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A probability-based indicator for measuring the degree of multimodality in transportation investments

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ABSTRACT

Although decision makers may favor a "multimodal" transportation system, it can be difficult to indicate the extent to which a given transportation investment is, or is not, multimodal. This lack of an indicator can be acute when the project selection process requires consideration of how a given investment supports increased multimodality. In response to this need, this research reports on a taxonomy for classifying the degree of multimodality for transportation projects. Probability theory was employed with principal component analysis to create a new indicator based on both demand (modal shares) and supply (monetary investment for each mode). The indicator offers three main benefits in the area of performance measurement: (1) it is applicable in cases when some data are missing; (2) it provides a way of comparing multimodality from diverse projects such as high-occupancy toll lanes or multimodal centers; and (3) it can help decision-makers quantify how multimodality has changed over time. For example, application of the indicator to six U.S. public-private partnership projects in Colorado, Florida, Rhode Island, and Virginia showed that the degree of multimodality increased by an average value of 57%. (While the manner in which the impact boundary is defined affects this calculation for specific projects, the average value remained relatively stable whether the impact boundary was equal to the average commute trip length or less than half that amount.) Given that some planners view multimodality as societally beneficial, the indicator proposed herein can help one evaluate the multimodal potential of proposed transportation investments.

1. Introduction

A recurring theme in evaluating candidate transportation investments is that a transportation system should actively support, rather than just allow, multiple modes. Reasons given for such a multimodal emphasis include addressing a community's vision such as "curbing urban sprawl" (Dowling et al., 2008), improving efficiency of the existing transportation system along with providing a variety of choices for users (Grant et al., 2012), and achievement of national policies such as reduced energy used or community policies such as increased "livability" (FHWA, 2015). Such an emphasis is not new: the 1962 Federal Aid Highway Act required multimodal coordination, and more recent changes in federal programming requirements provide greater ability to shift funds between transportation modes.

Yet while support for multimodal planning exists, a challenge facing decisionmakers is how to evaluate the extent to which a proposed project is multimodal. Part of this challenge is garnering agreement on what constitutes a mode: while

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most persons would agree that air and bus are two different modes, Vuchic (2007) classifies transportation modes on the basis of three general characteristics: technology (e.g., steel wheel versus rubber tire), right of way (e.g., a busway versus a general purpose lane), and service frequency. It is therefore not surprising that distinct modes of transportation reported elsewhere may include not just different technologies but also different uses of identical technologies, such as carpool versus a single occupant vehicle (Meyer and Miller, 2013) or finer gradations such as a shared ride of two people versus a three-person carpool (Koppelman and Bhat, 2006).

Yet another part of this challenge is determining the degree to which a given project is multimodal. In this regard, the literature is sufficiently permissive that almost any project can be viewed as multimodal (rather than unimodal). Litman (2014), for instance, defines multimodal planning as one "that considers various modes (walking, cycling, automobile, public transit, etc.) and connections among modes". Bielli et al. (2006) illustrate a multimodal transportation system as "the combination of all traveler modes and kinds of transportation systems operated through various systems", and Chen et al. (2011) describe it as pertaining to "the use of two or more modes involved in the movement of people of goods from origin to destination". According to all three definitions, therefore, a transportation node, such as the Miami Intermodal Center in Florida in the U.S., is a multimodal project: all modes were considered in its planning (in accordance with Litman's (2014) criterion); the operation of these modes was examined (in agreement with Bielli et al.'s (2006) criterion); and more than one mode is included in the system (in congruence with Chen et al.'s (2011) standard). Similarly, the I-495 Express Lanes on the Capital Beltway in Virginia, U.S., are multimodal, since, based on the definition of Chen et al. (2011); two modes—High-Occupancy Vehicle (HOV) and single auto—were considered. Because transit services are included in the corridor, this project also satisfies the planning criterion noted by Bielli et al. (2006).

Thus, virtually any proposed project can be multimodal if multimodality is defined as a binary question: is the proposed project multimodal or not? While this problem may affect many project selection processes, this paper considers the particular case of public–private partnerships (P3s). P3s are of particular interest because they are used increasingly to finance infrastructure (Kwak et al., 2009), yet, there is a risk that they may exclude multimodal components because such components do not directly increase revenue to the same extent achieved with auto-oriented modes. For example, in describing a potential "operate-design-build-operate" system in the Washington, D.C. metropolitan area that would include both highway and rapid commuter bus services, DeCorla-Souza (2006) notes that excess revenue from tolls for autos, along with other funding sources (such as savings obtained by transferring "freeway maintenance costs" to the private sector), would be needed to fund transit improvements (as the latter generally requires an operational subsidy). While P3s have been the focus of research in the areas of risk management, governance, investment environments (Ke et al., 2009) and public acceptance (Thia and Ford, 2009), as well as while multimodal transportation systems have received evaluation (e.g., Steiner et al., 2003; Alstadt and Weisbrod, 2008; Kanafani and Wang, 2010), empirical inquiries into *multimodal P3* projects are rare.

2. Purpose and scope

Rather than seeking to classify a project as multimodal or not, this research develops, applies, and interprets an indicator that defines the degree of multimodality for a given project. While P3 projects were an initial motivation for this work, the use of such an indicator has applications to other areas of transportation planning. This research encompasses four objectives:

1. Develop a new indicator for the degree of multimodality on a scale between zero and one.
2. Quantify the reliability of the proposed indicator as a function of the data available.
3. Apply the proposed indicator to multiple, and diverse P3 projects.
4. Explain how the results of the indicator may be used in policy decisions.

3. Methods

3.1. Probability-based multimodality indicator

A review of the literature offers several potential descriptors of multimodality. The "complete street score" is a supply-based measure that evaluates how a facility serves four groups of users—pedestrian, transit, auto, and bicycle—on the basis of criteria established by the community for a particular facility's functional class and context (Kingsbury et al., 2011). (For example, a street passing through the town center should serve both transit riders and bicyclists.) Another supply-based measure with a more operational focus is multimodal level of service where each of four modes—auto driver, bus passenger, bicyclist, and pedestrian are evaluated based on specific criteria (Dowling et al., 2008). (For example, pavement condition is one of ten factors used to evaluate bicycle level of service and distance from the sidewalk to the travel lane is one of twenty factors used to evaluate pedestrian level of service.) Although not expressly described as a multimodal indicator, a demand-based measure is implied by Grant et al. (2012), where more use of a facility by non-auto modes imply a greater degree of multimodalism. Owen and Levinson (2012) illustrate how "accessibility" can advance multimodal planning where, for example, one may calculate the number of jobs from a given location that are within half an hour based on walking, auto, and transit. A strength of these measures is that they can help identify needed improvements for a particular facility; indeed they