



# Evolving urban spatial structure and commuting patterns: A case study of Beijing, China

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## ABSTRACT

This research investigates how evolving urban spatial structure explains commuting patterns in Beijing, China. To describe the dynamic and multi-dimensional urban spatial evolution, we identify emerging-, persisting-, and non-center areas between 2000 and 2008 in Beijing's three subregions—the inner city, inner-ring suburbs, and outer-ring suburbs. Based on individual-level commuting data from the 2010 Beijing Household Travel Survey, we estimate workers' commute distance and time using multi-level regression models with interaction terms that capture the spatial evolution. Results reveal commuting differences among persisting-, emerging-, and non-center areas, and, more importantly, varying differences across the subregions: in the inner city, persisting and emerging center areas induce similarly longer commutes than non-center areas. In the inner-ring suburbs, commutes to emerging centers are shorter than those to persisting centers. In the outer-ring suburbs, emerging center areas incur the longest commutes, while persisting center areas the shortest. The results reflect varying economic and urban functions in different subregions of Beijing and caution us that promoting polycentric urban development may increase commutes and relevant negative externalities in Chinese cities.

## 1. Introduction

This study examines how evolving urban spatial structure explains commute patterns in Beijing, China. In the last three decades, the urban structure of many large Chinese cities has experienced significant transformations. The fast growth of jobs and population, as well as the expansion of urban areas, have reshaped travel demand and caused urban illnesses, such as long commutes, congestion, greenhouse gas emission, and air pollution. Many theoretical and empirical studies have analyzed the relationship between urban spatial structure and travel patterns. Yet, the majority of these studies were undertaken in the developed countries. Results of this study can enhance our knowledge on the connection between urban structure and travel in a different setting and provide policy implications for China and beyond.

In addition, this study makes two more contributions. First, we describe Beijing's urban structure along two spatial dimensions, identified by Anas et al. (1998). The first dimension captures spatial clustering of economic activities: a place can be a part of an employment center or not. The second dimension captures decentralization from the central city to the suburbs. We use three subregions—the inner city, inner-ring suburbs, and outer-ring suburbs—to reflect the outward expansion of urban areas. Describing the urban structure along the two dimensions in transportation analysis is conceptually appealing and empirically sound.

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Second, we focus on temporal changes in urban structure by identifying employment centers at different evolution stages: persisting-, emerging-, and non-center areas. The dynamic view of urban structure differentiates this study from existing research on the urban structure-commute relationship, which generally relies on cross-sectional data.

We acquire commute and other individual-level data from the 2010 Beijing Household Travel Survey. We investigate to what extent commute distance and time are explained by Beijing's urban structure evolution between 2000 and 2008, a period of fast urban development before the 2010 travel survey.

Results depict complicated relationships between urban structure evolution and commutes: commute differences exist among persisting-, emerging-, and non-center areas, and more importantly, these differences vary across the three subregions. In a sense, the finding that the evolving urban spatial structures affect commute patterns corroborates existing literature. But, some findings are new and different. Specifically, in Beijing's outer-ring suburbs, emerging centers have especially long commutes while persisting centers have very short commutes; these areas need research and policy attention. The results can inform land use planning that guides future urban structure and transportation policies that cater to future travel demands.

The paper is organized as follows. First, we review the literature on urban structure evolution and on the relationship between the evolution and commute travels. Second, we introduce the study area, data, and methodology. Specifically, we propose three hypotheses and the analysis framework to test how urban structure evolution affects commutes. In the result section, we first describe the urban structure evolution in Beijing and related commuting patterns, and then we provide regression estimation results to test the three hypotheses. Last, we conclude the paper with policy implications.

## 2. Evolving urban structure and commutes

We limit our review to the literature that focuses on intra-regional spatial structure, indicated by the spatial distribution of employment.

### 2.1. Describing urban structure evolution

Theoretically, the intra-regional urban spatial structure reflects rational decisions made by land users who compete for the limited supply of land (Von Thunen, 1826). Firms aim to maximize profits in the location decisions. In a conventional monocentric metropolitan area, the Central Business District (CBD) has the best access to transportation, market, and consumers, thus concentrating firms that value transportation accessibility and agglomeration economies (Alonso, 1964). In recent decades, the urban spatial structure of many metropolitan areas in developed countries has shifted away from the monocentric to the polycentric structure (Kloosterman & Musterd, 2001): jobs suburbanized and employment clusters emerged in the suburbs. Employment concentrates in suburban centers for the same reasons that it concentrates in the CBD: jobs collocate to benefit from agglomeration economies (Anas et al., 1998; Marshall, 1920; Rosenthal & Strange, 2004). In the transformation, high commuting costs encourage the emergence of subcenters (Fujita & Ogawa, 1982; McMillen & Smith, 2003). Yet, all these theoretical models are built upon an assumption of rational behavior in a market economy; their applicability might be limited in Chinese cities, where the market forces and government interventions twine together.

To describe the contemporary urban structure, Anas et al. (1998) identified two spatial dimensions: (1) centralization versus decentralization—the degree to which jobs are concentrated in a CBD or decentralized in the suburbs; and (2) clustering versus dispersion—the degree to which jobs are clustered in suburban centers or dispersed in a low-density and relatively uniform fashion. It is generally accepted that decentralization is the common trend in developed countries (Angel & Blei, 2016; Gordon et al., 1998; McMillen, 1996). However, in terms of the second dimension, the degree of clustering is still debatable. Some studies claim that dispersion is the common trend in the U.S. (Gordon & Richardson, 1996) as most jobs are located in non-center areas. Yet much research has been devoted to identifying and examining employment centers because they represent spatial irregularity and affect local labor markets (Cervero, 1989; Giuliano et al., 2007; Giuliano & Small, 1991; McDonald & McMillen, 1990; McMillen & Lester, 2003).

Over time, metropolitan areas in developed countries have become more decentralized. The urban density gradients have become flattened in cities in the U.S. (Mills, 1970), Canada (Bunting et al., 2002), and other developed countries (Mills & Tan, 1980), but not necessarily in developing countries (Mills & Tan, 1980). This is consistent with the expectation that cities first experience spatial concentration and then decentralization with economic development (Alonso, 1980).

The degree of employment clustering also has changed, but there is no consensus on the general trend of changes. Some studies claimed that dispersion is the common theme in the U.S. as CBDs and employment subcenters in major metropolitan areas lost employment share (Gordon & Richardson, 1996; Lee, 2007), while others underscored the stability of spatial agglomeration since most employment concentrations maintain their significance (Forstall & Greene, 1997; Giuliano et al., 2007; Redfean, 2009). In four Canadian cities, Shearmur & Coffey (2002) found very different trends: in Toronto, the CBD and employment centers lost jobs, in Montreal and Ottawa economic activities converged to the CBDs, and in Vancouver, both the CBD and subcenters grew significantly. Zhong et al. (2017) observed that the downtown area of Singapore gained importance while the city-state moved towards polycentricity.

Another way to describe changes in employment clustering is to identify emerging, persisting, and disappearing centers and examine their spatial characteristics and economic functions. Giuliano et al. (2007) observed that in the Los Angeles region centers emerged after 1990 had smaller employment size and lower density, compared with persisting centers that had existed before 1980. Cervero et al. (2010) suggested that between 1990 and 2000 the San Francisco Bay Area's emerging centers were specialized in high-

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