

# Spatial variation of self-containment and jobs-housing balance in Shenzhen using cellphone big data



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## ABSTRACT

Self-containment of employment and jobs-housing balance have been used to examine commuting patterns from different perspectives. Appropriate jobs-housing ratio may achieve high self-containment. However, self-containment may be affected by other factors. In this study, the spatial variation of self-containment of employment and jobs-housing balance is examined with job types, location, and housing prices using the cellphone data in Shenzhen, China. Jobs-housing balance is found to be more important in self-containment of employment for secondary-sector workers compared with that for tertiary-sector workers. Secondary-sector workers tend to reside near their workplaces because of relatively balanced jobs and housing, whereas tertiary-sector workers tend to reside farther away from their workplaces to save housing cost. The study enhances our understanding of self-containment of employment and jobs-housing balance which is primarily based on Western cities.

## 1. Introduction

The concept of self-containment was advocated in the early 1880s when Howard introduced the “Garden City of Tomorrow” (Howard et al., 1898). Garden cities are planned, self-contained communities surrounded by “greenbelts” and contain proportionate residential, industrial, and agricultural areas. These new towns aim to achieve a built environment that allows a large proportion of people to reside, work, and do other daily activities within a community (Burby & Weiss, 1976). Self-containment of employment (SCE) represents the percentage of workers who work and live locally out of the total number of workers residing in a particular zone (Cervero, 1995). High SCE not only reduces vehicle miles traveled, but also encourages non-motorized travel modes, such as walking and biking that are environmentally friendly (Ewing et al., 2001).

The spatial organization of residences and economic activities is one of the core areas of urban planning and exerts significant influences on transportation planning. Jobs-housing balance is an important transportation policy that brings workers and jobs closer, and reduces commuting distances (Cervero, 1989; Loo & Chow, 2011; Schleith et al., 2016). Some researchers corroborated that workers living in housing-rich areas and employees working in job-rich areas had to commute longer than those residing or working in jobs-housing balanced areas

(Horner & Murray, 2002; Sultana, 2002). Jobs-housing balance is typically measured by jobs-housing ratio, which refers to the number of jobs divided by the number of residents in a given area (Horner, 2004).

SCE and jobs-housing balance used to be difficult to measure. Journey-to-work trips are usually collected from travel survey data once for several years in traditional transport studies (Chen et al., 2011). Travel survey data are labor-intensive, and limited by relatively small sample sizes and spatial resolution (Chen et al., 2016). With the advances in cellphone technology, cellphones have become a ubiquitous sensor for tracking people's locations (Batty, 2012). With the availability of cellphone data, it is possible to measure and analyze journey-to-work trips for studying the spatial variation of SCE and jobs-housing balance at a detailed spatial scale and with large sample size. Cellphone data provide time-stamped locations based on cellphone towers, which can be used to explore people's mobility patterns (Yue et al., 2014). Given that people's daily activities are rather regular (Song et al., 2010), cellphone data can relatively reflect daily journey-to-work patterns of residents (Ahas et al., 2010). The daily mobility patterns of residents show considerable spatio-temporal similarities using cellphone data (Gonzalez et al., 2008). Studies have shown that cellphone data provide a momentum to explore journey-to-work patterns as a supplement to travel survey data. Cellphone data can provide individual-level journey-to-work trip data with finer spatial resolution,

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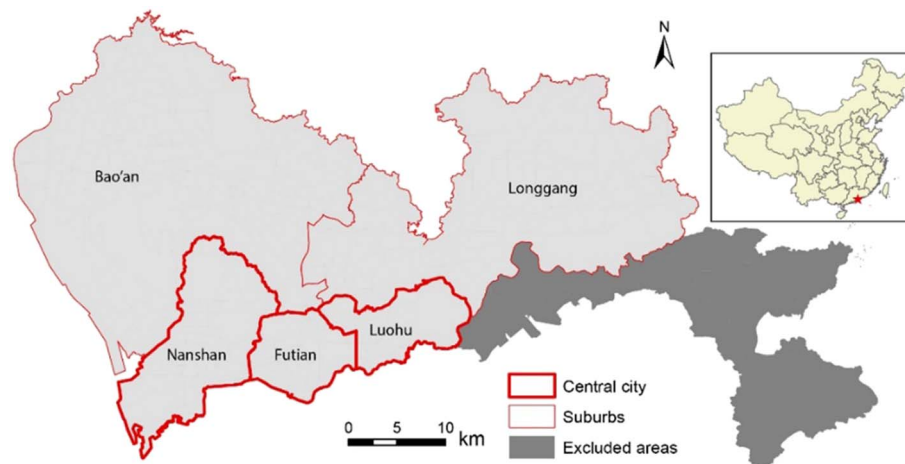


Fig. 1. Study site.

and produce detailed commuting patterns with a larger sample size (Alexander et al., 2015), as compared to “small data” like the travel survey data.

Although jobs-housing balance has been proposed to reduce commuting distance and encourage workers to work locally, few studies have examined its relationship with SCE in the literature. Cervero (Cervero, 1996) argued that the jobs-housing ratio and SCE had minimal association at the city level. Even if jobs-housing balance is achieved with jobs-housing ratio within a certain range, workers may not select jobs nearby, and SCE remains to be low. Other factors including job types, housing prices and location can also affect the relationship between jobs-housing balance and SCE. The relationship between jobs-housing balance and SCE remains to be examined. In this study, the spatial variation of SCE and jobs-housing balance and their relationship with job types, housing prices and location are analyzed using cellphone data in Shenzhen, a mega city in Southern China.

In many cities worldwide, suburbanization has led to the expansion of built-up areas and population decentralization. In Western cities, many well-off the residents have decentralized to the suburbs, whereas low-income residents are mainly concentrated in the central city (Bontje, 2001; Knox & Pinch, 2010). Many commerce, manufacturing, retail and office jobs have decentralized from city centers to edge cities or suburbs (Champion, 2001a). High-end suburban business and shopping centers are developed in the suburbs in the suburbanization process (Coffey & Shearmur, 2002). As a result, a large number of tertiary-sector workers reside in the suburbs and commute to the edge cities or central city for employment (Kwan & Chai, 2014). In addition, low-paid service and secondary jobs have decentralized to the suburbs, whereas low-income service and secondary-sector workers still live in the central city. Other commuting patterns such as reverse commuting or lateral commuting also exist (Champion, 2001b). Therefore, jobs-housing imbalance exists both in the central city and suburbs in most Western cities.

Chinese cities show different commuting patterns compared with Western cities (Feng et al., 2013; Wang & Chai, 2009). Although wholesale, retailing, and office-related jobs remain highly centralized, manufacturing industries tend to be decentralized to the suburbs, especially low-tech manufacturing jobs due to a number of reasons including cheaper land values and industrial decentralization policies (Zhou et al., 2017). The industrial parks and development zones in the suburbs accommodate manufacturing and service industries. Many industrial parks were established in Chinese cities since the 1980s (Feng et al., 2008). The industrial parks represented the planned jobs-housing relation, which was different from the market-based jobs-housing relation (Zhou et al., 2017). These industrial parks were relatively self-contained with a mixture of residential and industrial land use. A large

number of the secondary-sector workers reside near the factories or in worker housing provided by the factories in the suburbs instead of commuting to the central city (Ta et al., 2017). These secondary-sector workers need to commute only short distances to their workplaces. Thus, the suburbs in many large Chinese cities are relatively more balanced in jobs and housing, and relatively more self-contained in terms of secondary-sector workers compared with those in Western cities.

Previous studies on the spatial variation of the SCE and the jobs-housing balance are primarily based on a Western context, whereas studies in the developing countries are few (Martinus & Biermann, 2017; Wang et al., 2011). With differences in spatial structure (Cao, 2017), the spatial variation of SCE and jobs-housing balance in China may be different from that in Western cities. The study on the spatial variation of SCE and jobs-housing balance in Chinese context can enhance our understanding of self-containment of employment and jobs-housing balance which is primarily based on Western cities.

## 2. The case study of Shenzhen

### 2.1. The study site

The study site is the main built-up area in Shenzhen, excluding the southeastern parts (Fig. 1). The central city includes Nanshan, Futian, and Luohu, which are mainly for commercial and residential use. The suburbs include Bao'an and Longgang, which are mostly for industrial and residential use. Shenzhen is a metropolis in China which shares common characteristics with other large Chinese cities in terms of employment suburbanization.

### 2.2. Research methodology

This study explores the spatial variation of SCE and jobs-housing balance as well as their relationship. SCE for zone  $i$  is calculated by the number of workers living and working locally out of the total number of workers residing in zone  $i$ .

$$SCE_i = \frac{\text{Number of workers living and working locally}}{\text{Total number of workers residing in zone } i} \quad (1)$$

Jobs-housing balance was measured by Jobs-Workers Ratio (JWR), which was calculated as the number of jobs over the number of workers residing in a particular zone (Antipova et al., 2011). The number of jobs and workers is inferred from the cellphone data. SCE and jobs-housing balance are affected by the choice of the spatial analysis areal unit. Different geographic zones lead to varied proportion of intrazonal and interzonal trips (Ding, 1998). The larger the spatial analysis areal unit, the higher will be the SCE and jobs-housing will be more balanced. An

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