

# **MICROECONOMIC PERSPECTIVES ON TRAVEL BEHAVIOR AND VALUATION RESEARCH**

**Sergio R. Jara-Díaz**  
Universidad de Chile, Casilla 228-3, Santiago Chile

**Kara Kockelman**  
University of Texas at Austin

## **INTRODUCTION**

Over the years, the microeconomic framework has proved to be a very rich and useful approach for the understanding and modeling of travel behavior. This report summarizes two days of discussion on this topic, held among fifteen active participants in a workshop organized within the context of the IATBR Conference held in Gold Coast, Australia, 2000. The paper is organized as follows. First, we deal with the basic notion of what is understood as a “microeconomic perspective”. Then, we move into the main concepts that have attracted the attention of researchers using this framework in the travel behavior and valuation arenas, focusing on the evolution of the field and achievements to date. Finally, the issues and specific questions related to the challenges that lie ahead are proposed and discussed.

## **THE MICROECONOMIC PERSPECTIVE**

In essence, the main idea behind use of a microeconomic perspective in the fields of travel demand modeling and appraisal of transport projects, is to look at travel decisions through the eyes of consumer’s behavior theory, properly accounting for the specific dimensions involved, particularly time. It provides a framework for consistent and systematic examination of travel behaviors, aiding both specification and interpretation of functions that can be assigned a microeconomic meaning. Therefore, the microeconomic perspective should be understood as a theoretical approach particularly useful for

- specifying variables and properties of travel models;
- interpreting model results; and
- providing normative guidance for transport policy and project appraisal.

As is well known, the general idea behind a microeconomic framework for consumer behavior consists of looking at individuals' actions **as if** they were maximizing a utility function subject to constraints; thus, it is not conceived as a framework to understand the **motives** behind observed preferences. Using this approach in travel demand analysis requires a departure from the traditional consumer-behavior set up, in which direct utility depends upon continuous consumption of goods and an income budget is the only constraint considered. In the field of travel, instead, discrete choices and time costs play important roles. Through the influence of many areas within microeconomics, like labor economics and home production, the framework in which travel choices are analyzed has evolved (and still is evolving) towards more general formulations of consumer's behavior. These consider utility as a function of both time assigned to activities and goods consumption, and incorporate constraints of three types: the money budget, the time constraint, and a set of technological constraints that deal with the relations between activities and goods, including potentially exogenous minimum and maximum levels. The evolution of these can be traced through the works of Becker (1965), DeSerpa (1971), Evans (1972), Gronau (1986), Winston (1987), Juster (1990) and Jara-Díaz (1998).

## **EVOLUTION OF MICROECONOMICS IN TRAVEL DEMAND AND EVALUATION.**

The goods-leisure trade-off model (Train and McFadden, 1978) can be identified as the first attempt to understand discrete travel choices within a consumer behavior framework including goods consumption and time assignment. It is a major contribution toward the representation of mode choice as the discrete maximization of a **conditional indirect utility function** (CIUF), obtained as the best the individual can do given each alternative. Using aggregate variables, this model reproduces most of the properties of Becker's (1965) approach, including its limitations, particularly the fact that travel time savings are theoretically valued at the individual's wage rate. It is worth pointing out that the CIUF was later given a more specific treatment by McFadden (1981).

The specific subject of the estimation and interpretation of the subjective value of travel time savings (SVTTS) has stimulated much discussion on the specification of utility and constraints for travel demand modeling. The SVTTS can be calculated from the CIUF as the rate of substitution between time and cost, i.e. the ratio between the marginal utility of time and the marginal utility of cost (which is itself equal to minus the marginal utility of income as a property of the CIUF). It represents the amount the individual is willing to pay to diminish travel time by one unit. In his analysis of Truong and Hensher's (1985) paper, Bates (1987) showed that the SVTTS calculated from the CIUF is in fact the money value of the multiplier of a travel time constraint introduced by DeSerpa (1971), who had previously shown that it has two main components: the value of substituting travel time for other (more valuable or useful) activity, and the value of diminishing travel time itself (a result also obtained by Oort, 1969). From these central points, many aspects have been discussed in the literature, like the role of the wage rate, the case of a fixed income, the potential re-scheduling of activities, and the variation in consumption; for a synthesis, see Jara-Díaz (2000). The derivation of a time version of Roy's identity opens new possibilities for improvement in this area (Kockelman, 1998).

Individual time valuation has induced subliminally the idea that these values should be used directly in a project appraisal framework, a procedure that has been challenged and is presently under technical discussion using the tools of welfare analysis (Mackie et. al, 2001). In this context, it is interesting to realize that welfare measures (consumer's surplus) corresponding to the underlying demand models have been analyzed with particular care in the field of transport analysis. The so-called rule of a half, widely used in practice, was given a rigorous treatment by Williams (1976), who also found analytical expressions for the logit model and the entropy formulation (Williams, 1977). A strict link with the microeconomic formulation of the CIUF was provided by

McFadden (1981), who connected welfare measures (i.e. the log-sum expression) with the idea of a representative individual. Simultaneously, Small and Rosen (1981) developed the general welfare framework for discrete choices, establishing the conditions to obtain clear expressions of consumer's surplus from choice probabilities that depend on CIUF, which was later on used by Jara-Díaz (1990) to generalize the rule of a half and to identify a relation between the SVTTS and the consumer surplus.

In the paper mentioned above, McFadden (1981) brings together the microeconomics and the econometrics of discrete travel choice models. He presented the AIRUM model structure (additive income random utility maximizing), which has particularly attractive properties related with specification, estimation and interpretation of the CIUF that determines choice in travel models. However, the additive property also yields choice probabilities that are independent of current income (although he provided an excuse for the inclusion of income as a variable correlated with taste). Everything was connected, as Small and Rosen's formula needed the marginal utility of income to be independent of prices and qualities of alternatives. For short, this meant the absence of income effect in the discrete travel choice. This was explicitly formulated by Jara-Díaz and Videla (1989), who developed a test for it and, later on, showed analytically its effect in measuring welfare (Jara-Díaz and Videla, 1990). The correct calculation of a welfare measure with income effect was in later years faced and solved approximately by McFadden (1996) and exactly by Karlström (2000).

## WORKSHOP PRESENTATIONS

The workshop on microeconomic perspectives on traveler behavior and valuation research addressed a variety of substantive topics and methodological issues. Six papers were presented, spanning areas of mode reliability, non-linear income effects on measurement of willingness to pay, preferences and activity production, project comparison, discrete-choice specifications, and stochastic network equilibration. These papers touched on a variety of topics that engaged the participants as they sought to the state of art and practice in microeconomic frameworks of travel contexts.

Throughout the workshop, conversation emphasized several issue areas, including simplicity versus complexity in model specifications, the presence of significant uncertainty in model future inputs, the need for frameworks based on believable behaviors, model incorporation of imperfect information, consistent and equitable evaluation of policy impacts, model transferability, and the plausibility of utility maximization by travelers. The comment was made that lack of perfect information and presence of search costs inhibit globally optimizing behavior. Several participants felt that individuals are most likely sub-optimizing over a limited choice set and practicing satisficing behaviors. Other participants pointed out that modeling travel behavior **as if** there is an underlying preference system does not mean that travelers are doing the "correct choice" according to an external observer and, therefore, the consumer behavior paradigm can deal with this appropriately.

On the other hand, stagnation of modeling methods was a concern; as mentioned, the logit model has dominated this field for decades, and linear-in-parameter specifications represent almost all the applications. More innovation in theory and in functional – rather than stochastic – specification is highly desired. So far, the relation between income effect and non-linearity of the indirect utility has been identified. A broader perspective may come from contributors outside the transportation discipline, as it traditionally has been defined; for example, behavioral theorists and geographers may offer dramatic new insights.

Some of the methods likely to enhance the state of research in this field include construction of models which recognize imperfect information, deduction of restrictions of functional forms (before application!), surveys

specifically addressing mechanisms of choice (including intra-group versus individual contexts), formal research-team inclusion of experts from other disciplines (e.g., psychology and labor economics), use of non-linear specifications (for more functional flexibility), and publication of a good text on the subject of microeconomics and travel behavior modeling.

As for the workshop's series of paper presentations, John Bates examined work to date on the topic of travel-time reliability. He emphasized the importance of reliability from demand and supply sides (e.g., preferences/personal valuations along with when, where, and how). Bates's paper favorably reviewed Noland's work (1997) work on schedule delays, both early and late, for work using linear utility functions in a random-utility logit model of departure-time choices. Sergio Jara-Díaz discussed a structure for framing "technical relationships" between goods consumption and time assigned to activities. He reviewed classical approaches by Becker (1965), DeSerpa (1971), Collings (1974), and Evans (1972) and pursued the idea of isoconsumption relations over time dimensions as the dual of an activity possibility frontier (over goods dimensions), as well as isoactivity relations coupled to a goods consumption frontier. By imposing additional constraints involving time assigned to activities and goods consumption, Jara-Díaz added a new term to DeSerpa's resource value-of-time formulation.

Building on work by McFadden (1996), Herriges and Kling (1999), and Jara-Díaz and Videla (1989, 1990) Anders Karlström's investigated welfare effects under non-linear income effects. Karlström's paper emphasized the fact that only additive random utility functions under generalized-extreme-value error distributions and subject to constant marginal utility of money across choice alternatives would produce constant time valuation; therefore, only these conditions strictly permit use of logsum measures for welfare analysis. In practice, other assumptions commonly accompany application of the logsum as a welfare measure, and errors in interpretation result. In reality, there is no "representative individual" for a logit model if marginal utility of money is not constant (i.e., there are income effects on utility); under such conditions, there is no market demand function for integration of welfare impacts. Karlström showed that a linear-in-income indirect utility model would produce lower expected values of compensating variation (a common measure of welfare).

Gerard de Jong's paper provided a qualitative comparison of two methods of project evaluation. These are cost-benefit analysis, which is microeconomically based, and multicriteria analysis, which lacks an economic foundation but is based on "common sense." De Jong's presentation emphasized air-pollution impacts and difficulties in accommodating the value of externalities. He felt that repair and prevention costs are typically underestimated; he believes that society's willingness to pay is higher. De Jong also discussed contingent valuation surveys versus conjoint (i.e., stated preference) analysis and revealed-preference methods (e.g., hedonic models of prices) as tools for social valuation. Issues arising from contingent valuation methods include compliance bias, implied value cues, strategic and free-rider biases, as well as scenario misspecification. De Jong concluded that contingent valuation was a limited form of conjoint analysis and that both cost-benefit analyses and multi-criteria analyses should be combined (e.g., as many impacts as possible should be converted to monetary units, but perhaps not all).

Camilla Olsson presented a paper written jointly with Muriel Beser. The topic was an application of various specifications of discrete-choice models for travel demand in Sweden. A heteroskedastic extreme-value logit specification was examined and related to the results from multinomial and nested logit models. Otto Nielsen's application was on the Copenhagen road network in consideration of a new, tolled tunnel linking more directly to the city's downtown. A nested logit was used for mode choice as well as route choice, and travel times were updated until network times stabilized/equilibrated. This work's greatest contribution comes in the model's explicit recognition of various user classes via distributed/random variation in cost and time parameters.

## ISSUES IDENTIFIED BY PARTICIPANTS.

- Today, the field is dominated by the logit specification; modelers seem hard-pressed to advance new directions for travel behavior analyses based on microeconomic principles. A variety of substantive issues challenge transportation economists, modelers, planners, and engineers. These include model formulation, event prediction, group behavior, and human psychology. Reasonable specification of model structure (e.g., indirect utility) requires constraints on functional forms (e.g., non-negativity of consumption) and flexibility (e.g., the possibility of non-additive preferences). There is a need to recognize and supersede the behavioral restrictions that are implicit in most specifications (e.g., linear indirect utility). Moreover, proper interpretation of results (e.g., value of time) requires a strong appreciation of the data at hand, behavior, and model form. These issues are complex in a world where prices are only in terms of money (e.g., enforcing quasiconvexity of indirect utility and symmetry of compensated cross-price effects); there is little theory available in the realm of time costs.
- Also of great concern is the fact that models and their theory are growing more sophisticated, but forecasts seem to remain quite poor when models are used in isolation. Part of this apparent contradiction stems from high variability in day-to-day behavior by individuals (whence much of the data and many current models derive). But a great deal also stems from unobserved heterogeneity in situations and their actors. We may understand more, but we forecast poorly. If our forecasting ability does not improve significantly, the uncertainty associated with model results may overwhelm any suggestion of optimal policies and practices.
- Highly related to the topic of uncertain forecasts based on sophisticated econometrics is the mismatch of our tools and our understanding. In this regard, applied statistics and computational speed are much better than our understanding of the phenomena that govern travel choices. As an example, likelihood simulation is available for estimating an assortment of flexible specifications, but our choice of models aims to be behaviorally based, avoiding primitive comparisons of model fit.
- Another challenging area that calls for expanded research is the aggregation of preferences at the level of a group, allowing us to move from models of individual behavior to those of group behavior. Such models would be highly applicable at the level of household travel behavior, for example.
- There is a vast literature on travel choices and activities. So-called Activity Based Travel Models tend to be empirically oriented and offer rather intuitive discussion for the inclusion of variables at the usually many stages of the model system. Several of these, however, offer thoughtful insight into the activities-travel connection. They are very strong candidates for improved understanding a complex phenomenon in a more structured and general way. There should be an explicit effort to close the gap between these models and microeconomic theory, working with a critical attitude on both sides. A synthesis of such work promises a powerful framework for modeling, analysis, prediction and evaluation
- Related to these ideas is the need for a constructive and complementary interaction with other fields, like psychology and sociology. Travel-model results often can be interpreted from the viewpoint of motives and attitudes. We should more thoroughly investigate the “black box” (i.e. utility) that encompasses taste, preference, values, and attitudes.

- Although another milestone is incorporation of consumer surplus in practical applications of cost-benefit analysis (note the U.K.'s only recent formal recognition of demand elasticity in alternatives analysis), much remains to be done in terms of discussion. To begin with, many workshop participants felt that most policy still depends on political motivations and stakeholders who fight the hardest.
- Finally, welfare analysis for project appraisal lacks serious consensus. Many analytical problems have been solved in the areas that feed the evaluation schemes (consumers' surplus calculation and interpretation; same with the subjective value of travel time savings), but normative discussions are still pending within the cost-benefit analysis framework. For instance, should one value costs and benefits solely on the basis of willingness (which often translates to ability) to pay? The direct use of consumer surplus seem to reflect an innocent account of all individuals equally; in fact it means equality in terms of money, but not so in terms of utility (i.e. the implicit social weight on rich individuals is larger than that on the poor ones). Should we correct using the marginal utility of income? Should we measure benefits in another unit, such as time?<sup>1</sup>

### **SPECIFIC QUESTIONS TO BE ADDRESSED IN THE NEAR FUTURE.**

In order to ensure immediate progress in this field, there are some specific questions that may be plausibly addressed from a microeconomic perspective in order to help with the specification and use of travel models, improving our understanding of the underlying decision process. Some are the following:

- How may we rigorously formulate travel demand models within an activity framework?
- In theory, how should the question of scheduling and time reassignment be handled? For example, is optimal control the tool?
- How can we best integrate the theories of home production, labor economics, resource economics, location and land use, and travel choice? A comprehensive framework for behavior continues to elude us.

Facing these challenges should be of great help to unveil important issues, like the determinants of the value of time, the role of durable goods and life styles, the evolving perception of leisure and work, behavior under conditions of poverty or richness, and so on. In parallel, collaboration with other social science disciplines is becoming mandatory if we are to understand the results from an improved theoretical framework. Activity-specific positive or negative marginal utilities in the microeconomic jargon mean increasing or decreasing satisfaction from work, leisure or travel, which have both sociological and psychological components. Taken together, these topics may constitute a fruitful research agenda for the near future. To best address them, individual and family data will be needed including additional information, like work arrangements (contracts), or the identification of alternatives in those activities (other than transport) that present some type of trade-off between time and money. It is likely that small but detailed data sets are required for analysis and experiments using the analytical advancements made.

Regarding the area of transport project appraisal, the discussion should be focussed on the most appropriate use of consumer surplus measures (or individual willingness to pay) within the context of collective (public) decisions on transport projects. This is in the boundary of a political discussion, but our input is needed indeed.

---

<sup>1</sup> For a structured discussion on this point and its relation with the social value of time, see Gálvez and Jara-Díaz (1998).

## ACKNOWLEDGEMENTS

Professor Jara-Díaz would like to acknowledge Fondecyt, Chile, for help in funding his participation in the IATBR Conference.

## REFERENCES

- Bates, J.(1987) Measuring travel time values with a discrete choice model : a note. *The Economic Journal* **97**, 493 - 498.
- Becker, G. (1965) A theory of the allocation of time. *The Economic Journal* **75**, 493 - 517.
- Collings, J.J. (1974) The valuation of leisure travel time, a note. *Regional and Urban Economics* **4**, 65-67.
- DeSerpa, A. (1971) A theory of the economics of time. *The Economic Journal* **81**, 828 - 846.
- Evans, A. (1972) On the theory of the valuation and allocation of time. *Scottish Journal of Political Economy*, February, 1-17.
- Gálvez, T. and S. R. Jara-Díaz (1998) On the social valuation of travel time savings. *International Journal of Transport Economics* **25**, 205-219.
- Herriges, J.A., and C.L. Kling (1999) Nonlinear income effects in random utility models. *The Review of Economics and Statistics*, forthcoming.
- Jara-Díaz, S. R. (1990) Consumer's surplus and the value of travel time savings. *Transportation Research* **24B**, 73-77.
- Jara-Díaz, S. R. (1998) Time and income in travel choice: towards a microeconomic activity framework. In: *Theoretical Foundations of Travel Choice Modelling*, (T. Garling, T. Laitia and K. Westin, eds.) Pergamon, 51-73.
- Jara-Díaz, S. R. (2000) Allocation and valuation of travel time savings. In: *Handbooks in Transport, Vol. 1: Transport Modelling* (D. Hensher and K. Button eds.), Pergamon Press, Oxford, in press.
- Jara-Díaz, S. R. and J. Videla (1989) Detection of income effect in mode choice: theory and application. *Transportation Research* **23B**, 393 - 400.
- Jara-Díaz, S. R. and J. Videla (1990) Welfare implications of the omission of income effect in mode choice models. *Journal of Transport Economics and Policy* **24**, 83-93.
- Juster, F.T. (1990) Rethinking utility theory. *The Journal of Behavioral Economics* **19**, 155-179.
- Karlström, A. (2000) Non-linear value functions in random utility econometrics. *Proceedings of the 9<sup>th</sup> IATBR Conference*, Gold Coast, Australia.
- Kockelman, K. (1998) A Utility – Theory – Consistent System – of – Demand – Equations Approach to Household Travel Choice, Ph.D. Thesis, U. of California, Berkeley.
- Mackie, P., S. R. Jara-Díaz and T. Fowkes (2001) The value of travel time savings in evaluation. *Transportation Research E*, forthcoming.
- McFadden, D. (1981) Econometric models of probabilistic choice. In: *Structural Analysis of Discrete Data with Econometric Applications* (C. Manski and D. McFadden, eds). MIT Press, Cambridge, MA.
- McFadden, D. (1996) Measuring willingness-to-pay for transportation improvements. In: *Theoretical Foundations of Travel Choice Modelling*, (T. Gärling, T. Laitila and K. Westin eds.), 339-364.
- Noland, R.B. (1997) Commuter Responses to Travel Time Uncertainty under Congested Conditions: Expected Costs and the Provision of Information. *Journal of Urban Economics* **41**, 377-406.
- Oort, C. (1969) The evaluation of travelling time. *Journal of Transport Economics and Policy*, September, 279 - 286.

- Train, K. and D. McFadden (1978) The goods / leisure trade-off and disaggregate work trip mode choice models. *Transportation Research* **12**, 349 - 353.
- Truong, P. and D. Hensher (1985) Measurement of travel time values and opportunity cost from a discrete - choice model. *The Economic Journal* **95**, 438 - 451.
- Williams, H. (1976) Travel demand models, duality relations and user benefit analysis. *Journal of Regional Science* **16**, 147-166.
- Williams, H. (1977) On the formation of travel demand models and economic evaluation measures of user benefit. *Environment and Planning A* **9**, 285-344.
- Winston, G.C. (1987) Activity Choice: a new approach to economic behavior. *Journal of Economic Behavior and Organization* **8**, 567 - 585.

## **WORKSHOP PARTICIPANTS**

John Bates, Ken Button, Gerard de Jong, Karst Geurs, Peter Hills, Sergio Jara-Díaz (Chairman), Anders Karlström, Kara Kockelman (Rapporteur), David Levinson, Otto Anker Nielsen, Camilla Olsson, Juan de Dios Ortúzar, Yasuo Tomita, Jin-Ru Yen, and Yang Zhong Zhen.