Measuring Livability in Transportation Infrastructure Investments

Secretary of Transportation Ray LaHood announced "one of my highest priorities is to help promote more livable communities through sustainable surface transportation programs." [1]

This paper presents a framework for further research into measuring livability imbedded in transportation infrastructure investments. Traditional benefit-cost methodologies have difficulty estimating values for goods that are not exchanged in the market. This shortfall of standard benefit-cost analysis is problematic for transportation infrastructure investment choices since there are impacts beyond the measurable aspects of travel time, emissions, operating costs, and construction.[2] The impacts of transportation infrastructure investments on the community livability have been highlighted by the Obama administration. This paper will focus on a potential method to integrate into benefit-cost analysis the concepts of neighborhood livability issues including noise, walking environment, land use, an area's "sense of community" and other difficult to measure aspects to transportation choices. This paper will make the case that blending experimental economics with experimental economics and contingent valuation provides a way forward to measure the impacts of transportation externalities.

The paper will discuss the alternative method to measure the nonmarket components of transportation investment. This is method utilizes regression techniques with hedonic pricing methods. Hedonic prices relies on real estate prices to disentangle the value of local non-priced attributes (open space, mobility, noise, air quality etc.) from other real estate attributes (i.e. square feet, bathrooms, etc.) that make up the price of real estate. This methodology has some econometrical downfalls but also has a practical problem with the timing. Many eggs get thrown at economists since most models are tailored to understand the past. Forecasting presents unique and difficult challenges (just ask an Wall Street Economist these days). Hedonic prices fall into this group. With careful modeling results are available but only on real estate prices where the change has already occurred. In other words this analysis is retrospective - only available after transportation infrastructure is completed. In addition, since each major transportation infrastructure investment is unique research in one geographic location is often not transferable to another location.

This paper will focus on laboratory experimental economics where participants area provided with very controlled surveys - imbedding payoff and cost structures into the survey. These survey's are often called 'games' since participants 'play' the experiment subject to predetermined requirements. Experimental economics provides the structure necessary to telescope time and test the sensitivity of the commodity values for different

[1] Department of Transportation, Office of Public Affairs, March 18, 2009 http://www.dot.gov/affairs/dot3209.htm

[2] One exception to this shortcoming is the estimation associated with the value of a human life. This utilizes a combination of economic data and consensus to arrive at a generally agreed upon single value.

quantities. The use of surveys to estimate nonmarket prices is called *contingent valuation*. Contingent valuation researched in relationship to environmental aspects but this paper proposes that the analysis be expanded to generate livability measures.

This paper is organized around the discussion of economic modeling concepts for public goods, hedonic prices, contingent valuation and experimental economics. Using the discussion of these tools the paper will conclude with a discussion how these tools can be used to help measure the livability of alternative transportation infrastructure investments.

Economic Theory

Before delving into the more esoteric measurement methods it is useful to take a trip back to Microeconomics 101. Microeconomics focuses on how households and firms make decisions to allocate their scarce resources. Economics study how the decisions impact the demand and supply of goods and services. Figure 1 shows the standard downward slopping demand curve and upward sloping supply curve.

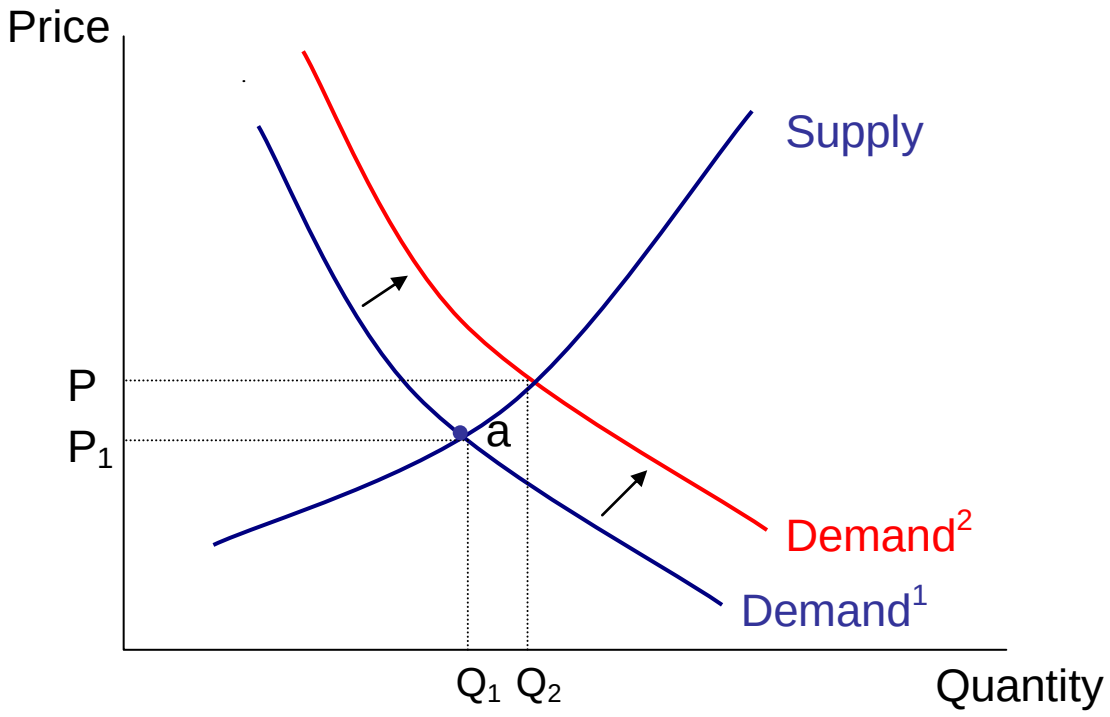

Figure 1. Demand and Supply for Perfectly Competitive Market

Students who remained wake in Economics 101 will remember that there are four basic important assumptions in the standard economic competitive market model. Competitive markets are those which exchange homogeneous goods, there are many buyers and many sellers, there is easy entry and exit from the market and there are no externalities.

The market is in equilibrium when the supply, the amount sellers are offering given their input costs, and the demand, the amount that purchasers are willing to buy, intersect at the price P_1 and quantity Q_1. The market example works for the housing or rental market where Q_1 is the quantity of housing provided and P_1 is the price of the housing. Now assume that additional transportation infrastructure is built in close proximity of the house allowing the home owners easier and faster access to labor and consumer markets. This will shift the demand to Demand^2. The price of the houses will increase to P_2 and sellers of housing respond by increasing the quantity to Q_2. These are long run impacts when more housing units can be developed and provided.

It is a gross oversimplification to say that housing markets follow the model of perfect competition as discussed in Economics 101. Houses are not homogeneous - there are a variety of factors that make each house unique such as schools, amenities, state of repair, and cost of transportation.

Public Goods

The provision of transportation infrastructure also complicates the market for housing since publicly funded transportation infrastructure is a *public good.* Public goods are non-rivalrous and non-excludable. There are many examples of public goods including transportation infrastructure, clean water, endangers species, parks, hiking trails, green spaces and others. These goods are non-rivalrous because the consumption of the good by one individual does not reduce the availability of the good for consumption by others. The goods are non-excludable because it is either ineffective or prohibitively expensive to exclude users from the good. In practice there is no such thing as a 'pure' public good but some goods approach the attributes of public goods close enough to warrant the special classification. These are differentiated from private goods. For example, a cheeseburger is a private good if you purchase and eat a cheeseburger you effectively prevent someone else from consuming that exact cheeseburger. Conversely a national park is enjoyed by all. Public goods can even have value to those who never see them such as preservation of the Grand Canyon view (Schulze, 1983).

Publicly funded transportation infrastructure falls into the category of public goods. Although one could devise a system to exclude an individual from the highway or transit facility, it would be costly. In addition, even if the home owner never used the transit system or highway, they would still receive benefits through the increased value of their home.

The essential feature of a public good is that there is no 'market' for exchanging the public good, unlike the previous example of the cheeseburger. For cheeseburgers there is a ready market with McDonald's, Wendy's and others specializing in the burgers. On the other hand there is no separate market for purchasing 'close assess to transportation infrastructure.' Instead transportation access comes bundled with the house purchase.

On problem with public goods is the 'free rider' problem. A free-rider exists because since society together must purchase the public good, people have an incentive to under represent their true value so that they will not have to pay for the transaction. For example a highway user may protest that they would never use the new roadway in order to avoid having their taxes increase. Then once the highway is complete the free-rider has every incentive to utilize the new roadway.

Hedonic Prices

Rosen (1974) proposed a model of "product differentiation based on the hedonic hypothesis that goods are valued for their utility-bearing attributes or characteristics." The model hypothesizes that observed prices of differentiated products (like houses) can be thought of as a bundle of prices for each of the attributes imbedded in the house. So if a house costs P_1 this bundled price would represent a price for the number of bedrooms and bathrooms as well as location features such as proximity to shopping, labor markets and transportation. The model econometrically estimates prices by a one-step regression analysis where product's price is regressed on the product's characteristics.

This theory is well established in the economic literature and particularly in real estate economics but major theoretical problems exist. Brown and Rosen (1982) note that regression for hedonic prices results in a price at a single point on the demand curve and therefore does not constitute a continuous demand curve. In Figure 1 this is represented by point 'a' at the intersection of Demand[1] and Supply. That point represents an equilibrium price for a bundled good such as a house. The problem is that econometrical techniques do not exist to test alternative bundles of goods. If one could independently vary the price of the goods in the bundle then it would be possible to construct a demand curve. For example if one could observe how house prices change as the transit stop or highway access is moved further and further from the house.

In addition there are problems with hedonic price measurement where the sum of the parts is larger than the total. This provides a very skewed analysis of values. Tsutsumi and Seya's (2008) study measuring the impact of large-scale transportation project on land use price is a good example of this problem. This research measures the benefits from four different land price models but the estimated values are much larger than the market prices of the properties.

The specification bias is evident in a study by Asabere and Huffman (2007) analyzing the relative impacts of trails and greenbelts on home prices. In an effort to capture all the possible components of housing prices they propose a disaggregation into 28 different house attributes. The house attributes focus on those that are readily available from the Multiple Listing Service (MLS) home information in addition to distance to trails and greenbelts. As anyone who has ever shopped for a house knows there are many other attributes that impact prices other than those listed in the MLS. The home's state of repair is usually a strong factor in house price that is very difficult to quantify for modeling purposes but essential for determining house price.

Contingent Valuation

Dissatisfaction with the hedonic approach led researchers to propose an alternative method. Although contingent valuation was first proposed by Ciriacy-Wantrup (1947) as a method to use surveys to elicit market valuation it was not until the 1960's that the method was truly analyzed as a technique. Ciriacy-Wantrup examined the value of parks by using the travel distance to the part as the 'price' of the park. The contingent valuation method rose to prominence and controversy in the 1980s when government agencies began using contingent valuation to estimate the value of non-market goods, primarily environmental costs.

The rise of contingent valuation is well documented by Portney (1994). He tracks the initial use of the method for real estate valuation to the eventual use of the technique as the leading method for nonmarket valuation utilized by U.S. government entities. In response to concerns about the use of the contingent valuation surveys in the Exxon Valdez case, the National Oceanic and Atmospheric Administration (NOAA) convened a high profile panel including Nobel Price laureates Kenneth Arrow and Robert Solow. The panel's most important recommendations are:

1. Applications of the contingent valuation method should rely upon personal interviews rather than telephone surveys.
2. Application of the contingent valuation method should elicit willingness to pay to prevent a future incident rather than the minimum compensation required for an incident that has already occurred.
3. Application of the contingent valuation method should utilize the referendum format; that is the respondents should be asked how they would vote if faced with a program that would produce some kind of environmental benefit in exchange for higher taxes or product prices.
4. Applications of the contingent valuation method must begin with a scenario that accurately and understandably describes the expected effects of the program under consideration.
5. Applications of the contingent valuation method must contain reminders to respondents that a willingness to pay for the program or policy in question would reduce the amount that they would have available to spend on other things.
6. Applications of the contingent valuation method must include reminders to respondents of the substitutes for the "commodity" in question.
7. Applications of the contingent valuation method should include one or more follow-up questions to ensure that respondents understood the choice they were being asked to make and to discover the reasons for their answer.

In addition the Department of the Interior re-proposed these regulations pertaining to contingent valuation in 1994 and added a requirement that the contingent valuation studies test for sensitivity to scope.

Laboratory Experimental Economics

There is one final puzzle piece of economics is necessary before demonstrating how one can measure livability of transportation infrastructure investments. This is the area of laboratory experimental economics as a tool for obtaining contingent valuation of nonmarket goods. Coursey and Schulze (1986) detail how experimental economics can improve the accuracy of the contingent valuation method and use the methods to consider the problem of constructing a survey to measure how much individuals are willing to accept in order to have a factory move into their physical environment.

Central to their approach is the construction of a hypothetical allocation of the public good. First the commodity is described in terms of quantity, quality, location, and time dimensions. Second the hypothetical market institutions, the allocation rules, the cost imputation rules and any adjustment process rules are described to the participants. Third each respondent chooses a message he or she wants to send to the interviewers. Finally the messages received are transformed into a final allocation outcome.

Laboratory economics also called experimental economics is field that has rapidly developed over the last 20 years. Smith and Kahneman shared the 2002 Nobel Price in Economics for their work in this area. Experimental economics methods are becoming a common tool in economics with a number of benefits. The experimental approach provides researchers with a relatively high degree of control of the manner in which the data are generated. The controlled environment of the experiment provides a tool that can be easily be adapted across a broad range of conditions. The broad range of conditions can include various levels of the nonmarket good overcoming the hedonic econometrical down fall. The experiments allow researchers to observe how people actual make choices. Finally experimental economics allows a researcher to telescope time to elicit responses for different phases of a project.

Measuring Livability

The economic tools of contingent valuation, experimental economics and hedonic price regression can all be pulled together to help define and measure livability. Livability is a new term that currently lacks definition and focus. Dictionary definitions provide little assistance, for example livability is "the property of being livable or suitable for living in." The term also suffers from a pejorative connotation. Who would not want to live in a 'livable community'? Who thinks that their current living environment is not 'livable'? Most livability discussions also focus on sustainability. Sustainability has a narrower focus brining into the equation fuel, time and environmental savings. This paper will not discuss the sustainability component since that can typically be measured with standard engineering and economic tools.

This paper proposes that experimental economics can help define livability as well as the market attributes of livable communities related to transportation infrastructure investments. To obtain this data a diversity of subjects would be drawn from both the potentially impacted and non impacted areas. It is important to conduct the experiments for survey responses in close proximity to the impact area since different parts of the country will likely have different preferences for transportation alternatives. It could be

the case that below ground fixed rail transit is more popular in colder climates compared southern locations. Unlike the old contingent valuation survey techniques, experimental economics techniques elicit willingness to pay as part of the structure.[3]

Following the example in Coursey and Schulze (1986) this paper discusses some aspects of a contingent valuation by assuming a city is considering placement of a new above-ground transit system for access between the residential zone to the business/market zone. In this illustrative example it is assumed that there are just two zones, one for work and one for non-work activities. The goal of the experiment is to determine how much individuals are willing to pay in order to provide a new above-ground transit stop. This is the value which is placed on the proximity by the participants.

A laboratory subject will receive an in initial allocation of wealth, sometimes called the initial endowment. The subjects will participate in a survey or game which offers choices for expending that wealth. The subject will list the choices from lowest to highest in terms of preference. A reigning offer price for all accepted offers will be determined according to rules of second-price auction.[4] This will alleviate the issue of winner's curse. If the offer price is above an established threshold then an individual would tentatively pay a set payment and the subjects will determine the transit station location.

These tentative results of the survey would then be put to a vote. All members of the group who were allocated a fixed location to the transit facility would vote to finalize the allocation of distance. If all voted yes, then everyone would realize their allocations. If at least one individual votes no then a new trial would begin, with a second survey being administered. The survey and voting processes would continue until a unanimous agreement occurred or until a maximum number of surveys had been performed. Monetary value can be induced upon the payment income level required for each individual to hypothetically consume a given distance from the fixed rail system. More complicated allocation mechanisms can be constructed and tested for cases where individuals may consume more than one type of transportation. As evident from this quick example there can be a trade off between the cost of the survey mechanism and the accuracy of the results. Utilizing a unanimous voting criterion can increase the number of iterations but the payoff is more rigorous testing of the willingness to pay.

In a similar method as discussed above one could create bundles of goods that might represent a 'livable community.' Experimental economics allows an approach of computing market values for that bundle of nonmarket goods. In addition once one understands the values through an application of experimental economics one can use special economic approaches to locate communities which realize the 'livability' market

[3] Although the methodology will produce a demand curve - representing the willingness to pay at a variety of price and quantity choices - the willingness to pay should not be confused with the cost of the project or the user fees on the project. Experimental Economics can yield input into those areas but this discussion focuses on measurement of the value.

[4] It is important to use a second price auction because as shown by Smith (1967) first price auctions potentially succumb to the winners curse where the price offered is greater than the person's true value.

bundle of goods. In reality there will be several bundles of goods with high valuations and are therefore determined to be 'livable'.

Conclusions

This paper demonstrates a path towards a better understanding of livability through an experimental economics approach to contingent valuation. The fundamental method has been rigorously tested by the Department of the Interior, Nobel Laureates and other governmental agencies. The methodology from NOAA's high profile panel can easily be adopted to meet the needs of defining and measuring livability. Experimental economics can yield valuable insights into the social structure that creates more 'livable' communities because it uses a behavioral approach estimating market prices.

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59 Federal Register 1062 (January 7, 1994) p. 1143

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