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# Vehicle kilometers traveled reduction impacts of Transit-Oriented Development: Evidence from Shanghai City

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ABSTRACT

The role of residential self-selection has become a major subject in the debate over the relationships between the built environment and travel behavior. Numerous previous empirical studies on this subject have provided valuable insights into the associations between the built environment and travel behavior. However, the vast majority of the studies were conducted in North American and European cities; yet this research is still in its infancy in most developing countries, including China, where residential and transport choices are likely to be more constrained and travel-related attitudes quite different from those in the developed world. Using the data collected from 2038 residents currently living in TOD neighborhoods and non-TOD neighborhoods in Shanghai City, this paper aims to partly fill the gaps by investigating the causal relationship between the built environment and travel behavior in the Chinese context. More specifically, this paper employs Heckman's sample selection model to examine the reduction impacts of TOD on personal vehicle kilometers traveled (VKT), controlling for self-selection. The results show that whilst the effects of residential self-selection are apparent; the built environment exhibits the most significant impacts on travel behavior, playing the dominant role. These findings produce a sound basis for local policymakers to better understand the nature and magnitude toward the impacts of the built environment on travel behavior. Providing the government department with reassurance that effective interventions and policies on land use aimed toward altering the built environment would actually lead to meaningful changes in travel behavior.



## 1. Introduction

The rapid growth of cities such as Shanghai in China has presented many transportation, land use and climate change challenges for local government officials, planning and transit practitioners and developers; including traffic congestion, energy consumption and greenhouse gas emission. Transit-Oriented Development (TOD) is one of the more visible urban forms of smart growth. Currently it is being actively promoted as a model for urban design in areas around transit stations (Vale, 2015). It has also been increasingly promoted as a solution to the aforementioned challenges (Litman, 2015; Jeihani

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et al., 2013; Haas et al., 2010; Arrington and Cervero, 2008), especially for China in recent years (Fang and Xue, 2015; Energy Foundation China, 2014; World Bank, 2013).

Numerous studies have found that TOD residents tend to own fewer car, drive less and travel by transit more often than those living in non-TOD areas, thus producing lower VKT (Jeihani et al., 2013; Arrington and Cervero, 2008; Chatman, 2006). However, association does not necessarily mean causality. For example, individuals who prefer transit or cycling may consciously choose to locate in certain locations where the alternative transport facilities and services (e.g., bus, transit, cycling) are more available, and hence are able to drive less. That is, the characteristics of the built environment do not majorly cause them to drive less; rather, their socio-demographics (e.g., income), travel-related attitudes (e.g., auto-disinclination, pro-bike/walk), personality (e.g., adventure seeker) and lifestyle (e.g., status seeking) cause them to select such a neighborhood with those characteristics that are compatible with their desire. In this case, individuals' travel behavior may be more a result of residential self-selection than the built environment, confounding the association between the built environment and travel behavior. Thus, the residential self-selection effect is at work.

Over the past decade, a large number studies have been conducted to address the residential self-selection issue (e.g., Bhat et al., 2016; Cao, 2015; Næss, 2014; Paleti et al., 2013; Aditjandra et al., 2012; Cao et al., 2009), which provide valuable insights into the associations and/or causalities involved in the relationship between the built environment and travel behavior. However, few have quantified the relative contribution of the built environment *itself* in influencing travel behavior. Moreover, most of the studies were carried out in North American or European cities, where the residents tend toward having more opportunities to realize their preferences in residential and transport mode choices than those in other parts of the world. These studies in developed countries do provide successful lessons and experiences for other countries such as China to build upon.

However, the impacts of the activity-travel environment will vary depending on specific social conditions in specific countries or jurisdictions (regions, states, etc.) (Litman, 2015). Substantial differences exist between developed countries and developing world, mainly concerning the freedom in residential choice, travel-related attitudes, personalities, etc. This is especially true for China, as residential and transport choices are probably more constrained than in North America, due to the existence of the government's replacement housing scheme and car-purchase restrictions policy. Individuals' travel-related attitudes, personalities and lifestyles may also be quite different from those in North American cities, due to the differences in socioeconomic development, cultural background and social institution. More importantly, China is undergoing rapid urbanization, at an urban growth rate of 2–4 percent per year, increasing from less than 30% in 1997 to more than 50% in 2011 (Zhang and Lin, 2012). This means that new urban structures, forms and designs, that could potentially influence travel patterns are quickly emerging (Zegras, 2010). Recognizing the potential differences, studies related to the causality between the built environment and travel behavior in other parts of the world are desperately required (especially in the Chinese context); as the results of such studies are crucial in forming the foundation and guidance for future urban design and planning. However, the research regarding resident self-selection from cities in the Chinese context remains relatively limited. Furthermore, the existing few studies in the Chinese context mainly focused on travel variables such as total travel distance (Næss, 2010), commute time by car (Zhao, 2011), trip frequency (Huang et al., 2016) and emissions (Cao and Yang, 2017), with less focus being placed on VKT.

In an effort to fill these gaps, this paper explores the causal relationship between the built environment and travel behavior within the Chinese context; specifically the relative contribution of both the built environment and self-selection to VKT. Using the highly detailed travel data collected from residents currently living in TOD areas and non-TOD areas in Shanghai City, this paper employs Heckman's sample selection model to answer the following two questions: (1) Do the observed associations between the built environment and travel behavior reflect a true impact of the built environment? (2) To what extent do self-selection effects account for the observed influences of residential location on travel behavior? Answering these questions could help us to answer the central question: Can land use policies be used as an effective means to reduce the number of motor vehicle trips, spur transit use and decrease VKT by influencing resident travel behavior? By answering these questions, this study contributes to the literature on this topic in several ways. First, it could drastically improve China's understanding of the residential self-selection issue in the developing world context, allowing for tailor-made and niche-targeting spatial planning. Second, the results of this study enable the research communities to compare the impact of the built environment on travel behavior between different geographical and planning contexts. Third, it enriches the limited existing knowledge base on this issue from the perspective of developing world societies, whilst complementing Western studies.

The remainder of this paper is organized as follows. Section 2 provides literature review on the residential self-selection issue. In Section 3, the sites for survey and data used in this study are introduced. This is followed by a description of the methodology, including the variables and the modeling approach used for the analysis in Section 4. Section 5 presents and discusses the model results. The paper ends with the key findings and policy implications in Section 6.

## 2. Literature review

Over the past decade, research into the residential self-selection issue has gained significant progress in the Western context, i.e. the North America and Europe (e.g., Næss, 2015; Cao and Schoner, 2014; Wang and Lin, 2014; Chatman, 2013; Aditjandra et al., 2012; Cao et al., 2009; Mokhtarian and Cao, 2008; Pinjari et al., 2007; Handy et al., 2005; Schwanen and