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The cost of electrifying private transport – Evidence from an empirical consumer choice model of Ireland and Denmark

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ABSTRACT

There is a growing consensus that moving to a low carbon future within the transport sector will require a substantial shift away from fossil fuels toward more sustainable means of transport. A particular emphasis has been given to battery electric vehicles (BEV) and plug in hybrid electric vehicles (PHEV), with many nations investing in improving their charging infrastructure and incentivising electric vehicle purchasing through offering grant schemes and tax relief to consumers. Despite these incentives, the uptake of BEVs and PHEVs has been low, while some countries, such as Ireland and Denmark, are in the process of removing the tax relief currently in place. This initial retraction has already been met with a fall in sales of BEVs and PHEVs, which is expected to continue decreasing as these incentives are further reduced. This study develops a socio-economic consumer choice model of the private transport sector based off national empirical data for Ireland and Denmark to analyse the long-term effects of these subsidy retractions, and to further analyse the policy measures and associated cost of moving toward a low carbon private transport sector.

1. Introduction & motivation

There is a growing consensus that moving to a low carbon future within the transport sector will require a significant shift from its current state, whereby conventional fossil fuelled internal combustion engines (ICE) dominate the market, to sustainable means of transportation (IPCC, 2014). This shift is considerable, as it requires a fundamental change in both the fuel type and the vehicle technology of the transportation sector. Considering private transport, which constitutes 42% of global well-to-wheel (WTW) transport related emissions (IEA, 2017), this shift will involve multiple agents. *Fuel suppliers* may provide emission reductions through altering the composition of the fuels offered to consumers vis-à-vis the blending of bio-ethanol and bio-diesel with gasoline and diesel respectively or providing new fuels (e.g. CNG, LPG or H_2). *Automobile manufacturers* may provide efficiency improvements and innovative technologies capable of reducing downstream vehicle emissions. *Governing bodies* may impose regulations through fuel standards and minimal requirements for the performance of new vehicles while also incentivising the sale of low emitting vehicles. Finally, *consumers* – arguably the most vital agent in private transportation – choose which vehicle technology to purchase.

The potential emission reductions available from these former two supply agents are constrained by current technological

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limitations. European fuel standards, for example, mandate a maximum blend of conventional biofuel with petrol and diesel ICEs at 5% (CEN, 2008) and 7% (CEN, 2009) respectively, while the long-term efficiency improvement potential available to conventional ICEs has been identified as 28% and 33% for a spark ignition and compression ignition engine respectively, relative to a 2005 spark ignition engine (IEA, 2008).[1] While these measures offer potential short-term and medium-term solutions to meeting national emissions reduction targets, increasing the penetration of low-carbon alternative fuelled vehicles (AFV) will be imperative in advancing toward carbon reductions capable of adhering to a future with a global temperature rise limited to less than 2 °C (IEA, 2017). Despite this necessity, the uptake of non-ICE vehicles has been very low, suggesting that numerous barriers prevent a significant deployment of these vehicles. Moreover, the price of removing these barriers can be rather costly in the short-term, with little certainty surrounding effectiveness.

To quantify these barriers, the many costs pertaining to vehicle consumer choice can be loosely grouped as *tangible costs* and *intangible costs*. *Tangible costs* consist of the actual costs the consumer is faced with when choosing a vehicle, e.g., investment cost, operational and maintenance costs (O&M), taxation, and fuel costs. The nature of these costs allows for a quantifiable monetary figure to be associated with each factor. *Intangible costs*, however, represent the many non-monetary perceived costs the consumer faces when using a vehicle, e.g., inconvenience due to low vehicle range and limited refuelling infrastructure, to acceptance of new and uncertain technologies and to fewer options about the characteristics of the vehicle, e.g., number of doors, colours available, size, etc. These costs are generally difficult to quantify, as their perception changes for different consumer groups. Nonetheless, for regulators it is important to account for these intangible costs in their planning as to elaborate effective strategies to remove these barriers.

This study presents a methodology which monetises these intangible costs using empirical data from national sources to create a dynamic consumer choice model of the private car sector for Ireland and Denmark. This consumer choice model is linked to a sectoral simulation model of the private car sector (the CarSTOCK model) to indicate the cost and potential effectiveness of policy interventions in the form of WTW carbon dioxide (CO_2) emission savings. Ireland and Denmark have been chosen as a case study as both are in the process of removing subsidies for battery electric vehicles (BEV) and plug in hybrid electric vehicles (PHEV) by the turn of the decade (see Fig. 1 for a detailed breakdown) (Department of Finance, 2017; Skatteministeriet, 2015). In the case of Denmark, the initial retraction of the VRT subsidy for BEVs and PHEVs in 2016 was met with a drop in combined BEV and PHEV sales of 42% relative to the previous year (EEA, 2017). These subsidy withdrawals have been announced despite both countries identifying the necessity of electrifying transport in moving toward a low carbon future (DECLG, 2016; The Ministry of Climate Energy and Building, 2013).

The purpose of this study is threefold; (i) to contribute to the current body of scientific literature surrounding the area of modelling consumer choice within the private transport sector through use of qualitative data, (ii) to determine the effect of revoking tax relief for BEVs and PHEVs in Ireland and Denmark on stock and emissions, and (iii) to determine the cost and effectiveness of implementing further governmental level policy measures incentivising BEV and PHEV purchasing, In keeping with the order of these points of purpose, this paper is structured similarly. Section 2 discusses the value of modelling consumer choice within the transport sector, Section 3 describes the model inputs, structure and operability, Section 4 presents the impact of varying the market determinants mentioned above and Section 5 concludes.

2. The importance of modelling consumer choice

There is a growing body of literature which emphasises the necessity of moving away from models driven solely by economic parameters by including attributes related to consumer behaviour, thus enabling a more accurate representation of consumer choice (Byun et al., 2018; Garcia-Sierra et al., 2015; He et al., 2012; Mabit, 2014; Tattini et al., 2018; Zhang et al., 2016). This is imperative when analysing how to facilitate the shift toward sustainable mobility: without differentiating heterogeneous consumer groups and capturing the barriers that oppose the uptake of alternative fuelled vehicles (AFV) for these groups, both governing bodies and modellers alike are liable to an over-simplified representation of the market which they are attempting to alter. This over-simplified representation in turn may lead to unrealistic scenarios for the modeller and ineffective policies for the policy maker.

In an ideal consumer choice model, each agent would have a singular representation, with every applicable behavioural attribute accounted for to determine the utility of each vehicle available to purchase. In this way, the least-cost process of improving AFV utility for each consumer could be tackled. Of course, the scope of such an ideal representation would not only require a substantial level of computing power to model, but also an extensive data set to drive achievable, possibly through a comprehensive stated preference survey (SPS). There is a certain need for consumer specific data to accurately model vehicle consumer choice (Daziano and Chiew, 2012), although the availability of data is constrained. Thus, while aiming at developing a representative and valid model, we need to limit both the number of consumer segments and applicable behaviour attributes.

2.1. Consumer segments

Behaviour economics and psychology play a central role in breaking down the complex nature of the rationale behind consumer behaviour into comprehensible segments (Mattauch et al., 2016). These segments can be defined by many different attributes, e.g., demography, geography, and driving profiles. While consumers can be defined by a wide ranging array of these segments branches, it

[1] These efficiency improvements are gained through a combination of reducing engine friction, starter-alternator components, variable valve lift and timing, advanced cooling circuits, electric water pumps, and transmission improvements.