Urban density and car and bus use in Edinburgh

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Abstract

Laissez-faire planning and insufficient integration of land use and transport planning in Britain in recent years has encouraged low density, out-of-town developments; the resulting urban form has little regard for energy efficiency and generates traffic demand, congestion and atmospheric pollution.

This paper presents results from an investigation of urban density and travel to work behaviour in Edinburgh based on the 1981 and 1991 Census Small Area Statistics. The results form part of a wider PhD study that aims to discover ways to plan and implement urban forms that encourage work trips to be made by modes other than the private motor car. The purpose of the research is to empirically explore certain aspects of the relationship between urban density and travel mode for the journey to work. It is intended that the results from this research will provide input into policies at the national, regional and local level whose principle objectives are traffic reduction and the transfer of trips from the private car to more sustainable modes.

1 Introduction

During the last few decades there have been numerous empirical studies that have investigated the relationship between urban density and transportation (e.g. public transport utilisation, the amount of walking and the length of car trips). Many of the early studies were carried out in response to the world energy crisis and were predominantly North American and Australian owing to their high per capita gasoline consumption (Newman & Kenworthy[1,2]. More recent work has looked at the relationship between urban density and the environmental impacts of transport, particularly global warming.

Surveys of cities throughout the United States showed that as urban density increased public transport use, bicycling and walking increased and car trips were shorter. Not only are these transport patterns due to shorter distances in high density areas but lower car ownership

is also found to be associated with higher density. Pushkarev & Zupan[3] suggest that "low density is both the consequence and cause of the USA's dependence on the car". An increasingly dispersed population within an ever-increasing urban area cannot support an efficient public transport system and the competitive advantage of the car increases.

2 Policy implications

A key feature of the late twentieth century is concern shown by policy makers, politicians and the general public about the rising use of the private car. Three major arguments against increasing car dependency include:

1. It restricts the mobility of groups of the population who do not have access to a car for reasons of health, age or income.
2. It causes inordinate energy consumption and is environmentally destructive.
3. The space within city centres cannot accommodate all car traffic at an acceptable cost.

More recently advocates of reducing car use have adopted a new idealism in the concept of 'sustainability' - that is "development which meets the needs of the present without compromising the ability of future generations to meet their needs" (World Commission on Environment and Development[4]). There is already evidence that policy makers are at least considering the concept of sustainability. PPG13 (DOE/DTp[5]) is aimed at reducing the growth in the length and number of motorised trips, encouraging alternative means of travel which have less environmental impact and reducing the reliance on the private car. The European Commission's 1990 green Paper on the Urban Environment (EC[6]) has advoacted revitalising city centres, encouraging greater land use diversity and avoiding urban sprawl. The report suggests that planning strategies which emphasise mixed land use and denser development are more likely to result in people living close to work places and the services they require for everyday life. On a more local scale Edinburgh's transport strategy, 'Moving Forward' (Lothian Regional Council[7]), embraces the concept of sustainability by aiming to reduce car use and prioritise travel by bus, cycle and foot.

Transport policies that aim to reduce car use can either make public transport more appealing, restrain car use, or, as seems likely, include both measures to some degree. The arguments for and against these measures are well documented elsewhere and will not be repeated here. If our cities are to become more sustainable whereby a large percentage of the population uses public transport, walking or bicycling as its chosen mode of travel the urban form (density) of the city must accommodate these greener forms of transport. A productive and effective public transport system cannot operate in a city that has low density housing coupled with low density employment centres - under such conditions the car will be king.

3 Case Study : Edinburgh

3.1 Introduction

The majority of the studies investigating the relationship between urban density and travel behaviour tend to compare different cities or concentric zones (CBD, inner and outer) within the same city. My research employs this approach but also includes analysis on a more micro-

scale level by comparing different areas (in this case electoral wards) within a single city, Edinburgh.

The advantage of using electoral wards over concentric zones is that there will be less variation in urban density and demographic characteristics of the population in these small wards than in concentric zones. Even if the concentric zones are sufficiently narrow so as to cover the same area as an electoral ward they will pass through considerably more different neighbourhoods.

The aim of my analysis is to investigate if differences in intra-city, (rather than inter-city) urban densities explain variations in transport modal split for the journey to work and car ownership. The data collected includes: population, car ownership, mode of travel to work by social economic group and density data using the 1981 and 1991 census and land use maps of the city. The results from this analysis will be useful for transport planners who are trying to reduce car use and increase public transport patronage within the city.

3.2 Definitions

The city can be defined using two different approaches. It can be divided into three concentric zones: CBD; inner and outer zones, based on distance from the city centre (Figure 1). This concentric zone approach has previously been adopted by Warnes[8]; Angel and Hyman[9]; Mogridge[10], and Newman and Kenworthy[1]. Alternatively the city can be divided into 58 electoral wards, an approach I have developed myself (Figure 2).

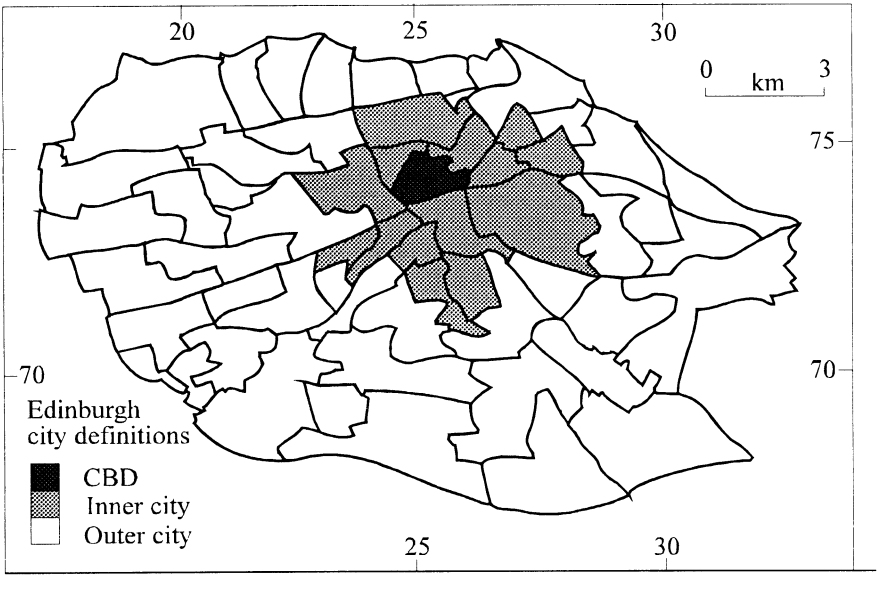

Figure 1. Composition of the city using concentric zones.

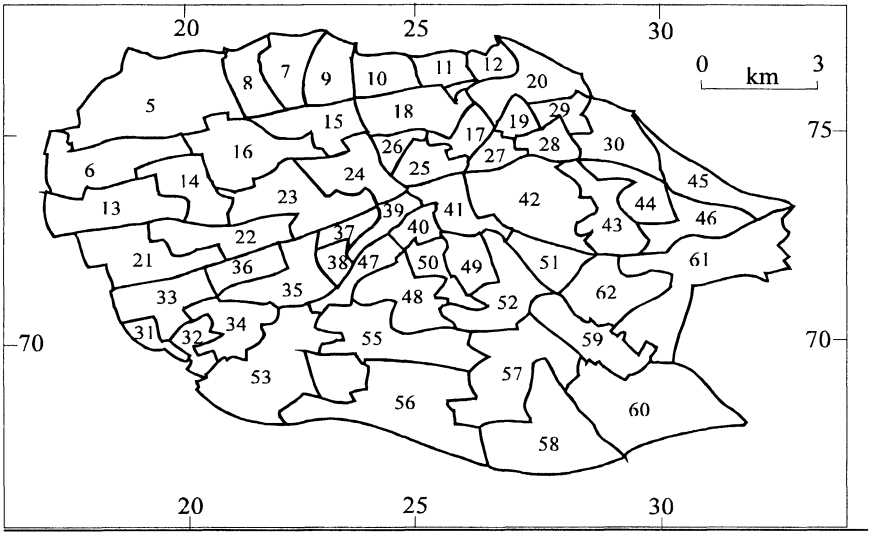

Figure 2. Composition of the city using electoral wards.

The concentric zones are aggregates of electoral wards based on the distance between the ward centroid and the city centre (Marks and Spencers). The CBD consists of a single ward that includes the main shopping area and much of Edinburgh's older office accommodation. The inner zone consists of fourteen wards whose centroids are within 2.5 km, straight line distance, from the city centre and the outer zone include all the remaining city wards.

The city boundary is defined on the basis of population density and the boundaries of electoral wards. The boundary closely follows the route of the Western Bypass that tends to separate the built up land of Edinburgh city from the surrounding countryside. Urbanised density is represented by the total number of persons per hectare of built up land using the method previously employed by Pushkarev and Zupan[3]. The area of built up land has been calculated using maps and a planimeter. Built up land includes land used for residential and industrial purposes as well as shops and offices.

3.3 Results of the Concentric Analysis

Concentric analysis of cities can be useful in analysing popualtion and employment trends that have occurred during a given period of time (Table 1). Analysis of this type has identified that population and employment within UK cities are decentralising as people and employers continue to prefer the space and accessibility afforded by a suburban location. Concentric analysis has also identified that the highest residential densities are predominantly found in areas close to the city centre and that density declines with increasing distance form the CBD. It is important to note that this type of analysis and the conclusions drawn from it could include several non similar areas, with very different urban form and population characteristics, within the same zone.

	CBD	Inner zone	Outer zone	Edinburgh
Employment	39 925	85 173	106 103	231 201
% city employment	17%	37%	46%	100%
employment change 1981-1991 (%)	16%	-1%	7%	5%
employment density (jobs/hectare)	361	69	20	35
Population	5295	68 203	311 646	385 144
% city population	1%	18%	81%	100%
population change 1981-1991 (%)	6%	4%	-3%	-1.5%
population density (persons/hectare)	48	55	59	59
Car ownership				
% households with at least 1 car	62%	45%	53%	51%
% households with at least 2 cars	14%	8%	12%	12%
Modal split (travel to work)				
% working residents using the car	25.5	26.0	37.4	34.6
% working residents using the bus	20.4	38.6	43.1	41.7
% working residents walking	39.4	27.7	13.1	16.8

Table 1. Transport and urban density data for Edinburgh, 1991

3.3.1 Employment

Edinburgh has a strong CBD in terms of both the proportion of jobs located within it and also by the density of employment. Almost one in five jobs within Edinburgh are located in the CBD even though this zone only accounts for 1% of the total city area. The CBD has experienced an increase in the number of jobs within its boundary between 1981 and 1991, higher in percentage terms than both the inner and outer zone. In absolute terms, however the greatest increase in the number of jobs has occurred in the outer zone.

It does not appear that employment in Edinburgh is decentralising however, it seems that the CBD and outer zone are attracting most new jobs that are created within the city. In recent years, however, several large employers (e.g. the Royal Bank of Scotland, Scottish Equitable, ICL and John Menzies) have relocated themselves from the CBD into the outer zone.

3.3.2 Population

The city of Edinburgh has experienced a population loss of 1.8% between 1981 and 1991. The greatest percentage population loss has occurred in the outer zone with both the inner zone and CBD gaining population. Edinburgh does not have the characteristic decentralising population that many cities are experiencing.

In terms of population density the CDB has the lowest population density whereas the outer zone has the highest. The urbanised density within Edinburgh increases with distance from the city centre a trend that is uncharacteristic of most other cities. Concentric ring

theory states that density declines with distance from the city centre. However, in Edinburgh this theory does not hold true.

3.3.3 Car ownership

Household ownership of both one and two or more cars is highest in the CBD despite the limited amount of parking space and the good public transport links available to residents in this zone. Car ownership is highly related to household income and so it might be the influence of income that accounts for the high car ownership level in the CBD.

3.4 Results of the Ward Analysis

The previous results have been obtained using concentric analysis and are useful in analysing trends that are occurring within the city. However, if we are to better understand the influence of intra-city differences in urban density on transport we have to look at the city in greater detail. The correlation between urban density and car ownership and modal split for the work journey by ward are given in table 2.

	Urbanised density	Distance form CBD
Car Ownership		
% of household owning at least one car	-0.56	0.13
% of households owning 2 or more cars	-0.57	0.26
Journey to work		
% professional and managerial workers using the car	-0.41	0.51
% non manual workers using the car	-0.55	0.33
% manual workers using the car	-0.39	0.58
% professional and managerial workers using the bus	0.45	0.06
% non manual workers using the bus	0.45	0.32
% manual workers using the bus	0.35	0.24
% professional and managerial workers walking to work	0.24	-0.7
% non manual workers walking to work	0.25	-0.72
% manual workers walking to work	0.23	-0.77

Table 2. Transport and urban form correlations, 1991

3.4.1 Car ownership

Urbanised density is a far more significant influence on car ownership than distance from the city centre. The weak relationship between car ownership and distance from the city centre suggests that people living in the outer areas of the city do not all enjoy car oriented lifestyles

and similarly people living in the CBD and inner city wards are not all dependant on public transport.

Although there is a strong negative relationship between urbanised density and car ownership for both one and two and more car owning households it is possible that income might also be correlated with urban density. It would be desirable to dissagregate car ownership by social economic group thereby removing the income effect. Unfortunately the census does not provide this data.

3.4.2 Journey to work

Urbanised density is negatively correlated with the percentage of households using the car for the journey to work and is positively correlated with percentage of households using both the bus and walking. The strength of these relationships varies with the mode of travel considered. The correlation between urban density and walking to work is the weakest of the three modes. It appears that walking is strongly related to distance from the CBD and this is perhaps due to the shorter distances between the home and the workplace for CBD and inner city residents.

The relationship between urban density and the percentage of workers using the bus is much stronger than the relationship between bus use and distance from the CBD. These results suggest that density might be related to travel system characteristics that significantly increase bus patronage, e.g. proximity to bus stops and frequency of service. Distance from the CBD and hence journey time does not appear to be a strong influence on bus use for the journey to work.

The relationship between urban density and mode of travel to work will not be significantly effected by underlying income effects because the working population has been dissagregated by social economic group. However, the fact that this analysis assumes that all workers are travelling to the CBD is a significant limitation.

4 Areas for further research

Residential density alone does not fully explain whether people will use the car or a more 'green' form of travel. The density of the destination of the work journey will play a significant role in determining choices of travel mode. For example, workers travelling to the CBD are more likely to use public transport than workers travelling to a suburban work site, simply because the former is at the hub of the public transport network. Unfortunately the census data I have collected to date does not provide information about where people are travelling to, and so I only have half the picture. I have recently commissioned the General Register Office for Scotland to produce specialised travel to work matrices for Edinburgh using the Special Workplace Statistics (Set C). This data will provide infomation about the origin and destination ward for 10% of all journeys to work. It will also be possible to dissagregate this data by travel mode (car, bus, walk and other) and by social economic group (professional and managerial, other non manual, skilled manual and semiskilled and unskilled manual).

The analysis I have completed to date does not recognise that density itself might not be the influencing variable on travel mode. Instead density may only be a proxy for a number of underlying factors that effect mode choice. These underlying factors are presented in Table 3.

To investigate the effect of these underlying factors it might be a profitable exercise to undertake a travel to work questionnaire at either the workplace or residential area.

attitude towards public transport
level of public transport service
car ownership levels
income
cost of parking
relative cost of the car and public transport
cultural background
perceived convenience of public transport over long distances

Table 3. Underlying factors associated with density that may affect mode choice

5 Conclusions

If the goal of urban planners is to transfer trip-makers (particularly commuters) from private cars onto public transport then the density of where people live and work are important prerequisites. Much of the previous work on urban density and transport has already shown that, at an inter-city level urban density is clearly related to car ownership and public transport patronage. My research attempts to apply these philosophies at an intra-city level with the aim of improving the effectiveness of transport planning strategies.

6 References

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