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RURAL ECONOMY

STAFF PAPER

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Habit Formation in a Discrete Choice Model of Recreation Demand: Estimation and Welfare Measurement

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Staff Paper 91-11

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INTRODUCTION

Economic models of recreation demand (models of site choice, trip frequency or recreation participation) typically ignore the dynamic aspects of choice.[2] In other literature, however, previous consumption habits are found to play a large role in consumer choice. In the recreation literature, for example, the fact that an individual is aware of a site (due to previous visitation for example) has been found to be a significant explanator of site choice (Perdue, 1987). Some economic examples have also found significant dynamic elements in recreation demand (McConnell et al, 1990; Adamowicz et al, 1990; Munley and Smith, 1976). Surprisingly, the recreation decision modeled in most economic analyses seldom contains previous experience with the sites as a characteristic of choice. The resulting welfare analyses have assessed the impact of site changes (attribute changes or site closures) without regard for consumption inertia, habit effects, or learning.

In this paper two models of habits are analyzed. The first model is a simple representation of habit in which previous visits to a site are included as attributes of the site. The second model is a more complex behavioral model in which the consumers are aware of the habit forming potential of the good and they factor this into a long term budget constraint. This model uses previous visits as a "stock" variable and the effective prices change in response to the knowledge that a habit will require consumption in the future period, thereby affecting budgets in the future. The statistical results indicate a significant improvement in the site choice model when previous consumption behavior is taken into account.

The welfare impacts of quality changes are examined for a base model (no habit effect) and the two habit models. The results indicate that the habit models produce a wider variation (over the sample) in welfare effects, relative to the non-habit model. In particular, it appears that if the individual has built up habits at a site, they will be sensitive to changes which affect that site but they will not be as sensitive to changes that affect other sites.

HABIT EFFECTS AND A RATIONAL HABIT MODEL

A number of approaches to habit formation have been discussed in the consumer demand literature. Theoretical analyses of habits include Pollak (1970, 1976), Hammond (1976), and Spinnewyn (1981). Several econometric approaches have also been developed. One approach includes lagged dependent variables in econometric specifications of demand equations (e.g. Johnson, et al, 1984). Another approach analyzes the state-dependence versus heterogeneity phenomenon (Heckman, 1981; Heckman and Willis, 1977). These approaches, however, concentrate on the econometric questions associated with demand models estimated from time series data. In the rational habit model presented below, the dynamic elements of consumer choice are highlighted.

One of the models estimated here represents habits by including a variable in the discrete choice regression model which indicates the number of previous visits a person made to each of the sites. This previous visits variable acts as a characteristic or attribute of the site. Using previous visits as an attribute, however, is a simplistic representation of habits since it ignores dynamic effects in choice. A rational consumer will be aware of the habit forming effect on choice in an intertemporal context and will consider this effect when maximizing a multi-period utility function. The model developed below incorporates rational habit formation in recreational site choice based on a framework developed by Pashardes (1986).

The consumer is assumed to maximize a utility function which spans several time periods subject to a multi-period budget constraint. This utility function, however, is composed of "stocks" of goods. Let X_{it} represent the quantity of good i in period t. P_{it} represents the price of good i in period t[3]. Consumption of these goods over time is represented by a "stock" variable which is the sum of current consumption and depreciated previous consumption. This stock variable is defined as

$$Z_{it}=\sum_{\tau=0}^{\infty} d_i^{\tau} X_{it-\tau}=X_{it}+d_i Z_{it-1} \tag{1}$$

where Z_{it} is the stock of good i in period t and d_i is a "depreciation" rate or habit effect associated with each good. A habit effect in this model is represented by negative values of d_i while the d_i parameters would be positive for durable goods. In a longer term context one may wish to incorporate discounting, however, this complication is suppressed here.

A consumer's utility function in time t is based on stocks Z_{1t} to Z_{nt}. The consumer is considering choice over T time periods. The quality attributes (also subscripted by time) associated with each good are components of the preferences. The multi-period utility function takes the form;

$$U([Z_{1t},..,Z_{nt};Q_{1t},..,Q_{nt}];...;[Z_{1T},..,Z_{nT};Q_{1T},..,Q_{nT}]) \tag{2}$$

where Q_{it} is the quality attribute associated with good i in period t. To simplify the notation the quality attributes are suppressed in the development of the model.

The consumer also faces an intertemporal budget constraint. This constraint, however, includes consideration of the habit effect. The consumer recognizes that purchases of a habit forming good will require outlays in the future, in part due to the habit effect. This "habit rationality" is represented by modifying the intertemporal price in the following manner;

$$\hat{P}_{it}=P_{it}-dP_{it+1} \tag{3}$$

where P_{it} is the market price of good i in period t and $\hat{P}_{it}$ is the dynamic price.

As in most dynamic analyses, separability of the time periods is assumed. In this case we denote a single time period separable sub-utility function as;

$$\hat{U}_t(Z_{1t},..,Z_{nt}) \tag{4}$$

Employing separability over time allows the maximization of each sub-utility function individually.

However, the habit effect represented in the prices must carry over to maintain the dynamic nature of the problem. The maximization problem can be written as;

$$Max\ \hat{U}_t(Z_{1t},..Z_{nt}) \tag{5}$$

$$subject\ to:\ \hat{M}_t = \sum_i \hat{P}_{it}Z_{it} \tag{6}$$

Where $\hat{M}_t$ is an income term which accounts for habit effects. This problem yields the demands for stocks of the goods;

$$Z_{it}=\hat{g}(\hat{P}_t,\hat{M}_t) \tag{7}$$

where $\hat{P}_t$ is the dynamic price vector over all goods. Using equation 1, this demand for stocks can be converted into the demand for goods in the current period. This demand for goods is a function of dynamic prices, income, the habit parameters d_i and the stock of goods accumulated in previous periods;

$$X_{it}=\hat{g}(\hat{P}_t,\hat{M}_t)-d_iZ_{it-1} \tag{8}$$

Estimation of the rational habit model can now proceed using a demand function (for goods) which depends on prices, income and previous consumption as well as the habit parameters, d_i. Pashardes (1986) uses this model to analyze consumer demand for categories of goods in the U.K. under the assumption of an AIDS functional form. In applying the model to recreational demand, some additional assumptions are required.

Let the goods described above be choices to visit a recreation site. Now the choices become mutually exclusive. The restriction added to the model is;

$$X_{it} \cdot X_{jt} = 0 \tag{9}$$

and the consumer is assumed to obtain the optimal amount of the good (site) or consume zero within each period[4].

$$X_{it} = X_{it}^{*} \text{ or } 0 \tag{10}$$

The choice problem can now be thought of as a problem of adding to "stocks" in each period by choosing a certain amount of one good (visit). The fact that choices are mutually exclusive in each period requires the development of a conditional utility function; conditional on the choice of good or additions to stocks. Conditional on the choice of good 1 to add to stocks the conditional indirect utility function (employing the separable utility function in equation 4[5], the optimal demand in equation 7 and the assumptions in equations 9 and 10) is[6];

$$V_{1t}(\hat{M}_t - \hat{P}_{1t}X_{1t}^{*},\ d_2 Z_{2t-1}, \ldots\ d_n Z_{nt-1}\ |Q_1) \tag{11}$$

where Q_1 is the set of quality attributes associated with good 1. The choice of good 1 over any other good implies that;

$$V_{1t}(\ \cdot\ ) \geq V_{jt}(d_1 Z_{1,t-1}, \ldots d_j Z_{j-1,t-1},\ \hat{M}_t - \hat{P}_{jt}X_{jt}^{*},\ d_{j+1}Z_{j+1,t-1}, \ldots d_n Z_{n,t-1}\ |Q_j) \tag{12}$$

Assuming a linear indirect utility function (as is common in discrete choice analysis) and rearranging the elements of the inequality, the choice of any site i over any other site j

implies;

$$V_i = \hat{M} - \hat{P}_i X_i^{*} - d_i Z_{it-1} + Q_i \geq \hat{M} - \hat{P}_j X_j^{*} - d_j Z_{jt-1} + Q_j = V_j \tag{13}$$

Augmenting this utility difference expression with type one extreme value error terms in the Random Utility Model fashion and adding parameters to the price and quality terms produces a discrete choice model in which site choices are a function of the quality attributes, the habit adjusted price and the stocks of visits accumulated in the past (see Maddala (1983) or McFadden (1973) for details on discrete choice modelling). The d_i parameters play two roles in this analysis. They are the depreciation factors and they modify the price vector to maintain the intertemporal budget constraint. It is also evident that a simple discrete choice model is a variant of this model in which all d_i's equal zero (no habits).

NAIVE HABITS, RATIONAL HABITS AND THE BASE MODEL

The model described above incorporates previous consumption decisions into the demand functions for goods in any time period. A base model can also be considered in which no previous consumption factors are included in the demand analysis. In the empirical analysis which follows three models (base, naive and rational) are estimated for the case of recreational hunting site choice[7]. The base model is estimated using choices of sites and standard multinomial logit maximum likelihood estimation. The naive model simply adds an attribute to each of the sites in the model; the number of previous visits to the site. The rational habit model requires a slightly more sophisticated estimation approach. The base for the likelihood function is the multinomial form, however, the d_i parameters are used to construct the relevant level of stocks of goods (see equation 1) and they affect the relevant prices. The model is estimated using repeated discrete choice data. Thus for each individual the d_i parameters are used to construct the stock level in every period assuming initial stocks are zero.[8]

EMPIRICAL MODEL: RECREATIONAL HUNTING

The data were obtained from a survey of recreational bighorn sheep hunters in Alberta, Canada in 1982. 1,000 licensed resident sheep hunters were sent questionnaires. Approximately 64% of these surveys were returned. Responses with missing observations were deleted resulting in 226 respondents with compete information on 423 hunting trips. In Alberta there were no restrictions on the site choices by the hunters thereby allowing all sites in the choice set to be included in the analysis for every individual.

Travel costs were computed by multiplying the round trip distance to each site for each individual by $0.18 per mile. Data on bighorn sheep populations and congestion were obtained from Alberta Fish and Wildlife Division Statistics and a larger survey of recreational hunting respectively. Site specific dummy variables were included for five sites. Three dummies were included for sites with relatively easy access (C1,C2,C3), one dummy was included for a site in which only bow hunting was allowed (C6) and another dummy (C10) was included for a remote, wilderness site (see Coyne and Adamowicz, 1992).

The base model is a simple discrete choice model in which the consumers choose 1 of 10 hunting sites. The components of the indirect utility function are price (travel cost), species population, congestion and the site specific dummies. The parameters of this simple model are presented in Table 1.

The naive habit model includes the number of previous visits to the site as an attribute of each site. This attribute is included in the indirect utility function. Since the data used in this study include information on all hunting trips, the information on previous trips can be used as an attribute for the current trip. The results from this model are also presented in Table 1.

RESULTS

The base model results indicate that travel cost (price) is a significant explanator of site choice, as is congestion, sheep population and the majority of the site specific dummies. A chi-squared test of the significance of the coefficients is rejected at the 1 percent level. Adding previous visits to the specification (the naive model) produces a better model. A likelihood ratio test of the naive model versus the base model suggests that the naive model is significantly different at a 1 percent level. The inclusion of previous visits affects the coefficient on price more than any other coefficient in the model. This effect will result in significant changes in welfare effects which will be examined below.

The rational habit model is also significantly different from the base model. Restricting the value of the parameters d_i to zero in the rational model will produce the base model. The likelihood ratio statistic is significant at the 1 percent level. A simple comparison between the rational and naive models, however, cannot be made. The naive and rational models are not nested models since the rational habit effects enter into the price variable and the stock variable in a complex fashion relative to the stock effect in the naive model. Nevertheless, examination of the likelihood functions suggests that both models perform adequately in explaining site choice. In both models the habit effects are significant. The habit parameters in the rational model (d_i) are negative and significant as expected. The price coefficient in the rational model is considerably smaller than in the other models. This arises because the price in the rational habit model is modified (using the habit parameters d_i) to reflect the effect of habits on intertemporal choice.

The habit parameter values are also of some interest. In the naive model the parameter simply indicates that the probability of visiting a site is increased if an individual has a history of taking trips to that site. This impact is independent of the price effect. In the rational model the information provided by the habit parameters is richer. The only habit parameter which is not significantly different from zero is the parameter associated with site 10. This is a remote wilderness site that may only be visited on a "special" trip. Visits to this site may not be associated with habit effects because of this characteristic. The habit effect is significant for all other sites, indicating that previous consumption is a significant determinant of choice.

The inclusion of habit parameters also has an impact of other parameters in the model. In the rational model many of the site specific constants become insignificant (although as a group they are still statistically significant). The inclusion of previous consumption patterns may capture the effects which were modeled with the site specific constants. Price and population effects are still significant but the congestion effect is only significant at a 10% level.

While it is clear that either the naive or rational forms of habit help to explain choice, the rational habit model provides a theoretical basis for the inclusion of previous consumption while the naive model suffers from all the criticisms associated with lagged dependent variable models.

WELFARE EFFECTS

In order to investigate the impact of habit effects on welfare measures, the three models estimated above are used to develop measures of compensating variation for attribute changes. In particular, the effects of a 10 percent increase in travel costs to all sites, the closure of site 1, a 50 percent increase in sheep population at site 1, and a 50% increase in hunter congestion are examined. The welfare measures are based on the expression developed by Hanemann (1982);

$$CV = \frac{1}{\mu}[\ln(\sum e^{V_j^0}) - \ln(\sum e^{V_j^1})] \tag{14}$$

where CV is the compensating variation, μ is the marginal utility of income (derived from the price coefficient in the discrete choice model), V^0 is the initial state and V^1 is the subsequent state.

Four statistics are presented for each welfare change (mean, standard deviation, maximum absolute value and minimum absolute value). These statistics are calculated over the sample of hunting trips. Examining the closure of site 1, the base model provides the lowest measure of impact per trip while the rational model provides the largest. The distributions of these impacts are interesting. The variation in the base model estimates are quite small when compared to the naive model. This may be interpreted in the following fashion. After building up stocks in a particular site, an individual will suffer a larger welfare loss from the closure of that site than will an individual who has not built up stocks in the site. Conversely, individuals who have not built up stocks in that site will not be affected by closure. The result is a larger variance in the welfare measure and a larger range. The rational model also produces a variance and range that is large relative to the base model but these measures are more conservative that those of the naive model. This is due to the fact that the habit parameter for site 1 is smaller than the parameter in the naive model and the habit effect to site 1 is small relative to some other sites. Also, this may be due to the price effect in the rational model which requires that the consumer be cognizant of the habit forming potential of the good in question.

The results for a 10% increase in travel costs to all sites are quite different than the results for site closure. The difference between the base and naive models is quite small. This is due to the fact that all sites (and all individuals) are subject to the same change in this case. The impact of the naive habit is minimal. However, the rational model provides larger estimates of welfare impact. This arises because there is a difference in the price coefficients between the rational model and the other two models. Population and congestion measures have the same pattern as site closure, although less pronounced. The welfare impacts of the naive model are larger in variance than those of the base model and the rational model provides the largest measures of welfare change.

CONCLUSIONS

Based on the comparison of habit and non-habit models it is apparent that dynamic elements influence choice. This conclusion has been identified in a number of studies of aggregate choice behavior (i.e food demand) but surprisingly it has not been investigated to a great degree in micro-data examples. This particular application to recreation demand raises a number of theoretical and empirical issues. First, recreation site choice appears to be affected by previous consumption behavior. This fact may be a function of habits or other factors including a lack of awareness of other sites or some other information issue. Second, although this paper assumes that initial "stocks" of visits to the site are zero, in reality, this initial condition will not be zero and an accurate description of initial stocks may involve the retrieval of a long history of choice behavior. Indeed, the problem of identifying initial conditions in models of this type has been recognized as a significant difficulty (Heckman 1981).

A third theoretical and empirical issue is the implication of habit effects for welfare measurement. It appears that the consideration of habits results in wider variation in welfare measures if the impact on a single site is examined. This results from the fact that those who have developed habits at the particular site are more adversely affected by a reduction in quality than they would be under a model with no habits. Undoubtedly these individuals will adjust their consumption and perhaps start to develop habits in other goods, however, the immediate impact of the change may be quite large.

This paper has only scratched the surface in identifying dynamic issues in recreation choice and welfare evaluation. A rational habit model has been used to explain choices of goods within a time period. The use of previous consumption as an attribute (either in a naive or rational form) seems to be an improvement over static models of choice.

REFERENCES

Adamowicz, W.L., S. Jennings, and A.G. Coyne. 1990. A sequential choice model of recreation behavior. *Western Journal of Agricultural Economics*. 15:91-99.

Bockstael, N.E., K.E. McConnell, and I.E. Strand. 1989. A random utility model for sportsfishing: Some preliminary results of Florida. *Marine Resource Economics*. 6:245-260.

Coyne, A.G. and W.L. Adamowicz. 1992. Modelling choice of bighorn sheep hunting site. *Wildlife Society Bulletin*. in press.

Hammond, P.J. 1976. Endogenous tastes and stable long-run choice. *Journal of Economic Theory*. 13:329-340.

Hanemann, W.M. 1982. Applied welfare analysis with qualitative response models. University of California, Berkeley Working Paper No. 241. California Agricultural Experiment Station.

Heckman, J.J. 1981. Heterogeneity and State Dependence. in S. Rosen (editor), *Studies in Labor Markets*. University of Chicago Press, Chicago. pp. 91-140.

Heckman, J.J. and R. Willis. 1977. A beta logistic mode for the analysis of sequential labor force participation of married women. *Journal of Political Economy*. 85:27-58.

Johnson, S.R., Z.A. Hassan and R.D. Green. 1984. *Demand Systems Estimation*. Iowa State University Press, Ames.

Maddala, G.S. 1983. *Limited-dependent and Qualitative Variables in Econometrics*. Cambridge University Press, New York.

McConnell, K.E., I.E. Strand and N.E. Bockstael. 1990. Habit formation and the demand for recreation: Issues and a case study. *Advances in Applied Micro-economics*. 5:217-235.

McFadden, D. 1973. Conditional logit analysis of qualitative choice behavior. In, P. Zarembka (editor) *Frontiers in Econometrics*. Academic Press, New York.

Munley, V.G. and V.K. Smith. 1976. Learning-by-doing and experience: the case of whitewater recreation. *Land Economics*. 52:545-553.

Pashardes, P. 1986. Myopic and Forward Looking Behavior in a Dynamic Demand System. *International Economic Review*. 27:387-397.

Perdue, R.R. 1987. The influence of awareness on spatial behavior in recreational boating. *Leisure Sciences*. 9:15-25.

Pollak, R.A. 1970. Habit formation and dynamic demand functions. *Journal of Political Economy*. 78:745-763.

Pollak, R.A. 1976. Habit formation and long-run utility functions. *Journal of Economic Theory*. 13:272-297.

Smith, V.K. 1989. Taking stock of progress with travel cost recreation demand models: Theory and implementation. *Marine Resource Economics*. 6:279-310.

Spinnewyn, F. 1981. Rational habit formation. *European Economic Review*. 15:91-109.

Weber, M. 1991. Dynamic aspects of recreation demand. Unpublished M.A. thesis, Department of Economics, University of Alberta, Edmonton, Alberta.

Table 1. Results of the base model, naive model and rational model.

Variable	Base Model	Naive Model	Rational Model
Travel Cost	-69.33	-59.48	-37.19
	(14.43)[7]	(12.74)	(11.11)
Population[1]	9.96	8.63	9.83
	(5.86)	(4.98)	(2.93)
Congestion[2]	-5.38	-4.89	-3.84
	(5.62)	(5.05)	(1.71)
C1[3]	0.56	0.54	-0.09
	(2.90)	(2.64)	(0.35)
C2[3]	2.70	2.37	2.03
	(6.73)	(5.71)	(2.53)
C3[3]	-1.96	-1.63	-1.77
	(5.69)	(4.67)	(2.45)
C6[3]	-.61	-.41	-1.26
	(2.18)	(1.39)	(2.81)
C10[3]	1.80	1.57	-0.23
	(5.48)	(4.87)	(0.27)
Stocks[4]	----	1.13	----
		(9.63)	
Z1[5]			-.64
			(4.40)
Z2			-.75
			(5.61)
Z3			-1.09
			(5.05)
Z4			-1.03
			(4.46)
Z5			-1.13
			(8.75)
Z6			-0.77

			(2.85)
Z7			-1.32
			(8.69)
Z8			-0.69
			(2.71)
Z9			-1.24
			(3.79)
Z10			-0.18
			(0.67)
VOF[6]	-680.81	-611.84	-630.78

[1] Sheep population.

[2] Hunter congestion factor.

[3] C1 to C10 are site specific constants, see text for details.

[4] Stocks in the naive model are the number of previous visits.

[5] Z1 to Z10 are the depreciated stocks as defined in the rational model.

[6] Value of the Objective Function.

[7] t-Statistics are in parentheses.

Table 2. Welfare impacts (per trip) of selected quality changes.

	Base Model	Naive Model	Rational Model.
Close Site 1			
Mean[1]	-4.30	-6.69	-8.21
Std.Dev.[2]	4.55	12.98	9.31
Maximum[3]	-11.75	-109.31	-33.71
Minimum[3]	0	0	0
50% Increase in Population at Site 1			
Mean[1]	4.36	4.13	7.96
Std.Dev.[2]	4.14	4.46	7.65
Maximum[3]	10.21	15.21	22.31
Minimum[3]	0	0	0
50% Increase in Congestion at Site 1			
Mean[1]	-2.60	-3.01	-3.84
Std.Dev.[2]	2.70	4.04	4.14
Maximum[3]	-6.84	-17.23	-13.54
Minimum[3]	0	0	0
10% Increase in Travel Costs (all sites)			
Mean[1]	-2.95	-2.96	-5.29
Std.Dev.[2]	1.74	1.78	2.87
Maximum[3]	-11.10	-11.21	-17.29
Minimum[3]	-0.45	-0.52	-1.30

[1] Mean over all trips in the sample.

[2] Standard deviation over all trips in the sample.

[3] Maximum and minimum absolute value.

1. The author benefitted from discussions with several individuals. Thanks to Marian Weber, Peter Boxall and Jim Eales. A preliminary investigation of the naive habit model presented here was performed by Marian Weber (1991).

2. With the notable exception of McConnell, et al, 1990 who incorporated habits into a traditional travel cost model and Weber, 1990 who performed some preliminary analysis of habits using the data analyzed in this study.

3. Since the price variation in this model is spatial (no temporal effects or discounting effects are considered) an additional restriction placed on the empirical models in this section is that $P_{it} = P_{it+k} \; \forall \; k$.

4. These assumptions, and their role in discrete choice modelling are described more completely in Hanemann, 1982.

5. In most examples of discrete choice analysis the quality attributes of all other sites are suppressed in the conditional utility and conditional indirect utility functions. This is an assumption about the structure of preferences that is maintained here.

6. The time subscripts on all elements are suppressed. This operation is relevant for every time period.

7. This empirical analysis is presented as an example of the use of habit formation models. These data suffer from the fact that participation in the activity is assumed. Conceptually, there is no difficulty in including an option of non-participation. Also, for use in the rational habit model these data are assumed to represent observations of recreation behavior over distinct time periods (weeks for example). In reality they are simply observations of consecutive trips with different lengths of time between trips. A data set with information on the dates of trips could be used to estimate a model based on distinct time periods with the option of non-participation included.

8. The data are only available for one season. A more realistic approach would include information from several periods.