer from a lack of storage space, so they need continuous inventory replenishment (De Magalhães 2010; Boulaksil et al. 2014). In this case, daily service is necessary, but at the same time, it has a strong social and environmental impact (Digiesi et al. 2012).

In urban areas, road freight transportation is the prime culprit for negative externalities related to delivering goods: as previously mentioned, they range from environmental impact to economic and safety issues. To decrease the impact of this phenomenon, switching fleets to electric could be a possible solution. However, commercial EV purchase costs are three times higher than conventional diesel vans, but the operating costs of conventional ones are almost four times higher than EVs (Digiesi et al. 2012). Delivery vans are more cost-effective for deliveries weighing 20 kg or more, and freight tricycles are more cost-effective with short time intervals (Tipagornwong and Figliozzi 2014). Focusing on the supply of SMEs and small shops in city centres, we want to investigate the use of medium-sized vans that are also necessary to deliver heavy and large packages (i.e., the typical size considered is a pallet).

Table 1 Interviews

Current role	Education	Experience
Logistics manager and deputy general manager	M.Sc.	>15 years
Operations manager	High School	>15 years
IT manager	M.Sc.	10 years

3 Method

To answer our research question, we decided to conduct a case study. This method is commonly used to consider context variables to explain a particular phenomenon, without the use of data but by creating a theoretical sample of single sources to obtain the information (Yin 2017).

In this specific case, we conducted an exploratory case study of a last-mile logistic service (LMLS) in Italy provided by a third-party company to different logistic operators who choose this neutral service for the last part of the delivery process. The effects of investments in greening this service are multiple, at the same time, we want to consider the effect on the city too and how the company wants to integrate EVs into its fleet.

The information was obtained through semi-structured interviews performed both in person and via video calls, confirmed with documents and direct observations. The limited number of experts belongs to the individual successful company and is identified through convenience sampling (Etikan 2016) and a summary of the LMLS managers interviewed is summarized in Table 1.

In these interviews, the two main topics were understanding the integration and measures LMLS has adopted in city centres and the barriers and benefits of switching its fleet to electric.

4 Results

The results of the interviews highlight several suggestions, thanks both to the extensive experience of the managers and the long company history, especially since this LMLS already tried a pilot scheme with one EV more than 10 years ago and it was unsuccesful.

Seven key aspects arose as reported in Table 2 and have been divided according to three main categories of the barriers to implementing the service: operational, safety, and economic (Paddeu et al. 2018).

The "payload and size of the van" is a real issue because of the market's lack of electric vans that do not exceed 7.5 tonnes equipped with a hydraulic tail. In this way, it is very difficult for LMLS to deliver medium-heavy packages to SMEs and city centre shops because smaller means of transport do not have the required payload and characteristics. Also, different van producers are innovating their offer

Table 2 Data structure

Example of quotes	First-order codes	Second-order themes
"We are rethinking our fleet: a part of small-medium-sized deliveries could be managed with a few LEFVs, so we could easily introduce some of them. At the same time, we have a problem with medium-heavy deliveries and the related vehicles to fulfil the operations"	The van's payload and size	Operational
"Personally, we have a sufficient energy infrastructure, even if it only gives us the possibility for slow charging. It is not currently feasible to foresee a scenario in which entire company fleets or a large part of the city switch to EVs that need to charge during the night"	Lack of energy infrastructure	Operational—Safety
"With EV we will sustain cheaper ordinary maintenance, but the real problem will be dealing with mechanical emergencies"	Maintenance	Operational—economic
"Our drivers need to work in safe and functional conditions, not only from an operational point of view but also from a personal one: having a van without the possibility of air-conditioning is out of the question"	Working conditions	Operational—safety
"There are several monetary incentives to modernise fleets, not necessarily to electric: EV costs are decreasing, but they are still very high"	Purchase cost	Operational—economic
"We are interested in medium-heavy duty vans, but the offer has only recently started to become available and affordable: the technological offer is rapidly changing, and it is tricky to predict which would be the best one"	Technological development	Safety
"A key issue is the constant high volatility on the electric market in terms of prices"	Energy costs	Economic

but the required applications (hydraulic tail, high durability batteries, etc.) use a lot of energy to operate and require more research and innovation to become affordable and reliable. This issue was highlighted by the pilot scheme that LMLS had tested previously because the van had a low battery after only a few deliveries.

A problem that cannot be ignored is the "lack of energy infrastructure" to charge EVs. The LMLS has its own source of electric energy production, thanks to its internal infrastructure developed in previous years using institutional financing sources in a Public–Private Partnerships (PPP), so it is not relevant to this case. However, the replicability of this service is at risk with the current energy infrastructure especially if some regulations push for the conversion of public and private fleets in an entire region or country. In this case, the capacity of the facilities would not be enough, and energy sources would not be from Renewable Energy Sources (RES), hindering the positive externality created by EVs. For this reason, the interviews also mentioned an interest in future financing sources of sustainable electric mobility and logistics from Ministries and from the National Resilience and Recovery Plan (NRPP).

Taking a deeper look into "maintenance costs", in the opinion of the qualified interviewed subjects operating and maintenance costs will be an estimated four times lower in comparison with diesel ones: the examined experience of the LMLS is controversial compared to some studies mentioned in the literature (Digiesi et al. 2017) that highlight higher costs. This point suggests further research and analysis by looking at innovations in batteries and related technology.

"Working conditions" cannot be underestimated or neglected: drivers cannot run out of power because of air-conditioning. On the other hand, less polluting vehicles, both from a reduction in GHG and noise, could also improve working conditions for them, creating better operating conditions.

Another issue that needs to be considered is the "purchase cost" mainly because the price gap between LPG/diesel ones could make a difference for last-mile logistic services. In this case, already having an LPG fleet the environmental impact is lowered compared to a diesel one, so the price of changing the entire fleet could not be sustained easily until a curtailment of prices. At the same time, knowing the precise cost of these new electric vans and how much they would cut fuel and operating costs, could help to anticipate, or delay the decision to change the fleet.

Focusing on "technological development", it is crucial not only to have strong progress on battery capacity for hydraulic tails but deliveries to city centre shops could also need refrigeration, which requires a significant amount of energy. Underestimating this issue could replicate the previous pilot scheme or delay switching the LMLS fleet to electric.

Finally, high volatility in terms of prices on the electric market cannot be disregarded. This increases the level of uncertainty the company is going to face because of the cost of fuel for the vans. Particularly, even if in this case, the energy to supply the fleet is internally produced by LMLS, this uncertainty factor affects the whole supply chain.

5 Discussion

Deepening the analysis of investments, we addressed the topic from three different perspectives, Economic, Governance, and Social (ESG), to gather the most important effects on costs and benefits highlighted by LMLS managers: economic (Table 3), environmental (Table 4), and social (Table 5) aspects.

As mentioned previously, fuel prices could be an issue: in this historical moment, the price of electricity is more convenient than diesel. If energy sources are going to be more expensive and the ownership of infrastructure is not going to be enough to sustain EV charging, from an economic point of view it will be more efficient to utilise vans powered by diesel or LPG. Focusing on "delivery times" of the service, with electric vehicles, there is the possibility to create incentives for municipalities and regulators to limit access to UVARs and LEZs in city centres to decrease congestion:

Table 3 Economic perspective

Example of quotes	First-order codes
"Due to current fuel prices and future EU directives, electric energy at the moment is the most convenient, even if it is risky"	Energy consumption
"With UVARs that many situations are experiencing with sustainable vehicles, delivery times are facilitated"	Delivery times
"Costs of purchasing EVs are high, but in comparison with diesel powered vehicles maintenance costs are lower"	Purchase cost

Table 4 Environmental perspective

Example of quotes	First-order codes
"To decrease GHG emissions we started with methane vehicles, but in general, with EVs, we could also achieve noise reduction in urban centres"	GHG and noise emissions
"Traffic congestion with EVs is less polluting, but still a huge loss of time and safety issues"	Traffic congestion
"The challenge is also to the energy supply chain. If I use the energy produced from polluting sources, I nullify the environmental benefits"	RES energy supply

Table 5 Social perspective

Example of quotes	First-order codes
"Safety for workers is a priority, if more sustainable means of transport are also sustainable and noiseless, they could work in a better way"	Safety
"Sustainability could be improved by optimizing routes, in our case, the years of experience of drivers requires an optimization led by technology"	Worker expertise

this way there will be considerable time savings for couriers who can be more efficient in terms of time saved and so increase the number of deliveries. Decreasing the amount of congestion is going to have a positive impact on GHG and noise emissions, thanks to a decrease in both the number of vehicles in circulation and the lower environmental impact that EVs have (see Table 4).

Focusing on the positive and negative environmental externalities of this case study, using EVs has a major positive impact. Starting from GHG emissions and noise, substituting LPG with an electric fleet could make considerable improvements to reducing these kinds of negative externalities, starting from improving air quality, reducing sound emissions of the vans, and improving living conditions, not just for the population, but for the drivers too with better working conditions (see Table 5).

As mentioned above, the RES energy supply is a key factor to consider: if EVs are not charged with this kind of power the whole effort is going to eliminate the reduced negative externality.

Now routing optimization of LMLS is entrusted to human choice by highly skilled workers (>10 years of experience). However, they are not able to recognise the best route to decrease environmental impact, nor probably the most efficient way to improve timing or avoid congestion. Therefore, it is key for this kind of service to use a routing optimization algorithm, implemented with the digital twin application to be more efficient, not only from an economic and environmental point of view but also from operational and social perspectives. To have efficient routing optimization, it is crucial to re-design cities and industrial zones, create and/or implement UCCs and unloading parking and mid-delivery points, to reduce duplication of the same routes by drivers.

6 Conclusion

From the interviews analysed with the ESG criteria, the high cost of EVs is the main issue that discourages LMLS from switching their fleet from fuel to electric, similarly to other studies. Despite this factor, there is still a great deal of interest in these kinds of investments to anticipate the expected future needs for more environmentally sustainable logistics. From the various solutions to be faced the purchase cost and upgrade to necessary infrastructure, PPPs and institutional financing are two that emerged as the most important. Collaboration between municipalities and public institutions and possibly with trade associations must be encouraged to split the costs of these investments. This partnership would facilitate the creation of UVARs and LEZs and so congestion and the number of vans in circulation in city centres could decrease. Institutional financing is one of the most attractive and challenging paths to follow from the recent NRRP and other financing methods that Ministries could propose.

The major limit of this analysis is that it is based on interviews with a single operating subject, and does not include the companies that buy this service, the municipalities involved, and SMEs that are the destinations of deliveries. It could be of great interest to implement this study with interviews with these other subjects and inspect the possibility to implement UCCs, mid-delivery points near to city centres and especially, unloading parking, the possibility to activate new UVARs, possibly new LEZs, and moreover to understand the intention to adopt more restrictive policies towards electric transportation.

Finally, two aspects of the LMLS that were only indirectly mentioned in the interviews but are crucial to decrease the impact of this kind of service are neutrality and consolidation. Conglomeration of orders and consolidation of packages from different last-mile logistic companies to a neutral third-party company is one of the great challenges to improve efficiency of last-mile logistics. In this way, congestion and environmental impact could be reduced, creating several positive externalities.

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