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AN APPLICATION OF TOPAZ TO LEEDS

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C O N T E N T S

AN APPLICATION OF TOPAZ TO LEEDS

1. Introduction

This paper is concerned with work undertaken for the International Study Group on Land Use Transport Interaction (ISGLUTI) which is coordinated by the Transport and Road Research Laboratory. In Phase I of the study computer models which represent the interaction between transport and land use have been used to examine the effects of an agreed set of policies. While this has produced interesting results, the models were applied to different study areas, and this made it difficult to distinguish between the effects of different model formulations and the effects of the study areas themselves. Therefore, in Phase II of the study, models and data sets are being exchanged so that results from a number of models applied to the same study area can be compared. This paper describes one contribution to this part of the study in which the TOPAZ model developed at CSIRO in Australia has been applied with data from Leeds. This makes possible comparisons with results from the LILT model (Mackett, 1979) which has been extensively applied to Leeds.

In Section 2 the TOPAZ model is described briefly. This is followed by a discussion of the data used in the application to Leeds. Section 4 describes the results of running the model with this data. Section 5 presents the results of varying certain inputs of the model in order to examine its sensitivity to such changes. In Section 6 the effects of the application of some of the policy tests devised for ISGLUTI are considered in relation to a base run of the model. The results from TOPAZ are also compared with those from the LILT model. The final section draws some conclusions from this work.

The TOPAZ programs, test data and documentation were supplied by Dr. Ron Sharpe of CSIRO to whom thanks are due. The description of TOPAZ in Section 2 is based on that given in the TOPAZ82 User Manual (Sharpe et al, 1983). Dr. Sharpe also provided some demonstration runs of TOPAZ on Leeds data, and answered several queries about the implementation of the model. The demonstration runs were successfully replicated here using the University of Manchester Regional Computer Centre's CDC 7600 computer which is similar to that used by CSIRO. All of the model runs described here were also undertaken on that computer.

2. A Brief Description of TOPAZ

TOPAZ (Technique for the Optimal Placement of Activities in Zones) has been under development at CSIRO in Melbourne since 1969. A fuller description of TOPAZ and some selected applications can be found in Brotchie et al (1980). TOPAZ is a general technique which has been applied at a variety of scales such as the planning of individual buildings and the planning of urban areas. It is the latter field of application which is of interest here and to which the following description relates.

The model is conceptually simple. It produces an allocation of land using activities (such as housing, industry, shops and so on) to a set of zones which minimises both the costs of establishing those activities and the costs resulting from the interactions between them (that is, travel costs). It is the incorporation of both land-use and transport elements that makes the model of interest to the ISGLUTI study. As TOPAZ is basically an optimising (prescriptive) model it is, however, rather different from most of the other models involved in the study, which are fundamentally predictive. This distinction is not necessarily clear cut, though, as has been pointed out by Sharpe et al (1981) and as will be seen TOPAZ can incorporate predictive elements.

In this application, a recent and not yet fully developed version of TOPAZ, TOPAZ82 has been used. TOPAZ82 takes account of activities already existing in zones and also allows these to be removed (that is, demolished). It does not however include modal split, assignment, air pollution or other sub-models which have been included in earlier versions of TOPAZ.

Following the notation of Sharpe et al (1983) the main variables of TOPAZ82 are as follows:

- A_i = planned level of activity i including existing development.
- b_{ij} = unit cost less benefit of incrementing the level of activity i in zone j.
- c_{ijkl} = cost less benefit per unit of interaction between activity i in zone j and activity k in zone .
- d_{ij} = unit cost less benefit of decrementing the level of activity in zone j.
- e_{ij} = level of activity i existing in zone j at the start.
- s_{ik} = level of interaction between a unit of activity i and a unit of activity k (assumed to be independent of zonal location of the activities).
- r_{ik} = $s_{ik}\ A_i/A_k$.
- T_{ijkl} = level of interaction or flow between activity i in zone j and activity k in zone l.
- x_{ij} = amount of activity i to be allocated to zone j.
- y_{ij} = amount of activity i to be removed from zone j.
- Z_j = capacity of zone j including existing development.

The model itself may be expressed mathematically, again following Sharpe et al (1983), as follows:

$$Z = \mathrm{Min}_{T,x,y} \sum_{ijkl} T_{ijkl}\, C_{ijkl} + \sum_{ij} b_{ij}\, x_{ij} + \sum_{ij} d_{ij}\, y_{ij} \qquad (1)$$

subject to constraints that:

(i) trip origins and destinations are given by trip generation and attraction rates applied to final activity levels,

$$\sum_{l} T_{ijkl} - s_{ik} \; (x_{ij} - y_{ij} + e_{ij}) = 0 \quad \forall ijk \qquad (2)$$

$$\sum_{j} T_{ijkl} - r_{ik} \; (x_{kl} - y_{kl} + e_{kl}) = 0 \quad \forall ikl \qquad (3)$$

(ii) each activity is fully allocated,

$$\sum_{j} (x_{ij} - y_{ij}) = A_i - \sum_{j} e_{ij} \quad \forall i \qquad (4)$$

(iii) each zone's capacity is not exceeded,

$$\sum_{i} (x_{ij} - y_{ij}) \leqq Z_j - \sum_{i} e_{ij} \quad \forall j \qquad (5)$$

and (iv) optional solution constraints.

$$0 \leqq (x_{ij})_{min} \leqq x_{ij} \leqq (x_{ij})_{max} \qquad (6)$$

$$0 \leqq (y_{ij})_{min} \leqq y_{ij} \leqq (y_{ij})_{max} \leqq e_{ij} \qquad (7)$$

$$0 \leqq (T_{ijkl})_{min} \leqq T_{ijkl} \leqq (T_{ijkl})_{max} \qquad (8)$$

The final set of constraints can be specified to suit the application or to examine the effects of a particular policy.

The problem specified by these equations is solved by linear programming. In order to make this manageable in terms of computer resources the problem is decomposed into a master problem concerned with the land use allocations only and a transportation sub-problem in which the land-use pattern is fixed.

An important extension of TOPAZ82 is to incorporate a gravity type trip distribution model of the form given by Wilson (1970):

$$T_{jl} = A_j B_l O_j D_l \exp(-\beta c_{jl}) \qquad (9)$$

This introduces a predictive element into the model, the objective function of which is now given by:

$$Z = \mathrm{Min}_{T,x,y} \sum_{i,j} b_{ij} x_{ij} + \sum_{ij} d_{ij} x_{ij} + \sum_{ijkl} T_{ijkl} C_{ijkl} + \sum_{ijkl} (T_{ijkl} (\log T_{ijkl})/ \beta_{ik}) \qquad (10)$$

As β tends to infinity so the solution reverts to one based on minimum transport costs. (In fact, the model treats any β value greater than 99.0 as infinite thereby producing a minimum cost solution.) A further option available is to introduce different weightings on the various components of the objective function. The model may also be interpreted as a game between two players, one player (the planning authority) optimising the land sub-problem and the other (the travelling public) optimising the transportation problem. Different solution methods may be adopted to simulate the 'players' acting competitively (leading to a Nash equilibrium solution) or cooperatively (which leads to a Pareto optimum solution). TOPAZ82 is the first version of the model to incorporate a Pareto optimum solution. Further details of this can be found in Sharpe et al (1983).

3. Data Requirements

This section describes the data requirements of TOPAZ82 and the ways in which these were met in the application to Leeds. In fact relatively little data is necessary to run the model and much of this is also used by the LILT model. Wherever possible, therefore, the categories and data used by LILT have been adopted for TOPAZ which, apart from being convenient, helps in making the results from the two models comparable. However, in some instances, mentioned below, data required by TOPAZ82 is not readily available for Leeds.

One of the first steps to be taken in an application of TOPAZ is to decide on the zoning system and on the activity categories to be located. In the application of LILT to Leeds there are 28 internal zones and 12 external zones. The model only locates activities within the internal zones, and these alone have been used with TOPAZ. In order to keep the application fairly simple and thus to permit a reasonable number of computer runs to allow scope for experimentation, three activities only were used. These were residential activity, non service industrial activity (excluding agriculture) and service industry. These were defined in accordance with the ISGLUTI recommendation and also correspond to categories to which output from LILT is aggregated.

A further basic consideration relates to the treatment of time. Although some applications of TOPAZ have involved more than one time period, in this case it has been assumed for the sake of simplicity (and because TOPAZ82 does not explicitly allow for multiple time periods) that the activities are to be located over one 20 year time interval.

Given the choice of activities, zoning system and time horizon, the data essential for running TOPAZ82 fall into two categories, relating to the activities to be located and the interactions between them, as follows:

Activity data

- the existing amount of each activity in each zone (the e_{ij} values of Section 2)
- the total amount of each activity over the study area as a whole, including both existing activity and that to be located (A_i)
- the size of each zone (Z_j)
- the cost of establishing one unit of activity in each zone (b_{ij})

- the cost of removing one unit of activity in each zone (d_{ij})

Interaction data

- an interzonal distance matrix
- the cost of one unit of interaction per unit distance between each pair of activities (which taken with the distance matrix gives c_{ijkl})
- the amount of interaction generated by one unit of each activity to each activity (S_{ik})
- the values of the β parameters for each pair of activities when a gravity type trip distribution model is used (β_{ik})

Although the model was described in Section 2 in terms of costs less benefits the latter have been omitted because of the difficulty of obtaining meaningful values for these.

Activity levels and zone sizes need to be expressed in consistent units and the only measure used for both inputs with LILT is land area. This has also been used in previous TOPAZ applications and was therefore chosen here. City-wide total levels of activity (existing plus that to be allocated) were taken from the LILT base forecast. Zone sizes excluded land deemed to be unusable in the LILT application.

The costs of establishing and removing activities (e.g. construction and demolition costs) on a zone to zone basis are not readily available for Leeds. Whether these costs should be the total cost of construction (or demolition) or just the costs incurred by public authorities (i.e. infrastructure costs) is also an interesting question. In the application of TOPAZ to Melbourne for ISGLUTI the latter were used. In this application to Leeds, because of the absence of more suitable data, average Melbourne values were used across the whole study area. As TOPAZ82 minimises total daily costs the construction and demolition costs were assumed to be spread evenly over the 20 year period and converted to costs per day. That these were based on another city and do not vary from zone to zone is clearly unsatisfactory. Sensitivity analyses on this data were therefore carried out, the results being given in Section 5.

Interzonal distance data presented no problem and the same matrix used with LILT could be used for TOPAZ82. The remaining interaction data is however required to be disaggregated by purpose, with travel between each pair of activities being a separate travel purpose with different characteristics To make the results comparable with those from LILT and because data on certain purposes (for example travel between industries) was not available, it was decided to consider work trips only. Interaction costs, trip generation rates and β-values were only specified therefore for the home to non-service industry, and home to service industry trip categories. Shopping trips were excluded from the latter category becaue otherwise it would be difficult to establish interaction costs and β-parameter values which are quite different from those for work trips. Also it would not have been possible to output results for work trips only.

The interaction cost was taken as the monetary cost of travel per unit distance for work journeys in Leeds in the 1971 base year. This was an average over all three modes (private, public and walk) represented in LILT, which are not differentiated in TOPAZ82. Trip generation rates were given by the total employment in each of the two sectors in Leeds projected for 1991 divided by the total land area of housing forecast for that year.

It was decided to make use of the option to incorporate a gravity type trip distribution submodel as this gives TOPAZ82 an element in common with the LILT model. However no calibration routine is provided in TOPAZ82 to estimate the β-parameters required for the trip distribution submodel. Neither could the values used in

LILT be applied directly because that model makes use of generalised cost rather than simple monetary cost. Instead it was assumed that the product of the mean trip length (in generalised cost units in the case of LILT and monetary cost in the case of TOPAZ82) and the β-values would be a constant for Leeds. The value of this product was found to be roughly 2.0 in the LILT application, and the values for TOPAZ82 could therefore be found by dividing this value by the mean money spent per work trip in Leeds in the base year. Again some sensitivity of the output to these values was investigated (including setting them to 100.0 to produce a minimum cost solution) and the results are presented in Section 5.

Two other options were chosen to be the same as in the demonstration runs initially undertaken by Dr. Sharpe in Melbourne. Thus the model was always run to produce Pareto optimal solutions (which are also global optima unlike Nash equilibrium solutions which may only represent local optima). An overall constraint on the maximum amount of any existing activity that could be removed from any zone was also imposed initially at a level of 10%.

4. Preliminary Results

This section considers the results of applying TOPAZ82 with data representing Leeds and derived as described in Section 3. Firstly, however, it is necessary to mention the outputs produced by TOPAZ82 and their values in the base run of the LILT model.

TOPAZ82 outputs the amounts of each activity newly allocated and removed and the resulting final level of activity in each zone. An option also allows trip matrices for each pair of activities and for all activities together to be produced. The output also includes details of the total cost of the changes broken down into transport and activity establishment/removal components.

In order to facilitate comparison with results generated for ISGLUTI by LILT, a short computer program was written to aggregate the TOPAZ82 results to three regions of the city and to calculate some additional indicators. A map of the zoning system and the regions to which these zones are aggregated is shown in Figure 4.1. A complete list of the indicators produced (for each 'region' of the city and as a city wide total or average) is as follows:

- area occupied by housing (ISGLUTI indicator ARHS)
- area occupied by retail and other service activities (ARRT and ARNR combined)
- area occupied by non-service activities (ARNS)
- area of undeveloped land (ARUN)
- total land area (ARTL)
- number of trips to work by origin (TOWK)
- number of trips to work by destination (TDWK)
- average distance travelled to work by origin (ADWA)
- average distance travelled to work by destination (ADWD)
- percentage of trips that are intrazonal.

The final indicator was not specified by ISGLUTI but was included for comparison with the results from LILT. Thus only nine out of the 94 potential indicators devised by ISGLUTI are considered here. This results from both the relatively simple specification of TOPAZ82 (for example, no differentiations between travel by different modes or between land area and building stock or activity levels are made) and the simplifications made in this application to Leeds (for example, only work journeys have been considered).

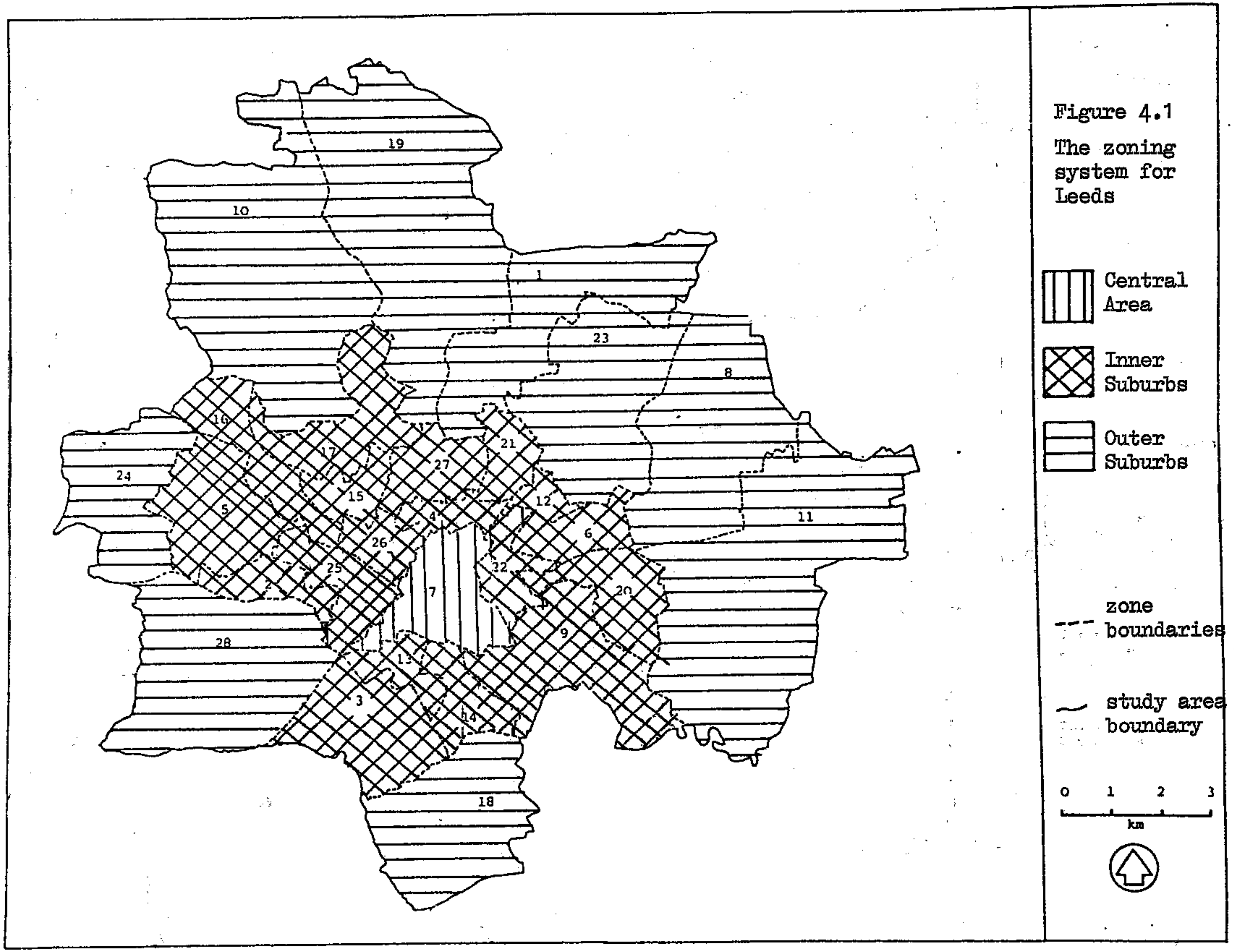

Figure 4.1
The zoning system for Leeds

Table 4.1 presents the values of these indicators for the base year (1971) in Leeds, the base forecast for Leeds from the LILT model, and the TOPAZ82 solution for the data described in the previous section. Areas are given in hectares and distances in kilometres. The values for trip numbers and trip distances by destination are not strictly comparable because the LILT 1991 forecast and 1971 Leeds results include trips from external zones while the TOPAZ82 results do not. The total land areas occupied by each activity in the TOPAZ82 results are exogenous inputs and set to the same values as those from the 1991 LILT base forecast. All other outputs are produced by the model.

It can be seen that the TOPAZ82 solution results in less decentralisation of activities than that forecast by LILT. (Here and elsewhere decentralisation is considered to be an increase in the proportion of an activity located in the outer suburbs, whereas centralisation is the reverse.) In particular there is no large decline in the area of non-service industry in the central area with TOPAZ82. This in fact would not be possible in TOPAZ82 because a maximum "demolition rate" of 10% is imposed. However even this limit is not reached in the solution. Also the areas of housing and service activities in the inner suburbs increase quite substantially with TOPAZ82 while there is very little change in the LILT forecast. Conversely the change in the outer suburbs is much smaller with TOPAZ82 than with LILT. The numbers of trips orginating in each area are rather different in the results from TOPAZ82 to those from LILT. In TOPAZ82 they reflect an overall trip generation rate per hectare of housing and do not take into account zonal variations in density and activity rates which are incorporated into LILT. The differences in trip numbers are much greater when disaggregated by destination (even taking into account the difference in definition already noted) because variations in density of employment are much greater than those for population. Thus the number of work trips arriving in the central area is very much lower with TOPAZ82 than with LILT. Finally, trip distances are

	CENTRAL AREA	INNER SUBURBS	OUTER SUBURBS	CITY TOTAL
LEEDS BASE YEAR (1971) VALUES				
AREA OF HOUSING	6.60	1971.21	3657.60	5635.41
SERVICE	188.50	467.20	695.40	1351.09
NON-SERVICE	217.60	687.70	453.60	1358.90
UNDEVELOPED	32.06	1874.34	6183.56	8089.97
TOTAL AREA	444.76	5000.45	10990.16	16435.37
WORK TRIP ORIGINS	4487	212998	222628	440113
WORK TRIP DESTINATIONS	199263	216214	95814	511290
MEAN DIST-WORK BY ORIGIN	2.03	4.13	6.81	5.47
MEAN DIST-WORK BY DESTN.	6.44	6.48	6.24	6.42
PROPN. TRIPS INTRAZONAL	57.47	9.66	14.26	12.46
LILT BASE FORECAST FOR 1991				
AREA OF HOUSING	4.19	2005.07	4376.37	6885.63
SERVICE	214.46	410.94	1015.96	1641.36
NON-SERVICE	114.02	724.63	733.97	1572.61
UNDEVELOPED	112.09	1859.82	4363.86	6335.77
TOTAL AREA	444.76	5000.45	10990.16	16435.37
WORK TRIP ORIGINS	2340	163969	213879	380188
WORK TRIP DESTINATIONS	136564	214983	159871	511418
MEAN DIST-WORK BY ORIGIN	2.61	4.63	6.65	5.75
MEAN DIST-WORK BY DESTN.	7.45	7.59	7.39	7.49
PROPN. TRIPS INTRAZONAL	54.13	9.86	17.93	14.68
TOPAZ INITIAL SOLUTION (RUN A)				
AREA OF HOUSING	9.30	2635.69	4240.64	6885.63
SERVICE	172.67	735.86	732.83	1641.36
NON-SERVICE	199.32	696.07	677.22	1572.61
UNDEVELOPED	63.47	932.83	5339.47	6335.77
TOTAL AREA	444.76	5000.45	10990.16	16435.37
WORK TRIP ORIGINS	516	146192	233517	380224
WORK TRIP DESTINATIONS	43758	169469	166997	380224
MEAN DIST-WORK BY ORIGIN	2.78	3.63	4.42	4.11
MEAN DIST-WORK BY DESTN.	4.89	4.59	3.42	4.11
PROPN. TRIPS INTRAZONAL	0.30	0.13	0.30	0.24

TABLE 4.1 BASE YEAR VALUES, RESULTS FROM LILT BASE FORECAST AND RESULTS FROM INITIAL TOPAZ SOLUTION

generally shorter with TOPAZ82 which is consistent with a less decentralised pattern of activities than that forecast by LILT. The proportion of trips that are intrazonal is also greater.

5. Sensitivity Analysis

As was mentioned in Section 3, it was difficult to decide on appropriate values to use for certain items of data input to TOPAZ82. This applies particularly to the β-values used in the trip distribution submodel and the costs associated with establishing and removing activities. A series of model runs was therefore undertaken with different values for these and other items of data. The aims of this were to investigate the sensitivity of TOPAZ82 to variations in these inputs and to investigate if results more closely corresponding to those from LILT could be produced. The results presented include details of the amounts of each activity established and removed, in addition to overall activity levels. Although the results for trip numbers are given these are not discussed as they follow directly from the land use pattern.

Changes to the values of the β-parameters

Three additional model runs were undertaken, as follows:

RUN B : β-values set to one-tenth of those orginally calculated.

RUN C : β-values set to 100.0 (which are treated as infinite by the model and result in a minimum cost solution)

RUN D : β-values set to one half of those originally calculated.

The results from these runs together with those from the original run described in Section 4 (RUN A) are presented in Table 5.1.

	CENTRAL AREA	INNER SUBURBS	OUTER SUBURBS	CITY TOTAL
TOPAZ INITIAL SOLUTION (RUN A)				
AREA OF HOUSING	9.30	2635.69	4240.64	6885.63
SERVICE	172.67	735.86	732.83	1641.36
NON-SERVICE	199.32	696.07	677.22	1572.61
UNDEVELOPED	63.47	932.83	5339.47	6335.77
TOTAL AREA	444.76	5000.45	10990.16	16435.37
WORK TRIP ORIGINS	516	146192	233517	380224
WORK TRIP DESTINATIONS	43758	169469	166997	380224
MEAN DIST-WORK BY ORIGIN	2.78	3.63	4.42	4.11
MEAN DIST-WORK BY DESTN.	4.89	4.59	3.42	4.11
PROPN. TRIPS INTRAZONAL	0.30	0.13	0.30	0.24
NEWLY LOCATED HOUSING	2.70	664.39	583.04	1250.13
SERVICE	0.00	273.10	54.40	327.50
NON-SERVICE	0.00	51.59	251.07	302.66
NEWLY REMOVED HOUSING	0.00	0.00	0.00	0.00
SERVICE	15.83	4.44	16.97	37.24
NON-SERVICE	18.28	43.22	27.45	88.95
RUN B (BETAS/10.0)				
AREA OF HOUSING	9.30	2705.21	4171.12	6885.63
SERVICE	172.67	771.61	697.08	1641.36
NON-SERVICE	199.32	696.83	676.46	1572.61
UNDEVELOPED	63.47	826.80	5445.50	6335.77
TOTAL AREA	444.76	5000.45	10990.16	16435.37
WORK TRIP ORIGINS	514	149382	230329	380224
WORK TRIP DESTINATIONS	43758	174034	162432	380224
MEAN DIST-WORK BY ORIGIN	4.51	5.82	7.83	7.03
MEAN DIST-WORK BY DESTN.	5.68	6.67	7.79	7.03
PROPN. TRIPS INTRAZONAL	0.13	0.04	0.06	0.05
NEWLY LOCATED HOUSING	2.70	733.91	561.98	1298.59
SERVICE	0.00	311.07	51.41	362.47
NON-SERVICE	0.00	59.48	257.70	317.18
NEWLY REMOVED HOUSING	0.00	0.00	48.46	48.46
SERVICE	15.83	6.66	49.72	72.21
NON-SERVICE	18.28	50.35	34.84	103.47
RUN C (BETAS=100.0)				
AREA OF HOUSING	9.30	2585.68	4290.65	6885.63
SERVICE	174.16	444.96	1022.24	1641.36
NON-SERVICE	201.05	642.93	728.63	1572.61
UNDEVELOPED	60.24	1326.88	4948.64	6335.77
TOTAL AREA	444.76	5000.45	10990.16	16435.37
WORK TRIP ORIGINS	510	142744	236920	380174
WORK TRIP DESTINATIONS	44136	127078	208960	380174
MEAN DIST-WORK BY ORIGIN	0.80	1.65	1.62	1.63
MEAN DIST-WORK BY DESTN.	3.69	1.89	1.04	1.63
PROPN. TRIPS INTRAZONAL	1.00	0.53	0.83	0.72
NEWLY LOCATED HOUSING	2.70	614.38	633.05	1250.13
SERVICE	0.00	0.00	332.56	332.56
NON-SERVICE	0.00	0.00	294.66	294.66
NEWLY REMOVED HOUSING	0.00	0.00	0.00	0.00
SERVICE	14.34	22.24	5.73	42.30
NON-SERVICE	16.55	44.77	19.63	80.95

TABLE 5.1 RESULTS FROM TOPAZ RUNS A-D (CONTINUED OVER...)

	CENTRAL AREA	INNER SUBURBS	OUTER SUBURBS	CITY TOTAL
RUN D (BETAS/2.0)				
AREA OF HOUSING	9.30	2696.27	4180.06	6885.63
SERVICE	172.67	744.51	724.19	1641.36
NON-SERVICE	199.32	701.26	672.03	1572.61
UNDEVELOPED	63.47	858.41	5413.89	6335.77
TOTAL AREA	444.76	5000.45	10990.16	16435.37
WORK TRIP ORIGINS	514	149015	230695	380224
WORK TRIP DESTINATIONS	43758	171128	165338	380224
MEAN DIST-WORK BY ORIGIN	3.81	4.72	6.06	5.53
MEAN DIST-WORK BY DESTN.	5.34	5.63	5.49	5.53
PROPN. TRIPS INTRAZONAL	0.19	0.07	0.16	0.12
NEWLY LOCATED HOUSING	2.70	724.97	522.46	1250.13
SERVICE	0.00	281.75	59.22	340.97
NON-SERVICE	0.00	59.08	250.62	309.70
NEWLY REMOVED HOUSING	0.00	0.00	0.00	0.00
SERVICE	15.83	4.44	30.44	50.71
NON-SERVICE	18.28	45.51	32.20	95.99

TABLE 5.1 (...CONTINUED) RESULTS FROM TOPAZ RUNS A-D

These quite large changes in the values of the β-parameters do not have a great effect on the land use pattern. Lowering the values appears to result in progressively less decentralisation whereas the minimum cost solution (RUN C) causes more decentralisation. Interestingly, service industry appears to be the most sensitive of the three activities. This is also the case in results from the LILT model where the cost of travel is altered. However in LILT this effect is actually built in to the structure of the model. In TOPAZ82 it can result only from differences in the input data. The only differences between service and non-service industry are in the initial spatial distribution of activities, the additional total amount of each activity to be located (which for service industry is about 30% greater than for non-service industry) and the trip generation rates from housing to each sector (which are about 15% higher for service industry).

In contrast to the land-use pattern, mean travel distances vary substantially with changes in the β-parameters. As might be expected distances are greater with smaller β-values and shorter for higher values. With a value one-half of that originally estimated the overall mean distance travelled is quite similar to that forecast by LILT. These β-values were therefore used in all further runs of TOPAZ82.

Changes to the costs of activity establishment and removal

In order to investigate the effects of changing the values of the costs of establishing and removing activities, four runs of the model were undertaken, as follows:

RUN E : all costs divided by 10.0
RUN F : all costs multiplied by 10.0
RUN G : establishment costs in the outer suburbs divided by 2.0

RUN H : all costs multiplied by 10.0 except establishment costs in the outer suburbs which were multiplied by 5.0.

The results are presented in Table 5.2 together with those from run D for comparison.

The effect of the overall reduction in costs (run E) can be seen to have little effect on the land use or travel patterns. For housing and service industry slightly more activity is located in the inner suburbs at the expense of the outer suburbs, whereas for non-service industry the reverse is true. The decrease in costs causes small increases in the amounts of construction and demolition in the inner and outer suburbs. The land areas occupied by different uses in the central area are the same as in run D.

The effect of the ten-fold increase in costs (run F) is a little greater, with the results for each sector being the opposite to those just described. Central area activities remain at their base year levels, the increased cost of demolition presumably outweighing any savings in transport costs that could be made. This results in slightly longer mean travel distances. In fact the increase in costs is sufficient to result in no demolition of any activity in any zone.

In run G costs are set at the original levels of runs A to D, except in the outer suburbs where they are halved. This results in a little more housing being located in the outer suburbs but there is not much difference in the allocation of the other activities. The overall mean travel distance is a little greater.

However when the same differential is applied but with all costs increased by a factor of 10.0 (run H), all of the additional activity is located in the outer suburbs, and no demolition

	CENTRAL AREA	INNER SUBURBS	OUTER SUBURBS	CITY TOTAL
RUN D				
AREA OF HOUSING	9.30	2696.27	4180.06	6885.63
SERVICE	172.67	744.51	724.19	1641.36
NON-SERVICE	199.32	701.26	672.03	1572.61
UNDEVELOPED	63.47	858.41	5413.89	6335.77
TOTAL AREA	444.76	5000.45	10990.16	16435.37
WORK TRIP ORIGINS	514	149015	230695	380224
WORK TRIP DESTINATIONS	43758	171128	165338	380224
MEAN DIST-WORK BY ORIGIN	3.81	4.72	6.06	5.53
MEAN DIST-WORK BY DESTN.	5.34	5.63	5.49	5.53
PROPN. TRIPS INTRAZONAL	0.19	0.07	0.16	0.12
NEWLY LOCATED HOUSING	2.70	724.97	522.46	1250.13
SERVICE	0.00	281.75	59.22	340.97
NON-SERVICE	0.00	59.08	250.62	309.70
NEWLY REMOVED HOUSING	0.00	0.00	0.00	0.00
SERVICE	15.83	4.44	30.44	50.71
NON-SERVICE	18.28	45.51	32.20	95.99
RUN E (CONSTR. + DEMOL. COSTS/10.0)				
AREA OF HOUSING	9.30	2705.45	4170.88	6885.63
SERVICE	172.67	747.49	721.20	1641.36
NON-SERVICE	199.32	697.55	675.74	1572.61
UNDEVELOPED	63.47	849.96	5422.34	6335.77
TOTAL AREA	444.76	5000.45	10990.16	16435.37
WORK TRIP ORIGINS	514	149490	230221	380225
WORK TRIP DESTINATIONS	43758	171091	165375	380225
MEAN DIST-WORK BY ORIGIN	3.81	4.73	6.02	5.51
MEAN DIST-WORK BY DESTN.	5.33	5.60	5.47	5.51
PROPN. TRIPS INTRAZONAL	0.19	0.07	0.16	0.13
NEWLY LOCATED HOUSING	2.70	734.15	584.69	1321.54
SERVICE	0.00	290.77	74.39	365.16
NON-SERVICE	0.00	59.48	255.85	315.33
NEWLY REMOVED HOUSING	0.00	0.00	71.41	71.41
SERVICE	15.83	10.48	48.59	74.90
NON-SERVICE	18.28	49.63	33.72	101.62
RUN F (CONSTR. + DEMOL. COSTS * 10.0)				
AREA OF HOUSING	9.30	2623.64	4252.69	6885.63
SERVICE	188.50	701.48	751.38	1641.36
NON-SERVICE	217.60	708.96	646.05	1572.61
UNDEVELOPED	29.36	966.37	5340.04	6335.77
TOTAL AREA	444.76	5000.45	10990.16	16435.37
WORK TRIP ORIGINS	514	144916	234795	380225
WORK TRIP DESTINATIONS	47771	166589	165865	380225
MEAN DIST-WORK BY ORIGIN	3.78	4.74	6.14	5.61
MEAN DIST-WORK BY DESTN.	5.41	5.74	5.53	5.61
PROPN. TRIPS INTRAZONAL	0.20	0.07	0.16	0.12
NEWLY LOCATED HOUSING	2.70	652.34	595.09	1250.13
SERVICE	0.00	234.28	55.98	290.26
NON-SERVICE	0.00	21.26	192.45	213.71
NEWLY REMOVED HOUSING	0.00	0.00	0.00	0.00
SERVICE	0.00	0.00	0.00	0.00
NON-SERVICE	0.00	0.00	0.00	0.00

TABLE 5.2 RESULTS FROM TOPAZ RUNS D-H (CONTINUED OVER...)

	CENTRAL AREA	INNER SUBURBS	OUTER SUBURBS	CITY TOTAL
RUN G (CONSTR. COSTS/2.0 IN OS ONLY)				
AREA OF HOUSING	8.87	2548.80	4327.96	6885.63
SERVICE	172.67	753.40	715.30	1641.36
NON-SERVICE	199.32	690.75	682.54	1572.61
UNDEVELOPED	63.90	1007.49	5264.37	6335.77
TOTAL AREA	444.76	5000.45	10990.16	16435.37
WORK TRIP ORIGINS	490	140779	238956	380224
WORK TRIP DESTINATIONS	43758	171077	165389	380224
MEAN DIST-WORK BY ORIGIN	3.79	4.73	6.07	5.57
MEAN DIST-WORK BY DESTN.	5.42	5.71	5.47	5.57
PROPN. TRIPS INTRAZONAL	0.19	0.07	0.16	0.13
NEWLY LOCATED HOUSING	2.27	577.50	707.28	1287.05
SERVICE	0.00	290.64	60.21	350.84
NON-SERVICE	0.00	51.06	262.12	313.18
NEWLY REMOVED HOUSING	0.00	0.00	36.92	36.92
SERVICE	15.83	4.44	40.31	60.58
NON-SERVICE	18.28	48.00	33.19	99.47
RUN H (CONSTR.+DEMOL. COSTS *10.0 EXCEPT IN OS: CONSTR. COSTS*5.0)				
AREA OF HOUSING	6.60	1971.30	4907.73	6885.63
SERVICE	188.50	467.20	985.66	1641.36
NON-SERVICE	217.60	687.70	667.31	1572.61
UNDEVELOPED	32.06	1874.25	4429.46	6335.77
TOTAL AREA	444.76	5000.45	10990.16	16435.37
WORK TRIP ORIGINS	365	108893	270967	380225
WORK TRIP DESTINATIONS	47771	134864	197590	380225
MEAN DIST-WORK BY ORIGIN	3.95	5.01	5.95	5.68
MEAN DIST-WORK BY DESTN.	5.80	6.13	5.34	5.68
PROPN. TRIPS INTRAZONAL	0.22	0.05	0.18	0.14
NEWLY LOCATED HOUSING	0.00	0.00	1250.13	1250.13
SERVICE	0.00	0.00	290.26	290.26
NON-SERVICE	0.00	0.00	213.71	213.71
NEWLY REMOVED HOUSING	0.00	0.00	0.00	0.00
SERVICE	0.00	0.00	0.00	0.00
NON-SERVICE	0.00	0.00	0.00	0.00

TABLE 5.2 (...CONTINUED) RESULTS FROM TOPAZ RUNS D-H

occurs anywhere. The final distribution of activities is then very similar to that in the LILT base forecast, except that with TOPAZ82 the decline in central area non-service activities does not occur. The overall mean travel distance is greater than in run D and the other runs in which location costs are changed.

These experiments suggest that when the original data is used, the costs associated with activity location are small relative to those associated with transport. In fact the TOPAZ82 output gives a breakdown of those costs and shows that in run D the cost of establishing <u>and</u> removing activities accounts for only 5% of the total solution cost (as given by equation 10 in Section 2). In run F however this figure rises to about 34%.

Two further runs were undertaken to change the constraints on activity location or removal:

RUN I : the constraint that only 10% of existing activity in any zone could be demolished was removed, and

RUN J : constraints were applied to prevent the building of any new housing in the central area and to force the removal of 100 ha of non-service industry from that zone. These were introduced to replicate processes actually occurring in Leeds and represented in the LILT base run.

The results from these runs are shown in Table 5.3. Again the results from run D are presented for comparison.

The removal of the overall constraint on demolition results in a substantial increase in the amount of non-service industry and service industry that is demolished. Almost no housing is demolished however, as in run D. Much of the demolition of industrial activity occurs in the central area. This is interesting because when the constraint is in operation the 10% limit is not reached for either industrial activity. Despite the

	CENTRAL AREA	INNER SUBURBS	OUTER SUBURBS	CITY TOTAL
RUN D				
AREA OF HOUSING	9.30	2696.27	4180.06	6885.63
SERVICE	172.67	744.51	724.19	1641.36
NON-SERVICE	199.32	701.26	672.03	1572.61
UNDEVELOPED	63.47	858.41	5413.89	6335.77
TOTAL AREA	444.76	5000.45	10990.16	16435.37
WORK TRIP ORIGINS	514	149015	230695	380224
WORK TRIP DESTINATIONS	43758	171128	165338	380224
MEAN DIST-WORK BY ORIGIN	3.81	4.72	6.06	5.53
MEAN DIST-WORK BY DESTN.	5.34	5.63	5.49	5.53
PROPN. TRIPS INTRAZONAL	0.19	0.07	0.16	0.12
NEWLY LOCATED HOUSING	2.70	724.97	522.46	1250.13
SERVICE	0.00	281.75	59.22	340.97
NON-SERVICE	0.00	59.08	250.62	309.70
NEWLY REMOVED HOUSING	0.00	0.00	0.00	0.00
SERVICE	15.83	4.44	30.44	50.71
NON-SERVICE	18.28	45.51	32.20	95.99

RUN I (NO MAX. DEMOLITION RATE CONSTRAINT)

	CENTRAL AREA	INNER SUBURBS	OUTER SUBURBS	CITY TOTAL
AREA OF HOUSING	9.30	2578.22	4298.11	6885.63
SERVICE	114.91	747.90	778.55	1641.36
NON-SERVICE	132.65	751.41	688.55	1572.61
UNDEVELOPED	187.90	922.93	5224.94	6335.77
TOTAL AREA	444.76	5000.45	10990.16	16435.37
WORK TRIP ORIGINS	514	142407	237304	380224
WORK TRIP DESTINATIONS	29121	177117	173986	380224
MEAN DIST-WORK BY ORIGIN	4.01	4.81	5.94	5.52
MEAN DIST-WORK BY DESTN.	5.40	5.65	5.40	5.52
PROPN. TRIPS INTRAZONAL	0.13	0.08	0.17	0.13
NEWLY LOCATED HOUSING	2.70	607.03	640.51	1250.24
SERVICE	0.00	280.70	127.13	407.83
NON-SERVICE	0.00	204.24	325.01	529.25
NEWLY REMOVED HOUSING	0.00	0.11	0.00	0.11
SERVICE	73.59	0.00	43.98	117.57
NON-SERVICE	84.95	140.53	90.06	315.55

RUN J (CONSTRAINTS ON CA ACTIVITIES)

	CENTRAL AREA	INNER SUBURBS	OUTER SUBURBS	CITY TOTAL
AREA OF HOUSING	6.60	2694.47	4184.56	6885.63
SERVICE	172.67	741.93	726.77	1641.36
NON-SERVICE	117.60	706.30	748.71	1572.61
UNDEVELOPED	147.89	857.75	5330.13	6335.77
TOTAL AREA	444.76	5000.45	10990.16	16435.37
WORK TRIP ORIGINS	365	148933	230926	380224
WORK TRIP DESTINATIONS	34691	171364	174169	380224
MEAN DIST-WORK BY ORIGIN	3.97	4.79	5.98	5.51
MEAN DIST-WORK BY DESTN.	5.32	5.60	5.46	5.51
PROPN. TRIPS INTRAZONAL	0.15	0.07	0.17	0.13
NEWLY LOCATED HOUSING	0.00	723.17	526.96	1250.13
SERVICE	0.00	279.17	61.80	340.97
NON-SERVICE	0.00	63.18	327.31	390.49
NEWLY REMOVED HOUSING	0.00	0.00	0.00	0.00
SERVICE	15.83	4.44	30.44	50.71
NON-SERVICE	100.00	44.59	32.20	176.78

TABLE 5.3 RESULTS FROM TOPAZ RUNS D, I & J

large change in activity location there is only a very small drop in mean travel distance relative to run D. This again reflects the fact that overall travel costs tend to outweigh activity location costs considerably in these TOPAZ82 solutions.

The effect of applying the two constraints on central area activities (RUN J) is not very great. The non-service activity removed from the central zone appears to be relocated in the outer suburbs. There is a slight drop in mean distance travelled relative to run D.

In summary, reductions in the values of the β-parameters or of the activity location costs from those calculated as in Section 3 do not appear to have a great effect on the model solution. Mean distance travelled, however, is sensitive to the values of the β- parameter. When the values are increased to 100.0 to give a minimum cost solution, the result is the decentralisation of activities particularly industrial activities. A tenfold increase in activity location costs, results in no demolition of activities and net decentralisation. When the higher level of cost is applied but differentially between zones so that the values for the outer suburbs are half of those elsewhere, all new development occurs in the outer suburbs. This results in a pattern of activities similar to that produced in the LILT base forecast. As "costs" may in fact be defined as costs less benefits it may be possible to justify the differential in terms of the higher attractiveness of the outer suburban zones. It would however be very difficult to determine exactly what values should be used. In any case it should not be expected to achieve similar results from the two models and when such results are achieved it is still through very different mechanisms. In general, all of the TOPAZ82 solutions result in a more centralised pattern of activities than in the LILT forecast.

6. Policy Analysis

This section describes the results of applying some of the policy tests devised for the ISGLUTI study, using TOPAZ82 with Leeds data. The results are compared with those from the LILT model.

The base run for these tests was taken as run I from Section 5. This uses the data used to produce the original model run described in Section 4 (RUN A) with two exceptions. Firstly, the β-values were those from run D which gave a mean travel distance very similar to that obtained with LILT. Secondly, the constraint that permitted only 10% of any activity to be demolished in any zone was removed as it seemed better to produce a solution as unconstrained as possible unless there were very good reasons otherwise.

A comparison of this TOPAZ82 base solution and the base forecast from the LILT model is shown in Figure 6.1. All of the results in this section are presented in this format, which has also been adopted by ISGLUTI. The indicators plotted are:

(i) the change in the proportion of each activity located in each region of the city, i.e.:

$$\left[\left(\frac{ARxx^{a}}{ARxx^{CT}} \right)_{t20} - \left(\frac{ARxx^{a}}{ARxx^{CT}} \right)_{t0} \right] \times 100.0$$

where ARxx indicates the area occupied by activity xx, the superscript a indicates one of the regions of the city (central area, inner suburbs or outer suburbs), CT indicates the value for the whole city and t20 and t0 indicate the forecast year and base year respectively.

[This is different from the indicator used originally by ISGLUTI for comparing changes in land area. It actually corresponds to that used for comparing population and employment levels and enables centralisation / decentralisation trends to be identified easily. It also differs by comparing change over time (rather than between a base 'forecast' and policy 'forecast').]

(ii) the change in the mean trip distance to work (ADTL) relative to the base year value, i.e.:

$$\frac{ADTL^{a}_{t20} - ADTL^{a}_{t0}}{ADTL^{a}_{t0}} \times 100.0$$

The values of these indicators are plotted as horizontal bars for both models with T representing TOPAZ results and L, LILT results. The actual values are also printed out alongside each bar. When the change shown is for a policy (as in Figures 6.2 onwards) the corresponding change in the base forecast is shown by an asterisk (*).

Figure 6.1 shows that in the LILT base run, there is a net decentralisation of activities over time particularly from the inner to the outer suburbs, whereas this is not true with TOPAZ82 except for non-service industry. For housing and service industry there is an increase in the proportion located in the inner suburbs and a decrease in the outer suburbs. As the central area is relatively small and has little land available for development these trends can be interpreted as relative centralisation. The changes in travel distance to work are however in the same directions in all regions of the city in the results from the two models, although the magnitudes of the changes differ.

The results from the policy tests attempted are now described. As well as stating the ISGLUTI test specification and discussing the results, the way each test was interpreted is given for each model because the different model formulations often necessitate different implementations. Only nine of the 43 policies

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AREA OF HOUSING ACT.(PROPORTN)    002ARHS  0                       PERCENTAGE CHANGE
                                                                                             POL   BASE
        -20.0      -15.0      -10.0       -5.0        0.0        5.0       10.0       15.0       20.0
          +----------+----------+----------+----------+----------+----------+----------+----------+
CA   T                                                T                                               0.0    0.0
CA   L                                                L                                              -0.1   -0.1
          +----------+----------+----------+----------+----------+----------+----------+----------+
IS   T                                                TTTTTT                                          1.9    2.5
IS   L                                     LLLLLLLLLLLLL                                             -6.0   -5.9
          +----------+----------+----------+----------+----------+----------+----------+----------+
OS   T                                          TTTTTT                                               -1.9   -2.5
OS   L                                                LLLLLLLLLLLLL                                   6.1    5.9
          +----------+----------+----------+----------+----------+----------+----------+----------+
        -20.0      -15.0      -10.0       -5.0        0.0        5.0       10.0       15.0       20.0

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SERVICE ACT.(PROP)                002ASRT  0                       PERCENTAGE CHANGE
                                                                                             POL   BASE
        -20.0      -15.0      -10.0       -5.0        0.0        5.0       10.0       15.0       20.0
          +----------+----------+----------+----------+----------+----------+----------+----------+
CA   T                                TTTTTTTTTTTTTTTT                                               -5.8   -6.9
CA   L                                             LLL                                               -0.4   -0.9
          +----------+----------+----------+----------+----------+----------+----------+----------+
IS   T                                                TTTTTTTTTTTTTTTTTTTTTTTTT                       9.7   11.0
IS   L                             LLLLLLLLLLLLLLLLLLLLL                                             -8.6   -9.5
          +----------+----------+----------+----------+----------+----------+----------+----------+
OS   T                                         TTTTTTTTT                                             -4.0   -4.0
OS   L                                                LLLLLLLLLLLLLLLLLLLLLLLL                        9.0   10.4
          +----------+----------+----------+----------+----------+----------+----------+----------+
        -20.0      -15.0      -10.0       -5.0        0.0        5.0       10.0       15.0       20.0

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NON SERVICE ACT.                  002ASNS  0                       PERCENTAGE CHANGE
                                                                                             POL   BASE
        -20.0      -15.0      -10.0       -5.0        0.0        5.0       10.0       15.0       20.0
          +----------+----------+----------+----------+----------+----------+----------+----------+
CA   T                               TTTTTTTTTTTTTTTTT                                               -8.9   -7.6
CA   L                            LLLLLLLLLLLLLLLLLLLL                                               -8.8   -8.8
          +----------+----------+----------+----------+----------+----------+----------+----------+
IS   T                                       TTTTTTT                                                 -0.7   -2.8
IS   L                                    LLLLLLLLLL                                                 -4.5   -4.5
          +----------+----------+----------+----------+----------+----------+----------+----------+
OS   T                                                TTTTTTTTTTTTTTTTTTTTTTTT                        9.6   10.4
OS   L                                                LLLLLLLLLLLLLLLLLLLLLLLLLLLLLL                 13.3   13.3
          +----------+----------+----------+----------+----------+----------+----------+----------+
        -20.0      -15.0      -10.0       -5.0        0.0        5.0       10.0       15.0       20.0

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DIST. PER TRIP  -WORK             002ADWT  0                       PERCENTAGE CHANGE
                                                                                             POL   BASE
        -20.0      -15.0      -10.0       -5.0        0.0        5.0       10.0       15.0       20.0
          +----------+----------+----------+----------+----------+----------+----------+----------+
CA   T                                                TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT  96.4   97.9
CA   L                                                LLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLL  29.1   28.8
          +----------+----------+----------+----------+----------+----------+----------+----------+
IS   T                                                TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT          16.2   16.4
IS   L                                                LLLLLLLLLLLLLLLLLLLLLLLLLLL                    12.2   12.1
          +----------+----------+----------+----------+----------+----------+----------+----------+
OS   T                   TTTTTTTTTTTTTTTTTTTTTTTTTTTTT                                              -12.7  -12.8
OS   L                                          LLLLLL                                               -2.6   -2.4
          +----------+----------+----------+----------+----------+----------+----------+----------+
CT   T                                                TTT                                             1.2    1.0
CT   L                                                LLLLLLLLLLLLL                                   5.2    5.3
          +----------+----------+----------+----------+----------+----------+----------+----------+
        -20.0      -15.0      -10.0       -5.0        0.0        5.0       10.0       15.0       20.0

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FIGURE 6.1 COMPARISON OF TOPAZ82 AND LILT BASE RUNS specified by ISGLUTI have been attempted with TOPAZ82. The other policies generally are intended to affect social groups or transport modes differentially. Different modes are not represented in TOPAZ82 at present, and although different social groups could have been included as separate activities this was not done. The numbering of the policies follows that specified by ISGLUTI. The results from the TOPAZ82 runs are given in the format of tables 5.1 to 5.3 in the Appendix.

Policy 10 - Rapid Population Growth

ISGLUTI specification

Population in the urban area grows at 2% p.a. while the demographic characteristics remain unchanged as far as possible: thus, the distribution of population across socio-economic, income and car ownership groups stays in the same proportion as in the base forecast. Employment grows in proportion to population, and the capacity of road and transit networks increases in proportion to the increased travel. Trends in land use policies and conditions continue as in the base forecast.

Interpretation for TOPAZ82

The total planned level of each activity (the A_i value) is increased by a factor of $(1.02)^{20}$.

Interpretation for LILT

The total population in each social group and total employment in each industrial sector are set, at each of the four forecast time points, to levels corresponding to a 2% p.a. growth rate. An additional amount of new housing is specified for each time period to accommodate the increased population at base year occupancy rates. No changes are made to capacities on the road network.

Results

The results are shown in Figure 6.2. In the TOPAZ82 results there is quite considerable decentralisation of activities relative to the base solution. In fact the change in the housing pattern is now very similar to that forecast by LILT. In general the changes in the land-use pattern relative to the base are much greater than with LILT. This is because in the LILT model densities are adjusted endogenously and an increased amount of activity can be located in the same land area. With TOPAZ82 this does not occur, the capacity of the inner suburbs is reached and a large amount of land in the outer suburbs which was undeveloped in the base is now occupied by one of the three activities. There is less effect however on the change in mean distance travelled to work with TOPAZ82 than with LILT.

Policy 11 - Rapid Population Growth with land use restrictions

ISGLUTI specification

As policy 10 except that restrictions are imposed on land use development on the fringes of the urban area so that, as far as practicable, land-use changes arise through redevelopment of existing areas and infilling.

Interpretation for TOPAZ82

As for policy 10, but the costs of development in the outer suburbs alone are increased by a factor of 10.0. (As almost all available land was used up in policy 10, any constraints on development in the outer suburbs would have resulted in an infeasible problem. The only other way of interpreting this policy would be to reduce the total areas of activity to be allocated relative to policy 10, thereby implicitly increasing density, and increase trip rates in compensation.)

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AREA OF HOUSING ACT.(PROPORTN)      102ARHS  0                                PERCENTAGE CHANGE
                                                                                                    POL   BASE
            -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0
              +---------+---------+---------+---------+---------+---------+---------+---------+
    CA   T                                            *                                               0.2    0.0
    CA   L                                            *                                              -0.1   -0.1
              +---------+---------+---------+---------+---------+---------+---------+---------+
    IS   T                                  TTTTTTTTTT     *                                         -5.1    2.5
    IS   L                                *LLLLLLLLLLL                                               -6.0   -5.9
              +---------+---------+---------+---------+---------+---------+---------+---------+
    OS   T                                 *    TTTTTTTTTT                                            4.9   -2.5
    OS   L                                      LLLLLLLLLLL*                                          6.1    5.9
              +---------+---------+---------+---------+---------+---------+---------+---------+
            -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0

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        SERVICE ACT.(PROP)          102ARRT  0                                PERCENTAGE CHANGE
                                                                                                    POL   BASE
            -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0
              +---------+---------+---------+---------+---------+---------+---------+---------+
    CA   T                                *TTTTTTTTTTTTT                                             -6.4   -6.9
    CA   L                                            * LLLLLLLLL                                     4.7   -0.9
    IS   T                                      TTTTTTTTTTTT          *                               6.0   11.0
    IS   L                           *    LLLLLLLLLLLLLL                                             -6.9   -9.5
              +---------+---------+---------+---------+---------+---------+---------+---------+
    OS   T                                      *       TT                                            0.5   -4.0
    OS   L                                      LLLLL                *                                2.2   10.4
              +---------+---------+---------+---------+---------+---------+---------+---------+
            -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0

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        NON SERVICE ACT.            102ARNS  0                                PERCENTAGE CHANGE
                                                                                                    POL   BASE
            -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0
              +---------+---------+---------+---------+---------+---------+---------+---------+
    CA   T                              T*TTTTTTTTTTTTTT                                             -7.9   -7.6
    CA   L                            * LLLLLLLLLLLLLLLL                                             -8.1   -8.8
              +---------+---------+---------+---------+---------+---------+---------+---------+
    IS   T                         TTTTTTTTTTTTTTT*TTTTT                                            -10.4   -2.8
    IS   L                                     *    LLLL                                             -1.6   -4.5
              +---------+---------+---------+---------+---------+---------+---------+---------+
    OS   T                                      TTTTTTTTTTTTTTTTTTTT*TTTTTTTTTTTTTTT                 18.3   10.4
    OS   L                                      LLLLLLLLLLLLLLLLLLL        *                          9.6   13.3
              +---------+---------+---------+---------+---------+---------+---------+---------+
            -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0

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DIST. PER TRIP  -WORK               102ADWT  0                                PERCENTAGE CHANGE
                                                                                                    POL   BASE
            -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0
              +---------+---------+---------+---------+---------+---------+---------+---------+
    CA   T                                      TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT*   107.3   97.9
    CA   L                                      LLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLL*    34.2   28.8
              +---------+---------+---------+---------+---------+---------+---------+---------+
    IS   T                                      TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT*TTTTTTT     19.8   16.4
    IS   L                                      LLLLLLLLLLLLLLL         *                     7.7   12.1
              +---------+---------+---------+---------+---------+---------+---------+---------+
    OS   T              TTTT*TTTTTTTTTTTTTTTTTTTTTTTTT                                      -15.2  -12.8
    OS   L                                  LLLLLL*LLLLL                                     -5.4   -2.4
              +---------+---------+---------+---------+---------+---------+---------+---------+
    CT   T                                      TT*                                           1.2    1.0
    CT   L                                      LLLLLLLL   *                                  3.8    5.3
              +---------+---------+---------+---------+---------+---------+---------+---------+
            -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0

==============================================================================================================
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FIGURE 6.2   RESULTS FROM POLICY 10   (RAPID POPULATION GROWTH)

Interpretation for LILT

As policy 10 but land use restrictions are applied by exogenously specifying that for each outer suburban zone extra land is held off the market for the forecast years in an amount equal to the vacant land in that zone in the base year. In addition the amount of land released for housing over the study area as a whole is reduced from 500 ha per 5 year period to 250 ha.

Results

The results are shown in Figure 6.3 in which the base figures refer to Policy 10. In general, this policy results in less decentralisation or more centralisation of activities with both models. The exception is for non-service industry in the TOPAZ82 solution which decentralises more than in policy 10. In general the differences in the effect of the policy are greater in the results from LILT. This is again because densities are allowed to adjust in this model. In TOPAZ82 a fixed area of land is allocated to each activity and, because of zonal capacity constraints, much of the additional development is forced to occur in the outer suburbs regardless of the increased cost. The overall mean travel distance increases less with LILT but is little changed with TOPAZ82 which reflects the land use effects discussed above.

Policy 20 - Decentralisation of non-service employment

ISGLUTI specification

50 per cent of non-service jobs are removed from the inner zones and redistributed pro-rata across all other zones.

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==========================================================================================================

AREA OF HOUSING ACT.(PROPORTN)      112ABHS  0                                  PERCENTAGE CHANGE
                                                                                                      POL   BASE
          -20.0     -15.0     -10.0     -5.0      0.0       5.0      10.0      15.0      20.0
             +---------+---------+---------+---------+---------+---------+---------+---------+
   CA   T                                            *                                               0.1    0.2
   CA   L                                            *                                              -0.1   -0.1
             +---------+---------+---------+---------+---------+---------+---------+---------+
   IS   T                                 * TTTTTTTTT                                               -4.2   -5.1
   IS   L                               *       LLLLLL                                              -2.6   -6.0
             +---------+---------+---------+---------+---------+---------+---------+---------+
   OS   T                                            TTTTTTTTT *                                     4.1    4.9
   OS   L                                            LLLLLL      *                                   2.6    6.1
             +---------+---------+---------+---------+---------+---------+---------+---------+
          -20.0     -15.0     -10.0     -5.0      0.0       5.0      10.0      15.0      20.0

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        SERVICE ACT.(PROP)          112ABRT  0                                  PERCENTAGE CHANGE
                                                                                                      POL   BASE
          -20.0     -15.0     -10.0     -5.0      0.0       5.0      10.0      15.0      20.0
             +---------+---------+---------+---------+---------+---------+---------+---------+
   CA   T                               *  TTTTTTTTTTT                                              -5.1   -6.4
   CA   L                                            LLLLLLLLL*LLLLLLLLLLLLLLLLLLLLLLLLLLLLLLL      22.1    4.7
             +---------+---------+---------+---------+---------+---------+---------+---------+
   IS   T                                            TTTTTTTTTTTT*TT                                 7.1    6.0
   IS   L                              *             LLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLL              15.9   -6.9
             +---------+---------+---------+---------+---------+---------+---------+---------+
   OS   T                                        TTTTT*                                             -2.0    0.5
   OS   L    LLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLL   *                                         -38.0    2.2
             +---------+---------+---------+---------+---------+---------+---------+---------+
          -20.0     -15.0     -10.0     -5.0      0.0       5.0      10.0      15.0      20.0

==========================================================================================================

        NON SERVICE ACT.            112ABNS  0                                  PERCENTAGE CHANGE
                                                                                                      POL   BASE
          -20.0     -15.0     -10.0     -5.0      0.0       5.0      10.0      15.0      20.0
             +---------+---------+---------+---------+---------+---------+---------+---------+
   CA   T                          *TTTTTTTTTTTTTTTTT                                               -7.6   -7.9
   CA   L                          *LLLLLLLLLLLLLLLLL                                               -7.6   -8.1
             +---------+---------+---------+---------+---------+---------+---------+---------+
   IS   T                TTTTTTT*TTTTTTTTTTTTTTTTTTTTTT                                            -14.0  -10.4
   IS   L                                          *  LLL                                            1.2   -1.6
             +---------+---------+---------+---------+---------+---------+---------+---------+
   OS   T                                            TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT*TTT  21.6   18.3
   OS   L                                            LLLLLLLLLLLLL      *                            6.3    9.6
             +---------+---------+---------+---------+---------+---------+---------+---------+
          -20.0     -15.0     -10.0     -5.0      0.0       5.0      10.0      15.0      20.0

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DIST. PER TRIP  -WORK               112ADWT  0                                  PERCENTAGE CHANGE
                                                                                                      POL   BASE
          -20.0     -15.0     -10.0     -5.0      0.0       5.0      10.0      15.0      20.0
             +---------+---------+---------+---------+---------+---------+---------+---------+
   CA   T                                            TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT*  104.8  107.3
   CA   L                                            LLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLL*   33.3   34.2
             +---------+---------+---------+---------+---------+---------+---------+---------+
   IS   T                                            TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT*   20.3   19.8
   IS   L                                            LLLLLLLLLLLL  *                                 5.9    7.7
             +---------+---------+---------+---------+---------+---------+---------+---------+
   OS   T              *TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT                                            -14.9  -15.2
   OS   L                                * LLLLLLLLLL                                               -4.6   -5.4
             +---------+---------+---------+---------+---------+---------+---------+---------+
   CT   T                                            TT*T                                            1.3    1.2
   CT   L                                            LLLLLL  *                                       2.7    3.8
             +---------+---------+---------+---------+---------+---------+---------+---------+
          -20.0     -15.0     -10.0     -5.0      0.0       5.0      10.0      15.0      20.0

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FIGURE 6.3   RESULTS FROM POLICY 11   (RAPID POPULATION GROWTH WITH LAND USE RESTRICTIONS)

Interpretation for TOPAZ82

The inner zones are taken to be the Central Area and the inner suburban zones. Constraints are imposed so that the land area occupied by the non-service activities is halved in each of these zones.

Interpretation for LILT

All zonal employment levels in the non-service sectors are specified exogenously in 1976. In the inner zones employment in each sector is set to one half of the base run level. The reduction in the total employment in each sector from these zones is redistributed among the remaining (outer suburban) zones in proportion to their 1976 employment in that sector. All non-service employment is located endogenously in the remaining forecast years.

Results (Figure 6.5)

The results from the application of this policy are shown in Figure 6.4. Clearly, the results for non service activity are similar from both models and are a direct result of the application of the policy. For both other activities there is either less decentralisation or more centralisation in the results from both models. In other words there is a net movement inwards and away from the newly decentralised non-service activity. There is a net drop in mean distance travelled overall and for residents of the outer suburbs, but a net increase for inner suburban and central area residents.

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AREA OF HOUSING ACT.(PROPORTN)      202ARHS  0                          PERCENTAGE CHANGE
                                                                                                POL   BASE
            -20.0      -15.0      -10.0      -5.0       0.0       5.0      10.0      15.0      20.0
               +----------+----------+----------+----------+----------+----------+----------+----------+
    CA   T                                                 *TTT                                         1.6   0.0
    CA   L                                                 *                                           -0.1  -0.1
               +----------+----------+----------+----------+----------+----------+----------+----------+
    IS   T                                                 TTTTT*TTTTTT                                 5.6   2.5
    IS   L                                      *LLLLLLLLLLL                                           -5.3  -5.9
               +----------+----------+----------+----------+----------+----------+----------+----------+
    OS   T                                    TTTTTTTTT*TTTTT                                          -7.2  -2.5
    OS   L                                                 LLLLLLLLLLL*                                 5.4   5.9
               +----------+----------+----------+----------+----------+----------+----------+----------+
            -20.0      -15.0      -10.0      -5.0       0.0       5.0      10.0      15.0      20.0

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        SERVICE ACT.(PPOP)          202ARPT  0                          PERCENTAGE CHANGE
                                                                                                POL   BASE
            -20.0      -15.0      -10.0      -5.0       0.0       5.0      10.0      15.0      20.0
               +----------+----------+----------+----------+----------+----------+----------+----------+
    CA   T                                   T*TTTTTTTTTTTTTT                                          -7.3  -6.9
    CA   L                                               * LLLLLL                                       2.7  -0.9
               +----------+----------+----------+----------+----------+----------+----------+----------+
    IS   T                                                 TTTTTTTTTTTTTTTTTTTTTT*TTTTTTTTTTTTTT       17.8  11.0
    IS   L                            *                    LLLLLL                                       3.1  -9.5
               +----------+----------+----------+----------+----------+----------+----------+----------+
    OS   T                              TTTTTTTTTTTTT*TTTTTTTT                                        -10.5  -4.0
    OS   L                                      LLLLLLLLLLLL                  *                        -5.8  10.4
               +----------+----------+----------+----------+----------+----------+----------+----------+
            -20.0      -15.0      -10.0      -5.0       0.0       5.0      10.0      15.0      20.0

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        NON SERVICE ACT.            202ARNS  0                          PERCENTAGE CHANGE
                                                                                                POL   BASE
            -20.0      -15.0      -10.0      -5.0       0.0       5.0      10.0      15.0      20.0
               +----------+----------+----------+----------+----------+----------+----------+----------+
    CA   T                                 TTT*TTTTTTTTTTTTTTT                                         -9.1  -7.6
    CA   L                            LLLLLL*LLLLLLLLLLLLLLLL                                         -11.9  -8.8
               +----------+----------+----------+----------+----------+----------+----------+----------+
    IS   T     TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT*TTTTTT                                          -28.7  -2.8
    IS   L     LLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLL*LLLLLLLL                                            -22.9  -4.5
               +----------+----------+----------+----------+----------+----------+----------+----------+
    OS   T                                                 TTTTTTTTTTTTTTTTTTTTT*TTTTTTTTTTTTTTTTTT    37.8  10.4
    OS   L                                                 LLLLLLLLLLLLLLLLLLLLLLLLLLL*LLLLLLLLLLL     34.8  13.3
               +----------+----------+----------+----------+----------+----------+----------+----------+
            -20.0      -15.0      -10.0      -5.0       0.0       5.0      10.0      15.0      20.0

======================================================================================================

   DIST. PER TRIP  -WORK            202AIWT  0                          PERCENTAGE CHANGE
                                                                                                POL   BASE
            -20.0      -15.0      -10.0      -5.0       0.0       5.0      10.0      15.0      20.0
               +----------+----------+----------+----------+----------+----------+----------+----------+
    CA   T                                                 TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT* 119.1  97.9
    CA   L                                                 LLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLL*  44.5  28.8
               +----------+----------+----------+----------+----------+----------+----------+----------+
    IS   T                                                 TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT*TTTTTTTT   23.4  16.4
    IS   L                                                 LLLLLLLLLLLLLLLLLLLLLLL*LLLLLLLLLLLL        19.1  12.1
               +----------+----------+----------+----------+----------+----------+----------+----------+
    OS   T                TTTTTTT*TTTTTTTTTTTTTTTTTTTTTTTTTTT                                         -16.3 -12.8
    OS   L                                    LLLLLLLLL*LLLLL                                          -7.0  -2.4
               +----------+----------+----------+----------+----------+----------+----------+----------+
    CT   T                                                TT *                                         -0.7   1.0
    CT   L                                                 LLLLLLLLL  *                                 4.1   5.3
               +----------+----------+----------+----------+----------+----------+----------+----------+
            -20.0      -15.0      -10.0      -5.0       0.0       5.0      10.0      15.0      20.0

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FIGURE 6.4   RESULTS FROM POLICY 20   (DECENTRALISATION OF NON-SERVICE EMPLOYMENT)

Policy 21 - The development of a suburban industrial estate

ISGLUTI specification

Redistribute 50 per cent of the central-area employment facilities into a single industrial estate situated on the periphery of the urban area.

Interpretation for TOPAZ82

Constraints are imposed so that the land area occupied by non-service industry in the central area is halved and increased by at least an equivalent amount in zone 28 on the periphery of the study area.

Interpretation for LILT

Non-service employment in 1976 is set to one half of the base run level in the central area. The total employment lost is all exogenously located in zone 28. All non-service employment is again located endogenously in the remaining forecast years.

Results (Figure 6.5)

As this policy involves a relocation of central area employment only, the effects are much smaller with both models. Again the effect on non-service industry is largely a direct result of the policy. There is no effect on the distribution of housing in the LILT forecast but increased centralisation with TOPAZ82, the land vacated by non-service industry in the central area being occupied by housing (as is the case with Policy 20). Retailing activity decentralises less with LILT than in the base run, whereas with TOPAZ82 there appears to be a net shift from the central area to the inner suburbs. There is a net increase in travel distances with TOPAZ82 but little change with LILT.

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AREA OF HOUSING ACT.(PROPORTN)  212ARHS  0                                 PERCENTAGE CHANGE
                                                                                                POL  BASE
          -20.0     -15.0     -10.0     -5.0       0.0       5.0      10.0      15.0      20.0
            +---------+---------+---------+---------+---------+---------+---------+---------+
 CA   T                                             *TTT                                        1.6   0.0
 CA   L                                             *                                          -0.1  -0.1
            +---------+---------+---------+---------+---------+---------+---------+---------+
 IS   T                                             TTTTT*                                      1.9   2.5
 IS   L                                 *LLLLLLLLLLLL                                          -5.9  -5.9
            +---------+---------+---------+---------+---------+---------+---------+---------+
 OS   T                                     TT*TTTTT                                           -3.5  -2.5
 OS   L                                             LLLLLLLLLLLL*                               5.9   5.9
            +---------+---------+---------+---------+---------+---------+---------+---------+
          -20.0     -15.0     -10.0     -5.0       0.0       5.0      10.0      15.0      20.0

========================================================================================================

     SERVICE ACT.(PROP)         212ARRT  0                                 PERCENTAGE CHANGE
                                                                                                POL  BASE
          -20.0     -15.0     -10.0     -5.0       0.0       5.0      10.0      15.0      20.0
            +---------+---------+---------+---------+---------+---------+---------+---------+
 CA   T                                 TT*TTTTTTTTTTTTTT                                      -8.1  -6.9
 CA   L                                           * L                                           0.1  -0.9
            +---------+---------+---------+---------+---------+---------+---------+---------+
 IS   T                                             TTTTTTTTTTTTTTTTTTTTTT*TT                  12.1  11.0
 IS   L                          *   LLLLLLLLLLLLLLLL                                          -7.5  -9.5
            +---------+---------+---------+---------+---------+---------+---------+---------+
 OS   T                                     *TTTTTTTT                                          -4.0  -4.0
 OS   L                                             LLLLLLLLLLLLLLL      *                      7.4  10.4
            +---------+---------+---------+---------+---------+---------+---------+---------+
          -20.0     -15.0     -10.0     -5.0       0.0       5.0      10.0      15.0      20.0

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     NON SERVICE ACT.           212ARNS  0                                 PERCENTAGE CHANGE
                                                                                                POL  BASE
          -20.0     -15.0     -10.0     -5.0       0.0       5.0      10.0      15.0      20.0
            +---------+---------+---------+---------+---------+---------+---------+---------+
 CA   T                          TTTT*TTTTTTTTTTTTTTT                                          -9.7  -7.6
 CA   L                      LLLLL*LLLLLLLLLLLLLLLLLL                                         -11.6  -8.8
            +---------+---------+---------+---------+---------+---------+---------+---------+
 IS   T                                      T*TTTTTT                                          -3.7  -2.8
 IS   L                                    *LLLLLLLLL                                          -4.5  -4.5
            +---------+---------+---------+---------+---------+---------+---------+---------+
 OS   T                                             TTTTTTTTTTTTTTTTTTTTT*TTTTTT               13.4  10.4
 OS   L                                             LLLLLLLLLLLLLLLLLLLLLLLLLLL*LLLLL          16.2  13.3
            +---------+---------+---------+---------+---------+---------+---------+---------+
          -20.0     -15.0     -10.0     -5.0       0.0       5.0      10.0      15.0      20.0

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DIST. PER TRIP  -WORK           212AIWT  0                                 PERCENTAGE CHANGE
                                                                                                POL  BASE
          -20.0     -15.0     -10.0     -5.0       0.0       5.0      10.0      15.0      20.0
            +---------+---------+---------+---------+---------+---------+---------+---------+
 CA   T                                             TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT* 102.3  97.9
 CA   L                                             LLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLL*  35.1  28.8
            +---------+---------+---------+---------+---------+---------+---------+---------+
 IS   T                                             TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT*         16.4  16.4
 IS   L                                             LLLLLLLLLLLLLLLLLLLLLLLL*LL                13.0  12.1
            +---------+---------+---------+---------+---------+---------+---------+---------+
 OS   T                           *     TTTTTTTTTTTTTTTTTTTTT                                 -10.2 -12.8
 OS   L                                       L*LLLLL                                          -2.9  -2.4
            +---------+---------+---------+---------+---------+---------+---------+---------+
 CT   T                                             TT*TTT                                      2.4   1.0
 CT   L                                             LLLLLLLLLLL*                                5.2   5.3
            +---------+---------+---------+---------+---------+---------+---------+---------+
          -20.0     -15.0     -10.0     -5.0       0.0       5.0      10.0      15.0      20.0

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FIGURE 6.5   RESULTS FROM POLICY 21   (DEVELOPMENT OF A SUBURBAN INDUSTRIAL ESTATE)

Policy 36 - Increasing the cost of travel by 50%

ISGLUTI specification

For all mechanised modes increase the monetary cost of travel per unit distance (i.e. the monetary component of the perceived or behavioural costs which govern location and mode choice - fares in the case of public transport) by 50%.

Interpretation for TOPAZ82

The unit costs of interaction for home to non-service and home to service industries are increased by 50%. (Other trip purposes have not been considered.)

Interpretation for LILT

The perceived operating cost per unit distance for private transport and public transport fares in each forecast year are set 50% higher than in the base forecast. Both the distance and boarding elements of public transport fares are increased.

Results (Figure 6.6)

With TOPAZ82 there is slightly less decline in the proportion of housing and service activity located in the outer suburbs and a greater increase in the proportion of non-service industry located there. The overall effect might therefore be described as decentralisation of land using activities relative to the base solution. With LILT there is slightly less decentralisation of housing and more decentralisation of service activity with no effect on non-service industry. There is a net decrease in travel distances in the results from both models, the greatest effect being with TOPAZ82. This can be explained by the fact that the travel deterrence function used in the trip distribution submodel contains monetary cost alone whereas in LILT there are

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AREA OF HOUSING ACT.(PROPORTN)     362ARHS  0                                    PERCENTAGE CHANGE
                                                                                                     POL   BASE
              -20.0      -15.0      -10.0      -5.0       0.0        5.0       10.0       15.0      20.0
                 +----------+----------+----------+----------+----------+----------+----------+----------+
    CA    T                                                  *                                              0.0    0.0
    CA    L                                                  *                                             -0.1   -0.1
                 +----------+----------+----------+----------+----------+----------+----------+----------+
    IS    T                                                  TTTTT*                                         2.1    2.5
    IS    L                                      *LLLLLLLLLLL                                              -5.7   -5.9
                 +----------+----------+----------+----------+----------+----------+----------+----------+
    OS    T                                             *TTTTT                                             -2.1   -2.5
    OS    L                                                  LLLLLLLLLLL*                                   5.8    5.9
                 +----------+----------+----------+----------+----------+----------+----------+----------+
              -20.0      -15.0      -10.0      -5.0       0.0        5.0       10.0       15.0      20.0

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        SERVICE ACT.(PROP)         362ARRT  0                                    PERCENTAGE CHANGE
                                                                                                     POL   BASE
              -20.0      -15.0      -10.0      -5.0       0.0        5.0       10.0       15.0      20.0
                 +----------+----------+----------+----------+----------+----------+----------+----------+
    CA    T                                     * TTTTTTTTTTTT                                             -5.8   -6.9
    CA    L                                                L*LL                                            -1.6   -0.9
                 +----------+----------+----------+----------+----------+----------+----------+----------+
    IS    T                                                  TTTTTTTTTTTTTTTTTTT   *                        9.2   11.0
    IS    L                          LL*LLLLLLLLLLLLLLLLL                                                 -10.4   -9.5
                 +----------+----------+----------+----------+----------+----------+----------+----------+
    OS    T                                          *TTTTTTTT                                             -3.4   -4.0
    OS    L                                                  LLLLLLLLLLLLLLLLLLLL*LLL                      12.0   10.4
                 +----------+----------+----------+----------+----------+----------+----------+----------+
              -20.0      -15.0      -10.0      -5.0       0.0        5.0       10.0       15.0      20.0

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        NON SERVICE ACT.           362ARNS  0                                    PERCENTAGE CHANGE
                                                                                                     POL   BASE
              -20.0      -15.0      -10.0      -5.0       0.0        5.0       10.0       15.0      20.0
                 +----------+----------+----------+----------+----------+----------+----------+----------+
    CA    T                              TTT*TTTTTTTTTTTTTTT                                               -8.9   -7.6
    CA    L                              *LLLLLLLLLLLLLLLLLL                                               -8.8   -8.8
                 +----------+----------+----------+----------+----------+----------+----------+----------+
    IS    T                                            *TTTTTT                                             -2.7   -2.8
    IS    L                                         *LLLLLLLL                                              -4.5   -4.5
                 +----------+----------+----------+----------+----------+----------+----------+----------+
    OS    T                                                  TTTTTTTTTTTTTTTTTTTTTTT*TT                    11.6   10.4
    OS    L                                                  LLLLLLLLLLLLLLLLLLLLLLLLLLL*                  13.3   13.3
                 +----------+----------+----------+----------+----------+----------+----------+----------+
              -20.0      -15.0      -10.0      -5.0       0.0        5.0       10.0       15.0      20.0

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DIST. PER TRIP  -WORK              362AIWT  0                                    PERCENTAGE CHANGE
                                                                                                     POL   BASE
              -20.0      -15.0      -10.0      -5.0       0.0        5.0       10.0       15.0      20.0
                 +----------+----------+----------+----------+----------+----------+----------+----------+
    CA    T                                                  TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT*    70.3   97.9
    CA    L                                                  LLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLL*    23.8   28.8
                 +----------+----------+----------+----------+----------+----------+----------+----------+
    IS    T                                                  TTT                             *              0.9   16.4
    IS    L                                                  LLLLLLLLL              *                       4.6   12.1
                 +----------+----------+----------+----------+----------+----------+----------+----------+
    OS    T      TTTTTTTTTTTTTT*TTTTTTTTTTTTTTTTTTTTTTTTTTTT                                              -28.1  -12.8
    OS    L                          LLLLLLLLLLLLLLLLL*LLLLL                                              -10.5   -2.4
                 +----------+----------+----------+----------+----------+----------+----------+----------+
    CT    T               TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT *                                            -15.3    1.0
    CT    L                                            LLLLLLL          *                                  -2.9    5.3
                 +----------+----------+----------+----------+----------+----------+----------+----------+
              -20.0      -15.0      -10.0      -5.0       0.0        5.0       10.0       15.0      20.0

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FIGURE 6.6   RESULTS FROM POLICY 36   (INCREASING THE COST OF TRAVEL BY 50%)

time components which are unaffected by this policy and therefore dampen its effects.

Policy 37 - Doubling the cost of travel

ISGLUTI specification

As policy 36, but costs are increased by 100%.

Interpretations for TOPAZ82 and LILT

As for policy 36, but costs are increased by 100%.

Results (Figure 6.7)

With TOPAZ82 the effects on the distribution of retail and non-service land uses are similar to those for policy 36 but with the differences from the base run being rather greater. The change in the distribution of housing is however very similar to that in the base run. Unlike the effect of changing the β-values, the location of service activity does not appear to be particularly more sensitive than non-service activity under this or the previous policy. The results from LILT are very similar to those from policy 36 but where there are differences from the base forecast these seem to be a little smaller than with policy 36. It might have been expected that the effects of this policy would be the same as for policy 36 only more pronounced. However, with both models this is not the case in terms of land use change. The effects on mean travel distances, though, are as might be expected.

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============================================================================================================

 AREA OF HOUSING ACT.(PROPORTN)     372ABHS  0                                 PERCENTAGE CHANGE
                                                                                                    POL   BASE
             -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0
                +---------+---------+---------+---------+---------+---------+---------+---------+
     CA   T                                             *                                            0.0    0.0
     CA   L                                             *                                           -0.1   -0.1
                +---------+---------+---------+---------+---------+---------+---------+---------+
     IS   T                                             TTTTT*                                       2.5    2.5
     IS   L                                *LLLLLLLLLLL                                             -5.8   -5.9
                +---------+---------+---------+---------+---------+---------+---------+---------+
     OS   T                                       *TTTTT                                            -2.6   -2.5
     OS   L                                             LLLLLLLLLLL*                                 5.8    5.9
                +---------+---------+---------+---------+---------+---------+---------+---------+
             -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0

============================================================================================================

         SERVICE ACT.(PROP)         372ABRT  0                                 PERCENTAGE CHANGE
                                                                                                    POL   BASE
             -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0
                +---------+---------+---------+---------+---------+---------+---------+---------+
     CA   T                               *TTTTTTTTTTTTTT                                           -6.9   -6.9
     CA   L                                          L*LL                                           -1.7   -0.9
                +---------+---------+---------+---------+---------+---------+---------+---------+
     IS   T                                             TTTTTTTTTTTTTTTTTT    *                      8.7   11.0
     IS   L                         L*LLLLLLLLLLLLLLLLLLL                                          -10.2   -9.5
                +---------+---------+---------+---------+---------+---------+---------+---------+
     OS   T                                     *   TTTTT                                           -1.8   -4.0
     OS   L                                             LLLLLLLLLLLLLLLLLLLLL*LLL                   11.9   10.4
                +---------+---------+---------+---------+---------+---------+---------+---------+
             -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0

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         NON SERVICE ACT.           372ABNS  0                                 PERCENTAGE CHANGE
                                                                                                    POL   BASE
             -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0
                +---------+---------+---------+---------+---------+---------+---------+---------+
     CA   T                        TTTTTT*TTTTTTTTTTTTTTT                                          -10.4   -7.6
     CA   L                           *LLLLLLLLLLLLLLLLLL                                           -8.8   -8.8
                +---------+---------+---------+---------+---------+---------+---------+---------+
     IS   T                                  TTTTT*TTTTTT                                           -5.5   -2.8
     IS   L                                     *LLLLLLLL                                           -4.5   -4.5
                +---------+---------+---------+---------+---------+---------+---------+---------+
     OS   T                                             TTTTTTTTTTTTTTTTTTTTT*TTTTTTTTTTT           15.9   10.4
     OS   L                                             LLLLLLLLLLLLLLLLLLLLLLLLLLL*                13.4   13.3
                +---------+---------+---------+---------+---------+---------+---------+---------+
             -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0

============================================================================================================

 DIST. PER TRIP  -WORK              372AIWT  0                                 PERCENTAGE CHANGE
                                                                                                    POL   BASE
             -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0
                +---------+---------+---------+---------+---------+---------+---------+---------+
     CA   T                                             TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT*   53.0   97.9
     CA   L                                             LLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLL*   19.5   28.8
                +---------+---------+---------+---------+---------+---------+---------+---------+
     IS   T                       TTTTTTTTTTTTTTTTTTTTTTT                                *         -11.2   16.4
     IS   L                                         LLLLL                       *                   -1.9   12.1
                +---------+---------+---------+---------+---------+---------+---------+---------+
     OS   T     TTTTTTTTTTTTTT*TTTTTTTTTTTTTTTTTTTTTTTTTT                                          -42.6  -12.8
     OS   L         LLLLLLLLLLLLLLLLLLLLLLLLLLLLLLL*LLLLL                                          -17.8   -2.4
                +---------+---------+---------+---------+---------+---------+---------+---------+
     CT   T     TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT *                                        -30.1    1.0
     CT   L                         LLLLLLLLLLLLLLLLLLLLL          *                               -10.1    5.3
                +---------+---------+---------+---------+---------+---------+---------+---------+
             -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0

============================================================================================================
```

FIGURE 6.7   RESULTS FROM POLICY 37   (DOUBLING THE COST OF TRAVEL)

Policy 70 - Economic Recession

ISGLUTI specification

Recession in the economy: the number of jobs is reduced by 20 per cent; housing costs and travel costs rise by 20 per cent in the face of fixed incomes.

Interpretation for TOPAZ82

The total planned levels of service and non-service activities are reduced by 20% of their base run values. Trip rates to these activities are also reduced accordingly. The unit interaction costs are increased by 20%.

Interpretation for LILT

City-wide employment totals in all twelve industrial sectors are set 20% lower than in the base run for all forecast years. The boarding and distance elements of public transport fares and the perceived operating cost of private transport are all increased to 20% above their values in the base run for all forecast years. Housing costs and incomes are not directly modelled.

Results (Figure 6.8)

There are quite substantial differences in the land use changes that occur with TOPAZ82 under this policy from those in the base run. In fact for both industrial activities there is relatively little change from the base year pattern with this policy. This is because the (reduced) activity levels are not very different (in fact, a little lower) than those in the base year. For housing however the changes under this policy are greater than in the base run with a larger increase in the proportion of housing located in the inner suburbs and a larger decrease in the proportion in the outer suburbs. With LILT the changes in the

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AREA OF HOUSING ACT.(PROPORTN)     702ARHS  0                           PERCENTAGE CHANGE
                                                                                              POL  BASE
           -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0
                +---------+---------+---------+---------+---------+---------+---------+
    CA   T                                              *                                      0.0   0.0
    CA   L                                              *                                     -0.1  -0.1
                +---------+---------+---------+---------+---------+---------+---------+
    IS   T                                              TTTTT*TTTTTTTTT                        7.2   2.5
    IS   L                                  *LLLLLLLLLLL                                      -5.8  -5.9
                +---------+---------+---------+---------+---------+---------+---------+
    OS   T                                TTTTTTTTT*TTTTT                                     -7.2  -2.5
    OS   L                                              LLLLLLLLLLL*                           5.8   5.9
                +---------+---------+---------+---------+---------+---------+---------+
           -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0

=====================================================================================================

        SERVICE ACT.(PROP)         702ARRT  0                           PERCENTAGE CHANGE
                                                                                              POL  BASE
           -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0
                +---------+---------+---------+---------+---------+---------+---------+
    CA   T                                 *        TTTTT                                     -1.9  -6.9
    CA   L                                          LL*LL                                     -2.2  -0.9
                +---------+---------+---------+---------+---------+---------+---------+
    IS   T                                              TTT                   *                1.0  11.0
    IS   L                            *LLLLLLLLLLLLLLLLL                                      -9.0  -9.5
                +---------+---------+---------+---------+---------+---------+---------+
    OS   T                                       *      TTT                                    0.9  -4.0
    OS   L                                              LLLLLLLLLLLLLLLLLLLLL*L               11.1  10.4
                +---------+---------+---------+---------+---------+---------+---------+
           -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0

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        NON SERVICE ACT.           702ARNS  0                           PERCENTAGE CHANGE
                                                                                              POL  BASE
           -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0
                +---------+---------+---------+---------+---------+---------+---------+
    CA   T                                 *            TTTT                                   1.3  -7.6
    CA   L                             *LLLLLLLLLLLLLLLLLL                                    -8.9  -8.8
                +---------+---------+---------+---------+---------+---------+---------+
    IS   T                                          *TTTTTT                                   -2.4  -2.8
    IS   L                                        *LLLLLLLL                                   -4.2  -4.5
                +---------+---------+---------+---------+---------+---------+---------+
    OS   T                                              TTT                  *                 1.1  10.4
    OS   L                                              LLLLLLLLLLLLLLLLLLLLLLLLLLL*          13.1  13.3
                +---------+---------+---------+---------+---------+---------+---------+
           -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0

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DIST. PER TRIP  -WORK              702AIWT  0                           PERCENTAGE CHANGE
                                                                                              POL  BASE
           -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0
                +---------+---------+---------+---------+---------+---------+---------+
    CA   T                                              TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT*  79.1  97.9
    CA   L                                              LLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLL*  25.5  28.8
                +---------+---------+---------+---------+---------+---------+---------+
    IS   T                                              TTTTTTTTTTTTTTTTTTTTT            *        10.1  16.4
    IS   L                                              LLLLLLLLLLLLLLLLLLLLLL  *                 10.4  12.1
                +---------+---------+---------+---------+---------+---------+---------+
    OS   T                       *TTTTTTTTTTTTTTTTTTTTTTTTTT                                 -13.1 -12.8
    OS   L                                       LLLLL*LLLLL                                  -5.2  -2.4
                +---------+---------+---------+---------+---------+---------+---------+
    CT   T                                          TTTTTT *                                  -2.3   1.0
    CT   L                                              LLLLLLL    *                           2.8   5.3
                +---------+---------+---------+---------+---------+---------+---------+
           -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0

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FIGURE 6.8   RESULTS FROM POLICY 70   (ECONOMIC RECESSION) land-use pattern are little different from those of the base run. There is a little more decentralisation of service activity and a little less decentralisation of housing which is in response to the increase in travel costs. This increase also results in net reductions in mean travel distances relative to the base forecast values in both models as in policies 36 and 37.

Policy 80 - Decentralisation of shopping facilities

ISGLUTI specification

Through zoning policies and urban renewal, gradually reduce town centre shopping floorspace to half its present amount over a period of about 10 years. Allow new shopping to be established anywhere else in the town.

Interpretation for TOPAZ82

A constraint is imposed to reduce the amount of area occupied by service activities in the central area by an amount equal to half of the area occupied there by shopping in the base year.

Interpretation for LILT

Shopping is modelled in terms of employment rather than floorspace. The amount of retail employment in the central area (zone 7) in 1976 is therefore set exogenously to $1/\sqrt{2}$ times the base run value for that year, and to half the base run value in 1981. Total retail employment in the study area as a whole remains unchanged. All retail employment is located endogenously in the remaining forecast years.

Results (Figure 6.9)

With both models the land use changes that occur under this

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AREA OF HOUSING ACT.(PROPORTN)      802ABHS  0                                PERCENTAGE CHANGE
                                                                                                     POL   BASE
             -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0
                 +---------+---------+---------+---------+---------+---------+---------+---------+
    CA    T                                              *T                                           0.5    0.0
    CA    L                                              *                                           -0.1   -0.1
                 +---------+---------+---------+---------+---------+---------+---------+---------+
    IS    T                                              TTTT *                                       1.6    2.5
    IS    L                                   *LLLLLLLLLLL                                           -5.7   -5.9
                 +---------+---------+---------+---------+---------+---------+---------+---------+
    OS    T                                         *TTTTT                                           -2.2   -2.5
    OS    L                                              LLLLLLLLLLL*                                 5.8    5.9
                 +---------+---------+---------+---------+---------+---------+---------+---------+
             -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0

==========================================================================================================

        SERVICE ACT.(PROP)          802ABRT  0                                PERCENTAGE CHANGE
                                                                                                     POL   BASE
             -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0
                 +---------+---------+---------+---------+---------+---------+---------+---------+
    CA    T                                 *TTTTTTTTTTTTTT                                          -7.1   -6.9
    CA    L                                          L*LL                                            -1.4   -0.9
                 +---------+---------+---------+---------+---------+---------+---------+---------+
    IS    T                                              TTTTTTTTTTTTTTTTTTTTTT *                    10.0   11.0
    IS    L                         LL*LLLLLLLLLLLLLLLLL                                            -10.3   -9.5
                 +---------+---------+---------+---------+---------+---------+---------+---------+
    OS    T                                       * TTTTTTT                                          -2.9   -4.0
    OS    L                                              LLLLLLLLLLLLLLLLLLLLL*LL                    11.7   10.4
                 +---------+---------+---------+---------+---------+---------+---------+---------+
             -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0

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        NON SERVICE ACT.            802ABNS  0                                PERCENTAGE CHANGE
                                                                                                     POL   BASE
             -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0
                 +---------+---------+---------+---------+---------+---------+---------+---------+
    CA    T                              TT*TTTTTTTTTTTTTTT                                          -8.5   -7.6
    CA    L                             *LLLLLLLLLLLLLLLLL                                           -8.8   -8.8
                 +---------+---------+---------+---------+---------+---------+---------+---------+
    IS    T                                          *    TT                                         -0.3   -2.8
    IS    L                                         *LLLLLLLL                                        -4.5   -4.5
                 +---------+---------+---------+---------+---------+---------+---------+---------+
    OS    T                                              TTTTTTTTTTTTTTTTTTTT  *                      8.8   10.4
    OS    L                                              LLLLLLLLLLLLLLLLLLLLLLLLLLLL*               13.3   13.3
                 +---------+---------+---------+---------+---------+---------+---------+---------+
             -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0

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DIST. PER TRIP  -WORK               802AIWT  0                                PERCENTAGE CHANGE
                                                                                                     POL   BASE
             -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0
                 +---------+---------+---------+---------+---------+---------+---------+---------+
    CA    T                                              TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT*  97.9   97.9
    CA    L                                              LLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLL*  31.9   28.8
                 +---------+---------+---------+---------+---------+---------+---------+---------+
    IS    T                                              TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT*       16.4   16.4
    IS    L                                              LLLLLLLLLLLLLLLLLLLLLLLLLLL*LL              12.8   12.1
                 +---------+---------+---------+---------+---------+---------+---------+---------+
    OS    T                           *TTTTTTTTTTTTTTTTTTTTTTTTTTTTT                                -12.8  -12.8
    OS    L                                          LL*LLLLL                                        -3.3   -2.4
                 +---------+---------+---------+---------+---------+---------+---------+---------+
    CT    T                                              TT*                                          1.0    1.0
    CT    L                                              LLLLLLLLL *                                  4.7    5.3
                 +---------+---------+---------+---------+---------+---------+---------+---------+
             -20.0     -15.0     -10.0      -5.0       0.0       5.0      10.0      15.0      20.0

==========================================================================================================
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FIGURE 6.9   RESULTS FROM POLICY 80   (DECENTRALISATION OF SHOPPING FACILITIES) policy are quite similar to those in the base runs. In fact, with TOPAZ82, the amount of service activity exogenously specified to be removed from the central zone is only about one-half of what is actually removed in the base solution, and this policy does not significantly change that amount. Given that fact, it is perhaps suprising that the changes which occur are as large as they are particularly for non-service industry which decentralises less under this policy. The only significant difference from the base forecast in the LILT results occurs for service activity and this can be directly attributable to the policy. Travel distances change exactly as in the base run with TOPAZ82 but increase slightly less with LILT as the additional service employment is located in the middle of a predominantly residential area, offering the opportunity for shorter trips to work.

Policy 81 - Development of a new suburban shopping centre

ISGLUTI specification

A new shopping centre is built in the most accessible location (possibly the intersection of two freeways) on the periphery of the town, with a floorspace equal to 1/4 of present city centre floorspace and development taking place over five years.

Interpretation for TOPAZ82

A constraint is imposed to increase the land area occupied by service industry in zone 19 by an amount equivalent to 25% of the area occupied by service industry in the city centre in the base year. The city-wide total land area occupied by that sector is also increased by this amount.

```
AREA OF HOUSING ACT.(PROPORTN)     812ARHS  0                              PERCENTAGE CHANGE
                                                                                                  POL   BASE
          -20.0    -15.0    -10.0    -5.0     0.0      5.0     10.0    15.0    20.0
            +--------+--------+--------+--------+--------+--------+--------+--------+
   CA  T                                        *                                          0.0    0.0
   CA  L                                        *                                         -0.1   -0.1
            +--------+--------+--------+--------+--------+--------+--------+--------+
   IS  T                                        TTTTT*                                     1.8    2.5
   IS  L                             *LLLLLLLLLLL                                         -6.0   -5.9
            +--------+--------+--------+--------+--------+--------+--------+--------+
   OS  T                                   *TTTTT                                         -1.8   -2.5
   OS  L                                        LLLLLLLLLLL*                               6.1    5.9
            +--------+--------+--------+--------+--------+--------+--------+--------+
          -20.0    -15.0    -10.0    -5.0     0.0      5.0     10.0    15.0    20.0
```

```
RETAILING ACT.(PROP)               812ARRT  0                              PERCENTAGE CHANGE
                                                                                                  POL   BASE
          -20.0    -15.0    -10.0    -5.0     0.0      5.0     10.0    15.0    20.0
            +--------+--------+--------+--------+--------+--------+--------+--------+
   CA  T                           * TTTTTTTTTTTT                                         -5.9   -6.9
   CA  L                                      *LL                                         -0.4   -0.9
            +--------+--------+--------+--------+--------+--------+--------+--------+
   IS  T                                        TTTTTTTTTTTTTTTTTTT  *                     9.6   11.0
   IS  L                      * LLLLLLLLLLLLLLLL                                          -8.6   -9.5
            +--------+--------+--------+--------+--------+--------+--------+--------+
   OS  T                                 *TTTTTTTT                                        -3.7   -4.0
   OS  L                                        LLLLLLLLLLLLLLLLLL  *                      9.0   10.4
            +--------+--------+--------+--------+--------+--------+--------+--------+
          -20.0    -15.0    -10.0    -5.0     0.0      5.0     10.0    15.0    20.0
```

```
NON SERVICE ACT.                   812ARNS  0                              PERCENTAGE CHANGE
                                                                                                  POL   BASE
          -20.0    -15.0    -10.0    -5.0     0.0      5.0     10.0    15.0    20.0
            +--------+--------+--------+--------+--------+--------+--------+--------+
   CA  T                        TTT*TTTTTTTTTTTTTT                                        -8.9   -7.6
   CA  L                        *LLLLLLLLLLLLLLLLL                                        -8.8   -8.8
            +--------+--------+--------+--------+--------+--------+--------+--------+
   IS  T                                   *    TT                                        -0.4   -2.8
   IS  L                                 *LLLLLLLL                                        -4.5   -4.5
            +--------+--------+--------+--------+--------+--------+--------+--------+
   OS  T                                        TTTTTTTTTTTTTTTTTTTT *                     9.3   10.4
   OS  L                                        LLLLLLLLLLLLLLLLLLLLLLLLLLL*              13.3   13.3
            +--------+--------+--------+--------+--------+--------+--------+--------+
          -20.0    -15.0    -10.0    -5.0     0.0      5.0     10.0    15.0    20.0
```

```
DIST. PER TRIP  -WORK              812ADWT  0                              PERCENTAGE CHANGE
                                                                                                  POL   BASE
          -20.0    -15.0    -10.0    -5.0     0.0      5.0     10.0    15.0    20.0
            +--------+--------+--------+--------+--------+--------+--------+--------+
   CA  T                                        TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT*  96.9   97.9
   CA  L                                        LLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLL*  29.1   28.8
            +--------+--------+--------+--------+--------+--------+--------+--------+
   IS  T                                        TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT*         16.2   16.4
   IS  L                                        LLLLLLLLLLLLLLLLLLLLLLLL*                  12.2   12.1
            +--------+--------+--------+--------+--------+--------+--------+--------+
   OS  T                  *TTTTTTTTTTTTTTTTTTTTTTTTTT                                    -12.5  -12.8
   OS  L                                   *LLLLL                                         -2.6   -2.4
            +--------+--------+--------+--------+--------+--------+--------+--------+
   CT  T                                        TT*                                        1.2    1.0
   CT  L                                        LLLLLLLLLL*                                5.2    5.3
            +--------+--------+--------+--------+--------+--------+--------+--------+
          -20.0    -15.0    -10.0    -5.0     0.0      5.0     10.0    15.0    20.0
```

FIGURE 6.10   RESULTS FROM POLICY 81 (DEVELOPMENT OF A NEW SUBURBAN SHOPPING CENTRE)

Interpretation for LILT

City-wide retail employment in all forecast years is increased by an amount equivalent to 25% of the retail employment in zone 7 in the base forecast for 1976. This extra employment is exogenously located in zone 19 for that year. In subsequent forecast years all retail employment is endögenously located.

Results (Figure 6.10)

With TOPAZ82 there is less of a decrease in the proportion of service activity located in the outer suburbs and less of an increase in the proportion located in the inner suburbs. With LILT the results are exactly the opposite. In the central area, however, and rather unexpectedly, both models forecast less of a decline in the proportion of service activity located there. LILT forecasts little effect on the other activities with this policy, but with TOPAZ82 there is less centralisation of housing and less decentralisation of non-service industry compared to the base. There is little effect on travel distances relative to the base forecast with either model.

7. Conclusions

An attempt has been made to apply TOPAZ82 to Leeds. The model has been used in a fairly basic way and some rather sweeping assumptions have been made. For example work trips alone have been considered. Also, because of lack of data, it has been assumed that activity location costs do not vary between zones. This may not be particularly important for, with location costs at their assumed levels, travel costs account for by far the largest component of total TOPAZ82 solution costs.

The model used is aso a relatively simple version of TOPAZ and it would be interesting to incorporate some of the refinements (such as modal split and assignment) used in previous applications. Nevertheless the conceptual simplicity of the basic model used here has some benefits.

All of the model runs have been undertaken using a gravity type trip distribution model (except in the minimum travel cost solution - RUN C). This means that TOPAZ82 represents trip-making behaviour in a similar way to most of the other models in the ISGLUTI study. It also means that the outputs of TOPAZ82 are a blend of prescription and prediction. This is possibly a disadvantage because it makes it difficult to interpret the results. To what extent do they represent what would happen or what should happen?

The results from TOPAZ82 have been compared with those from LILT. Any such comparison is inevitably difficult because of the very different nature of the models both in terms of the degree of detail represented in each and their basic structure. It should be borne in mind that although the TOPAZ82 application described here represents very few of the processes included in LILT a TOPAZ82 solution takes less than one-hundredth of the computer time needed for a LILT forecast.

Comparisons of the effects of policy are complicated by the fact that the base runs of the two models are quite different. LILT forecasts decentralisation of activities. The TOPAZ82 solution, however, represents a generally more centralised pattern of activities than in the base year and this is particularly true for housing. This difference underlies the results from all the model runs and so the effects of policy have been considered in relation to the change in the base run. The differences and similarities in the results from the policy tests have already been described. However, of particular interest is the fact that in some cases the models produce similar results, but ones which are rather unexpected. One example is the fact that with both models when the cost of travel is increased (policy 36) and then increased further (policy 37) the land use changes with the second increase are not at all a simple extrapolation of the changes that occur with the initial increase. Another is that decentralisation of non-service industry (in policy 20) causes relative centralisation of other activities in each case. Also in policy 81 the development of a suburban shopping centre leads to slightly less decline in the level of central area service activity with both models.

There is one difference between the implementation of the two models which has a particularly large impact on their results. This is that with TOPAZ82 activities have been described in terms of the land area occupied by them. In LILT they are represented by numbers of people, houses, jobs and so on which are then converted to land area by means of zone specific densities. Densities have been assumed to be constant across the whole study area with TOPAZ82 and this has led, for example, to a large underestimation of trips to the central area. A particularly useful extension of the model would therefore be the incorporation of zone and activity specific densities, which could also be different for new and existing activities. [Of course in this application of TOPAZ82 it was not essential for activity levels to be measured in terms of land area. Floorspace could have been used or population and numbers of jobs. In either case, however, it would have been difficult to define zone capacities.]

Finally, it should be said that the approach to using TOPAZ82 here has been influenced considerably by the ISGLUTI study. Most of the models considered in the study, like LILT, for example, are rather different to TOPAZ82 and it is perhaps inappropriate to use the model in this way. Important outputs from the model such as the various costs associated with each solution have not been mentioned. Little has been said about the results from extreme solutions (such as minimum or maximum total cost) or from varying the weightings on the components of the objective function. These can be produced easily with TOPAZ but not with many other models. It may be therefore rather inappropriate to attempt simply to compare results in the way that has been done here. Instead it might be better to consider the results from TOPAZ as a complement to those from the other models, providing additional insights of value to ISGLUTI.

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APPENDIX: RESULTS FROM TOPAZ POLICY RUNS

	CENTRAL AREA	INNER SUBURBS	OUTER SUBURBS	CITY TOTAL
RUN I				
AREA OF HOUSING	9.30	2578.22	4298.11	6885.63
SERVICE	114.91	747.90	778.55	1641.36
NON-SERVICE	132.65	751.41	688.55	1572.61
UNDEVELOPED	187.90	922.93	5224.94	6335.77
TOTAL AREA	444.76	5000.45	10990.16	16435.37
WORK TRIP ORIGINS	514	142407	237304	380224
WORK TRIP DESTINATICNS	29121	177117	173986	380224
MEAN DIST-WORK BY ORIGIN	4.01	4.81	5.94	5.52
MEAN DIST-WORK BY DESTN.	5.40	5.65	5.40	5.52
PROPN. TRIPS INTRAZONAL	0.13	0.08	0.17	0.13
NEWLY LOCATED HOUSING	2.70	607.03	640.51	1250.24
SERVICE	0.00	280.70	127.13	407.83
NON-SERVICE	0.00	204.24	325.01	529.25
NEWLY REMOVED HOUSING	0.00	0.11	0.00	0.11
SERVICE	73.59	0.00	43.98	117.57
NON-SERVICE	84.95	140.53	90.06	315.55
POLICY 10				
AREA OF HOUSING	29.32	3061.64	7140.72	10231.67
SERVICE	175.29	947.78	1213.75	2336.82
NON-SERVICE	197.06	981.05	1260.86	2438.97
UNDEVELOPED	43.09	9.99	1374.84	1427.91
TOTAL AREA	444.76	5000.45	10990.16	16435.37
WORK TRIP ORIGINS	1619	169121	394253	564993
WORK TRIP DESTINATICNS	43882	228285	292827	564993
MEAN DIST-WORK BY ORIGIN	4.20	4.95	5.78	5.53
MEAN DIST-WORK BY DESTN.	5.62	5.78	5.31	5.53
PROPN. TRIPS INTRAZONAL	0.14	0.07	0.20	0.16
NEWLY LOCATED HOUSING	22.72	1119.65	3483.13	4625.50
SERVICE	0.00	480.58	526.75	1007.33
NON-SERVICE	0.00	354.39	822.08	1176.47
NEWLY REMOVED HOUSING	0.00	29.31	0.00	29.31
SERVICE	13.21	0.00	8.40	21.61
NON-SERVICE	20.53	61.04	14.83	96.40
POLICY 11				
AREA OF HOUSING	26.73	3144.81	7060.13	10231.68
SERVICE	206.84	973.38	1156.60	2336.82
NON-SERVICE	206.42	891.81	1340.74	2438.97
UNDEVELOPED	4.76	-9.55	1432.69	1427.90
TOTAL AREA	444.76	5000.45	10990.16	16435.37
WORK TRIP ORIGINS	1477	173707	389809	564993
WORK TRIP DESTINATIONS	49004	222148	293841	564993
MEAN DIST-WORK BY ORIGIN	4.15	4.97	5.80	5.54
MEAN DIST-WORK BY DESTN.	5.62	5.81	5.32	5.54
PROPN. TRIPS INTRAZONAL	0.15	0.07	0.19	0.15
NEWLY LOCATED HOUSING	20.13	1186.44	3402.54	4609.11
SERVICE	18.34	506.99	461.20	986.53
NON-SERVICE	0.00	220.27	887.14	1107.41
NEWLY REMOVED HOUSING	0.00	12.94	0.00	12.94
SERVICE	0.00	0.81	0.00	0.81
NON-SERVICE	11.18	16.16	0.00	27.34

APPENDIX (CONTINUED)

	CENTRAL AREA	INNER SUBURBS	OUTER SUBURBS	CITY TOTAL
POLICY 20				
AREA OF HOUSING	118.10	2794.89	3972.64	6885.63
SERVICE	109.83	859.11	672.42	1641.36
NON-SERVICE	108.80	343.90	1119.91	1572.61
UNDEVELOPED	108.03	1002.55	5225.19	6335.77
TOTAL AREA	444.76	5000.45	10990.16	16435.37
WORK TRIP ORIGINS	6524	154371	219330	380224
WORK TRIP DESTINATIONS	25838	145844	208542	380224
MEAN DIST-WORK BY ORIGIN	4.44	5.10	5.70	5.43
MEAN DIST-WORK BY DESTN.	5.02	5.43	5.49	5.43
PROPN. TRIPS INTRAZONAL	0.12	0.06	0.21	0.15
NEWLY LOCATED HOUSING	111.50	823.59	315.04	1250.13
SERVICE	0.00	391.91	62.97	454.88
NON-SERVICE	0.00	0.00	709.44	709.44
NEWLY REMOVED HOUSING	0.00	0.00	0.00	0.00
SERVICE	78.67	0.00	85.94	164.62
NON-SERVICE	108.80	343.80	43.12	495.72
POLICY 21				
AREA OF HOUSING	118.10	2541.30	4226.23	6885.63
SERVICE	96.51	765.31	779.53	1641.36
NON-SERVICE	99.23	737.27	736.11	1572.61
UNDEVELOPED	130.92	956.56	5248.29	6335.77
TOTAL AREA	444.76	5000.45	10990.16	16435.37
WORK TRIP ORIGINS	6523	140376	233325	380224
WORK TRIP DESTINATIONS	23107	177732	179386	380224
MEAN DIST-WORK BY ORIGIN	4.10	4.81	6.12	5.60
MEAN DIST-WORK BY DESTN.	5.33	5.68	5.55	5.60
PROPN. TRIPS INTRAZONAL	0.10	0.07	0.16	0.13
NEWLY LOCATED HOUSING	111.50	570.00	568.63	1250.13
SERVICE	0.00	298.11	139.11	437.23
NON-SERVICE	0.00	170.33	318.42	488.76
NEWLY REMOVED HOUSING	0.00	0.00	0.00	0.00
SERVICE	91.99	0.00	54.98	146.97
NON-SERVICE	118.37	120.76	35.91	275.05
POLICY 36				
AREA OF HOUSING	9.30	2554.44	4321.90	6885.63
SERVICE	134.21	718.73	788.42	1641.36
NON-SERVICE	111.41	753.00	708.20	1572.61
UNDEVELOPED	189.84	974.29	5171.64	6335.77
TOTAL AREA	444.76	5000.45	10990.16	16435.37
WORK TRIP ORIGINS	515	141363	238347	380225
WORK TRIP DESTINATIONS	29185	173637	177403	380225
MEAN DIST-WORK BY ORIGIN	3.45	4.17	4.90	4.63
MEAN DIST-WORK BY DESTN.	5.14	5.01	4.18	4.63
PROPN. TRIPS INTRAZONAL	0.17	0.11	0.25	0.20
NEWLY LOCATED HOUSING	2.70	583.14	664.30	1250.13
SERVICE	0.00	260.41	148.00	408.41
NON-SERVICE	0.00	186.06	367.18	553.23
NEWLY REMOVED HOUSING	0.00	0.00	0.00	0.00
SERVICE	54.29	8.88	54.98	118.15
NON-SERVICE	106.19	120.76	112.57	339.53

APPENDIX (CONTINUED)

	CENTRAL AREA	INNER SUBURBS	OUTER SUBURBS	CITY TOTAL
POLICY 37				
AREA OF HOUSING	9.30	2583.24	4293.09	6885.63
SERVICE	114.91	710.95	815.51	1641.36
NON-SERVICE	89.13	709.01	774.47	1572.61
UNDEVELOPED	231.42	997.26	5107.09	6335.77
TOTAL AREA	444.76	5000.45	10990.16	16435.37
WORK TRIP ORIGINS	515	142941	236769	380225
WORK TRIP DESTINATIONS	24293	167781	188151	380225
MEAN DIST-WORK BY ORIGIN	3.10	3.67	3.91	3.82
MEAN DIST-WORK BY DESTN.	4.71	4.31	3.27	3.82
PROPN. TRIPS INTRAZONAL	0.20	0.14	0.36	0.28
NEWLY LOCATED HOUSING	2.70	612.05	635.49	1250.24
SERVICE	0.00	250.85	181.18	432.04
NON-SERVICE	0.00	175.09	442.35	617.44
NEWLY REMOVED HOUSING	0.00	0.11	0.00	0.11
SERVICE	73.59	7.11	61.08	141.78
NON-SERVICE	128.47	153.78	121.48	403.73
POLICY 70				
AREA OF HOUSING	9.30	2905.80	3970.53	6885.63
SERVICE	158.12	467.20	687.80	1313.12
NON-SERVICE	217.60	607.04	433.44	1258.08
UNDEVELOPED	59.74	1020.40	5898.39	6978.54
TOTAL AREA	444.76	5000.45	10990.16	16435.37
WORK TRIP ORIGINS	411	128448	175348	304207
WORK TRIP DESTINATIONS	43968	125931	134308	304207
MEAN DIST-WORK BY ORIGIN	3.63	4.55	5.92	5.34
MEAN DIST-WORK BY DESTN.	5.11	5.47	5.29	5.34
PROPN. TRIPS INTRAZONAL	0.24	0.07	0.19	0.14
NEWLY LOCATED HOUSING	2.70	934.50	312.93	1250.13
SERVICE	0.00	0.00	0.00	0.00
NON-SERVICE	0.00	0.00	0.00	0.00
NEWLY REMOVED HOUSING	0.00	0.00	0.00	0.00
SERVICE	30.38	0.00	7.60	37.98
NON-SERVICE	0.00	80.66	20.16	100.82
POLICY 80				
AREA OF HOUSING	44.92	2520.84	4319.87	6885.63
SERVICE	112.86	731.48	797.01	1641.36
NON-SERVICE	117.49	791.15	663.97	1572.61
UNDEVELOPED	169.49	956.97	5209.31	6335.77
TOTAL AREA	444.76	5000.45	10990.16	16435.37
WORK TRIP ORIGINS	2481	139242	238501	380225
WORK TRIP DESTINATIONS	27183	179469	173572	380225
MEAN DIST-WORK BY ORIGIN	4.01	4.81	5.94	5.52
MEAN DIST-WORK BY DESTN.	5.40	5.66	5.38	5.52
PROPN. TRIPS INTRAZONAL	0.12	0.08	0.17	0.13
NEWLY LOCATED HOUSING	38.32	549.54	662.27	1250.13
SERVICE	0.00	264.28	156.59	420.88
NON-SERVICE	0.00	220.02	322.94	542.96
NEWLY REMOVED HOUSING	0.00	0.00	0.00	0.00
SERVICE	75.64	0.00	54.98	130.62
NON-SERVICE	100.11	116.57	112.57	329.25

APPENDIX (CONTINUED)

	CENTRAL AREA	INNER SUBURBS	OUTER SUBURBS	CITY TOTAL
POLICY 81				
AREA OF HOUSING	9.30	2540.00	4336.33	6885.63
SERVICE	134.21	727.47	779.68	1641.36
NON-SERVICE	111.41	785.11	676.08	1572.61
UNDEVELOPED	189.84	947.86	5198.07	6335.77
TOTAL AREA	444.76	5000.45	10990.16	16435.37
WORK TRIP ORIGINS	514	140302	239408	380225
WORK TRIP DESTINATIONS	29184	178297	172743	380225
MEAN DIST-WORK BY ORIGIN	3.98	4.80	5.95	5.53
MEAN DIST-WORK BY DESTN.	5.43	5.69	5.38	5.53
PROPN. TRIPS INTRAZONAL	0.13	0.08	0.17	0.13
NEWLY LOCATED HOUSING	2.70	568.70	678.73	1250.13
SERVICE	0.00	260.27	132.22	392.49
NON-SERVICE	0.00	218.18	335.06	553.23
NEWLY REMOVED HOUSING	0.00	0.00	0.00	0.00
SERVICE	54.29	0.00	47.94	102.23
NON-SERVICE	106.19	120.76	112.57	339.53