Analysing the take up of Battery Electric Vehicles: An investigation of barriers amongst drivers in the UK

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Original citation & hyperlink:
Berkeley, N, Jarvis, D & Jones, A 2018, 'Analysing the take up of Battery Electric Vehicles: An investigation of barriers amongst drivers in the UK' *Transportation Research Part D: Transport and Environment*, vol 63, pp. 466-481.
https://dx.doi.org/10.1016/j.trd.2018.06.016

DOI 10.1016/j.trd.2018.06.016
ISSN 1361-9209
ESSN 1879-2340
Publisher: Elsevier

1. Introduction

Threats arising from climate change and the depletion of natural resources have brought governments together through international treaties to set targets for carbon reduction and the use of alternative sources of energy. Given its significant contribution to carbon emissions globally, as well as utilisation of increasingly scarce resources, the transport sector has in the last decade become a major focus of attention for governments across the world. Significant investment in policy instruments to stimulate the design, production and adoption of electric vehicles (EVs) [1] has been put in place to support a transition to greener, more sustainable automobilities. Manufacturers have responded to the challenge, producing an increasing range of EVs within their fleets (Berkeley et al, 2017). However, to date in the overwhelming majority of countries, take-up has been far short of the level required to propel EVs into the mainstream. Data for the first quarter of 2017 shows EV sales in Europe at 0.84% share of the market, compared to 0.68% in 2016 and 0.49% in 2014. Only in two countries, Netherlands (2.1%) and Norway (21.1%) has market share reached more than 2% (Automotive Industry Data Newsletter, 2017, p4). Whilst Norway is clearly bucking the trend, and is the global EV success story[2], the overall picture is a key concern given that alternatively fuelled non-internal combustion engine (ICE) vehicles are a critical component of the future transport mix needed to meet internationally agreed carbon reduction targets (Rezvani et al., 2015, Steinhilber et al., 2013, Gunther et al., 2015) Moreover, as battery electric vehicles have now been available to consumers for more than five years, yet remain the only viable mainstream alternative to the internal combustion engine, it is both timely and important to focus on this segment of the market and interrogate the factors underlying the problem of their low market penetration. This issue has gained even more importance in 2017 given the announcements by manufacturers and several national governments pledging to end production and sales of internal combustion engine vehicles within the next fifteen-twenty years.

A growing body of literature has identified a multitude of barriers to EV adoption (i.e. Steinhilber et al., 2013, Browne et al., 2012, Wikstrom et al., 2016). However, the currency of this discourse in helping to better understand and conceptualise these barriers, and to inform effective policy solutions to EV take-up is limited. In Europe, the majority of empirical studies report on the results of small metropolitan based demonstrator trials which tend to attract drivers already disposed towards green technologies (i.e. Graham-Rowe et al., 2012, Bunce et al., 2014, Burgess et al., 2013, Jensen et al.,

[1] For the purpose of this study EVs are defined as vehicles with an all-electric drivetrain powered from a battery which is charged from the electricity grid. In this case, EVs do not refer to hybrid (HEV) or range-extended (REEV) vehicles.

[2] Norway's drivers enjoying high living standards, cheap electricity and favourable environmental policies, have benefited from a holistic package of incentives that put EVs on a par with internal combustion engine (ICE) cars in terms of their price. On the supply side, Norway has also seen significant investment in charging infrastructure, especially in cities such as Oslo (Berkeley et al, 2017)

2013, Franke et al., 2012, Wikstrom et al, 2016). Many other studies consider the North American setting (i.e. Carley et al., 2013, Egbue and Long, 2012, Krause et al, 2013, Hidrue et al., 2011, Krupa et al., 2014) focusing on the utility of alternatively fuelled vehicles in a context where driving conditions and the 'everyday' realities of required mileage are very different from those in Europe. There is, therefore, a gap in knowledge, a demand for original research that investigates the reality and importance of identified barriers to EV adoption from the perspective of a large sample of mainstream car market consumers in Europe. Moreover, within this context there is a need to explore the extent to which the multitude of individual barriers are connected and inter-related, part of larger explanatory 'factors'. This would help considerably in reducing the complexity of the barrier problem thereby better informing both academic and policy discourses. In addition, access to a large consumer dataset provides the opportunity to explore the extent to which barriers are influenced by driver characteristics. This is important as academic discourse suggests that to facilitate the breaking down of barriers in the long-term, a short–term solution would be to strategically target EV policy intervention on segments of the market where EV penetration might be easier to achieve. These might include: specific locations where there is likely to be the greatest interest or impact, e.g. core cities; higher-earners, not dissuaded by price and attracted by the pull of new technology; and younger people, less attached to the established ICE ecosystem, more likely to have an interest in technology and the convenience afforded by EVs (Serra, 2012; Krause et al., 2014; Carley et al., 2013; Skerlos and Winebrake, 2010).

This paper addresses these gaps through research which has generated data from over 26,000 drivers of internal combustion engine vehicles in the UK. As the second largest vehicle market in Europe with a national fleet of 31.6 million licenced cars[3], the UK provides an interesting context in which to explore EV adoption issues. The apparent failure[4] of multiple UK government policy instruments and investment to stimulate EV adoption over a seven-year period, reinforces the richness of the context. Analysis and exploration of the data provides a model for interrogating the 'EV market share problem', and at the same time has considerable potential to inform and underpin more effective manufacturer and government–led strategy and policy.

The paper makes several important contributions. First, it draws on UK, European and North American literature to synthesise the various obstacles to EV adoption that have been identified. Second, a large scale survey of drivers in the mass ICE market provides a unique dataset that allows the importance

[3] See Department for Transport Vehicle Licencing Statistics Table VEH0128, Available from https://www.gov.uk/government/statistical-data-sets/all-vehicles-veh01#table-veh0150

[4] Market share of EVs in the UK remains below 0.6% for the first 3 months of 2017, AID Newsletter, 1708.

of these barriers to be evidenced and, through exploratory factor analysis enables a robust conceptualisation of barriers to be presented. Third, multivariate regression analysis allows us to uniquely test the extent to which conceptualised barriers are mitigated (or indeed aggravated) by driver characteristics such as age, socio-economic status, place of residence and gender. In doing so, the paper enriches the debate on barriers to EV adoption as well as providing practical, empirically-informed 'pointers' for stakeholders engaged in addressing the EV uptake problem.

2. Barriers to electric vehicle take-up: A systematised review of the literature

An increasingly wide body of literature from a multitude of disciplinary perspectives considers 'barriers' influencing consumer attitudes towards new transport technologies. These include researchers publishing in the fields such as energy (e.g. Krause et al., 2013), technology (e.g. Serra, 2012), innovation studies (e.g. Noppers et al., 2014), behavioural studies (e.g. Caperello & Kurani, 2012) and transport studies (e.g. Graham-Rowe et al., 2012). In reviewing this breadth of literature, a core of 95 papers, which drew on surveys of drivers, or consumers more broadly, to evidence and analyse barriers to the adoption of EVs, were identified. The wide range of barriers to emerge from this evidence base are discussed here.

It is interesting to note that despite advancements in EV technology over recent years negative perceptions around limited driving range and lengthy charging times (Schuitema et al., 2013, Lane and Potter, 2007, Daziano and Chiew, 2012) appear to be enduring. This suggests that consumer concerns about the 'inferiority' or 'unproven' nature of EV technology are still prevalent (i.e. Greene et al., 2014, Egbue and Long 2012, Steinhilber et al.,2013, Graham-Rowe et al., 2012, Axsen and Kurani., 2013, Wan et al., 2015).

A number of studies reinforce this point, referencing consumer concerns surrounding range and battery durability (Daziano and Chiew, 2012, Carley et al, 2013, Axsen and Kurani, 2013, Franke et al., 2012). Moreover, evidence from Egbue and Long (2012) suggests that driving range is the most important factor in limiting EV adoption. Although academic and policy discourse seems often to dismiss these barriers as the product of a mismatch between the actual and imagined driving distance required by motorists, prior studies have shown that range 'anxiety' can have a detrimental effect on the lived experience of EV owners, with drivers potentially compromising safety by electing not to use in-car features (such as heaters) to preserve battery life (Jensen et al., 2013; Office for Low Emission Vehicles, 2013). Furthermore, apprehension about range mean that many EV drivers do not even attempt longer journeys and consider EVs only as a second car (Graham-Rowe et al., 2012), an outcome which, it could be argued, is at loggerheads with the supposed environmental benefit of mass market EV adoption.

In addition to battery performance, range anxiety is strongly linked with the availability of charging stations. Recharging an EV represents a radical shift from normalised refuelling behaviour in the ICE ecosystem, one which is perhaps not clearly understood by consumers, despite evidence from EV drivers suggesting that the recharging process is both simple and convenient (National Research Council, 2015, Bunce et al., 2014). Whilst home or work charging is favourable, evidence from some demonstrator trials suggests a lack of faith in existing public infrastructure as drivers avoid these stations (i.e. Bunce et al., 2014, Wikstrom et al., 2016, Skippon and Garwood, 2011). Despite these stations not being frequented, other studies point to a shortage of this infrastructure as a deterrent to purchase (Lane & Potter, 2007, Egbue and Long, 2012, Browne et al., 2012, Axsen and Kurani, 2013, Wan et al., 2015, Graham-Rowe et al., 2012). At the same time, for those in multi-unit dwellings, or without access to off street parking, where home charging is less feasible, anxieties over public charging infrastructure are very real (Todd et al, 2013).

An outcome of the multiplicity of concerns touched upon thus far is that many motorists are unwilling to pay a premium price for new EV technology (Bakker et al., 2014). At the same time, the current high initial cost of the technology is prohibitive for those who would count themselves as potential adopters (Egbue and Long, 2012; Diamond, 2009; Carley et al, 2013; Heffner et al 2007; Browne et al 2012; Lane and Potter, 2007). Further uncertainty over the availability of downstream maintenance, service and repair infrastructure adds to confusion and raises doubts in consumers' minds about when or indeed whether the premium 'list' price of EVs can be 'offset' by lower total operational costs (Graham-Rowe et al., 2012). This potentially presents a significant barrier to widespread EV adoption. Participants in a study conducted by Skippon and Garwood (2011), for example, suggested that some consumers would be willing to accept a maximum period of four-years for higher EV purchase prices to be offset by lower fuel costs. This was without considering any other costs in relation to the battery, servicing or maintenance. Even without taking these elements into account, Skippon and Garwood (2011) believed that over this timescale the price premium would be over four times greater than the annual running cost savings. Such findings raise concerns about the economic benefits of EV ownership, if the high premium price and long payback period negatively influence consumer demand (Hardman et al., 2015). At the same time, recent research published by the European Consumer Association claims that the difference in the four-year total cost of ownership of a C-segment vehicle such as the electric Nissan Leaf compared to the petrol Vauxhall Astra will reduce from c.€2,000 in

2015 to c.€1,000 in 2020 (European Consumer Association, 2017). Whilst encouraging news, clearly more needs to be done to convince consumers. In the short-term uncertainty will continue to create barriers whether perceived or real.

In the absence of a mature second-hand resale or recycling market, the residual-values achieved by current EVs are low when compared to ICE alternatives, and represents a further factor compounding high initial purchase prices (National Research Council, 2015). Research in the US has also highlighted the difficulties faced by consumers calculating electricity costs and when and where to charge their vehicles in order to maximise savings and efficiencies. This, it is argued, creates uncertainty and doubt and, as such, another potential obstacle (National Research Council, 2015).

Whilst financial incentives are being used as a policy lever to lower the price of EVs, research suggests limited awareness of this amongst consumers, particularly in major markets such as the US. Here, just 5% of the population in the 21 largest cities were aware of EV incentives (National Research Council, 2015). At the same time, the variability, inconsistency and time-limited nature of incentives adds to confusion for consumers. Coupled with the fact that for many mainstream motorists the potential benefits and different experiences of driving an EV are largely unknown, this confusion, combined with uncertainty, myths and misinformation, means that relatively few are willing to 'take the financial risk' of EV adoption (National Research Council, 2015).

Other research captures barriers linked to market acceptance, or social and cultural perceptions and norms. This includes, for example, the perceived aesthetics and design of EVs. Reporting on a trial based study, Graham-Rowe et al (2012) present evidence to suggest some drivers view EVs as being 'soulless' and lacking in visual appeal. Such perceptions are important given that the car is arguably more than a form of technology and a mode of transport. Instead it might be described as an 'avatar', representing a driver's personality, and as such poor or bland design will negatively affect the satisfaction that a motorist can draw from owning a EV (See Schuitema et al. 2013). Such issues are compounded by current limited choice and availability of EVs relative to the well-established ICE market, with its vast array of model niches. Notably just three models (Nissan Leaf, Renault Zoe and BMW i3) accounted for 62% of EV sales in Europe in the first three months of 2017 (Automotive Industry Data Newsletter, 2017). In terms of raising awareness and visibility, the lack of availability of EVs in showrooms and dealerships is another concern (National Research Council, 2015).

Although EVs are promoted based on their environmental benefit, evidence suggests that some potential early adopters – those motorists with the greatest concern for sustainability issues – are yet to be convinced by the reported 'green benefits' of EVs, especially given the energy mix of electricity grids in most developed world economies (Heffner et al., 2007; Graham-Rowe et al.; 2012; Egbue and Long, 2012; Jensen et al., 2013). Beyond disquiets about electricity supply, there are also concerns surrounding battery disposal (National Research Council, 2015). While uncertainty over such issues remains, scepticism amongst consumers will persist and perhaps deter purchase, particularly amongst those having a strong desire to protect the environment.

This review of literature has revealed a complex set of barriers seemingly acting against mass adoption of EVs. In triangulating the literature sources considered here, it is possible to summarise 19 headline barriers (Table 1). However, presented in this way, the list of barriers provides a complex, multifaceted picture, which is relatively unhelpful to policy makers in planning for and promoting the uptake of EVs. As such attempting to better understand and reduce this complexity, and ultimately group barriers into categories or factors has considerable value.

Table 1: Summarising barriers to purchase of electric vehicles

Barrier	Authors
Availability of public charging stations	Lane & Potter (2007), Egbue & Long (2012), Browne et al (2012), Axsen & Kurani (2013), Wan et al (2015), Graham-Rowe et al (2012)
Length of time it takes to charge a EV	Graham-Rowe et al (2012), (Steinhilber et al., 2013)
Limited vehicle driving range for my day-to-day needs	Ebgue & Long (2012), Carley et al (2013), Axsen & Kurani (2013), Rezvani et al (2015)
Concerns over durability of the battery	Daziano & Chiew (2012), Lane & Potter, (2007)
Concern that driving behaviour and using vehicle features will diminish driving range	Office for Low Emission Vehicles (2013)
Uncertainty concerning the process of home/public charging	Bunce et al (2014), National Research Council (2015)
Expectation that EV technology will improve in the future so are delaying purchase	Egbue & Long (2012)
My dwelling would be unsuitable for home charging	Todd et al (2013)
Belief that EVs are an inferior/unreliable technology	Steinhilber et al (2013), Egbue & Long (2012), Graham-Rowe et al (2012), Axsen & Kurani (2013), Wan et al (2015)
Expectation that improvements in ICE will continue thereby offsetting environmental benefits of EVs	Tran et al (2013)
The high purchase price	Egbue & Long (2012), Carley et al (2013), Diamond (2009), Heffner et al (2007), Browne et al (2012), Lane & Potter (2007).
Length of time to offset higher purchase price through savings made in fuel and taxation	Lane &Potter (2007), Skippon & Garwood (2011), Hardman et al (2015)
Anxiety over the re-sale value	National Research Council (2015)

Uncertainty over maintenance, service and repair infrastructure	Lane & Potter (2007), Graham-Rowe et al (2012)
Lack of choice and availability in the EV market	National Research Council (2015)
Difficulties in understanding how to calculate fuel costs and potential savings of EVs	National Research Council (2015)
Vehicle design/aesthetics are inferior compared to market for Internal Combustion Engine vehicles	Lane & Potter (2007), Graham-Rowe et al (2012)
Concern over the real environmental impact of electric vehicles	Egbue & Long (2012), Graham-Rowe et al (2012)
A lack of general understanding of the benefits of driving EVs	National Research Council (2015)

Some key examples of prior research which has sought to conceptualise the barriers to EV adoption and provide less complex sets of barrier factors include: Browne et al (2012) who identify an extensive set of barriers comprising financial, technical or commercial, institutional and administrative, public acceptability, legal or regulatory, policy failures, and physical constraints ; and Graham-Rowe et al (2012) who use grounded theory to identify factors such as cost minimisation, vehicle confidence, adaption demands, environmental beliefs, impression management, and EVs as a 'work in progress'. Other, frameworks have been outlined by Haddadian et al (2015) who split barriers into technical, economic and consumer perception, and Egbue & Long (2012) and Steinhilber et al (2013) who state that EVs were part of a 'socio-technical system' which encompassed economic, political, technological, cultural, and social barriers. Lane and Potter (2007) have discussed the importance of psychological and situational factors, such as values, beliefs, attitudes, vehicle attributes, economics, regulation and past behaviours, in influencing car buying behaviour; whilst Carley et al (2013), Daziano and Chiew (2012), Silvia and Krause (2016), Nie et al (2016) and Axsen and Kurani (2013) argue that there are financial and technical barriers, the latter being strongly influenced by consumers' concerns surrounding the practicalities of vehicle operation.

To date, the dominant approach to examining adoption barriers in the literature has been to evaluate small-scale EV demonstrator trials. While valuable, these studies tend to be biased towards participants who are already considering adoption. On the other hand, Rezvani et al (2015) contend that the alternative, addressing mass-market consumers, means these participants may be less informed about EV technology, potentially limiting the validity of responses. However, it is posited here, that to understand mass-market attitudes towards EV technologies, there is a clear need to sample *motorists* who may not be naturally inclined to EVs. Ultimately it is these drivers, ill-informed or not, who need to be persuaded to adopt EVs if wide scale market penetration as envisaged by policy makers is to be achieved.

Studies that have surveyed mass market drivers are limited. Many that have, have taken place in very different contexts for drivers, such as North America, with scarce examples of the UK and European market being covered in this manner. The generalisability of insights provided is open to discussion.

Hidrue et al (2011), for example, present a 'representative' sample of US residents over the age of seventeen, whilst Carley et al (2013) and Krause et al (2013) examine a limited number of US urban centres. In the European literature, Noppers et al (2014) take respondents from a single city, whilst Lieven et al (2011) draw responses from e-commerce customers only. Moreover, in some cases it is not specified as to whether the sample was drivers only, as terms such as 'residents' gives the impression that both drivers and non-drivers were sampled. This ambiguity creates challenges in interpreting results as non-drivers may have limited ICE experience, whilst, on the other hand, there could also be individuals within this group attracted by new forms of automobility. To supplement the dominant approaches and settings used in prior research in this area, the intention of this paper is to investigate the reality and importance of barriers to EV adoption from the perspective of a large sample of mainstream car market consumers in the UK

3. Survey method and findings

In operationalising this research, each barrier in Table 1 was translated into a questionnaire item that utilised a 5-point Likert Scale where '1' indicates the barrier item to be 'of no concern at all' and '5' indicates it to be 'a really serious concern'. Approval was sought and given to run the 'questionnaire' through the Automobile Association's (AA) Motoring Panel, maintained by Populus[5]. The justification for using the panel was that it: (a) provided access to motorists who by definition should be better informed about the automobile market; (b) enabled a survey of significant scale in terms of potential sample size; and (c) of significant reach, facilitating understanding of attitudes towards EVs at national level. The resultant data reported here provide a sample that can be stratified by driver characteristics such as gender, age, occupation of chief earner and place of residence (see Appendix 1). They are not wholly representative of the UK motoring context as the sample underrepresents female motorists.

To ensure the logic, applicability and phrasing of questions, the survey instrument was tested and revised through consultation with *Populus*. The finalised survey instrument was subsequently incorporated into the AA's January 2016 survey. Analysis of findings collated from 26,195 drivers are presented below and summarised in Table 2.

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5 The AA-Populus Motoring Panel was launched in 2008. It currently has over 180,000 members. Samples of approximately 25,000 complete surveys every month. Surveys are conducted on-line. The January 2016 survey was conducted between January 18th and 25th and, in addition to EV barriers explored issues such as: drivers using hand-held mobile telephones, petrol choice and price, car tax, parking, older cars and road traffic accidents. See: http://www.theaa.com/public_affairs/aa-populus-panel/#tabview%3Dtab1

High purchase price and availability of charging stations are the principal barriers cited, as reflected through well over 50% of respondents in each case suggesting that these are 'really serious' concerns, resulting in a mean score on the Likert scale of more than four. In a UK context, this observation is consistent with empirical evidence from the '*Public attitudes to electric vehicles*' survey. This government survey of 649 full driving licence holders in the UK in 2016 found that recharging, battery and cost issues were the most important factors deterring people from buying a EV (Department for Transport, 2016).

Whilst concerns expressed by UK drivers over charging infrastructure are consistent with evidence from academic literature (Tran et al 2013, Egbue and Long 2012, Graham-Rowe et al 2012, and Carley et al 2013), there is a question as to whether this is a real or perceived concern. Data on charging points in the UK indicates that there has been a substantial increase in their number since 2013. By the end of 2015, there were almost 10,000 charging stations nearly double the number available in 2013 (Zap Map, 2016). That it remains a significant deterrent based on the survey findings presented here suggests that visibility and awareness of charging stations is a key issue. Consistent with the observations of Hardman et al (2015) the 'length of time to offset higher purchase price through savings made in fuel and taxation' also emerged as a key barrier; a net concern for 68% of drivers.

That two of the three most cited barriers might be viewed as 'financial' deterrents should not be considered as a surprise. The aforementioned Department for Transport (DFT) survey on vehicle attitudes found that some 80% of respondents cited financial issues such as purchase price, running costs and resale value as of importance when selecting a vehicle (Department for Transport, 2015, 2016). In reference to the latter, the issue of 'anxiety over resale value' emerged as a net concern with over half of surveyed drivers in this study

Other concerns for drivers include the performance and durability of the EV battery; the time taken to charge a EV; and the availability of downstream infrastructure for vehicle maintenance, service and repair. This suggests that the ecosystem and associated behaviours required for the electric vehicle market vis-à-vis those required for ICE vehicles is currently a stretch for drivers and creates a barrier whether perceived or real.

Table 2: Barriers to EV purchase in the UK

	Barrier to EV Purchase	Barrier is a NET CONCERN* n	Barrier is a NET CONCERN* (%)	Barrier is NOT a Concern n	Barrier is NOT a Concern (%)	Median	Mean
1	**The high purchase price**	21,604	82	1,675	6	5	4.28
2	**Availability of public charging stations**	21,294	81	1,956	7	5	4.25
3	**Length of time to offset higher purchase price through savings made in fuel and taxation**	17,828	68	2,987	11	4	3.89
4	**Concerns over durability of the battery**	17,059	65	3,370	13	4	3.83
5	**Limited vehicle driving range for day-to-day needs**	15,357	59	5,725	22	4	3.65
6	**Uncertainty over maintenance, service and repair infrastructure**	15,320	58	4,353	17	4	3.63
7	**Length of time it takes to charge a EV**	14,520	55	4,670	18	4	3.60
8	**Lack of choice and availability in the EV market**	13,143	50	5,204	20	4	3.45
9	**Uncertainty concerning the process of home/public charging**	13,629	52	6,435	25	4	3.42
10	**Anxiety over the re-sale value**	13,828	53	5,294	20	3	3.50
11	**Concern that driving behaviour and using vehicle features will diminish driving range**	11,123	42	7,239	28	3	3.21
12	**Expectation that EV technology will improve in the future so are delaying purchase**	10,627	41	6,983	27	3	3.17
13	My dwelling would be unsuitable for home charging	10,633	41	10,970	42	3	2.98
14	A lack of general understanding of the benefits of driving EVs	8,968	34	9,068	35	3	2.96
15	Concern over the real environmental impact of electric vehicles	8,736	33	9,096	35	3	2.96
16	Expectation that improvements in ICE will continue, offsetting environmental benefits of EVs	7,654	29	8,206	31	3	2.95
17	Difficulties in understanding how to calculate fuel costs and potential savings of EVs	8,273	32	9,826	38	3	2.88
18	Vehicle design/aesthetics are inferior compared to market for Internal Combustion Engine vehicles	7,471	29	10,422	40	3	2.80
19	Belief that EVs are an inferior/unreliable technology	6,800	26	10,499	40	3	2.78

**Net Concern = 4-5 on Likert Scale; Not a Concern = 1-2*

In comparison to the top 12 barriers identified in Table 1, the remaining seven barriers emerged as much less of a concern to drivers, evidenced by a mean score on the Likert scale of less than three (see Figure 2). Trust and faith in new technology can often act as a barrier to purchase and has certainly been raised with respect to EVs in relation to the market readiness of the technology and its reliability (Lane and Potter, 2007, Steinhilber et al., 2013, Egbue and Long, 2012, Graham-Rowe et al, 2012, Axsen and Kurani, 2013, Wan et al., 2015). Despite these issues, the barrier of least concern from the survey was the 'belief that EVs are an inferior or unreliable technology'; perhaps suggesting that as EV technology and models have developed over the last few years the impact of this barrier has diminished. In a similar vein, just 29% of responding drivers suggested that EV design and aesthetics would act as a barrier to EV purchase, with 40% reporting that this would not be a concern. However, whilst EV technology might have improved, it is still seen by many in the mass market as too immature, especially in the context of its likely continued rapid evolution. Some 41% of respondents held the view that there would be future improvements to EV technology; hence any decision to purchase would be delayed. This observation is consistent with other research (see Graham-Rowe et al, 2012; and Rezvani et al, 2015) which suggests that potential purchasers of EVs might be deterred due to a belief that the technology will dramatically improve in the near future rendering current product offerings obsolete.

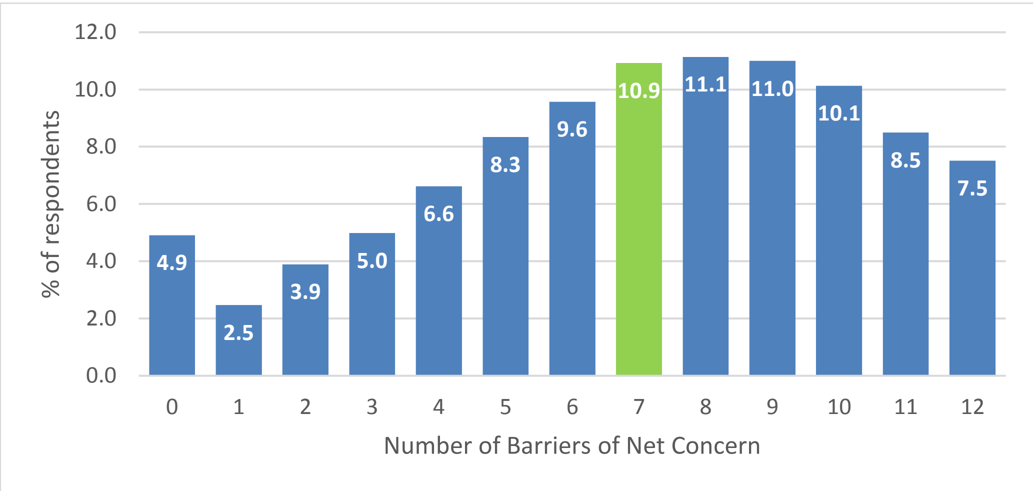
Potential barriers regarding: understanding how to calculate costs and savings; general awareness and understanding of the benefits of EV ownership; concern over the real environmental impact of EVs; and the unsuitability of dwellings for home charging, emerged as not of concern for the majority of the drivers in our sample. Interestingly prior research that identified these barriers was undertaken in the USA where, as suggested earlier, driving conditions and the 'everyday' realities faced by consumers are very different from those in Europe. Moreover, this may also suggest that in the context of the UK more effective work has been done to educate the driving public on EVs.

This section of the paper has presented findings from empirical research examining the extent to which drivers in the UK recognise individual barriers as concerns which would deter them from buying a EV. Twelve barriers emerged as key deterrents on the basis that they were a net overall concern for respondents. Whilst this analysis is important in identifying the strength and relative importance of individual barriers it does not recognise that individuals may perceive multiple barriers, nor does it recognise any association between them. As suggested earlier in the paper, solving the EV mass market take-up problem and providing evidence that can be useful for policy makers in shaping more informed, effective and holistic solutions, is likely to be more complex than dealing with barriers individually. As such, the next logical step, drawing on the reduced set of twelve barrier items, is to evidence the complex multiplicity of barriers perceived by individual motorists and attempt to reduce or consolidate their number further.

4. Analysing the association between barriers

Evidence from the survey reveals that for the overwhelming majority of ICE drivers there are multiple barriers representing concerns that would deter them switching from an ICE vehicle to a EV (Figure 1). Indeed, the average driver pointed to as many as *seven* barriers as being of major concern. Even discounting outliers, where just under 2,000 respondents (7%) indicated that all 12 barriers were deterrents, these data are still very revealing. Some 53% of the sample identified between 6 and 10 barriers as concerns, whilst only 6% recognised one or two.

Figure 1: Number of Barriers of Net Concern to ICE drivers



As such whilst barriers such as purchase price and public charging station availability might be viewed as the most important by rank they do not exist in isolation from each other nor from other barriers. To this end the paper proceeds rationally to test the extent to which variables are correlated and might be associated with a latent explanatory 'factor' or construct. The paper proceeds to test this through the application of exploratory factor analysis (EFA) to the dataset.

Using a Varimax rotation and Principal Component Analysis method in SPSS, the EFA results in an initial two factor solution with the factors between them explaining 53% of the variation. As one factor on its own does not explain more than 50% of the variation, common method bias is not a concern (see Podsakoff et al, 2003); the primary factor in this case accounts for 44% of the variation explained. In order to test for reliability, the extent to which the individual barrier items are measuring the same factor (or construct) and hence are inter-related, the Cronbach's alpha test was applied (Tavakol and

Dennick, 2011). For the first factor the value of Cronbach's α=0.821, indicating a high level of internal consistency (Tavakol and Dennick, 2011). Removing any items from the factor would result in a lowering of the Cronbach's α value. This would suggest that the individual items are indeed measuring the same construct. To test for unidimensionality, EFA was applied to the five items and revealed only one factor with an eigenvalue above 1 (2.93) and explaining 59% of the total variance. This would suggest that the items are unidimensional. For the second factor the value of Cronbach's α=0.808, again suggests a high level of internal consistency. However, in this case the test indicated that removing the *Expectation that EV technology will improve in the future so are delaying purchase* item would improve Cronbach's α, albeit marginally, to a value of 0.814. Further analysis reveals a much lower corrected-item total correlation value for this item (0.36 compared to 0.55-0.64 for the other items). It was therefore decided to remove this item from the second factor. EFA was then applied to the remaining six items and revealed only one factor with an eigenvalue above 1 (3.14) explaining 52% of the total variance which would suggest unidimensionality. EFA was subsequently applied to the revised 11 barrier items and produces the final solution shown in Table 3 which confirms the reduction of barriers identified to two factors: 'economic uncertainty' and 'socio-technical issues'. In both cases factor loadings are high indicating the individual variables to be strongly correlated to their respective factors. Whilst this solution is consistent with previous classifications (see Browne et al, 2012; Carley et al, 2013; Axsen and Kurani, 2013) it adds considerable value as a contribution to the academic discourse. Firstly, it is underpinned by much more substantial survey evidence. Secondly, barrier items were drawn principally from existing studies of motorists and potential adopters who cited specific concerns surrounding EVs. As a result, the two barrier factors are taken from a consumer perspective, reflecting attributes of the vehicles as they seem them, new insights that are arguably critical in addressing barriers to adoption.

The first factor comprises five barrier items which collectively describe a level of economic uncertainty amongst potential EV drivers, whether related to purchase prices, resale values, energy savings, servicing and repair or a perceived lack of choice in the market place. While fundamentally economic issues, in each case the underlying focus of concern relates to whether anticipated costs, savings, choices as 'advertised' will prove real for the adopters of such vehicles. In essence, this points to a need to better support the development of the EV ecosystem as a whole, such that it becomes normalised in terms of behaviours and infrastructure, in the same way as the current ICE system (Lane and Potter 2007). This transition will be gradual, with both ecosystems existing alongside one another for some time, and during this phase overcoming economic uncertainty barriers will demand that the

EV ecosystem becomes more visible and operates with the same degree of ease, efficiency and convenience as that experienced by ICE drivers currently.

The second factor brings together a set of barrier items characterised by socio-technical concerns. These include charging infrastructure, charging time, driving range, durability, and driving behaviour. Again, the underlying focus of these concerns might be considered perceptional, a fear of diminished vehicle performance, convenience, capability and lifespan relative to the established ICE ecosystem. These fears endure despite huge technical advances over the past decade which have witnessed dramatic improvements in battery durability and performance, and perhaps in part reflect the lack of a visible second-hand market for EVs; something which once established would reassure consumer concerns about durability as well as some of the economic uncertainty highlighted by factor one here. Of key note for policy makers, therefore, and cutting across both identified factors, is a need for all stakeholders in the EV ecosystem to enhance its visibility, increase awareness and thereby shift driver behaviours and market acceptance.

Table 3: Final Exploratory Factor Analysis and Barrier Conceptualisation

Item / Factor	**Factor Loadings**		**Barriers Conceptualised**
	Factor 2	**Factor 1**	
The high purchase price	0.15	**0.80**	**Economic Uncertainty**
Length of time to offset higher purchase price through savings made in fuel and taxation	0.18	**0.83**	
Anxiety over the re-sale value	0.29	**0.72**	
Uncertainty over maintenance, service and repair infrastructure	0.40	**0.64**	
Lack of choice and availability in the EV market	0.44	**0.52**	
Availability of public charging stations	**0.56**	0.42	**Socio-technical concerns**
Length of time it takes to charge a EV	**0.76**	0.23	
Limited vehicle driving range for my day-to-day needs	**0.75**	0.12	
Concerns over durability of the battery	**0.62**	0.43	
Concern that driving behaviour and using vehicle features will diminish driving range	**0.64**	0.23	
Uncertainty concerning the process of home/public charging	**0.64**	0.18	

Having identified 'economic uncertainty' and 'socio-technical concerns', the analysis proceeds to uniquely explore the strength of these barriers as measured against several key motorist characteristics. Such analysis is useful both conceptually and for policy makers; are barriers more (or less) of an issue for different demographic groups? As highlighted earlier, literature proposes that short-term solutions to EV penetration issues might be to strategically target EVs at certain market segments: locations where there is likely to be the greatest interest or impact, e.g. major cities; or where ownership is thought to provide the maximum environmental benefit; higher-earners, not put off by price and attracted by the pull of new technology; and younger people, less attached to the ICE ecosystem, more likely to have an interest in technology and the convenience afforded by EVs (Serra, 2012; Krause et al., 2014; Carley et al., 2013; Skerlos and Winebrake, 2010). Our large dataset facilities exploration of the logic of such strategies having access to data on respondents' age, occupation of chief earner in the household (as a proxy for purchasing power); and UK region in which they are domiciled. The dataset also contained data on gender, and whilst not explicitly identified in the literature, it was deemed prudent to explore any relationships with the identified barriers.

Further statistical tests were therefore conducted using a multivariate regression framework aiming to get a better understanding of the position of individuals, based on their demographic characteristics, on economic uncertainty and socio-technical issues as barriers to EV adoption. Multivariate models permit the exploration of interactions between variables i.e. how a persons' age and earning power affect their attitude towards EVs. Such analysis provides powerful new insights adding to the academic and policy discourse. The models are based on a series of interacting binary variables. For example, each male (female) respondent within the first age group (18 to 34) is assigned the value of 1 (0). The two factors: economic uncertainty and socio-technical issues are used as dependent variables derived from their factor scores[6]. All regressions have been carried out using the Newey-West procedure to control for possible issues of autocorrelation and heteroscedasticity.

Findings reveal that there are clear differences in the relationship between driver characteristics and the examined dependent variables, especially economic uncertainty (Tables 4-7). For example, there is a significant negative relationship between the 18-34 and 35-54 age groups for males (GEN1AGE1 and GEN1AGE2) and females (GEN2AGE1 and GEN2AGE2) with economic uncertainty (coefficients of -0.30, -0.09, -0.28 and -0.05 respectively). However, this is not the case for males and females in the older 55+ age group where the relationship is positive in both cases (GEN1AGE3 = 0.08 and GEN12AGE3 = 0.10). This suggests that that economic uncertainty is an important barrier to older men and women buying electric vehicles, much less so for younger people (Table 4). This pattern is largely consistent across occupational groups (e.g. for young men, coefficients of -0.32, -0.29, 0.32 and -0.21; and for older men, 0.05, 0.12, 0.10 and -0.01) suggesting that economic uncertainty is not as affected by purchasing power for young people as it is for older people.

[6] Factor scores calculated using Regression method in SPSS Factor Analysis. Scores are positive indicating a high level of for example 'economic uncertainty', and highly negative indicating a low level

[*insert table 4 here*]

In terms of place of residence, an initial Error Bar plot comparing means of economic uncertainty against region revealed a potentially significant London factor, with economic uncertainty appearing much less of an issue for those living inside the capital than outside (Figure 2). This was tested for in the regression model presented in Table 5. Results confirm a relationship between economic uncertainty and the interaction of age, gender and residence. For men living in London this relationship is significant and consistently negative, though decreasing with age group (18-34 = -0.38; 35-54 = -0.28 and 55+ = -0.14). However, for men living outside London, a notable difference is observed; the relationship is significantly negative for the 18-34 age group (GEN1AGE1REST = -0.27), whilst being significantly positive for the 55+ age group (GEN1AGE3REST = 0.11). A similar pattern is observed for females but for those resident in London, is not significant. Adding occupation into the interacting demographic variables does not influence the effect of age. Whilst for young men (18-34) in all occupation groups there is a negative relationship with economic uncertainty for those living in and outside London, albeit stronger in London (e.g. GEN1AGE1OCC1LON = -0.38; GEN1AGE1OCC2LON = -0.46; GEN1AGE1OCC1REST = -0.29; GEN1AGE1OCC2REST = -0.25); for the 55+ age group that relationship is positive for those living outside of London across all occupation groups (e.g. GEN1AGE3OCC3REST = 0.15), at the same negative for those living inside (e.g. GEN1AGE3OCC3LON = -0.32). Findings overall suggest that economic uncertainty as a barrier to EV purchase is less of an issue in London than the rest of the country and especially with regard to older drivers.

[insert Figure 2 and Table 5 here]

Turning to the second dependent variable, socio-technical issues, the differences in the relationship with gender, age and occupation of chief earner are less significant, but at the same time different to those observed for economic uncertainty (Table 6). Interestingly, when compared to the economic uncertainty variable, age is not found to be an influencing factor on socio-technical issues. This is somewhat of a surprise as older drivers are typically characterised as more entrenched with prevailing ICE technological ecosystem. There is evidence though that gender is important in this case. For example, for women across the three age groups there is a weak positive relationship with socio-technical issues as a barrier to EV purchase (GEN2AGE1 = 0.07; GEN2AGE2 = 0.08; GEN2AGE3 = 0.07), whereas for men that relationship is weakly negative (GEN1AGE2 = -0.08; GEN1AGE3 = -0.07). This suggests that women are perhaps more skeptical about the readiness and reliability of EV technology and infrastructure than men are, something that may be linked to levels of interest in technology generally, and vehicle technology in particular, but could also reflect personal safety concerns linked to the perceived potential to be left 'stranded' by the lack of reliability or range of a given electric vehicle. The difference between males and females on socio-technical issues is also observed when occupation is added to the interaction. Data shows, for example, that for women in higher-end occupations in the middle and older age groups (34-54 and 55+) there is a significantly positive relationship with socio-technical issues (GEN2AGE2OCC1 = 0.07; GEN2AGE2OCC2 = 0.09; GEN2AGE3OCC1 = 0.07; GEN2AGE3OCC2 = 0.07) whilst for men in the same age groups and higher-end occupations, that relationship is negative (GEN1AGE2OCC1 = -0.11; GEN1AGE2OCC2 = -0.07; GEN1AGE3OCC1 = -0.09; GEN1AGE3OCC2 = -0.04). Evidence of a London factor influencing the socio-technical issues variable was weak and largely insignificant (Table 7). Findings do suggest that difference between genders hold true for those resident outside London especially in middle and older age groups, and in higher-end occupations (e.g. EN1AGE2OCC1REST = -0.11; GEN1AGE2OCC2REST = -0.07; GEN2AGE2OCC1REST = 0.08; GEN2AGE2OCC1REST = 0.09).

[*insert Tables 6 and 7 here*]

5. **Discussion and conclusions**

Despite a favourable landscape for electric vehicles to achieve significant market share, barriers to take-up amongst drivers endure. This has been uniquely evidenced in the analysis presented in this paper. Twelve barriers, from nineteen identified in the literature, are recognised as key concerns for UK drivers. High purchase price and the availability of public charging stations emerged as the most substantive barriers to EV adoption, whilst other significant barriers included: the length of time taken to offset the higher purchase price through savings made in fuel and taxation, and anxiety over re-sale values; battery performance, the time taken to charge a EV, and the availability of a wider downstream infrastructure for maintenance, service and repair. Whilst reducing the complexity down to 12 barriers is useful, it is not hugely helpful from a policy perspective given that barriers are proposed to be multifaceted and interrelated. Indeed, the overwhelming majority of respondents cited several barriers, not just one. An exploratory factor analysis supported the proposition, reducing barriers to two broad factors: 'economic uncertainty' and 'socio-technical issues'. In both cases, the underlying focus of concern is perhaps more perceptual than real and linked to fears about the reliability of available 'intelligence' about the functioning of the EV ecosystem, whether in relation to costs, savings, vehicle performance, battery durability, refuelling, repair or resale.

A subsequent multivariate regression analysis revealed a number of more nuanced associations between economic uncertainty and age and geography, and to a lesser extent between socio-technical issues and gender. Of particular interest in in this respect is the fact that economic uncertainty appears to be a greater barrier for older rather than younger drivers. This is somewhat counter intuitive, given that older consumers typically have greater financial resources, and is perhaps indicative of economic uncertainty as a 'norm' for younger generations of consumers, many of whom have grown up with models of consumption based on high levels of indebtedness and leasing (for example through personal contract plans) rather than outright ownership. The second strong association to emerge from the regression analysis, that economic uncertainty as a barrier is particularly low amongst young people in London, helps to support this hypothesis. However, it also raises questions about the links between intentions and behaviours, given low rates of car ownership in the capital relative to the rest of the UK, and whether a lack of economic uncertainty is linked to a lack of awareness. Equally, this finding can be 'flipped', and the question posed, why is economic uncertainty such a barrier outside of London? Is it simply a reflection of wider economic disparities between London and the rest of the UK, or are there other factors at play?

With regard to the socio-technical factor, the regression analysis suggests that to some extent, this barrier is more of an issue for women than it is for men. The association is relatively weak, but does perhaps hint at two issues potentially influencing perceptions of electric vehicles amongst female motorists. First, that a perceived lack of reliability, either mechanical or more likely due to range anxieties, may be playing to fears about personal safety. Second, on the whole, the current generation of electric vehicles are not typical of the large family cars, either estates or now more often SUVs, which are ever more favoured by women with children. Whilst not impractical in themselves, electric vehicles may appear so compared to the size of vehicles that are increasingly becoming the norm for families with children.

The strong statistical evidence for the two-barrier factorisation is revealing, suggestive of a significant demand side problem facing the EV industry. The plethora of announcements in 2017 reporting bans on new petrol and diesel vehicles within the next 20 years, indicate how governments are effectively seeking to regulate EVs into the mainstream, and several global manufacturers have already announced that new petrol and diesel cars will, in the near future, no longer be available in their fleets. Whilst this is welcome, outside of well-meaning debate, there has been much less policy intervention with regard to the demand side problem evidenced in this paper. This relative omission can be illustrated through the current UK governments' recently published Industrial Strategy where the key demand side initiatives are to provide a further £100m to the plug-in car grant scheme, and commit to 25% of central government department fleets being electric by 2022; this compares to a £400m fund for charging infrastructure (BEIS, 2017, p. 144).

There is a clear indication from the two-factor solution and regression analysis that the barriers to EV adoption are complex and multi-faceted, not easily solved by tackling individual issues, but requiring a more holistic ecosystem approach by policy makers.

In tackling socio-technical issues such holistic strategies might include for example, on the supply side, investing in the broader EV ecosystem in terms of day-to-day vehicle operation, by developing effective charging, driving and parking networks both within and between cities; whilst also supporting manufacturers to continue to invest in R&D to improve battery performance and durability issues. Alongside this, and on the demand side, there is a clear need to challenge the perceptual concerns of motorists through co-ordinated market awareness campaigns, public information and education. The provision of reliable information is key to countering misinformed perception and exaggeration which can bread mistrust of new technologies amongst consumers. Such issues, though not new in themselves, have not adequately been tackled by policy issues to date, nor has there been a focusing of action on the basis of gender, which this research shows to be important in the context of socio-technical perceptions of EVs. Although this insight is new, it is perhaps telling that the majority of policy stakeholders engaged in the EV debate at national level are male, implicitly influencing the focus and nature of intervention (see Electric Vehicles Bill, House of Lords Roundtable, 26th April 2018).

An example initiative which would appear to have a tangible scale and the appropriate accessibility to female as well as male motorists, is the EV Experience Centre located in central Milton Keynes[7] which opened in 2017 with the aim of providing an impartial, brand neutral setting for residents to receive advice, learn about and experience a wide range of EVs either through test drives or week-long loans. In addition, Milton Keynes itself has an emerging EV ecosystem offering free parking, rapid charging, access to bus lanes, and access to free charging at popular resident destinations such as supermarkets, petrol stations and leisure centres. Public and industry support for more widespread adoption of this joined-up supply and demand side approach to tackling socio-technical issues should help in overcoming barriers, not only through direct experience of EVs, but also indirectly, through increased visibility and awareness encouraging others. Such a roll-out also points to the need to devolve more responsibility for delivering such market influencing activities away from central government. Alongside this, there needs to be a push to encourage more female representation in the automotive policy arenas shaping the EV debate.

[7] See https://evexperiencecentre.co.uk/

In addressing the economic uncertainty barrier, a holistic solution necessarily involves multiple stakeholders including policy makers, manufacturers and dealerships. Different business models are appropriate, especially in the short term whilst upfront purchase prices remain prohibitively high for many. Again, analysis presented here suggests that the adoption and 'widespread normalisation' of such models could be hastened by targeting those segments of the market for who economic uncertainty is already less of an issue, specifically young drivers. This might include, EV dealers framing their offers in such a way as to appeal to younger buyers, for example, by promoting a shift from purchasing to leasing as a model of ownership. This model of consumption is congruent with many other areas of life for young people, would allow easier comparison of whole life costs, remove the negative effects of higher initial purchase price and transfer some of the anxiety and risk of second hand values to sellers. Similarly, other new models of ownership, such as access to an EV through a car club could, play to the growth of a 'shared economy' amongst younger consumers and falling desire to acquire and own physical assets such as homes and cars. In addition, such innovative models of ownership can help support those who are currently facing mobility challenges, reducing economic uncertainty by lessening the cost and risk of a consumer switching to an EV.

Conversely, there is also an argument that policy could tackle high economic uncertainty amongst older drivers, and cautious EV purchasing behaviour, by shifting from focusing on purchase costs to total cost of ownership. EVs' advantage come in their significantly lower running costs which over time can offset the differential in initial purchase price. Recent research published by the European Consumer Association[8] claims that the difference in the four-year total cost of ownership of a C-segment vehicle such as the electric Nissan Leaf compared to the petrol Vauxhall Astra will reduce from c.€2,000 in 2015 to c.€1,000 in 2020; converging by 2030 (this could come earlier if battery costs fall rapidly). Shifting support to grants which work overtime to offset the total costs of ownership could be effective in stimulating the market but also in shifting behaviour away from a focus on the upfront price. Given that the C-segment is also the most popular in Europe consideration could be given to focusing subsidies here, and away from more premium and luxury segments. In addition, retailers can further increase the range and visibility of EVs in their showrooms and help to allay economic uncertainty fears through provision of clear full cost of ownership information, alongside running and maintenance cost information. This already takes place in the United States, where an Environmental Protection Agency/Department of Transport 'stickering' scheme for new EVs displayed in car dealerships clearly shows fuels savings and ownership costs over a five-year period relative to an equivalent ICE vehicle.

[8] European Consumer Association (2017) Low Carbon Cars in the 2020's, BEUC, Brussels, Belgium

In both of the examples above, younger and older drivers, the research presented in this paper indicates the need to be mindful of geography, and apparent regional differences in perception. This should be accounted for in the roll out of policy, with younger people in London seemingly particularly receptive to EV adoption, and motorists beyond the capital, especially older drivers, needing greater convincing. Clearly, these older drivers comprise the bulk of the motoring population, and so if policy is to have real impact, concerted effort needs to be placed on nudging their perceptions and behaviour in relation to EV adoption.

Overall evidence suggests that strategies comprising a range of mutually enforcing policies will be needed if socio-technical and economic uncertainty issues are to be overcome and for EVs to break out of being merely a niche. Of key note for policy makers, therefore, and cutting across both factors, is a need to focus more on demand side policies that work in tandem with the multitude of supportive supply side policies. Stakeholders in the EV ecosystem need to work together to enhance its visibility, increase awareness and thereby shift driver behaviours and market acceptance, with a variety of solutions appealing to demographic groups across society.

In concluding, the research presented here has made an empirical contribution, significantly enriching the literature, by reducing the complexity of the EV 'barrier problem' through research with drivers in the mass ICE market, and through a subsequent multivariate regression analysis that has brought attention to a number of key associations between barrier factors and age, geography and gender. Notwithstanding the usefulness of these insights, it is of course important to recognise that other variables, not incorporated in this analysis, may also have an influence on EV purchasing behaviour. These could include for example, ethnicity, marital status, housing type/tenure, and vehicle type and brand preferences. Although limited to a UK context, the analysis presented here, has uniquely exposed the interrelatedness of barriers and enabled an initial set of nineteen literature derived barriers to be reduced to just two key factors: economic uncertainty and social-technical issues. In turn, the factor and demographic analysis provides a more manageable and effective steer for policy makers in similar European contexts seeking to erode barriers and facilitate transition to widespread EV adoption. Beyond such contexts, the methodology applied in this research provides a framework for others to interrogate how identified barriers to adoption can be reduced to more helpful explanatory factors.

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TABLE 4: Multivariate Regression Model - Relationship between age, gender and occupation of chief earner on ECONOMIC UNCERTAINTY

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.0040	0.0109	-0.3629	0.7167
GEN1AGE1	**-0.3042**	0.0316	-9.6201	**0.0000**
GEN1AGE2	**-0.0912**	0.0173	-5.2729	**0.0000**
GEN1AGE3	**0.0760**	0.0142	5.3511	**0.0000**
C	0.0016	0.0077	0.2139	0.8307
GEN2AGE1	**-0.2737**	0.0297	-9.2063	**0.0000**
GEN2AGE2	**-0.0525**	0.0190	-2.7640	**0.0057**
GEN2AGE3	**0.1016**	0.0170	5.9784	**0.0000**
C	-0.0040	0.0109	-0.3628	0.7168
GEN1AGE1OCC1	**-0.3205**	0.0554	-5.7796	**0.0000**
GEN1AGE1OCC2	**-0.2959**	0.0433	-6.8419	**0.0000**
GEN1AGE1OCC3	**-0.3205**	0.0704	-4.5538	**0.0000**
GEN1AGE1OCC4	-0.2167	0.1264	-1.7151	0.0863
GEN1AGE2OCC1	**-0.1523**	0.0246	-6.1822	**0.0000**
GEN1AGE2OCC2	**-0.0947**	0.0247	-3.8294	**0.0001**
GEN1AGE2OCC3	0.0019	0.0332	0.0557	0.9556
GEN1AGE2OCC4	-0.0040	0.0573	-0.0692	0.9448
GEN1AGE3OCC1	**0.0560**	0.0165	3.3852	**0.0007**
GEN1AGE3OCC2	**0.1275**	0.0208	6.1177	**0.0000**
GEN1AGE3OCC3	**0.1050**	0.0289	3.6374	**0.0003**
GEN1AGE3OCC4	-0.0018	0.0348	-0.0521	0.9585
C	0.0016	0.0077	0.2138	0.8307
GEN2AGE1OCC1	**-0.2530**	0.0498	-5.0772	**0.0000**
GEN2AGE1OCC2	**-0.2877**	0.0410	-7.0233	**0.0000**
GEN2AGE1OCC3	**-0.3224**	0.0812	-3.9693	**0.0001**
GEN2AGE1OCC4	-0.1381	0.1355	-1.0191	0.3082
GEN2AGE2OCC1	**-0.0858**	0.0268	-3.2071	**0.0013**
GEN2AGE2OCC2	-0.0056	0.0276	-0.2043	0.8381
GEN2AGE2OCC3	**-0.1410**	0.0564	-2.4986	**0.0125**
GEN2AGE2OCC4	0.0326	0.0926	0.3523	0.7246
GEN2AGE3OCC1	**0.0459**	0.0235	1.9548	**0.0506**
GEN2AGE3OCC2	**0.2037**	0.0254	8.0150	**0.0000**
GEN2AGE3OCC3	-0.0036	0.0625	-0.0577	0.9540
GEN2AGE3OCC4	0.0906	0.0536	1.6891	0.0912

Notes

Method: Least Squares

Sample: 26194

Included observations: 26194

HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 14.0000)

Bold = Significant at the 5% level

Variable Key

GEN1 = Male

GEN2 = Female

AGE1 = 18-34

AGE2 = 35-54

AGE3 = 55+

OCC1: Higher & intermediate managerial, administrative, professional occupations

OCC2: Supervisory, clerical & junior managerial, administrative, professional occupations

OCC3: Skilled manual occupations

OCC4: Semi-skilled & unskilled manual occupations, Unemployed and lowest grade occupations

TABLE 5: Multivariate Regression Model - Relationship between age, gender, occupation of chief earner and place of residence on ECONOMIC UNCERTAINTY

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.0101	0.0066	1.5301	0.1260	C	-0.0290	0.0103	-2.8134	0.0049
GEN1AGE1LON	**-0.3787**	0.0925	-4.0938	**0.0000**	GEN1AGE1REST	**-0.2719**	0.0333	-8.1704	**0.0000**
GEN1AGE2LON	**-0.2824**	0.0532	-5.3134	**0.0000**	GEN1AGE2REST	**-0.0510**	0.0174	-2.9250	**0.0034**
GEN1AGE3LON	**-0.1445**	0.0408	-3.5417	**0.0004**	GEN1AGE3REST	**0.1150**	0.0140	8.2131	**0.0000**
C	0.0012	0.0065	0.1918	0.8479	C	0.0000	0.0075	0.0011	0.9991
GEN2AGE1LON	-0.1875	0.1325	-1.4155	0.1569	GEN2AGE1REST	**-0.2779**	0.0304	-9.1468	**0.0000**
GEN2AGE2LON	-0.0711	0.0630	-1.1281	0.2593	GEN2AGE2REST	**-0.0495**	0.0195	-2.5323	**0.0113**
GEN2AGE3LON	-0.0030	0.0653	-0.0460	0.9633	GEN2AGE3REST	**0.1109**	0.0174	6.3746	**0.0000**
C	0.0101	0.0066	1.5298	0.1261	C	-0.0290	0.0103	-2.8130	0.0049
GEN1AGE1OCC1LON	**-0.3818**	0.1484	-2.5726	**0.0101**	GEN1AGE1OCC1REST	**-0.2895**	0.0594	-4.8738	**0.0000**
GEN1AGE1OCC2LON	**-0.4591**	0.1462	-3.1400	**0.0017**	GEN1AGE1OCC2REST	**-0.2525**	0.0450	-5.6140	**0.0000**
GEN1AGE1OCC3LON	-0.0635	0.2306	-0.2752	0.7831	GEN1AGE1OCC3REST	**-0.3230**	0.0733	-4.4042	**0.0000**
GEN1AGE1OCC4LON	**-0.6998**	0.2572	-2.7210	**0.0065**	GEN1AGE1OCC4REST	-0.1320	0.1364	-0.9678	0.3331
GEN1AGE2OCC1LON	**-0.4175**	0.0802	-5.2064	**0.0000**	GEN1AGE2OCC1REST	**-0.1002**	0.0252	-3.9707	**0.0001**
GEN1AGE2OCC2LON	**-0.1775**	0.0867	-2.0463	**0.0407**	GEN1AGE2OCC2REST	**-0.0644**	0.0254	-2.5328	**0.0113**
GEN1AGE2OCC3LON	-0.2307	0.1298	-1.7770	0.0756	GEN1AGE2OCC3REST	0.0399	0.0342	1.1658	0.2437
GEN1AGE2OCC4LON	0.0589	0.2049	0.2873	0.7739	GEN1AGE2OCC4REST	0.0145	0.0588	0.2469	0.8050
GEN1AGE3OCC1LON	**-0.1474**	0.0547	-2.6964	**0.0070**	GEN1AGE3OCC1REST	**0.0950**	0.0164	5.7861	**0.0000**
GEN1AGE3OCC2LON	-0.0654	0.0695	-0.9423	0.3460	GEN1AGE3OCC2REST	**0.1647**	0.0210	7.8432	**0.0000**
GEN1AGE3OCC3LON	**-0.3168**	0.1448	-2.1878	**0.0287**	GEN1AGE3OCC3REST	**0.1529**	0.0293	5.2201	**0.0000**
GEN1AGE3OCC4LON	-0.1404	0.1303	-1.0768	0.2816	GEN1AGE3OCC4REST	0.0295	0.0357	0.8275	0.4080
C	0.0012	0.0065	0.1918	0.8479	C	0.0000	0.0075	0.0011	0.9991
GEN2AGE1OCC1LON	-0.3323	0.1826	-1.8192	0.0689	GEN2AGE1OCC1REST	**-0.2438**	0.0515	-4.7302	**0.0000**
GEN2AGE1OCC2LON	-0.1880	0.2137	-0.8798	0.3790	GEN2AGE1OCC2REST	**-0.2924**	0.0412	-7.0948	**0.0000**
GEN2AGE1OCC3LON	**0.5868**	0.1674	3.5065	**0.0005**	GEN2AGE1OCC3REST	**-0.3579**	0.0828	-4.3215	**0.0000**
GEN2AGE2OCC1LON	-0.1782	0.0939	-1.8970	0.0578	GEN2AGE1OCC4REST	-0.1364	0.1355	-1.0071	0.3139
GEN2AGE2OCC2LON	0.0012	0.0944	0.0127	0.9899	GEN2AGE2OCC1REST	**-0.0760**	0.0277	-2.7447	**0.0061**
GEN2AGE2OCC3LON	0.0975	0.2114	0.4614	0.6445	GEN2AGE2OCC2REST	-0.0045	0.0283	-0.1581	0.8744
GEN2AGE2OCC4LON	0.2634	0.1962	1.3429	0.1793	GEN2AGE2OCC3REST	**-0.1464**	0.0576	-2.5435	**0.0110**
GEN2AGE3OCC1LON	-0.0664	0.0876	-0.7577	0.4487	GEN2AGE2OCC4REST	0.0160	0.0985	0.1620	0.8713
GEN2AGE3OCC2LON	0.1465	0.0976	1.5009	0.1334	GEN2AGE3OCC1REST	**0.0577**	0.0242	2.3898	**0.0169**
GEN2AGE3OCC3LON	-0.3773	0.4150	-0.9093	0.3632	GEN2AGE3OCC2REST	**0.2093**	0.0262	7.9895	**0.0000**
GEN2AGE3OCC4LON	-0.0208	0.3435	-0.0606	0.9517	GEN2AGE3OCC3REST	0.0089	0.0630	0.1411	0.8878
					GEN2AGE3OCC4REST	0.0962	0.0542	1.7771	0.0756

Notes

Method: Least Squares
Sample: 26194
Included observations: 26194
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 14.0000)

GEN1 = Male — OCC1: Higher & intermediate managerial, administrative, professional occupations
GEN2 = Female — OCC2: Supervisory, clerical & junior managerial, administrative, professional occupations
AGE1 = 18-34 — OCC3: Skilled manual occupations
AGE2 = 35-54 — OCC4: Semi-skilled & unskilled manual occupations, Unemployed and lowest grade occupations
AGE3 = 55+ — LON: Place of residence = London; REST: Place of Residence = Outside London

The Variable GEN2AGE1OCC4LON is dropped of as it was perfectly colinear with the regressor (no observations in this case)

TABLE 6: Multivariate Regression Model - Relationship between age, gender and occupation of chief earner on SOCIO-TECHNICAL ISSUES

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.0472	0.0108	4.3720	0.0000
GEN1AGE1	-0.0293	0.0329	-0.8891	0.3740
GEN1AGE2	**-0.0792**	0.0179	-4.4235	**0.0000**
GEN1AGE3	**-0.0694**	0.0144	-4.8183	**0.0000**
C	-0.0225	0.0076	-2.9637	0.0030
GEN2AGE1	**0.0662**	0.0301	2.2014	**0.0277**
GEN2AGE2	**0.0758**	0.0186	4.0693	**0.0000**
GEN2AGE3	**0.0656**	0.0176	3.7206	**0.0002**
C	0.0472	0.0108	4.3713	0.0000
GEN1AGE1OCC1	-0.0461	0.0537	-0.8591	0.3903
GEN1AGE1OCC2	-0.0518	0.0485	-1.0684	0.2853
GEN1AGE1OCC3	0.0557	0.0735	0.7578	0.4486
GEN1AGE1OCC4	-0.0713	0.1397	-0.5104	0.6098
GEN1AGE2OCC1	**-0.1094**	0.0243	-4.5039	**0.0000**
GEN1AGE2OCC2	**-0.0714**	0.0262	-2.7221	**0.0065**
GEN1AGE2OCC3	-0.0386	0.0347	-1.1119	0.2662
GEN1AGE2OCC4	-0.0675	0.0580	-1.1644	0.2443
GEN1AGE3OCC1	**-0.0924**	0.0170	-5.4442	**0.0000**
GEN1AGE3OCC2	**-0.0412**	0.0211	-1.9536	**0.0508**
GEN1AGE3OCC3	-0.0377	0.0282	-1.3397	0.1803
GEN1AGE3OCC4	**-0.0732**	0.0340	-2.1546	**0.0312**
C	-0.0225	0.0076	-2.9632	0.0030
GEN2AGE1OCC1	-0.0117	0.0506	-0.2311	0.8173
GEN2AGE1OCC2	**0.1010**	0.0423	2.3901	**0.0169**
GEN2AGE1OCC3	**0.1748**	0.0820	2.1331	**0.0329**
GEN2AGE1OCC4	-0.0386	0.1451	-0.2659	0.7903
GEN2AGE2OCC1	**0.0656**	0.0276	2.3765	**0.0175**
GEN2AGE2OCC2	**0.0944**	0.0265	3.5620	**0.0004**
GEN2AGE2OCC3	0.0851	0.0521	1.6346	0.1021
GEN2AGE2OCC4	-0.0361	0.0951	-0.3800	0.7039
GEN2AGE3OCC1	**0.0741**	0.0244	3.0433	**0.0023**
GEN2AGE3OCC2	**0.0669**	0.0270	2.4775	**0.0132**
GEN2AGE3OCC3	0.0153	0.0604	0.2534	0.8000
GEN2AGE3OCC4	0.0598	0.0507	1.1800	0.2380

Notes

Method: Least Squares
Sample: 26194
Included observations: 26194
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 14.0000)

GEN1 = Male	OCC1: Higher & intermediate managerial, administrative, professional occupations
GEN2 = Female	OCC2: Supervisory, clerical & junior managerial, administrative, professional occupations
AGE1 = 18-34	OCC3: Skilled manual occupations
AGE2 = 35-54	OCC4: Semi-skilled & unskilled manual occupations, Unemployed and lowest grade occupations
AGE3 = 55+	

TABLE 7: Multivariate Regression Model - Relationship between age, gender, occupation of chief earner and place of residence on SOCIO-TECHNICAL ISSUES

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.0002	0.0064	0.0380	0.9697
GEN1AGE1LON	-0.1212	0.0958	-1.2651	0.2059
GEN1AGE2LON	0.0158	0.0495	0.3201	0.7489
GEN1AGE3LON	0.0047	0.0375	0.1261	0.8997
C	-0.0004	0.0063	-0.0581	0.9537
GEN2AGE1LON	0.0143	0.1254	0.1142	0.9091
GEN2AGE2LON	0.0038	0.0662	0.0571	0.9544
GEN2AGE3LON	0.0357	0.0602	0.5931	0.5531
C	0.0002	0.0064	0.0380	0.9697
GEN1AGE1OCC1LON	-0.1986	0.1496	-1.3279	0.1842
GEN1AGE1OCC2LON	-0.1184	0.1571	-0.7535	0.4512
GEN1AGE1OCC3LON	0.0087	0.2311	0.0376	0.9700
GEN1AGE1OCC4LON	-0.0908	0.2513	-0.3613	0.7179
GEN1AGE2OCC1LON	0.0413	0.0717	0.5762	0.5645
GEN1AGE2OCC2LON	0.0281	0.0868	0.3243	0.7457
GEN1AGE2OCC3LON	-0.0903	0.1237	-0.7300	0.4654
GEN1AGE2OCC4LON	0.0044	0.2029	0.0219	0.9825
GEN1AGE3OCC1LON	-0.0740	0.0489	-1.5127	0.1304
GEN1AGE3OCC2LON	**0.1386**	0.0715	1.9380	**0.0526**
GEN1AGE3OCC3LON	0.0324	0.1201	0.2694	0.7876
GEN1AGE3OCC4LON	0.0563	0.1413	0.3982	0.6905
C	-0.0004	0.0063	-0.0581	0.9537
GEN2AGE1OCC1LON	0.1886	0.1602	1.1775	0.2390
GEN2AGE1OCC2LON	-0.0277	0.2020	-0.1372	0.8909
GEN2AGE1OCC3LON	-0.7048	0.4107	-1.7162	0.0861
GEN2AGE2OCC1LON	-0.0879	0.1037	-0.8481	0.3964
GEN2AGE2OCC2LON	0.0655	0.0877	0.7463	0.4555
GEN2AGE2OCC3LON	**0.3756**	0.1785	2.1041	**0.0354**
GEN2AGE2OCC4LON	0.0639	0.2578	0.2477	0.8043
GEN2AGE3OCC1LON	-0.0084	0.0792	-0.1056	0.9159
GEN2AGE3OCC2LON	0.1085	0.1022	1.0620	0.2883
GEN2AGE3OCC3LON	-0.2191	0.4338	-0.5050	0.6136
GEN2AGE3OCC4LON	0.2126	0.2361	0.9008	0.3677

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.0408	0.0100	4.0961	0.0000
GEN1AGE1REST	-0.0062	0.0342	-0.1823	0.8554
GEN1AGE2REST	**-0.0769**	0.0178	-4.3066	**0.0000**
GEN1AGE3REST	**-0.0648**	0.0140	-4.6322	**0.0000**
C	-0.0211	0.0074	-2.8573	0.0043
GEN2AGE1REST	0.0669	0.0307	2.1776	0.0294
GEN2AGE2REST	**0.0782**	0.0191	4.0907	**0.0000**
GEN2AGE3REST	**0.0648**	0.0181	3.5869	**0.0003**
C	0.0408	0.0100	4.0954	0.0000
GEN1AGE1OCC1REST	-0.0148	0.0572	-0.2581	0.7963
GEN1AGE1OCC2REST	-0.0314	0.0500	-0.6268	0.5308
GEN1AGE1OCC3REST	0.0717	0.0773	0.9276	0.3536
GEN1AGE1OCC4REST	-0.0564	0.1540	-0.3660	0.7144
GEN1AGE2OCC1REST	**-0.1141**	0.0249	-4.5752	**0.0000**
GEN1AGE2OCC2REST	**-0.0689**	0.0267	-2.5770	**0.0100**
GEN1AGE2OCC3REST	-0.0263	0.0354	-0.7444	0.4567
GEN1AGE2OCC4REST	-0.0632	0.0603	-1.0486	0.2944
GEN1AGE3OCC1REST	**-0.0838**	0.0169	-4.9481	**0.0000**
GEN1AGE3OCC2REST	**-0.0438**	0.0212	-2.0648	**0.0390**
GEN1AGE3OCC3REST	-0.0326	0.0282	-1.1570	0.2473
GEN1AGE3OCC4REST	**-0.0710**	0.0345	-2.0539	**0.0400**
C	-0.0211	0.0074	-2.8568	0.0043
GEN2AGE1OCC1REST	-0.0342	0.0526	-0.6498	0.5158
GEN2AGE1OCC2REST	**0.1065**	0.0431	2.4696	**0.0135**
GEN2AGE1OCC3REST	**0.2085**	0.0823	2.5316	**0.0114**
GEN2AGE1OCC4REST	-0.0399	0.1451	-0.2751	0.7832
GEN2AGE2OCC1REST	**0.0759**	0.0284	2.6729	**0.0075**
GEN2AGE2OCC2REST	**0.0936**	0.0275	3.3994	**0.0007**
GEN2AGE2OCC3REST	0.0746	0.0532	1.4034	0.1605
GEN2AGE2OCC4REST	-0.0472	0.1004	-0.4695	0.6387
GEN2AGE3OCC1REST	**0.0783**	0.0252	3.1040	**0.0019**
GEN2AGE3OCC2REST	**0.0612**	0.0278	2.2020	**0.0277**
GEN2AGE3OCC3REST	0.0201	0.0607	0.3317	0.7401
GEN2AGE3OCC4REST	0.0522	0.0518	1.0079	0.3135

Notes

Method: Least Squares

Sample: 26194

Included observations: 26194

HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 14.0000)

GEN1 = Male — OCC1: Higher & intermediate managerial, administrative, professional occupations

GEN2 = Female — OCC2: Supervisory, clerical & junior managerial, administrative, professional occupations

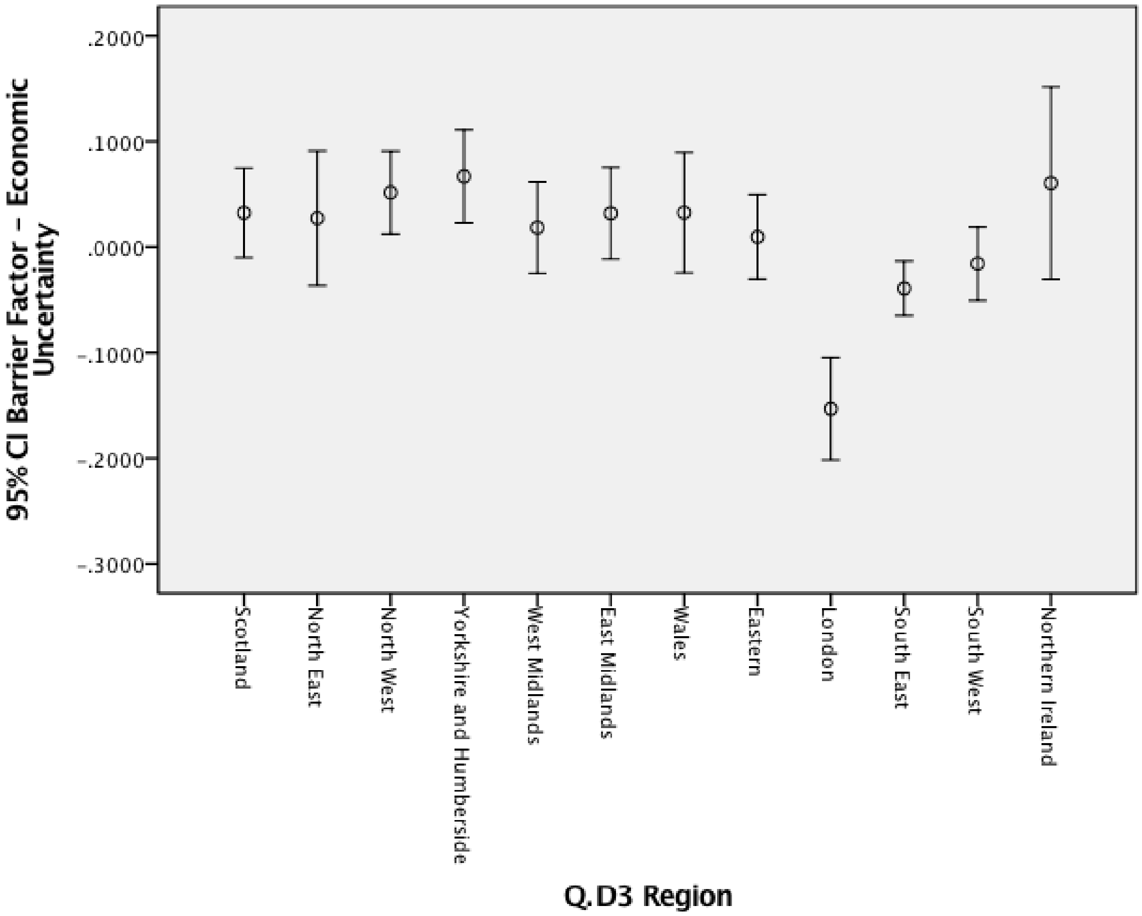
AGE1 = 18-34 — OCC3: Skilled manual occupations

AGE2 = 35-54 — OCC4: Semi-skilled & unskilled manual occupations, Unemployed and lowest grade occupations

AGE3 = 55+ — LON: Place of residence = London; REST: Place of Residence = Outside London

The Variable GEN2AGE1OCC4LON is dropped of as it was perfectly colinear with the regressor (no observations in this case)

Figure 2: Error Bar Plot: Economic Uncertainty and region of residence



Appendix 1: Driver Characteristics

Age of drivers in the sample

Age Group	Count	%
18-24	727	2.7
25-34	1443	5.5
35-44	2840	10.7
45-54	5516	20.8
55-64	7384	27.9
65+	8548	32.3
Total	**26458**	**100**

Source: AA-Populus Motoring Panel, January 2016

Occupation of chief earner of drivers in the sample

Occupation of chief income earner	Count	%
AB - Higher or middle level managerial, administrative or professional position	11914	45.0
C1 - Supervisor or clerical position - junior managerial, administrative or professional position - self-employed	8675	32.8
C2 - Skilled manual or service worker	3675	13.9
DE - Semi skilled or unskilled manual or service worker - dependent on state benefits - unemployed for six months or longer	2198	8.3
Total	**26463**	**100**

Source: AA-Populus Motoring Panel, January 2016

Gender of drivers in the sample

Gender	Count	%
Male	17731	67.7
Female	8463	32.3
Total	**26194**	**100**

Source: AA-Populus Motoring Panel, January 2016

Place of residence of drivers in the sample

Region	Count	%
North East	959	3.7
North West	2459	9.4
Yorkshire and Humberside	1964	7.5
West Midlands	2072	7.9
East Midlands	2079	7.9
Eastern	2325	8.9
South East	5557	21.2
South West	3127	11.9
Northern Ireland	448	1.7
Scotland	2161	8.2
Wales	1206	4.6
London	**1820**	**6.9**
Total	**26177**	**100.0**