Journal of the Eastern Asia Society for Transportation Studies, Vol. 6, pp. 4097 - 4112, 2005

INCREASING ACCESSIBILITY TO WORK OPPORTUNITIES IN METROPOLITAN ADELAIDE

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Abstract: This paper discusses the use of accessibility measures to create and evaluate urban planning policies aimed at improving the accessibility of individuals to work opportunities. The measures were developed from a behavioural-based framework that determines the benefit or need for an individual or group of people to travel to an activity. The accessibility measures will show that despite one fifth of the labour force market of metropolitan Adelaide residing in the neighbouring areas of Salisbury and Tea Tree Gully, residents in these areas have among the lowest levels of accessibility to work opportunities. A policy aimed at improving the number of work opportunities in and around theses areas will be evaluated using measures of accessibility. Further research and recommendations to improve the capability of accessibility for use as a tool by policy makers will also be discussed.

Key Words: Accessibility, Travel behaviour modelling, Policy evaluation

1. INTRODUCTION

In the context of accessibility, land-use policies are generally evaluated using supply-based measures of accessibility without considering the demand for such opportunities. The danger of assuming that the demand for supplied opportunities will occur can provide misguided evaluations of policies. When remedying issues of accessibility of individuals to activities, the travel patterns of those individuals need to be considered so that their reasons for travel and the obstacles that may exist can be appropriately considered.

It will be argued that the focus should be on accessibility for individuals to activities rather than accessibility being purely a property of locations. Among factors that should be considered in a measure of accessibility are those related to the attributes of individuals who undertake travel for the purpose of accessing activities.

The accessibility measures derived from the framework are used to calculate accessibility levels within metropolitan Adelaide, Australia where it will be shown that Salisbury and Tea Tree Gully have low levels of accessibility to work opportunities. Despite the low levels in accessibility, Australian census data shows that one fifth of the total labour force market of metropolitan Adelaide resides in these two neighbouring areas. It will be shown that the accessibility of residents of these areas to work opportunities is below the average for metropolitan Adelaide. Further, the residents in the two areas are among those that travel the longest to work and pay more for travel than residents in most other parts of metropolitan Adelaide.

Although accessibility levels to job opportunities for residents of both Salisbury and Tea Tree Gully are low, the positive side to this from a planning perspective is that these two areas neighbour each other and so there is a large group of individuals that can benefit from policies applied to a small part of metropolitan Adelaide. In other words, a boost in accessibility in a spatially small area can significantly benefit the entire metropolitan Adelaide region.

The policy created for evaluation increases the number of job opportunities in Salisbury, Tea Tree Gully and surrounding areas by an order of magnitude that raises the number of jobs to a similar level as the rest of metropolitan Adelaide.

The paper discusses the framework and demonstrates how it can be used to identify areas with low accessibility levels, used to create policies for remediation of identified problems, and evaluate the effectiveness of policies to achieve their intended objectives. The results from the application of accessibility measures will be discussed along with a demonstration of how the benefits of the policy are distributed throughout metropolitan Adelaide and how the residents of Salisbury and Tea Tree Gully would benefit.

Based on the application of the accessibility framework to the problem of addressing the issue of accessibility to work opportunities, further research and recommendations are discussed to further improve the capability of accessibility for use as a tool by policy makers.

2. ACCESSIBILITY

2.1 Defining Accessibility

Within transport planning, accessibility is generally defined as the ease for people to participate in activities from specific locations using a transport mode (Dalvi, 1978, Koenig, 1980, Niemeier, 1997). This definition of accessibility can be expanded to being the *ease* for *people* to participate in *activities* from specific locations to a *destination* using a *mode* of transport at a specific *time*.

The above definition of accessibility acknowledges the differences between the people for whom the measure is calculated, the activities to which people need access, the properties of the locations of activities, the modes of transport that overcome the spatial separation between people and activities and the effects of available time on accessibility.

The *ease* of participation in activities is estimated to determine accessibility and refers to any benefits or costs associated with travel. The ease of accessibility can vary depending on the:

- person (or people) undertaking travel;
- characteristics and the importance of the activity to be undertaken;
- characteristics and spatial separation of the physical location of the activity from the origin;
- mode of travel and how well it is supported by the transport system; and
- availability of activities and the characteristics of the transport system at a given point in time.

2.2 Measures of Accessibility

A significant amount of research focuses on advancing the methods used for calculating accessibility and how to identify and encourage its use in transport and urban planning. There are two possible directions with respect to calculating accessibility measures (Morris J. M. et al, 1979): one where the measure is *supply* based; and the other where the measure also contains a contextual component representing *demand*.

Supply-based measures of accessibility measure the accessibility to opportunities based solely on the properties of the physical transport and traffic system and the arrangement of land-uses. A combined measure that incorporates a contextual component representing demand however includes non-physical characteristics of the urban system such as the population's characteristics and their travel behaviour.

The accessibility measures shown in Table 1 are those commonly in use. These measures of accessibility measures are in one form or another dependent on the following three components, the:

- Traveller (individual or group);
- Transport system (mode, roads and traffic characteristics); and
- Land-use (characteristics of land-uses at origins and destinations).

Along with the three components of accessibility identified above, Guers and van Wee (2004) identified a temporal component reflecting the constraints of time on the availability of opportunities and the ability of individuals to access such opportunities. Time is not considered a component of accessibility explicitly here because the influence of time is determined by the three identified components of accessibility, ie the traveller, the transport system, and the activities available at locations.

Table 1. Types of Accessibility Measures Commonly Used

Name	Type	Description	Typical Formulation
Geometric	Supply	Nearness of geographic locations within a network.	$A_{ij} = \min \sum_{e} \delta_{eij} C_e$ where $\delta_{eij} = \begin{cases} 1 & \text{if } e \text{ is on min path } i \to j \\ 0 & \text{otherwise} \end{cases}$
Space-time	Supply	Determines the constraints of time with space to determine the behavioural possibilities of an individual.	$A_{ij}^t = \begin{cases} A_{ij} & \text{if } T \geq t_{ij} + t_j \\ 0 & \text{otherwise} \end{cases}$ where $t_{ij} = d_{ij} / v_{ij}$ is the travel time from *i* to *j*; T is total time available; and t_j is time required at the destination.
Potential Accessibility	Supply	All possible opportunities that exist weighted by a cost function.	$A_{ij} = O_j f(C_{ij})$
Behavioural Utility	Demand/ Supply	The derived benefit from available alternatives given their preferences.	$V_n' = \ln \sum_{i \in C_n} e^{V_{in}}$
Economic	Demand/ Supply	The change in benefit attributed to a change in the urban system.	$\Delta E(CS) = \frac{1}{\alpha}\left[\ln\left(\sum_{j=1}^{J^1} e^{V_j^1}\right) - \ln\left(\sum_{j=1}^{J^0} e^{V_j^0}\right)\right]$

None of the measures of accessibility shown in Table 1 can solely cater for all the issues associated with transport and urban planning. Limitations of some of the accessibility measures include:

- Advanced measures of accessibility such as the potential measure include characteristics of locations of activities that make them more attractive for visitors, however the properties of the activity itself and the importance of that activity to the individual also needs consideration;
- The behavioural-based measures consider the individual, however most measures only do so as a by-product of a travel demand model and so are very limited in what they can be used for in transport and urban planning;
- The time-space prism concept considers both spatial and temporal separation, which is useful in determining what is realistically accessible to an individual however it still lacks the behavioural foundations, and does not fully consider characteristics of activities at locations.

The answer to determining a measure of accessibility suitable for policy evaluation and analysis may be found in using a behavioural-based framework. Behavioural modelling techniques based on multi-variate analysis can provide a technique to ascertain the influence of factors on accessibility and dissect accessibility into its various components for analysis. Such a measure of accessibility provides the transport or urban planner with the ability to isolate components of accessibility that need to be influenced by policies to improve accessibility. An attempt at such a framework is discussed in the following section.

3. ACCESSIBILITY FRAMEWORK

The accessibility framework used was developed to combine the strengths of existing accessibility measures for use in transport and urban planning. The aim was to have a framework where policies related to transport and urban form could be tested and implemented to improve accessibility for all socio-economic groups. For further details of the accessibility framework beyond that discussed here, refer to Primerano (2004).

3.1 Data Used

Data related to metropolitan Adelaide used to develop the accessibility framework included:

- information on the metropolitan Adelaide transport system that includes the road network, the public transport system (particularly the level of service), and provisions available for private motor vehicles (such as parking);
- land-use datasets depicting population, employment, education enrolment places, retail facilities and social and recreational facilities in Adelaide to provide an indication of what and how much is offered for activities at various locations; and
- survey data revealing the travel patterns of households throughout metropolitan Adelaide.

The revealed preference data used were collected from the 1999 Metropolitan Adelaide Household Travel Survey (MAHTS99). MAHTS99 was conducted by Transport SA to gather information on the population's travel behaviour for the purpose of planning Adelaide's transport needs (Transport SA, 1999). The survey gathered information based around people's day-to-day activities over two consecutive days within the Adelaide Statistical Division. A sample of approximately 9,000 homes, representing 2% of all private dwellings, was randomly selected. The final information gathered also included household and personal characteristics of participants.

3.2 Overview of Framework

The accessibility framework used was activity-based rather than just location-based. This means that the accessibility framework determines the accessibility of an individual to an activity rather than just the accessibility between locations.

Policies aimed at improving accessibility for people by targeting issues such as social welfare and social exclusion need to consider the characteristics of the people for which the policies are targeted towards. Without considering the travel patterns of people, there is no indication of the extent that policies will be received or target the people for whom they were intended.

The behavioural models incorporate into the accessibility framework the preferences and needs of individuals travelling and participating in activities within an urban space. Analysis of the MAHTS99 data revealed the travel behaviour characteristics of the population in metropolitan Adelaide and provided insight into:

- the relationships between decisions made by individuals;
- data preparation for development of the behavioural models; and
- the influence of variables on the decision making process to aid development of behavioural models.

The accessibility framework is based on a hierarchy of decisions made by a decision-making unit. The travel decisions modelled from the highest to the lowest in the system model hierarchy are the choice of activity, time of departure, the possible trip-base from where travel to the activity can originate from, the possible location of such activities and the modal choice options available to the individual. A feedback mechanism exists within the framework where the benefit derived by an individual from the alternatives available to them at a lower decision choice level feed into the higher choice level. As an example of this, the modal alternatives (mobility) available to an individual will influence the set of locations they are able to travel to participate in their chosen activity.

Ultimately, this accessibility measure provides the benefit associated with participating in an activity. The more disaggregate models also provide the benefit of participating in an activity but at a finer detail. So based on an individual's circumstances and other influential factors, the individual will select an activity and then based on their selection will choose when, where and how to participate in that activity.

3.3 The accessibility measures within the framework

The accessibility measures shown in Table 1 were integrated within the accessibility framework in the following ways:

- The geometric measure was included by considering the transport network to determine travel distances, which were then used to calculate travel times and costs.

The shortest path along road links between zone centroids was calculated to determine these travel distances.

- The space-time framework was used to determine the possible locations individuals could access given their current location, mobility resources, and time availability.
- Supply of opportunities and service provided by the transport system were considered to determine what was potentially accessible to individuals.
- Behavioural choice models integrated the travel patterns and preferences of individuals within the framework.
- The inclusive values derived from the behavioural models were used to calculate the consumer surplus, an economic measure used to evaluate transport (demonstrated in the next section) and land-use policies.

The combining of these measures has a number of benefits. One benefit is that combining the measures within a framework can reduce or even eliminate the weaknesses of each measure by using the strengths of other measures. Another benefit is that such a framework can provide the possibility of isolating results to consider a particular kind of measure given the policy that requires evaluation (eg. one can choose from using travel distance as form of accessibility through to the use of the inclusive values to determine user benefit).

4. INVESTIGATION OF ACCESSIBILITY LEVELS

4.1 The Study Area

The population of metropolitan Adelaide is over a million people and of those, over 80 per cent are aged 15 years and over. Nearly 47 per cent of the population in 1996 were part of the labour force market of which, more males were in the labour force than females with the majority of males being employed full-time. There were significantly more females employed part-time than males and there were more females employed part-time.

According to the Census collection in 1996 by the Australian Bureau of Statistics (ABS), approximately 81 per cent of all trips to work were made by car as driver. Other modes that were significantly used for work travel were car passenger, bus and walk. Many of the trips made to work in 1996 were made by a single mode only with less than two per cent using more than one mode of travel. At least 3.4 per cent of the population were able to work from home.

4.2 General Levels of Accessibility in Metropolitan Adelaide

The first step to examine the accessibility of individuals within an urban area is to analyse a measure that provides an indication of the overall levels of accessibility. The inclusive values from the activity choice model were calculated using

$$V_n^{'} = \ln \sum_{i \in C_n} e^{V_{in}} \tag{1}$$

where $V^{'}$ is the systematic component of the maximum utility for an individual n and V_{in} is the systematic component of each secondary choice i in the set of choices C_n. This measure represents in a single value the benefit an individual obtains from a set of alternatives. The inclusive values from the activity choice model were aggregated from the individual disaggregate level to the Local Government Area (LGA) and to a level indicating accessibility for the entire metropolitan area of Adelaide. The inclusive value for each LGA is normalised by dividing them by the inclusive value for metropolitan Adelaide (with an inclusive value of 5.266) as a means of gauging the level of accessibility of each LGA in comparison with all of the LGAs combined.

The map in Figure 1 shows the levels of accessibility for each LGA as compared to the entire metropolitan area. The areas close to and including the Adelaide Central Business District (CBD) and Glenelg have the highest levels of accessibility. The Adelaide CBD has the highest accessibility level of all areas, which is to be expected as many activities are available within the Adelaide CBD and the population living in the Adelaide CBD are generally of a high socio-economic status. Areas found to have lower levels of accessibility are areas furthest away from the Adelaide CBD, including Gawler, Willunga, and Noarlunga.

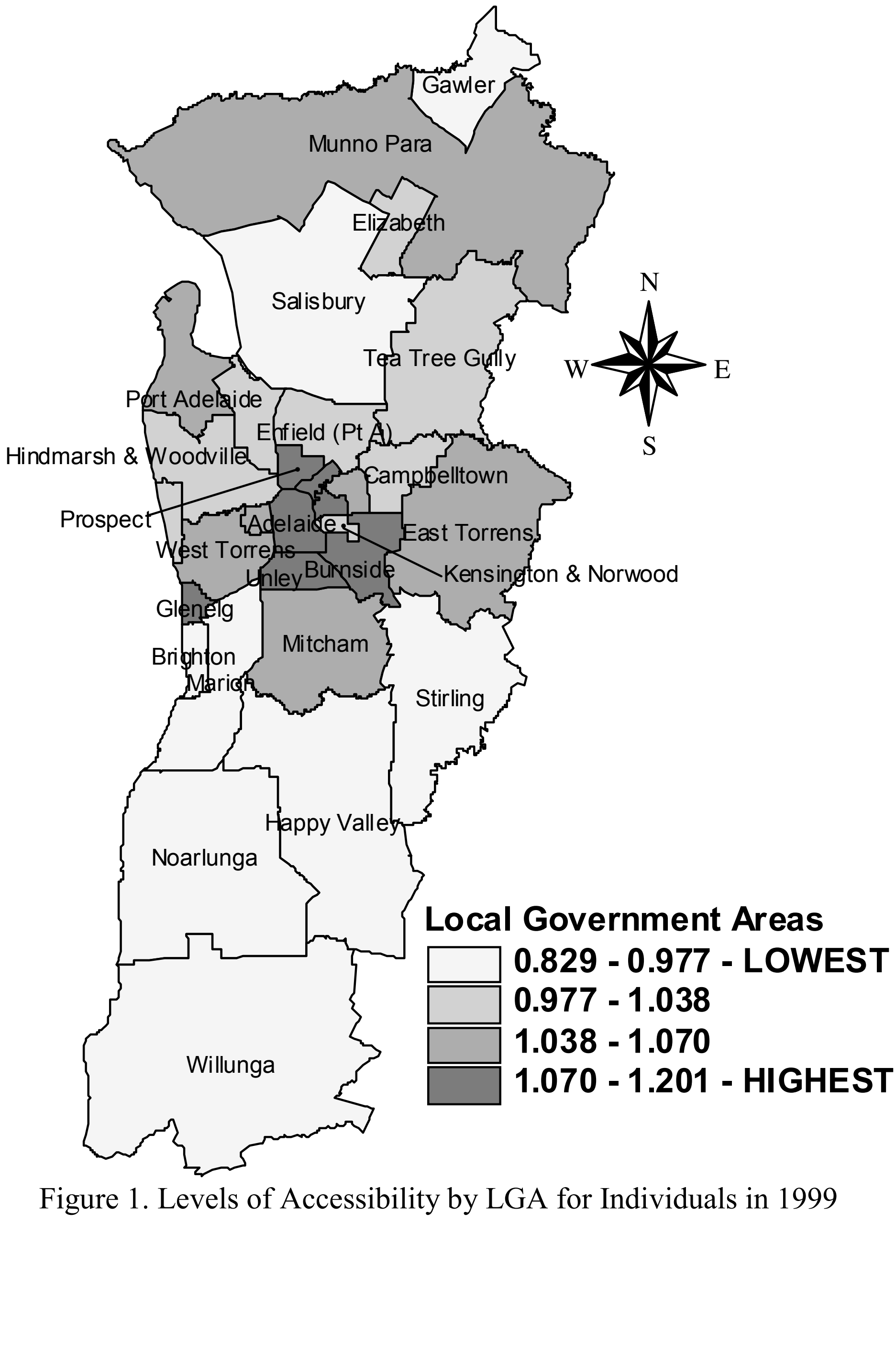

Figure 1. Levels of Accessibility by LGA for Individuals in 1999

The accessibility levels shown in Table 4 indicate that Salisbury had the fourth lowest level of accessibility (as indicated by the "rank" column) with the neighbouring LGA Tea Tree Gully being only just above the level for metropolitan Adelaide (as indicated by the "New IV" column). Interestingly though, the census data from 1996 indicates that the two LGAs combined contain 20.3 per cent of the total working population (10.1 per cent and 10.2 per cent for Salisbury and Tea Tree Gully respectively) and 20 per cent of all unemployed individuals (12.6 per cent and 7.4 per cent for Salisbury and Tea Tree Gully respectively) in metropolitan Adelaide. Thus a fifth of the total labour force market of metropolitan Adelaide resides in these two neighbouring LGAs.

The travel times and costs in Table 2 were calculated using the following equation

$$TT_i = \sum_{m=1}^{M} W_i(m) TT_m \tag{2}$$

where $W_i(m)$ is the proportion of individuals in zone i that choose mode m (using the modal choice model and aggregated using a form of sample enumeration derived from Ben-Akiva and Lerman, 1985) and TT_m is the average travel time (or cost) for mode m. The travel times (costs) are not the average travel times (costs) as such but are a representative taking into account the probability of an individual choosing each of the alternatives. If the probability of choosing a mode were one and the rest zero, then the travel time (cost) would simply be the average time (cost) for that alternative with a probability of one. This equation also has the property that the higher the probability of choosing (say) slower modes the higher the travel time and the higher the probability of choosing faster modes, the lower the estimated travel time.

Despite the large work force for these two areas, the travel times and costs and the normalised work accessibility levels derived from the inclusive value of the time period work model as shown in Table 2, indicate that accessibility levels for both Salisbury and Tea Tree Gully are below the average for metropolitan Adelaide. In addition, the residents in the two LGAs are among those that travel the longest to work and pay more for travel than most other residents in metropolitan Adelaide.

Table 2. Comparison of times and costs for travel to work and work accessibility levels in 1999 between Salisbury, Tea Tree Gully and metropolitan Adelaide

LGA	Travel time	Travel cost	Normalised work accessibility
Salisbury	24.29 minutes	\$0.87	0.874
Tea Tree Gully	26.75 minutes	\$0.84	0.968
Metropolitan Adelaide	23.11 minutes	\$0.80	1

The graph in Figure 2 shows the cumulative probabilities of the distance travelled by residents in various LGAs in metropolitan Adelaide with those of Salisbury and Tea Tree Gully highlighted. The graph confirms that residents in the two LGAs also travel the furthest distances for work than most others in metropolitan Adelaide since plots representing the cumulative probabilities of travelling certain distances by residents in Salisbury and Tea Tree Gully for work from home lie below most of the other cumulative probability lines for the shorter distances. In addition, over half of all work travel by Tea Tree Gully residents and approximately 45 per cent by Salisbury residents are over 13 kilometres.

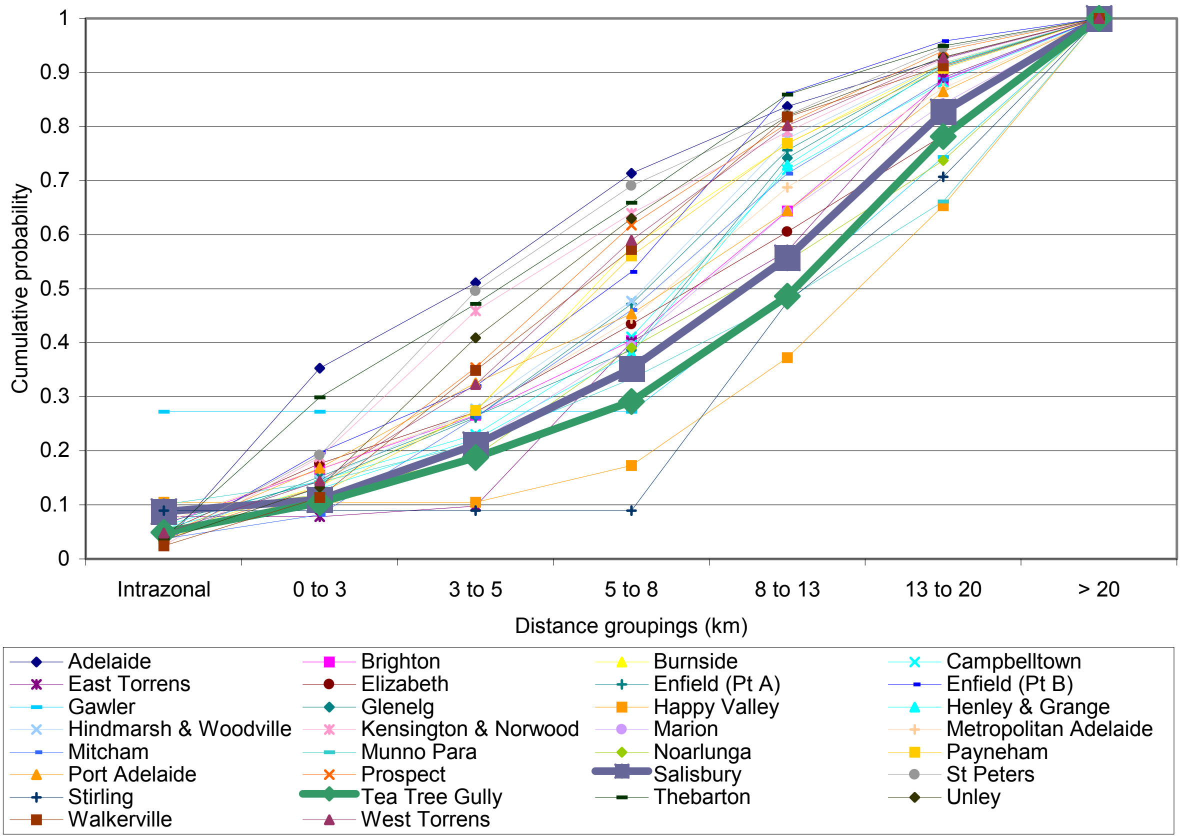

Figure 2. Cumulative Probabilities of Individuals in Each LGA Travelling a Specific Distance to Work Activities in 1999

Another interesting statistic derived from the 1996 Australian Census data is the unemployment rate of 12.9 per cent in Salisbury, which is significantly higher than the overall 10.6 per cent unemployment rate for metropolitan Adelaide in 1999. With a large workforce and a high unemployment rate within Salisbury, an increase in the number of jobs within and in close proximity of Salisbury should improve access of the employed to work activities and also provide job opportunities for the unemployed residing in Salisbury, further improving the welfare of residents in Salisbury. This benefit to the unemployed however will not be detected by the accessibility framework as discussed at the end of this paper.

Table 3 indicates the number of jobs available per labour force member residing in each of the LGAs in close proximity and including Salisbury and Tea Tree Gully. The figures show that there are two jobs available in Salisbury and one job available in Tea Tree Gully for every four people from the labour force market that reside in those respective LGAs. These ratios are lower than that for metropolitan Adelaide where there are nearly three jobs for every four labour force market members.

The above analysis suggests that there are not enough job opportunities close enough to the residents of both Salisbury and Tea Tree Gully considering that one in every five labour force members come from one of these areas. The positive side to this from a planning perspective is that these two LGAs neighbour each other (as evident in Figure 1) and so there is a large group of individuals that can benefit from policies applied to a small portion of metropolitan Adelaide. In other words, a boost in accessibility in a spatially small area can significantly benefit the entire metropolitan Adelaide region.

Table 3. Employment per Labour Force Member Residing in and around Salisbury and Tea Tree Gully including their Rank in Comparison with Other LGAs in 1999

Local Government Area	Jobs per labour force member	Rank (of 30)
Enfield (Part B)	2.51	2
Elizabeth	1.22	5
Enfield (Part A)	0.72	9
Salisbury	0.47	19
Campbelltown	0.26	24
Tea Tree Gully	0.25	26
East Torrens	0.23	28
Munno Para	0.23	29
Metropolitan Adelaide	0.7	

5. DEVELOPMENT OF POLICY

The policy tested is to increase the amount of employment in Salisbury, Tea Tree Gully and surrounding LGAs in order to increase the number of jobs per labour force member in these areas to a similar level for the rest of metropolitan Adelaide. The LGAs listed in Table 3 are those that were investigated for an increase in jobs.

Tea Tree Gully, Munno Para, Campbelltown and East Torrens had the number of jobs increased by 200 per cent and Salisbury had an increase of 50 per cent to be in line with metropolitan Adelaide (which will increase slightly with the increase in jobs in these LGAs). Elizabeth, Enfield (Part A) and Enfield (Part B) remained unchanged since they were already above the metropolitan Adelaide level.

The increase in jobs in the LGAs resulted in an increase in density of employment of the Transport Area Zones (TAZ) (a finer spatial resolution to the LGA) within the LGAs. Accordingly, the employment densities were updated for each alternative in the location choice model's dataset where the TAZ with the increased employment density represented zones for that alternative.

6. RESULTS

6.1 Introduction

The policy of increasing the number of work opportunities around the Salisbury and Tea Tree Gully areas was implemented to determine its impact on accessibility levels for areas in metropolitan Adelaide if the policy was implemented in 1999. The consumer surplus measure was used to evaluate the policies by comparing them to the scenario that was metropolitan Adelaide when the MAHTS99 data collection was conducted. The estimated change in consumer surplus was formulated as

$$\Delta E(CS) = \frac{1}{\alpha}\left[\ln\left(\sum_{j=1}^{J^1} e^{V_j^1}\right) - \ln\left(\sum_{j=1}^{J^0} e^{V_j^0}\right)\right] \tag{3}$$

where the superscripts 0 and 1 represent before and after scenarios, the two logsums represent the inclusive values derived from the behavioural models under the two scenarios, and α represents the negative of the coefficient of time or cost within the behavioural model to give the estimated change in consumer surplus a unit of measure (Train, 2002). The benefits of using the consumer surplus measure is that it is well suited for comparing policies and it also allows a unit of measure (usually in terms of time or cost) to be applied to the value to provide meaningful results.

6.2 Presentation of Results

The outcomes from an increase in employment opportunities around Salisbury and Tea Tree Gully in 1999 are shown in Table 4. The data in Table 4 include inclusive values (IV) (as formulated in equation 1) and estimate of the change in consumer surplus (CS) (as formulated in equation 3). The new inclusive value as compared to the old inclusive value represents the improvement in accessibility for that area with respect to metropolitan Adelaide due to the land-use policy. The change in consumer surplus, represented for both time and money shows the time and money saved for each trip made by each resident with the increase in the number of work opportunities as compared to the original scenario. The figures include an estimate of the change in consumer surplus per year, which represents the distribution of cost savings from all work travel made by all residents per year if the increase in work opportunities occurred in 1999.

Table 4 is sorted by the change in consumer surplus per person per trip to show the level of benefit derived from the land-use policy by each resident of each LGA. This provides the true benefit derived from the policy on a per capita basis without the influence of other factors such as population.

The greatest beneficiary to this policy by a significant margin was Tea Tree Gully with significant benefits also obtained by Salisbury, Campbelltown and Enfield (Part A). The areas least affected (with many registering almost no change) were areas distant from Salisbury and Tea Tree Gully in the south and the west of metropolitan Adelaide.

Table 4. Benefits Obtained by Residents of LGAs by Increasing Employment Opportunities around Salisbury and Tea Tree Gully in 1999

Local Government Area	Rank	Old IV	New IV	CS ($A)	CS (min)	CS ($A) per year
Tea Tree Gully	20	5.323	5.345	$0.015	0.180	$2,024,131.09
Salisbury	27	4.944	4.949	$0.004	0.047	$634,898.12
Campbelltown	22	5.231	5.236	$0.003	0.041	$221,954.17
Enfield (Pt A)	21	5.259	5.264	$0.003	0.036	$173,578.12
Adelaide	1	6.326	6.330	$0.004	0.035	$23,688.49
Kensington & Norwood	16	5.464	5.468	$0.003	0.032	$40,143.05
Munno Para	14	5.520	5.522	$0.002	0.019	$103,720.58
Payneham	13	5.550	5.552	$0.002	0.018	$25,130.21
St Peters	5	5.971	5.973	$0.002	0.018	$14,004.23
Elizabeth	18	5.411	5.412	$0.001	0.009	$23,898.36
Gawler	30	4.365	4.366	$0.001	0.008	$12,693.14
Prospect	3	6.143	6.144	$0.001	0.010	$18,739.49
Burnside	7	5.758	5.759	$0.001	0.008	$46,433.26
Port Adelaide	11	5.591	5.592	$0.000	0.004	$34,388.85
Thebarton	10	5.600	5.601	$0.000	0.004	$3,386.65
Enfield (Pt B)	17	5.449	5.449	$0.000	0.003	$5,829.19
East Torrens	12	5.565	5.566	$0.000	0.003	$2,216.01
Marion	24	5.138	5.139	$0.000	0.002	$15,243.93
Hindmarsh - Woodville	15	5.468	5.469	$0.000	0.003	$25,058.04
West Torrens	8	5.634	5.635	$0.000	0.002	$13,341.82
Mitcham	9	5.619	5.619	$0.000	0.002	$15,451.08
Unley	4	6.131	6.131	$0.000	0.002	$16,429.26
Henley & Grange	19	5.355	5.355	$0.000	0.002	$2,706.52
Glenelg	2	6.256	6.256	$0.000	0.002	$3,060.42
Walkerville	6	5.773	5.773	$0.000	0.001	$1,013.90
Brighton	26	4.985	4.985	$0.000	0.001	$3,108.55
Stirling	25	5.038	5.038	$0.000	0.001	$2,612.31
Happy Valley	23	5.145	5.145	$0.000	0.001	$3,119.35
Noarlunga	28	4.820	4.820	$0.000	0.000	$3,418.33
Willunga	29	4.572	4.572	$0.000	0.000	$0.00
Metropolitan Adelaide		5.266	5.270	$0.002	0.028	$3,513,396.51

The chart in Figure 3 shows the cumulative probability distribution for travel to locations for work purposes with distributions plotted for Salisbury and Tea Tree Gully both with and without the increase in employment opportunities. The two cumulative distributions that represent an increase in employment opportunities are well above the cumulative distributions representing the pre-policy scenario for the respective LGAs. At the 5 to 8 km distance group, the proportion of residents of Tea Tree Gully able to get to their employment location with the increase in employment opportunities increased from 29 per cent to 40 per cent. For the same distance grouping, the increase for Salisbury residents was from 35 per cent to 39 per cent.

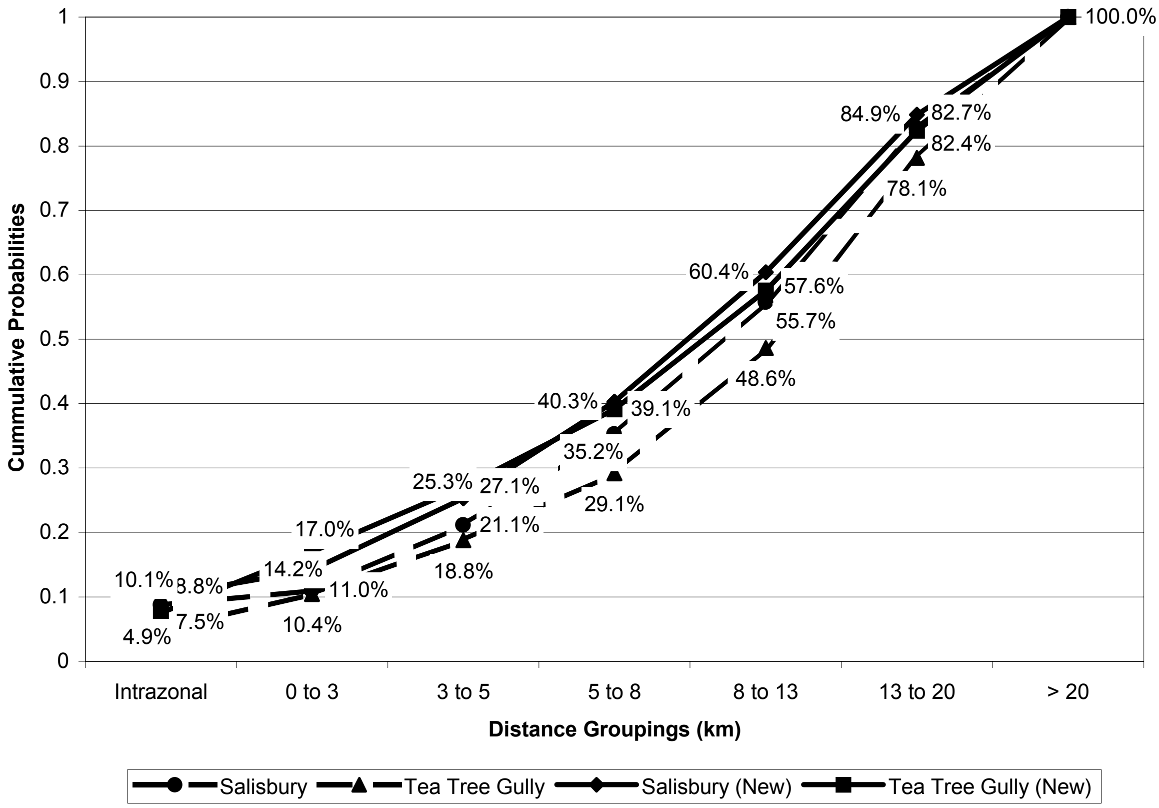

Figure 3. The Change in the Cumulative Probability Distribution Function for Travel to Locations for Work Before the Increase and After the Increase in Employment Opportunities around Salisbury and Tea Tree Gully in 1999

The reasons why the improvement in accessibility was far greater for Tea Tree Gully than for Salisbury was due to the employment opportunities in Tea Tree Gully being increased by a significantly greater factor than for Salisbury and there were fewer opportunities available within Tea Tree Gully relative to the number of labour force members residing there.

7. CONCLUSIONS

Accessibility was defined as the ease for individuals to participate in activities. The ease is influenced by five factors, namely: the individual; activities; destinations; transport modes; and time.

A number of methods used to calculate measures of accessibility that were supply-based as well as those that included demand were identified and discussed. It was found that no single measure can cater for all the issues associated with transport and urban planning. An accessibility framework was discussed which combines the strengths of some of the existing methods of calculating accessibility measures to develop a powerful and sophisticated accessibility framework for policy analysis and evaluation.

The accessibility framework determines the benefit or need for an individual or group of people to travel to an activity. The framework revolves around a hierarchy of decisions individuals make when deciding to participate in an activity. The benefits of binding the framework around behavioural models includes:

- incorporating the influence of the individual's behavioural characteristics by considering their socio-economic characteristics and the influence of time and space constraints on their travel behaviour;
- user benefit estimates obtained from available choice alternatives of individuals; and
- allowing for the various components of accessibility to be dissected.

The framework was used to evaluate a policy to increase the work opportunities for residents of the two neighbouring areas of Salisbury and Tea Tree Gully. It was found that the residents in these two areas had levels of accessibility to work opportunities less than the average for metropolitan Adelaide despite one fifth of the labour force market residing in the two areas. The policy showed that if implemented in 1999, the benefit to metropolitan Adelaide would equate to a little over $A3.5 million. The accessibility framework showed that a land-use policy can prove to be an effective means of improving accessibility and is a real option to consider instead of or in conjunction with transport related policies (which can also be evaluated by using this accessibility framework as shown in Primerano and Taylor, 2004).

8. FURTHER RESEARCH

Through the development and application of the accessibility framework to urban planning policies, a number of issues were identified. These issues are now discussed to progress towards an accessibility-based tool that can be used by planners to identify and improve levels of accessibility through land-use policies.

As mentioned earlier, the accessibility framework does not take into consideration the benefit obtained by the unemployed from an increase in work opportunities. The reason is that MAHTS99 from which the behavioural models were based upon was a revealed preference survey. This means that since those unemployed during the period of the survey would not have undertaken work-related travel, the MAHTS99 data does not show their travel patterns if they were employed. Hence, the travel patterns of the unemployed are completely independent of the work opportunities available. This is incorrect since if there was an increase in job opportunities, then one would expect that many of the new job opportunities made available (or job opportunities vacated by those obtaining the new job opportunities) would be obtained by the unemployed. This phenomenon alone would have large benefits not detected by the accessibility framework. Furthermore, the behavioural characteristics of the newly employed would be unknown and so the benefit of the location of the work opportunities would also be unknown. To remedy this problem, an additional stated preference survey is required where questions can be asked of the unemployed to ascertain the types of decisions they would make if their circumstances changed and they became employed. Such a stated preference survey would need to ask questions that would determine the type of employment they would seek, how far they would be prepared to travel for unemployment, the hours and duration they would likely or be prepared to work, and how would they travel to there place of employment.

During data preparation for the development of models, many assumptions were made due to data availability or to simplify the development of the models. In the case of the work-related behavioural models, the following aggregations were made:

- Employment types were split into being employed full-time or employed by other arrangement (ie. part-time or casual).
- The type of worker was split into three types: professionals (professionals and managers); tradespersons (including related areas of work); and all other employment types.
- Employment opportunities were considered equal.

The assumptions and aggregations made should be revisited and challenged to be more specific, particularly in regards to the employment opportunity types. Individual types and activity types can be further refined, particularly for work activities where the occupation type can be matched with the employment type offered at a location. This can provide greater power to the policy maker to further narrow down the target population for the policy and to provide relevant work opportunities.

The behavioural models were built using Multinomial Logit and Nested Logit models. Although useful, they satisfy the Independent from Irrelevant Alternatives (IIA) property, which is restrictive by making some unrealistic assumptions. There are a number of other behavioural choice models that aim to relax the assumptions governing Multinomial Logit models to introduce more realism into the behavioural models. These models include the Multinomial Probit and Mixed Logit models. The problem with these methods is that their formulation is not of a closed form and therefore do not have an inclusive value equivalent to these models, which was crucial in the development of the accessibility framework. There is a need to either determine an inclusive value equivalent to these models (ie. expand on the work by Ben-Akiva and Lerman (1978) which discusses the derivation of an inclusive value from Multinomial Probit models) or explore other methods for modeling travel patterns, as it is important from an accessibility-based policy evaluation perspective that travel patterns of the population are considered.

To make the concept of accessibility more usable by transport and urban planners, an accessibility-based planning tool implemented within a Geographical Information System (GIS) platform is required. Such a tool should allow planners to:

- Identify any transport and/or urban planning issues that are negatively impacting the social welfare of people and the viability of businesses;
- Create policies that target these issues and make change according to the objectives of the policies; and
- Evaluate these policies to determine their effectiveness in targeting the issues in question by showing the distribution of benefits throughout Adelaide and by showing that certain targets and objectives will be achieved.

Such a tool should also simplify policy implementation. In the case of the land-use policy evaluated in this paper, the policy could have been implemented by either physically creating a work-related land-use or adjusting the characteristics of the land-uses on land parcels within GIS. In a similar way, transport policies can be implemented making modifications to the transport system within GIS (Primerano and Taylor, 2004).

ACKNOWLEDGEMENTS

The authors would like to thank the Department of Transport and Urban Planning for providing the travel diary survey data. We would also like to thank Planning SA and GISCA for providing spatial datasets and to the staff from the Transport Planning Agency of the Department of Transport and Urban Planning for their support. We would also like to acknowledge the funding support provided by the Australian Research Council.

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