JOINT TRANSPORT RESEARCH CENTRE

Discussion Paper No. 2007-14
December 2007

Progress and Challenges in the Application of Economic Analysis for Transport Policy and Decision Making

Glen E. WEISBROD, Brian Baird ALSTADT
Economic Development Research Group, Inc.
Boston, USA

Progress and Challenges in the Application of Economic Analysis for Transport Policy and Decision Making: *Concluding Comments for the Research Roundtable on Infrastructure Planning and Assessment Tools*

Glen E. Weisbrod and Brian Baird Alstadt
Economic Development Research Group, Inc.
Boston, Mass., USA

Abstract

This concluding paper discusses key aspects of the five research papers presented at this Roundtable in terms of their policy applications. It notes problems concerning how policy makers make use of economic analysis findings, and then summarizes the breadth of macro-, meso- and micro-economic methods in terms of their predictive use for infrastructure assessment and planning. It then examines tradeoffs and limitations among all the methods that affect their policy application, and it identifies directions needed to enhance the applicability of future economic models for policy makers.

1. INTRODUCTION: RESEARCH DIRECTIONS AND POLICY ASSESSMENT NEEDS

Over time, policy-makers have seen research on transport-economic interactions evolve to become increasingly sophisticated in the breadth of interactions being recognized. Yet it is not the proliferation of complexity that policy makers seek, but rather, better coverage of applicable situations and more accuracy in findings and applicability for policy appraisal. In that respect, there are two important elements of this evolution of research that are highlighted by the OECD "Research Round Table on Macro-, Meso- and Micro-Infrastructure Planning and Assessment Tools."

- *Value of Different Spatial Perspectives* - One element of this research evolution is a more explicit recognition that the nature of transport problems and their interactions with the economy can appear different when viewed from alternative perspectives -- the macro scale of nations, the meso scale of metropolitan areas or the micro scale of local communities. The effects of trade flows, agglomeration economies and spatial spillovers each tend to emerge as particularly important at a different level of spatial focus.

- *Importance of Recognizing Wider Effects* -- A second element of this research evolution is the growing appreciation that the effects of transport on the economy can be significantly "wider" than has been recognized by traditional transport appraisal methods. The implication is that appraisal techniques need to be expanded to recognize broader interactions of transport systems and economic systems, such that they can enlarge, diminish or otherwise change our measurement of the economic benefits arising from our transport investments.

From the perspective of policy makers, these two elements of research progress are necessary and important, but they are still insufficient to enable better transport investment decisions. There are at least two additional needs. One is the need for models with adequate "policy levers." Whereas researchers often look for universal relationships that enable broad generalizations about the magnitude of economic effects, policy makers often seek differentiators that can help them distinguish among alternative policies or investments. So while researchers may bemoan a lack of consensus about whether economic spillover effects of highway investment are positive or negative, policy makers may see that both findings can apply in different situations and they may seek information to help make those differentiations. Similarly, while researchers may struggle to reconcile different findings on the importance of agglomeration economies, policy makers may seek to distinguish the conditions under which such effects actually become important. From the viewpoint of policy analysis, an unfortunate reality today is that many past research studies have not adequately differentiated the types of policies or situations in which they were meant to apply. The result, not surprisingly, is misinterpretation via overgeneralization of research results by both proponents and opponents of transport projects and policies.

The other need of policy makers is for economic models that can help improve the applicability of benefit-cost appraisal for decision making. The recognition of wider "external" benefits is critically important in accomplishing this objective. However, as we shift between macro and micro levels of spatial and economic perspective, we may also see shifts in our definitions of who is the "user" or "decision-maker" (e.g., vehicle drivers, travelers, commodity shippers and receivers, or larger industry units) and what constitutes so-called "wider effects." As a result, while we commonly refer to economic development or economic reorganization as externalities with regard to the effects of transport investment, they can actually be core motivations rather than just side effects of some projects or policy interventions.

Given these policy interests, the current research on wider economic effects of transport investment can indeed be quite relevant for decision makers. This paper reviews both the progress that is being made and the challenges that remain in applying economic research findings for transport policy and investment decisions. First, we review definitions of what constitute wider economic effects. Then we classify the different perspectives inherent in different types of economic modeling tools and methods of policy analysts, noting how they focus on different types of externalities and wider effects. Finally, we discuss limitations and challenges confronting the use of these economic modeling approaches for policy analysis.

2. WHAT DO WE MEAN BY "WIDER" EFFECTS?

The question, "what are the wider benefits of transport investment?" begs a follow-up: "wider than what?" Among the authors who have prepared papers for this Forum, these related questions are met with varying interpretations. Cohen (2007), for example, considers that "'wider' benefits refer to the "benefits beyond the geographic region in which the investment is undertaken." (p. 2) He then reviews empirical tools and results on wider "spatial spillover" effects. Others, such Graham (2007), discuss wider impacts as those that "are typically not captured in a standard cost-benefit appraisal" (p. 1). More specifically, he presents methods of expanding impact measures to include the productivity effects of agglomeration. Sue Wing, Anderson, and Lakshmanan (2007) interpret "wider" to mean the degree to which the mechanisms of economic adjustment are endogenized in the analytic process. Models such as they present in their paper, "provide a more complete [wider] picture of the economic impacts of infrastructure" (p. 2) For Johansson (2007), "wider" is interpreted simultaneously as the breadth of geographic scale and the inclusion of inter-urban network effects into modeling. He discusses ways in which access patterns can shift economic behavior and spatial organization *between and among* urban centers in functional urban regions.

Finally, Vickerman (2007) reinforces the ideas of the other authors by reviewing recent research with the goal of reconciling the "standard" benefit/cost approach with macroeconomic findings. He suggests that the standard analysis may be widened to include several phenomena, including spatial externalities, agglomeration, and firm-level effects (input substitution). More generally, he suggests that benefit/cost work can be expanded beyond the (unnecessarily narrow) market for transport to include the broader markets for activities that use transport.

For even this limited survey, the diversity of responses to the question of "wider impacts" is reassuring, and each paper helps to broaden our understanding of the relationship between transport and economic interactions. More importantly, these papers make more explicit the shortcomings of current appraisal techniques, and they identify ways to restructure future methods to incorporate this broader understanding.

3. CLASSIFICATION OF PREDICTIVE TRANSPORT ECONOMIC MODELS

Empirical analysis and statistical studies also provide a foundation for the development of *ex ante* models and other appraisal techniques that support policy and investment decision making. Indeed, existing predictive modeling methods represent a range of different macro-, meso- and micro-level perspectives that reflect various elements of these “wider effects.” Yet across that range of views, there are two consistent tradeoffs:

(1) *Precision Tradeoff* -- Models with greater precision along one dimension of effect (such as spatial or industrial detail) tend to have less precision along other dimensions, and

(2) *Complexity Tradeoff* – Models with greater complexity and breadth of effects tend to require a greater amount of simplifying assumptions that also constrain their realism.

These types of tradeoffs tend to occur across all types of models. They do not necessarily undermine the usefulness of predictive models, but they do highlight the importance of continuing research to improve the accuracy and usefulness of such models for policy and investment decision making. To understand these relationships, it is useful to briefly review the breadth of *ex ante* appraisal techniques and models, the tradeoffs they embody, and how they have evolved over time. The review shows that every type of modeling approach and perspective has a different set of inherent advantages and inherent limitations.

Interaction of Transportation and Economic Models

Following the introduction of computers, the 1960s and 1970s saw the development of several useful tools. Among the most important of these were travel demand models and input-output models. Travel demand models greatly facilitated impact appraisal because they provided a method of simulating supply-demand relationships in the market for transport *at the level of the individual traveler*. These models were very conducive to benefit/cost calculations because they provided user-level metrics (travel time, travel cost) that could easily be converted into benefits on a project-specific basis.

Input-Output models were also extremely useful for policy analysis. They simulated the matrix of inter-industry interactions for one or more regions, and therefore provided a method for assessing the macroeconomic impacts *at the level of the specific industry*. Moreover, the macro-scale input-output framework was seen to complement the micro-scale travel demand model, because it predicted the economy-wide impacts of travel cost changes and project-related spending. Projects that used both could therefore predict a wide range of likely outcomes at a variety of scales.

Although these models represented great improvements in appraisal techniques, early generations were rather limited. Travel models, for example, relied on overly simple assumptions such as fixed trip matrices, straight-line growth in total demand, and simple assignment methods based primarily on travel times. Input-output models were limited as well, particularly because they were non-spatial and did not account for the effect of transport instrumentally, but only as commodity produced by a single sector. The result of these shortcomings was that benefit/cost appraisals were “agnostic” of wider macroeconomic interactions, just as region-wide economic impact assessments were naïve to changes in travel times and access.

These limitations were recognized and understood by many early researchers, and much progress has been made in addressing them. In particular, micro-level travel models and macro-level economic impact models are now frequently merged into larger “connected” modeling frameworks, or are otherwise mathematically integrated. These developments have blurred the once clear distinction between travel models and economic impact models. One consequence of this trend is that the concepts of *benefit* and *impact* have sometimes also been blurred.

Travel Demand Models

Travel demand models have evolved greatly since their early use. A general view of their evolution is one of relaxing restrictive assumptions and expanding the breadth and realism of the transport market being analyzed. In particular: fixed trip matrices can be replaced with dynamic ones; networks can be made more realistic with respect to traffic flow; traffic assignment techniques can be made using generalized cost functions and can be stochastic rather than deterministic; models can incorporate multiple modes and trip purposes; and induced travel can be accommodated.

On the other hand, few planning processes today incorporate all of these features. Most economic impact models still use generalized costs that do not distinguish peak from off-peak effects. Most transportation models used in planning practice do not fully distinguish differences in the mix and time sensitivity value of freight moving through different corridors and regions. These shortcomings continue to frustrate business organizations, which believe that the result is a dilution of the apparent benefit of policies and actions that reduce congestion delays at peak times, or congestion at particularly critical locations such as airports, seaports, intermodal rail facilities and international borders.[1]

Land Use-Transport Interaction (LUTI) Models

LUTI models build on improvements to travel demand models by recognizing that over sufficiently long time periods, origin-destination patterns are endogenous to transportation demand. In effect, this improvement merely relaxes an assumption of "standard" travel models – that land use remains constant. LUTI models can vary widely in structure ("integrated" vs. "connected" models), as well as scope. In some applications, travel models interact with land use models only; in others, transport markets interact via social-accounting-matrices with land markets, labor markets, and commodity markets. In the latter case, the model can operate on several scales simultaneously: the input-output framework may operate for a small number of large areas, land use changes may operate on an intermediate scale, and travel demand may operate at the highest level of disaggregation.[2]

An advantage of these types of models are that they make it possible to assess the impacts on transportation projects on business market expansion and dispersion of residential and business locations at a highly detailed spatial level. However, one tradeoff that is commonly made to enable the greater spatial detail of land uses is reliance on less detail in the classification of industries and inter-industry flows associated with those regions. Another tradeoff is that they usually focus on just road system access and travel costs, and usually do not address rail, air or marine modes or specialized freight transportation requirements.

A notable modeling feature of many LUTI models is that the individual markets being simulated (transportation, land use, labor, commodity) are not solved simultaneously, but rather in a step-wise fashion. That aspect may not necessarily compromise their usefulness for planning purposes, but it may have implications for their use in benefit/cost analysis. Because the overall model is comprised of several sub-models that may be calibrated and solved separately (and not simultaneously), estimated benefits across all markets may not always capture or reflect all project-wide benefits. Notwithstanding, LUTI models have been successfully used to estimate economic impacts, with the majority of applications being for single metropolitan areas or states, where detailed spatial data is needed to calibrate dense travel demand networks.

General Equilibrium Models

As opposed to LUTI models, which endogenize broader market behavior by "connecting" separate market simulations via larger frameworks, general equilibrium models endogenize broader market behavior into a unified mathematical framework. These are frequently not solved analytically but rather computationally through iteration, and are therefore also referred to "computable" general equilibrium (CGE) models. As with LUTI models, CGE models vary considerably in their methods and scope, but most are based on a set of simultaneous equations representing supply, demand, equilibrium conditions, and interactions between the markets for transport, land, labor, and commodities. CGE models are typically based on a single- or multi-regional input-output framework, and are therefore not well suited to applications where great spatial detail is necessary. As such, the majority of applied CGE models have worked at the international, national, or inter-metropolitan area level.[3]

---

[1] Examples of North American business organizations funding research to emphasis freight issues missed by traditional transportation planning models include the Oregon Business Council, Chicago Metropolis 2020 and Vancouver (BC) Gateway Council.

[2] Integrated land use and transportation models vary in their features. Examples include MEPLAN (e.g., Echenique 1994) , PECAS (Hunt and Abraham, 2005), and TELUM (Pignataro, 2000).

[3] CGE models vary in features and spatial breadth. Examples include the integrated transport-network-multiregional CGE model for Korea (Kim and Hewings, 2003) and PINGO, a spatial CGE model for Norway (Ivanova, 2004).

While CGE models operate at a coarser level of spatial detail than LUTI models, they can more easily provide multi-modal coverage of transportation conditions and be more detailed in terms of distinguishing industry-specific changes in inter-regional freight shipment costs. They also differ from LUTI models in that they are solved simultaneously. In theory, that allows them to obtain valid estimates of benefits across all markets at once, without double-counting (to the extent that market assumptions remain valid as well). However, one trade-off to the complexity and theoretical rigor of CGE models is the need for simplification of various cost measures and response mechanisms to enable simultaneous equations to be solved. That includes mathematical "tricks" such as iceberg costs that are typically used instead of solving for supply-demand equilibrium at the level of individual links and routes. It also includes reliance on production functions with constant elasticities, even as emerging empirical research is showing the existence of non-linearities and threshold effects in transport impacts relating to economies of scale, agglomeration, supply chain dispersion and spatial spillovers.

Economic Simulation Models
Economic simulation models are software tools available for general use in policy analysis. For transport appraisal, they are distinguished from general equilibrium models in the types of impacts they predict. Accordingly, Sue Wing et al (2007) note: "[I]t is useful to make a distinction between two classes of economic impacts, which we call *static general equilibrium* impacts and *dynamic developmental* impacts" (p. 4, italics added). The first of these reflects the short-term changes in travel, labor, and commodity markets, whereas the latter reflects longer-term endogenous induced impacts such as population and employment migration, input substitution, and changes in household preferences. Some economic simulation models also attempt to predict these additional dynamic impacts down to the county or sub-provincial level.[4]

Whereas CGE models most commonly focus on predicting economic growth, some economic simulation models also attempt to predict time paths of input substitution, housing and labor price shifts, migration shifts and changes in consumer purchasing patterns. Furthermore, this type of model is differentiated from the LUTI approach because it typically operates at a larger (regional or multi-regional) scale, and has a more naïve (less developed) treatment of land use and transportation interactions. That is the tradeoff: a greater detail of economic sectors at the expense of less detailed spatial zones.

For policy analysis, economic simulation models are commonly seen as an improvement over earlier "static" input-output models because they can forecast demographic and labor-force impacts and do so over a time-path. However, for transport appraisal, economic simulation models have limitations similar to CGE models – namely, that they incorporate simplifying assumptions about transport costs. In fact, their added complexity is achieved by adding yet more simplifying assumptions about the elasticities of import substitution, labor cost responses, migration responses and timing of impact adjustments. While there is a clear theoretical basis for including these additional effects, the empirical backing for their values (as model coefficients) is often thin, and simplifying assumptions of linear responses can also be suspect. The applicability of transferring large scale impact responses onto small scale study areas has also been questioned.

Access Models
Another type of model has emerged in policy research to predict economic growth following a transport investment. Access models are typically econometric models that draw from literatures on agglomeration, spatial spillovers, supply chain productivity, and new economic geography to predict the increase in local economic development likely to result from a particular transport investment. They are based on econometric studies showing that economic impacts on business location and attraction are subject to non-linear effects that are beyond traditional impacts of travel time costs and travel expenses, as demonstrated by Johansson (2007). These non-linear factors include economies associated with expanding labor market access, delivery market access and supply chain market access. Besides agglomeration economies of enlarged market access, some access models also consider economies associated with greater supply chain connectivity to highway networks and intermodal rail, air and marine facilities (Weisbrod, 2007).

---

[4] Examples of dynamic simulation models operating at sub-national regional zones include ASTRA (Cambridge Econometrics, 2003) and REMI Policy Insight Model (Treyz, 1993).

Such models tend to work independently of travel demand and macroeconomic adjustment models, and are in effect ad-hoc methods of capturing the economic impacts that each of these models miss in their "traditional" form. Graham (2007) makes this point explicit:

> A crucial issue here is that agglomeration economies are *externalities*, that is, they arise as a side effect of the activities of firms which have consequences for the wider economy. This is very important from the point of view of transport appraisal because the traditional methods of appraisal based on valuation of travel times do not recognise these types of externalities. For this reason agglomeration effects of transport investment can be classed as *wider economic benefits* because they represent market imperfections that are not accounted for in a standard cost-benefit appraisal (p. 6, emphasis in original).

Access models are very diverse in nature, and can be used to capture a wide variety of phenomena, but have frequently been used to estimate impacts relating to agglomeration. Johansson (2007) notes that infrastructure properties can be measured in three ways: (1) by the capital value of the investment, (2) by link properties, and (3) network or accessibility properties. The key feature of access models is that they focus on the third measure. Productivity gains or other benefits are thus predicted based on prior empirical work relating changes in these measures to past observed growth. Access models have the benefit of being flexible enough to work with traditional travel demand models but they are subject to a number of limitations. Graham (2007) notes several, including that fact that an access model "does not actually tell us much about where the productivity benefits of agglomeration come from" (p. 16). Similar comments can apply to models of the impact of airport, seaport and rail access improvements on economic growth, and also to some models of the spatial spillover impacts of transportation improvements. In each case, the predicted effects reflect a combination of net productivity gain and spatial transfer of activity (business location shift), but the models often do not distinguish the extent of each element.

4. MODELING IMPLICATIONS OF RECENT RESEARCH

Each of the papers presented at this forum (and the respective fields of research they represent) has implications for the different types of models discussed above.

At first glance, Cohen's (2007) review of production and cost function studies with spatial spillover adjustments might seem to have limited relevance to the predictive policy impact model for reasons identified by Vickerman (2007), who notes that a problem with such an approach is that "it takes no account of the way in which infrastructure is used by the activities within the economy in question" (p. 7). That is, it is blind to the mechanisms by which any measured impacts arise, and therefore has limited application to *ex ante* research. This does not, of course, diminish its importance in conditioning our overall *understanding* of transportation's affect on economic performance, particularly with respect to the existence of spatial spillover effects, but merely limits its applicability as a policy research tool.

However, we identify one very critical implication of this line of work: namely, the importance of addressing spatial autocorrelation in any empirical work. All of the modeling techniques discussed in the previous section must be calibrated to particular geographies in order to be valid for project appraisal. These calibrations come in many forms, but frequently involve econometric analysis of spatial data. Travel demand models and input-output models, for example, both rely on "gravity models"; LUTI models may incorporate dozens of spatial regressions. In each case, residuals should be tested for spatial autocorrelation, but in practice rarely are. The critical point here, quoting Cohen (2007) is that "spatial autocorrelation implies interdependencies among different localities." (p. 7). However, in calibrating a spatial model, this is precisely what is trying to be captured in the *parameters* (and not among the residuals). Therefore, unidentified spatial autocorrelation is a form of bias in the model and amounts to misspecification. Unfortunately, a survey of applications of *ex ante* appraisal methods previously discussed is nearly void of any consideration of these phenomena.

Graham's (2007) research also has focused implications for certain types of policy analysis. As discussed above, his research outlines one approach to exogenously estimating economic impacts that are "external" to traditional benefit/cost and economic impact methods. He identifies several extensions of this line of research that may improve appraisal techniques, such as increasing the industrial resolution of results, accounting for differential impacts across space, and using generalized travel costs (on multimodal networks) to measure accessibility rather than distance-based measures.

More generally, we recognize that the work of estimating such "externalities" has the dilemma of remaining outside of broader modeling frameworks vs. being endogenized into LUTI, CGE, or economic simulation approaches. On the one hand, separately estimating these impacts is attractive because of the empirical difficulty of doing so, and because impacts can vary substantially from place to place. As such, access models may provide the most accurate estimates of project-specific impact at a localized level of impact. On the other hand, it is also clear that agglomeration impacts have micro-, meso-, and macroeconomic implications that require feedback mechanisms to benefit/cost work and input-output work. This is precisely the point made by Johansson's (2007) paper, which builds access measures into an empirical framework operating on three interrelated geographic levels. It recognizes the importance of distinguishing between local and distant markets, and that changes in infrastructure may affect one, the other, or both. In essence, access measures are the ties that bind local welfare impacts to macroeconomic growth impacts.

However, Johansson's work also reveals that current appraisal techniques may discount the importance of threshold effects and non-linearities when assessing the economic impact of an access improvement. He provides an example of these phenomena as they relate to the labor market. Commuting preferences are shown to vary considerably over different ranges of access to employment, and one source of these non-linearities is that labor markets are local, but are also embedded in larger functional urban regions. His work thereby demonstrates a method of incorporating the effects of agglomeration into predictive models, with the most direct application to the LUTI framework.

The work of Sue Wing et al (2007) touches on the themes raised by the other authors – in particular, the need to account for spatially mobile economic factors, and the need to expand benefit/cost work beyond its narrow view of the transport market only. General equilibrium models are, in principle, a method of doing both. The primary benefit of such models is that they provide for a wide range of economic adjustments across a broad range of markets while preserving the assumptions that underlie benefit/cost analysis. Results therefore reflect gains in consumer and producer surplus (as before), but transportation is treated not only as an isolated market, but also as having an instrumental impact on *all* markets. Despite the tremendous theoretical benefits of this approach, Sue Wing et al (2007) and Vickerman (2007) each note its limitations. In the context of the models discussed above, the most significant limitation of CGE models is that they may be impractical or invalid for analysis at small geographic scales. This limits their use to a small number of very large-scale projects, but does not assist in the vast majority of appraisals focusing on a single network link or node.

Finally, the authors reviewed here collectively raise a critical issue regarding the nature of a project's *benefit* versus its *impact*. In early *ex ante* appraisal work, this distinction was very clear (if somewhat naïve), but the evolution of methods described above has blurred it in many cases (see Alstadt and Weisbrod, 2007). The nature of this blurring follows from Sue Wing et al's (2007) discussion of the traditional benefit/cost analysis.

> "[T]he beauty of [benefit/cost analysis] lies in the theoretical argument that consumer surplus, which is a measure of travelers willingness-to-pay, captures the full range of economic benefits. For example, other measurable benefits, such as property appreciation near the improved facility, are chiefly outcomes of reduced travel time so including them in benefit calculation constitutes double-counting (p. 8)."

A benefit, therefore, is a precise outcome of a change in equilibrium in a well-defined market, as reflected by supply, demand, and internal costs (prices). But each successive improvement of travel modeling techniques has, in essence, expanded the scope of the market under consideration. LUTI models, for example, have expanded the scope by "connecting" related models together. CGE models integrate markets into a unified framework. Business access models (as do estimates of environmental impacts) separately calculate impacts external to the markets discussed above. In each case, the assumptions that underlie the model(s) indicate whether certain benefits may be redundant. The quote above indicates that in the traditional analysis, benefits in rental markets would be redundant to those in the transport market. However, for CGE models, they would not, because prices in one area a function of prices in the other, and markets clear simultaneously. For some LUTI models, the interpretation can be ambiguous, and would depend on the specific nature of how the "connected" models interact.

Moreover, as noted by Vickerman, all the appraisal methods reviewed here measure welfare impacts. Even when precise benefit/cost work is unnecessary or imprecisely determined, LUTI and economic simulation models (as well as traditional input-output models) estimate changes in personal income. Sue Wing et al (2007) have demonstrated a way of potentially reconciling potential differences between welfare as measured by benefit/cost analysis vs. changes in personal income. Namely, by introducing a time constraint on household utility, they can estimate the welfare impacts of travel time changes in the context of a macroeconomic adjustment model.

5. METHODOLOGICAL ENHANCEMENTS NEEDED FOR POLICY EVALUATION

The growing research on wider impacts of transport and multiple levels of spatial analysis is an encouraging direction, as it increases the range of methods available for transportation planning and assessment. The challenge moving forward is to enhance the ability of models to address policy issues across a broad range. To do so, four sets of issues will have to be pursued:

1) *Matching the Spatial Scales of Models and Transportation Policy Issues* – The types of benefit evaluation methods needed for large area, program-wide funding decisions are very different from those needed for local facility design and location decisions. The economic issues are at different spatial scales and the justifiable budgets for appraisal are also of different magnitudes. There are also tradeoffs in the spatial, transport and economic resolution of various models. Thus, it can be appropriate to allow different types of models to be applied to different policy contexts. Such a approach could provide superior detail and policy sensitivity compared to attempts to develop complex mega models that try to apply the same macroeconomic processes at all possible spatial scales of study.

2) *Recognizing Non-Linear Factors* – The growing research on agglomeration economies is a start towards what are actually a much broader need to recognize non-linear factors and threshold effects that are important for decision-making. For instance, if the question is "how much public investment in infrastructure is the right amount?" then the predictive model should be able to show steep returns from new investment where the current situation is particularly deficient, but diminishing returns from over-building. If the question is "how can a new highway affect the local economy?" then the predictive model should be able to show potentially dramatic impacts from reducing isolation and improving system connectivity, but trigger little impact from small, incremental savings in average travel times even if they affect a large population. Many current models that have constant response elasticities are ill equipped to differentiate these non-linear factors. However, policy makers become suspect when economic models with linear responses purport to show wage rates and population migration shifts occurring from small improvements in transportation conditions.

3) *Recognizing Multi-modal and Inter-modal Factors* – With growing globalization of products, services and supply chains, economic growth is becoming more sensitive to multi-modal freight transportation performance and inter-modal transportation connections. Many current economic models that purport to address returns from transportation investment are actually focused just on highway system performance. Even those that also include rail transport costs often do not capture the special economic consequences of constraining global trade growth and reducing freight reliability due to congestion at marine ports, airports and intermodal rail terminals. For such facilities, the issue is often not high transport costs, but actually decreasing reliability and outright growth constraints. The economic consequences can also be particularly sever for those

transportation facilities that serve particularly important gateway and network connectivity functions.

4) *Modeling Policies Affecting Service Quality and Economic Feasibility* – Many economic impact and benefit-cost models represent changes in travel times, safety, frequency, reliability and even market access as changes in a generalized transport cost. Many regional location models represent transport access in terms of time distances. While there is a theoretical clarity to these simplifications, such approaches can be inappropriate for transport projects that are designed to enable activities that were previously not economically feasible due to insufficient market size or insufficient service frequency or deficient service quality. This is most aptly illustrated by cases where transport improvements enable just-in-time production processes that were previously not even possible. In effect, such projects may be changing basic characteristics of available transport modes, or they may be changing the location options for economic growth in certain industries. Failure to allow for such impacts can lead to under-statement of the economic value of associated transportation investments.

The four general classes of issues that were described here represent common concerns of economic developers – that transportation policies can affect multiple modes of travel, the service quality attributes of locations, the feasible of economic activities and threshold effects that can preclude or enable particular forms of economic activity. Ultimately, a common accounting framework is needed to span the wide range of economic impact and benefit-cost studies, making it possible to include recognition of the potential for wider economic benefits while avoiding the pitfall of double-counting. That, in turn, can promote greater convergence of perspectives between transport economists and economic developers. The end result can be an enhanced relevance of models for decision-making, and an enhanced capability for transportation investments to be designed and implemented in ways that maximize productivity and job growth.

REFERENCES

Alstadt, B., and G. Weisbrod (2007). "A generalized approach for assessing the direct user impacts of transportation projects." *Transportation Research Board Annual Meeting*, 2008; publication forthcoming. http://www.edrgroup.com/edr1/bm~doc/a-generalized-approach-fo.pdf

Cambridge Econometrics (2003). *Transport Infrastructure and Policy Macroeconomic Analysis for the EU*, European Commission, 2003.

Cohen, Jeffrey P. (2007). "Wider economic benefits of investment in transport infrastructure," paper prepared for the Roundtable on Macro-, Meso- and Micro-Infrastructure Planning and Assessment Tools, Organization for Economic Co-operation and Development).

Echenique, Marcial H. (1994). "Urban and Regional Studies at the Martine Centre: Its Origin, Its Present, Its Future", *Environment and Planning B*: *Planning and Design*, Volume 21, pp. 157-533.

Graham, Daniel J. (2007). "Agglomeration economies and transport investment," paper prepared for the Roundtable on Macro-, Meso- and Micro-Infrastructure Planning and Assessment Tools, Organization for Economic Co-operation and Development).

Hunt J.D. and Abraham J.E. (2005). "Design and implementation of PECAS: A generalized system for the allocation of economic production, exchange and consumption quantities"; Chapter 11in *Foundations of Integrated Land-Use and Transportation Models: Assumptions and New Conceptual Frameworks*, Elsevier, London, pp:217-238.

Ivanova, Olga (2004), "Evaluation of infrastructure welfare benefits in the Spatial Computable General Equilibrium (SCGE) Framework," Department of Economics, University of Oslo. http://www.oekonomi.uio.no/seminar/torsdag-v03/ivanova.doc

Johansson, Börje (2007). "Transport Infrastructure Inside and Across Urban Regions: Models and Assessment Tools," paper prepared for the Roundtable on Macro-, Meso- and Micro-Infrastructure Planning and Assessment Tools, Organization for Economic Co-operation and Development).

Kim, Euijune and Geoffrey Hewings (2003). "An Application of Integrated Transport Network-Multiregional CGW Model," presented at the 42nd Meeting of the Southern Regional Science Association.

Pignataro, Louis J et al (1998). "Transportation Economic and Land Use System", *Transportation Research Record*, #1617, Transportation Research Board.

Sue Win, I., W. Anderson, and T. Lakshmanan (2007). "The broader benefits of transportation infrastructure," paper prepared for the Roundtable on Macro-, Meso- and Micro-Infrastructure Planning and Assessment Tools, Organization for Economic Co-operation and Development).

Treyz, George (1993). *Regional Economic Modeling: A Systematic Approach to Economic Forecasting and Policy Analysis*, Kluwer Academic Publishers.

Vickerman, Roger (2007). "Recent evolution into the wider economic benefits of transport infrastructure investments," paper prepared for the Roundtable on Macro-, Meso- and Micro-Infrastructure Planning and Assessment Tools, Organization for Economic Co-operation and Development).

Weisbrod, Glen (2007). Models to predict the economic development impact of transportation projects: historical experience and new applications. *Annals of Regional Science*, forthcoming. http://www.edrgroup.com/edr1/bm~doc/models-to-predict-the-eco.pdf