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# A CHOICE MODELLING APPROACH TO INVESTIGATE BIASES IN INDIVIDUAL AND AGGREGATED BENEFIT ESTIMATES DUE TO OMISSION OF DISTANCE

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WORKING PAPERS

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2004/12

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# A CHOICE MODELLING APPROACH TO INVESTIGATE BIASES IN INDIVIDUAL AND AGGREGATED BENEFIT ESTIMATES DUE TO OMISSION OF DISTANCE

**Abstract:**
This paper describes a Choice Modelling experiment set up to investigate the relationship between distance and willingness to pay for environmental quality changes. The issue is important for aggregation and transfer of benefits. So far the problem has been analysed though the use of Contingent Valuation-type of experiments, producing mixed results. The experiment allows testing distance effects on parameters of environmental attributes that imply different trade-offs between use and non-use values. The distance covariate enters the estimated utility function in a flexible form to accommodate for several possible relationships. The sampling procedure is designed to provide a "geographically balanced" sample. Welfare analysis shows that disregarding distance produces under-estimation of individual and aggregated benefits and losses, seriously hindering the reliability of cost-benefit analyses.

**Keyword:** Choice Modelling techniques, distance, aggregation.

September 2004

## 1. Introduction

While improvements in model specification and estimation techniques are recorded every day in the environmental valuation literature (see, for instance, Evans *et al.*, 2003, Hofler and List, 2004, Swait *et al*, 2004), an uncontested definition of the relevant population of environmental assets still eludes researchers' efforts. The problem of how to define the market for environmental goods is important both for aggregation purposes and for benefit transfer across populations. Indeed, assumptions on the relevant population, when coupled with random sampling, may provide non-representative samples and distort parameter estimates. Aggregating incorrect individual estimates over the assumed number of beneficiaries – that can be very different from the actual number – increases the potential for over or underestimation of the total value of an environmental commodity.

Some rules of thumb are usually adopted. For instance, it is customary in empirical studies to assume the scope of the market for an environmental asset – i.e. its market area - coincides with some political or administrative boundary (see, for instance, Keith *et al.*, 1996, Hadker *et al.*, 1997, Amigues *at al*, 2002). The assumption is justified on the basis that the costs of environmental projects are borne locally, even if the benefits may be spread out nationally or internationally. Assuming that the market area corresponds to some political boundaries implies that values differ from zero inside these boundaries and are null outside, and the parameters of the valuation function are constant inside these boundaries. There is no reason for the actual and assumed market areas to be the same. In fact, Loomis (1996) and Pate and Loomis (1997) have shown that restricting estimation of benefits of an environmental program to the political jurisdiction in which the natural asset is located would considerably underestimate the aggregate benefits.

Several studies have investigated the relation between values and distance via Contingent Valuation methods. Sutherland and Walsh (1985) found that WTP for water quality improvement approaches zero at around 640 miles from the study area. Loomis (1996) found that the effects of distance are negligible, and WTP for the restoration of a river system is positive even at 3000 miles away from the site. Mixed results are obtained by Pate and Loomis (1997) that estimated WTP for three environmental programs. For two of them distance effects are negative and small, while for the third program distance does not affect WTP.

Bateman and Langford (1997) also found that WTP of past users are negatively affected by distance, while WTP of 'pure' non users (i.e. respondents that never visited nor plan to visit the environmental asset) do not depend on distance.

These results are conditioned by the features of the assets under valuation, the sample's geographical distribution, and the specified functional form of the distance/WTP relationship. In Loomis (1996) and Pate and Loomis (1997), for instance, the samples strongly over-represent close respondents. Bateman and Langford (1997), on the contrary, sample correcting for decaying response rates. Distance covariates enter in linear (Sutherland and Walsh, 1985, Loomis, 1996) or log-linear form (Pate and Loomis, 1997, Bateman and Langford, 1997).

In this paper we investigate the consequences of disregarding distance on individual and aggregated benefit estimates using the Choice Modelling approach. The sampling procedure is designed to provide a "geographically balanced" sample, i.e. a sample that mirrors the spatial distribution of the population around the asset under valuation. Two choice models are estimated, one without distance and another with a flexible specification of the distance covariates in order to capture possible complex forms of the distance-values relation. The two models are compared through a specification test for nested models. Also tests on the equality of individual parameter estimates are performed. Implicit prices and aggregated benefits are computed for the two models. We found that the consequences of disregarding the complexity of the distance/WTP relationship are quite severe. It produces under and over estimation of individual parameters and gross under-estimation of benefits and losses from management programs.

The paper is organized as follow. Section 2 describes the Choice Modelling technique. In section 3 we discuss the reasons for the use of a flexible functional form of the distance variable. We propose a Gamma Transformation function whose parameter are estimated via a grid search. Section 4 briefly describes the asset under valuation, the design of the CM experiment and the sampling procedure. In section 5 we discuss the result of the grid search and compare different model specifications. Section 6 illustrates the results of the CM experiment while section 7 shows the welfare effects of distance omission. Section 8 concludes.

## 2. The Choice Modelling approach.

The Choice Modelling approach (also known as Choice Experiment) is basically "a structured method of data generation" (Hanley *et al.*, 1998). It has been used in a large number of marketing, transportation and health care applications (see Louviere *et al.*, 2000). Increasingly, it has been applied also to environmental valuation studies. The first recorded application in this field is due to Adamowicz *et al.* (1994).

The theoretical foundations of CM are Lancaster's characteristic approach (Lancaster, 1966) and Random Utility (RU) theory. Two elements link these theories (Hensher and Johnson, 1981):

a) the function which relates the utility $U_{ij}$ of each alternative $j$ for an individual $i$ to the set of the alternative's attributes ($Q_j$) and individual characteristics ($S_i$):

$$U_{ij}=V_{ij}(Q_j, S_i) + \varepsilon_{ij} \tag{1}$$

It is assumed that each utility value can be partitioned into two components: an observable or systematic component $V_{ij}$ and an unobservable, random component, $\varepsilon_{ij}$:

b) the function linking the probability of an outcome to the utility associated with each alternative:

$$\Pr_{ij}\left[j \middle| Q_j, S_i\right] = \Pr\left[\left(V_{ij} + \varepsilon_{ij}\right) > \left(V_{ik} + \varepsilon_{ik}\right)\right] \qquad \forall j \neq k \tag{2}$$

Individuals are assumed to choose the alternative that yields the highest utility. That is, the alternative $j$ is chosen if $U_{ij}>U_{ik}$ for each $j\neq k$. Equation (3) becomes:

$$\Pr_{ij}\left[j \middle| Q_j, S_i\right] = \Pr\left[\left(\varepsilon_{ik} - \varepsilon_{ij}\right) < \left(V_{ij} - V_{ik}\right)\right] \qquad \forall j \neq k \tag{3}$$

To make the model operationally tractable, several assumptions are introduced. For instance, if the errors are assumed to be independent and identically distributed with a type I extreme distribution (or Weibull distribution) whose cumulative distribution function is $F(\varepsilon_i<\varepsilon)=exp(-e^{\varepsilon})$, it can be shown that the probability of individual $i$ choosing alternative $j$ is

$$\Pr_{ij}\left[j\middle|Q_j, S_i\right] = \frac{e^{\mu V_i(Q_j, S_i)}}{\sum_{j=1}^{J} e^{\mu V_i(Q_j, S_i)}} \tag{4}$$

This is known as McFadden's Conditional Logit Model (see Maddala, 1983). $\mu$ is a scale parameter that depends on the variance of the statistical error inherent in the modelling.

The welfare measure for a quality change from this model can be defined in terms of compensating surplus ($CS_i$) (Boxall *et al.*, 1996):

$$CS_i = -\frac{1}{\beta_{Inc}}\{V_{ij} - V_{ik}\} \tag{5}$$

Since -$\beta_{Inc}$ is assumed to be the constant marginal utility of income, multiplying it by the difference of the observable utilities converts the expected utility change into a monetary measure.

In CM applications, a set of attributes differing in levels describes the choice alternatives (the choice set). These attributes and levels must be policy relevant and meaningful to individuals. Respondents are usually asked to make from six to eight comparisons of the status quo and other proposed alternatives in the choice set. The choice set is designed in order to isolate the effects on choices of each attribute (Cox and Reid, 2000). Respondents' comparisons allow determining the trade-offs between attributes people is willing to make. It is also possible to estimate how much respondents are willing to pay for a unit change in an environmental attribute. This measure is called part-worth or implicit price. An implicit price is the ratio

$$\mathrm{IP}_q = \beta_q / \beta_{inc} \tag{6}$$

where $\beta_q$ is the coefficient of the $q$ attribute and $\beta_{inc}$ is the estimated parameter for the monetary (income) attribute. Implicit prices are useful information for policy makers in that they provide a measure of the benefits or costs of small changes in a single environmental feature.

The empirical structure of the utility function - i.e. the model mapping the attributes of the alternatives and the individual's socio-economic characteristics into utility - influences the choice probabilities and hence the predictive capacity of the model. It is common to assume that $V_{ij}$ is a linear additive function of the set of $Q$ attributes (Louviere *et al.*, 2000):

$$V_{ij} = \sum_{q=1}^{Q} \beta_{jq} X_{ijq} \tag{7}$$

Attributes and individual's characteristics that do not vary across choices enter the model by interacting with attributes that do change. It is then possible, for instance, to compute the effect of distance, or income, on the parameter of an environmental attribute such as hectares of wilderness. In environmental valuation experiments, distance enters the deterministic elements usually in linear or log-linear form. Other functional forms are sometimes recorded, as we discuss in the next section.

## 3. Distance effects on willingness to pay.

There are several theoretical reasons that suggest distance should enter the stochastic elements of the utility function.

The use of environmental assets incurs in travel costs, corrupting the 'purity' of the public goods (Scotchmer and Thisse, 1999). Distance indeed works as a weak exclusion mechanism via travel cost. Its effects on use, and hence on use benefits, is comparable to the effect of prices on commodity demands. These effects are also expected to vary according to the type of environmental goods and services (Clawson and Knetsch, 1966). At least use benefits are expected to be negatively dependent on distance.

Distance effects are also expected because, as distance increases, the number of substitution opportunities may increase as well. The size and the content of individual choice sets are indeed affected by the spatial distribution of substitutes (Parson and Hauber, 1998). As the demand of a commodity is linked to the price of substitutes, so WTP for and environmental good is expected to vary with the availability on space of substitutes. This effect can be termed 'locational' substitution, as opposed to economic substitution (Lo, 1998).

Further, it has been documented that information and familiarity affect use and non-use benefits (Sutherland and Walsh, 1985, Parson *et al.*, 2000) and that information is, on a certain degree distance dependent (Beckman, 1999).

A negative relation between distance and WTP is then expected.

On empirical ground, the study of the effects of distance on human interactions in the field of transportation, regional science and economic geography has shown that the possible forms of these effects are vast

(Beckman, 1999). In the environmental valuation literature, along linear (Sutherland and Walsh, 1985, Loomis, 1996), log-linear (Silberman, 1992, Pate and Loomis, 1997, Bateman and Langford, 1997) and quadratic specifications (Breffle *et al.*, 1998, Hanink and White, 1999), more complex forms of the distance-WTP relation are sometimes recorded. Espey and Owusu-Edusei (2001) found that proximity to an environmental amenity drives house prices down in the short distance. Then prices tend to increase at a decreasing rate as distance increases. Similarly, Imber *et al.* (1991) found that people living closer to a national park value it less than people living farther away. In this last two cases, the trade-offs determined by the availability of the public good are not simply negatively affected by distance. A more complex relation emerges. Therefore, one may want to specify a flexible functional form for the distance variable in the utility function (1) in order to pick up these 'irregularities', and eventually test for the best specification.
In this paper we investigate several possible functional forms by using a Gamma Transformation of the distance variable:

$$DIST2 = a_0 (DIST1)^{a_1} e^{(a_2 DIST1)} \tag{8}$$

where *DIST1* is the individual distance from the asset under valuation and $a_0$, $a_1$, $a_2$ are parameter to be estimated. $a_1$ and $a_2$ are determined through a grid search procedure, while $a_0$ is estimated along other parameter in the final maximum likelihood estimation of model (1)-(4). A grid search involves selecting starting values of the parameters, define their range and step, and routinely estimate the model for each pair of value, record the value of the likelihood function, and take the parameters that maximize that value. These are maximum likelihood estimates of the parameters. The advantage of the Gamma Transformation is that it can replicate the shape of a linear, log-linear, quadratic (or higher order polynomial), power, exponential and logarithmic function. It also can represent more complex relationships, as shown in figure 1. Using a grid search procedure has an important drawback. It does not provide the standard errors of the estimated parameters. Unless it is possible to give up the linear-in-parameter model in equation (9), the distributional property of the parameter $a_1$ and $a_2$ are not known. However, McFadden (1998) has shown that in the context of least square estimation, grid searches are equivalent to estimation by non-linear models under mild conditions. It seems plausible that this is true also for maximum likelihood estimation. Further, note that the

Gamma Transformation model collapses into simpler models such as linear or exponential if the one of the parameters is zero. For instance, if $a_1$ is zero, the model in (10) becomes an exponential model. If the estimated value for $a_1$ is not statistically different from zero, the Gamma Transformation and the exponential model should not perform differently. Therefore, a series of tests for nested and non-nested models comparing functional form specifications also provides an indication whether the parameters estimated by the grid search are statistically significant. Once the best statistical model is identified, it is possible to compare its individual and aggregate benefit estimates with those obtained by a model that omits distance from equation (9). Before showing the results of the model comparisons, we briefly describe the asset under valuation, the questionnaire design and the sampling procedure.

## 4. The case study.

*The asset under valuation.* The asset under valuation is the bushland of Kings Park & Botanic Garden in Perth (hereafter referred as Kings Park). Kings Park is located in the heart of the Perth metropolitan area, just 1 km away from the Central Business District. It is used by daily visitors for a range of activities from bird and fauna watching to family activities in the park's playground. Several surveys conducted by the Park Authority have shown the strong cultural and historical attachment of Western Australia residents (Kings Park and Botanic Garden, 1995). The management authority indicated three major problems in the conservation of the park's bushland: weeds that replace native species, degradation caused by human treading, and fires. Focus groups were set up to test a questionnaire in which respondents are asked about their preferences over different management strategies for Kings Park's bushland. Management strategies were described by four attributes, each having four levels, as identified in collaboration with the park authority and other experts. For a complete discussion on the design of the CM experiment see Concu (2004). Table 1 shows the attributes and their levels.

**The Weed attribute** (Weed): it describes the percentage of bushland freed from weeds. Weed eradication substitutes non-native species for native species. It emerged in focus groups that respondents care about native species but cannot distinguish between natives and non-natives.

Hence we do not expect that this attribute affects the use of the bushland. Iit evaluates the non-use values for the native species. If non-values are distance-independent, we also expect that the coefficient of the Weed attribute is not affected by distance.

**The Accessibility attribute** (Acc): the second attribute represents the percentage of bushland that is accessible to the public (Acc). Restricting people's access to the bushland would reduce human treading that damages native flora and increases weed encroachment. Restricted access increases the non-use values (more and healthier native species) and decreases the use values of the bushland. Given the simultaneous change of use and non-use values, the effect of distance on this attribute cannot be foreseen a-priori.

**The Fire attribute** (Fire): the third attribute represents the hectares of bushland annually destroyed by fire. On average every year around 6 ha of the park under valuation is damaged by fire. Preventing fires will make some people gain some non-use and use values for the bushland. Again, the likely simultaneous change in use and non-use values does not permit predicting the effects of distance on this attribute.

**The Cost attribute** (Cost): the fourth attribute is the cost of each alternative. Respondents are asked to support the preferred alternatives by paying via a tax increase. This payment vehicle is likely to create some protest, but it appears the most plausible given that the park is actually funded with taxpayers' money. Donations were also considered during the focus groups, but participants indicated they did not think they are a viable instrument.

Respondents were asked to choose the preferred alternative, made up of four different levels for each attribute and the cost attribute (table 1). Using a fractional factorial Graeco-Latin square procedure we designed the choice set containing the status-quo alternative (describing the actual state of the bushland) and 16 alternative management strategies. All these alternatives were combined in 8 sets of three management strategies. An example of a single set is given in figure 2.

*Sampling procedure and data collection*. The sampling procedure was devised to collect a geographically balanced sample to mimic the spatial distribution of the population in Western Australia (WA). West Australian residents were divided in 11 distance zone, according to their location in regards to Kings Park. Zone 1 contains residents in a area between 0 and 5 Km away from Kings park, and zone 11 contains respondents living no closer than 700 Km. From each zone we sampled a number of residents equal to the population share of the zone. 750 questionnaires were posted in succession, allowing us to send more questionnaires in zone with low response rate.

Data were collected between mid June and mid-September in Western Australia (WA). 348 questionnaires were returned, of which 24 are protests. In the estimation we also dropped 88 questionnaires in which respondents complained about the difficulty of the choice task. 29 questionnaires are also not completed. We ended up with 207 questionnaires in which each respondent chooses the best alternative from a group of three in 8 choice sets. We have 24 observations for each respondent. Observations are treated as independent in the estimation model. The final number of observations is equal to 4968.

Distance is calculated as the geographical distance ("as the crow flies") of respondents from Kings Park (ICSM, Geocentric Datum of Australia, 2001). The sample under-represents residents in the 50 to 100 Km area, and over-represents the 15 to 20 Km and 20 to 30 Km zones. For the other zones the difference between sample and population share is no greater than 1% (table 2). The most distant observation comes from a respondent living as far as 1300 Km from Kings Park.

From the questionnaires we recover socio-economic characteristics of respondents, knowledge and pattern of use of Kings Park, use, type and number of substitutes of Kings Park and a set of other attitudinal information, as explained in table 3.

As a whole, the sample has a higher percentage of female respondents than the population share. The mean age in the sample is 49 years against 34 of WA. Further, the sample over-represents high income earners and university educated WA residents.

**5. Results of the grid search and model comparisons.**

The grid search procedure provides the maximum likelihood estimates of the $a_1$ and $a_2$ parameters for the Gamma Transformation. These estimates are reported in table 4, along with the estimates for the $a_0$ parameters obtained by the model estimation. While for the Weed attribute, these parameters indicate there are no distance effects ($a_0$ is not statistically significant at 10%), for the other two attributes the sets of parameters describe two different relations between values and distance. It is necessary to explore the hypothesis that some of the parameters estimated in the grid search are not significantly different from zero. As already stated, the grid search does not provide information on the distributional properties of the estimated parameters. It is however straightforward to test if one or all of them are different from zero by comparing model specifications. The Gamma Transformation indeed collapses to a linear, exponential or other functional form whenever one of the parameters is equal to zero. If this is the case, the Gamma Transformation should not be statically superior to the other model. Testing the hypothesis that one of the parameters is equal to zero turns to be a test on the model specification. The models that result from the hypotheses to be tested are nested with the Gamma Transformation. Non-nested models are also compared.

Nested models are compared using the likelihood ratio criterion (Louviere *et al.*, 2000) and non-nested models using Clarke's distribution-free test (Clarke and Signorino, 2003). The likelihood ratio test takes the form:

$$-2\ln L^{*} = -2\ln\left(\frac{\max L(\omega)}{\max L(\Omega)}\right) \tag{9}$$

where max $L(\omega)$ and max$L(\Omega)$ are the maximum likelihood values of respectively the constrained and the general model. This statistics is approximately distributed as a chi-squared with degrees of freedom equal to the number of constraints.

The distribution-free test is a modified paired sign test that determines if the median log-likelihood ratio is statistically different from zero. If the two non-nested models are equally close to the true specification, *individual* log-likelihood ratios should be equally divided between greater than and less than zero. For instance, comparing the Gamma Transformation and a $2^{nd}$ order polynomial specification, the first is "better" than the second if more than half of the individual log-likelihood ratios are greater than zero and vice versa. The number of positive difference is distributed binomial(# *of obs*, 0.5).

Table 5 synthesizes the results of the tests for each attribute and a selection of model specifications. The tests indicate that the Gamma Transformation is the preferred specification for the distance variable in the interaction with the Fire and Accessibility attributes. Distance does not appear to affect the Weed attribute, no matter the form in which it enters the utility function.

## 6. Results of the Conditional Logit Models.

Conditional logit results are reported in table 6 for a model that omits distance interactions for all attributes and a model specified according to a Gamma Transformation for the Fire and Accessibility attributes. For both models, likelihood Ratio tests suggest that the same set of independent variables (distance omitted) is to be included in the estimation model.

In the Gamma model, the significant negative sign of the ASC indicates that the utility associated with moving away from the status quo is negative. This is known as a status quo bias or endowment effect. There is significant evidence in the literature that status quo bias is a common economic phenomenon (see Adamowicz *et al.*, 1998).

The base parameter for the Weed attribute indicates its value for the base category made up by respondents that do not think more should be spent on the environment (*EnvAtt*=0) and stated that KP has no substitutes (*Subst*=0). The base parameter has a significant negative sign. However, given that the *Subst* variable for the other classes of respondents is never significant, the base parameter is dependent only on individual's *EnvAtt*. Income in logarithmic form and *EnvAtt=1* have both significant and positive parameters. Substitution variables, even if retained on the basis of the Likelihood Ratio test, are not significant. The non-use values embedded in the Weed attribute are dependent only on income and environmental attitude. In presence of non-use values, substitutability among environmental goods is dictated by economic substitution (the budget constraint) other than by locational substitution (Lo, 1990).

Income and environmental attitude are found significant also for the Fire attribute in the Gamma Transformation model. Its base category is made up by the same class of respondents as for the Weed attribute. Note the sign of parameters for the log of income and *EnvAtt*=1. The Fire attribute implies that higher levels of the attribute represent an increased probability of fire damages in KP. Hence, the negative coefficients indicate a willingness to pay to prevent fire damages. The parameters estimated in the grid search procedure (table 4) summarize the distance effects on the Fire attribute. Using these parameters, we plot figure 3. It shows the complexity of the relation between distance and values when the attribute involves *both* use *and* non-use value changes. The utility of preventing fires in Kings Park decreases with distance and then increases again. Several factors are likely to be working together in shaping the distance function. Firstly, one can claim that it is the nature, possibly the complexity, of the trade-offs involved by the Fire attribute that create such spatial behaviour. Secondly, it is possible to claim that it is the attribute in itself which is the source of the problem. It may be that respondents are focusing on the general problem of fires, their prevention and management, rather than on the possible losses to Kings Park. It should be noted however that during the test of the questionnaire and the pilot sessions there was no sign of such interpretation of the attribute. Note, however, that these findings resemble those by Imber *et al.* (1991) who found that people from throughout Australia were willing to pay more to preserve the Kakadu Conservation Zone from mining than people in the Northern Territory who were closer to the site.

Effects of distance on the third attribute (Accessibility) take a different form (fig. 4). They are negative and disappear within 10 km.. Reducing accessibility to Kings Park bushland does not concern residents living further away than 10 km. Other variables affect the magnitude of the values for the Accessibility attribute. Adding to the individuals' environmental attitude variable ***EnvAtt*** and the ***Country of origin***, we find that other socio-economic characteristics affect the value. So the ***Rank*** and ***Org*** variables, other measures of individuals' attitude toward the environment, have a significant negative sign, in accordance with expectations. Indeed, Accessibility describes the increases in the percentage of Kings Park's bushland closed to the public for restoration/conservation purposes. Being more environmentally aware translates into favouring less bushland to be left accessible. The sign of the parameters for the education level, ***Educ***, the individual's Knowledge of Kings Park, ***Info***, and the number of children in the family indicates that the more educated, more informed and more numerous family members have a preference toward having the bushland accessible. The ***Subst*** index is significant and the coefficient values indicate that it is important only if the respondent reputes Kings Park substitutable or not. The composition of the individual choice set seems to be less important.

The cost attribute has a negative and significant parameter, as expected. What is unexpected is the sign of the income effect on the cost attributes. It is negative, showing that higher income earners are more concerned about paying for Kings Park.

The consequences of omitting distance from the estimation can be seen in the last three columns of table 6. *t*-tests on the hypothesis that the parameters of the Gamma Transformation and the 'No Distance' models are equal is strongly rejected for all parameters except the alternative specific constant, the base coefficient for the weed attribute, the interaction between income and Weed, environmental attitude and Weed, environmental attitude and Fire. The effect of distance omission in the other parameters depends upon the degree and direction of correlation with distance. For 16 of the 21 significant coefficients, the omission of distance determines underestimation of the parameter. Omission of distance causes the interaction parameter between Fire and income to be not significant. These effects are expected to create furthers biases in aggregate estimates. It must be stressed that omission of distance can determine error heterogeneity and hence violation of the IIA implied in the Conditional Logit Model (McFadden, 1986). Hausman-McFadden's test for IIA indicates there is not evidence that the IIA assumption has been violated (Chi2(33)=19.57, Pr>chi2=0.969).

**7. Effects of omission of distance on implicit prices and aggregate benefits.**

Implicit prices are calculated according to (6) and reported in table 7 for both the Gamma Transformation and the No Distance models. The parameters of the Weed and Fire attributes are computed for a representative respondent with an income level equal to the sample average (Au$ 989.5 per week), living at distance from Kings Park equal to mean distance in the sample (132 km.), and belonging to the class of *EnvAtt=1*. The Accessibility parameter is calculated for a respondent that living at the average distance and belonging to the class *Rank=2*. The implicit prices for the Weed attribute tells us that a 1% increase in the area of bushland freed from weeds is valued around Au$0.7. Note that the Gamma Transformation gives an implicit price for the Fire attribute that is more than three times larger than the implicit price calculated using the parameters estimated omitting distance.

Welfare measures for Kings Park's bushland management strategies are computed using equation (5). In the sampling procedure, the relevant population is identified with residents in Western Australia that are supporting Kings Park via direct or indirect taxation. In the light of the results of the CM analysis we can state that the geographical extent of the market for Kings Park is at least as large as the sampled area. For the Weed attribute distance effects are nil. They disappear in the long distance for the Fire and for the Accessibility attributes. There are only "local" effects, i.e. effects are limited to a range of distance values. Nevertheless, the consequences on aggregated estimates of disregarding these local effects are quite serious. We confront the benefit from the status quo ($V_0$) with then benefits from four other management scenarios ($V_1$), as reported in table 8. Scenario 1 hypnotizes that the Kings Park's management authority sets up a project to further reduce weed encroachment in the bushland. It aims to increase the bushland area free from weed by another 20%. As an alternative, the park managers may decide to increase the efforts to prevent fires and bring the average area of bushland annually damaged down to 1% (Scenario 2). Scenario 3 supposes that the park authority would improve the conditions of the bushland by preventing access to people. Every year, 25% of the bushland area is set aside as a nature reserve. A fourth scenario, named the "worst case scenario" would determine a deterioration of the conditions of the bushland. Weed encroachment increases, bringing the percentage of weed free area down to 30%; fires destroy around 9% of the bush (on average). Scenario 5 embodies a change in all the three attributes.

The effects of omitting distance are determined by confronting aggregate benefits for the five programs computed using two different aggregation procedures:

- Procedure A1: aggregate benefits are obtained using parameters estimated using distance (the Gamma Transformation estimates) and the geographical distribution of the population;
- Procedure A2: assumes that the distribution of the population is not important and makes use of incorrect parameters obtained omitting distance.

We use information on income and distance distribution of WA residents (Australian Bureau of Statistics, 2001 Census). However, information is not sufficient to determine where Western Australians stand in relation to the "pro-environment" and the "conservative" individuals. In the aggregation procedure, then, we need to assume that the population percentage of WA residents that would like the government to spend more money on the environment (***EnvAtt=1***) equals the sample share (68%). In each income class, Western Australians are distributed according to this rule (68% have ***EnvAtt=1***,

32% ***EnvAtt=0***). The other socio-economic variables are assumed to take the most conservative values (***Country of origin= O/seas***, ***Subst=3***).
The results are summarized in table 8. The consequences of ignoring distance and assuming a uniformly distributed population can be assessed by observing the last two columns of table 8. They describe the percentage difference between estimates. Disregarding distance determines underestimation of benefits and losses. The effects are quite dramatic. Underestimation of scenario 5 benefits is so large that turn them into a loss.
The impacts of omitting distance in decision-making are clear. It can easily lead to an inefficient allocation of resources because of underestimations of welfare gains and losses.
Table 8 tells also that the benefits the public will receive from scenario 1 are positive. By construction, this scenario implies a change in the Weed that is, a change in non-use values. Non-use values of native species in Kings Park bushland, created by increasing the area free of weeds, are worth around Au$5.2 million. Further, the values that the public assigns to the actual services of the bushland are substantial. Losing part of the bushland because of fires and weed encroachment produces a loss of $22.6 million (scenario 4). Contrasting this figure with the amount of money the park authority actually spend on the bushland (Au$330.000), it shows that there is huge scope for increasing public funding of the park. The "endowment effect" in scenario 3 is also quite substantial. The loss of accessibility of 25% of Kings Park's bushland amounts to around Au$12.3 million.

## 8. Conclusion.

Using spatial information in environmental valuation could help to avoid under and over estimation of individual parameters and to identify the relevant population of a natural asset. Failing to take into account distance would determine underestimation of aggregate benefits and losses, depending on the distance effects on individual parameters and the geographical distribution of the sampled population.
In this paper we use a Choice Modelling experiment to test if values are distance-dependent. Non-use values are found to be distance-independent, affected by income level and by individuals' environmental

attitude. For aggregation purposes, these indications are a supportive starting point.
The behaviour of the distance functions for the other two attributes suggests that:

- The loss of values, as incorporated in the increase of the Fire attribute, is decreasing with distance, and then increasing again. Predictions on the tail of the distance function suggest that it tends to an asymptote. Distance effects are mixed; at long distance, however, they appear to be nil;
- The gains of values represented by an increase in the Accessibility attribute, are initially decreasing with distance and then become distance-independent.
- The point at which the distance effect is zero varies for the two attributes.

For the asset under valuation and the management programs used in our survey, underestimation of benefits and losses is very likely if one disregards the spatial behaviour of the attribute values. The magnitude of the error could be as large as 107% (scenario 5) of the estimated benefits, severely hindering the possibility of using benefit estimates in a cost-benefit analysis.

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Table 1. Attribute, levels and corresponding variables.

| Attributes | Levels | Variable in Model |
|---|---|---|
| Weed-free Bushland (in %) | 30, 40 (sq)*, 50, 60 | ***Weed*** |
| Bushland annually destroyed by Fire (in %) | 1, 3, 6 (sq)*, 9 | ***Fire*** |
| Bushland accessible to the Public (in %) | 25, 50, 75, 100 (sq)* | ***Acc*** |
| Cost (in $) | 0.30 (sq)*, 1, 3, 6 | ***Cost*** |

*(sq) = status quo levels

Table 2. Definition of distance zones, population and

| | Distance from Kings Park | Population share | Sample share | Differences (in%) |
|---|---|---|---|---|
| ZONE 1 | 0-5 Km | 9.4 | 10.1 | -0.7 |
| ZONE 2 | 5-10Km | 18.2 | 17.4 | 0.8 |
| ZONE 3 | 10-15 Km | 17.4 | 17.9 | -0.5 |
| ZONE 4 | 15-20 Km | 12.3 | 14.0 | -1.7 |
| ZONE 5 | 20-30 Km | 8.6 | 9.7 | -1.1 |
| ZONE 6 | 30-50 Km | 6.9 | 6.8 | 0.1 |
| ZONE 7 | 50-100 Km | 4.3 | 2.9 | 1.4 |
| ZONE 8 | 100-150 Km | 4.8 | 4.8 | 0.0 |
| ZONE 9 | 150-300 Km | 3.9 | 3.9 | 0.0 |
| ZONE 10 | 300-700 Km | 5.3 | 6.3 | -1.0 |
| ZONE 11 | Over 700 Km | 8.9 | 6.3 | 2.6 |
| | | 100.0 | 100.0 | |

Table 3. Definitions of variables.

| Variable | Type | Values/Meaning |
|---|---|---|
| **EnvAtt** | Categorical | *Respondents answered the question: "Should the government spend more on the protection of the environment?"*<br>Values: 0 = No/Don't know<br>1= Yes |
| **Rank** | Categorical | *Respondents ranked environmental issues in relation to other policies (education, health, security, etc.):*<br>Values: 1 (less important) to 5 (most important) |
| **Info** | Continuous | *Respondents' knowledge of KP computed as % of correct answers to a set of questions on KP location, extension, facilities on site :*<br>Value: 0 to 100 |
| **Subst** | Categorical | *Respondents indicated if they would consider to use KP and in case of a positive answer where they would go in case KP was not available:*<br>Values: -1= KP is not considered as a choice / No answer<br>0= Nowhere (KP has not substitutes)<br>1 to 3 = Number of stated substitutes for KP |
| **Substitution Index (SI)** | Continuous | *# of matches between activities performed in KP and in its substitute / # of Substitutes (if Subst>0)*: Values 0 = no substitution<br>100 = perfect substitution |
| **Distance** | Continuous | *Respondents' geographical distance from Kings Park* |
| **Gender** | Categorical | Values: 0= female<br>1= male |
| **Age** | Continuous | *Age of the respondent* |
| **Child** | Continuous | *Number of children in the household* |
| **Country** | Categorical | *Country of origin:* Values: 0 = born in Australia<br>1 = born overseas/other |

Table 3. Definitions of variables.

| Variable | Type | Values/Meaning | |
|---|---|---|---|
| **Educ** | Categorical | *Attained level of education:* Values: | Y10= up to year 10 |
| | | | Y12= up to year 12 |
| | | | Cert= Certificate |
| | | | Uni=University |
| | | | Oth= Other |
| **Empl** | Categorical | *Employment status :* Values: | Emp=employed by someone else |
| | | | Self= self employed |
| | | | Unemp=unemployed |
| | | | Stu=student |
| | | | Ret=retired |
| | | | Oth= other |
| **Income** | Continuous | *Weekly household income* | |
| **Prop** | Categorical | *Ownership of the house/apartment actually occupied:* | |
| | | Values: | 0=own |
| | | | 1 =rent/other |
| **Org** | Categorical | *Membership in environmental organizations:* | |
| | | Values: | 0 = No/no answer |
| | | | 1 = Yes |

Table 4. Results from the grid search procedure.

| Attribute | Gamma function: $DIST2 = a_0(DIST1)^{a_1} e^{(a_2 DIST1)}$ | | |
|---|---|---|---|
| | $a_0$ [(a)] | $a_1$ | $a_2$ |
| ***Weed*** | -0.0040 | -0.3 | -2.4 |
| ***Fire*** | 32.08** | 3 | -6 |
| ***Accessibility*** | 7.10E-19* | -6 | -6 |

*** Statistically significant at 5%.*

** Statistically significant at 10%.*

[(a)] *The values reported here are* $a_0$ *times the parameter estimates for the interaction terms* $\beta_{DIST}$, $\gamma_{DIST}$,, $\omega_{DIST}$.

Table 5. Nested and non-nested specification tests.

| | **Nested Models: LR tests** | | |
|---|---|---|---|
| Attribute | Ho: a1=1, a2=0<br>*Gamma vs Linear* | Ho: a1=2, a2=0<br>*Gamma vs Quadratic* | Ho: a1=0, a2>0<br>*Gamma vs Exponential* |
| ***Weed*** | 0.513 | 0.159 | 0.333 |
| ***Fire*** | 12.716 | 14.831 | 14.338 |
| ***Accessibility*** | 8.272 | 6.274 | 7.231 |

*Figures are the calculated chi2 value (-2lnL*). chi2* critical value(2) at 5%=5.99

| | **Non-nested Models: Clarke's test** |
|---|---|
| | *Gamma vs 2nd Order Polynomial* |
| ***Fire*** | Pr[#positive>=1042)=binomial(n=1656,x>=1042, p=0.5)=0.000 |
| ***Accessibility*** | Pr[#positive>=933)=binomial(n=1656,x>=933, p=0.5)=0.000 |

*Confidence level: 5%. Gamma is "better" than Polynomial*

Table 6. Results of the Conditional Logit Model with the Gamma Transformation and distance omitted.

| | | ***Gamma Transformation*** | | | ***No Distance*** | | |
|---|---|---|---|---|---|---|---|
| **Variable** | | **Coef.** | **Std. Err.** | **P>z** | **Coef.** | **Std. Err.** | **P>z** |
| **ASC** | $\alpha_{ASC}$ | -0.21817** | 0.09104 | 0.017 | -0.21734** | 0.09071 | 0.017 |
| ***Weed*** | $\boldsymbol{\beta}_{Weed}$ (base parameter) | -0.08227** | 0.04066 | 0.043 | -0.08111** | 0.04050 | 0.045 |
| | $\boldsymbol{\beta}_{\text{Log (Inc)}}$ | 0.01267** | 0.00585 | 0.030 | 0.01242** | 0.00583 | 0.033 |
| | $\boldsymbol{\beta}_{\text{EnvAtt =1}}$ | 0.03518*** | 0.00891 | 0.000 | 0.03492*** | 0.00888 | 0.000 |
| | $\boldsymbol{\beta}_{\text{Subst (=1)}}$ | -0.01658 | 0.01289 | 0.198 | -0.0160193 | 0.01282 | 0.212 |
| | $\boldsymbol{\beta}_{\text{Subst (=2)}}$ | 0.01146 | 0.01229 | 0.351 | 0.0120279 | 0.01224 | 0.326 |
| | $\boldsymbol{\beta}_{\text{Subst (=3)}}$ | 0.01379 | 0.01172 | 0.239 | 0.0142997 | 0.01166 | 0.220 |
| | $\boldsymbol{\beta}_{\text{Subst (not applicable) (a)}}$ | -0.01113 | 0.01705 | 0.514 | -0.0102817 | 0.01686 | 0.542 |
| ***Fire*** | $\gamma_{Fire}$ (base parameter) | 0.15409 | 0.14207 | 0.278 | 0.1847491 | 0.14133 | 0.191 |
| | $\gamma_{\text{Dist}}$ | 32.1751*** | 8.49469 | 0.000 | - | - | - |
| | $\gamma_{\text{Log (Inc)}}$ | -0.03459* | 0.02039 | 0.090 | -0.0323217 | 0.02030 | 0.111 |
| | $\gamma_{\text{EnvAtt =1}}$ | -0.07162** | 0.03189 | 0.025 | -0.07176** | 0.03176 | 0.024 |
| | $\gamma_{\text{Subst (=1)}}$ | 0.00707 | 0.04699 | 0.880 | -0.0220994 | 0.04619 | 0.632 |
| | $\gamma_{\text{Subst (=2)}}$ | -0.07056 | 0.04473 | 0.115 | -0.09000** | 0.04424 | 0.042 |
| | $\gamma_{\text{Subst (=3)}}$ | 0.05697 | 0.04355 | 0.191 | 0.0181442 | 0.04222 | 0.667 |
| | $\gamma_{\text{Subst (not applicable) (a)}}$ | -0.00013 | 0.06179 | 0.998 | 0.0300455 | 0.06031 | 0.618 |
| ***Acc*** | $\omega_{Acc}$ (base parameter) | -0.01211 | 0.01530 | 0.429 | -0.0041907 | 0.01514 | 0.782 |
| | $\omega_{\text{Dist}}$ | 6.68E-19* | 0.00000 | 0.088 | - | - | - |
| | $\omega_{\text{Log(Inc)}}$ | -0.00204 | 0.00179 | 0.255 | -0.0019489 | 0.00179 | 0.276 |
| | $\omega_{\text{EnvAtt =1}}$ | -0.00415 | 0.00284 | 0.145 | -0.0034109 | 0.00282 | 0.227 |
| | $\omega_{\text{Rank (=2)}}$ | 0.02206*** | 0.00703 | 0.002 | 0.02175*** | 0.00703 | 0.002 |
| | $\omega_{\text{Rank (=3)}}$ | 0.01431** | 0.00658 | 0.030 | 0.01304** | 0.00656 | 0.047 |
| | $\omega_{\text{Rank (=4)}}$ | 0.00919 | 0.00700 | 0.189 | 0.0078467 | 0.00699 | 0.261 |
| | $\omega_{\text{Rank (=5)}}$ | 0.01508** | 0.00747 | 0.043 | 0.01289* | 0.00742 | 0.082 |
| | $\omega_{\text{Subst (=1)}}$ | -0.00778** | 0.00395 | 0.049 | -0.00862** | 0.00394 | 0.029 |
| | $\omega_{\text{Subst (=2)}}$ | -0.0082** | 0.00382 | 0.032 | -0.00950** | 0.00380 | 0.012 |
| | $\omega_{\text{Subst (=3)}}$ | -0.00784** | 0.00370 | 0.034 | -0.00840** | 0.00370 | 0.023 |
| | $\omega_{\text{Subst (not applicable) (a)}}$ | 0.00076 | 0.00531 | 0.887 | -0.0015121 | 0.00522 | 0.772 |
| | $\omega_{\text{Country (o/seas)}}$ | -0.01289*** | 0.00244 | 0.000 | -0.01216*** | 0.00242 | 0.000 |
| | $\omega_{\text{Education (=Y12)}}$ | 0.00669** | 0.00320 | 0.037 | 0.00776** | 0.00344 | 0.024 |

Table 6 Continuous

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | $\omega$ Education(=Cert) | 0.00828** | 0.00345 | 0.016 | 0.00781*** | 0.00290 | 0.007 |
| | $\omega$ Education (=Uni) | 0.00814*** | 0.00291 | 0.005 | 0.00599* | 0.00318 | 0.059 |
| | $\omega$ Org (=Yes) | -0.00847*** | 0.00309 | 0.006 | -0.00618** | 0.00302 | 0.041 |
| | $\omega$ Info | 0.00029*** | 0.00009 | 0.001 | 0.00021** | 0.00008 | 0.011 |
| | $\omega$ Child | 0.00222** | 0.00101 | 0.028 | 0.00199** | 0.00100 | 0.046 |
| ***Cost*** | $\eta_{COST}$ (base parameter) | -0.08647** | 0.04189 | 0.039 | -0.08927** | 0.04180 | 0.033 |
| | $\eta_{Inc}$ | -0.00015*** | 0.00004 | 0.000 | -0.00014*** | 0.00004 | 0.000 |
| Obs | | 4968 | | | 4968 | | |
| Log Likelihood | | -1556.4585 | | | -1569.1188 | | |
| Pseudo $R^2$ | | 0.1445 | | | 0.1375 | | |

**** significant at 1%*

*** significant 5%*

** significant at 10%*

*(a)* ***Subst(not applicable)****= this class groups Non-users and respondents that did not provide answer to the number of substitutes.*

Table 7. Implicit prices for the Gamma Transformation and No Distance models.

| | Models | |
|---|---|---|
| | ***Gamma Transformation*** | ***No distance*** |
| Attribute | | |
| ***Weed*** | -0.651 | -0.758 |
| ***Fire*** | 4.466 | 1.378 |
| ***Accessibility*** | -0.415 | -0.494 |

Table 8. Aggregate benefits for alternative management strategies.

| | Models | | |
|---|---|---|---|
| | ***Gamma Transformation*** | ***No Distance*** | ***% difference*** |
| *Management Alternative* | | | |
| **Status Quo** | | | |
| *Fire* *Weed* *Axc*<br>6 40 100 | | | |
| **Scenario 1** | | | |
| *Fire* *Weed* *Axc*<br>6 60 100 | -5,182,975 | -4,808,673 | -7.22 |
| **Scenario 2** | | | |
| *Fire* *Weed* *Axc*<br>1 40 100 | -19,294,512 | -476,789 | -97.53 |
| **Scenario 3** | | | |
| *Fire* *Weed* *Axc*<br>6 40 75 | 12,394,170 | 12,115,670 | -2.25 |
| **Scenario 4** | | | |
| *Fire* *Weed* *Axc*<br>9 30 100 | 22,628,783 | 10,854,340 | -52.03 |
| **Scenario 5** | | | |
| *Fire* *Weed* *Axc*<br>3 60 75 | -10,811,674 | 800,786 | -107.41 |

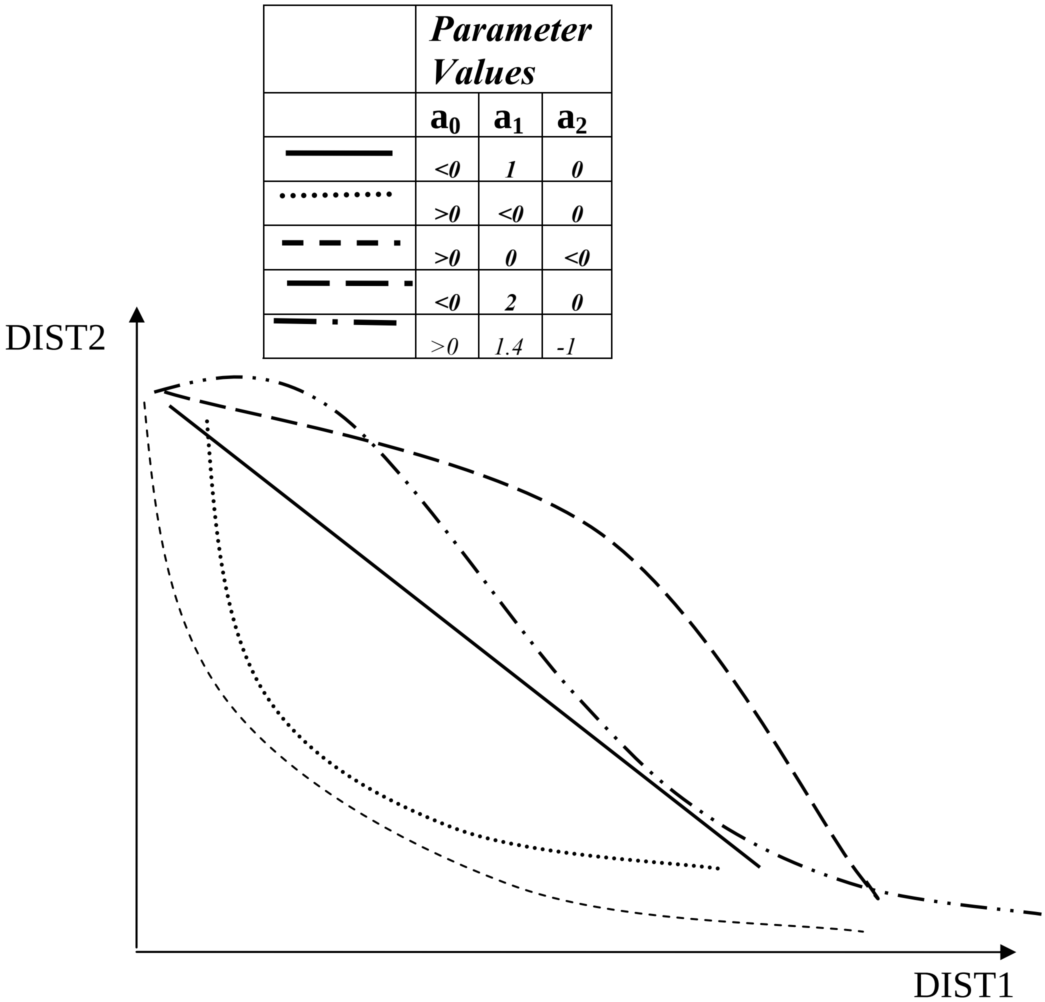
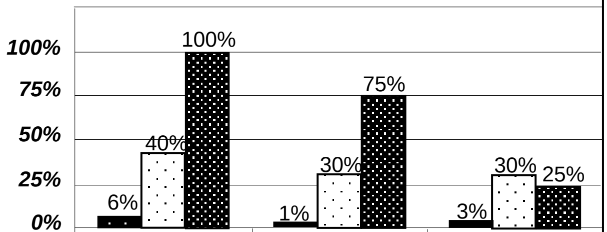



Figure 1. Gamma Transformations of the Distance variable

**9) Suppose for now that these programs are the ONLY options to choose from. Please TICK below your preferred one.**




| | **Current Status** | **Alternative 1** | **Alternative 2** |
|---|---|---|---|
| % of Bushland annually destroyed by Fire | 6% | 1% | 3% |
| % of Bushland freed from Weeds | 40% | 30% | 30% |
| %of Bushland accessible to the Public | 100% | 75% | 25% |
| **Cost to you ($)** | **$ 0.30** | **$ 0.30** | **$ 6** |
| ***Please tick your preferred option*** | ☐ | ☐ | ☐ |

Figure 2. An example of choice set.

Figure 3. **Fire and Distance**

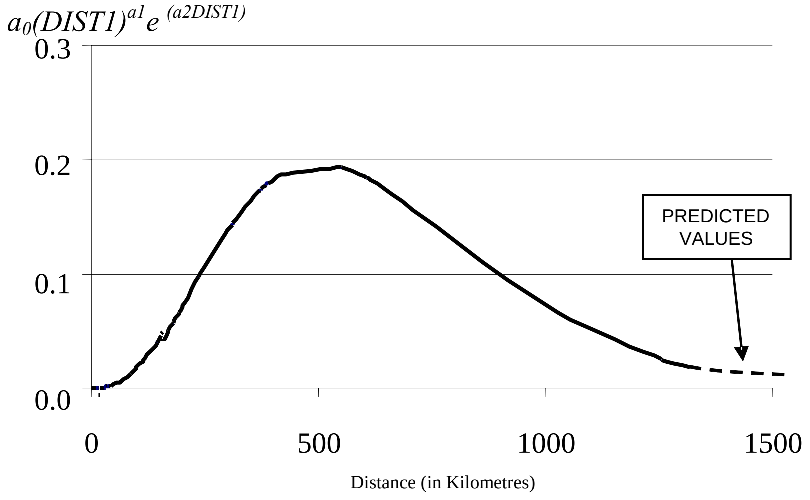


Figure 4. **Accessibility and Distance**