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Intentions to introduce electric vehicles in the commercial sector: A model based on the theory of planned behaviour

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ABSTRACT

Light and heavy duty commercial vehicles are a cause of concern in urban areas because of their cumulative stress on the system in terms of air pollution, congestion, and noise. This cumulative stress is expected to increase with the expected growth in commercial vehicle movements. While electric commercial vehicles (ECVs) may provide a possible technological solution, the research on the market penetration of ECVs is scarce. This study proposes a comprehensive framework for understanding the motivations and barriers of small and medium-size firms to the introduction of ECVs in commercial vehicle fleets. The framework is based on the Theory of Planned Behaviour (TPB), and it is modelled with a structural equation model with latent variables. The model is estimated on the basis of 1443 responses from a large-scale survey in Austria, Denmark, and Germany. The results establish a linkage between the ECV procurement intentions, the TPB constructs (i.e., positive attitudes and subjective norms towards ECVs, familiarity with ECVs and perceived operational ease) and their relative importance. It also provides information regarding the relationship between the TPB constructs and the characteristics of the fleet manager as the individual decision maker, the industrial sector and the fleet management and tour pattern. Last, it provides insights regarding the transferability of the revealed TPB- ECV procurement intentions across industrial sectors and across countries.

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1. Introduction

Light and heavy duty commercial vehicles are a cause of concern in urban areas. While they account for about 6–18% of the vehicle-kilometres travelled, they have a far greater impact than their share in terms of air pollution. In fact, a single percentage increase in the number of trips induces twice as high an increase of HC, CO_x and particulate matter (PM) emissions (Figliozzi, 2007; Kanaroglou & Buliung, 2008). Urban freight and commercial vehicles make up about 10% of the share of vehicle-miles travelled in the United States, they account for 50% of the CO_x emissions and 90% of the NO_x and PM emissions (Feng & Figliozzi, 2013). The cumulative stress imposed by commercial vehicles on urban systems in terms of air pollution, congestion, and noise, is expected to increase in the

future, due to the high share in the light-duty vehicle sales and the fast growth rate of commercial vehicle activity (Feng & Figliozzi, 2012). Thus, when facing the challenge of combining economic and sustainable growth in the urban freight market, the recent developments in electric commercial vehicles (ECVs) are viewed by stakeholders in the transport sector as technology-oriented solutions that, along with improvements in vehicle routing efficiency, can lead to mitigating the effect of commercial vehicles in urban areas (Bakker, Maat, & van Wee, 2014; Feng & Figliozzi, 2013).

Urban commercial vehicle fleets are also considered as good candidates for the early adoption of electric vehicles (EVs) because of their high mileage compared to household usage and possibility of frequent maintenance (Nesbitt & Sperling, 2001), and because of the greater possibility for a higher density of recharging stations in urban areas (Feng & Figliozzi, 2013). Indeed, global retail and delivery companies have started to consider alternative fuel vehicles (AFVs), although so far the consideration concerns only a marginal share of the fleet (Bae, Sarkis, & Yoo, 2011). Nevertheless, The literature on vehicle fleet procurement decisions is scarce (Nesbitt & Sperling, 2001), and little is known regarding the behavioural

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framework underlying ECV purchase decisions, as well as internal and external barriers to ECV adoption.

This study proposes a behavioural framework on the basis of Ajzen's (1991) Theory of Planned Behaviour (TPB) for understanding the motivations and barriers to procurement intentions of ECVs in commercial vehicle fleets. This study is the first to employ the TPB to explore ECV procurement intentions of firms, and to establish the validity of the TPB in this context with the statistical model. The use of the TPB is empirically supported by the existing knowledge regarding vehicle procurement decisions and the application of TPB in similar business contexts. The purchase of alternative fuel vehicles is commonly viewed as a fleet level decision, made by the fleet manager (Nesbitt & Sperling, 2001). To avoid the complexity of organizational constraints such as group decisions, procedural rules, and bidding processes, this study focuses on private sector small and medium size enterprises (SMEs). SMEs are an ideal focus for early adoption of ECV because their autocratic decision style allows high openness to innovative change, risky decisions, and government incentives (Nesbitt & Sperling, 2001). The TPB is applied to corporate decisions in similar contexts of environmental responsibility (Papagiannakis & Lioukas, 2012; Wang, Cheng, Keung, & Reisner, 2015) and technology adoption (Altobello Nasco, Grandón Toledo, & Mykityn, 2008; Riemenschneider, Harisson, & Mykityn, 2003).

The contribution of this study is fourfold. Firstly, this study anchors the firms' internal and external motivations in a rigorous behavioural framework on the basis of the TPB, thus producing deeper knowledge about the internal and external motivations for ECV adoption by firms for commercial transport. Secondly, this study integrates motivating factors and barriers related to the supply-side perspective, such as vehicle technology, availability of infrastructure and price, and the demand-side perspective, by focussing on firm characteristics, vehicle fleet composition, and use patterns. Thirdly, this study expands the canvas of fleet managers' considerations to include environmental, economic, and technological attitudes, financial and non-financial policy incentives, subjective norms, knowledge regarding ECVs and perceived operational ease. Lastly, this study is the first to base the analysis on a large-scale sample of disaggregate data at the firm level.

The remainder of the paper is structured as follows. Section 2 introduces the existing knowledge, including a literature review and the case-study background. Section 3 presents the research methods in terms of collected data and estimated model. Then, results are presented and discussed in Section 4. Finally, conclusions and policy implications are drawn.

2. Existing knowledge

2.1. Literature

Research on the market penetration of ECVs is new. Contrary to the ample body of research investigating the factors underlying the market penetration of EVs in households, only a few studies explore motivations and barriers for the introduction of ECVs and other AFVs in the commercial sector (Globisch, Schneider, & Dütschke, 2013).

Haller, Welch, Lin, and Fulla (2007), Ehrler and Hebes (2012), and Wikström, Hansson, and Alvfors (2014) focused on an ECV adoption decision outcome. Haller et al. (2007) presented an interim assessment of a local government's voluntary ten-year plan for converting to AFVs as an example of small to medium public fleets. The study analysed the vehicle fleet operational data and evaluated the cost effectiveness and emission reductions as a result of the programme. The study discusses the difficulties in attaining the goals due to delays in anticipated grants for installing fast fuel

stations, which considerably reduced the use of alternative fuels in the converted fleet. Ehrler and Hebes (2012) analysed stakeholders' expectations and experience following a pilot project for courier services in Berlin. The stakeholders included drivers, shift managers, customers and their neighbours, and the results showed high user acceptance, perceived technical usability and customer satisfaction. Wikström et al. (2014) followed the experimental introduction of 174 EV in commercial fleets and investigated their driving and charging patterns as well as the user experience. They found that EV user satisfaction and confidence are related to drivers' better adaptation of the driving patterns to optimize the vehicle performance. They also showed that the ECV operation has been reduced with operational difficulties due to charging problems and winter conditions.

Wikström et al. (2014) focused on demand-side needs by focussing on vehicle use patterns. In contrast, Bae et al. (2011) and Sierzchula, Bakker, Maat, and van Wee (2014) concentrated on the supply-side availability by focussing on government policies, technological and infrastructure availability, and price. Bae et al. (2011) focused on external stimuli for ECV adoption by developing a theoretical game theory equilibrium model. The theoretical model explores the likely effects of external policy instruments on the adoption of AFVs by firms. The results indicate that government subsidies, energy price shocks, energy savings and environmental regulations could be meaningful drivers towards ECV adoption in commercial fleets. Sierzchula et al. (2014) used regression analysis on aggregate data at the national level from 30 countries and found that the market penetration of EVs is related to financial incentives, charging infrastructure, and local presence of car manufacturers.

Nesbitt and Sperling (2001) analysed the decision processes of fleet managers concerning and discussing their implications in terms of purchase of AFVs. The findings suggest that there are four decision styles: autocratic, bureaucratic, hierarchic and democratic, with autocratic decision style pertaining to SMEs, and bureaucratic and hierarchic styles pertaining large public or private organizations. Kirk, Bristow, and Zanni (2014) and Sierzchula (2014) focused on the motivating factors and barriers underlying the purchase of ECVs and establish the importance of external considerations in the decision process. Kirk et al. (2014) interviewed 17 stakeholders, including six company fleet managers, in a qualitative study in the U.K. regarding the market penetration of condensed natural gas commercial vehicles and found that possible motivating factors and barriers were fuel costs, refuelling infrastructure, vehicle purchase cost and residual value, the removal of the London congestion charge exemption, lack of knowledge regarding EV and vehicle weight. Sierzchula (2014) explored fleet managers' considerations regarding environmental impacts, financial incentives and perceived operational ease with a qualitative study among 14 U.S. and Dutch organizations that adopted ECVs. The findings suggest the relevance of testing new technologies, receiving government grants, and improving the organization's public image, suggesting that attitudes towards technology and subjective norms play a role in the company's decision.

2.2. Case-study description

Although the total market share of EVs in Austria, Denmark and Germany is marginal at about 0.1–0.3% of the annual car sales in 2013 (Mock & Yang, 2014), these countries show commitment to the introduction of EVs by introducing policy tools for EV market penetration and encouraging test projects to demonstrate the operability of EVs.

The Austrian Transport Master Plan set a goal for 19% reduction in CO₂ emissions, 50% reduction in particle matter emissions

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