

Research Agenda – Committee on Demand Forecasting, A1C02, Transportation Research Board (TRB)

Chair: Chandra Bhat, University of Texas at Austin, Key Members: Tom Rossi, Research Agenda Sub-Committee Chair, Cambridge Systematics, Inc., T. Keith Lawton, Portland Metro and Venky Shankar, Assistant Professor, University of Washington, Seattle

PURPOSE OF DOCUMENT

The research agenda outlined here presents a list of priority research issues and an action plan framework for the committee to work toward achieving the agenda in the coming five to ten years.

BACKGROUND

In the last decade or so, since the advent of micro-simulation and activity modeling, the field of travel demand has evidenced several parallel scientific advances in travel behavior analysis and, to a lesser extent, the forecastability of demand. At the same time, data from several independent surveys conducted in the U.S. and in other parts of the world have allowed us to observe and analyze travel patterns,” much more so on the analytical side than the observational side. The “observational dimension” of travel demand still remains unresolved in many ways – what should be observed, when, where and how. In addition, the evidence that has been brought to bear on our understanding of individual travel behavior continues to evolve, most notably due to lifestyle changes – whether or not it has significantly improved our ability to forecast travel demand remains in question still. Behavior and forecasting are hypothetically assumed to be connected – good explanatory power comes from the correct causal links. The profession is a long ways off from establishing the correct causal links, yet well-positioned with a body of empirical evidence that may point to a critical mass of socio-economic, and to a lesser extent, land use factors correlated with travel behavior. Hence, a fundamental objective of this research agenda is to parse the “demand forecasting problem” along behavioral lines first by putting forth priority questions that can leverage the empirical knowledge gathered to-date to fruitful purpose, as well as set an action plan to pursue efforts that will bring to bear forecasting methodologies that are sensitive to policy and technology, yet robust to the usual temporal and spatial characteristics of travel demand data. Identifying “common denominators” in the correlational and causal linkages along socio-economic, land use and contextual fronts is an important theme driving this agenda.

At the outset of the new year, committee chair Professor Chandra Bhat put forth a revised scope draft that outlines a broader responsibility for the committee in the coming years. Most notably, the scope brings into its scientific and philosophical focuses, the need for forays into freight and passenger demand, keeping an eye on implementability of analytical techniques and methods for forecasting. Given this background, the rest of this document presents, in order, the revised new scope draft, a set of research priority issues, and an action plan framework. The statements outlined here draw motivation in part from the “millennium document” prepared for the TRB by Chandra Bhat and T. Keith Lawton in the year 2000, as well as a collective assessment of

numerous papers sponsored by committee A1C02, related committees of the TRB and research published in the International Association of Travel Behavior Research (IATBR) proceedings.

NEW SCOPE DRAFT

Scientific Focus: The scientific focus of this committee includes the development, application, and dissemination of improved demand forecasting techniques for passenger and freight transportation, within the integrated context of the interaction of transportation demand with the land-use form, demographic composition, and technological state of the activity-travel environment. All aspects related to data collection, data generation, theory and estimation methods, model implementation, and model evaluation are of direct interest to the committee.

Philosophical Focus: The committee supports basic academic research on issues related to transportation demand forecasting. However, its emphasis is on research developments which have the potential to be implementable in the near future. The committee will play a proactive role in facilitating the adoption and application of new, improved, techniques in the face of inertial forces to stay with traditional methods.

PRIORITY ISSUES

To enact a research agenda for A1C02, several priority questions were raised reflecting along two broad lines focus points relating to behavior and forecasting. The following priority question statements reflect those focus points, with behavioral issues being discussed first, followed by forecasting. It is likely that some priority questions will overlap behavioral and forecasting dimensions (microsimulation for example.) Collaboration with other TRB committees as well as subcommittees under the purview of A1C02 will be required. Depending on the priority question, the extent of the collaboration can vary.

TRAVEL BEHAVIOR PRIORITY QUESTIONS

Priority Question 1: What are the mechanisms and pathways underlying individual activity involvement?

Since the advent of microsimulation and activity analysis, several efforts have resulted in the identification of spatial and temporal bases as the primary calling cards of individual travel behavior. The priority question here relates to the collective evidence at this point regarding behavioral linkages given the vast amount of empirical study. Consistent causal signals are yet to be determined through the existing formulation of activity involvement, be it in duration analysis, impact of urban form measures on travel behavior, spatial engagement or substitutability of in-home and out-of-home activities. The problem could potentially be riddled with paradoxes. For example, correlational insights on the aggregate conflicting with those at the disaggregate or even spatial and temporal conflicts in inference cast considerable suspicion on our ability to identify true behavioral determinants. The sources of these paradoxes are

manifold and are, at the very least, related to the nature of data that is collected. Methodological foray hence, building on collective evidence to-date, needs to contend with issues relating to the “mechanistic analysis” of behavior. Furthermore, the traditional “paths” to trip-making analysis may need to be revisited to determine at a minimum, what we know as “common denominators” from various studies. As an example, microsimulation as a plausible approach needs to be evaluated.

Is microsimulation a reliable and robust method for addressing such issues? For example, interactions among decision-making agents, and the effect of such interactions on activity patterns, are topics that have received limited attention thus far in the travel demand analysis literature. Interactions among decision-making agents might take the form of joint participation in certain activities (such as shopping together or engaging in recreational/social activities together), “serve-passenger” and “escort” activities where one individual facilitates and oversees the participation of another in activities (for example, the “soccer mom” activity pattern), and allocation of activities among decision-making agents. Such interactions can lead to constraints or inter-agent re-allocation of tasks that may be very important in activity/travel responses to changes in the transportation or land-use environment. Research is needed in the areas of allocation of time in activities among agents, allocation of number of episodes of activities among agents, impact of inter-agent interactions on activity-travel patterns of individuals and shipping firms, analysis of the characteristics of agents *vis-à-vis* the types of activities pursued by them, analysis of the effect of attributes of agents that affect the number and type of episode participations, and incorporation of such interactions within the context of examining travel impacts due to changing demographics, land-use patterns, technology, and transportation control strategies.

Priority Question 2: What parameters define accurate and useful temporal and spatial metrics?

Work in recent years has focused on trip planning and execution, and perhaps only started on individual activity planning and execution. These efforts result from incomplete inferences from travel behavior research on bodies of behavior metrics often collected through surveys. The behavioral motivation the demand researcher is trying to uncover is often masked because the intervals of measurement and intervals of behavior (and decision-making leading to that behavior) are misaligned. Consistent and continual effort needs to be expended on a well-defined problem set to unravel the “correct interval” of inference, both from a temporal and spatial standpoint. Aggregation issues, state dependence and unobserved effects confound our inferences and compound error propagation especially when measurement and observation intervals are misaligned.

Priority Question 3: Is the time-space approach sufficient dimensionally to identify and define the behavioral process?

Activity analysis especially has derived a great deal of motivation in recent works from the time-space prism approach to mapping individual activities. Yet, the predominantly social nature of the travel behavior process dictates that human and contextual dimensions may dominate more so than previously thought, to the point, where they may need to be identified as prior constraints. While this increases the dimensionality of the problem, it may provide important clues to identifying the problem. For example, focusing concerted efforts on the impact of children or elderly parents on individual travel behavior may uncover important linkages affecting intra-household and inter-person trip travel behavior. Likewise, context may add constraints to identify the problem as well. Choosing the “correct” constraints appears to be an issue that is gaining eminent value in terms of problem identification, and may lead us down the path where simpler, equally powerful parsimonious constructs have the potential to provide consistent and efficient inferences on causal linkages.

Priority Question 4: Is the experimental design of activity surveys adequate in providing useful and appropriate instruments for travel behavior measurement?

Attrition and non-response bias have over the years come to cloud our inferences on travel behavior, especially in our ability to forecast and provide sufficiently powerful explanatory models. While statistical treatments are available from the econometric literature for mismeasured data, large-extent biases result in improper identification of the problem as a whole, and also result in poor parametric inferences. The question then is to revisit the experimental design process which is used to generate data. What methodological combinations are available at our disposal to create information through synthetic and measured data designs, and at what levels?

FORECASTING PRIORITY QUESTIONS

Priority Question 5: How should the forecasting process be organized philosophically vis-à-vis the behavioral approach?

The travel demand field has preferred to rely on explanatory models to also serve as forecasting tools. Given the myriad issues relating to causality and problem identification, the philosophical question arises relating to the interaction between forecasting needs and behavioral model building. Specifically, how much of behavioral realism needs to be captured in order to obtain good forecasts? What are the characteristics of the forecasting process that dictate the extent of behavioral realism needed? How can insights from detailed behavioral studies be used to formulate simple, less-behavioral, forecasting processes that nevertheless are adequate in emulating underlying behaviors.

Priority Question 6: What opportunities exist for integration with existing and emerging demand models?

The field has evidenced significant exogenous linkages with other modeling elements in recent history, such as air quality, land use, and demographic modeling. Integration within existing and emerging demand models in an endogenous sense is a formidable problem to pursue. Linking air pollution, land use simulation, and demographic models in “live” interactions with demand models may pose, at the very least, issues related to system identification. However, the benefits that can be gained in terms of policy-and technology-sensitive analyses are significant that efforts should be made to integrate demand models endogenously. The question is what temporal and spatial levels of aggregation are suitable for model integration testbeds? Land use and freight need to be examined with regard to integrability into travel demand models.

For example, several conceptual and technical issues remain to be addressed in the area of integrated transportation-land use model systems, including (but not limited to) time scales and spatial scales for different components of an integrated modeling system, the temporal and spatial dynamics in the interaction between and within the land-use and transportation systems, causal linkages between urban form and travel behavior, data requirements and modeling methods for integrated models, measures of evaluation for assessing performance of integrated systems, and policy analyses using integrated models.

Freight demand and integrability into passenger demand models has raised issues relating to aggregation as well as identification and generation of freight behavior data. Given the spatial variations and challenges raised by rural and urban freight forecasting areas, several conceptual and technical issues remain. As an example, the usability of national transportation analysis region (NTAR) data poses a significant modeling challenge in terms of integration with other freight metrics.

Priority Question 7: What opportunities exist for leveraging technologies for observational analyses?

Geographic information systems (GIS) have been referred to in recent years as a medium for model representation. This however may only be the tip of the technological iceberg. Depending on the perspective and scale of observation, the level and extent of multi-scale representation of travel behavior may dictate the direction of effort behind unraveling common patterns in “behavioral manifests” at large scales. Incorporating remote-sensing technologies with GIS-based or other compatible mapping tools may prove to be a valuable asset in determining our ability to forecast large-scale patterns of travel. In the area of non-motorized transportation, graphical and visualization approaches may offer very useful insights.

Priority Question 8: What are the mechanisms for model portability?

Academically, the mechanism for model portability has been investigated through well-established statistical and econometric procedures relying on parametric stability. And the answer almost always is models are not portable from a statistical standpoint, especially considering the temporal characteristics of travel behavior. Spatially however, there is promise. The larger and more challenging question relates to implementability and portability of the information in the models. It is not uncommon for the parameters of interest to be defined on different scales and measured with varying levels of accuracy, and hence imputing and extrapolation become issues of valuable importance for research and application. It is hence important to identify portions of the activity model structure that are transferable and portions that require data supplementation and model redevelopment. When one considers the integration of model systems, this issue assumes greater complexity due to both increased dimensionality and error propagation pitfalls.

Generating an Action Plan: The priority issues raised above clearly point to the need for well-defined actions that would encourage, support as well as create opportunities for setting in motion research along the various dimensions outlined in the priority issues discussion. The action plan should at the very least be a) retrospective, b) innovative in leveraging opportunities for financing pilot studies, and c) integrative in bringing practitioners and academics to work on contemporary issues, and d) temporally consistent with the planning schedules of MPOs.

A retrospective session that gathers the pre-eminent findings from labors of the last decade is in order. This could be done in the form of an inaugural Summer Meeting of travel demand researchers and practitioners. Inventorying what we know and what we don't, while humbling, may be exactly what the doctor ordered for the profession.

Innovative funding schemes in the form of pooled-fund studies may be the trigger behind bringing to a common table the experiences of leading MPO efforts on assimilating activity-based models into the planning process. It is eminently important that leading MPOs in North America be targeted first for pooled-fund studies to ensure the viability of activity-based models and forecasting tools that are being developed on that basis.

Regular annual summer meetings that alternate between practical and academic themes may serve as a useful forum for keeping the groups connected and working towards a common goal. It also provides two year windows for the relevant to organize and present their efforts, while being financially not too burdensome for participation. Logistically, this undertaking could occur initially on the basis of site visits at leading MPOs.

Maximizing opportunities for integrative and collaborative thinking requires consistency of timelines. This is an issue of eminent importance, especially for MPOs who wish to take advantage of model portabilities. It is hence useful to

continue to support activities through the committee that help align MPO modeling efforts.

Concluding Remarks: It is clear that simulation-based approaches have come to dominate the field of travel behavior and forecasting. While these approaches are data-intensive and as the debate on model parsimony with limited data rages on, it is eminently important for the travel demand profession to get back to the basics and conduct an “observational” analysis of the problem. Outlining a desired set of qualitative outcomes and working back to the type and frequency of data collection required to accomplish those outcomes is in order. In concert with this fundamental effort, the priority issues outlined previously should be pursued, keeping in mind implementability and relevance of those approaches to policy and technological developments. This effort should be collaborative and inclusive of international experiences and needs, while engendering integration with other elements relating to air quality, land use, demographics, and technology.