Representing accessibility in property valuations and willingness-to-pay

Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 41 (2019) 617–620

Transportation Research Procedia

www.elsevier.com/locate/procedia

International Scientific Conference on Mobility and Transport
Urban Mobility – Shaping the Future Together
mobil.TUM 2018, 13-14 June 2018, Munich, Germany

Representing accessibility in property valuations and willingness-to-pay

He He[a]*, Roberto Ponce-Lopez[a], Le Thi Diem Trinh[b], Joseph Ferreira[a], P. Christopher Zegras[a]

[a]*Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, 02139, United States*
[b]*Singapore/MIT Alliance for Research and Technology (SMART) Centre, Singapore*

Keywords: Accesibility; Property valuation; Willingness-to-pay; Hedonic pricing.

1. Introduction

The importance of accessibility as a performance indicator for the transportation-land use system is well recognized. However, despite its importance, there is not a consensus about its definition. Amongst the frequently adopted definitions is the *"the potential of opportunities for interaction"* proposed by Hansen (1959), which laid the foundation for gravity-based accessibility measures. Ben-Akiva and Lerman (1979) suggested that accessibility is *"the benefits provided by a transportation/land use system"*. The operationalization of this definition involves calculating individuals' consumer surpluses in activity or travel choice situations. The formulation has strong theoretical appeal because of its consistency with economic theory. Geurs and van Wee (2004) provide a comprehensive overview of these and other measures of accessibility. With the numerous definitions, it is important to acknowledge; first, that accessibility is a construct and therefore does not have one true interpretation; and second, that each measure of accessibility has its own advantages and limitations vis-à-vis representation of preferences, data

* Corresponding author. Tel.: +1-617-955-3922.
E-mail address: thehe@mit.edu

10.1016/j.trpro.2019.09.110

requirements, communicability, theoretical appeal, etc. For example, Dong et al. (2006) used activity-based accessibility (ABA), a disaggregate measure that accounts for individuals' daily activity schedules, to study the impacts of a highway toll. Consequently, they were able to capture population heterogeneity and determine market segment-specific distributions of accessibility impacts. Conversely, the relative simplicity of aggregate measures, such as gravity-based accessibility, lends itself well for analyses in data-poor environments, e.g. Peralta Quirós and Mehndiratta (2015), and for stakeholder engagement, e.g. Stewart and Zegras (2016).

Real estate agents will often tell you that the three most important factors in real estate are *"location, location, location"*. Although they do not use the term 'accessibility' or consider it in its academic sense, what they in part refer to – access to opportunities, amenities and transportation options – is exactly what accessibility should capture. Understanding this relationship between accessibility and location preferences is fundamental to transportation-land use policies and infrastructure investments that rely on assumptions about the future spatial distribution of population, as well as to transit-oriented development – especially those involving land value capture financing schemes. Several researchers have demonstrated the link between accessibility and the desirability of a property or residential location. In particular, residential location choice models are often estimated with various measures of accessibility, e.g. Zondag and Pieters (2005). The value of accessibility has also been explored through hedonic price models, e.g. Srour et al. (2002). However, despite these efforts, it is not clear how to best represent the value that households and the market place on accessibility. In other words, do the increasingly sophisticated accessibility measures reflect real preferences or are they merely figments of theorists?

2. Study Objective

The objective of the study is to determine how well different measures of accessibility represent household and market preferences in property valuations. Specifically, we explore the appropriateness, advantages, and limitations of personalized accessibility measures (consumer surplus, ABA) compared to aggregate accessibility measures (gravity-based accessibility). Similarly, we compare accessibility measures that account for individuals' daily activity schedules (ABA) to those that do not (consumer surplus, gravity-based accessibility). Furthermore, we consider different approaches to aggregating personalized measures when necessary. Namely, a household's willingness-to-pay should reflect a summary of the accessibility its members, and the market price for a property should reflect a summary of the market's accessibility preferences.

3. Analysis Methods

We conduct our study in the context of Singapore. The study compares three measures of accessibility: gravity-based accessibility, trip-based consumer surplus, and activity-based accessibility. These measures are used to estimate a hedonic price model and a bidding model that probabilistically combine households' willingness-to-pay and sellers' bid acceptances. Both the bidding model, which is proposed by Castillo (2014) based on Martinez (1996), and the hedonic price model are embedded in the long-term module of SimMobility; see Adnan et al. (2015). The models, estimated with different measures of accessibility, are compared on model fit, and where possible, validated using a holdout sample. The following sections provide brief descriptions of the accessibility measures used in this study.

3.1. Gravity-based Accessibility

Gravity-based accessibility represents the potential opportunities for interaction from a given zone (e.g., home) by counting the number of desired opportunities that exist within each zone and discounting them based on the travel times from/to the, e.g. home zone. The gravity-based accessibility of zone i for activity type p is:

$$A_{p,i}^{G} = \sum_j D_{p,j} \cdot f\left(t_{ij}\right) \tag{1}$$

where $D_{p,j}$ is the number of destinations of type p in zone j and $f\left(t_{ij}\right)$ is the travel time impedance function between zones i and j.

3.2. Trip-based Consumer Surplus

In random utility theory, the expected maximum utility (EMU) of a choice is equal to the consumer surplus of the choice situation. In the context of individuals' transportation-land use decisions, this can be interpreted as accessibility per Ben-Akiva and Lerman (1979). Here we consider the multinomial logit mode and mode-destination choice models by purpose. The consumer surplus, also known as the logsum, for person n is:

$$A_n^{CS} = \frac{1}{\alpha_n} \ln\left(\sum_m e^{V_{nm}}\right) \quad (2)$$

where α_n is the negative of the marginal utility of travel cost for person n, and V_{nm} is the systematic utility of choosing mode m for person n.

3.3. Activity-based Accessibility

ABA is an extension to the consumer surplus measure in that it reflects the EMU of an entire day activity schedule as opposed to simply a mode or mode-destination choice. It requires that day activity patterns be modelled in a nested structure, such that the top-level schedule choice encompasses the consumer surplus of every sub-choice. The equation for ABA is the same as (2) except the systematic utility for each choice option should reflect the EMU of sub-level choices and socioeconomic and demographic variables.

4. Expected Results

ABA is undoubtedly richer in information than trip-based consumer surplus, which in turn is richer than gravity-based accessibility. However, the question remains if these additional dimensions in fact better represent people's preferences. For willingness-to-pay, gravity-based accessibility is unable to capture heterogeneity. Thus, disaggregate measures will likely prove advantageous. As activity-travel behavior becomes more complex, e.g. with the introduction of new modes, flexible work hours, and virtual activities, more sophisticated measures, such as ABA, will likely become favored. Furthermore, we expect personalized measures to reveal locations that are desirable to specific market segments, e.g. areas that attract students due to proximity to a university or good transit connectivity. For hedonic price models, sophisticated accessibility measures still capture more detail. However, since the hedonic price is a reflection of aggregate market preferences, we suspect that the advantages of disaggregate measures are less pronounced. Additionally, the appropriateness of the individual accessibility measures depends on the method of aggregation. While averaging individual accessibilities is straightforward, it may not predict the market value accurately if there are large variations across different segments. In such cases, the market value will likely shift towards the maximum willingness-to-pay.

By testing these hypotheses, we can better understand how to represent market and household preferences for accessibility.

5. References

Adnan, M., Pereira, F., Azevedo, C.M.L., Basak, K., Lovric, M., Feliu, S.R., Zhu, Y., Ferreira, J., Zegras, C., Ben-Akiva, M., 2015. SimMobility: A Multi-Scale Integrated Agent-based Simulation Platform. Presented at the TRB Annual Meeting.

Ben-Akiva, M., Lerman, S.R., 1979. Disaggregate travel and mobility choice models and measures of accessibility. In: Hensher, D.A., Sopher, P.R. (Eds.), Behavioural Travel Modelling. Croom Helm, Andover, Hants, pp. 654–679.

Castillo, V.A.R., 2014. Microsimulación de Transacciones en el Mercado Inmobiliario.

Dong, X., Ben-Akiva, M.E., Bowman, J.L., Walker, J.L., 2006. Moving from trip-based to activity-based measures of accessibility. Transportation Research Part A: Policy and Practice 40, 163–180. https://doi.org/10.1016/j.tra.2005.05.002

Geurs, K.T., van Wee, B., 2004. Accessibility evaluation of land-use and transport strategies: review and research directions. Journal of Transport Geography 12, 127–140. https://doi.org/10.1016/j.jtrangeo.2003.10.005

Hansen, W.G., 1959. How Accessibility Shapes Land Use. Journal of the American Institute of Planners 25, 73–76. https://doi.org/10.1080/01944365908978307

Martinez, F., 1996. MUSSA: land use model for Santiago city. Transportation Research Record: Journal of the Transportation Research Board, (1552), pp.126-134.

Peralta Quirós, T., Mehndiratta, S.R., 2015. Accessibility Analysis of Growth Patterns in Buenos Aires, Argentina: Density, Employment, and Spatial Form. Transportation Research Record: Journal of the Transportation Research Board 2512, 101–109. https://doi.org/10.3141/2512-12.

Srour, I., Kockelman, K., Dunn, T., 2002. Accessibility Indices: A Connection to Residential Land Prices and Location Choices. Transportation Research Record: Journal of the Transportation Research Board 1805, 25–34.

Stewart, A.F., Zegras, P.C., 2016. CoAXs: A Collaborative Accessibility-based Stakeholder Engagement System for communicating transport impacts. Research in Transportation Economics 59, 423–433. https://doi.org/10.1016/j.retrec.2016.07.016

Zondag, B., Pieters, M., 2005. Influence of accessibility on residential location choice. Transportation Research Record: Journal of the Transportation Research Board 63–70.