TRANSPORT IMPACTS ON LAND USE: POTENTIAL METHODS AND THEIR RELEVANCE TO STRATEGIC PLANNING

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1. INTRODUCTION

1.1 Transport impacts on land use and their potential importance

This paper presents the main findings from a PhD research project into the treatment of transport impacts on land use in the UK strategic planning system. 'Transport impacts on land use' are broadly defined as any alteration to the pattern of urban, social or economic development caused by transport policy. The central indicators of distributional change can thus be either economic (such as property rents, employment levels or gross domestic product per head), or social/demographic (such as population or households).

There is considerable interest in the role of transport policy in shaping urban development, especially in terms of fostering economic growth, most clearly seen by the recent commissioning of the Standing Committee on Trunk Road Assessment to consider the links between transport and economic development (Department of Transport, 1996).

1.2 The current treatment of transport impacts on land use

An earlier stage of this research into the current examination of transport impacts on land use (Still, 1996), found no consistent or formal assessment of possible impacts as part of the transport or land use planning processes. The reasons for this centred around four issues. Firstly there is a lack of requirement to examine such impacts, and practically no mention of them in PPG13, the government guidance note on land use and transport (Dept. of Transport and Dept. of Environment, 1994). Secondly, there is a perception among planners that the development control process can prevent unwanted impacts from occurring. Thirdly, the exact circumstances under which impacts occur are only vaguely perceived, with a belief that they are difficult to readily predict. Finally, and most relevant to this study, planners (both land use and transport) tended to be unfamiliar with the methods that can be applied to estimate transport impacts on land use.

This lack of understanding means that the potential of transport policy to contribute to wider urban goals has either been ignored, or worse, used to justify transport schemes without good quality research into the likely impacts for a given urban area. Transport impacts on urban development are highlighted when they are perceived to benefit a
transport scheme, and ignored when not. Methods, when used, tend to be ad hoc and rarely comparable with other studies.

This situation creates a need to identify the methods that are most appropriate to examine transport impacts on land use, in terms of the requirements of strategic urban planning, and its resource constraints.

1.3 Structure of the paper

This paper therefore outlines the research undertaken to systematically examine which methods of assessing transport impacts on land use are most relevant to strategic land use and transport planning. To do this, several illustrative forecasting methods were applied to a common study area (Edinburgh and its surrounding region). These are discussed in Section 2. Section 3 then briefly compares and contrasts the results. The methods and their results were then assessed by a panel of strategic planners from the study area, who had agreed to assist in this project. The main points from these discussions are given in Section 4. Conclusions were then drawn regarding the validity of the methods, and the relevance and plausibility of the forecasts.

2 THE METHODOLOGIES

Table 1 below outlines the possible methods for determining the impacts of transport on land use. Within this table, method (1); planners judgement, was identified by Still (1996) as the most commonly used in the UK. The illustrative methods applied in this research focused upon one example from each of (3), (4) and (5). These are discussed in sections 2.2 to 2.5.

<table>
<thead>
<tr>
<th>Method</th>
<th>Comments/example methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  Individual planners</td>
<td>Often used in typical desktop based impact studies.</td>
</tr>
<tr>
<td>2  judgement</td>
<td></td>
</tr>
<tr>
<td>3  Informal use of group</td>
<td>Professional panel from planning and</td>
</tr>
<tr>
<td>4  expert opinion</td>
<td>property/development sector.</td>
</tr>
<tr>
<td>5  Formal use of expert</td>
<td>Delphi method, deriving quantified</td>
</tr>
<tr>
<td>6  opinion</td>
<td>responses from a similar panel to (2).</td>
</tr>
<tr>
<td>7  Simple modelling</td>
<td>Static land use models linked to standard or existing transport models.</td>
</tr>
<tr>
<td>8  Complex modelling</td>
<td>Dynamic land use transport model.</td>
</tr>
</tbody>
</table>

2.1 The Study Area and policies tested

Edinburgh was selected as the study area for this research for a number of reasons. Firstly it is a growing urban area, with a clear urban centre and supporting hinterland. It is of sufficient size to warrant strategic planning (with a population of around 750,000, and a land area of 1723 sq. km.). In common with many other UK cities, it is facing decentralisation pressures of both population and employment. Secondly, it
is a city of high architectural and cultural value, yet one in which increasing traffic congestion is threatening to reduce its environmental quality.

Edinburgh is also innovative in terms of its transport policy. It was one of the first UK cities to adopt an 'integrated urban transport strategy' (May, Roberts and Mason, 1992), and is actively considering both light rapid transit (LRT) and road pricing. The region also has a number of transport models relevant to strategic planning and the methods considered below. Most important here is an early version of The MVA Consultancy's 'Strategic and Regional Transport Model' (START; Bates, Brewer, Hanson, MacDonald and Simmonds, 1991). This model was made available for the purposes of this research.

Figure 1 shows the study area, the districts that comprised the Lothian Region, and the zones in the Lothian START model. Note that since the 1996 local government reorganisation, Lothian Regional Council has been abolished, and replaced by four Unitary Authorities following the original district boundaries.

Each of the three methods was implemented for two policy tests, (which were based upon elements of the best performing strategies in the Lothian integrated transport strategy, as outlined in May et al, 1992). However, the policies used here were hypothetical only, and applied solely for the purposes of this research project. The first was a road pricing cordon around the city centre (zones 1, 2 and 12 in Figure 1). A charge of £1.50 was applied for traffic passing each way through the cordon, operating all day. The second was an LRT system, with two lines operating with a five minute headway, each passing through the city centre (Waverley Station). The 'East-West' line ran from the airport (zone 16) to Leith (zone 4), the North-South line ran from zone 3 down to the 'South-East wedge' (Zone 5), an area earmarked for major housing and commercial development. LRT charges were assumed to be set as equal to bus fares. Note that each method also required a 'do-minimum', assuming no additional transport infrastructure and fares, prices and frequencies following historic trends.

2.2 The Delphi method

The Delphi method aims to obtain quantified opinions of experts in a subject area, in a systematic and non-biased manner using repeated questionnaires. Each panellist remains anonymous to the others, hence reducing the risk of 'interpersonal static' and individual bias. Panellists can adjust their responses to the questions, once presented with the results from the previous round. This process aims to obtain a consensus on the direction and magnitude of the impacts within the panel.

The Delphi method has not been applied widely in transportation studies, and is most commonly used in assessing the impact of new transport technologies. In assessing transport impacts on land use it has been applied in the United States (Cavalli-Sforza and Ortolano, 1984), and also to assess the impacts of the Sheffield Supertram (Antwi and Hennebury, 1995).

In these cases the Delphi offered a cheap and practical means of obtaining opinions on likely impacts, using experts in the subject area, without the expense of developing a mathematical model. However, as a tool in planning, it is more limited than a
mathematical model, for example because it cannot be used to test the impacts of strategies other than those considered in the questionnaire. Furthermore, the sample must be carefully selected (and ideally multidisciplinary) to encompass a variety of perspectives and minimise strategic bias. There is also a limit to the length of the questionnaire that can be successfully applied without respondent fatigue.

The panel approached consisted of property experts from the study area (property agents, surveyors and developers), planners from the Regional Councils, and planning consultants. The sample completing the entire Delphi consisted of 20 members, a typical number for a Delphi exercise (Amara and Lipinski, 1972).

The Delphi developed for Lothian was more ambitious than the previous ‘transport impact’ Delphi studies (referenced on the previous page) in terms of the spatial disaggregation, but considered less indicators as a result of this. The indicators selected were retail and office rents, and population distribution. These indicators represent those considered both sensitive and intermediary (i.e. commercial rents), and less sensitive and ‘end-state’ (i.e. population distribution). The 25 zones shown in Figure 1 were aggregated to 9 zones for the Delphi. The main aim of the questionnaire was to obtain responses regarding:

- the changes in office and retail rents over the next 15 years expected in each zone;
- the changes in population over the next 15 years expected in each zone;
- the impacts on these changes (expressed as percentage changes from the do-minimum forecast year) due to the LRT strategy, and the road pricing strategy;
- the timescale over which the impacts are likely to take place (in years).

The general results showed that there was a reduction in the standard deviation of the responses in the second round, suggesting that a better consensus was being obtained. However, resources did not permit more than two rounds of questionnaires to be undertaken.

2.3 The Static land use model (land use change indicators)

Static land use models generally work by taking a set of forecast year accessibilities from a do-minimum and a given transport strategy, and calculating the changes in the activity distribution that is possible given the changes in accessibility. For this reason they are termed indicators rather than forecasts, as they are both simplistic and have no explicit time element.

The static model LUCI (Land Use Change Indicator) used in this research was developed by David Simmonds Consultancy, using accessibilities generated from the Lothian START strategic transport model (see Roberts and Simmonds, 1995). It was a simple model, for example not including any feedback relationships. Thus no constraints were imposed on the amount of floorspace available in each zone, and market rent mechanisms were not represented. These simplifications mean that the model can be run very quickly once set up, requiring minimal additional resources or expertise.

The LUCI model had been calibrated using cross sectional data (Simmonds, 1991). It used the same zoning system as in Figure 1, and gave indicators of the likely impacts
in each zone on population distribution, and employment, the latter split into retail and service sectors.

2.4 The Dynamic land use transport model

Significant study resources were devoted to the development of a dynamic land use transport model for the Edinburgh study area, in conjunction with David Simmonds Consultancy and The MVA Consultancy. The START model formed the transport model, largely unchanged in terms of its datasets, but modified to run dynamically, and for time periods of two years. To this was added a new land use model, DELTA, which represented the following urban processes:

- development of housing and commercial floorspace, via the operation of the private sector development process;
- demographic change via a 'transition' model of probabilities that households of one type will transform into other types (e.g. by the processes of child birth, children leaving home, migration, death, divorce etc.);
- the location choices of employment and households, taking into account accessibilities and transport related environmental quality (from START), plus the quality of the urban fabric and a measure of the amount of space demanded by each household (utility of consumption);
- the process by which urban areas increase or decease in quality, based upon the income of the residents living there.

DELTA is considerably more complex than the LUCI static model, but was designed so that the submodels represent familiar urban processes, that were felt to be important in urban development. In particular:

- the explicit incorporation of time, with the model moving forward in two year steps;
- time lags are therefore able to be represented, for example development takes two years from the decision to build to when the floorspace becomes available;
- feedback effects, for example the land market is explicitly modelled, with increasing demand leading to rising rents;
- a variable representing the differing, and changing, quality of urban districts.

The result of the feedbacks and modelling of time periods is that land use and transport affect each other dynamically over time. This is shown in Figure 2. The DELTA model is designed so that the individual submodels are calibrated individually. Due to the limited resources of this research, cross sectional coefficients were used for the location model, and some parameters (for example in the development model and quality model) were estimated without formal calibration (this is discussed in more detail in Simmonds and Still, 1997).

The DELTA/START model required several hours computing time for a typical (20 year) forecast period. However, it generates a wide range of forecasts by zone and time period, including floorspace changes, rents, densities, employment and population estimates.
3 COMPARISON OF THE METHOD RESULTS

3.1 Introductory comments and the Do-Minimum forecasts

The do-minimum forecasts, which provided the basis for the comparison of the methods, thus each came from a different source. The Delphi panel were asked to estimate zonal changes in rents and population from current conditions, for a horizon year of 2010. The LUCI model itself is not capable of forecasting, and future year estimates were taken from the Lothian Regional Council planners’ zonal 2010 estimates for their region. The DELTA/START model produced its own population (household) forecasts, but used control totals from the Lothian Structure plan to guide the overall population totals, and give the employment projections by sector.

Table 2 gives a sample of the comparable forecasts. For simplification, the study area is divided into the city centre, a ring encompassing the rest of Edinburgh city, and an outer ring enclosing the remaining districts (see Figure 1). Note that two versions of the DELTA/START forecasts are given, the first (B7) being the results that were discussed with the study area planners (see Section 4), and second (R4) being results improved following some revisions to the model datasets (most importantly an input error which was allowing too much growth in Fife: zones 24 and 25).

Table 2: Do-minimum forecasts (% changes 1991-2011)

<table>
<thead>
<tr>
<th>Population</th>
<th>Delphi</th>
<th>Lothian planners</th>
<th>DELTA B7</th>
<th>DELTA R4</th>
</tr>
</thead>
<tbody>
<tr>
<td>City centre</td>
<td>+2.4</td>
<td>+15.6</td>
<td>-5.6</td>
<td>+8.7</td>
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<tr>
<td>Rest of Edinburgh</td>
<td>+3.3</td>
<td>-6.5</td>
<td>-10.0</td>
<td>-0.8</td>
</tr>
<tr>
<td>Rest of study area</td>
<td>+2.6</td>
<td>+20.0</td>
<td>+14.5</td>
<td>+7.4</td>
</tr>
<tr>
<td>Total study area</td>
<td>+2.8</td>
<td>+5.9</td>
<td>+4.4</td>
<td>+4.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Employment</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>City centre</td>
<td>N/A</td>
<td>+9.8</td>
<td>-0.5</td>
<td>-1.4</td>
</tr>
<tr>
<td>Rest of Edinburgh</td>
<td>N/A</td>
<td>+15.6</td>
<td>-1.2</td>
<td>+1.1</td>
</tr>
<tr>
<td>Rest of study area</td>
<td>N/A</td>
<td>+11.8</td>
<td>+15.3</td>
<td>+13.8</td>
</tr>
<tr>
<td>Total study area</td>
<td>N/A</td>
<td>+13.1</td>
<td>+6.0</td>
<td>+5.6</td>
</tr>
</tbody>
</table>

* used to provide LUCI horizon year land use distributions.

Table 2 illustrates that there is some disagreement between the methods on the distribution of change, both in terms of direction and the magnitudes. In particular the Delphi results predict growth throughout the study area, but are of a much lower magnitude compared to the planners’ predictions or the DELTA model. The growth outside of the city illustrates the decentralisation pressures that Edinburgh faces, but note that there is agreement that the city centre will be able to withstand these decentralisation pressures. The most significant disagreement shown in Table 2 is where employment is most likely to grow. While the Lothian planners predicted further growth in the centre, the DELTA model estimates greater decentralisation.
3.2 Forecasts of transport impacts on land use

Although there was some disagreement between the do-minimum forecasts from methods, Table 3 shows that all the methods’ predictions agree that the impact of road pricing on the study area will be slight, relative to the respective do-minimums. The main exception is the impacts on employment, which are larger and (mostly) negative within the cordon area (note that the Delphi panel also predicted strong depressive effects on office and retail rents within the cordon). There is a complex distribution of gainers in employment in response to this decline in central area activity, again with DELTA predicting more extreme decentralisation than the static LUCI model.

By contrast, LRT is forecast by the models (although not the Delphi panel), to have a much larger impact (Table 4). This is due in part to the high frequency of the LRT service, but also, in DELTA/START it can be seen that over time land use shifts occur which reinforce the patronage of LRT, with higher growth along LRT corridors. LRT is predicted to encourage strong population centralisation, which is partly a feature of the accessibility function (as households find the city attractive as a location from which to get to other parts of the region with ease). However, on the wider scale, it also appeared to encourage focus of activities within Edinburgh city generally.

Table 3: Impacts from the road pricing policy (% change for 2011 forecasts)

<table>
<thead>
<tr>
<th>Population</th>
<th>Delphi</th>
<th>LUCI</th>
<th>DELTA B7</th>
<th>DELTA R4</th>
</tr>
</thead>
<tbody>
<tr>
<td>City centre</td>
<td>-1.3</td>
<td>+1.4</td>
<td>-1.9</td>
<td>-1.8</td>
</tr>
<tr>
<td>Rest of Edinburgh</td>
<td>+0.2</td>
<td>-0.3</td>
<td>+0.8</td>
<td>+0.9</td>
</tr>
<tr>
<td>Rest of study area</td>
<td>+1.0</td>
<td>+0.1</td>
<td>-0.3</td>
<td>-0.4</td>
</tr>
<tr>
<td>Total study area</td>
<td>+0.4</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Table 4: Impacts from the Light Rapid Transit policy (% change for 2011 forecasts)

<table>
<thead>
<tr>
<th>Population</th>
<th>Delphi</th>
<th>LUCI</th>
<th>DELTA B7</th>
<th>DELTA R4</th>
</tr>
</thead>
<tbody>
<tr>
<td>City centre</td>
<td>+0.9</td>
<td>+11.1</td>
<td>+15.7</td>
<td>+25.6</td>
</tr>
<tr>
<td>Rest of Edinburgh</td>
<td>+1.3</td>
<td>+2.6</td>
<td>+1.1</td>
<td>+3.6</td>
</tr>
<tr>
<td>Rest of study area</td>
<td>+1.3</td>
<td>-3.8</td>
<td>+13.4</td>
<td>-9.4</td>
</tr>
<tr>
<td>Total study area</td>
<td>+1.3</td>
<td>0.0</td>
<td>+4.4</td>
<td>0.0</td>
</tr>
<tr>
<td>City centre</td>
<td>N/A</td>
<td>+10.7</td>
<td>+19.0</td>
<td>+13.0</td>
</tr>
<tr>
<td>Rest of Edinburgh</td>
<td>N/A</td>
<td>-0.9</td>
<td>-5.0</td>
<td>-0.2</td>
</tr>
<tr>
<td>Rest of study area</td>
<td>N/A</td>
<td>-10.0</td>
<td>-5.4</td>
<td>-5.9</td>
</tr>
<tr>
<td>Total study area</td>
<td>N/A</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>
Aside from the results presented here, the Delphi and DELTA/START models also predicted significant changes to the distribution of rents, with larger percentage changes than the impacts on activities. Again, the magnitude of the change forecast by the DELTA model was greater that given by the Delphi panel. Using the DELTA/START model it was also found that the transport indicators resulting from incorporating land use change gave different results from the START transport-only model. For example, the public transport mode shares were slightly higher for LRT when land use was allowed to respond.

It was felt that all the methods (although the modelling results more so than the Delphi), predicted results that could potentially have impacts on structure planning. In particular, LRT may encourage demand for floorspace (both commercial and residential) in the city centre, increasing the social and economic pressures on this area. The ‘negative’ economic impacts of road pricing would need to be studied more carefully, especially as two independent methods, both the Delphi panel and the models, predicted similar effects on employment and/or commercial rents.

In summary, all the methods predicted that the two hypothetical transport policies would have effects on the land use pattern. Clearly though, more tests (or Delphi surveys) would be required before specific policy inferences could be drawn.

4 THE PLANNER INTERVIEWS

The results from the methods outlined above were given to a sample of six strategic planners, both land use and transport, from the study area, and the planners were interviewed to discuss the methods and their results. Prior to these interviews, a subgroup of these planners (informally termed the ‘steering group’) were given additional presentations on the DELTA/START model, to explain its increased complexity, and illustrate its wider range of outputs.

The planners were asked to consider the appropriateness of the methods based on:
1. the relevance of the indicators produced by the methods;
2. the validity of the methods used;
3. the plausibility of the results produced;
4. and hence finally, the importance of these methods to different aspects of planning.

4.1 Relevance and choice of indicators

The first issue regarding relevance that immediately became clear in the interviews was that planners in different organisations tended to share the same technical views on relevant indicators, without necessarily having the same needs for a strategic assessment of land use impacts. Thus the central Government planners in the sample tended to have a much greater ‘hands off’ approach to modelling than district (and regional) planners. However, within the districts, the practical interest in the methods
depended upon whether the planners were considering transport policies that (they felt) would have land use impacts.

It was clear from the planners' comments that certain indicators were of more relevance than others, and there was significant consensus within the sample to this effect. Those indicators considered essential for planning tasks tended to be 'final' outcomes, such as the estimates of distribution of population and employment. These appeared important because of their role in conventional transport forecasting (i.e. trip generation), and because this is the 'hard data' with which planners work. There was also a focus on 'horizon' years, rather than on outputs for intermediate years. Clearly this suits methods which only work to a given forecast year (Delphi or LUCI), and shows that the time period data, while essential for the theoretical underpinning of any land use transport model, has limited appeal as an indicator in itself.

The choice of spatial scale was very important. It was clear that land use planning requires information on a fine scale, in order for the distribution of the impacts to be clear. However, the planners noted that too large a number of zones can hinder analysis, and that some tiers of planners require more aggregated data than others. It is therefore important for land use data zoning to be flexible for aggregation, but still using spatial units that the planners are familiar with. This was particularly apposite in Lothian, where local government re-organisation has reduced the spatial scale of interest for any one of the Unitary Districts which comprised the former Regional Authority. It was also clear that the 9-zone system used in the Delphi was too coarse for detailed use. The planners considered the use of GIS in modelling to offer a potential advance in allowing flexibility in zoning.

4.2 Validity of the methods

The planners' views on the methods ultimately reflected their views on modelling in planning generally, and in particular the additional complexity to transport modelling implied by the incorporation of land use. While this was not a large issue for the LUCI approach, it was more important for DELTA, which required substantial resources in addition to the transport model. However, complexity was perceived as beneficial if it made explicit the processes that underlay the model results. In this sense the Delphi was criticised as offering little formal explanation for the views of the sample. This is especially the case compared to DELTA where the production of intermediate indicators such as rents and accessibilities was seen to aid transparency.

Transparency was a key element which contributed to the planners' confidence in a given method. From the interviews, it was discerned that confidence comprised two broad areas; firstly technical issues, such as the ease of calibration, validation and use of the model, coupled with the plausibility of the forecasts (see below); and secondly qualitative issues, such as the reputation of the model and the modelling team, perception of the success of past applications, and the training/education of the planner(s) in the method from the modelling team.
4.3 Plausibility of the results

The plausibility of the forecasts was closely related to the confidence in the method used to produce them. Thus one planner was critical of the Delphi results because of the 'positive' bias in its do-minimum forecasts. For the modelling methods, given the comments in Section 4.2, it is perhaps not surprising that these forecasts were treated with some caution by the planners. Firstly the planners (with one exception) had little familiarity with the methods, were perhaps not given sufficient description of the calibration procedures or sensitivity testing, and not given the chance to comment on early forecasts. This view was expressed by even those planners who had additional exposure to the DELTA/START via the 'steering group sessions' and implies that a great deal of interaction is necessary between the modelling team and planner clients during modelling (especially model development) projects.

The second important finding relating to the plausibility of results concerned the process by which forecasts were considered reasonable. In terms of the do-minimum forecasts given in Table 2, the planners tended to take the LRC(LUCI) forecasts as being most plausible, partly because they were developed by a team within the old Regional Authority. However, this meant that the DELTA do-minimum, despite the data error in Fife, was seen as more plausible because it was a closer approximation to the LRC forecasts than the Delphi forecasts. This was especially the case as differences between the LRC and DELTA do-minimum forecasts could readily be explained by some differing base assumptions.

However, in terms of determining the reasonableness of the forecast transport impacts on land use, there was much less to serve as a benchmark for comparison. There was a general consensus that the directions of change were reasonable, although several aspect went against the 'deductive' (or professional) expectations of the planners. For example the impacts of LRT from DELTA were felt to be too large, especially the centralisation of population. Interestingly, there was interest in the relative impact between zones, even if there were doubts about the absolute magnitudes of impacts predicted.

4.4 Overall importance and planning tasks

The planners were asked about the types of planning task to which methods of assessing transport impacts on land use were considered relevant. A task identified by those with land use planning backgrounds was in testing the links between land use and transport plans for the early stages of structure planning. In particular this was related to how transport could influence the city's urban regeneration initiatives. However, the main purposes identified by both land use and transport planners still focused upon transport planning tasks, such as the appraisal of potential transport policies, and their sensitivity to land use assumptions.

Although in general the planners' comments were very favourable towards incorporating assessment of transport impacts on land use in planning, the planners would not commit themselves upon whether future forecasting commissions would incorporate these relationships, although their desirability (despite the cost and
resource implications) was claimed not to be in doubt. This uncertainty is perhaps a limitation of researching into planners’ views rather than their actions.

5.0 CONCLUSIONS

Conclusions to this research can be grouped into two areas. Firstly, with regard to the importance of transport impacts on land use, it was found that:

- the methods predicted that transport impacts on land use are likely to occur in the study area, and would have policy significance;
- the DELTA/START framework showed that the transport indicators for the horizon year can differ, (especially in the distributions of impacts) when land use response is considered, due to the changing pattern of future trip generation;
- the planners agreed that there were likely to be impacts, and commented that this was a relationship that they considered desirable to incorporate, with strong benefits to strategic planning, although not necessarily as a final object of study in its own right.

Secondly, with regard to the attributes of appropriate methods:

- it was clear that a dynamic modelling framework, that is intuitive and internally consistent, is best able to meet the ‘transparency’ and ‘confidence’ criteria discussed in Section 4;
- such modelling frameworks should be sufficiently complex, in order to incorporate the main relationships thought important, and hence offer advantages in terms of explanation of the forecasts;
- however, this places increased demands on the users of the results to understand the modelling process in order correctly to explain results;
- the Delphi, or expert panel approach can be seen as complementary to modelling work;
- static land use models offer a relatively cost effective method of examining land use issues, but fall short of offering a strong theoretical or transparent approach, and hence are limited in their explanatory power;
- any method must engender confidence via both its technical merit, and a clear process by which the plausibility of the results are determined.

In summary, from the planners’ comments it is clear that of the methods applied here, the constituent components of an ideal ‘appropriate method’ already exist in terms of the desired outputs, theoretical basis, and necessary complexity. However, only through increased practical application, discussion, and dissemination of results will our understanding of this important relationship improve.

ACKNOWLEDGEMENTS

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The author is also grateful to the planners in Lothian who participated in this research, The Scottish Office for use of the JIF model, and those at MVA and DSC who worked on the development of the DELTA/START model.

REFERENCES


Figure 1: Study area map showing District Boundaries, zones and aggregations used in tables 2-4.

Delphi Zone aggregation:  
1 = 1, 2, 12  
2 = 3, 4  
3 = 9-11, 13, 14  
4 = 5-7  
5 = 8, 16, 21  
6 = 15, 22, 23  
7 = 17, 18  
8 = 19, 20  
9 = 24, 25

Figure 2: Operation of DELTA/START over time

Transport Model  
EFM START

Database year t  
Time t

Land-use Model  
DELTA

Time t + 1

Transport Model  
EFM START

Database year t+1

Land-use Model  
DELTA

EFM: External Forecasting Model (trip generation model)