

# Incorporating Endogenous Perceptions of Environmental Attributes in RUMs: The Case of Congestion

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## 1. INTRODUCTION

Congestion is a critical attribute associated with many forms of recreation: with greater levels of the number of recreationists anticipated, fewer will wish to participate. This raises an issue regarding the impact of environmental quality changes at recreation sites in that positive changes will attract more visitors, which in turn increases congestion. However, what is a congested recreation facility to some may not be to others and, in fact, may actually be attractive to some others. In other words, the degree of interaction among people could differ between individuals and plays a role in the effect of the interaction. Thus, congestion could be characterised by considerable heterogeneity in terms of the critical number of people an individual sees or interacts with before they decide not to participate.

One way to understand congestion may be the concept of a critical mass or a critical number (Schelling 1978:94). This is described by the observation that an individual's behaviour is dependent upon how *many* others are behaving in a particular way or how *much* they are behaving that way. This system of interactions can involve heterogeneity in that the critical number for one individual may not be the same for another individual in the group.

Defining a suitable measure of congestion has been difficult for economists, however. Early research on this issue used the density of recreationists at sites or the number of interactions with other recreationists as measures of congestion or "crowding" (e.g. Cicchetti and Smith 1973; McConnell 1977; Deyak and Smith 1978). Shelby (1980), however, showed that neither of these measures affected recreationists' assessments of satisfaction nor did they represent suitable assessments of crowding.

Jakus and Shaw (1997) suggest that *ex ante* assessments of congestion may be the most relevant measures of congestion determining recreation site choice decisions, particularly in

models that use revealed preference information. Jakus and Shaw (1997) define anticipated congestion as an individual's own estimate of congestion that holds at a site prior to when they actually visit that site. Their concept of anticipated congestion clearly captures the important role *ex ante* assessments of congestion may play in recreation demand. Jakus and Shaw (1997) suggest that in order for economists to conduct empirical analyses of congestion effects, individual-specific demand modeling should be undertaken in which anticipated congestion levels vary with the individual. An implication of anticipated congestion playing a role in recreation site choice is the fact that the demand model must incorporate possible endogenous effects.

The objective of this study is to incorporate anticipated congestion in an individual-specific demand framework using random utility theory. In this process the notion of interdependent utility functions will be utilized and implemented in a relatively simple econometric structure. The model will be illustrated in an empirical application to wilderness recreation in which congestion plays a key role in recreation site choice behaviour.

## 2. THEORY

A recreationist (indexed  $n$ ) receives utility,  $U$ , from visiting a site (indexed  $i$ ) equal to  $U_{ni}=U(X_i, Z_n)$ , where  $X_i$  is a vector of characteristics of site  $i$ , and  $Z_n$  is a vector of individual characteristics. Random utility theory considers  $U$  as a random variable where part is known or observable to the investigator and the remainder is not. Thus,  $U_{ni}=V_{ni}+\varepsilon_{ni}$  where  $V_{ni}=f(X_i, Z_n)$  is the former component and  $\varepsilon_{ni}$  the latter.  $\varepsilon$  is considered an error term related to researcher error or to randomness (hence the term random utility) of the individual

The probability that site  $i$  will be visited by  $n$  is equal to the probability that the utility gained from visiting  $i$  is greater than or equal to the utilities of choosing any other site in some finite set of available sites,  $C_n$ . Thus, the probability,  $\pi$ , of visiting

site  $i$  is:

$$\pi_n(i) = \Pr \{ V_{ni} + \varepsilon_{ni} \geq V_{nk} + \varepsilon_{nk}; \forall k \in C_n \}. \quad (1)$$

The conditional logit model, developed by McFadden (1974), can be used to estimate these probabilities if the  $\varepsilon$ 's are assumed to be independently distributed Type-I Extreme Value variates. McFadden (1974) shows that this assumption allows the choice probabilities to take the form:

$$\pi_n(i) = \frac{\exp \mu (V_{ni})}{\sum_{k \in C_n} \exp \mu (V_{nk})}. \quad (2)$$

where  $\mu$  is a scale parameter that is typically assumed to equal 1.

Congestion in this theoretical context can be considered a site attribute, and can be separated from other elements in the vector of site characteristics,  $X_i$ . The utility function is now represented by:

$$V_{ni} = f (X_i, Z_n, c_i), \quad (3)$$

where  $c_i$  represents congestion at site  $i$ . Based on discussion in the recreation literature (e.g. McConnell and Sutinen 1984), one can assume that  $\partial V_i / \partial c_i < 0$  for the majority of individuals. However, as pointed out by Jakus and Shaw (1997), utilizing this structure using revealed preference data is problematic because recreationists can only experience the level of congestion by visiting the site (an *ex post* measure). Thus, it is difficult for researchers to incorporate current levels of congestion because congestion cannot enter the utility function and influence site choice before it is experienced. An approach that properly incorporates congestion should consider its uncertain nature and individual variability in the disutility (or indeed for some utility) that it may provide.

The uncertain nature of congestion could be manifested in the formation of prior expectations or anticipations of congestion levels and choices could be made on the basis of these prior perceptions of congestion and other choice attributes, not necessarily objective measures of them. Empirical support for the hypothesis that recreation site choice could be made on the basis of perceptions of environmental quality has been obtained by Adamowicz et al. (1997). One way to consider anticipated congestion in the theoretical framework outlined above is to assume that individual recreationists make *forecasts* of congestion levels at sites before visiting them. An individual's forecast of congestion at site  $i$  is based on their view of the probabilities of other recreationists visiting the site. Considering person  $n$ 's utility function and expanding congestion in (3) yields:

$$V_{ni} = f (X_i, Z_n, (-n \bullet Pr_{-ni})), \quad (4)$$

where  $-n$  represents the number of other recreationists (not including  $n$ ) who would visit  $i$ , and  $Pr_{-ni}$  portrays the probability of these other people visiting site  $i$ . Thus, the congestion level in this expression is represented by the number of people who may visit this site multiplied by their probabilities of choosing this site. However, the probabilities of other recreationists visiting  $i$  are related to their indirect utility functions as explained above, making congestion endogenous. Incorporating this idea into (4) produces:

$$V_{ni} = f (X_i, Z_n, G(-n, V_{-ni}(X_i, Z_{-n}, c_i))) \quad (5)$$

where congestion is captured in the function  $G(\cdot)$  which provides  $n$ 's estimate of  $-n$ , in turn depending on  $V_{-ni}(\cdot)$ .

This way of thinking about congestion results in interdependent utility functions in that  $n$ 's choice of a particular recreation site is dependent on  $-n$ 's choice of that same site. Each recreationist in the market does not have information about how others choose sites but may anticipate other recreationists' choices.<sup>1</sup> Since each person selects a site to maximize his or her utility, given the other recreationists' utility maximizing behaviour, the behaviour associated with recreation site choice is analogous to the behaviour hypothesized in a Nash game. In this case, the arguments of the game are the forecasts of others visitation levels which are taken as given. Thus, recreationists are assumed to predict  $V_{ni}$ , take this as given, and act on their best response to the resulting expected structure of the market.

An outcome of this framework is that environmental quality changes at site  $i$  appear not only in  $n$ 's indirect utility function, but also in the functions of the other recreationists. Thus, site quality improvements may have a positive effect on the recreation benefits provided by a site on  $n$ , but may have an opposite effect through their impact on congestion levels by making the site attractive to other recreationists. To illustrate this (5) can be rewritten as:

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<sup>1</sup> Note that this formulation differs from other examinations of interdependent preferences in which the mean or some other measure of the demand of the population or reference group enters the analysis (e.g. Pollak 1976).

$$V_{ni} = g(X_i) + h(Z_n) + k(V_{-ni}), \quad (6)$$

and examining the effect on  $n$  of a change in quality at site  $i$  yields:

$$\frac{\partial V_{ni}}{\partial X_i} = g'(X_i) + k'(V_{-ni}), \quad (7)$$

$$\text{where } k'(V_{-ni}) = \frac{\partial V_{ni}}{\partial V_{-ni}} \bullet \frac{\partial V_{-ni}}{\partial X_i}.$$

The latter term in (7) represents the reaction function of  $n$  to the other recreationists following a quality change at site  $i$ . Therefore, measuring the benefits of environmental quality changes must include both of these forces.

### 3. APPLYING THE FRAMEWORK

For the framework presented above, recreation site choice would involve individuals forecasting congestion levels based on their view of the probabilities of other recreationists visiting the sites of interest. Modelling this theoretical structure of recreation choices in the presence of congestion as interdependent utility functions could involve representing the visitation reaction functions depicted by the term  $k'(V_{-ni})$  by some instrument such as congestion forecasts,  $F(c_i)$ . Thus, the indirect utility function of  $n$  for site  $i$  could be represented by:

$$V_{ni} = f(X_i, Z_n, F(c_i)) \quad (8)$$

Empirical implementation of this idea requires explicit estimation of anticipated congestion levels at some set of sites.

For example, forecasts of congestion at site  $i$  may be some function of the qualities or characteristics of site  $i$ , the experience levels, and socioeconomic characteristics of the individual. Now the utility function can be portrayed by:

$$V_{ni} = f(X_i, Z_n, F(c_i)); \quad (9)$$

$$\text{where } F(c_i) = f(X_i^s, Z_n^s)$$

where the superscript  $s$  refers to a subset of the vector of site or individual characteristics. Empirical implementation of this theoretical structure requires information on anticipated congestion levels at some set of recreation areas and information on trips to these same areas, the development of an anticipated congestion function, and the use of this function in an instrumental variables procedure with the site choice model. Note that now congestion is not only a site attribute, but is also an individual attribute. Thus,  $n$ 's forecast of congestion is unique to  $n$ . This framework now allows for the existence and inclusion of Schelling's (1978) concept of the critical number, in this case the critical number of recreationists.

#### Data and Econometric Analysis

During 1995, a sample of 1000 visitors to Nopiming and Atikaki Provincial Parks in Manitoba, and Woodland Caribou,

Quetico, and Wabakimi Provincial Parks in Ontario was drawn from park registrations or on-site registrations administered by the Canadian Forest Service. About 71% of individuals in this sample were from Quetico, about 18% from Woodland Caribou, 10% from both Manitoba parks, and about 1% were from Wabakimi. This distribution was selected because it approximately represented the levels of visitation across the five parks (see Boxall et al. 1999). Respondents took 1,723 trips to the 5 parks during 1995 and 1996. The most frequently visited parks were Quetico and the BWCA.

A questionnaire was developed that gathered information about opinions of wilderness management, levels of past visitation to the 5 parks<sup>2</sup> and an additional park, the Boundary Waters Canoe Area (BWCA), descriptions of a typical wilderness trip, and socio-demographic characteristics. One section of the questionnaire solicited perceptions of congestion at each of the five parks. These perceptions were solicited using the following question: "In planning your last trip to wilderness parks or areas, what were your perceptions of existing park conditions and management?" A table was presented to respondents and they were asked to indicate the number of expected encounters per day with other wilderness visitors in each park by checking one of four levels: none, 1-3 groups, 4-9 groups, or over 9 groups. The questionnaire was mailed to respondents during 1996 and after two follow-ups and adjustment for non-deliverables, an 80% response rate was achieved.

The responses to the congestion question were pooled ( $N=1,297$ ) and these formed dependent variables of the anticipated congestion model ( $F(c_i)$  in equation (9)). A number of individual-specific variables formed the  $Z_n$  vector in the congestion forecast model. These variables included: years of experience in wilderness trips in the region, membership in a conservation or recreation organization, the typical trip length, gender, income, education, and household size.<sup>3</sup> Since the five parks represent an increasingly highly sought wilderness experience (Boxall et al. 1999), and that in at least one park (the BWCA) visitors were increasingly "feeling crowded" (Cole et al. 1995), the years of experience variable was expected to have a positive effect on increasing congestion forecasts. The rationale here was that individuals visiting the area many times in the past would have experienced the increasing visitation levels over time.

<sup>2</sup> In this analysis Nopiming and Atikaki parks were combined into an eastern Manitoba Parks unit.

<sup>3</sup> It is recognized that this is a limited set of variables and that others, such as attitudes towards crowding, may be better explanators of congestion forecasts.

Similarly, those who belonged to organizations would have more information on visitation levels and the increasing use of the parks over time. Thus, the effect of membership was also expected to be positive.

However, individuals who typically take short trips were thought to take more of them with families or other types of social groups. This characteristic suggests that they may not have experienced the increasing use of backcountry areas and may not be as sensitive to congestion as those taking longer trips to congestion levels. Thus, it was thought that this variable would have a negative effect on congestion forecasts. Similarly, the household size variable was hypothesized to have a negative effect on congestion forecasts due to the fact that families with many children would not have the time or background to have experienced the increasing visitation levels. The signs of the other individual-specific variables were uncertain.

Finally, the perceived level of development at a park was thought to influence anticipated congestion. In this case the development category reported by each respondent from a park for which a congestion forecast was received was used. It was hypothesized that forecasted congestion would be greater if an individual thought that the level of development was greater. Thus, the parameter on development was expected to be positive.

For the  $X_i$  vector, there were few choices relating specifically to each of the limited set of parks and due to the diversity of routes in each park an individual was able to choose. However, the size of the park is probably representative of the number of routes one is able to take, and may affect the spacing of recreationists such that their chances of encountering each other are reduced. Thus, park size was expected to have a negative effect on congestion forecasts. In addition, the degree of access of the routes at each of the five parks varies and was thought to play an important role in determining congestion levels. This variable was expected to have a positive impact on congestion forecasts; greater accessibility would mean more visitors.

Since the dependent variable was discrete, but ordered, ordered logit models were used to determine the effects of individual respondent and park characteristics on forecasts of congestion levels. The results are shown in Table 1 on page 7.

In both models, being male and preferring long trips is inversely related to increasing congestion perceptions. As expected, high levels of wilderness recreation experience and membership in a conservation or recreation organization have positive effects on the levels of anticipated congestion. These relationships point to a connection between the highly specialized recreationist (likely male, experienced, takes long trips and is a member of an organization) probably visiting

places where they do not expect to see high numbers of other individuals. Finally, as expected, high levels of perceived human development at wilderness parks have a significant positive effect on congestion levels. All other individual-specific variables were statistically insignificant in explaining congestion forecasts

These individual effects on congestion are probably mediated by relationships between visitation levels and park characteristics, however. In this data the size of the wilderness area has a negative effect, while the number of roads accessing a wilderness area has a positive effect on congestion forecasts. These relationships support the hypothesized connections between park size, access, and congestion levels.

Park choice models were estimated using the revealed preference information collected in the survey. Park choice was modelled as a function of travel costs, perceived chances of entry, perceived development levels, the size of the park, the number of roads accessing the park, and an alternative specific constant. Congestion was included in these models in two different ways. The first used the congestion level by park reported by each respondent from the questionnaire.<sup>4</sup> The model using this variable is termed the reported congestion (RC) model since respondents reported their prior congestion forecast. This way of including perceptions of attributes has been suggested in other studies of recreation choice behavior in the literature (e.g. Adamowicz et al. 1997). The second approach used predictions from the congestion forecast models described above and this choice model will be called the anticipated congestion (AC) model.

The parameter estimates (Table 2) suggest that the variables generally perform as expected in each of the models. For example, travel costs are negative and significant, higher chances of entry to a park are a positive influence on park choice, higher congestion levels are a negative influence on choice, and park size and the number of roads accessing a park have a positive effect on choice. The signs of these variables are consistent across the model, but the magnitude and statistical significance of the effect of these features are different.

A number of findings are noteworthy. First, perceived development has a negative, but insignificant effect on park choice in the RC model. This variable is positive and significant in the AC model. Second, higher congestion levels had a significant negative effect on park choice. However, the

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<sup>4</sup> If this information was missing for a park the modal perception level calculated over the sample was used for a respondent.

negative effect of congestion is much more pronounced in the AC model than the RC model. This further suggests that using predictions from the congestion forecast function as instruments rather than using the reported congestion forecasts, is adding significant information to the analysis of park choice behaviour. The instrumental variables approach is revealing that congestion has a greater effect on park choice than could be understood with the other more typical modelling approach. See Table 2 on page 7

Third, while the size of the park and the number of roads accessing a park have positive effects on choice in both models, there are differences in the sizes and the statistical significance of the parameters. In the RC model the park size parameter is highly significant and about six times larger than in the AC model. Roads, however, are not statistically significant in the RC model, but are in the AC model and the parameter is quite large signifying that roads have a large influence in determining park choice. Once again this effect has been uncovered as a result of using the congestion forecasts.

Finally, there are other important differences between the RC and AC models. In the latter, congestion and roads have been estimated with much greater precision than in the former. On the other hand the travel cost, chances of entry, park size and the alternative specific constant were estimated with less precision. This effect is particularly pronounced with the park size variable. In the RC model the greater precision may be spurious due to the incorrect specification of congestion. In the AC model the instrument (in this case the  $F^{\oplus}$ ) function) has successfully identified the endogenous congestion condition in the choice models. This is further supported by the observation that the value of the log likelihood at convergence and the  $\rho^2$  statistic for the AC model are larger than those for the RC model.

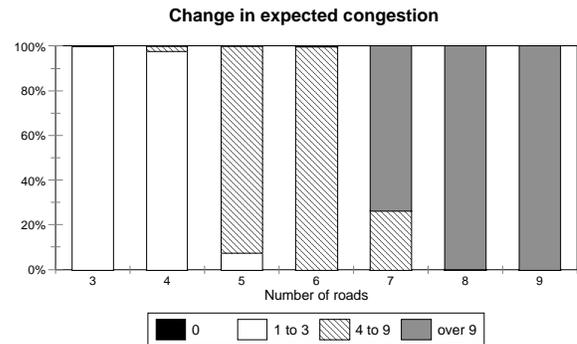
**Welfare Implications**

A question that remains with the endogenous congestion condition is the effect it would have on welfare measures associated with environmental quality changes. To examine this issue a policy simulation was imposed on one of the five parks. The policy involved increasing road access to Quetico Provincial Park. While this increased road access is hypothetical at present, it is plausible given possible expansion of forest harvesting and the need for increasing access for logging trucks and other equipment to remote areas. For most of the 5 parks examined in this study, industrial forestry is occurring near these parks, and in some cases (e.g. Woodland Caribou Park), harvesting takes place right up to their boundaries.

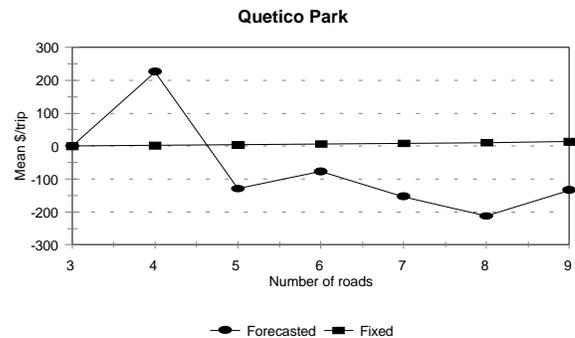
The welfare implications of road access expansion were examined using Hanemann's (1982) formula for estimating

compensating variation in conditional logit models. For the AC model this involved estimating the change in congestion forecasts through adjusting the numbers of roads accessing each of the parks and then incorporating these new forecasts in the park choice model. However, the roads variable must also be modified in the choice model holding all of the other variables (except congestion) at their original values. For the RC model, congestion remained constant and only the roads variable was changed in the choice model.

For the current access level at Quetico (3 roads) the ordered logit model predicts that a majority of respondents (575 of 580 individuals), forecast an encounter level of 1-3 groups per day (Figure 1). However, increasing road access at this park would change this forecast. With six roads for example, every individual in the sample forecasts congestion to be 4-9 groups/day and beyond this road access level, an increasing percentage of the sample forecasts congestion at the highest level (Fig. 1).



**Figure 1:** The effects of changing road access on congestion forecasts of wilderness recreationists



**Figure 2:** The effects of changing road access on the welfare of wilderness recreationists

The welfare implications of this expansion of access are shown in Figure 2. Note that an additional road at Quetico would generate benefits valued at over \$200/trip. More than one additional road, however, generates dis-benefits. At

five roads, this drop is pronounced and is congruent with a major shift in congestion forecasts. These findings support Schelling's (1978) notion of thresholds. These effects are not picked up by the RC model in which increasing road access does not feed back on congestion with the result that each additional road generates additional benefits through their impact on site choice utility.

#### 4. DISCUSSION

The theoretical framework introduced in this chapter offers a viable solution to incorporating interdependent behaviour in economic choice models. The notion of interdependent utility functions has a great deal to offer economists in studying a wide variety of issues, not only congestion. Part of the appeal of this framework is the notion of incorporating endogeneity through forecasts of other individuals' behaviour. These other individuals may be competitors, in which case the interactions are attenuating, or they may be facilitators in which case the interactions are reinforcing. This proposed framework may be a better basis for conducting policy analysis, especially if the analysis is capable of exploring heterogeneity in these types of interactions. This, in particular, is the case Schelling (1978) alludes to where "simple summations or extrapolations to aggregates" are not possible. In the example examined in this present study, the aggregate assessments of welfare masked considerable variation in the impacts of hypothetical policies.

This is not to say that the analysis presented in this chapter cannot be improved. For example, the econometric analysis could be improved to incorporate more fully the statistical linkages between the congestion forecast model and the economic site choice model. For example the standard errors in the choice model should be adjusted using corrections to the variance-covariance matrix in the manner suggested by Murphy and Topel (1985). Alternatively, the parameters of the ordered logit and conditional logit models could be estimated simultaneously using full information maximum likelihood techniques. These procedures will solve potential statistical issues resulting from the generated regressor problem. However, these techniques were beyond the scope of the current analysis.

Another limitation involved the discrete nature of the forecast function. This was restrictive in the number of categories (four) included in the data collection effort. The information displayed in Figure 1 initially had more categories, but these had to be collapsed to the four used in the ordered logit analysis for space considerations in the questionnaire. This discrete approach likely masked considerable additional variation among individuals in the data. While a continuous forecast function may be a better method to examine the issues raised in this chapter, this requires a different way to collect data and poses a considerable challenge for future studies addressing this issue. However, the result of using

continuous data may point to the presence of considerably more heterogeneity in preferences, and might uncover more useful information on thresholds in behaviour.

An immediate extension on this present work might be to link the information portrayed in Figure 1 into the two-stage model process. One approach may be to introduce a threshold effect (through the threshold outlined in Fig 1) exogenously and then instead of impacting the utility function through the congestion variable, this threshold could operate to change the choice set in which the unattractive alternative is removed. It remains to be seen, however, if this approach would provide more useful information to decision makers.

Another extension to this analysis includes understanding and incorporating heterogeneity in terms of the types of interactions with people. In the context of wilderness canoeing, this may involve encounters between groups at entry points, while paddling on the water, at portages, and at campsites. In these instances, the critical numbers may differ at each type of location. Furthermore, in recreation contexts the types of people one encounters may have a profound influence on satisfaction levels and consequently may feed back on choice behaviour. For example, I tend to avoid camping at managed sites on long weekends to avoid encountering other campers more interested in drinking and making noise. I perceive that on long weekends these types of people are more likely to be encountered than during the week or on regular weekends.

These types of interactions will be complex to examine and incorporate in choice models. Some of these interactions may be more appropriately modelled using different types of equilibriums. For example, one could envision a leader-follower model in which large recreation groups involved with organizations such as Outward Bound or the Scouts Canada decide to visit wilderness areas and thereby affect the behaviour of the more solitary and smaller groups of recreationists.

Regardless of the improvements and enhancements one could make to the analysis reported here, we believe that the interdependent utility approach used by economists offers considerable promise in addressing the issues raised by Schelling (1978), and others.

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**Table 1.** Parameter estimates for an ordered logit model explaining perceived congestion at five wilderness park areas in eastern Manitoba and northwestern Ontario.

Variable	Parameters (t-statistics)
Constant	2.2632 (5.028)
Gender (male)	-0.4268 (-1.999)
Years of experience in backcountry areas in the study area	0.0122 (2.328)
Typical trip length (days)	-0.0569 (-3.354)
Member of a conservation or recreation organization	0.2457 (2.094)
Perceived level of development	0.1470 (1.825)
Size of park	-0.0584 (-6.997)
Number of roads accessing park	0.9007 (22.373)
$\mu_1$	3.4918 (26.891)
$\mu_2$	5.8445 (33.935)
Log likelihood	-1216.28
% correct predictions	60.8

**Table 2.** Parameter estimates for conditional logit choice models explaining wilderness park choice among five areas in eastern Manitoba and northwestern Ontario.

Variables	Reported congestion	Anticipated congestion
Travel cost	-0.00415 (-9.553)	-0.00221 (-5.153)
Perceived chances of entry	0.48283 (12.049)	0.18530 (4.048)
Perceived levels of development		
Congestion	-0.12246 (-1.815)	-3.22100 (-13.893)
Park size	0.06186 (11.222)	0.01571 (1.994)
Roads	0.02592 (0.956)	0.93324 (13.139)
ASC - Manitoba Parks	-1.03280 (-9.772)	-1.08730 (-8.668)
Log Likelihood at convergence	-2312.01	-2204.4
$\rho^2$	0.164	0.203