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Synergistic effects of the built environment and commuting programs on commute mode choice

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ABSTRACT

Although many studies explore built environment (BE) effects on commuting behavior, most overlook BE characteristics at workplace locations and their non-linear impacts. More importantly, limited effort is placed on the integrative effects of the BE and transportation policies. Using the data in Washington, D.C., this study applies a gradient boosting logit model to examine the influences of BE characteristics at both residential and workplace locations and commuting programs (transit/vanpooling subsidies and parking provision) on commute mode choice. We found that BE variables collectively contribute to 65% of the predicting power for mode choice. Although workplace BE variables are more important than residential BE elements, the difference is mainly due to distance to CBD (central business district). Furthermore, most variables show non-linear effects on car mode choice. There are also synergistic effects between BE variables and parking policy and between BE variables and transit/vanpooling subsidies. Therefore, land use policies will be more effective where supportive transportation policies exist.

1. Introduction

Many governments worldwide have proposed and adopted a variety of land use policies (such as smart growth, compact development, and urban renewal) to counter suburban sprawl and reduce auto use (Nelson, 2017; Stevens, 2017). To offer implications for such policies, many scholars have investigated the relationships between the built environment and travel behavior (as reviewed in Cao et al., 2009; Ewing and Cervero, 2010), particularly commute mode choice. However, most of the studies focus on the residential dimension of the built environment, but omit the characteristics of destination locations such as workplaces (Sun et al., 2017; Tran et al., 2016). This omission overlooks the important role of land use policies in shaping the characteristics of employment locations and it biases the influence of the residential built environment. Furthermore, few studies have explored the possibility that the built environment affects travel behavior in a non-linear manner (van Wee and Handy, 2016). In fact, a built environment variable may not be equally effective across the entire range of the variable. A threshold of a variable may have to be reached so that individual travel behavior is more responsive to land use policies that change the variable (Frank and Pivo, 1994). For example, Ding et al. (2018) concluded that densification within 12 km of the city center of Oslo is the most efficient in reducing driving distance.

As the growing travel demand has far outpaced road capacity during peak hours, transportation management organizations provide

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various services to promote economic growth through enhanced transportation options. The programs include, but are not limited to, discounted transit pass, preferential carpool/vanpool parking, parking cash out, free bike racks, and commuter fairs. Although some studies examine the effectiveness of these programs in driving reduction, there is very limited attention to the synergy between complementary land use policies and transportation policies (Boarnet, 2010; Handy, 2017). Moreover, researchers called for a change in the built environment and travel research by focusing on the more important issue—free parking (Manville, 2017; Shoup, 2005).

This study fills gaps by employing a machine learning approach on the regional travel survey data in the Washington, D.C. metropolitan area. It addresses the following research questions: (1) What is the overall effect of the built environment on commute mode choice? (2) Which is more important, residential locations or employment locations? (3) Do built environment characteristics have linear impacts on mode choice? (4) Are the effects of built environment measures larger with supportive transportation policies?

This paper is organized as follows. The next section reviews the literature on the relationship between the built environment and commuting behavior and the synergy between land use strategies and transportation policies. Section 3 introduces the data and modeling approach. Section 4 presents the results. The final section summarizes the key findings and offers implications for planning practice.

2. Literature review

Since the 1990s, many studies have examined the relationship between the built environment and travel behavior (Handy, 1996; Stevens, 2017). Empirically, different measures of the built environment, such as density, diversity, design, destination accessibility, and distance to transit, tend to have varying influences on vehicle miles traveled (VMT), walking behavior, and transit use (Ewing and Cervero, 2010). In terms of the scale of the built environment, regional accessibility tends to have a larger influence on travel behavior than built environment variables at the neighborhood level, but the collective influence of these neighborhood characteristics is also substantial (Ewing and Cervero, 2001). Therefore, it is important to include both regional measures and neighborhood measures of the built environment in the analysis of travel behavior (Hu et al., 2018; Næss et al., 2017).

The commute is a major source of recurring congestion, and as such, it has always been a central topic in the field of land use and travel behavior. For instance, by analyzing the 1985 American Housing Survey, Cervero (1996) found that the proximity of a residence to commercial land uses is positively associated with commuting by alternative modes. Using the 2000 San Francisco Bay Area Travel Survey, Pinjari et al. (2007) concluded that built environment characteristics such as population density, employment density, and street block density are associated with commute mode choice, even after accounting for residential self-selection effects. Ding et al. (2018) employed gradient boosting decision trees to examine the influence of residential built environment on weekday VMT. They concluded that distance from residence to the city center of Oslo has the largest impact among all the built environment variables tested.

More importantly, Ding et al. (2018) found that built environment variables tend to show non-linear relationships with travel distance. This implies that land use policies targeted to influence travel behavior by changing the built environment may be more effective at a certain range of built environment variables than at other ranges of the variables. Finding the right range or thresholds can be cost-effective (Frank and Pivo, 1994). However, few studies have examined the non-linear effect of land use on travel behavior (van Wee and Handy, 2016). In the literature, scholars assume that the built environment and travel follows a pre-defined or parametric relationship.

Previous studies on the relationships between land use and commuting behavior mostly focus on the residential environment (Sun et al., 2017). This tells only part of the story because commuting is also related to the characteristics of workplace locations (Chatman, 2003; Hu and Schneider, 2017; Zhang, 2004). Ignoring these characteristics tend to produce omitted variable bias and overlook the influence of employment-centered land use policies. Moreover, since a commute journey has at least two locational anchors: residence and workplace, an open question emerges: which built environment has a more important influence on commuting behavior? Residence or workplace? The answer will inform urban planners whether planning effort should be centered on residential neighborhoods and employment locations. The literature offers some evidence. Based on the data in Montgomery county, MD, Cervero (2002) found that land use variables at workplace traffic analysis zones (TAZs) are more likely to be significant in the model of commute mode choice than those at residential TAZs. Ding et al. (2014) produced a similar outcome using the data in Washington, DC. By contrast, Sun et al. (2017) concluded that the built environment at residential locations has a larger impact on commuting behavior than that at workplaces in Shanghai, China, partly because of the uniqueness of the city.

Commute mode choice is not only affected by the built environment but by employer-sponsored commuting programs. In the 1980s, transportation management organizations (TMOs) emerged as an entity to coordinate public and private effort to address traffic congestion and other transportation-related issues (Schreffler, 1986). For example, there are four TMOs in the Twin Cities: Move Minneapolis, St. Paul Smart Trip, Anoka County Commute Solutions, and 494 Corridor Commission. One of their major tasks is to work with employers to reduce travel demand by advocating and implementing telecommuting, carpooling, transit, and other programs. These programs are effective in mitigating transportation problems in the region (through personal communications with TMO managers). In California, a program of cashing out employer-sponsored parking reduces solo-driving by 17% (Shoup, 1997). At the University of California Los Angeles, having a discounted transit pass is negatively associated with student car mode choice (Zhou, 2012). By contrast, transportation subsidies (offering cash to employees) in Shanghai increase car ownership and undermine the role of public transportation in commute mode choice (Shen et al., 2016).

Although both land use policies and transportation demand management (TDM) strategies (including commuting programs) can affect travel choice in their own right, integrating them may produce a synergistic effect (Cao, 2015; van Wee and Handy, 2016). To reduce driving effectively, it is necessary to make driving more expensive (through “stick” policies such as parking and congestion pricing) and also make it possible to drive less (through “carrot” polities such as a pedestrian-friendly environment and improved transit service) (Handy, 2006). However, there is lack of coordinated policy debate between “advocates of pricing who see little (if any) role for land use, and advocates of land use who similarly ignore or minimize the role of pricing” (Boarnet, 2010, p. 588).