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Research Paper

Transit-oriented development on greenfield versus infill sites: Some lessons from Hong Kong

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ABSTRACT

This study examines whether the medium-term impact of rail transit on development near the transit stations differs if it is built in areas which are largely undeveloped (greenfield sites) as opposed to areas which have a certain level of development (infill sites) after a period of five to ten years. Hong Kong, a metropolitan city committed to rail-based transit-oriented development (RTOD), has been chosen to examine this main research question. Data related to changes in the population and employment size, development intensity, detailed land use pattern, and travel behavior of people living around transit stations along two railway lines (one primarily running through greenfield sites and the other running through infill sites), with both having an alignment running from the city's urban core to the periphery and built in the mid-2000s, were collected and compared. The analysis provides some useful evidence about the actual impact of RTOD under different urban settings. Infill site development has indeed been more successful in re-generating employment growth, housing new population, or both and also has a more healthy mix of land uses. In greenfield sites where the establishment of transit infrastructure preceded urban development, RTOD provided the opportunity to reshape the built environment and introduce more innovative planning concepts like "comprehensive development".

1. Introduction

In light of unsustainable transport trends in cities (Banister, 2005), transit-oriented development (TOD) is considered by some scholars to be a promising policy to curb urban sprawl, relieve traffic congestion, reduce air pollution and address public-health problems associated with an automobile-dependent lifestyle (Calthorpe, 1993; Cervero & Bernick, 1997; Cervero et al., 2004; Gilbert & Ginn, 2001; Haywood & Hebbert, 2008; Loo, Chen, & Chan, 2010; Parker, McKeever, Arrington, & Smith-Heimer, 2002). Academic interests about TOD have gone far beyond using it as a strategy for reducing private car usage but also for fostering and maintaining healthy and vibrant local communities around well-planned transit stations (Belzer, Srivastava, Wood, & Greenberg, 2011; Ewing & Cervero, 2010; Jacobson & Forsyth, 2008). At the local level, transit stations may be built on relatively undeveloped new areas or infill sites made available due to urban redevelopment. This contrast gives rise to the main research question of this study, namely, would the major characteristics of TOD differ systematically for railway stations built on greenfield and infill sites in the medium term of up to ten years after the operation of the new railway lines?

2. Background to RTOD

As opposed to transit-adjacent development, TOD refers to a combination of characteristics about the built environment which promotes walking and the use of public transport (Ewing & Cervero, 2010; Jacobson & Forsyth, 2008; Loo & du Verle, 2017; Reconnecting America, 2016; Victoria Transport Policy Institute, 2015). These TOD characteristics range from the road network, parking availability, public transport services, pedestrian and cycling facilities, general land-use pattern, housing types and density, public and private facilities and public space (Loo, 2009b). Geographically, TOD is best studied at the neighborhood level (that is, within walking distance of a transit station) rather than the city level.

If the transit stations are railway stations, the TOD can be described more precisely as rail-based TOD (RTOD). In particular, underground heavy railways in cities (hereafter metros) can be one of the key components of an integrated sustainable urban transport strategy in large cities of 5 million population or above (Loo & Cheng, 2010; Meyer & Dauby, 2002). Sustainability is, in turn, seen to encompass the three inter-related dimensions of environmental, economic and financial, and social sustainability (Janic, 2006; Loo, 2008; World Bank, 1996). In large cities, an electrified metro system can fulfill the

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economic and other mobility needs of people with its high carrying capacity, affordable fare and universal access but minimal low greenhouse gas emissions.

Nonetheless, the building of a metro system often involves very high capital investment and a long planning horizon (Loo & Li, 2006). While empirical studies about RTOD experiences on railway finance and other economic impacts, such as increase in property prices are abundant (Cervero & Duncan, 2002; Kay, Noland, & DiPetrillo, 2014; Lo, Tang, & Wang, 2008; Mushongahande, Cloete, & Venter, 2014; Sun, Zheng, & Wang, 2015), the relationship between the building of a new railway line and the medium- to long-term levels of population size, employment opportunities, land use patterns and residents' travel behavior in the neighborhood communities has not been well understood. One of the earliest studies discussing the implications of different site settings on RTOD was by Knight and Trigg (1977). Their work suggested that the barriers of developing rail transit in an already established area might reduce the rail's attractiveness for new intensive development. These barriers include the added complexities of the land take-up process and obsolescent transport infrastructure, such as narrow roads. Nonetheless, the discussion has been restricted to the general level. Recently, there has been renewed interest on the role of new rail transit in revitalizing the downtown or declining central inner cities (Amekudzi & Fomunung, 2004; Deakin, 2001; Gospodini, 2005; Hess & Lombardi, 2004). Under the smart growth strategy, some research studies have pointed out that infill development is perhaps more suitable for RTOD because of the higher existing densities nearby to support transit usage (Bae, 2002; Cervero & Bernick, 1997; Loo et al., 2010). In this study, infill development is defined as the more intensive use of a site, which may be vacant between buildings or previously occupied but becomes available due to redevelopment, with existing infrastructure such as power, water, sewerage, transport and telecommunications (Giannakodakis, 2013; Productivity Commission, 2011). The availability of "major infrastructure" (though enhancements may still be required in view of the more intensive development of the infill sites) is a major distinction of infill versus greenfield sites (Giannakodakis, 2013; Productivity Commission, 2011). An infill site needs not be near the core or downtown area but may be located at the periphery or suburb where human settlements and infrastructure existed historically (Alker, Joy Roberts, & Smith, 2000). Conceptually, this terminology is similar to the term "brownfield", especially in the United Kingdom planning system (see Alker et al., 2000 for a good review). Nonetheless, brownfields often refer to contaminated sites in the United States and sites with real or perceived contamination problems mainly in developed urban areas in Germany (Ferber & Grimski, 2002; US EPA, 2016). Hence, this paper uses the term "infill development" for the sake of clarity and consistency. With other developments nearby, infill sites tend to have higher land price and probably higher permissible development intensity. Yet, they also face more constraints of existing (sometimes obsolete) infrastructure, including underground utilities, and other pre-existing land uses nearby.

In contrast to infill development, a distinctive feature of greenfield development is that it "comes at a substantially higher infrastructure cost" (Giannakodakis, 2013, p. 5). In this paper, a greenfield site refers to a piece of land not in active use with little or no previous buildings, and any new development will require substantial infrastructural development in terms of power, water, sewerage, transport and telecommunications. In theory, greenfield sites are more abundant in the periphery or suburb of a city where there are more vacant lands and the land price is cheaper. In practice, they can also be near the core or downtown areas through means of reclamation along the waterfront and/or conversion of hilly areas/parks to more intensive urban uses. Nonetheless, the term "greenfield" should not be taken to refer to "green belt" or "natural or arable areas" (Alker et al., 2000; Bartke & Schwarze, 2015). On the one hand, development on greenfield sites requires substantially higher infrastructure cost. On the other hand, the land price tends to be lower and the constraints of land-use zoning tend to be fewer for large-scale development. The development of some greenfield sites may also involve covering healthy soils and disturbing the ecosystem. Hence, an integrated assessment of major transport infrastructure projects is always important (Bartke & Schwarze, 2015; Schädler, Morio, Bartke, & Finkel, 2012).

A review of the rich RTOD literature shows that no paper has focused on differences in changes happening around railway stations built on infill versus greenfield sites of the same city over a substantial period of time. Recent studies that tracked station-area changes have mainly analyzed specific land use/employment types (such as retail activity in Schuetz, 2015), property development/prices (Cervero & Duncan, 2002; Kay et al., 2014; Lo et al., 2008; Mushongahande et al., 2014; Sun et al., 2015), and overall economic benefits (Bollinger & Ihlanfeldt, 1997; Cervero & Landis, 1997; Mejia-Dorantes & Lucas, 2014). Studies that quantified and carefully examined the built environment characteristics have mainly focused on their relationship with station ridership (Jun, Choi, Jeong, Kwon, & Kim, 2015; Loo et al., 2010; Park, Deakin, & Jang, 2015). Houston, Boarnet, Ferguson, and Spears (2015) is one of the few studies that distinguished the differential impact of an "older subway corridor" and a "newer light rail line" within the same area – Los Angeles. Nonetheless, their findings are limited due to different railway technologies (subway versus light rail) and different time frames (the same changes may eventually happen for the newer rail line). While the studies of Cervero and Landis (1997) and Mejia-Dorantes and Lucas (2014) covered longer periods of time (10 years or more), their studies on the San Francisco Bay area, and on London and Madrid respectively were mainly qualitative and at the corridor level.

This paper addresses an important gap in the literature by explicitly recognizing the prior condition of infill or greenfield sites along two railway lines opening at about the same time and tracing the changes and development around the two different types of RTOD by multiple sets of quantified variables for a substantial period of five to ten years after their respective start of operation within the same jurisdiction of one city, Hong Kong. With the relatively stable administrative environment and the comparable time frame, results of this observational study are similar to a natural experiment in social sciences that captures the impact of an intervention (the building of a new rail line in this case) for two "as if" random groups (greenfield and infill sites here), recognizing that many other factors cannot be "controlled" (Brady & Collier, 2004; Dunning, 2008, 2012).

3. The geographical context and specific research hypotheses

Hong Kong, a city with the transport policy of "railways as the backbone", is chosen to examine the main research question. The "railways as the backbone" policy was introduced in 1999 in *Hong Kong Moving Ahead: A Transport Strategy for the Future* (Transport Bureau, 1999). The policy has then been implemented persistently and backed by government initiatives in planning and building new railways lines over the last two decades, notwithstanding the political handover in 1997 (Transport Bureau, 2000; Transport and Housing Bureau, 2014). Moreover, a multifaceted pricing strategy has been in place to keep the household car ownership rate in Hong Kong (14.4%) one of the lowest in the world despite its high income per capita (US$ 40,170 per capita, in current US$, in 2014) (Hau, Loo, Wong, & Wong, 2011; Loo, 2003; Transport Department, 2011; World Bank, 2016).

Following the recommendations of the Railway Development Strategy (Highways Department, 1994), two new rail lines were completed around the turn of the millennium. These two railway lines are the Tung Chung Line (TCL) completed in 1998 and the West Rail Line (WRL) completed in 2003. The construction phases of both lines have witnessed the handover of Hong Kong's sovereignty from the British to the Chinese in 1997. Nonetheless, there has not been any major disruption or change regarding the institutional setting and planning process of the transit lines. In retrospect, these two railway lines represent a rare opportunity for researchers to conduct an observational