Quantifying the Long-Range Impacts of Transit on Travel and Land Use

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IV Encuentro UPR/MIT sobre el Tren Urbano
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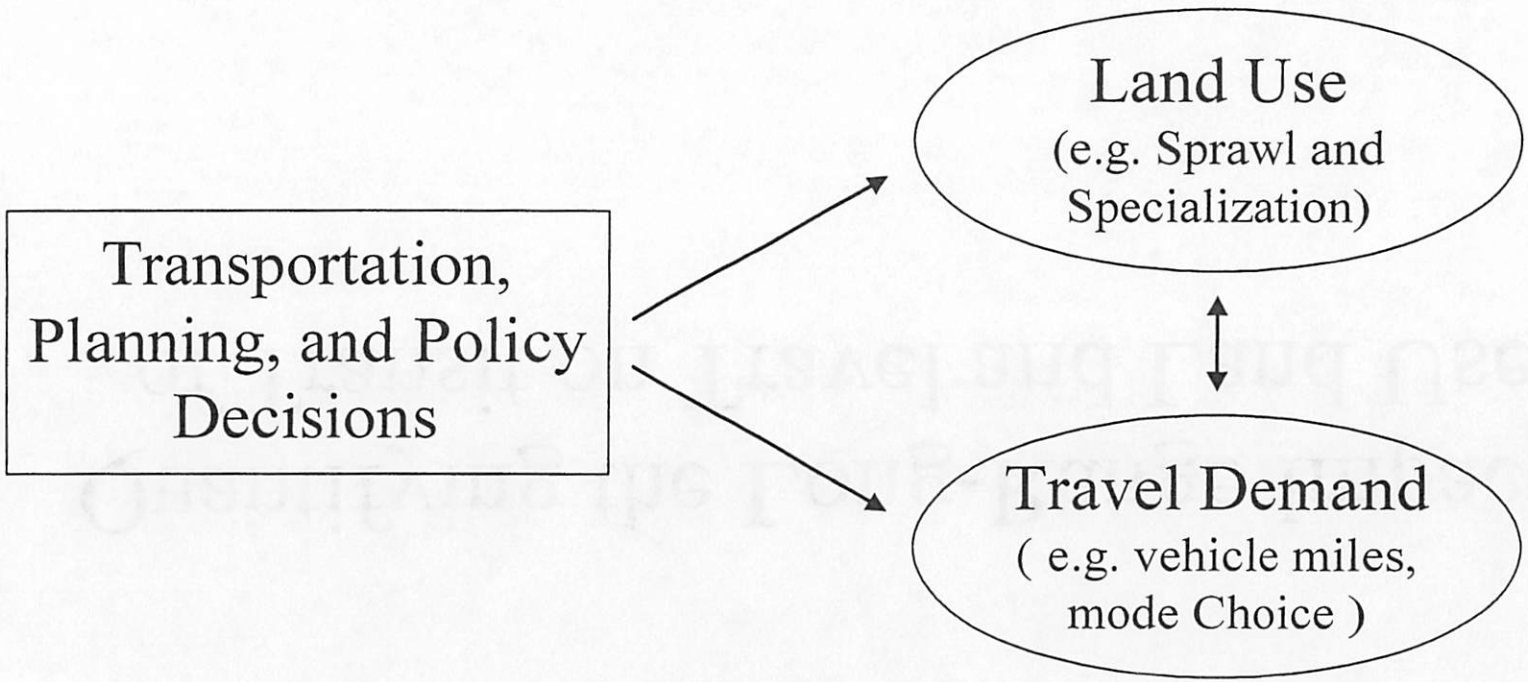
Research Objective

To quantify the long-range impacts of transportation, planning, and policy decisions on travel and land use, in particular, the potential impact of transit.



Motivation

- Sustainability -- how to best manage growth
- The potential influence of transit

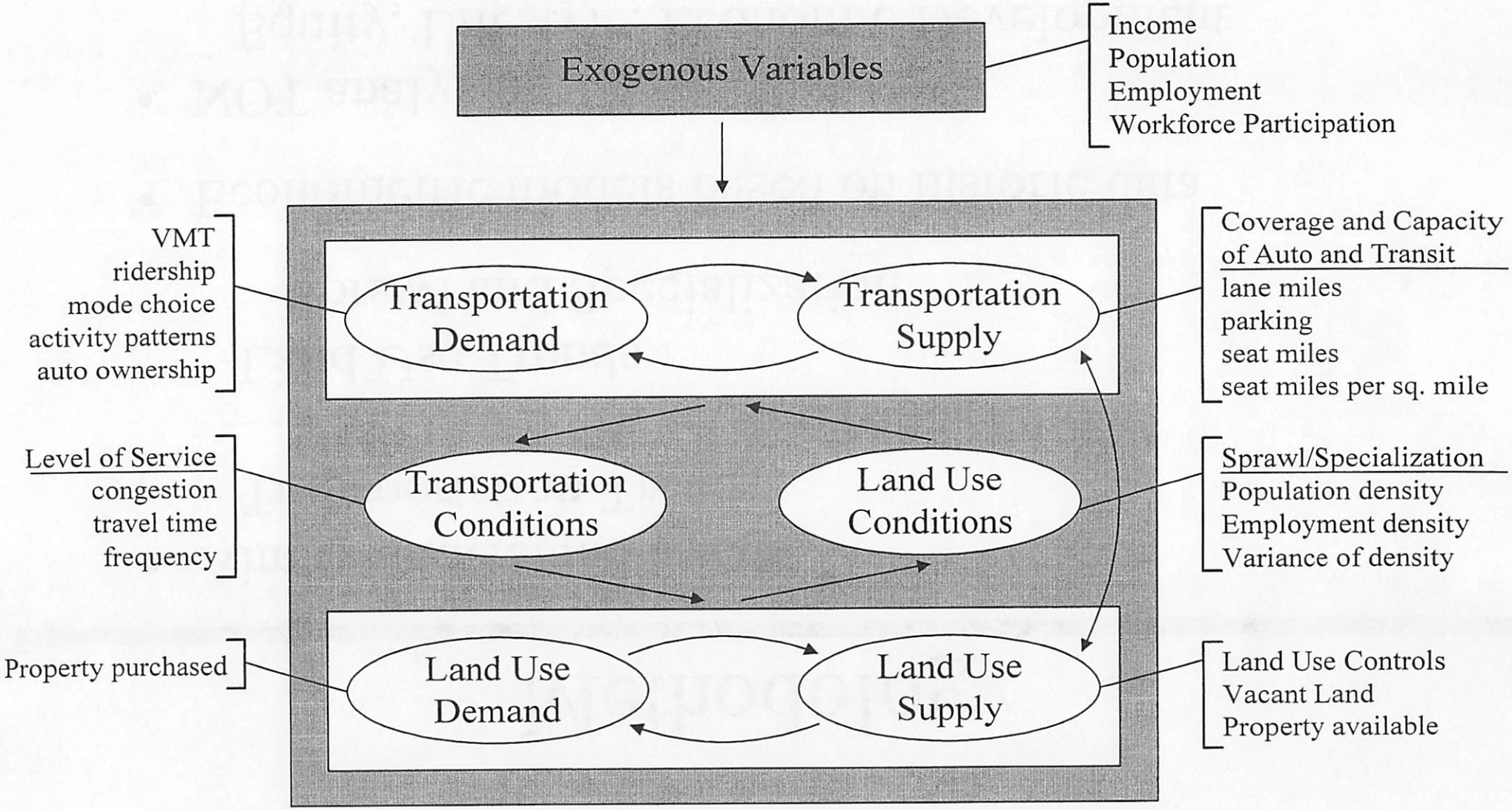
Applications to Tren Urbano

- Understanding potential impacts of Tren Urbano and the important factors
- Potential to use resulting models as a planning tool
- Including San Juan in data set will provide quantitative information about similarities and differences in behavior from mainland

Methodology

- Aim to understand trends:
  - Transportation Trends
    - VMT/Auto Ownership/Mode Choice
  - Land Use Trends
    - Sprawl and Specialization
- Econometric models based on historic data
- NOT analyzing:
  - Equity, Lifestyle, Economic Development

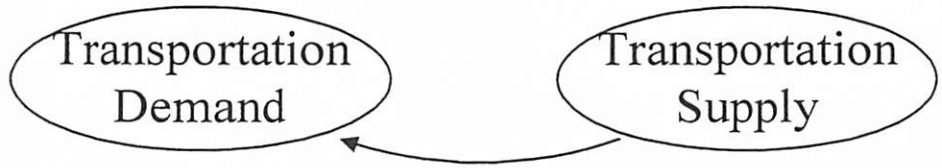
General Framework



Example of Related Approach

(Hansen and Huang, Transportation Research 1997)

Framework:



Data Sample: 30 Counties in California
18 Years (annual data 1973-1990)

Model: vehicle miles traveled
= f(lane miles, population, income)

Results: lane mile elasticity = 0.6-0.9
Δ VMT captured by constants ~50%

Desired Results

- Impact of transit on trends (e.g. elasticities)
- Understand the importance of the land use component for transit

Issues

- Ability to capture impact of transit on regional level
- Simultaneity in the model system causes identification problems
- Defining a piece of big picture that will provide insight
- Availability of Data

Research Plan

- Literature Review
- Refine, Define, Simplify Framework
- Investigate Data Sources and Collect Data
- Estimate the Model
- Analyze Results

DRAFT

Tren Urbano Research Proposal

Measurement of Accessibility for the Study and Evaluation of Transportation Investments

Joan Walker, MIT

October, 1997

Introduction

Increasingly, there is a desire to use accessibility as an evaluation measure for urban planning decisions. This is a shift from the traditional measure used to reflect benefits of proposed transportation investments, which focus on the level of service of the transportation system. The interest in accessibility has taken place because, unlike the traditional measures that are reflective only of the transportation system, accessibility incorporates a notion of the interaction of transportation and land use. After all, transportation is a demand derived from the need to pursue activities, and it is its connection with activities that gives it value.

With this growing importance placed on accessibility, the time is ripe to closely investigate existing measures, including an examination of their strengths and weaknesses and asking the question of whether we can do better at quantifying accessibility. There are three primary methods that are currently used to measure accessibility: isochrone analysis, gravity measures, and the maximum expected utility measure from discrete choice models. While capturing some measure of tradeoff between travel and activities, these measures are in the end fairly mechanistic measures that represent something that *analysts have defined* to be measures of accessibility, but that do not necessarily reflect the accessibility that is *perceived* by individuals or businesses. Therefore, there is a need to both test whether the existing measures capture perceived accessibility, and to investigate the possibility for improvement in the measures.

There is great potential to improve existing methods by taking advantage of advances in numerous related fields. New information technologies have facilitated the collection and dissemination of large quantities of detailed data,

thus enabling the development of more refined models. The rise of Geographical Information Systems and Artificial Intelligence provide the means of making more sophisticated techniques accessible to practitioners. There are also numerous methodological advances that are applicable to this problem, particularly in the areas of activity based models, latent (i.e. unobservable) variable models, the incorporation of psychometric data (e.g. attitudes and preferences), stated preference techniques, and the combination of multiple data sources.

Research Objective

The focus of this research is accessibility: its measurement and its role in the planning process. The primary objectives are to both evaluate existing measures and to seek improved measures of accessibility that are representative of perceived accessibility, provide information on the distribution of benefits, and allow comparison of impacts across various scenarios. The ultimate objective of the research is to improve the methods used for evaluating transportation investments.

Measuring the efficiency with which the transportation network connects people and activities involves complex behavior and interactions that are difficult to quantify. The approach to be followed in this research is to use methodological advancements to develop models with increased behavioral complexity to determine how well we can measure accessibility, what the cost and potential gains are from added complexity, and, in the process, provide a means for evaluating existing measures of accessibility.

Big Picture and Scope of Research

Before proceeding further, it would be useful to have a clear definition of accessibility. There are two dimensions of accessibility: accessibility of individuals or households and accessibility of businesses. People desire easy access to their daily activities, for example jobs, stores, banks, and friends. Businesses desire access to employees, customers, and goods. Keeping these dimensions in mind, a definition of accessibility follows:

> Accessibility is an abstraction that represents the ease with which the transportation and land use system allows:
>
> - People to pursue activities that they desire and
> - Businesses to connect with consumers, employees, and goods.
>
> Accessibility is specific to a point in space and to an individual/household or firm, and is determined by both patterns of land use and by the nature of the transportation system.

It would also be useful to examine the role of accessibility in the planning process. Figure 1 displays the modeling process used in Urban Planning. Briefly, the model system relies on a variety of inputs that describe the scenario being studied, including information on the characteristics of people, businesses, transportation, and land use. The model system represents the interaction between transport demand and supply. Demand consists of long term decisions such as firm location, residential choice, and long term activity (e.g. work participation) and mobility (e.g.

auto ownership) decisions as well as short term activity and travel decisions (e.g. shopping and recreation). The demand models predict lifestyle and mobility characteristics of the households, and produce an origin-destination (OD) trip matrix for each travel mode and time-of-day. The supply model assigns the OD matrices from the demand model to the network, resulting in the performance of the network, such as link flows, travel times, speeds, and queues. Based on the notion of equilibrium between supply and demand, the models may be run iteratively until the outputs are consistent. The model can be solved at different points along the planning horizon; a short term analysis would treat the long term activity, location, and mobility decisions as fixed. The model system generates outputs that can be used for the analysis of impacts of alternative policy scenarios. Outputs include residential and commercial settlement patterns, auto ownership levels, link flows, speeds, and queues specific to particular modes and times of day. Such outputs are used to calculate summary statistics that represent the level of impact of the scenario, which can then be used for policy analysis.

As shown in the figure, accessibility enters the planning process in two primary ways. The first is that accessibility can be used as exogenous variables in the demand models to explain behavior: accessibility of businesses impacts firm location and accessibility of individuals impacts residential location, mobility decisions (e.g. auto ownership), and activity decisions (e.g. what to do, where and when to do it, and how to get there). The other place that accessibility enters the picture is in impact analysis. As described in the introduction, accessibility can be used in evaluation to represent the benefit that changes in transportation and land use have on users (both business and individuals).

The focus of this research is on the measurement of accessibility for evaluation purposes, and not on the dynamics of how accessibility impacts behavior. The research will consider both accessibility of business and accessibility of the individual, and will indirectly work on auto ownership, residential location, and firm location models (see *Proposed Methodology*). Although the focus here is on the measurement tool itself, in general, the better we can measure accessibility, the better we can do in modeling the dynamics of travel demand.

Proposed Methodology

As described above, we are interested in measuring both accessibility of businesses and of individuals. At this point in the research, a framework for measuring accessibility of individuals has been developed, which is described in this section. Similar techniques can be used to measure accessibility of businesses, and such a model will be developed in the next phase of the research.

The model is based upon the following observations about accessibility:

- Accessibility is a hypothetical construct for which their exists no operational methods for direct measurement
- Any measurement must be consistent with perceptions that users have about their level of accessibility
- We have several imperfect, mechanistic measures of accessibility
- We have a sense of what impacts accessibility: sociodemographics, transportation, and land use
- We have a sense of what accessibility impacts: residential choice, auto ownership, and property values

Given these observations, the natural model to apply is a latent variable model. In latent variable models, an unobservable (i.e. latent) variable is indirectly measured by observing causes of the latent variable, observing manifestations of the latent variable, and by assuming causal relationships between the causes, the manifestations, and the latent construct. Figure 2 shows the modeling framework for the latent model of individual accessibility. Although accessibility is not directly observable (i.e. latent), we can *indirectly* measure accessibility by observing aspects that impact one's accessibility (e.g. socioeconomics, transportation, and land use), observing manifestations of accessibility (e.g. residential property values and the joint residential location and auto ownership decision), and assuming a causal relationship between the constructs (represented by the arrows in the figure). In addition, we can create survey questions that ask people directly about their perceived accessibility, for example:

Rate your level of satisfaction with the following aspects of the transportation system:

	extremely.....extremely dissatisfied.....satisfied				
Ease with which you can get to work	1	2	3	4	5
The availability of alternatives for getting to work	1	2	3	4	5
Ease with which you can run errands within walking distance of home	1	2	3	4	5
Ease with which you can run errands within walking distance of work	1	2	3	4	5
Ease with which you can run errands on the way to or from work	1	2	3	4	5
Ease with which the transportation system allows you and your household to accomplish your daily activities (shopping, recreation, personal business, getting to work/school, etc.)	1	2	3	4	5
Ability to travel where you want to go on transit	1	2	3	4	5

The responses to such survey questions are considered manifestations of accessibility, and are used as *indicators* in the model. By including such indicators in the model, we can generate a measure of accessibility that is more reflective of perceived accessibility. Note that the indicators are only used for estimation of the model (i.e. estimating the parameters of the accessibility equation), but are not used in application of the model.

The variables summarizing transportation and land use (the inputs shown at the top of the figure) will be traditional measures of accessibility. The measures could be composite measures of accessibility, such as gravity measures or

logsums, or simple measures of accessibility, such as distance to transit or opportunities within walking distance of home. Thus, accessibility will be a function of both sociodemographic information and a set of directly measurable summary statistics of the transportation and land use system.

The proposed model for accessibility of individuals take advantage of advances in methodology to improve the measures of accessibility by generating statistics that are, potentially, more reflective of people's perceptions of accessibility. The model also provides a means for evaluating the extent to which traditional measures reflect perceived accessibility, by examining the correlation between the indicators of accessibility and the direct measures of accessibility.

Work Plan

The research methodology consists of the following 7 tasks. Tasks 1 and 2 have largely been completed except for written summaries. Task 3 is well underway, although the model for business accessibility must be developed and many of the details of the entire model have to be finalized. Some aspects of Task 4 have been investigated, and the remaining Tasks have not yet begun.

Task 1 - Review of Accessibility Literature

A focused review of literature on measures and uses of accessibility has already been conducted, however the references will be expanded throughout the course of the research as new articles are discovered.

Task 2 - Define and Rank Desirable Properties

The literature review and further research into accessibility will help to generate a clear definition of the desired characteristics of the accessibility measure and the relative importance of these characteristics. Preliminary lists have already been developed.

Task 3 - Refine Framework

The general idea for the modeling framework for individual accessibility is fairly clear, but many of the details have to be defined. This includes specifying the property value model, the joint residential choice and auto ownership model, the transportation and land use explanatory variables, and the indicators of accessibility. In addition, the model of business accessibility also must be developed.

Task 4 - Gather Data

These models require some fairly intensive data, including disaggregate, cross sectional survey data (with sociodemographics, daily activity diary, and indicators of accessibility), aggregate zonal data on both commercial land uses (including type, number of jobs, and size) and residential attributes (including characteristics of the zone such as crime rates and schools), and information on the transportation network with (projected) link costs. Due to the intense data requirements of the model, the plan is to apply the model to a region that already has most of the

necessary data. For the model of individual accessibility described above, there are two possible regions, Boston and Portland, which have most of the data necessary to estimate the model. Therefore, one of regions will be used for estimation and evaluation of the methodology. The only data that are not available are the indicators of accessibility, and so a separate, small survey will have to be conducted to obtain the data. Once the model for business accessibility is developed, its data requirements will also be addressed.

Task 5 - Test the Methodology

Once the data is collected, the model will be estimated to evaluate the methodology. The traditional measures will be tested to see how well they reflect perceptions of accessibility, and an effort will be made to develop improved measures of accessibility. Due to the complexity of the entire model system, it is likely that a piece of the model will be extracted for demonstration and evaluation purposes, which will provide insights on the entire model structure.

Task 6 - Develop Recommendations for Measuring Accessibility

Based on the results of Task 5, recommendations will be made on how best to measure accessibility, including an evaluation of various accessibility measures and guidelines for survey design, model specification, and estimation of advanced accessibility measures.

Task 7 - Extend Findings to San Juan

The findings will be extended to San Juan, as described in the next section.

The Tren Urbano Context

This research aims at evaluating the state of the practice and advancing the state of the art used for measuring accessibility. In addition, the research will place some much needed emphasis on accessibility of businesses, which has thus far been less studied than accessibility of individuals. This research will produce guidelines for the best practice of measuring accessibility for evaluation purposes, including presentation of the state of the art and discussion of the performance of traditional methods. Recommendations will also be provided for implementation in San Juan's Long Range plan, including discussions of survey design, modeling design, and estimation techniques. The goal is to provide improved measures of accessibility, from both the business and individual perspective, to aid in the evaluation of transportation and land use policies in San Juan.

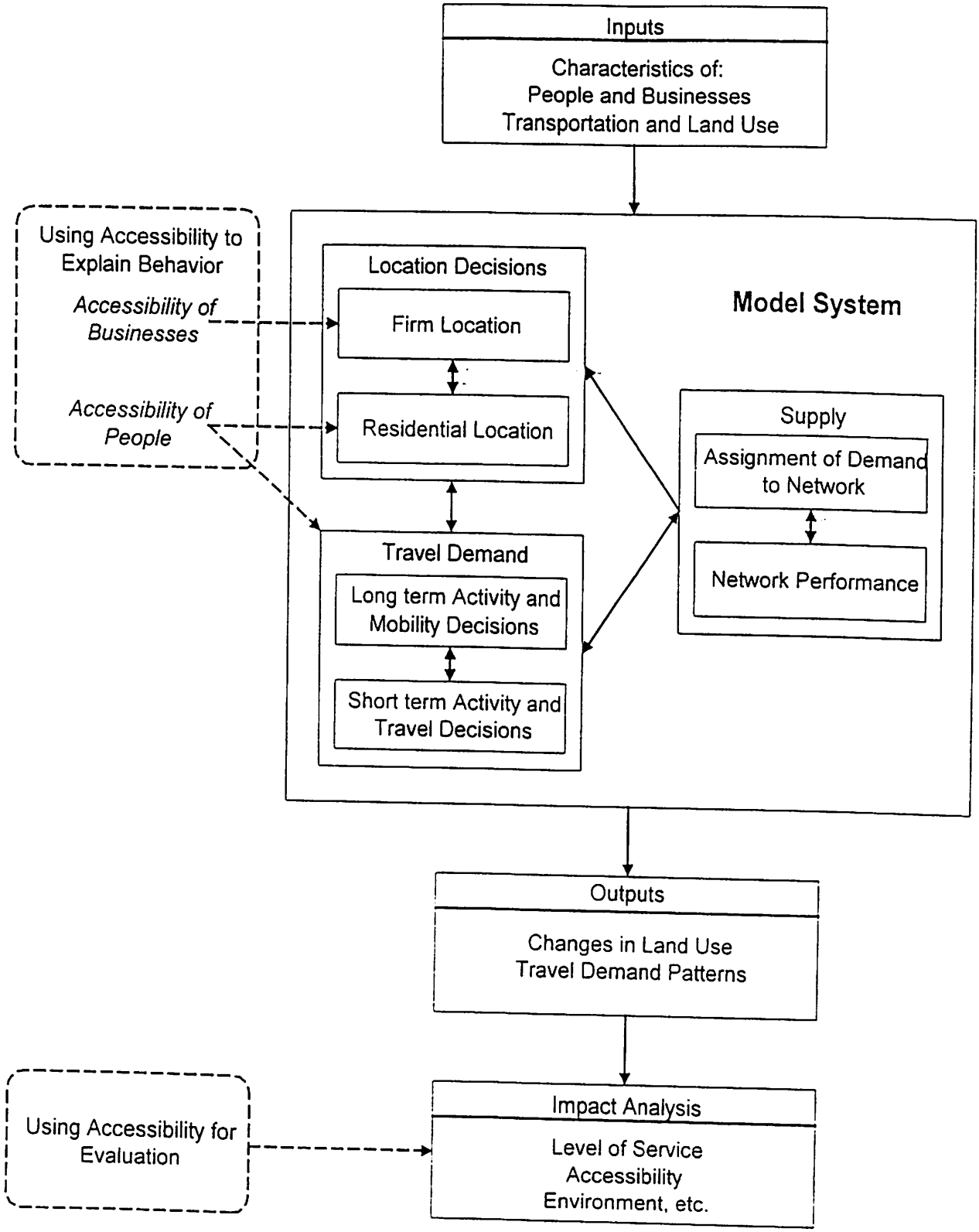


Figure 1: The Role of Accessibility in the Planning Process

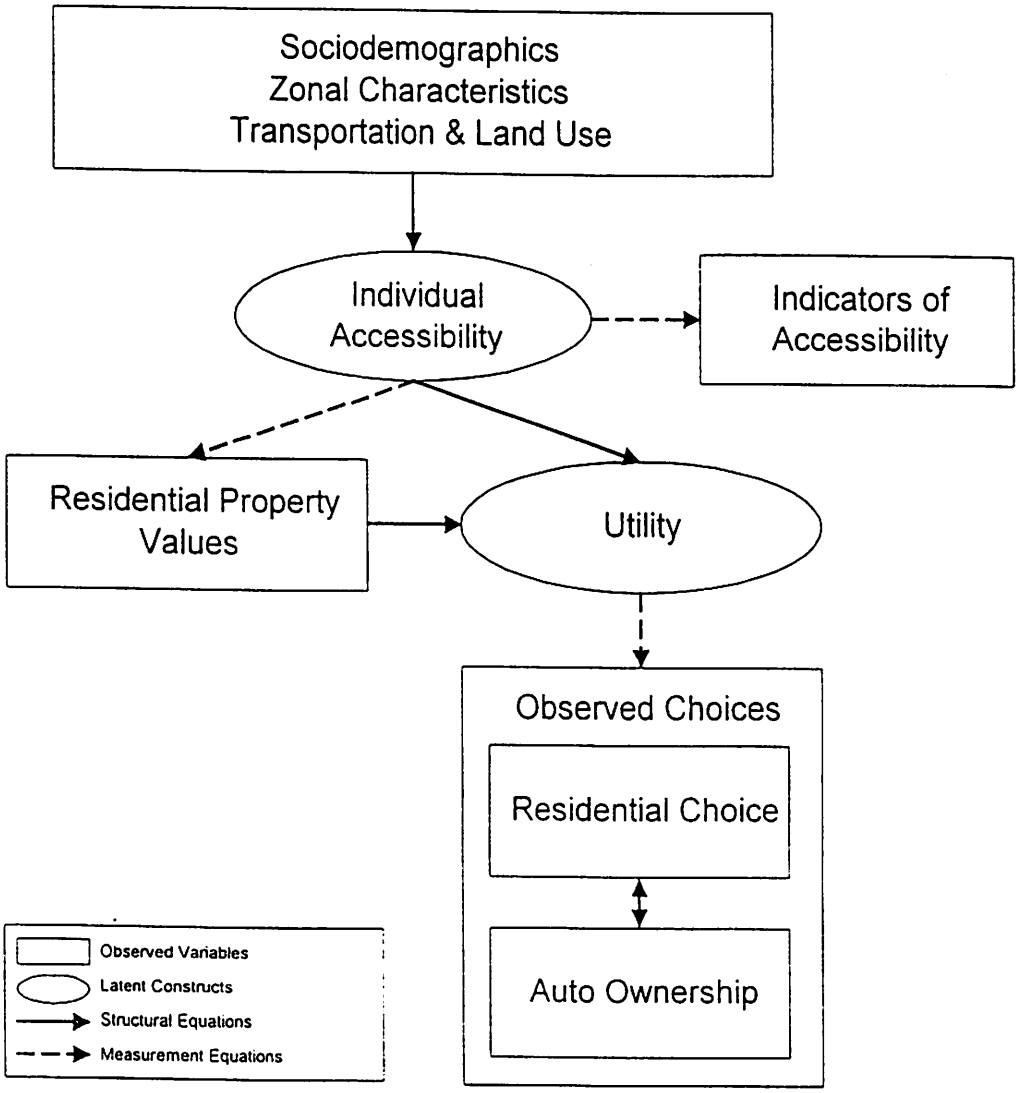


Figure 2: Proposed Model to Measure Individual Accessibility

Addendum to my (Joan's) Tren Urbano Research Proposal

Nigel and Fred,

Here's a crack at describing how my research fits in with other research being conducted in the Tren Urbano group, with particular emphasis on the relationship between Ming's and my work. I imagine this section going after the section titled The Tren Urbano Context. I'm not aware of similar work being done by the folks in San Juan... is there some other research I should be mentioning?

Joan

Relationship with Other Tren Urbano Research

This research is closely related with other research being conducted at MIT in conjunction with Tren Urbano. There is a sub-group within MIT Tren Urbano led by Professor Joe Sussman that meets on a regular basis, which is addressing many dimensions of the economic development opportunities arising from Tren Urbano. Within this group, Ming Zhang (working with Professor Qing Shen) and I are both addressing the issue of accessibility. While the general focus of our research is the same, our angle of approach is quite different, with both studies offering valuable yet distinct improvements to the planning process in San Juan. Ming's research focuses directly on San Juan, and, in particular, on measuring the impact that Tren Urbano and related policies will have on accessibility to jobs. One of the primary goals of his research is to exploit data that already exists for San Juan, therefore providing tools and information that can be immediately applied to aid in policy and planning decisions. Examples of direct applications of his work to San Juan are provision of information to aid in the system phasing of Tren Urbano and analysis on how development around stations will impact accessibility to jobs. My work, as described above, focuses on the measurement tool itself, with a dual emphasis on evaluating traditional measures and advancing the state of the art. The application of my research to San Juan has a more long term focus, and will primarily be in the form of recommendations regarding data collection and modeling methodology for a state of the art (or of any specified level of complexity) long range planning process. The work being conducted by Ming and myself is extremely complementary, and we are benefiting from coordinated efforts.