The influence of urban form on car travel following residential relocation: a current and retrospective study in Scottish urban areas

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Abstract: Spatial planning and policy continues to be used as a tool to bring about changes in travel behavior. Policy suggests that by creating particular urban forms, demand for travel by car can be reduced. This paper uses data collected in 2006 from 280 households in Glasgow and Edinburgh to analyze the relationships between urban form and vehicle miles driven, with an emphasis on those who had recently relocated. Population densities, housing type, distance to urban center, and measures of mix were collected for the current residential location and prior residence for those who had relocated in the previous three years. An ordinal regression model of change in urban form showed significant associations with reported change in miles driven, although the effect was small compared with the effects of socioeconomic factors and car ownership. While the results give some weight to intensification as a policy to bring about a reduction in average distance driven, there may be an increase in total distance driven in the intensified area with a corresponding increase in congestion. Whether such intensification can be enacted against a backdrop of preferences toward suburban, car-oriented living is contentious. As such, this study calls into question the use of planning policy as a means to reduce car use in Scottish cities.

1 Introduction

There has been a long-standing interest in the nature of the relationship between land use configuration and travel demand. The principal motivation is to evaluate the extent to which land use regulation can be used to bring about more sustainable patterns of travel behavior. As in many countries, regions, and cities around the world, land use planning policy in Scotland promotes intensification of the built environment in order to address problems of environmental and resource degradation (Williams 2004). Planning policy in Scotland (National Planning Framework 2004; Scottish Planning Policy 2010) is based on the premise that land use planning can be used to reduce the growth, or the level, of car traffic. This paper describes a study that aims to inform policymakers of the validity of this premise by providing fresh evidence of the causal relationship between urban form and the distance traveled by car in Scottish cities.

The continued use of land-use planning policies to influence travel behavior has led to an increasing level of research into the nature of the relationship. Since the early work by Newman and Kenworthy (1989), who found an association with petroleum consumption and city density for 33 cities across the world, most studies have focused on one or more urban areas within a particular region or country, although there are a small number of more recent transnational studies of travel behavior and urban form such as Timmermans et al. (2003) and Souche (2010). Most subsequent studies have focused on single cities or countries, addressing much of the criticism of the early work by Newman and Kenworthy for its lack of control for other factors that are likely to affect the travel behavior of residents from different national or regional contexts—including government policy, incomes, and costs of transport (Gordon and Richardson 1989). While some subsequent studies found no significant associations between urban form and travel behavior (e.g., Boarnet and Sarmiento 1998), the majority of subsequent research based in the United States found that “neo-traditional” attributes of mixed use and higher densities arranged around a grid street pattern were associated with less distance traveled by car or fewer trips made by car (Cervero and Kockelman 1997; Cervero 2002; Ewing et al. 2003; Khattak and Rodriguez 2005).

A similar pattern of findings has been reported in Europe, where “neo-traditional” attributes are more commonplace. Findings from studies of a range of urban forms also suggest that higher residential density, closer to an urban center, and more mixed land uses are associated with a lower demand for travel by car (Stead 2001; Dieleman et al. 2002; Snellen et al. 2002; Naess 2005).

However, association does not demonstrate causation between urban form and travel behavior (Handy et al. 2005). Longitudinal observations or experiments are particularly useful in demonstrating the time order of changes in urban form and changes in travel behavior. However, longitudinal studies are rare because of the timescales over which urban forms and travel behavior change and difficulties in controlling for other factors over such a period of time. From analysis of a longitudinal aggregate dataset of travel and urban form in Lon-
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Don, Williams (1997) found that “…three London Boroughs which had been intensified over a ten year period showed no reductions in car use. Travel patterns were so complex, due to lifestyle shifts such as cross-London commuting for work, and increased journeys for leisure, that no relationship could be found.” There are a small number of quasi-longitudinal studies in the U.S. and China (Cervero and Day 2008; Handy et al. 2005) that have utilized current and retrospective recalled data. Similarly, in the U.K., Aditjandra et al. (2012) analyzed the relationships between neighborhood design and travel behavior for 219 households in 10 neighborhoods in northeast England. The study found that changes in socio-demographic characteristics explained much of the changes in car ownership. Changes in urban form influenced small changes in travel behavior directly and also indirectly through change in car ownership.

While there is limited evidence as to how changes in urban form are associated with changes in travel behavior (Krizek 2003; Vandermeiren et al. 2003; Aditjandra et al. 2012; Handly et al. 2005; Su 2010), such studies are rare and as such, no consistent body of evidence exists on those measures of urban form that are important in any particular national or regional context. Moreover, studies that have investigated travel related to specific activities do not consider that reductions in travel for one activity might be offset by increases for other activities (i.e., compensation) (Naess 2005). Although a body of evidence is emerging on the associations between urban form and travel behavior, studies that have investigated travel related to specific activities do not consider that reductions in travel for one activity might be offset by increases for other activities. This research was carried out as part of the wider City-Form research program that investigated links between urban form and several aspects of sustainability including travel behavior (Jenks and Jones 2010). The aim of the study reported in this paper was to examine the effect of a change in urban form arising from a residential relocation on car use. This is one of only a handful of studies to adopt a quasi-longitudinal design and is the first to be carried out in a Scottish context.

This design enabled an analysis of change in urban form and change in car use for all activities to be analyzed, thus providing new evidence as to whether changing urban forms can reduce car use and hence, the efficacy of Scottish planning policies.

2 Research design

The study utilized a current and retrospective recall survey of households in Glasgow and Edinburgh, with a focus on those who had moved home in the preceding three years. Information was collected on levels of car ownership and use and residential and employment locations, along with other socio-demographic data. Anitudinal data were excluded from this analysis, as respondents might not reliably recall attitudes held some time before the date of the survey (Wall and Williams 1970).

3 Case study neighborhoods

Glasgow and Edinburgh, which are Scotland’s two largest cities, are situated approximately 65 kilometers apart in the most populated part of Scotland. Each city has a suburban rail network, extensive bus routes, and in the case of Glasgow, a small underground rail line. Within each city, three case study areas were selected: in Glasgow they were the Merchant City/Calton area, Pollokshields, and Darnley; in Edinburgh, they were Dalry, Restalrig, and Corstorphine. The areas were chosen to reflect the urban form typically found in the inner, middle, and outer areas of each city, respectively. Figure 1 shows the road network and location of each case study area within each city.
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A survey was undertaken in the six neighborhoods, which provided information about respondents’ travel behavior and available transport resources as well as household characteristics. The questionnaire was 14 pages long, including a four-day diary, and was conducted using a mail-out/mail-back format.

The survey was carried out in June 2006. Respondents were asked a series of questions related to their current circumstance and their previous circumstances at the end of 2002, thus enabling any changes that had taken place in this three-and-a-half-year period to be recorded, as per Handy et al. (2005). This period was deemed to strike an appropriate balance between the need to identify a sufficiently large number of home-movers and the ability of respondents to provide reliable recalled data. Data were obtained from the Registers of Scotland for all property sales that had taken place from 2003 to 2006. All addresses highlighted as having been sold in the three-year period were selected for possible inclusion in the sample. Addresses that appeared commercial in nature or incomplete were removed. A further set of residential addresses obtained from the Ordnance Survey (2008) were added to this list. A total of 2,495 addresses were selected, of which approximately two-thirds were addresses for which a sale had taken place before receipt of the questionnaire. This letter introduced the household to the study and explained its purpose. A follow-up letter was sent to households that had not responded within a two-week period. A total of 452 letters were returned as “address unknown.” In total, 281 completed questionnaires were returned, which represents a response rate of 13.7 percent. This was in line with expectations given the burden of completing the questionnaire, particularly the four-day travel diary, and it is within the range achieved in similar studies such as the 11 percent response achieved by Kitamura et al. (1997) and 16 percent by Xing et al. (2010).

Respondents were asked to compare their current car use as a driver or passenger with their car use at the end of 2002. Permissible responses were (a) a lot less, (b) a little less, (c) about the same, (d) a little more, and (e) a lot more. Similarly, respondents were asked to provide details of their current household income and to compare this with their income at the end of 2002. For each respondent, the survey also collected details of current and previous (end of 2002) residential location, car availability, possession of driving license, employment status, workplace location and parking availability, and mode of transport used for commuting to work.

To determine whether a statistically significant association between changes in urban form and in self-reported distance driven existed, and to control for the effects of socioeconomic variables, an ordinal regression model was developed. A negative-log-log link function was found to be related to the best model fit. Reported change in driving, measured on a Likert scale from “a lot less” to “a lot more”, was entered as the dependent variable. Explanatory variables, as described in Tables 2 and 3, were entered into the model and refined using a backwards removal method. Missing data were excluded on a list-wise basis.

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Three variables were selected to characterize urban form: (1) residential population density, (2) the ratio of employment to residential population, representing land use mix, and (3) the distance to the city center. Residential population and employment data were obtained from the 2001 census (General Register Office for Scotland 2001). The distance to the city center was taken as the Euclidian distance from the residence to the city center. If a respondent had relocated recently, then the jobs-to-population ratio, there was an increased ordered log odds of being in a higher category of change in car use (beta value multiplied by s.d.). That is, increased distance from the urban center had a statistically significant effect (p-value of 10 percent). An increase in the number of jobs to population ratio of the ward also had a statistically significant effect, with an increase in the number of jobs to population ratio of the ward also had a statistically significant effect, with an increase in the number of jobs to population ratio of the ward also had a statistically significant effect, with an increase in the number of jobs to population ratio of the ward also had a statistically significant effect, with an increase in the number of jobs to population ratio of the ward also had a statistically significant effect, with an increase in the number of jobs to population ratio of the ward also had a statistically significant effect, with an increase in the number of jobs to population ratio of the ward also had a statistically significant effect, with an increase in the number of jobs to population ratio of the ward also had a statistically significant effect, with an increase in the number of jobs to population ratio of the ward also had a statistically significant effect, with an increase in the number of jobs to population ratio of the ward also had a statistically significant effect, with an increase in the number of jobs to population ratio of the ward also had a statistically significant effect, with an increase in the number of jobs to population ratio of the ward also had a statistically significant effect, with an increase in the number of jobs to population ratio of the ward also had a statistically significant effect.
Table 4: Change in urban form and distance driven parameter estimates. 

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>Sig (p-value)</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
</tr>
<tr>
<td>Drive a lot less</td>
<td>-0.92</td>
<td>.347</td>
<td>-3.061</td>
</tr>
<tr>
<td>Drive a little less</td>
<td>-0.49</td>
<td>.671</td>
<td>-2.517</td>
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<tr>
<td>Drive about the same</td>
<td>1.32</td>
<td>.212</td>
<td>-0.757</td>
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<tr>
<td>Drive a little more</td>
<td>2.28</td>
<td>.034</td>
<td>-0.171</td>
</tr>
<tr>
<td>Age 55 – 64</td>
<td>-0.21</td>
<td>.852</td>
<td>-2.846</td>
</tr>
<tr>
<td>No change in income</td>
<td>-0.64</td>
<td>.019**</td>
<td>-1.180</td>
</tr>
<tr>
<td>Increase in income</td>
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<td></td>
<td>0</td>
</tr>
<tr>
<td>Age 16 – 24</td>
<td>-0.74</td>
<td>.126</td>
<td>-1.795</td>
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<tr>
<td>No change in license</td>
<td>0.04</td>
<td>.894</td>
<td>-0.610</td>
</tr>
<tr>
<td>Age 35 – 44</td>
<td>-0.23</td>
<td>.510</td>
<td>-0.912</td>
</tr>
<tr>
<td>Age 45 – 54</td>
<td>-0.59</td>
<td>.040*</td>
<td>-1.421</td>
</tr>
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<td>No change in work status</td>
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<td></td>
<td>0</td>
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<tr>
<td>Gained employment</td>
<td>1.14</td>
<td>.008</td>
<td>-2.25</td>
</tr>
<tr>
<td>Lost employment</td>
<td>0.04</td>
<td>.883</td>
<td>-0.556</td>
</tr>
<tr>
<td>Gained driving license</td>
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<td>.000***</td>
<td>-1.575</td>
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<tr>
<td>No change in license</td>
<td>0</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>No change in distance to work</td>
<td>0.05</td>
<td>.000***</td>
<td>-0.002</td>
</tr>
<tr>
<td>Change in ward density</td>
<td>0.02</td>
<td>.581</td>
<td>-0.010</td>
</tr>
<tr>
<td>Change in distance to urban center</td>
<td>0.08</td>
<td>.100*</td>
<td>-0.016</td>
</tr>
<tr>
<td>Change in jobs-pop ratio</td>
<td>-0.09</td>
<td>.073*</td>
<td>-0.194</td>
</tr>
<tr>
<td>Change in car ownership</td>
<td>0.04</td>
<td>.811</td>
<td>-0.042</td>
</tr>
<tr>
<td>Previously Large Urban area</td>
<td>-2.13</td>
<td>.763</td>
<td>-3.196</td>
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<tr>
<td>Previously Other Urban area</td>
<td>-0.79</td>
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<td>-2.595</td>
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<td>Previously Greater London</td>
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</tr>
<tr>
<td>N</td>
<td>183</td>
<td></td>
<td>0.809</td>
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</table>

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While change in car use was explained to a large extent by change in car ownership, a number of urban form variables were also statistically significant predictors of change in car use for those who had moved home in the previous three years. For such households, increased distance to the nearest urban center and a reduction in the number of jobs in the ward compared to the population (a proxy for land-use mix) both related to a reported increase in car use; however, the magnitude of the effects was small compared to car ownership. Having one less car had the similar effect on reported change in car use as having three more jobs in the ward per person, or moving more than 4 km closer to a city center. These results are similar to those presented by Stead (2001), who found through cross-sectional analyses that socio-demographic variables, including car ownership, explained between 19 and 24 percent of distance traveled, while urban form explained only 5 percent. It may be the case, however, that urban form also influences car ownership, and thus the total impact (direct and indirect) of urban form on car use may be greater.

These findings give some support to Scottish Planning Policy, which suggests that by intensifying urban areas, average household distance driven can be reduced. It is important to recognize, though, that the result of changing the built form of urban areas in Scotland may not be comparable to the result of relocation to a different urban form in Scotland presented here, as a relocation creates an instantaneous change in urban form, whereas intensification, by its nature, is a more gradual process. However, if the effects were similar, very large changes to Scottish urban areas would be required to reduce car use by any significant magnitude. Also, it is important to recognize that while intensification might lead to a reduction in the average distance driven, intensification would also mean more people in a given area. Hence, unless the reduction was substantial, there would be a greater distance driven per unit area as a result of intensification, with the associated problems of congestion and poor air quality that intensification policies were supposed to reduce. The magnitude of any reduction in distance driven cannot be determined through the analysis presented in this paper, as it is self reported on a Likert scale; however, the percentage change in distance driven would need to be greater than the percentage change in population density for a reduction in distance driven per unit area. Echenique et al. (2012) estimated that a doubling of density would relate to a 10 percent reduction in vehicle miles traveled (VMT) for three case study areas in the southeast of England. Ewing and Cervero (2001; 2010) found a 5 percent reduction in VMT as a result of doubling density in the U.S. Unless the magnitude of the effect of intensification was far greater in Glasgow and Edinburgh, intensification would therefore not reduce distances driven in the two cities. Although the average distance driven per person would be slightly less, this driving would be intensified into the city.

Urban forms may require longer time scales to be changed, and the effect on distance driven may be relatively small. Given the greater effect of car ownership on distance driven, policies aimed at reducing car ownership may encourage a more immediate and significant reduction in car use than can be achieved through intensification.

Moreover, whether such intensification can be brought about in urban Scotland remains unclear. The study population showed a general preference for low-density areas, with preference for lower-density neighborhoods being stronger for households that already live in suburban areas (Jenks and Jones 2010). Clearly, policy aimed at intensifying Glasgow and Edinburgh needs to consider such residential preferences. Given the choice, it appears most people would choose suburban living, however, the choices available to householders are constrained by household resources and by property markets. It is possible that over longer periods of time, policy could manipulate the choice set available to householders by limiting the construction of more suburban forms and encouraging more compact urban development, thus pushing suburban lifestyles out of the economic reach of more households, despite their preference for suburban living.

Glasgow has experienced a dramatic loss of population...
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City Council, Sheffield Wildlife Trust, Strathclyde Passenger Council, Groundwork UK, The Landscape Institute, Leicester partners: Corus, the Environment Agency, Glasgow City Heriot-Watt, Oxford Brookes, Sheffield, and Strathclyde. The number GR/520529/01). The consortium comprised a multidisciplinary team based at the universities of the Montfort, Henio-Watt, Oxford Brookes, Sheffield, and Strathclyde. The consortium was supported by the following non-academic partners: Corus, the Environment Agency, Glasgow City Council, Groundwork UK, The Landscape Institute, Leicestercity Council, Oxford City Council, The Prince’s Foundation, Rogers Stirk Harbour + Partners, Scottish Executive, Sheffield City Council, Sheffield Wildlife Trust, Strathclyde Passenger Transport, and URBED.

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