Institute for Transport Studies
FACULTY OF ENVIRONMENT

UNIVERSITY OF LEEDS

The Value of Spatial Analysis in Understanding the Demand for Cars

Evidence from an emerging field of inquiry

AUTHOR

Dr Craig Morton (c.l.morton@leeds.co.uk)

RESEARCH CONTRIBUTORS

Professor Jillian Anable (j.l.anable@leeds.ac.uk)

Dr Robin Lovelace (r.lovelace@leeds.ac.uk)

Dr Giulio Mattioli (g.mattioli@leeds.ac.uk)

Dr Ian Philips (I.Philips@leeds.ac.uk)

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INTRODUCTION

The provision of personal mobility in the United Kingdom (UK) has become increasingly reliant on the use of private cars over the past twenty years. This reliance is clearly apparent in public statistics which describe Great Britain's transport system[1], whereby cars, vans and taxis accounted for 658 billion passenger kilometres travelled in 2015, which represented an 83% share of the market. Indeed, over 30 million cars were registered for use on Great Britain's roads in 2015, with the level of registrations having expanded by 41% since 1995. The dominance of the car in providing personal mobility is motivated by its relative advantage compared to other modes of transport, granting drivers unique affordances such as seamless mobility, luggage capacity and a personal environment in which to travel in. Though a range of scenarios, normative visions and radically different alternative futures for transport have been proposed, it is challenging to produce a realistic forecast for transport demand which does not see the dominance of the car continuing for foreseeable future.

The current central position on the car in the delivery of personal mobility means that understanding the features of the system represents an important issue for the governance of the transport sector. These system features can be approached from a number of different perspectives, which each reveal unique insights. In this report, focus is given to the geographical format of the car fleet in order to consider how its structure changes across space. Such an approach is useful in comprehending the influential role that environmental circumstances play in conditioning the geographical organisation of the fleet. To demonstrate this, the report provides a brief overview of the conceptual framework which directs spatial investigations in fleet structures and concludes with a number of short case studies to illustrate the value to be gained through applications of spatial analysis concerning fleet organisation.

[1] Transport Statistics Great Britain – available at: https://www.gov.uk/government/collections/transport-statistics-great-britain

BACKGROUND

As a result of the widespread uptake of cars across the UK, local markets can be distinguished whereby individual registrations are aggregated together to reveal the cumulative preferences of the population. These aggregated preferences can be mapped to illustrate the spatial heterogeneity which exists regarding the characteristics which are being examined. For instance, aggregating vehicle registrations by fuel type allows for regions to be identified that have higher market shares of certain propulsion systems (i.e. petrol or diesel engines).

The identification of spatial heterogeneity in the car fleet indicates the presence of underlining factors which direct the aggregated purchasing behaviours observed in certain areas. To date, researchers have tended to approach these underlining factors from an environmental deterministic perspective. That is to say, the reasons why certain areas display particular preferences for cars is due to the unique conditions present within those areas. These environmental conditions can be assigned to three broad categories. The first is the demographic arrangement of the population, covering such issues as age structures, education levels, household incomes and gender splits. The second is the features of the application environment, linked with the travel patterns of the population, the structure of the road network and the prevailing climatic conditions. The third is the presence of local policies, such as preferential parking for certain car variants, local fuel duties and road user charging. Figure 1 illustrates how these three categories of environmental conditions affect the structure of the local car fleet.

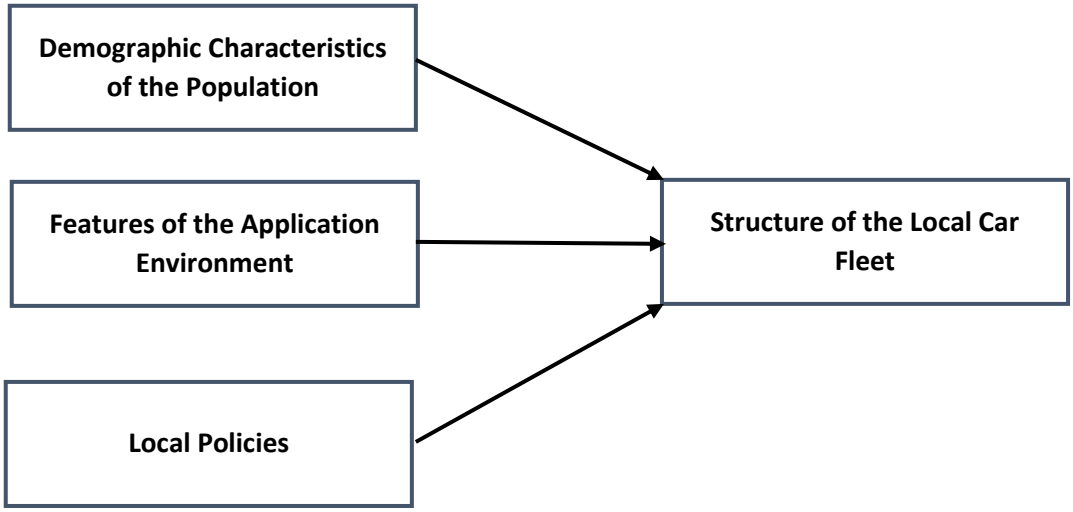

Figure 1: Structural framework illustrating the environmental conditions which effect the configuration of local car fleets

To begin with, research principally focused on understanding the environmental conditions which explained household car availability. This initial research brought to light the different factors which appear to direct households towards car based mobility, allowing strategies to be developed in order to reduce car reliance. Currently, research into the geographical structure of the car fleet is progressing due to increases in the richness of the data available which allows local fleets to be distinguished according to a wide range of technical characteristics. The following three case studies demonstrate how this data can be utilised in order to provide knowledge regarding the development and effectiveness of government transport policy. Illustrations linked to the case studies are available in the appendix of this report.

CASE STUDIES

Case Study One

Title

Evaluating the Impact of Local Transport Policies over the Adoption of Low Emission Vehicles

Topic Outline

Local transport policy makers have a variety of different options available to them in order to stimulate the demand for certain types of vehicle. One such option is associated with urban vehicle access regulations, whereby certain vehicles can be granted preferential terms of access. An example of this is the London Congestion Charge (LCC), where buyers of new Hybrid Electric Vehicles (HEVs) in the UK were exempt from having to pay the entrance fee up to 2013.

Research Focus

This project considered if the exemption of HEVs from the LCC promoted the adoption of these vehicles and, if so, if this effect decays as nearness to the LCC diminishes.

Research Status

This project has been completed.

Results

A substantial degree of geographical variation in the adoption of HEVs is present across the local authorities of Great Britain (Figure 2a). This variation exhibits a significant level of spatial organisation, with a hotspot of uptake (shaded deep red) centred on the metropolitan area of London (Figure 2b). As local authorities retreat in contiguity to the LCC, the rates of HEV adoption tend to decrease (Table 1). As local authorities recede in proximity to the LCC, the rates of HEV adoption tend to decrease (Figure 3a). As local authorities increase in interaction with the LCC, the rates of HEV adoption tend to increase (Figure 3b). These effects remain having controlled for the influence of demographic characteristics of the population and features of the application environments.

Insights

The findings of the research suggest that the exemption of HEVs from the LCC stimulated uptake of these vehicles in the vicinity of London. As the primary objective of the of the LCC is to reduce congestion, the efficacy of the HEV exemption in achieving this objective is questionable, which demonstrates the trade-offs that are often present in transport policy where different objectives might be mutually exclusive.

Case Study Two

Title

Spatial Arbitrage in Fuel Prices and its Effect on the Structure of the Car Fleet

Topic Outline

The crossing of national borders often involves switching from one fiscal regime to another. Moving between different taxation policies has the potential to generate economic opportunities, if the regime in one of the jurisdictions is more conducive to a certain activity. Of particular relevance to the transport sector, the rate of duty imposed on fuels can be asymmetrical in different areas, which may allow for marginal profits to be generated if the fuel is purchased in one taxation regime and sold or used in another (i.e. a spatial arbitrage). A possible example of this is present in Northern Ireland, whereby the price of diesel is noticeably higher as compared to the Republic of Ireland (21 pence per litre as of 2012). This price differential may encourage a number of different activities, such as drivers in Northern Ireland refuelling in the Republic or the smuggling of fuel across the border.

Research Focus

This project considers if the diesel fuel price differential observed between Northern Ireland and the Republic encouraged Northern Ireland residents to purchase diesel cars.

Research Status

This project is currently active.

Preliminary Results

The structure of Northern Ireland's car fleet is rather similar to other Government Office Regions on a number of characteristics, with its local authority fleets being middle of the road in terms of average engine size (Figure 4a), average age (Figure 4b) and average mass (Figure 4c). Concerning the proportion of local authority fleets fuelled by diesel, Northern Ireland stands apart from the other Government Office Regions, displaying a substantially higher mean percentage of diesel cars at 55%, whereas the rest of the UK has an average of around 35%. Exploring the percentage of the local car fleet fuelled by diesel across the super output areas of Northern Ireland, the results indicate that areas closer to the border with the Republic tend to have higher rates of diesel cars (Figure 5). These preliminary results suggest that nearness to the border with the Republic is positively associated with the registration rates of diesel cars. In order to determine if access to cheaper fuels across the border is promoting the adoption of diesel cars, further analysis is required to control for the effect of confounding factors such as rurality (with rural areas expected to display higher levels of diesel car registrations), population age structures (with middle aged populations expected to display higher levels of diesel car registrations) and travel to work patterns (with longer commutes by car expected to display higher levels of diesel car registrations).

Insights

When finalised, this research is anticipated to illustrate how the ability of national governments to influence the structure of the car fleet can be constrained by factors outside of their immediate control. That is to say, the influence of the fuel duty policy in effect in Northern Ireland is diluted by the influence of the fuel duty policy in effect in the Republic.

Case Study Three

Title

Assessing the Distribution Impacts Associated with the Introduction of Vehicle Access Regulations

Topic Outline

Across the UK, cities are investigating the possibility of introducing vehicle access regulations which restrict the access of certain polluting vehicles to specified areas in order to improve levels of air quality. For instance, the Mayor of London is considering the introduction of an Emission Surcharge, which would cover an additional fee of £10 to cars not compliant to the Euro 4 emission standard to enter the LCC. The possibility exists for such a policy to introduce outcome inequalities, whereby the interests of certain social cohorts (i.e., those currently exposed to high levels of pollution in the centre of London) are given precedence over the interest of other social cohorts (i.e., those that currently own non-complaint cars). If such an outcome is likely to occur, it is important to consider who these marginalised groups are and if any adverse consequences of policies of this nature can be mitigated.

Research Focus

This project measures the geographical variation in the rate of non-compliance to the proposed Emission Surcharge across the lower super output areas of London and links this to the demographic arrangement of the population.

Research Status

This project is currently active.

Preliminary Results

London on average has the highest rate of cars not compliant to the Euro 4 emission standard of all Government Office Regions (Figure 6). The rate of non-compliant cars varies substantially across the lower super output areas of London (Figure 7a). This variation is also spatially concentrated, with a number of hot spots (shaded deep red) and cold spots (shaded deep blue) of compliance being present (Figure 7b). Linking the rate of non-compliance to the demographic structure of London's population, a number of significant relationships are identified. Non-compliance is positively associated with the rate of unemployment (Figure 8b), bad health (Figure 8c), black, Asian or ethnic minority (Figure 8d), Muslims (Figure 8e), lone parents (Figure 8f), no educational qualifications (Figure 8g) and social renters (Figure 8h) whilst being negatively associated with median household incomes (Figure 8a). To consider if this generates adverse consequences requires further work to better assess the level of exposure to the policy (taking into account additional factors such as differences in levels of motorisation between areas and the degree of interaction between an area and the LCC), as well as the sensitivity to the surcharge (i.e. the financial capacity to maintain current travel patterns by paying the surcharge) and the level of adaptive capacity (measured by the ability to transfer mobility to active and public transport in order to access the LCC).

Insights

When finalised, this research will likely demonstrate that cars not compliant to the Emission Surcharge tend to

be registered in areas that have a higher prevalence of marginalised social groups. Thus, the pursuit of one government policy (i.e. air quality) could led to the degradation in another (i.e. social equality).

Summary

One of the biggest challenges facing the transport system is the requirement to transition towards a sustainable pathway, where mobility is affordable, equitable and clean. Currently, it is difficult to envisage a realistic future for the transport system where the car no longer has a prominent role, due to the lack of an apparent successor. As a result of this, determining how the car fits into a sustainable future is of clear importance, one that will significantly affect whether or not a sustainable future for the sector is achieved.

Through the case studies presented, this report demonstrates how an understanding of the geographical demand for cars across the United Kingdom can reveal a number of hitherto unobserved issues that are closely connected to the governance of the transport system. The insights generated from analysis of this nature have practical value in the development of strategies to support a sustainable transition. For instance, knowing the degree to which the market for low emission vehicles can be stimulated by local policies could be useful to transport planners that are considering introducing vehicle access regulation schemes. Moreover, understanding how the transport system of one jurisdiction is effected by the policies enacted in another jurisdiction signifies the need for collaboration between and across regional and national transport bodies to limit the occurrence of unintended consequences.

The opportunities which exist for further work which utilises the novel data concerning the spatial configuration of the car fleet to generate new insights regarding what factors shape the fleets' organisation are extensive. The research summarised in this report represents only the initial steps along this new direction for transport research, with valuable knowledge still remaining to be discovered.

APPENDIX

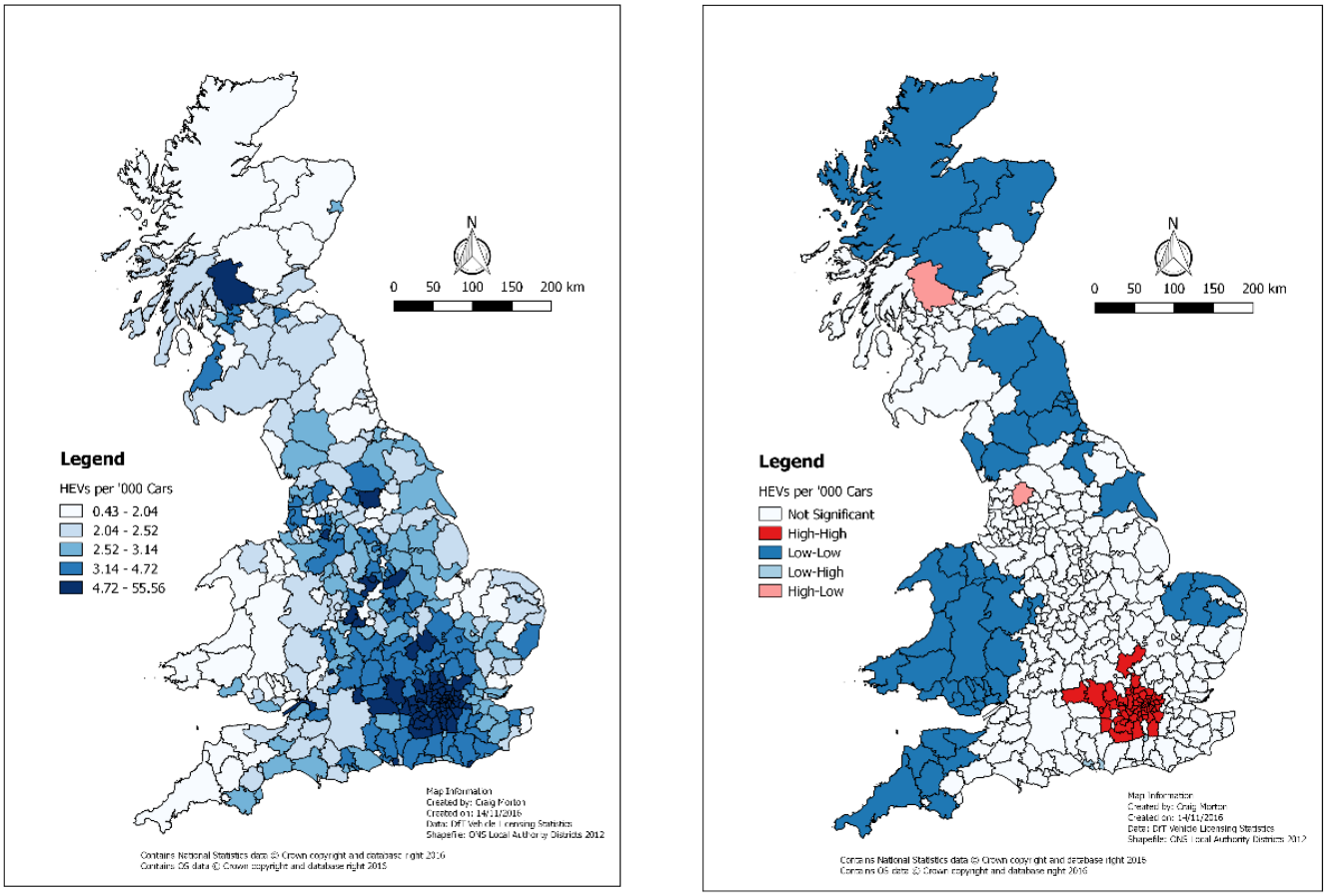

Figure 2: Maps illustrating the (a) rate of Hybrid Electric Vehicle adoption and (b) clusters of Hybrid Electric Vehicle adoption across the local authorities of Great Britain

Table 1: Descriptive statistics of Hybrid Electric Vehicle registrations (per thousand private cars) across different local authority categories

Local Authority Category	Mean	Std. Dev.	Min.	Max.
London Boroughs (n = 32)	10.58	6.81	2.00	30.98
First Order Neighbours to Greater London (n = 16)	8.34	8.88	2.61	38.96
Second Order Neighbours to Greater London (n = 23)	4.31	1.33	2.27	6.90
Rest of Great Britain (n = 303)	3.22	4.00	0.43	55.56

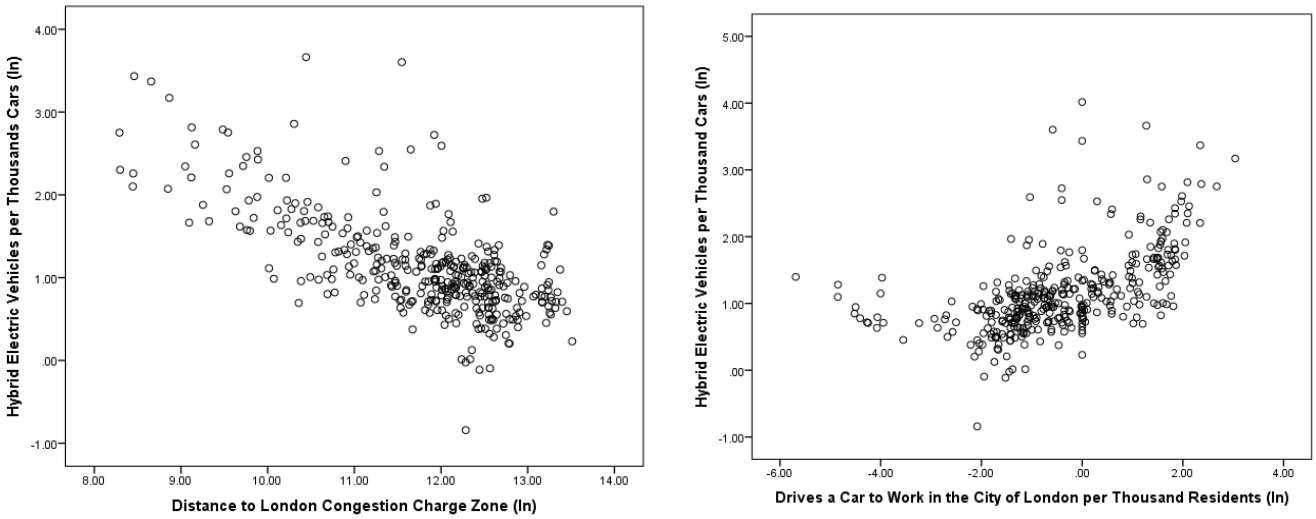

Figure 3: Scatterplots of Hybrid Electric Vehicle registrations (per thousand private cars) against (a) distance to London Congestion Charge and (b) residents that drive a car to work in the City of London (per thousand residents)

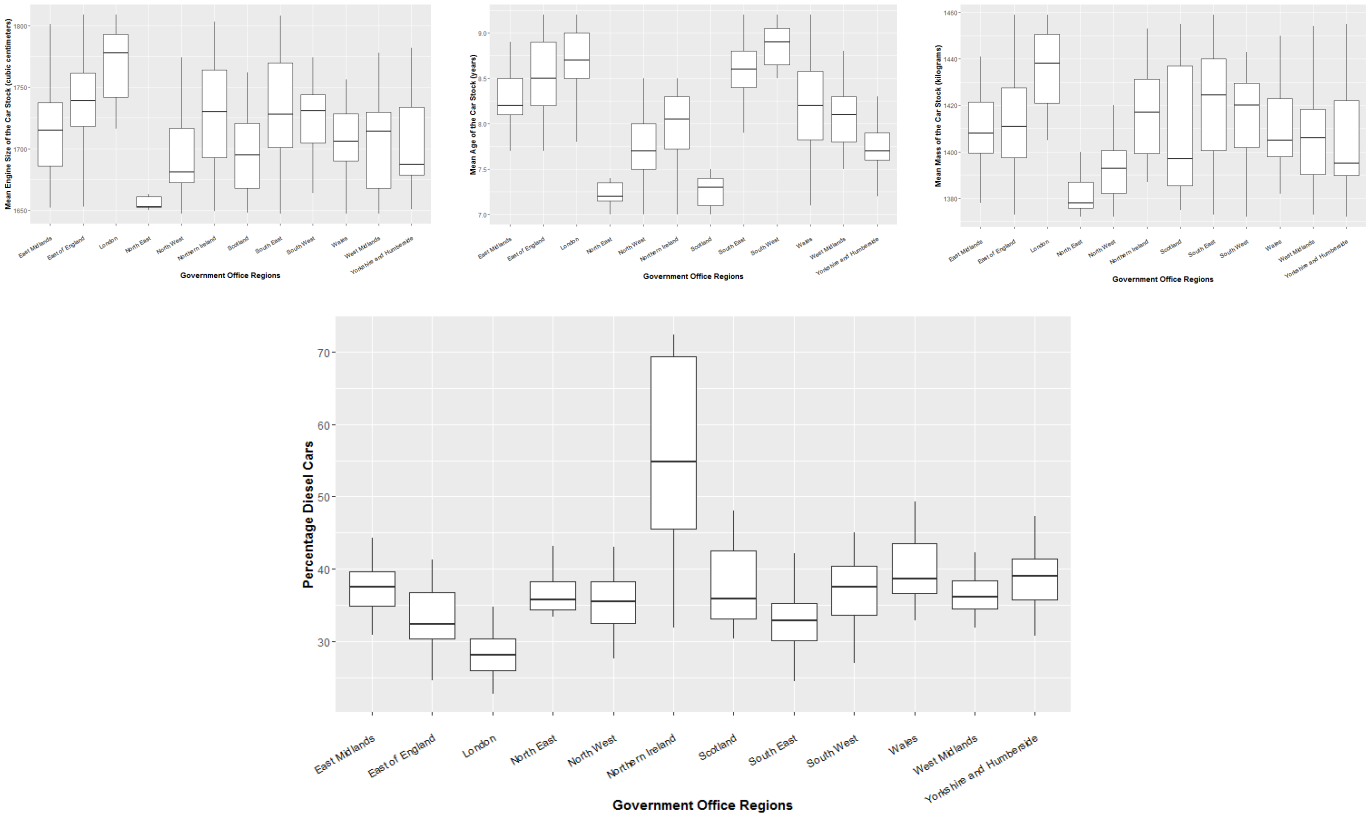

Figure 4: Boxplots displaying the distribution of local authority car fleet technical characteristics grouped by Government Office region for (a) mean engine size, (b) mean age, (c) mean mass and (d) proportion diesel

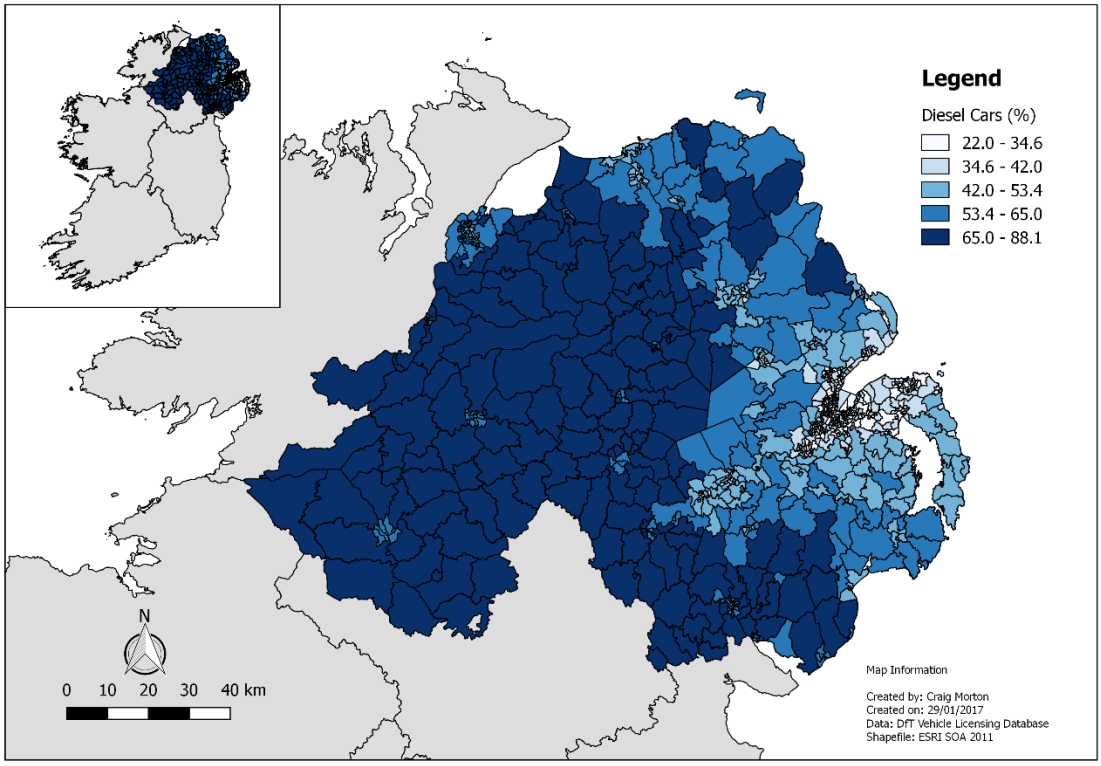

Figure 5: Choropleth map displaying the proportion of the local fleet fuelled by diesel across the super output areas of Northern Ireland

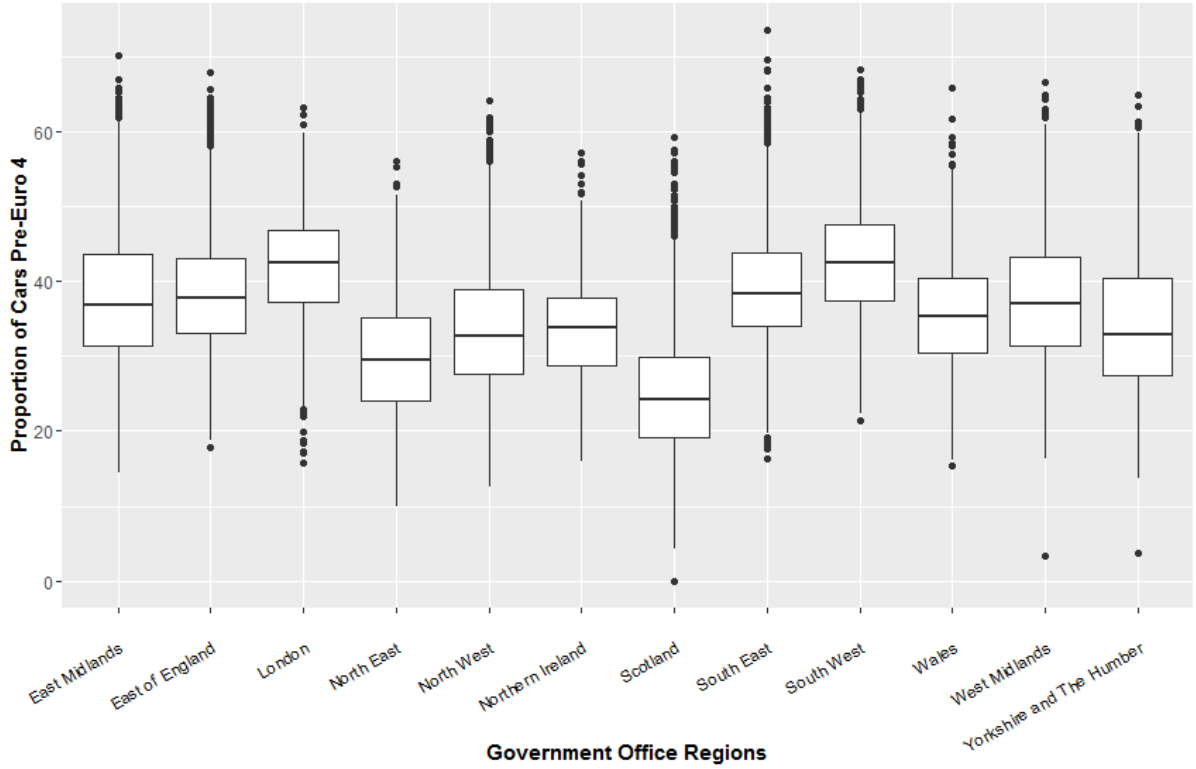

Figure 6: Boxplots of the percentage of cars that are diesel fuelled across lower super output areas grouped by Government Office Region

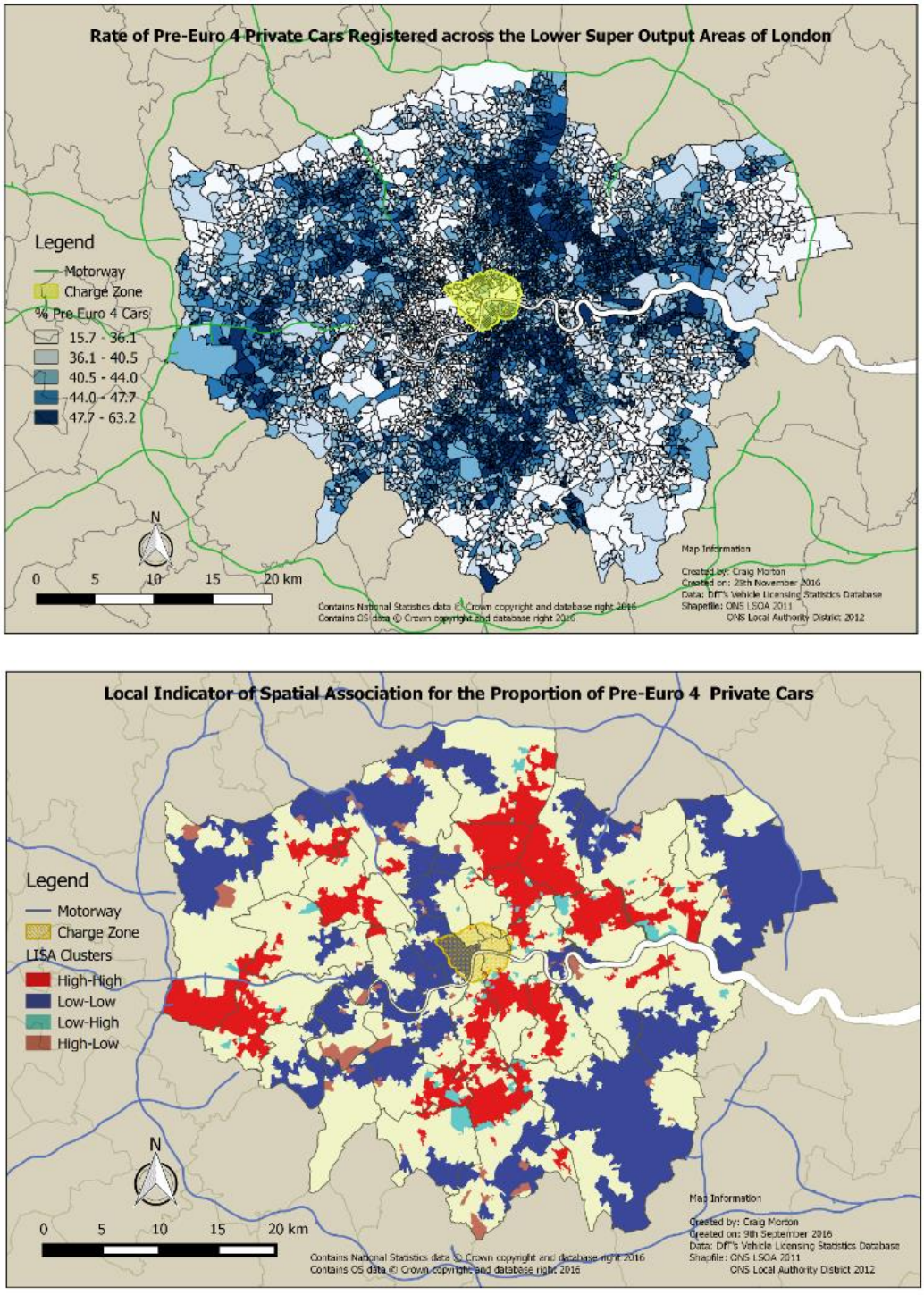

Figure 7: Maps illustrating the (a) rate of Diesel Car ownership and (b) clusters of Diesel Car adoption across the lower super output areas of London

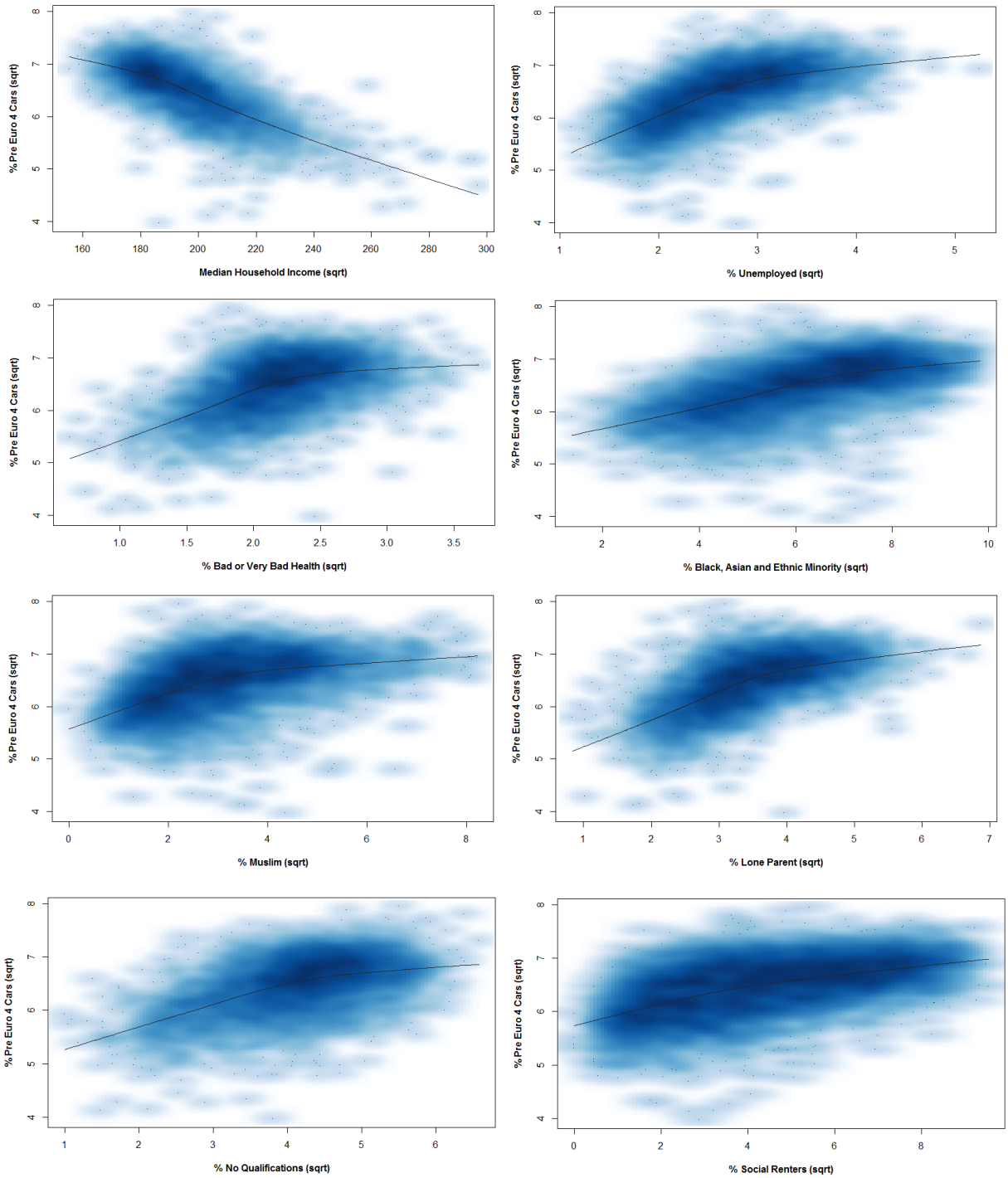

Figure 8: Scatterplots which chart rate of non-compliance to the Emission Surcharge (y-axis) against elements of (a) household income, (b) unemployment, (c) health, (d) ethnicity, (e) religion, (f) household structure, (g) education and (h) household tenure