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Using geo-demographic analysis to calculate patronage figures for rural buses. Final report

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Using Geo-Demographic Analysis to Calculate Patronage Figures for Rural Buses

Final Report to EPSRC: July 2002

Introduction

This paper reports on the results of an EPSRC Future of Integrated Transport feasibility study – *Using geo-demographic analysis to calculate patronage figures for rural buses (FITBUS)*. The project aimed to develop a geo-demographic analysis-based tool for those involved in planning and operating public transport, and then test the feasibility of using the technique to determine the levels of bus patronage and thus economic viability of new and altered bus routes.

Background

Increasing concern over the decline of rural areas has raised the political profile of the problem to its highest point for a number of years - witness the recent furore over bank and post office branch closures. High petrol prices too, have given cause for concern as many rural dwellers feel they have no alternative but to use their cars to access shops, schools, work, hospitals etc. The Government has attempted to address this. The Rural White Paper (DEFRA, 2000) promised additional rural bus services through increased funding. It is, therefore, important that we have a sound basis for decisions on the rural bus services in which to invest in order to maximise benefits.

Planning-based approaches to providing public transport services are fairly common around the world. In Ottawa, Canada for example, all large-scale employment and retail developments must be located on the Transitway busway network (Enoch, 1998). In Britain too, such an approach was the norm until fifteen years ago. One notable example is the development of the new town of Runcorn, which was actually built around a busway system. However, the 1985 Transport Act shifted the operation of the vast majority of bus services to the private sector, and thus planning data (outside London at least) became very much a secondary resource compared to bus usage and financial information.

With the Government projecting a need for three million more homes in the England by 2021 (DETR, 1999), it may be desirable to coordinate housing developments with improved bus services. This will enable more journeys to be made by public transport and decrease rural isolation for those without a car. For this to happen, a method needs to be developed linking population demographics and spatial information to bus patronage.

Current practice in determining the expected patronage from a new route or change to an existing route is crude. Household surveys are costly and cannot be commissioned for every route change. Car ownership levels, whilst an important factor in mode choice, only goes part way to explaining travel behaviour. The analytical capabilities of geographical information systems (GIS) and the availability of demographic and lifestyle data, provide the ideal opportunity to move away from specially commissioned surveys to more generic techniques based on available digital data.

Local transport authorities are beginning to make use of GIS technology and take advantage of spatial data analyst tools. For example, Strathclyde Passenger Transport (SPT) has linked its database containing information on bus routes, timetables and registrations for services operating within the SPT area to a GIS. However, the system falls short of being able to identify mismatches between supply and demand. Geo-demographics may provide the answer.

The technique of geo-demographics, as has been applied to retail, works by aggregating the population into groups based on their geographical location and demographic characteristics. The definitions of the groups are based on typical retail habits. The distribution of these groups around the proposed site for a new store, together with the transport network and distribution of other retail facilities can then provide retailers with an estimate of the expected revenue of the store, using location allocation modelling. A similar technique could be used to determine the likely patronage of a new bus service, or the effect of new developments along a route on the number of passengers.

Aims

To test the feasibility of using geo-demographic analysis techniques to determine the levels of bus patronage and thereby the economic viability of new and modified bus routes.

Objectives

1. To establish current and best practice in determining the economic viability of bus services through literature search and interviews with practitioners;
2. To establish through literature review and discussions with practitioners, key determinants of bus patronage in terms destinations served, population demographics and service quality.
3. To develop a methodology for estimating the patronage of bus routes using geo-demographic analysis techniques;
4. To apply this methodology to a number of bus routes and test the validity of the methodology by comparing our estimates with actual patronage figures.
5. To ascertain the usefulness of such a technique to practitioners, through a series of workshops and through a web-site and to examine the feasibility of applying this technique to other public transport schemes.

Programme of Work

Work was carried out in four overlapping phases. Phase 1 was to investigate how bus services are currently planned and marketed, through literature review and interviews with practitioners and academics in the field, meeting objectives 1 and 2. Phase 2 developed a methodology for estimating bus usage, and went on to develop a classification of bus users, meeting objective 3 and part of objective 4. In Phase 3, the methodology and classification were applied to West

Sussex. The results were compared with data from a number of sources. This phase addressed objective 4. The final phase looked at the feasibility of applying the technique developed to innovative public transport modes. Two workshops were held, involving practitioners from a variety of organisation types, to disseminate the results of the project and get feedback on the technique. The results of each phase of work are given below.

Phase 1: Current Practice

The first stage of the FITBUS study reviewed the factors that affect bus use, and looked at how commercial and social bus services were currently planned and marketed (Enoch et al, 2001). The inadequacies of current methodologies were identified. It was found that there are a number of ways that a geo-demographic analysis tool may be used to provide an effective way to overcome some of these failures.

Specifically, the work revealed that there are three, albeit strongly interdependent, major influences on public transport. These are:

1. Public transport supply features (quality, level, type and cost of public transport provision);
2. Personal factors (age, sex, income, socio-economic group, car availability); and
3. Area characteristics (distance from town centre, population density, distribution of homes, workplaces and other facilities, road layout, relationship between local transport authority and company, presence of complementary land use, environmental, social, fiscal and transport policies).

The study also showed that the structure of the bus industry in Britain has resulted in two types of public transport planner - the commercial and the social. The former (bus operators), are primarily concerned with maximising profits, while the latter (those who work for local authorities, Passenger Transport Executives, and London Transport), aim to use public transport to meet wider social, economic and environmental objectives.

Commercial operators tend to plan bus networks by the 'seat of the pants', that is, by relying on previous experience and local knowledge and using ticket machine data. Factors that trigger changes to a route or network can be broadly split into two categories: supply-side and demand-side. Supply-side factors occur when the performance of a route invites changes, or when the level of resources alters. Demand-side triggers include changes to housing, employment, leisure or retail development patterns. Commercial operators have not tended to use geo-demographic data in planning routes and services. In the few cases where geo-demographic information has been gathered and used, it has tended to be used more to market existing services. As for the use of Geographical Information Systems, so far this has not been widespread.

When planning routes in rural areas, the over-riding objective that social planners are aiming to meet, is to improve accessibility to shopping, health, education, leisure and employment centres for residents without access to a car. This contrasts with urban objectives, which now often focus on stimulating a modal shift from the car to the bus to reduce congestion, noise and air pollution. For the social planner, triggers to route changes tend to be where 'gaps' are identified by local individuals or councillors. Route planning is often done in conjunction with operators. Especially in towns, operators come to the council and discuss options. Once again, highly-skilled planners are required for such an approach to work effectively.

From the review, there are three roles for which geo-demographic data could be used in order to improve bus services – planning, monitoring and marketing.

In Planning and monitoring such a tool could be designed to:

1. Plot the optimum route between two points to give highest revenue return, patronage, lowest cost, or least emissions;
2. Generate statistics for a number of route options so various 'tweaks' could be tested and compared. This could double as a monitoring tool, allowing actual and predicted performance to be compared.
3. Determine cost-effective service types (e.g. conventional buses, shared taxi, demand responsive bus, and community transport services), depending on expected patronage levels.
4. Test how route performance would change in response to external changes, such as new developments.
5. Determine bus passenger profiles so that services could be tailored to suit.

In marketing such a tool would be designed to:

1. Determine the types of persons using buses so information and promotional effort could be better targeted; or
2. Target marketing spend at routes performing less well than their profile would suggest.

Of these, it is suggested that social planners would be most concerned with the monitoring and planning tools, while the commercial planners would use the marketing and planning functions.

Phase 2: Methodology and Classification Development

In order to develop a classification of bus users, data was required on socio-economic characteristics, transport supply, land-use and travel behaviour, at a fine spatial scale such as the individual, household, unit postcode or ED level. The first stage in the process of constructing a geo-demographic classification was to ascertain what data were available to produce the classification.

Data sources

Four main data sets that contained a mixture of socio-economic and transport related data were identified: Census data (including journey to work data), commercial lifestyles data, the National Travel Survey (NTS), and local travel surveys. A fifth possible source is survey and ticketing data belonging to transport operators. This data was reserved for the purposes of validating the classification and patronage estimation technique, so was not considered at this stage of the project.

These data sets were compared using SWOT (strengths, weaknesses, opportunities, threats) analysis (Titheridge et

al, 2002). It was found that no single data set would provide all the information required at a sufficiently fine spatial scale. The solution was to combine two of the data sets, with additional local data. NTS data was used to provide information on travel behaviour for different demographic groups and location types. The clusters developed were subsequently applied to Census data at enumeration district (ED) level and supplemented by information on the public transport availability.

Developing indicators of bus use

The next stage was to determine an indicator (or set of indicators) of bus usage. The purpose of developing a classification of bus users is to enable the number of bus trips to be calculated from geo-demographic data. In addition, it would be useful for route planning and timetabling purposes to know the origin, destination and timing of trips.

From this the following four indicators of bus usage were developed, where journey purpose is a proxy for destination and time of travel:

1. Number of commute stages by bus per week;
2. Number of education stages by bus per week;
3. Number of shopping and personal business stages by bus per week; and
4. Number of leisure and social stages by bus per week.

The classification

Following a review of retail-based geo-demographic classifications such as ACORN and MOSAIC (Enoch et al, 2001), it was felt that a hierarchical classification would provide the most versatility in terms of application. This approach also enabled us to ensure that the bus use indicators formed the main determinates of the groupings. The top level of the hierarchy, therefore, is based on travel demand, the second level on transport supply and area characteristics, and the third level on socio-economic characteristics – relating to the three types of influence on public transport demand identified in Phase 1 of the project. Thus, at the top level, there are six clusters classifying bus users according to the types and numbers of bus trips made. These clusters are:

- Commuters;
- Learners;
- Weekly shoppers;
- Frequent shoppers;
- Pleasure seekers;
- Non-/Casual bus users.

Each of these classes is then sub-divided according to a number of transport availability and area characteristics. For example, 'Learners' are divided into seven groups, three of which relate to rural and small urban areas. These are further sub-divided, where appropriate, by age and working status. For example, Inner-city learners are sub-divided by age into students and school children. In all, there are over 100 clusters and ANOVA tests indicate that each of these clusters is significantly different, although membership of some clusters is small (Titheridge et al, 2002).

Classification visualisation

To help the users of the FITBUS classification scheme quickly identify different clusters within the scheme each *class* (1st level clusters) is identified by a letter, i.e. Class A is commuters. Second level *groups* are identified by a letter and number (e.g. A1). For third level *sub-groups* a second number is appended after a decimal point (e.g. A1.1). Each class was also allocated a unique colour, which is used in any tables, charts and maps displaying information about that class (or groups and sub-groups within the class).

Table 1 shows the full classification scheme including the colour coding.

Methodology for applying the classification to an area

The first stage in developing the methodology for applying the FITBUS classification to an area was to determine which variables used to construct the classification were available from Census data and other sources at the ED level.

The bus users classification was based on individuals, including their travel behaviour. Census data provides counts of persons (residents) within each area with certain characteristics. The variety of cross-tabulations e.g. car availability by age, is limited; as is the type of travel behaviour information. Usual means of travel to work is available, but only as a 10% sample at ward level. The cross-tabulations were required in order to identify the number of individuals within each ED, for example, of a given age band, gender and working status.

In addition to Census data, a number of transport supply and area characteristics were determined for each ED, using overlay techniques within a GIS. Walk-time to bus stop was calculated using a walking speed of 6km/hr and the distance between the ED centroid (the centre of population) and the nearest bus stop. Area type was determined using Census data urban area key counts. Local authority population density was calculated using Census data, and bus frequency was extracted from bus maps and timetable information.

From this analysis of nationally available data at the local level, it was established that cluster membership would need to be determined from a limited number of variables – namely age, gender, working status, car availability, area type, area density, distance to bus stop and bus frequency. All of these variables are 2nd or 3rd level cluster determinants. Because no 1st level cluster determinants were available at the local level, it was not possible to assign individuals (groups of individuals) uniquely to a single cluster. There was a strong possibility that two persons with identical values for the eight variables available could belong to different clusters.

Using the eight variables available, the probability that a person of a given set of characteristics living in a particular type of area belongs to a particular cluster was determined by cross-tabulating the eight variables from the NTS database used to construct the clusters with the cluster names. This was carried out for each level within the classification hierarchy. Probabilities were also calculated using a smaller number of variables. Thus, for each class, group and sub-group within the classification a series of cluster membership lookup tables was produced in spreadsheet form.

The number of persons in each ED belonging to a particular class, group or sub-group was then determined by applying the probabilities contained in the lookup tables to the Census (and supplementary) data for that ED. The results

were then summed to give the total number of persons likely to belong to each cluster for each ED.

The number of bus trips generated by an ED was then determined by multiplying the mean number of trips made per person for each purpose within that cluster with the number of persons within the ED belonging to that cluster.

Phase 3: Pilot Study

The methodology for applying the classification to a rural area was tested using a case study area. West Sussex was chosen, because of data availability for the County and because geographical information system tools are being incorporated by the County Council into its planning processes. The classification was applied to all EDs within the County for which information was available. Data for some EDs was suppressed as the small size of the area could lead to the disclosure of individuals.

Trip rates were calculated based on three area characteristics (area type, local authority density and distance to bus stop) and three socio-economic variables (gender, age and working status). The numbers of people belonging to each FITBUS class (1st level clusters) was calculated using the methodology described above. These were then multiplied by mean trip rates for each class.

Using this technique it was estimated that the population of West Sussex makes just under 80,000 bus trips per year; this equates to 59 bus trips per person per year. DETR (1997) gives per capita bus trips for the South East region (excluding London) as 65 bus trips per annum. The 59 trips consist of 10 commute trips, 8 education trips, 28 shopping trips and 12 leisure trips. This compares with DETR figures of 12, 11, 30 and 12 respectively.

The process was repeated at the group level (2nd level), resulting in a slight increase in the estimated number of bus trips per year. Analysis at the sub-group level increases the estimated number of bus trips still further to 63 trips per person per annum.

The next stage of the project was to use the FITBUS tool to estimate patronage on two bus services. The criteria for selecting these routes were as follows:

- Availability of patronage data
- A single service operating along substantial parts of the route
- Serving a rural area (interurban or rural-to-urban)

These criteria narrowed the choice of routes considerably. Two routes were selected for analysis – one rural-to-urban, the other interurban. The bus trips generated by each ED were allocated to the bus stop nearest to the ED centroid. The total number of bus trips allocated to the bus stops along each route was then calculated. This method resulted in considerable over estimation of bus patronage, as a number of the EDs are served by several other routes, or several services along the same route (1033 trips on one of the routes, compared with 570 trips based on ticket machine data). However, the ticket machine data was incomplete – data for selected services only were available. This was multiplied up to give an estimated total patronage. In addition, ticket machine data can be unreliable as season ticket and bus pass fares are not always logged.

Several other allocation techniques were also tested, such as assigning the bus trips generated by an ED equally between all bus stops falling within the ED. Although these techniques produced estimates of patronage that were closer to actual patronage levels, none was entirely satisfactory. Feedback from bus industry professionals suggest that an allocation technique based on a combination of service frequency and reliability, destinations served and journey times would be an appropriate refinement.

Phase 4: Extending the technique to innovative modes

The final stage of the project was to explore the feasibility of extending the scope of the FITBUS geo-demographic analysis tool to innovative rural public transport modes (Enoch et al, 2002).

Objectives

The following questions were considered:

1. What are these innovative alternative modes?
2. What are the characteristics of these modes?
3. How and where do they currently operate?
4. Could the FITBUS technique be applied to these?
5. What additional data would be needed?
6. Does this data already exist?

Innovative rural public transport modes

Several innovative rural public transport modes were identified; these were: semi-demand responsive buses, demand responsive transport (DRT) buses, shared taxis of various types and car share clubs. The characteristics of each were then determined, and a SWOT analysis conducted looking at the potential use of a FITBUS-type tool for each mode.

Data availability

Operational and performance data was sought from the operators of the 'innovative' schemes funded through the three years of Rural Bus Challenge schemes, and one year of Urban Bus Challenge projects. In general, A telephone survey of these operators found that, as with conventional rural bus services, very little data at the level of the detail required to extend the FITBUS tool is available.

This is due to a number of reasons. First, for the most recent grant winners the schemes were yet to be, or had only just been, set up. For the more established schemes, data "is not readily accessible", is still in the hands of transport operators (with the associated commercial confidentiality issues) or is simply not being collected. Taxi companies seem particularly lax at recording information.

This lack of detailed data is borne out by the findings of an initial review of the effectiveness of the Rural Bus Challenge and Rural Bus Grant programmes by the TAS Partnership in 2000, which was able to make limited cost and usage calculations. It has also been recognised as a problem by the Government, which has commissioned Steer Davies Gleave to conduct around six case studies to determine user socio-economic profiles in a follow up study to the TAS Partnership report.

Some exceptions to the lack of data do exist. In particular, reports on the performance of the Wiltshire Wigglybus and the Lincolnshire InterConnect projects have provided fairly

detailed data on financial and operational issues as well as on the socio-economic profile of users. They also explained qualitative matters relating to setting up and running innovative public transport operations. Broadly these studies found that demand responsive services could be economically viable once a number of technical and operational teething problems had been overcome. They also indicated that the services were used by groups that did not often use a conventional bus, e.g. by more men.

Results

The SWOT analysis demonstrated that all of the modes identified would benefit to some degree from using the FITBUS tool. These ranged from using the FITBUS framework to record and process data gathered from existing services – as a monitoring instrument – to the tool predicting the most 'attractive' route, operating base or station.

The main strengths identified were that the tool would be able to predict the most suitable areas for operation, therefore lessening need for route modifications and speeding up successful implementation as compared to the 'trial and error' approach.

Weaknesses centre on the lack of good data in many circumstances, either because it is commercially confidential, or more often because it does not exist. Other barriers include the 'cultural' problem of persuading transport operators to use computer-based packages, and the relatively high cost of setting up the package (for small operators) compared with testing new services for real.

There are numerous opportunities for its application since many of the modes are only just beginning to take off in Britain and further afield. The tool could also be developed to help local authorities determine the best mode for a particular service, perhaps to justify it replacing infrequent bus services with higher quality innovative modes. Where modes require routing software packages, it could be possible to link them to a FITBUS-type tool.

The main threats to the tool were that some operators may consider it cheaper to experiment with 'real services' and modify by trial and error rather than to set up the tool. But, this would only apply to smaller operators that only altered a very few services each year. Once the tool is set up with the data in place, further tests would be relatively cheap.

Conclusions

Bus service planners are currently planning services as they always have, by counting "chimney pots", and relying on the skill and experience of individuals to plan and market the most effective services. Only in a very few places is geo-demographic data used to either plan or market bus services. In the past, this was because such data was expensive and time consuming to collect, and took a lot of effort to analyse. It was therefore considered an impractical possibility. Now however, it is possible to analyse data sets appropriate to bus planning thanks to the availability of GIS. There is the opportunity to mirror what the retail sector has appreciated and applied for many years.

The development of such a tool for the bus industry is timely, because more is expected of public transport as a social, economic and environmental policy instrument. Public money is also becoming ever more tightly controlled by central Government through the Local Transport Plan and 'Best Value' processes. The old approach of 'managing decline' is becoming less and less acceptable.

Finally, and most crucially, the number of very highly skilled and experienced people on whom the bus industry depends to plan bus services using conventional individual-centred 'knowledge' methods is in decline, and not enough people are being trained to replace them. The 'black art' of bus service planning is beginning to break down, and so a more systematic method is needed that allows more of the 'influential factors' to be taken into account. So far though, there is little sign that the bus industry has confronted this issue.

Although the technique has been used at ED level there is no reason why it could not be extended to any level of spatial aggregation from the individual or unit postcode upwards. Indeed if the technique is to be used successfully for calculating bus patronage then it will have to be applied at a smaller spatial scale than EDs.

Extending the FITBUS tool to other rural public transport modes would be feasible. However, there is currently very little data available, and this would need to be remedied if the use of such a tool was to be extended. Specifically, more widespread surveys of the socio-economic characteristics of users would need to be conducted, especially if the tool was to be used to develop shared taxi services.

A further barrier to the model being developed in this way, is that innovative public transport systems are often small scale and organised on an ad-hoc basis. This makes it far less likely that operators would buy and use a tool like FITBUS. There is, however, the potential for consortia, or bureau based arrangements in the context of this highly fragmented industry. On the other hand, demand responsive systems already require a significant investment in computer software, and so it may be possible for a FITBUS framework, adapted for demand responsive transport (or FITDRT), to be linked to or integrated with this.

There is also scope for developing the tool abroad. Indeed, attendees to the final seminar included bus planers from Ireland and France, while interest in research papers was received from as far afield as Dubai.

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Table 1: The FITBUS geodemographic classification

Classes		Groups		Sub-groups	
A	Commuters	*A1* *A2* *A3* *A4* *A5* *A6* *A7*	*Inner city dwellers, no car* *Inner city dwellers, car access* *City suburbanites, low car availability* *Large town residents, no car* *Town suburbanites, no car* *Small town residents* *Villagers*		
B	Learners	*B1* *B2* *B3* *B4* *B5* *B6* *B7*	*Inner city dwellers* *City suburbanites* *Town suburbanites* *Small town, good buses* *Small town, limited service* *Rural, limited commercial buses* *Rural, no commercial bus services*	*B1.1* *B1.2* *B2.1* *B2.2*	*Students* *School children* *Students* *School children*
C	Weekly Shoppers	*C1* *C2* *C3* *C4* *C5* *C6*	*Inner city dwellers, no car* *Inner city dwellers, car access* *Suburbanites* *Town residents, low car availability* *Villagers, no car* *Villagers, car access*	*C1.1* *C1.2* *C1.3* *C1.4*	*School children* *Pensioners* *Other non-working adults* *Working adults* NB: C2-C6 are subdivided into similar groups as C1. The adults in groups C2, C3 and C5 are divided by family type rather than by working status, as these groups contain very few working adults.
D	Frequent Shoppers	*D1* *D2* *D3* *D4* *D5* *D6*	*Inner city dwellers, no car* *Inner city dwellers, car access* *Large town residents, no car* *Large town residents, car access* *Small town, low car availability* *Villagers, no car*	*x.1* *x.2* *x.3* *x.4*	*School children* *Pensioners* *Other non-working adults* *Working adults* NB: All 6 2nd level groups are divided into these 4 sub-groups.
E	Pleasure Seekers	*E1* *E2* *E3* *E4* *E5*	*Inner city dwellers* *City suburbs* *Town centres* *Town suburbs* *Villagers*	*x.1* *x.2* *x.3* *x.4*	*School children* *Pensioners* *Other non-working adults* *Working adults* NB: All 5 2nd level groups are divided into these 4 sub-groups.
F	Casual Users	*F1* *F2* *F3* *F4* *F5* *F6*	*Inner city dwellers, no car* *Inner city dwellers, car access* *City suburbs* *Medium-sized towns* *Villagers, no car* *Villagers with car access*	*F1.1* *F1.2* *F1.3* *F1.4* *F1.5*	*School children* *Pensioners* *Non-working adults, young children* *Working adults with young families* *Working adults with older children* NB: F2-F6 are subdivided into similar groups as F1. The groups F2 and F6 have a sub-group for non-working adults with older children in replace of the school children sub-group.