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(article starts on next page)

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Drivers for and barriers to electric freight vehicle adoption in Stockholm

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ABSTRACT

Freight transport in urban areas needs to become more sustainable. There is much potential to reduce emissions by transitioning to electric freight vehicles (EFVs). The context of this study is Sweden, a country with ambitious goals for transitioning to fossil-free road transport that incentivizes the adoption of EFVs through regulations, subsidies and environmental zones. However, it seems that few companies are adopting EFVs. This paper aims to explore why that is by investigating drivers for and barriers to the adoption of EFVs. An embedded case study of five firms in Stockholm that are exploring the possibilities of using EFVs is conducted. The findings reveal a number of drivers and barriers, which are then categorized as internal, external or governmental. The results show uncertainties at the micro, meso and macro levels. Uncertainties relate to political and legal uncertainties, technological and infrastructure-related uncertainties, customer expectations and willingness to pay, and operational uncertainties.

1. Introduction

There is much focus on how freight transport in urban areas can become more sustainable (Kin et al., 2017; Rai et al., 2017). In particular, there are concerns regarding the negative environmental and social impact of freight transport, such as greenhouse gas (GHG) emissions, air pollution, traffic congestion and noise in cities. One solution for urban freight transport is the transition to electric freight vehicles (EFVs) (de Oliveira et al., 2017), which has enormous potential for reducing environmental impact (Biresselioglu et al., 2018). There has been much focus on the transition from combustion engine cars to electrical vehicles (EVs), and it has been shown that the transition to EVs would reduce GHG emissions considerably (Xu et al., 2020). However, less is known about how freight transport can be electrified.

Improving the state of the environment by reducing emissions is high on the Swedish political agenda. A third of Sweden's GHG emissions come from transport (Naturvårdsverket, 2020). A target has been set to reduce transport emissions by 70% by 2030 compared to 2010 emission levels (Energimyndigheten, 2018). The majority of transport emissions come from road traffic, in particular cars and heavy vehicles (Naturvårdsverket, 2020). To reduce emissions, it has been suggested that the transport sector needs to make continuous improvements in efficient logistics and transition towards fossil-free fuels (Naturvårdsverket, 2020).

Sweden has set tough goals for the transition towards fossil-free freight transport and is providing monetary incentives for firms to invest in EFVs through regulations, subsidies and environmental zones (for example in Stockholm). One incentive is Bonus Malus

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(Transportstyrelsen, 2021), which aims to increase the proportion of environmentally friendly vehicles and contribute to a fossil-free vehicle fleet in Sweden. Bonus Malus means that environmentally friendly vehicles with relatively low CO_2 emissions are rewarded with a bonus, while vehicles with relatively high CO_2 emissions are subject to higher taxes. Bonus Malus includes vehicles under 3.5 t. Another incentive is Klimatpremie (Energimyndigheten, 2020), by which the government pays a premium for certain environmental trucks (heavier than 3.5 t). The premium will promote the introduction of environmental trucks on the market and contribute to the reduction of greenhouse gas emissions. Klimatklivet (Naturvårdsverket, 2022) provides support for public charging stations and for non-public charging stations for vehicles other than passenger cars, for example trucks, regardless of whether or not they are publicly operated. In Stockholm there are two environmental zones (Stockholms stad, 2020). On 1 July 2022, the requirements for environmental zone 2 in Stockholm will be strengthened such that diesel-powered cars, light buses and light trucks will need to meet the emission requirements for the Euro 6 class. Despite this, it seems that uptake is slow and that few companies are adopting EFVs. For example, Sweden has around 84 000 heavy trucks (trucks over 3,5 tons), and at the end of 2020 there was a total of 30 electrified heavy trucks in Sweden (Power Circle, 2021). In February 2022, there was about 9 000 light trucks that were either fully electric or hybrid vehicles (Power Circle, 2022).

We want to understand what is influencing the speed of this transition by investigating the drivers and barriers that exist for the adoption of EFVs in Stockholm. Sweden is an interesting case as it has high ambitions for a transition to EFVs, but, despite taking actions to promote it, it has not taken off. Hence, this paper aims to investigate: (i) what drivers exist for adopting EFVs and (ii) what barriers exist to adopting EFVs. These questions are investigated through an embedded case study of firms operating in Stockholm that are exploring the possibilities of using EFVs. Through our study, other actors can learn from both what drives and what hinders the transition to EFVs. The study is limited to commercial companies and does not include fully or partly state-owned companies.

The findings from the study point to a number of drivers and barriers, which are categorized as internal, external or governmental. Internal refers to firm-specific drivers and barriers related to individual firm characteristics, such as management engagement or its own infrastructure investments. External refers to the environment outside of the firm, including stakeholders such as customers but excluding governmental organizations. The governmental dimension refers to governmental drivers and barriers, such as taxes, subsidies and political decisions. While the governmental dimension could be viewed as part of the external dimension, we opted to keep it as a separate dimension. There is a clear distinction between market-driven factors (what we call external in this paper) and governmental factors. The study provides extensive examples of both drivers for and barriers to EFV adoption in urban areas. The results also show uncertainties on the micro, meso and macro levels. The micro level refers to that of the organization and includes individual firms and organizations. The meso level consists of business networks and includes collaborations between firms, such as inter-organizational collaborations and partnerships (Garcia et al., 2019). Finally, the macro level consists of social and environmental factors such as governmental and policy decisions. On the micro level, firms struggle with uncertainties over investing in EFVs as it is not clear if electromobility is the most suitable transport solution for the future. Firms also struggle with the uncertainties of planning, executing and managing a mixed fleet of vehicles. On a meso level, there are uncertainties in the business network related to customer demand, expectations and willingness to pay for electrified transport. On the macro level, there is society-wide uncertainty over potential political and legal changes born out of political ambivalence towards future transport solutions, incentives, investments and regulations. There are also uncertainties related to available charging infrastructure and grid capacity. In addition, there are uncertainties related to the development of and political views towards electrification, hydrotreated vegetable oil (HVO), hydrogen gas and biogas.

This paper is structured as follows. First, research on EV adoption and EFV adoption is presented. Next, the methodology is described. The case findings are then presented, followed by the drivers for and barriers to EFV adoption. Finally, conclusions are provided, including theoretical, managerial and policy implications.

2. Literature

2.1. Electrical vehicle adoption

Unlike for EVs, few studies have investigated the drivers for and barriers to EFV adoption. In this section, we point out the main drivers for and barriers to EV adoption, some of which may be similar to those to EFV adoption. A recent literature review found that drivers for EV adoption included potential environmental benefits, purchase-based incentive policies, business model development, government regulations, symbolic attributes, use-based incentive policies and environmental concerns in their decision-making (Kumar & Alok, 2020). The same study identified many more barriers related to, e.g., charging, infrastructure, cost and behaviours. However, a recent study of Nordic countries found that the most commonly identified barriers to EV adoption were range, price, public charging and mental barriers (Noel et al., 2020). The literature review on EV adoption by Kumar and Alok (2020) shows that most publications focus on electrical cars. There are also a number of studies that have investigated drivers for and barriers to electrical car adoption (e.g. Giansoldati et al., 2020; Jansson et al., 2017; Priessner et al., 2018; Thøgersen & Ebsen, 2019).

A number of studies have investigated what motivates individuals to adopt EVs. These motivations consist of the environmental, economic and technical benefits associated with EVs, as well as personal and demographic factors (Biresselioglu et al., 2018). Hence, there are a wide range of factors that influence and motivate individuals in deciding to use EVs. An Austrian study found that psychological and socio-demographic factors play a role in predicting EV adoption (Priessner et al., 2018). The authors also found that early adopters of EVs tend to live in areas with EV-policy incentives. Similarly, a study conducted in Sweden points to the importance of interpersonal influences and attitudinal factors as drivers for EV adoption (Jansson et al., 2017). Meanwhile, a Korean study shows that driving range and financial incentives, such as subsidies and tax exemption, act as motivators for EV adoption (Kim & Heo, 2019).

Monetary incentives such as rebates on energy bills, parking fees and subsidies for upfront purchase costs are useful for promoting EVs (Gong et al., 2020). Motivators related to environmental benefits and monetary incentives (such as subsidies) would also probably be motivators for EFV adoption. Other EV adoption drivers, such as psychological and socio-demographic factors and interpersonal influences and attitudinal factors would probably not be as important drivers for EFV adoption, as these are used in business contexts and not for private use (which is the setting for most EV adoption studies). However, creating incentives and building infrastructure may not be sufficient to push a fast transition. As Thøgersen and Ebsen (2019) point out, although Denmark applies subsidies to EVs and has well-developed infrastructure to support them, the adoption of EVs in the country is still slow. Hence, there are other barriers slowing the pace of EV adoption.

There are a number of recent publications that address barriers to EV adoption in different geographical areas (Asghar et al., 2020; Biresselioglu et al., 2018; Giansoldati et al., 2020; Tarei et al., 2021). A recent literature review of barriers to EV adoption points to those related to technology, infrastructure, finance, behaviour and external factors (Tarei et al., 2021). Another review, focusing on Europe, shows that barriers include a lack of charging infrastructure, economic restrictions and cost concerns, technical and operational restrictions, lack of trust, lack of information and knowledge, limited supply of electricity and raw materials, and practicability concerns (Biresselioglu et al., 2018). A review based in Pakistan points to state financial subsidies, market prices, technical malignancy and social drawbacks as barriers for EV adoption (Asghar et al., 2020). An Italian study finds that insufficient density of fast charging stations and the high initial purchase price were the two most important obstacles to EV adoption (Giansoldati et al., 2020). Some of these barriers may also act as EFV adoption barriers, such as the lack of charging infrastructure and cost related issues such as the high initial purchase cost, which affect both businesses and individuals.

2.2. *Adoption of electrical freight vehicles*

While research on the adoption of EVs is plentiful, fewer studies have been conducted on EFV adoption. Research into EFV adoption has been done by Anderhofstadt and Spinler (2019), who conducted a Delphi study in Germany and found that motivators for EFV adoption with regard to heavy vehicles were the ability to enter low-emission zones, total cost of ownership (TCO) and emissions reductions. They found that the barriers consisted of the purchase price, charging infrastructure and range issues. Another German study points to a need for policies to support EFV adoption, such as support for company-charging infrastructure and municipal tenders that request emission-free vehicles (Taefi et al., 2016a). Public sector customers can demand more sustainable transport in their tenders and thus push firms to invest in EFVs. However, it may be that government policy actually works against EFV adoption, for instance Skippon and Chappell (2019) showed that public sector procurement contracts restrict contractors to acquiring vehicles from framework suppliers that do not supply EFVs. Ablola et al. (2014) conducted a Delphi study and found that cost and vehicle performance were the main barriers to the adoption of EFVs in London. A recent Italian study of food transport shows the need for governmental intervention to overcome barriers to EFV adoption, such as simplifying issues related to installing charging points, reinforcing green local urban policies, providing financial and non-financial incentives for EFV purchases (e.g. parking-space privileges and charging station presence) and investing in charging infrastructure (Galati et al., 2021).

A comparative analysis of EFV initiatives between five European countries identified barriers that included a lack of profitability, small operating ranges, loss of payloads and a lack of after-sales services (Taefi et al., 2016b). The same study identifies having a green image as the main motivator for EFV adoption and emphasizes the need for subsidies and operational privileges such as access to city zones. Our study provides empirical examples that complement existing literature on drivers for and barriers to EFV adoption, confirming the findings of previous studies while also providing new examples. In addition, we discuss uncertainties related to EFV adoption on the micro, meso and macro levels.

3. Methodology

3.1. *Research design*

This research was based on a qualitative study of an embedded case study that included five firms. A qualitative approach was selected due to the explorative nature of the research (Yin, 2009). We aimed to use an information-rich setting, hence the study being based in Sweden, a country with tough transport regulations and ambitious environmental goals for road transport. The city of Stockholm was selected since it has implemented environmental zones and has much freight traffic, to both private and public customers. We applied a purposeful sampling strategy (Patton, 2002) in collaboration with the firm Novoleap, which focuses on helping firms transition to sustainable transport options. All of the case study firms participated in a research project run by Novoleap, through which they aimed to explore the possibility of increasing their usage of EFVs. Novoleap used their customer base of freight transport firms operating in Stockholm to identify potential case companies. These companies were contacted and asked if they were implementing, or planning to implement, EFVs in their fleet. From this sample, five haulage firms operating in Stockholm looking to expand their EFV fleets and that showed interest in participating in the project were selected for the study. These five firms represented the sample for the research project. No additional firms were asked to participate. When analysing the data, we discovered that after analysing three firms, no new themes of drivers or barriers were discovered. However, the additional two firms provided more nuances and examples for these themes. Therefore, we decided that no additional case firms were needed as we had reached data saturation. The research project consisted of two parts, a qualitative part, which is reported in this paper, and a quantitative part, in which route data from the five companies was collected and analysed and scenarios for emissions and costs were developed for three different fleet set-ups (only combustion engine vehicles, only EFVs, and a mixture of combustion engine vehicles and EFVs). The quantitative study facilitated the discussion in the workshops, as it presented scenarios of costs and emissions depending on the firms' mix of EFVs and combustion engine vehicles in their fleets.

The embedded case study included five companies (Firms A, B, C, D and E). Table 1 shows an overview of the firms in the study covering their business and sustainability focuses and fleet set-ups. Firm A is the largest online food store in Sweden; it employs 1,700 people and has locations in the three largest cities in Sweden. Firm B delivers food to restaurants and businesses and has a leading position in the Swedish market; it employs about 3,200 workers and serves the entire Swedish market. Firm C belongs to a large international business focusing on textile rental; however, the part of Firm C that is included in our study only provides rental services for door mats in the Stockholm area. Firm C has 1,500 employees in Sweden. Firm D is a family business that provides vending machines to workplaces and refills them with coffee, tea, breakfast, lunch, fruit and other items; it has 250 employees. Firm E delivers food to restaurants, schools and other organizations; it has about 400 employees and belongs to a larger company group. All of the firms in the study provide delivery services within the city of Stockholm and operate transport routes to Stockholm and smaller cities nearby, for example Stockholm-Uppsala-Stockholm. The firms have their premises in Stockholm, where they start their duty cycle and then transport either within Stockholm or to smaller cities in the Stockholm-Mälaren region. The average distance covered and operating hours for the firms' fleets were as follows: Firm A – 86 km and 07:00–22:00, Firm B – 48 km and 05:30–18:00, Firm C – 73 km and 07:00–18:00, Firm D – 25 km and 07:00–16:00; we were not able to access this information for Firm E.

3.2. Data collection

Data has been collected from multiple sources (Eisenhardt & Graebner, 2007), including semi-structured interviews, workshops and secondary sources. We conducted five interviews with seven respondents. An overview of the respondents is presented in Table 2. An interview guide was developed that focused on background information about the company, transport strategies, vehicles, charging infrastructure, regulations, business relationships, activities, future considerations and aspects of environmental sustainability. The interview guide consisted of open questions, allowing for follow-ups and flexibility during the interviews. The interviewees at each firm were sampled based on their knowledge of transport, routes and charging infrastructure, as well as their strategic insight into distribution. When contacting each firm, we described our study and requested the most suitable respondents. Hence, the sampling of respondents was done in collaboration with the firms. We interviewed the most knowledgeable individuals involved in the EFV strategies at the firms. All our respondents are experts on EFV implementation within their firm and hold management positions. The respondents had varied levels of experience of freight transport, ranging from 4 to 25 years. The interviews were conducted through online video calls and lasted between 45 min. and 1 h. All interviews were recorded and transcribed. Secondary sources used were books, journal papers and conference papers as well as corporate documentation, consisting of company and transport information (routes and fleet composition) as well as press releases and news articles. These secondary sources were used to verify and validate the data from the interviews and workshops.

About three months after the interviews, workshops were conducted with each of the involved firms to present, discuss and validate preliminary findings as well as collect additional data. In total, ten individuals from the firms participated in the workshops; these are listed in Table 2. Five workshops were conducted, and each workshop lasted 1 h and 30 min. First, the firms were asked if they had made any changes or investments or had new experience of EFVs since the time of the interview. Thereafter, preliminary findings from the interviews and secondary sources related to each company were discussed. A number of drivers for converting to EFVs were presented and discussed with the participants followed by barriers. Finally, a summary of preliminary findings was presented and discussed with the participants. Hence, through the workshops, preliminary findings were presented, discussed and validated and additional information was collected. The respondents restricted discussion to the types of vehicles used in their own operations (Firm A, C and D refer to EFVs under 3.5 t while Firm B and E refer to EFVs over 7 t). The respondents discussed the freight transport that they

Table 1
Overview of firms in the study.

Firm	Business focus	Sustainability focus	Fleet set-up
Firm A	Home food delivery	Green deliveries Daily route optimization to reduce CO_2 emissions	1 EFV out of about 300 vehicles Fuel: diesel, HVO100, electricity
Firm B	Food delivery to restaurants and businesses	Route optimization to reduce filling rate and CO_2 emissions	400 large goods vehicles (LGVs) 1 EFV ordered Fuel: diesel, HVO100 and biogas
Firm C	Renting carpets to schools, hotels, companies, etc.	Circular business model	6 EFVs out of 64 vehicles Plan to replace another 16 with EFVs Fuel: diesel and electricity
Firm D	Food and drinks delivery to businesses and organizations	Route optimization Eco-driving education for drivers	1 EFV out of 110 vehicles Fuel: HVO100 and electricity
Firm E	Food delivery to restaurants and organizations	Shared deliveries through collaboration with other firms Eco-driving education for drivers	108 LGVs, 3 run on gas No short-term plan for EFVs Fuel: diesel, and compressed biogas (CGB)

Table 2
Interview respondents and workshop participants.

Firm	Respondent(s)	Interview	Workshop	Abbreviation
Firm A	Regional distribution manager	X	X	A1
	Sustainability manager	X	X	A2
Firm B	Transport manager	X	X	B1
	Service and maintenance manager		X	B2
Firm C	Distribution manager	X	X	C1
	Logistics manager		X	C2
	Planner		X	C3
Firm D	Vehicle manager	X	X	D1
Firm E	Transport manager	X	X	E1
	Data analytics manager	X	X	E2

use in their operations, which for all respondents included city transports within the city of Stockholm and regional transports operating between Stockholm and nearby cities.

3.3. *Data analysis*

The analysis started with individual case descriptions and analysis for each embedded case (Eisenhardt, 1989). The collected data was divided into topics, such as challenges of EFVs, benefits of EFVs, experience of EFVs, alternative fuels, infrastructure, network actors, infrastructure, sustainability and future outlook. The lead author coded the data before discussing it with the other authors. Hence, the authors reviewed the coding structure, which ensured an in-depth understanding of the data set between the authors. Several themes from the literature guided the coding process (i.e. regulations, lack of infrastructure and range limitations). Hence, we ensured that there was a link to previous literature while allowing for flexibility to incorporate themes from our data (i.e. profiling firms, teaching customers and software limitations). The coding was done in three steps (Gioia et al., 2013). First, we used open coding and sorted the information into first order codes (see Fig. 1). The open codes were descriptive and related to positive (drivers) and negative (barriers) statements. Second, open codes were clustered into second order themes. Following the initial concepts, we revisited the data to see which first order concepts fitted into which second order themes. In total, we identified ten themes for drivers and ten themes for barriers. Third, we created aggregated dimensions underlying the second order themes. Firm-level themes such as ‘the firms’ own engagement’, ‘branding’, ‘cost reductions’ and ‘learning opportunities’ were combined into an internal driver (aggregated level). The aggregated levels in our analysis are internal, external and governmental, which are derived from the data. Internal refers to drivers and barriers within the firms (i.e. their management engagement, infrastructure investments and software

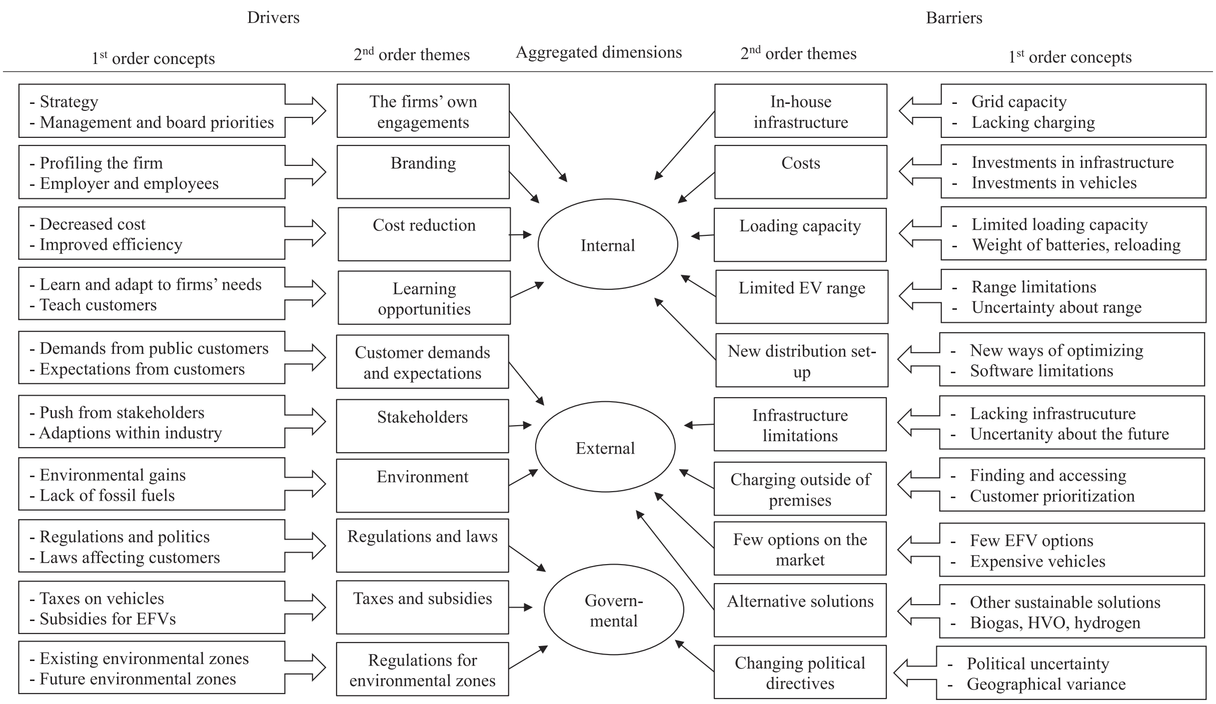

Fig. 1. Data coding and structure.

limitations). External drivers and barriers refer to the environment outside of the firm, including stakeholders such as customers but excluding governmental organizations (i.e. public charging infrastructure, other sustainable solutions and adaptions within the industry). The governmental dimension refers to governmental drivers and barriers (i.e. taxes, subsidies and political decisions). See Fig. 1 for our data coding and structure. While analysing our data, we moved back and forth between clusters and categories, revisiting data and developing new categories to better explain the themes of our study. Following this analysis, we identified uncertainties related to these drivers and barriers, which we categorized into micro (company), meso (business network) and macro (society) levels (Garcia et al., 2019; Leviäkangas & Öörni, 2020). The micro level relates to that of the organization and includes individual firms and organizations. The meso level consists of business networks and includes collaborations between firms, such as interorganizational collaborations and partnerships (Garcia et al., 2019). Finally, the macro level consists of social and environmental factors such as the government and policies.

All interviews and workshops were conducted in Swedish, and thus the quotes in the paper are translated. A final report of our findings was written and made available for the respondents in our study to provide feedback on the results. Hence, there were several feedback loops between the researchers and respondents (i.e. we enabled discussion of preliminary results during the workshops, we sent emails to participants after the workshops to provide an opportunity for clarification or give additional statements and we provided a final report that the respondents could review and comment on). We developed a data repository for our case study research, containing all the transcribed interviews, secondary data, discussion notes and intermediate results development accounts.

4. Results: Adopting EFVs for distribution

4.1. Drivers

Findings from the embedded case study indicate clear engagement with sustainability; however, the firms identify a number of limitations and issues. An important starting point for the firms in the study was their own interest in becoming more sustainable. The management of these firms were all pushing for the use of EFVs, particularly in urban areas. For instance, *"It's a way for us to differentiate ourselves from our competitors and strengthen our brand – not only as a supplier but also as an employer, to show that we take our responsibility seriously." (C1)* All of our interviewees pointed to their firm's own sustainability engagement. For example, *"It's foremost the firm's own engagement in making the transition towards more sustainable transport solutions that is driving this change." (B1)* The firms are also aware of their image and want to be known as sustainable brands: *"We want stakeholders to be aware that our brand is highly engaged in these issues and that we are innovative and part of these future sustainability developments [in transport]." (A1)*.

When considering the total cost of the vehicle, it is believed that EFVs can actually be the cheaper option, as described by Firm C: *"You have to look at the overall cost. If someone asks me what the vehicles cost to buy, then sure, EFVs are more expensive than diesel vehicles. But, when I look at the total cost, including subsidies, taxes and fuel, then that is no longer true." (C1)*.

Customer demand and expectations push firms to convert to EFVs. Public customers in particular are increasing their demands for fossil-free deliveries. *"We have some customer segments that want us to transition to EFVs; many public customers are pushing pretty hard. Some private customers are also interested, but they are still few in number." (B1) "Public organizations face demands on how deliveries are conducted, whether you use delivery sharing, the types of vehicle you use and so on. These demands are increasing. Also, private customers have started having similar demands. It's right on time." (E1)* Firms are aware of rising customer expectations for fossil-free transport, and thus the transition towards EFVs. Here, they have identified the need for learning opportunities before customers demand EFV transports. *"We need to relearn everything, how the trucks work, how the charging works; we need to learn how to build our routes. There are a lot of new things to consider and we need to learn how to get our customers to accept this and to share the costs." (B1)*.

All of the firms studied have public actors as customers. They have experienced how environmental demands have increased in the public procurement process and become more important for this customer group. *"Public procurement has started to include clear demands for fossil-free transport. It is actually a starting point in public procurement nowadays." (D1)* Previously, fossil-free deliveries were something that could be negotiated outside of a contract, but that is no longer the case. *"It is becoming more and more a standard in public procurement that you need to promise a certain percentage of fossil-free transport. Previously, this was something that you could say was difficult to accomplish, and contractors would let you get away with not fulfilling it. But today, it is becoming a non-negotiable demand. It has moved up the priority list and become the most important thing." (A1)*.

Regulations and political decisions, such as on environmental zones, subsidies and increased taxes on diesel vehicles, have an impact on the transition towards EFVs: *"Laws and regulations govern the whole of society. It puts demands on our customers, who in turn put demands on us and so on." (E1)* Urban transport has been in focus when it comes to regulations; in Sweden, the centre of Stockholm has tough regulations and strict environmental zones. *"We see regulations in various parts of Stockholm, and we believe that more restrictions on particular vehicles will be implemented in the near future."* (E1) *"We saw the rise of environmental zones in Stockholm, and it was time to find an alternative solution to diesel vehicles." (D1)*.

To summarize, we have identified a number of drivers for adopting EFVs in distribution that we have categorized as internal, external or governmental. First, for internal drivers we have identified four groups, namely the firms' own sustainability engagements, branding (including personnel issues), cost reduction, and learning opportunities before demand from customers and new regulations. Second, for external drivers we have identified three groups, namely customer demand and expectations, stakeholders and the environment. Third, for governmental drivers we have identified three groups, namely regulations and laws, taxes and subsidies, and environmental zones. The drivers are illustrated in a number of ways; these are presented in Table 3.

4.2. Barriers

The firms in the study pointed to a number of limitations of the EFVs that are available on the market today. All the firms were concerned with the limited payload of the vehicles due to the weight of the batteries. The difference in the payload of an EFV compared to a diesel truck is quite significant: *"We have difficulties using EFVs as they have a very limited load capacity; we can only load 55% of what we would normally load on a diesel vehicle." (A1)* As a result, Firm C had changed its planning and distribution, splitting one trip for a diesel truck into two trips for an EFV: *"Our market area is geographically small, so it's not time that's the issue, it's the load capacity; EFVs have a smaller load capacity and thus need to be reloaded." (C1)* These changes also impact the drivers: *"It's a change for the drivers, who have an attitude of 'we've always done it this way' and don't want to return to our location to reload, which they didn't need to do with the diesel trucks." (C3)*.

The optimization and route planning that is used today by Firm A seems not to be suitable for EFVs. *"We have two main limitations when we optimize our distribution: how many hours a person works and load capacity.... Theoretically, the EFV would be great if it could load three times as much as it can today. It could make many deliveries in the city centre over small distances, but due to current limitations we get none of the capabilities we want from a vehicle. We get a vehicle that has a short range, needs to come back for recharging and can't carry as much weight as we would like." (A1)* Due to the different characteristics of EFVs, firms need to adapt the way they operate, optimize and plan their distribution to accommodate reduced load capacities and shorter ranges. Operationally, it is difficult for Firm A to include EFVs in the same planning as diesel vehicles, particularly if the EFV needs to be charged during the route. *"We plan for 500 routes every day. But we can't plan for charging in the programs that are available today. Where to charge on the route is a difficult problem to solve and it costs us in time and planning as well as time for the drivers when charging." (A1)*.

Another issue experienced by the firms in the study with EFVs is their limited range, depending on the size of the battery. Firm A, which was the first in Sweden to use an EFV for distribution, realized that the promised range of an EFV was not its actual range. As a

Table 3
Drivers and examples of how they are illustrated.

Level	Identified drivers	Illustrated through
Internal	The firms' own engagements in sustainability	Strategic decisions made by firms
		Management prioritizing sustainability and pushing for fossil-free transport
		Being innovative and implementing new sustainable solutions
		Clear message from the board of directors regarding sustainable transport
	Branding	Profiling as more sustainable compared to competitors
		Strengthening the brand
		Aiming to be a sustainable and trendy brand to customers, investors and employees
		Not limiting sustainability to intangible values but doing something concrete that is visible to everyone
		Visualizing the brand in connection with sustainability issues (EFVs)
		Sustainable innovation as part of the brand
		Being first on the market with EFVs
		Showing that the firms take responsibility as employers
		Employees being proud that their firm uses EFVs
		Attracting personnel: today's youth want to work at environmentally friendly firms
	Cost reduction	Decreased costs for usage and service
		Decreased TCO compared with diesel vehicles
		Possibilities for increased efficiency, particularly if it becomes possible to load more into smaller trucks (this refers to a possible change in future regulations, which would allow heavier loading in smaller trucks compared with today, as discussed in Torgnyson Klemme et al. (2020))
	Learning opportunities before demand from customers and new regulations	Learn how the vehicle and charging process work
		Learn how to build a distribution strategy with EFVs,plan for new routes and create a good working environment
		Learn how to adapt the EFVs to the firms' needs (such as specialized modules for the vehicles)
		Need to teach customers to accept EFVs and make customers request EFVs
		Explore how customers can help with charging possibilities
External	Customer demands and expectations	Public customers are pushing for fossil-free transport
		Public procurement demands for fossil-free transport
		Private customers asking for a transition to fossil-free transport
		Larger private customer groups have environmental demands for transport
	Stakeholders	Many stakeholders are pushing for sustainable transport
		Actors within the industry are adapting to EFVs
	Environment	Environmental gains
		Less availability of fossil fuels
Govern-mental	Regulations and laws	Political decisions
		Laws and regulations that directly or indirectly put demands on firms
	Taxes and subsidies	Increased taxes on diesel vehicles
		Low taxes on EFVs
		Subsidies for EFVs
	Environmental zones	Existing environmental zones and restrictions in urban areas regarding the types of vehicles that are allowed
		Future fossil-free zones in parts of Stockholm

result, the vehicle ran out of power many times and could not be driven back. *"A comment we often got when we started using the EFV was that it was more often towed than driven back to our parking lot. Today, we can use it in our operations, but we'd rather not since it's the weakest vehicle in our fleet." (A1)* The limited range of EFVs is a concern not only for individual firms, but for the transport sector as a whole. *"A challenge for the whole industry is the limited range of EFVs, especially for vehicles that use electricity for a lot of other functions, such as cooling, heating, lifting and so on." (E1)*.

Firm C thinks that there are few electrical options available for trucks. Firm C, which has the most EFVs of the firms in our study and also has a strategy to exchange more diesel trucks for EFVs, views the electrical truck market as slow. *"I wish the market had come a bit further, that manufacturers had been a bit more alert and were now providing second-generation EFVs. They have been quite slow, but maybe that market was not ready." (C1)* Firm C believes that manufacturers are uncertain about the future and therefore have been slow to develop EFVs and introduce new products to the market. *"We see that many vehicle manufacturers are waiting to introduce new vehicles because they are uncertain about the future. Many manufacturers are late in their developments and have only a few or no vehicles on the market. It's clear that the manufacturers see many uncertainties." (C2)*.

The firms in our study expressed concerns that there are limitations in the power grid that makes it difficult to make investments that would allow for a fleet of EFVs to charge simultaneously: *"I see the limitations of the grid that supplies our facilities even today. Already, when we add electric cars from our office personnel, we experience capacity problems. It would not work to have trucks charging as well." (D1)* The problem is not local but national: *"No matter which location, be it Stockholm, Göteborg or Malmö, the discussion is always the same, that we don't get as much electricity as we would like." (A1)* Looking at the larger picture, there would be an increase in the need for electricity if many more EFVs were used in distribution. A shortage of electricity could lead to the need to import it: *"There are shortages of electricity, limited charging infrastructure, deficiencies in transmission. There is also the risk of allowing dirty electricity into the grid if we need to import it." (C2)* The cost of investing in charging infrastructure is seen to be high. In addition, initial purchase cost is an issue where the difference between an EFV and diesel truck becomes apparent: an EFV is much more expensive.

Related to charging infrastructure, there are a number of issues that the firms in our study experienced with respect to charging on route. The first issue concerns the time it takes to charge, which several of the respondents believed would be too much for their already tight delivery schedules: *"If we need to charge in the city, then we have a problem finding a location that works, for instance finding a place to charge where the driver can eat lunch. Unfortunately, everyone eats lunch about the same time, which results in a shortage of charging capacity." (D1)* In contrast, firm C uses public chargers for their EFVs. *"Today our drivers charge the EFVs in the city all the time. We are completely dependent on the stations for fast charging." (C1)* However, the set-up of charging infrastructure could be improved to make it easier for drivers to find a place to charge. *"There are many different providers. I would like for there to be a universal card that works on all chargers, even if the suppliers have different costs for charging. It should be as easy as possible." (C1)* The way that charging is done, by connecting a cord, is seen as problematic. *"I am convinced that public charging will never work if you need to use a cord. These cords will be broken all around the country." (A1)*.

The firms in our study that use EFVs for deliveries have received both positive and negative feedback from customers. Many customers are positive about the use of EFVs for their deliveries. Some customers have chargers available in their parking spaces, which are usually available for their customers. However, on the occasions that our studied firms used the chargers while making deliveries, they were told not to because the chargers were for customers not suppliers. The customers want to prioritize their own customers. *"We thought that we would get more positive feedback from our customers, but we have several stories of customers that have criticized us for using their fast chargers while making deliveries. I thought they would view it as something positive, but instead they saw it as us taking a space from their customers." (C1) "The customer [food shop] told me that if they put up a charger, we would not be allowed to use it. They would prioritize their customers." (B1)* The firms in our study that had public customers expressed that public procurement was putting demands on the use of EFVs, which requires firms to invest in a fleet of EFVs as well as increasing the need for charging infrastructure. Firms may be uncertain about the future of EFVs and thus hesitant about making the investment. Here, longer contracts could help to alleviate these concerns. There also needs to be infrastructure available for these vehicles.

The firms in the study are aiming to increase their number of fossil-free transports, and there are a number of different options available to help them reach that goal, not just the use of EFVs. *"We are open to a range of different sustainable options for the future.… We are investigating fossil-free distribution where electrification is one solution, another type of fuel could be another solution." (A2)* One available solution is to replace diesel with HVO Renewable Diesel, a premium fossil-free diesel product made of 100% renewable raw materials that does not release any new carbon dioxide into the atmosphere. It is produced through the hydrotreatment of vegetable oils and/or animal fats. By making this change, transports are viewed as being fossil free. *"By changing to HVO, we can be classified as having fossil-free transports." (A2) "This year we have changed to the use of HVO as our only fuel for diesel trucks. This change has been very easy, but on paper it's a very big step for us, and one that's cost neutral. That's always appreciated." (D1)* In this quote, D1 refers to the fact that changing to HVO is easier and includes fewer costs than changing to electric vehicles.

Another fuel option is hydrogen gas, which is currently only available in a few locations. However, until investments are made to create a network of fuel stations, few will be open to investing in these vehicles. *"We are in limbo regarding hydrogen gas. Who will invest in gas stations? Will anyone do so before there's an actual market? Do we dare invest in hydrogen gas vehicles before there are any gas stations available? I don't know. But we are very excited to try it out and see if it's something for us." (C1)* There are also some hesitations over how sustainable hydrogen gas actually is. *"We will transition to hydrogen gas, but that's still somewhere in the future. But hydrogen gas isn't as sustainable as some tend to believe." (B1)* Yet another option is biogas trucks, a possibility discussed by the two firms in our study that use larger trucks in their fleet. Biogas is seen as a first transition move, which will be followed by other options. *"First, we need to change some diesel trucks for biogas trucks, and then we'll gradually transition towards electricity, using railroads and any new technology that may become available. There are a number of different options available, but it's not clear that there is one standout solution." (B1)* Since there is so much uncertainty over what the solution for the future will be, firms tend to keep their options open and not invest in just one. *"We will* *not be able to have 100% EFVs; we'll need to have a mixed fleet, perhaps with hydrogen gas and biogas." (C2).*

Regulations to promote green areas and create a more sustainable environment limit what transport is allowed. Hence, the ability to make deliveries in the city centre is affected. *"It doesn't work for us to only have a three-hour time window for deliveries with our EFVs. That will lock our capacity with these vehicles. We need a bigger time window for deliveries to motivate investments in EFVs. We can't afford to buy as many EFVs without increasing how much we use them. Instead of 10–12 h a day, we need to use them about 16 h a day. To do that we need access to the streets and to be allowed to deliver at other times. And, we need customers that accept these delivery times. All of these are challenges." (B1)* Another issue is that changes in political decisions, priorities and regulations lead to uncertainties over which solutions will be preferred in the future. *"Considering the large increase in taxes on diesel vehicles, we feel there are uncertainties regarding who is making the decisions for the next ten years. Will there be alternative solutions to EFVs that lead to changes in the rules? What if we have invested a lot in a solution that will not be the solution for the future after all?" (D1).*

Our study reveals a number of barriers that hinder the adoption of EFVs by the studied firms. These can be categorized as internal, external and governmental barriers. First, within internal barriers we have identified five groups of barriers: limitations in charging infrastructure and grid capacity problems, costs, loading capacity, the limited range of EFVs and new ways of managing distribution. Within external barriers we have identified four groups of barriers: limitations in charging infrastructure and grid capacity problems, problems charging outside of premises, few options on the market and alternative sustainable solutions. Finally, regarding governmental barriers, we have identified one group: changing political directives. Table 4 shows the barriers and how they are illustrated.

5. Discussion

This paper sought to investigate drivers and barriers for adopting EFVs. The results clearly shows that environmental sustainability is an important motivator for adopting EFVs, but also that economic and social aspects function as drivers. In addition to external and governmental drivers, the firms have internal motivators in the form of strategic decisions, management pushing for a sustainable transition, branding, cost reduction, as well as the desire to be seen as a responsible employer to attract new workers, several of which are reinforced by first-mover advantages. Although all the studied firms were committed to transitioning to more sustainable transport, several barriers for EFV adoption were identified. There was much uncertainty regarding the solutions that they believed would be preferred in the future. Alternatives to EFVs mentioned included fuels such as hydrogen gas, biogas and HVO. Similar to previous studies, our findings point to uncertainties regarding the use of EFVs and possible governmental investment in charging infrastructure (Melander et al., 2019; Monios & Bergqvist, 2020). These, in addition to other uncertainties, such as which sustainable transport

Table 4
Barriers and examples of how they are illustrated.

Level	Identified barriers	Illustrated through
Internal	Limitations of charging infrastructure and grid capacity problems	Grid capacity limitations to premises Not possible to charge all EFVs at the premises (space limitations) Lack of fast charging at premises
	Costs	Vehicle purchasing costs Charging infrastructure costs
	Load capacity	Limited load capacity in EFVs due to heavy batteries Loading limitations reduce the markets that can be served by one vehicle Need for reloading due to limitations in load capacity
	Limited range of EVs	Limited range of EFVs is viewed as a challenge Uncertainty of range results in the need to tow vehicles back to premises Some vehicles need electricity for cooling or lifting goods, further limiting the range
	New ways to manage distribution	Rethinking distribution with EFVs, not possible to use the old ways of optimizing distribution No available route planning program that allows planning for charging during the route More stressful for drivers to reload (not required with a diesel vehicle)
External	Limitations in charging infrastructure	Lack of charging infrastructure on routes Municipalities make demands on EFVs but are not investing in charging infrastructure Uncertainties about the expansion of charging locations
	Problematic to charge outside of premises	Dependence on the availability of fast charging stations, e.g. during lunch breaks Different suppliers, charging stations and costs make it difficult for drivers to find suitable charging stations Customers prioritize their own customers and do not allow suppliers to charge EFVs
	Few options on the market	Few homogenous and expensive EFVs on the market, all with similar limitations Vehicle manufacturers have not come very far in the development of EFVs
	Alternative sustainable solutions	Electrification is only one solution among many for more sustainable distribution HVO, biogas and hydrogen gas alternatives to electrification Ease and limited cost of changing to HVO to become fossil free No single solution is obvious for the future
Govern-mental	Changing political directives	Not clear what will be prioritized politically in the future, could be changes in political instruments such as taxes, subsidies, etc. Different countries have their own regulations and local conditions (such as environmental zones) Uncertainty about which sustainable solution will be preferred and supported by politicians in the future

solution will be preferred in the future, act as deterrents for our studied firms, making investments in EFVs uncertain.

The study finds barriers on the micro (firm), meso (network) and macro (society) levels (Garcia et al., 2019). On the micro level, firms struggle with uncertainties of investing in EFVs, both for vehicles and infrastructure, as they do not know if, and for how long, EFVs will be the most suitable transport option in the future. They also struggle with the uncertainties of planning, implementing and managing a mixed fleet of vehicles. On the meso level, there are uncertainties in the business network related to customer demands, expectations, willingness to pay for electrified transport and acceptance of new delivery times. On the macro level, there are society-wide uncertainties over political and legal changes, and there is political ambivalence to future transport solutions, incentives, investments and regulations. Uncertainties also relate to changing political preferences, locally, nationally, regionally (EU region) and globally. There are also uncertainties related to the pace of infrastructure expansion (charging infrastructure) and uncertainties over grid capacity and access to green electricity. A study of household adoption of EVs shows that there is little reason to be concerned about grid capacity (Delgado et al., 2018). While that study looked at household EV charging, fleets of EFVs would have greater impact on the grid, even if they were charged at drivers' homes (Skippon & Chappell, 2019). However, as in our study, firms charging large fleets at their premises would have a much greater impact on the grid. Finally, there are uncertainties over how future solutions will look, and firms cannot accurately predict developments in electrification, HVO, hydrogen gas and biogas. There are also uncertainties regarding future cost changes and the political decisions that will be taken in relation to different sustainable transport options. There are also uncertainties around the pace of development of new EFVs. Fig. 2 depicts questions that illustrate uncertainties on the micro (firm), meso (network) and macro (society) levels derived from the empirical data.

The results from the study show a number of uncertainties at the micro, meso and macro levels, which act as deterrents for firms to invest in EFVs. While on the micro level there are subsidies and taxes in place to encourage firms to invest in EFVs and charging infrastructure, such as Bonus Malus (Transportstyrelsen, 2021), Klimatpremie (Energimyndigheten, 2020) and Klimatklivet (Naturvårdsverket, 2022), there are still uncertainties within firms as to when they should make these investments. Adopting EFVs also results in uncertainties over how to manage daily operations, such as how to plan routes, where to charge and how firms can manage a mixed fleet of vehicles. While individual firms can make an impact by adopting EFVs, this will not be sufficient for a transition towards the electrification of freight transports. On a macro level, customers can act as drivers by demanding fossil-free transport. In particular, public actors can use their tenders to specify EFVs in their public procurement, as discussed by Taefi et al. (2016a). On the macro level, governments can apply regulations, such as environmental zones, to increase the pace of transition towards the electrification of freight transport. However, while subsidies on EFV purchases and increased taxes on diesel vehicles seem a straightforward solution to EFV adoption, there are political uncertainties (i.e. uncertainties about how long these subsidies will be available and if politicians will favour other sustainable transport solutions in the future, and thus no longer support EFVs) making firms hesitant to invest in EFVs.

6. Conclusions

6.1. Theoretical contributions

This study contributes to the ongoing discussion about EV adoption (see e.g. Asghar et al., 2020; Biresselioglu et al., 2018; Tarei

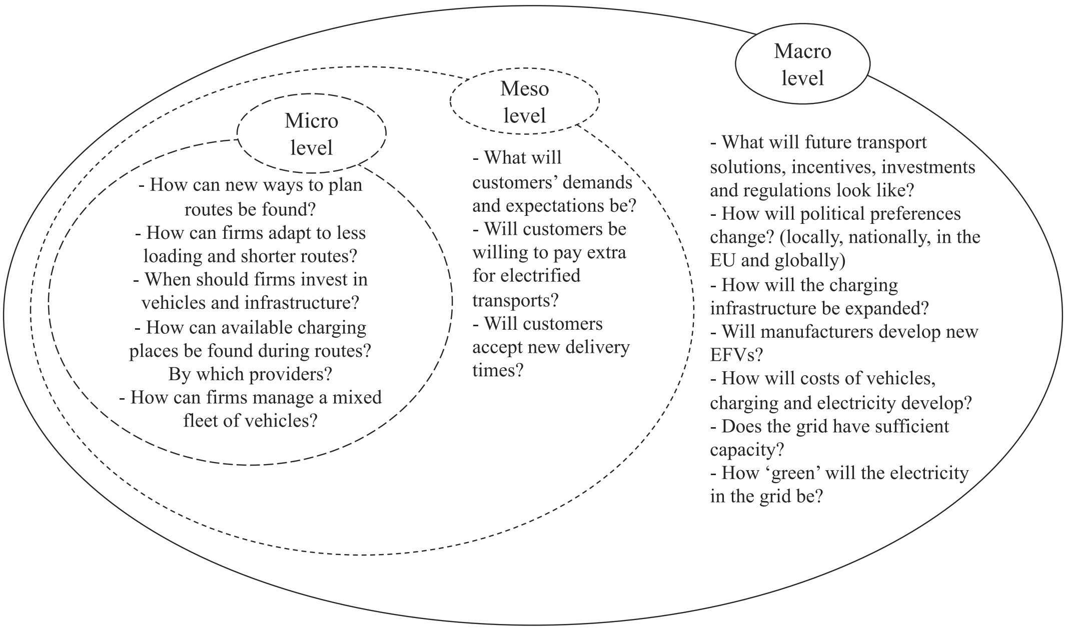

Fig. 2. Uncertainties on micro, meso and macro levels.

et al., 2021) by providing examples of EFV adoption, which has additional characteristics compared to EV adoption. The study explores existing drivers and barriers, which are categorized as internal, external and governmental. Our findings confirm those from previous studies of EFVs, which show that government incentives (Taefi et al., 2016a), customer demands (Skippon & Chappell, 2019), the regulatory environment (low-emission zones), cost factors (reducing TCO) and the environment (reduction of emissions) are drivers for adoption (Anderhofstadt & Spinler, 2019). We add to the literature by exploring these drivers in detail (see Table 3) (Ablola et al., 2014; Galati et al., 2021) and providing examples of barriers for EFV adoption (see Table 4). What acts as a driver for one firm may constitute a barrier for another firm. In our study, one firm had cost as a driver, where it identified reduced TCO as a cost related driver for EFV adoption. However, other firms in our study identified the initial purchase cost of EFVs and charging infrastructure as a cost related barrier for EFV adoption. Hence, the potential to lower costs may be viewed as a driver on the one hand, while the high initial purchase cost is viewed as a barrier on the other.

This study also contributes to the field of studies aimed at future developments of sustainable transport and uncertainties related to this transition (Deb et al., 2018; Lind & Melander, 2021; Monios & Bergqvist, 2020). We found uncertainties on the micro, meso and macro levels. On the micro level, firms struggle with uncertainties over whether to invest in EFVs and the required infrastructure. In addition, there are uncertainties related to planning and distribution when using EFVs. On the meso level, uncertainties revolve around customer demands and expectations. On the macro level, uncertainties relate to political and legal changes, both short- and long-term, and range from local to global in scope. Additional uncertainties include grid capacity, access to green electricity and which sustainable solutions will be preferred by political actors in the future.

6.2. *Managerial implications*

This study raises a number of managerial implications. First, there are several drivers for firms to adopt EFVs, including internal, external and regulatory issues, which include economic, environmental and social drivers. It seems that the internal motivation for adopting fossil-free transport is very strong and runs right through the organizations, from the strategic decisions of top management to requests from new drivers. Increasing regulation in urban areas, such as environmental zones, creates a need for fossil-free vehicles to serve markets in these areas. Public procurement also acts as a motivator for investing in sustainable transport solutions, as more public actors put strict requirements on these types of transport. There are still some barriers to overcome for EFVs, such as charging infrastructure, load capacity, costs and range, which have been discussed previously in the literature (Ablola et al., 2014; Anderhofstadt & Spinler, 2019). Large EFV fleets will cause significant peak electricity demand, for example during loading/unloading or during over-night charging. Even firms with small fleets reference the potential limitations of their facilities, which are being designed for large-scale EFV fleets. Managers need to take this into account when introducing EFVs, for example planning measures to ensure that there are not too many vehicles charging at one time, using energy storage solutions to take pressure off the grid or decentralizing the firm's charging strategy by having drivers charge before returning home. However, more importantly, firms need to change their mindset to plan for and operate EFVs; in this case the barriers include a lack of route planning programs that address charging alternatives. Planners need to plan distribution in new ways and drivers need to change their behaviour, such as by making time for charging during routes as well as reloading. Hence, to successfully adopt EFVs, managers and employees need to think in new ways about how they plan and implement transport solutions.

The pressure to change behaviour is evident; however, this can be quite painful for companies, especially if investments need to be made now to improve efficiency and competitiveness in 5–10 years. More convenient alternatives, such as hydrogen and biofuels, require little or no change in behaviour since firms can implement them in their current operations. However, there are risks to not changing behaviour: biofuels are exposed to political risk because they are dependent on subsides to be competitive. There is some uncertainty over the sustainability of biofuels, for instance Sweden obtained a short-term exemption from the EU to provide tax exemptions for HVO as it only partly contributes to more sustainable transport (Finansdepartementet, 2020). It is argued that the EU's promotion of biofuel has resulted in significant deforestation, thus bringing into question its sustainability (Transport & Environment, 2021). There are also uncertainties over hydrogen, which, unless produced renewably, may not be as sustainable as once thought (European Commission, 2021).

6.3. *Policy implications*

This study points to a number of policy implications related to the adoption of EFVs. Sweden is a suitable context as it has high ambitions for more sustainable road transport. However, despite clear goals and future targets, there is still some uncertainty as to the political willingness to facilitate a transition towards electrified transport. Long-term commitments and clear communication about future changes to taxes, subsidies and regulations could help firms when making decisions about investments in EFVs. Public tenders that include requirements for sustainable transport, as well as longer contracts, could also enable firms to invest in EFVs.

6.4. *Limitations and future research*

This study focused on transport in Stockholm and its surrounding areas. It would be interesting to compare this to studies of rural areas, where alternative sustainable solutions might be preferred to EFVs. In the urban context, it would be interesting to investigate how actors using EFVs can collaborate to overcome barriers related to scarcity and the high cost of investing in charging infrastructure. Our study has some limitations. The study is limited to commercial companies and does not include fully or partly state-owned companies. The result from our study is limited to short- and regional haul fleets. It may be that fleets in other operation settings, such as long haul or in other applications experience other drivers and barriers. Although our case study firms are highly interested in EFVs and can be considered as first movers, some of them have limited experience using them in their operations. The sample is limited to five companies and cannot be viewed as representative of all freight transporters in Stockholm. Instead, the study should be viewed as an exploratory investigation of the potential drivers and barriers for EFVs. Our sample is not representative of all fleet operators in Stockholm, as we specifically sampled firms that are interested in and some that have already invested in EFVs. For some of our cases we only had access to one interviewee. However, in each instance this individual was the most knowledgeable respondent from the respective firm. By having few respondents, the data may reflect the respondents' own views and social desirability, and not necessarily that of the firms.

Declaration of Competing Interest

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

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