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COMPARING TRAVEL COST MODELS AND THE PRECISION OF THEIR CONSUMER SURPLUS ESTIMATES: ALBERT PARK AND MAROONDAH RESERVOIR

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Section 1: Introduction

Travel Cost models (TCMs) use data on costs incurred by visitors travelling to a park to infer their willingness to pay for the recreation facilities that the park offers. This enables estimation of the demand curve for recreation at the park and therefore provides an estimate of the recreational value of the park. This paper uses Travel Cost models to estimate the recreational values of Maroondah and Albert Parks, parks in Victoria, Australia.

We compare only the recreational values for Albert Park and Maroondah Reservoir as estimated by different forms of Travel Cost models. To estimate the total economic value of a park involves estimating use values and non-use values. While it is important to consider the total economic value that parks provide to the community, an estimate of recreational value alone is useful as a lower bound for a park's value. It would also be useful in providing a component of the total valuation of one of these parks, in comparing recreational values across parks and in assessing the trends of parks recreational values.

This study has useful policy implications in terms of approximating the recreational value that is placed on two parks in Melbourne. It also provides useful information for the comparison of an inner city park (Albert) and a regional park (Maroondah), in terms of total value and the pattern of visitation. The 'pattern of visitation' refers here to two of the properties that the demand curves for park recreation may reveal. These are the "pulling power" of a park, meaning that a park is unique or of special character or quality so that it 'pulls' relatively large proportions of its visitors from further distances. The other property referred to is the "proximity power" of a park, meaning that a park situated in a highly populated area is likely to have a high consumer surplus due to its convenient location, thus attracting large number of visitors from nearby.

The recreational value of Albert Park is found to be almost ten times that of Maroondah Reservoir, a possible indication of the superior proximity power of the inner city park. The greater pulling power of Maroondah Reservoir is demonstrated by its less steep Marshallian demand curve. Its visitors are less price sensitive.

The rest of the paper is organised as follows. Section 2 summarises the benefits from parks and gives a brief description of the two parks studied in this paper. Section 3 discusses the theoretical background behind travel cost models. Section 4 explains the methodology and the assumptions used to form these models. Section 5 presents the results and Section 6 provides a discussion and the limitations of the study. Section 7 concludes the paper.

Section 2.1: Benefits from Parks

Communities gain recreational benefits from parks through activities such as walking or hiking, picnicking, sightseeing, studying plants and animals, general relaxation, socialising and camping (Parks Victoria 1999). They also provide ecological benefits for, and resulting from, flora and fauna. The reservation of open space for the health and spiritual well being of people is another justification for parks (Ulph and Reynolds 1984).

The various benefits provided by parks are often grouped into direct and indirect benefits. Direct benefits can be categorised into use and non-use benefits. Direct benefits are obtained by actual visits to the park (use values) such as the physical challenges provided by a park and educational experiences. Direct benefits are also obtained via non-use values such as the knowledge that the park exists for the

Section 3.1: Theoretical Framework of Travel Cost Models

In travel cost models, the consumer is assumed to choose her visits to a park (v), just as she chooses a basket of other goods (x). Let P_0 be the cash-costs associated with a visit to the park (for example petrol costs) and assume x to be the numeraire. Also assume that the individual works L hours at a wage w to earn her income. Her utility maximisation problem is therefore to $\text{Max}_{x,v} U(x,v)$ subject to the budget constraint: $wL = x + P_0 v$.

Consider now the costs additional to the cash-costs born by the individual in visiting the park. Time must be spent travelling to and from the park and also at the park. Consider the individual has T hours of time to spend working or visiting parks. Where t_t is the travel time to and from the park and t_v is the time spent at the park, the individual faces the time constraint: $T = L + (t_t + t_v)v$.

Therefore the maximisation problem can be re-written as: $\text{Max}_{x,v} U(x,v)$ subject to $wT = x + (P_0 + w(t_t + t_v))v = x + P_v v$. Here Travel Cost (TC) is given by the price of the visit: $TC = P_0 + w(t_t + t_v) = P_v$.

This utility maximisation problem is standard except that the 'price' of a visit is considered not only in money spent but also in time.[3] Solving the above maximisation problem will yield a demand function for visits to the park for each individual i: $v_i = f(TC_i; X_{1i}, \ldots, X_{ni})$. This would form the basis of an Individual Travel Cost model. Here $X_1, \ldots, X_n$ are other socioeconomic variables that may be included in the model such as income, education, age, preferences and close

[3] This example shows time being valued at the wage rate (Kolstad 2000). However, as leisure time is unlikely to be viewed as interchangeable with work time on a one to one basis, and also due to the possibility of set salaries and contracts, time is unlikely to be valued at the full wage rate.

substitutes (Hanley and Spash 1993).[4] The individual travel cost method uses individual data separately but requires that visitors visit the park frequently in any one year. It is very data intensive. Additionally, as the data is generated by actual park visitors, the sample is self selected and is not a random sample of all possible visitors. This could, if left uncorrected in the modelling process, lead to a sampling bias.

Individuals are often grouped into 'zones' in which case the variables 'average travel cost per zone: TC_z' and 'visits per zone per year: v_z' are used in the regression analysis.

$$v_z = f(TC_z, X_{1z}, \ldots X_{nz})$$

Zonal TCMs divide the area around the site to be valued into 'zones of origin'. These zones might be concentric zones radiating from the site, or they might be 'local government administrative districts' such as suburbs, areas governed by the one local council, or postcodes. Zonal models may include socio-economic variables, averaged for zones. The dependant variable is the visits per year from zone z, per population of that zone (or trips per capita). The population levels of zones must be included in zonal models (Hanley and Spash 1993).[5] This method implicitly assumes that all visitors from each zone have the same probability of visiting and the same travel cost. There is little consensus in the literature as to which method (zonal or individual) is theoretically preferable. Only zonal methods are used in this study due to limitations on available data (zonal methods have less data requisites).

Once the functional relationship has been estimated using survey data, it is used to estimate other points on the demand curve:

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[4]The quantity of a good demanded is generally considered to be a function of the quality of the good, the price and availability of substitutes, the price and availability of compliments and even weather conditions in addition to the socio-economic variables described above (Ward and Beal 2000). These variables could all be incorporated in the X's.

[5] For a more detailed description of the zonal model used see Section 4.

$Q = f(P_v, X_1,...X_n)$

Where, $Q = \sum_{z=1}^{N} V_z$ (the estimated total number of visits per year to the park), and

P_v = TC + hypothetical "entry price". By varying the hypothetical "entry price" (and thus P_v), and using the functional relationship determined by $Q = f(P_v, X_1,...X_n)$, Q can be estimated for varying prices.

This is the process by which the entire Marshallian or normal demand curve is derived (Gillespie 1997). This Marshallian demand curve predicts how the total number of visits would change if the costs of visiting the park changed. Rational individuals will weigh up the recreational benefits against the costs of that recreation and will visit the park only if the net value of the visit is positive.

The basic principal for the valuation provided by the TCM is consumer surplus. An individuals consumer surplus is the amount she would be willing to pay less the amount she actually pays to visit the park. The total consumer surplus of the park is the sum of individual consumer surpluses. It follows that the area under the Marshallian demand curve is the estimated consumer surplus. If the park has no entry fee then the area under the demand curve gives the economic benefit to consumers from visiting the park.

Section 3.2: Issues in Travel Cost Models

Some issues that arise in the literature associated with travel cost methods include the treatment of time, multiple destinations, substitute activities, the choice of functional form and user demographics. McConnell 1975 and Cesario 1978 posited that the time taken to travel to the park is an important cost variable in determining demand. If time costs are not included in the TCM, the demand curve will be biased downward (as the travel cost used is less than its true value) and consumer surplus estimates will be conservative (Cesario 1978). The practice of including time cost in travel cost considerations is now widely accepted.[6] Therefore this study assumes that time spent travelling to both Albert and Maroondah parks is 'costly' to individuals and should be included in the travel cost variable.

The choice of a value for the cost of time is an arbitrary one. Including time costs in the model adds the same problem that is involved in valuing parks themselves, that is time has no conventional market price and varies between individuals and situations. A conventionally agreed upon method of accounting for these time costs in the literature has been through the use of a fixed proportion of the persons wage rate. However that proportion is arbitrary. Studies in the 1960's and 1970's to value travel time by American transportation planners indicated the figure was between 1/4 to 1/2 the wage rate (Cesario 1978). Read Sturgess 1999 used 25% of the average wage in their study on Victorian Parks. The same value for time is adopted in this study.

Multipurpose trips have created uncertainty and disagreement in the literature. If a park visit is a smaller part of a large trip, involving other beneficial activities, the proportion of the total travel costs to be allocated to each trip is unclear. There is no single accepted method of allocating costs between visits, it remains an arbitrary decision. In her study of Hinchinbrook Island, Shoeckl 1993 allocated costs according to the time spent on the island as a proportion of the total time spent at sites

[6] Walsh, Sanders and McKean 1990 raise the point that travel to and from a site may be beneficial and be a complement to the park visit (some people enjoy the drive). This assumption seems unlikely to hold for Albert Park, as there are few if any people who enjoy driving in the city. However, for Maroondah Park, those driving from country areas may value the trip itself. Nevertheless, as Maroondah is within close proximity to the Melbourne metropolitan area, the assumption of costly travel time was considered appropriate. According to McConnell 1975 the time spent at the park should

nominated by visitors as being important to their trip (Bennet 1995). Bennet divided the total cost of a trip according to visitors stated relative importance of the different destinations visited. Read Sturgess 1999 did not have the data available to use either of these methods and so attempted to 'guess' the likely extent of multiple destination trips per zone. They found that there was a strong tendency for the proportion of destinations per trip to increase with the distance traveled and so formed the proportions for the two zonal models (Melbourne and Non-Melbourne) shown in Tables 1a and 1b.

Due to the existence of multiple destinations in data, applying the entire consumer surplus estimated by the TCM for a park overestimates the recreational value of the park. Hanley and Spash 1993 suggest that "meanderers" be excluded from the TCM. Therefore the visitors with very large travel costs and extremely high probabilities of visiting many other destinations on their trip were removed from the data because (considering the limited reputations of both the parks) it is unlikely that the parks would have played a major role in their decision to travel.

There are a number of functional forms that are consistent with economic theory. The linear form is most commonly estimated (Ward and Beal 2000), however there are many examples of other functional forms being used. Choosing the linear form implies that as travel costs increase visits per year decrease by a constant amount. Other forms often used include the quadratic, reciprocal, linear-log, log-linear and the double log forms. The double log form is commonly used as it accounts for extreme values (Ward and Beal 2000). Beal 1995 chose to use the double log form in her TCM of Carnarvon Gorge. In the double log functional relationship as travel costs

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also be taken into consideration. However, time spent at a park is presumably positively regarded and so time spent at the park was not considered costly.

increase from zero, visits fall (assuming the coefficient on travel costs is negative) at a decreasing rate. The coefficient on the travel costs variable measures the elasticity of visits with respect to travel costs.

The Kakadu study (Ward and Beal 2000) used reciprocal form and rejected double log. As travel costs increase indefinitely, their inverse approaches zero and visits approach an asymptotic or limiting value given by the constant in the regression equation. This implies that visits per year will never fall below this limiting value, which if above zero may not be a realistic outcome. Allen, Stevens and Barrett 1981 adopt the linear log form for their TCM. The linear log functional form is useful where there is an interest in studying an absolute change in visits for a percentage change in travel costs. Christiansen 1997 tested a linear and a double log functional form and preferred the double log. This paper assesses all these functional forms.

The only control variable used in this paper is the travel cost. Other control variables that could have been used include the average zonal: income; age; substitutes' prices; education; preferences etc. These variables were not used because visitors did not report on these variables in the surveys used by this study. If variables are constant across the relevant sample population they will be incorporated in a 'constant' in the demand equation, and therefore do not need to be included as their values do not change (Ward and Beal 2000). It is likely that the average values of the many of these variables would not have shown enough variation across zones to be of use in the model. This is more likely in the concentric zone TCMs than in the postcode TCMs.

One of the aims of this study was to provide results enabling comparison between these methods and so it was considered appropriate to use the same control variables for all methods.[7] As a result an implicit assumption in this and many other TCMs is that the visitors utility function is "separable" in the park recreation. That is the demand for visits to the park can be estimated independently of demand for other goods (Hanley and Spash 1993).

Caulkins, Bishop and Bouwes 1986 found that by leaving out the prices of substitutes to visits to the one park caused the slope of the estimated demand curve to be biased. However the issue is complicated as relevant substitutes may vary with visitors personal preferences. Substitute prices were omitted from this study for the same reasons as other control variables.

Many studies argue that the costs used in a TCM should be consumers perceived costs rather than the actual costs (for example, Seller, Stoll and Chavas 1985, Beal and Ward 2000). It has been argued by Seller, Stoll and Chavas 1985 that this cost is the cost of petrol only. However many studies, have used the cost of petrol plus insurance, depreciation and maintenance costs, in calculating the cost associated with visiting a park. This study assumes that these extra costs are generally not relevant to park visitor decisions and so excludes them from analysis. Hanley and Spash 1993 also agree that this is the more attractive option .

Struck by how sensitive CS estimations can be to the functional form specified by TCMs, Chotikapanich and Griffiths 1998 believe that it is important to have an appreciation of the reliability of any estimate of value. They suggest that an indicator of reliability is obtained from the "standard error and a consequent interval estimate". This is known as the confidence interval (CI) of the estimate. A CI is calculated using

[7] Another motivation for this study was to allow future comparison of the results of this study with those of the Read Sturgess 1999 study, which did not include other control variables.

the standard error associated with the value for which a CI is being obtained. For example, where v is estimated from a regression based on the equation:

$$v_i = f(TC_i; X_{1i}, \ldots, X_{ni})$$

The standard error can be used to construct a Confidence Interval for the estimation of v. This is done according to the relationship:

$$\Pr\left[v' - (2 \times SE) \leq v \geq v' + (2 \times SE)\right] \approx 95\%$$

Where Pr stands for probability and v' the estimated value for v which is the true value. SE is the standard error for the regression used to obtain v' (Gleitman 1991). A CI can be interpreted as meaning that in the long run in 95 out of 100 cases the CI will contain the true value. In this study the confidence interval is estimated for the functional form equations, so that there are three equations used to calculate three Marshallian demand equations which are then used to give three CS estimates, i.e.:

$$v_z = f(TC_z)$$
$$v_{z,upper} = f(TC_z) + 2 \times SE$$
$$v_{z,lower} = f(TC_z) - 2 \times SE$$

These are used to derive:

$$Q = g(P) = f(v_z)$$
$$Q_{upper} = f(v_{z,upper})$$
$$Q_{lower} = f(v_{z,lower})$$

which give: CS, CS_{upper} and CS_{lower}

Section 4: Methodology

The data were obtained from Parks Victoria surveys conducted over the period 1997 to 1999. The data were combined to provide a larger sample size. The surveys were conducted by interviewers, generally in summer and often on Sundays. Over the three survey periods (each year the survey was different) between 5 and 15 questions were asked of the respondents. The only information from these surveys that this study uses is the visitors' postcode, obtained by asking the question: 'Can I please have your home postcode?'[8]

The two basic types of methods used for the TCMs in this study are referred to as 'concentric ring zonal' and 'postcode' models. They are both different applications of the zonal TCM discussed previously, with the postcode model being more dis-aggregative than the concentric ring zonal model. There are two concentric ring zonal models used in this study, the 'city zone' and the 'regional zone'. Only the city zone model was used for Albert Park, as the 'regional zone' contained a large number of non-visit zones (from distances far from the park) and was therefore not considered useful. For Maroondah Reservoir, both the city and regional zones were used in order to compare differences in the Consumer Surplus derived from using different sized zones. In order to aggregate the data into zones, each respondent was allocated to a zone according to the distance that they must travel to visit the park calculated using their stated postcode of origin. The zones used in the city and regional methods are shown in Table 2.

This resulted in a sample size of ten zones. The aggregated zonal data was used to determine the appropriate functional form and the consequent Marshallian demand curve and corresponding Consumer Surplus estimates. For zonal models, the travel costs for all the postcodes in a zone were averaged, and the estimated travel cost per zone was assumed to be the average of the actual travel costs per zone. The

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[8] Other questions asked in the survey were concerning the size of the group the visitor was a part of, how often the visitor visited the park, how the visitor enjoyed her visit, the purpose of the visit etc.

populations per zone were calculated by summing the populations of all postcode areas in that zone.

The 'postcode' method uses each postcode as a separate zone and therefore has many more zones, or data points, to be used in the regression analysis than the city and regional zone models. The postcode method was used for both Albert Park and Maroondah Reservoir. In this method visitors from any one postcode area are grouped together, their travel costs calculated and the dependent variable, V_z, is the visits per 1000 population to the park per annum predicted by residents from that postcode area. Chotikapanich and Griffiths 1998 believe that zonal models with relatively few zones result in a loss of information due to their aggregation of the data. They suggest that a method that utilised single observations may yield more precise estimates.

This study uses this 'postcode' method to assess whether utilising the single observations (which does involve an aggregation of data into postcode groups, but this is far less of an aggregation than with the other zonal methods used) causes the precision of the TCM to increase as measured by the relevant Confidence Interval.

Distance traveled to the park was calculated by first using straight-line distances from the centroid of the visitors' postcode origin to the centroid of each park. The return distance was then increased by 30 percent (allowing for roads not existing in a straight line to the park). The petrol cost per visitor from each zone was constructed by multiplying the true distance by the RACV petrol cost estimate for that period which is 9.52 cents per km, and dividing this figure by 2.7 (the average number of occupants per car visiting the parks, as determined by Parks Victoria). Time spent travelling was calculated by dividing the true distance by the speed traveled. Average travel speeds of 40 km per hour for city travel and 80 km/hour for country travel were used. Time cost was calculated by multiplying the time spent travelling by $4.80 (one quarter of average wage rate). Total travel cost was estimated by adding petrol cost to time cost.

Visits per 1000 postcode or zone population per year (v_z) were calculated by dividing the total number of visitors in the sample from a particular zone (n_z) by the total number of visitors in the sample (v_t) (who visited from different zones and were surveyed). This gives the proportion of park visitors from each zone. This proportion was then multiplied by the estimated total number of visitors to the park per year (T), (where T = 3,000,000 for Albert Park and 204,850 for Maroondah Reservoir). This gives the estimated visits for each zone per year. This figure was divided by the relevant population for each zone (Pop_z) and then multiplied by 1000 to give v_z, the estimated visits per year per thousand population for each zone as depicted below. Figures for the postcode populations (1996) were obtained from the Australian Bureau of Statistics.

$$v_z = \left[\left(\frac{n_z}{v_t}\right)T\right] * 1000 / Pop_z$$

The estimated total number of visitors to the park per year (T) were obtained from Parks Victoria 1998. The figure for Albert Park included visitors to the sporting and club facilities. These visitors are not included in the data used in this study. It was therefore necessary to reduce the figure for Albert Park by what was in the end, despite discussions with Parks Victoria, an arbitrary amount of 1,293,310 visitors. The Read Sturgess 1999 study did not account for this difference between formal and informal recreation values, this should be taken account of in any future comparison between the results of this study with theirs.

The regression equation uses visits v as the dependent variable and Travel Cost TC as the independent variable. Dummy variables for the years 1997 through to 1999 were included in the regression but were generally insignificant and so the data for the separate years were combined into one sample. After testing models for heteroskedasticity and using Robust (Whites corrected) standard errors and covariances if it was present, the two or three best functional forms for each park and method were chosen. As the theory behind the park's visitation is not strong enough to suggest one particular functional form, the question of which functional form to choose becomes essentially an empirical one. It is important to note that in order to compare the adjusted R squared values for different functional forms the dependent variable must be the same. As the double log and log linear functional form dependent variable is different to the other functional forms tested, a transformation is necessary in order to obtain comparable R squared, Akaike and Schwarz values. This was done by estimating the log of visits using OLS regressions, obtaining the antilog values of the estimated values of log of visits and then computing the R squared value between the antilog values and the actual visits values. This R squared value is comparable with the R squared values from models with the linear dependent variable. The t-tests for variable significance, observation of scatter diagrams, the adjusted R squared, Schwarz and Akaike Criterion values were all considered in choosing functional forms for each of the TCMs (see Tables 3 to 7).

For each functional form chosen, a forecast of the model was obtained in addition to the corresponding standard error for each zone. The standard errors were used to create the Confidence Interval for the estimated equation. The estimated equation and its upper and lower Confidence Interval limit were then used to determine the Marshallian demand curve as discussed previously.

The Marshallian demand curve was estimated by adding various hypothetical entry prices (0, 5, 10, 15, 20, 30, 40, 50, 70, 80 and 100) to the travel costs.[9] The previously estimated equation was then used to determine the estimated visitors per thousand-zone population per year at each entry price. These figures were multiplied by the relevant zone population divided by 1000, which gave the total visitors predicted at that hypothetical entry price from each zone. Due to the fact that in reality there can not be a negative number of visits to a park, any negative values derived by this process were given a zero value. By summing all of the estimated visits for each zone in the model the overall annual total visits to the park is obtained (Q). Plotting Q against the hypothetical entry price (P), gives the Marshallian demand curve. This process was done for the estimated equation, and its upper and lower Confidence Interval bounds.

The consumer surplus estimates were obtained by calculating the area under the actual curves shown in the results section. The curve was divided into a series of smaller triangles and rectangles whose areas were calculated and summed to give the estimated consumer surplus per year (see Figure 1). This was also done for the upper and lower Confidence Interval Marshallian demand curves to give upper and lower confidence levels of consumer surplus estimates per year.[10]

[9] A maximum entry price of $100 was set as an upper bound. This was considered necessary as some of the functional forms result in Marshallian demand curves that never cross the X-axis and so would result in infinite CS estimates if there was no upper limit set.

[10] For example, the CS under a segment of a demand curve with the (P,Q) coefficients (5, 100), (10, 75) and (20, 25) was obtained by adding the areas of the two triangles and the two rectangles, where triangle areas are given by the formula base by height over two, and rectangle areas are given by base by height. The area of the segment shown in Figure 1 was calculated as:

Section 5: Results

The consumer surplus estimates per year vary considerably depending on which method of TCM is used. For example, TCMs for Maroondah Reservoir arrive at Consumer Surplus values of $2.2 and $2.3 million per year using the regional zone method, $1.5 and $1.9 million using the city zone method and from $8 to $108 million depending on the choice of functional form for the postcode method. The Albert Park methods are not quite so distinguished from one another, with the city zone method Consumer Surplus per year estimates ranging from $12 to $23 million and $77 to $317 for the postcode method (see Table 8).

Comparing like methods and functional forms across the parks it is clear that the Consumer Surplus for Albert Park is considerably larger than that for Maroondah Reservoir. In fact, Consumer Surplus estimates for Albert Park are usually an order of magnitude higher than that for Maroondah Reservoir. For both parks the Confidence Intervals are very large, indicating that little confidence should be placed on the actual CS estimates (see Table 8).

Examining the CI ranges for both parks we find that the double log regional zone model is the most precise for Maroondah Reservoir and the double log city zone model gives the most precise CS estimate for Albert Park. The Albert Park double log city zone TCM has an adjusted R squared value of 0.98, meaning that 98 percent of the log of V_z can be explained by the log of TC_z. The TC_z variable is significant at the 5 percent level and the Schwarz and Akaike criterion are relatively small, indicating that the estimated equation has relatively good predictive power (see Table 3). About 99 percent of V_z in the Maroondah Reservoir double log regional zone model is explained by TC_z, and the predictive power of the estimated equation is again good.

CS = ((100-75).(10-5)/2) + ((75-25).(20-10)/2) + (25.(20-10)) + (75.(10-5)) = 937.5

As a result of the findings above the "best" estimates for Consumer Surplus, or the recreational value of each of the parks by this study are: $19.2 million for Albert Park and $2.2 million for Maroondah Reservoir.

Albert Park draws many more visitors per year, as expected, because of its central location. As travel costs increase the park attracts fewer visitors. Thus it appears that Albert Park has a larger "proximity power" than Maroondah Reservoir (seen by the difference in numbers of visitors), but less "pulling power".

The steeper slope of the Albert Park Marshallian demand curve in Figure 2 (from the chosen double log city zone TCM) reflects the fact that the demand for Albert Park is considerably reduced by an increase in price. As seen in Figure 3, Maroondah Park does not exhibit the same trend in demand. This is again due to the "pulling" power of Maroondah Reservoir, which may be greater because it has less available close substitutes than Albert Park.

The functional form chosen can influence the estimate of consumer surplus derived, as Gillespie 1997 notes, in his study on the Minnamurra Rainforest Center where a linear specification resulted in 13 percent to 28 percent higher consumer surplus estimates than did a log linear specification. Hanley and Spash 1993 found that Consumer Surplus estimated using the linear log and log linear functional forms were greater than that estimated with a double log form. There was no such obvious trend in the results of this study. For linear, linear log and reciprocal models Chotikapanich and Griffiths 1998 found that zero was contained in the CI, illustrating the considerable unreliability of CS estimates. The only model for which this was observed for in this study was the postcode linear log TCM for Albert Park (see Table 8).

For Albert Park city zone and postcode models and for Maroondah Reservoir's regional zone and postcode model the double log functional form result in the lowest Confidence Interval, thus the most precise Consumer Surplus estimates of the functional forms used for those models. The double log form for the Maroondah city zone model was extremely imprecise but as will be discussed in the following section, the city zone model was not found to be suitable for Maroondah Reservoir.

Concentric zonal models provide consumer surplus estimates with more precision than postcode models. It was thought that the loss of information due to aggregation of data into fewer zones may cause a loss of precision. However the opposite was observed (see Confidence Intervals in Table 8). There are a number of reasons why this may be the case. The loss of information may not be such a problem because the TCM is interested in total visitors to the park rather than visitors from many different areas. The aggregation of the data into 10 concentric ring zones greatly reduces the effect of outliers.

The zonal method used in this study also eliminates the zero visit problem that exists with postcode methods. There are many postcodes within proximity to the parks from which there were no visitors to the park. This created a bias in the postcode model as these postcodes were not included in the model. This meant that a visitor from a postcode with a small population a fair distance from the park was given a great deal more weight than a visitor from a postcode with a larger population. The result is a bias toward visitors with higher travel costs which increases the Consumer Surplus estimate. The higher Consumer Surplus estimates using the postcode method are obvious in Table 8. This bias decreases the precision of the postcode model. Zonal models lessen this selection bias by including the populations of all postcodes in the zone.

The specification bias due to the omission of control variables other than travel cost (for reasons discussed previously) is likely to be larger in postcode models than the concentric zone models, because the demographic variables are more likely to vary between the many and smaller postcodes than between the large concentric zones.

The Confidence Interval range is highly variable within the city zone method for Maroondah Reservoir (compared to other TCM methods for both parks, see Table 8) which, when considered in addition to the lower adjusted R squared values and higher Akaike and Schwarz criterion values leads to the conclusion that the city zones are less suitably applied to Maroondah Reservoir than the regional zones.

Using the data available for this study it was found that the city zone method was the most appropriate for the estimation of the recreational value of Albert Park, and the regional zone method for Maroondah Reservoir. However, there may be situations when the postcode method is more appropriate. These include when other data such as income, substitutes, preferences, education and age is available and when there is enough survey data that most postcodes in the sample area have at least one visit to the park recorded. This will increase the precision of the postcode method.

Section 6: Discussion

This study has used confidence intervals as the major tool to assess the precision of the Consumer Surplus estimates. The Confidence Intervals used are estimated using the standard errors from the OLS estimation of various functional form equations. Therefore they do not include errors from sampling and inaccurate assumptions in the model (such as incorrect estimates of the total visits per year to the parks or of time costs).

The surveys used in this study were generally conducted on Sundays and early in the year. This is likely to have biased estimates upwards as it may be the case that a higher proportion of midweek visitors live nearby compared to weekend visitors. To overcome this bias, future studies could take samples from different periods throughout the year, as was done in Gillespie 1997's TCM of the Minnamurra Rainforest Centre.

One of the problems with TCMs is that those who live close to the park may have chosen to do so in order to reduce travel cost and time required to visit the park. Therefore the travel cost estimated by TCMs underestimates the true amount that visitors who have deliberately chosen to live close to the park for its recreational benefits have actually paid for their visits to the park (Lockwood and Tracy 1995).

There may also be a strategic bias in the TCMs due to three different surveys being used in the sample and the type of visitors likely to respond to the surveys etc. There is also likely to be a mis-specification bias due to respondents reporting their home postcode rather the postcode from which they decided to travel to make the trip (for example, they may have been staying with friends). In addition the omission of overseas visitor will introduce a bias into the study and consumer surplus is likely to be underestimated (Beal 1995).

It may be that the problems associated with multiple destinations are greater than allowed for in the models due to the close proximity of Maroondah Park to Healesville Sanctuary and Albert Park to the formal recreation facilities, restaurants and workplaces.

Section 7: Conclusion

The recreational value for Albert Park is estimated to be almost ten times the value of Maroondah Reservoir. This is due to the proximity power of Albert Park. Many residents live near-by and there are many other possible compliments to a park visit close by, such as shops, restaurants and formal sporting facilities. The less steep Marshallian Demand curves demonstrates the superior pulling power of Maroondah Reservoir compared to Albert Park. This is due to Maroondah Reservoir's uniqueness such that it draws visitors from further distances.

Despite the fact that use values are only one of the types of benefits that parks provide, a tangible economic estimate of their value is an important step in order to aid government policy and strategic direction, to guide government resource allocation, and to begin monitoring changes over time. Ward and Beal 2000 rightly argue that the travel cost method is one of the few techniques that is available for estimating some of the values of these natural environments that allows them to consistently be compared with competing values.

This study has found that the Consumer Surplus estimates provided by zonal TCMs depend greatly on the zones used and on the choice of functional form. Using 95% confidence intervals it was found that the most precise models were the zonal models utilising concentric ring zones around the park rather than individual postcodes as zones. The choice of concentric ring zones could be made with the help of the estimates (such as the significance of variables, adjusted R squared, Akaike and Schwarz Criterion), and the Confidence Interval range of the corresponding Consumer Surplus estimation. This study found that the double log functional form generally resulted in the most precise Consumer Surplus estimates.

There continues to be much debate over many of the issues involved in measuring recreational benefits using travel cost methods. Studies such as this will help decipher why different kinds of travel cost models differ and therefore how models may be improved. For governments and individuals to give weight to the CS estimates provided by TCMs and thereby adopt them into policy decisions, TCMs must be credible. More TCM studies and discussions will help to increase the breadth and depth of knowledge about TCMs and help increase their precision and therefore credibility. TCM studies in different parks using different methods and assumptions are essential in order to refine and increase the robustness of this method, and to increase the understanding of its capabilities and limitations.[11]

[11] Read Sturgess 1999 undertook an assessment of the recreational values of approximately 150 parks including Albert Park and Maroondah Reservoir throughout Victoria using TCMs for the Department of Natural Resources and the Environment (DNRE). While the data used in this paper, provided by Parks Victoria, is not the same data used by Read Sturgess 1999 and where appropriate, different assumptions were made and different methodologies used, Parks Victoria expressed an interest in the comparison of the Consumer Surplus estimates obtained by this study and those obtained by Read Sturgess 1999. As the Read Sturgess 1999 study has not been released, it was not used in its entirety as a resource for this paper. A copy of chapter two which covers the "methodologies for assessment of recreational values" was provided for our use, and is quoted in this study. However results for individual parks were not available and so are not compared with the results in this paper. This is left for future research.

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Tables

Table 1a)
Multiple Destinations for City Parks Parks

Zone	Distance	% V	Av dest
1	5	100	1
2	9	100	1
3	13	100	1
4	17	100	1
5	21	100	1
6	25	100	1
7	50	100	1
8	100	90	1.1
9	250	70	1.43
10	250+	50	2

Table 1b)
Multiple Destinations for Regional

Zone	Distance	%V	Av dest
1	50	100	1
2	100	100	1
3	150	90	1.1
4	200	80	1.25
5	250	70	1.43
6	300	60	1.67
7	800	50	2
8	1300	40	2.5
9	1800	30	3.3
10	1800+	20	5

Note: %V refers to the percentage of recreational value of the trip belonging to the park, Av dest refers to the implied average number of destinations per trip and distance refers to the maximum distance from the park for that zone.

Table 2
Distances used for zones

Zone Number	City Zone (km)	Regional Zone (km)
1	0 to 5	0 to 50
2	5 to 9	50 to 100
3	9 to 13	100 to 150
4	13 to 17	150 to 200
5	17 to 21	200 to 250
6	21 to 25	250 to 300
7	25 to 50	300 to 800
8	50 to 100	800 to 1300
9	100 to 250	1300 to 1800
10	> 250	> 1800

Table 3 **Estimated equations to fit the Albert Park city zone data**

Equations tested: **Albert City Zone**					
linear			adjusted Rsq	Akaike	Schwarz
no heteroskedasticity (white test Pr 0.359)					
V =	**1888.75 -**	**36.06277TC**			
tstats	1.905895	-1.083057	0.018861	18.62399	18.6845
prob	0.0931	0.3103			
double log			adjusted Rsq	Akaike	Schwarz
heteroskedasticty (white test Pr 0.0077)					
LV =	**9.292445 -**	**1.761476LTC**			
tstats	17.05182	-5.200087	0.981883	14.54991	14.58017
prob	0	0.0008			
linear-log			adjusted Rsq	Akaike	Schwarz
heteroskedasticity (white test Pr 0.0097)					
V =	**4334.657 -**	**1414.432LTC**	0.503717	17.94242	18.00293
tstats	2.318552	-2.032555			
prob	0.049	0.0766			
log-linear			adjusted Rsq	Akaike	Schwarz
no heteroskedasticity (white test Pr 0.822)					
LV =	**7.082942 -**	**0.09004TC**	0.385449	18.07395	18.10420
tstats	15.4754	-5.855255			
prob	0	0.0004			
reciprocal			adjusted Rsq	Akaike	Schwarz
no heteroskedasticty (white test Pr 0.860)					
V =	**-433.405 +**	**7133.367/TC**	0.989173	14.11728	14.1778
tstats	-4.34365	28.69286			
prob	0.0025	0			

Where: V = visits per thousand population, lv = the natural log of V; and
TC = travel costs (petrol costs plus time), ltc = the natural log of TC; and
Heteroskedasticity was tested for at the 5% level and where found corrected for using Whites heteroskedasticity-consistent standard errors and covariance. Unless otherwise stated assume no heteroskedasticity is present.

Table 4 **Estimated equations to fit the Albert Park postcode data**

(Note that negative adjusted Rsq are possible as they are not pure Rsq, but adjusted)

Equations tested:		**Albert postcodes**			
linear			adjusted Rsq	Akaike	Schwarz
V =	**4.163.493 -**	**8.897534TC**	-0.00039	20.46273	20.49174
tstats	8.130585	-0.246781			
prob	0	0.8053			
double log			adjusted Rsq	Akaike	Schwarz
heteroskedasticity (white test Pr 0)					
LV =	**8.360917 -**	**0.455516LTC**	0.350897	20.02326	20.03776
prob	60.32802	-4.851302			
tstats	0	0			
Log-linear			adjusted Rsq	Akaike	Schwarz
no heteroskedasticity (white test Pr 0.721)					
LV =	**7.67378 +**	**0.000407TC**	-0.000099	20.45475	20.46926
tstats	98.58644	0.077838			
prob	0	0.9409			
Linear-log			adjusted Rsq	Akaike	Schwarz
heteroskedasticity (white test Pr 0)					
V =	**8706.769 -**	**3070.745LTC**	0.214659	20.22135	20.25035
tstats	6.192832	-3.764372			
prob	0	0.0002			
Reciprocal			adjusted Rsq	Akaike	Schwarz
heteroskedasticity (white test Pr 0.0001)					
V =	**423.8839 +**	**9583.865/TC**	0.619851	19.49579	19.5248
tstats	1.146891	9.163499			
Prob	0.2526	0			

Table 5 Estimated equations to fit the Maroondah Reservoir city zone data

Equations tested: (All with no heteroskedasticity)		Maroondah reservoir City Zone			
Linear			adjusted Rsq	akaike	schwarz
V =	**664.5126 -**	**15.53132TC**			
Tstats	1.861316	-1.16238	0.047765	16.30579	16.32565
Prob	0.112	0.2892			
double log			adjusted Rsq	akaike	schwarz
LV =	**6.345351 -**	**1.391961LTC**			
Tstats	5.56177	-3.22554	0.937274	13.48991	13.49984
Prob	0.0014	0.018			
linear-log			adjusted Rsq	akaike	schwarz
V =	**1075.33 -**	**357.9859LTC**			
	5.7433	-5.05479	0.778137	14.84904	14.8689
	0.0012	0.0023			
log-linear			adjusted Rsq	akaike	schwarz
LV =	**6.372745 -**	**0.15209TC**			
	12.44207	-7.93393	0.612243	15.31151	15.32144
	0	0.0002			
Reciprocal			adjusted Rsq	akaike	schwarz
V =	**90.51744 +**	**241.5044/TC**			
	1.47138	12.53766	0.957106	13.20571	13.22557
	0.1916	0			

Table 6 Estimated equations to fit Maroondah Reservoir regional zone data

Equations estimated	Maroondah Regional Zone				
Linear:			Adjusted Rsq	Akaike	Schwarz
No heteroskedasticity					
V =	**91.41408 -**	**1.752389TC**			
tstats	3.345345	-2.6151	0.538692	9.992558	9.85617
prob	0.0287	0.0591			
Double log			Adjusted Rsq	Akaike	Schwarz
No heteroskedasticity					
LV =	**9.026421 -**	**1.977159LTC**			
tstats	7.194213	-5.47266	0.994814	5.327252	5.292545
prob	0.002	0.0054			
Linear-log			Adjusted Rsq	Akaike	Schwarz
No heteroskedasticity					
V =	**216.5928 -**	**55.44944LTC**			
tstats	5.331712	-4.74034	0.811113	9.032669	8.963255
prob	0.006	0.009			
Log-linear			Adjusted Rsq	Akaike	Schwarz
No heteroskedasticity					
LV =	**4.787659 -**	**0.068669TC**			
tstats	6.67061	-3.9015	0.913835	8.137592	8.102885
prob	0.0026	0.0175			
Reciprocal			Adjusted Rsq	Akaike	Schwarz
No heteroskedasticity					
V =	**-21.8347 +**	**1152.199/TC**			
tstats	-4.29988	12.58049	0.969187	7.219458	7.150045
prob	0.0126	0.0002			

Table 7 Estimated equations to fit the Maroondah Reservoir postcode data

Equations estimated:	Maroondah postcode				
linear			Adjusted Rsq	Akaike	Schwarz
No heteroskedasticity					
V =	**371.1485 -**	**8.234347TC**			
tstats	4.712992	-1.79034	0.007652	15.69636	15.72186
prob	0	0.0745			
Double log			Adjusted Rsq	Akaike	Schwarz
heteroskedasticity (white test Pr 0.0397)					
LV =	**6.416792 -**	**0.615739LTC**			
tstats	32.5454	-7.83729	0.116555	15.57665	15.58940
prob	0	0			
Linear-log			Adjusted Rsq	Akaike	Schwarz
No heteroskedasticity					
V =	**1043.801 -**	**310.3717LTC**			
tstats	7.700178	-6.08433	0.111854	15.58543	15.61093
prob	0	0			
Log-linear			Adjusted Rsq	Akaike	Schwarz
heteroskedasticity (white test Pr 0)					
LV =	**5.266124 -**	**0.028446TC**			
tstats	28.02654	-2.28198	0.020820	15.67954	15.69229
prob	0	0.0232			
Reciprocal			Adjusted Rsq	Akaike	Schwarz
no heteroskedasticity					
V =	**204.598 +**	**237.6227/TC**			
tstats	5.885206	6.312599	0.119591	15.57668	15.60218
prob	0	0			

Table 8 Consumer Surplus and Confidence Interval Estimates

	Functional form	CS estimate ($pa)	95% Confidence Interval		Range	Rank
			upper limit	lower limit		
Albert Park Postcodes Model	double log	317698613	1969594515	51250493	1918344023	4
	linear log	76646393	3557280008	0	3557280008	5
	reciprocal	295189025	3587600873	4133818	3583467055	6
Albert Park City Zone Model	**double log**	**19225628**	**156714205**	**2513070**	**154201135**	1
	log linear	23045298	256574500	2074305	254500195	2
	reciprocal	11605410	278045435	5102645	272942790	3
Maroondah Postcodes	double log	28163478	157546490	5035913	152510578	5
	linear log	8197618	496975963	30505	496945458	6
	reciprocal	108900565	714771228	50476	714720752	7
Maroondah City Zone models	double log	1867333	317801753	12730	317789023	4
	log linear	1488893	15117625	146773	14970853	2
Maroondah Regional Zone models	**double log**	**2210488**	**9719245**	**510268**	**9208978**	1
	log linear	2297273	15482435	343158	15139278	3

FIGURES

Figure 1

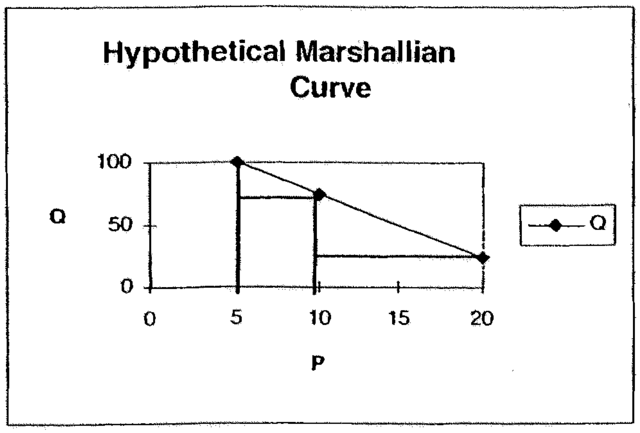


Figure 2 Albert Park Marshallian Demand Curve constructed using the double log functional form and the city zone model

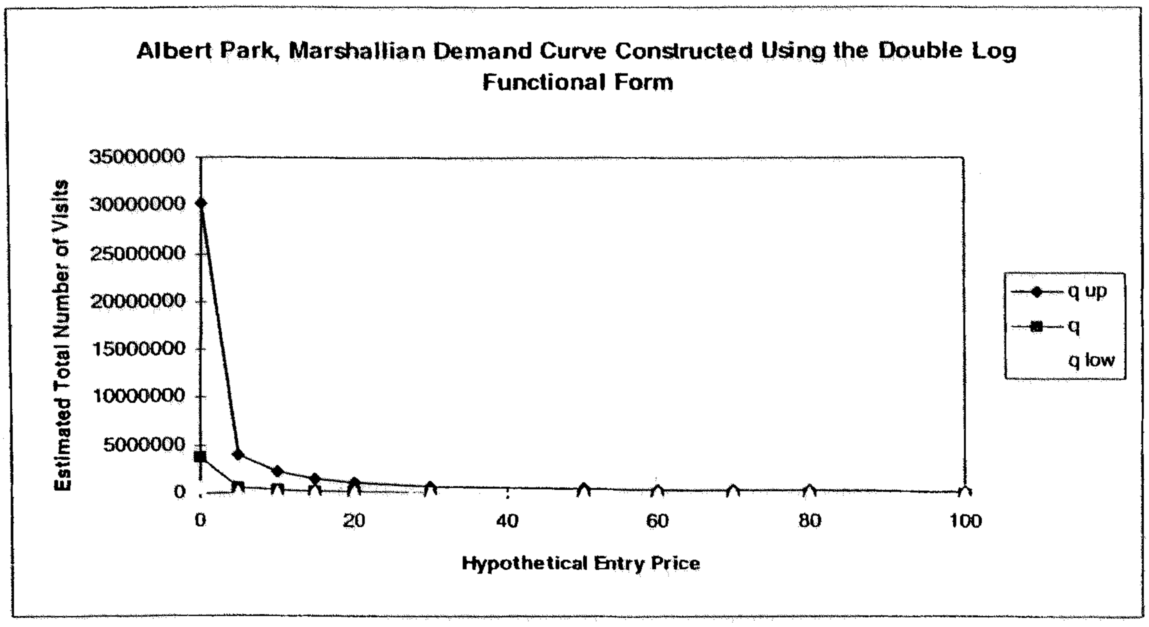
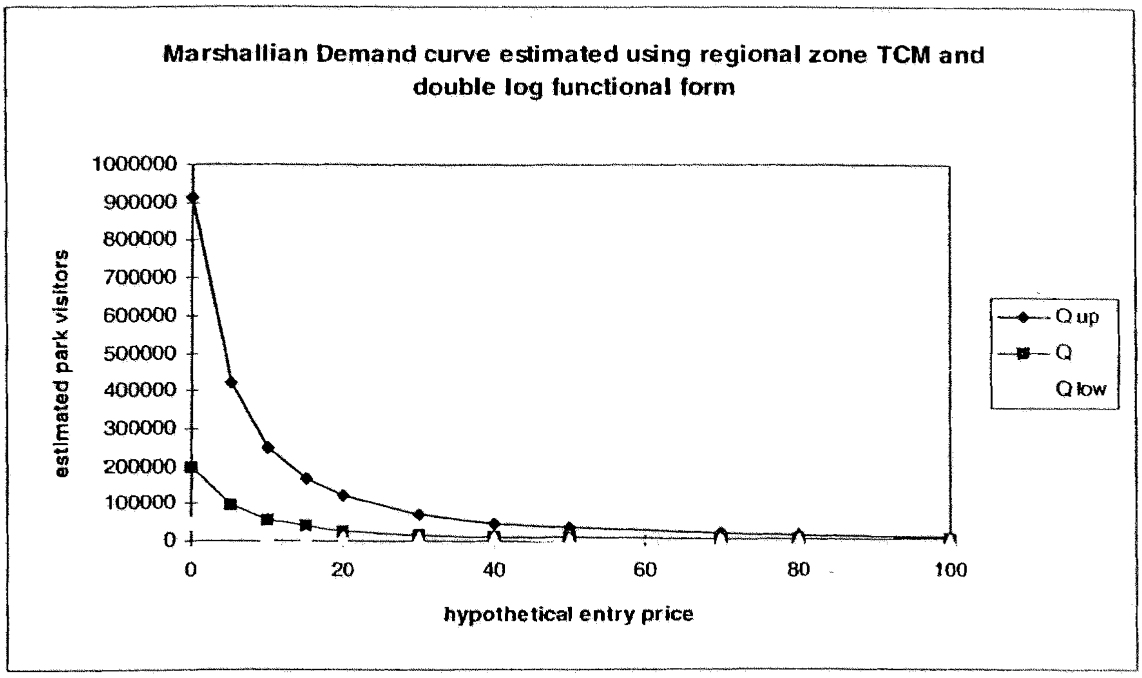


Figure 3 Maroondah Reservoir Marshallian Demand Curve constructed using the regional zone method and the double log functional form



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