Transit Oriented Development and its effects

Exploring relationships between TOD, accessibility and labour productivity in Beijing, China

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Chapter 1 Introduction

1.1 Motivation
Many cities all over the world are facing similar problems, such as road congestion, air pollution, urban sprawl, and increasing scarcity of available urban land. Transit Oriented Development (TOD) is widely recognised as an urban planning strategy that can address these challenges (Cervero et al., 2004; Curtis et al., 2009; Handy, 2002; Renne, 2009). TOD is often advocated as a generic, ubiquitously applicable concept that can integrate urban transport and land use systems, by combining a high level of public transport connection with high-density, mixed-use, cycling- and pedestrian-friendly developments, centred around a transit station (Calthorpe, 1993). However, studies have demonstrated that the effects of TOD policies are greatly dependent on the context where the TOD policy was applied and how it was implemented (e.g., Bertolini et al., 2012; Cervero et al., 2004; Chorus and Bertolini, 2016; Curtis et al., 2009; Joshi et al., 2017; Knowles, 2012; Loo et al., 2010; Mu and De Jong, 2016; Pojani and Stead, 2014; Yang and Lew, 2009; Zhang and Liu, 2007). It is within this tension between a generic concept and specific contexts that this thesis is nested.

The point of departure of this thesis is the notion that while TOD can deliver many benefits in theory, the actual impacts of TOD vary depending on the context (sometimes having unintended, negative consequences) (Jones and Ley, 2016; Toole, 2007). The Chinese context is a particularly interesting case. First, Chinese cities suffer from the numerous, aggravated urban problems that TOD is expected to address: traffic congestion, air pollution, urban sprawl and increasing scarcity of available urban land. China might profit from TOD, and many Chinese cities are advocating for TOD. Second, TOD policy is being implemented in some Chinese cities for more than a decade. It seems like an appropriate time to provide insights from the Chinese TOD experience to the rest of the world. Third, as a Chinese citizen, the author has a strong motivation to do research on the Chinese context and to offer a personal contribution to his home country.

The following sections provide an international literature review on the debate around the effects of TOD and, more specifically, a systematic review of TOD studies in the Chinese context. Based on the literature review, the knowledge gaps and research questions are identified, followed by a brief introduction of the selected case city of Beijing. The chapter closes with an outline of the thesis.
1.2 Identifying and debating the potential effects of TOD

1.2.1 Identifying the potential effects of TOD
The properties of an area that align with TOD principles are relatively high urban density, diversity, cycling- and pedestrian-friendly development and high quality transit node or public transport connection (e.g., Bertolini and Spit, 1998; Cervero, 1998; Cervero et al., 2004; Curtis et al., 2009). Given these properties and under certain conditions, TOD is expected to have positive effects on many aspects. For instance, TOD can enhance accessibility 1) by bringing origins and destinations closer together and 2) by reducing the disutility of covering distances between origins and destinations (Curtis and Scheurer, 2010; Handy, 2002; Papa and Bertolini, 2015). TOD is also expected to encourage changes in travel behaviour (i.e., more cycling or walking, more public transport use, and less private car use), with a likely positive effect on human health (Langlois et al., 2016; Solitare et al., 2012) and the environment (Kimball et al., 2013). Furthermore, TOD is expected to have positive effects on the urban economy by creating potential for land value capture (e.g., Bartholomew and Ewing, 2011; Cervero et al., 2004; Cervero and Murakami, 2009; Duncan, 2011; Mathur and Ferrell, 2009), by reducing transportation cost (e.g., Mudigonda et al., 2014; Nahlik and Chester, 2014), by stimulating employment (Belzer et al., 2011; Schuetz, 2015), by spurring company founding and relocation (Iseki and Jones, 2014; Noland, Chatman, et al., 2014; Zheng et al., 2016), and by increasing industry net income (Seo et al., 2013). Moreover, TOD may foster the development of social sustainability. As found by Kamruzzaman et al., (2014b), individuals living in TOD areas had a significantly higher level of social capital compared to those who lived in transit adjacent development areas (TADs are station areas characterised by low densities, limited or no pedestrian accessibility and segregated land uses [Renne, 2009]). Besides, TOD is said to contribute to spatial equity (e.g., Fernandez and Creutzig, 2017; Jang et al., 2017; Kaplan et al., 2014) and social inclusion (Waintrub et al., 2016).

1.2.2 Debating the potential effects of TOD
TOD has also come under criticism. For instance, some argue that TOD might increase car traffic (Rubin and Mansour, 2013; Toole, 2007), due to the often accompanying gentrification push (Jones and Ley, 2016). TOD can lead to increases in property/land values and rents, with higher-income residents/renters potentially displacing lower-income residents/renters within very desirable TOD areas. A population shift towards a higher-come group is expected to increase the vehicle ownership rate and car traffic
in TOD areas. And driving the lower-income groups out of the TOD areas is expected to increase the travel distances to reach public transits for the lower-income groups.

Critics also argue that the high-density development within a TOD area may actually cause congestion and noise, lowering the quality of the living environment in that area (Lin and Gau, 2006). The implementation of TOD might also raise spatial and social equity issues. The growing differences in public transit service and urban developments between transit areas and other areas can potentially increase spatial inequity (Lin and Gau, 2006). The gentrification dynamics induced by this spatial differentiation in urban qualities might then reinforce social inequity (Jones and Ley, 2016).

Others warn that TOD can deliver many benefits in theory but that the actual effects of TOD vary. The literature documents that the connection between implementation of TOD policies (measured as TOD-ness in some literature, see Singh et al., 2014) and their actual effects largely depends on the context and on how TOD was implemented (e.g., Bertolini et al., 2012; Cervero et al., 2004; Chorus and Bertolini, 2016; Curtis et al., 2009; Joshi et al., 2017; Knowles, 2012; Loo et al., 2010; Mu and De Jong, 2016; Pojani and Stead, 2014; Yang and Lew, 2009; Zhang and Liu, 2007).

Policy goals and TOD implementation strategies differ according to context specifics. For instance, in North America and Australia, TOD seems mostly to be aimed at curbing suburban sprawl by relatively high-density and diverse developments around transit stops (e.g., Cervero, 1998; Cervero et al., 2004; Dittmar and Ohland, 2004; Hemsley, 2009). In Europe it seems often to focus on the redevelopment of existing station/urban areas (e.g., Bertolini and Spit, 1998) and on improving regional accessibility (e.g., Papa et al., 2013). In Asia and South America, TOD seems to be utilized as a strategy for channelling or managing the growth of megacities along mass rapid transit corridors (e.g., Chorus and Bertolini, 2016; Rodriguez and Vergel Tovar, 2013; Yang and Lew, 2009).

The literature also shows differences in the form and the actual effects of TOD – both within the same context and across similar contexts. For instance, Papa and Bertolini (2015) found varying TOD degrees across six metropolises within the European context and discovered that cumulative rail-based accessibility was higher in cities with a higher TOD degree. Kamruzzaman et al., (2014a) identified four types of TOD areas – residential TODs, activity centre TODs, potential TODs (TADs), and non-TOD within the context of the same city (Brisbane). They found that inhabitants in residential TODs and activity centre TODs had a significantly higher level of trust,
reciprocity and connections with neighbours compared to inhabitants in potential TODs.

To summarise, TOD can deliver many effects, but the actual effects of TOD vary depending on the context of application (sometimes even leading to unintended, negative consequences).

1.3 TOD studies in China

1.3.1 Why study TOD in China

This section provides an introduction to the Chinese context, a discussion of why China might need TOD policies, and the position of this PhD study in the broader academic context of TOD studies in China.

Since 1978, when the Chinese central government started implementing an open-door policy of economic reform, the country has been undergoing rapid urbanisation. From 1978 to 2011, the urban population of China increased from 172 million to 690 million, and the urbanisation ratio rose from 17.9% to 51.3% (Pan and Xu, 2014). According to United Nations estimates, nearly 70% of Chinese will live in urban areas by 2030 (United Nations Department of Economic and Social Affairs, 2018).

The first challenge for planning professionals and policymakers comes from the pressures brought on by this accelerated urbanisation. The provision of urban services may not expand as rapidly as the urban population, resulting in a dramatic decrease of per capita urban services for residents.

A second challenge is the disappearance of the Danwei – the self-contained, live-work units (neighbourhoods that balance housing and access to jobs) – during this prolonged economic boom. The end result is the creation of relatively separate living and work districts, which leads to longer commutes (Wang and Chai, 2009).

Third, Chinese cities face increasing urban land scarcity due to growing urban sprawl. With the implementation of the farmland protection policy in 1994, this challenge has become more visible and felt (Lichtenberg and Ding, 2008). For example, in recent years, a large share of high-quality farmland is being lost due to rapid urban sprawl. Consequently, the farmland protection policy has become increasingly stricter, further constraining the area of available urban land.

Rapid urbanisation coupled with wealth increases also induced a drastic growth in private motorised mobility in China. Car passenger numbers in the main metropolitan cities (e.g., Beijing, Shanghai, Guangzhou, Tianjin, Wuhan, Xi’an) have been growing by 15.1% annually since 2000 (Zhao, 2014). This rapid growth of private motorised mobility has greatly increased people’s mobility and improved their quality of life;
however, it has also brought on severe urban problems: high energy consumption, growing greenhouse gas emissions, air pollution, noise pollution and poor road safety.

Many authors find that TOD is well positioned to address the challenges discussed above, for three main reasons (Doulet et al., 2017; Lu and Zhao, 2008; Wang, 2013; Wang et al., 2007; Xu et al., 2017; Zhang and Liu, 2007). First, TOD seems to offer solutions to the Chinese urbanisation problems described above: 1) by providing a relatively cheap, clean, safe mass rapid transportation to a growing urban population and commuter base, and 2) by infill developments around transit nodes, which help elevate the economic efficiency of areas. Second, the Chinese context is already aligned with TOD principles to some extent (see the similar arguments by Doulet et al., 2017): 1) Chinese cities are already very dense; 2) private car use is not that high; and 3) rail/metro-based public transit is relatively abundant. Third, since the land is owned by the state or by collectives (e.g., a village community), it is easier to implement TOD policy or planning than in other countries where the state has weaker control over development.

Many Chinese cities are advocating for TOD (Xu et al., 2017) and also implementing TOD policies, in some cases for more than a decade, such as in Beijing. Therefore, it seems like an appropriate time to provide insights on the Chinese experience with TOD. Besides its specific empirical relevance and interest, a study focusing on the Chinese context will contribute to the evolving international literature on TOD by providing insights from a context with characteristics markedly different from those of the North/South American, Australian, and West European contexts discussed so far, and yet a context with a very large global weight.

1.3.2 Previous TOD studies in the Chinese context

Existing TOD studies in the Chinese context can be subdivided into three groups. The first group introduces what TOD is and what it can deliver in the Chinese context; the second concerns the effects of implemented TOD policies; and the third looks at the challenges and the arrangements for implementing TOD (see more in each specific section of Appendix. Table 1-1).

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1 The majority of previous TOD studies in the Chinese context was identified according to a key word search of the Google Scholar Search Engine (‘Transit Oriented Development’ and ‘China/Chinese’), carried out at the start of the PhD project in October 2014 and updated in January 2018. In addition, all references of the reviewed literature were scanned to identify those TOD studies that referred to the Chinese context.
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The first part of the literature mainly focuses on introducing TOD and what it can deliver in the Chinese context (e.g., Li et al., 2015; Wang, 2013; Wang et al., 2007). Several researchers looked at the experiences with TOD practices in the Chinese context (e.g., Yang and Li, 2004; Zhang and Liu, 2007) and proposed guidelines of TOD principles appropriate for the Chinese context (e.g., Wang, 2013; Zhang and Liu, 2007). Furthermore, some researchers examined what TOD means for the station area from an urban design perspective. Based on their interpretation of TOD, these authors proposed land use optimisation models that follow general TOD principles for the targeted station areas (Li et al., 2010; Lu and Zhao, 2008). While covering the concept of TOD and its principles for the Chinese context, these studies neglect a key point made by the international literature, namely that the actual implementation of TOD varies in different contexts, even within the same city. A TOD typology within a Chinese city is yet to be elaborated (Li et al., 2015).

The second group in the literature concerns the benefits that TOD has actually delivered to Chinese cities. In line with other international TOD studies, TOD is found as having delivered several benefits. For instance, TOD enhances accessibility (Cervero and Day, 2008; Dou et al., 2016), reduces urban carbon emissions (Dou et al., 2016), encourages transit use (Cervero and Murakami, 2009; Huang et al., 2016; Pan et al., 2015) and walking (Jiang et al., 2012), and spurs urban expansion (Xu et al., 2017) and the urban economy (Li et al., 2011). Studies also found a positive correlation between TOD and transaction price of land (Yang, Chen, et al., 2016; Yang, Quan, et al., 2016) and between TOD and housing price (Zhang et al., 2014; Zhang and Wang, 2013). However, Pan et al. (2011) found that in the urban periphery TOD did not effectively reduce car ownership and use, contrary to findings from the international literature (e.g., Cervero, 2006; Noland, Ozbay, et al., 2014), but in line with others (Rubin and Mansour, 2013; Toole, 2007), suggesting the need for further enquiry. Also when not controversial, most of these studies are based on findings from very specific geographical contexts (a single or a few cities). However, the international literature warns that they might not apply to other contexts, suggesting the need of a broader empirical base and methodologies for systemic comparison.

The third group of the literature concerns the challenges and the necessary arrangements for implementing TOD policies in the Chinese context. For instance, several studies focus on the pre-conditions (Mu and De Jong, 2012), built environment factors (Qu et al., 2014) or the challenges (Thomas and Deakin, 2008) for effectively implementing TOD policies. Some studies emphasise successful TOD experiences, by looking at governance (Mu and De Jong, 2016) or financial arrangements (Li et al.,
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2013) that have made TOD implementation possible. This literature highlights the importance of contextual variables for successful TOD implementation in China; however, it usually lacks the quantitative analysis—a growing requirement under evidence-based planning in China (Liu et al., 2015) that can clarify the relationship between specific contexts (e.g., a geographic or planning context) and the implementation of TOD measures and the delivered benefits.

1.4 Knowledge gaps and research questions
This section identifies the knowledge gaps and research questions that emerged from the review of international and Chinese TOD studies. The central notion is the argument that TOD can deliver many benefits in theory, but that both the form and actual effects of TOD vary in different contexts, even within the same country or city. Therefore, a context-based TOD typology should be developed as a starting point for exploring the relationship between TOD and its actual effects in context.

The overarching research questions of the thesis (ORQ) are: How to develop a context-based TOD typology in a systematic way? And how is TOD related to its effects in a specific context? For both questions, Beijing city will be the context of application (see point 1.5 below for the justification of this choice), in order to fill the specific knowledge gaps on TOD in China.

The literature shows that a context-based TOD typology could provide many insights for improving TOD planning and implementation (e.g., Kamruzzaman et al., 2014a; Vale, 2015). The similarities within one area type could allow to develop more targeted sets of strategies to promote TOD or maximise its effects (Reusser et al., 2008). And, a context-based typology could improve the planning professionals’ understanding of the relationships between TOD and its effects, by allowing for comparison of the effects in the identified TOD area types. Many authors (Austin et al., 2010; Kamruzzaman, Baker, et al., 2014; Vale, 2015; Zemp et al., 2011) have developed context-based TOD typologies to account for the fact that the actual effects of TOD vary depending on the context of application. However, no study has systematically developed a TOD typology for a Chinese city, and Chapter 2 (originally published in 2016) fills this knowledge gap by answering the first research sub-question (RQ1):

RQ1: How to develop a context-based TOD typology for a city in a systematic way?

The international and Chinese literatures present substantial empirical evidence of the positive relationship between TOD and the effects that TOD is expected to deliver (e.g., Cervero and Day, 2008; Dou et al., 2016; Duncan, 2011; Kimball et al.,
They found that 1) changes in accessibility can be recognised as the primary and direct effects of TOD; and 2) accessibility is closely associated with other indirect, secondary effects of TOD (Papa and Bertolini, 2015). However, previous TOD accessibility studies (e.g., Dou et al., 2016; Papa and Bertolini, 2015) did not explore the relationships between specific TOD components (e.g., the position of a station in the city and the transit network, the frequency of transit service, density and diversity of land uses, or walkability) and accessibility. Furthermore, also here the specificities of the Chinese context demand a targeted, contextual analysis of the relationship between TOD and accessibility. And the analyses of previous studies are limited at the intercity or regional levels and, therefore, do not provide insights regarding the relationship between TOD and accessibility at the local, i.e. station area level. In addition, the findings of previous studies on the relationship between TOD and accessibility paint a mixed picture with respect to the land use component (e.g., Chatman, 2013; Levine et al., 2012; Papa and Bertolini, 2015). Understanding which TOD components (e.g., public transport connection, pedestrian-friendly urban design, or densification or diversity land use) should be emphasised in order to enhance a station area’s accessibility provides valuable insights for urban planning professionals. Therefore, Chapter 3 will explore the relationships between specific TOD characteristics and accessibility via the second research sub-question (RQ2):

**RQ2: How does Transit Oriented Development contribute to station area accessibility?**

With the relationship between TOD and accessibility already elaborated, Chapter 4 turns to the relationship between TOD and its indirect effects. TOD’s link with economic development is a particularly important field of investigation (e.g., Bartholomew and Ewing, 2011; Belzer et al., 2011; Cervero and Murakami, 2009; Duncan, 2011; Noland et al., 2014a; Schuetz, 2015; Seo et al., 2013; Yang et al., 2016a, 2016b; Zhang et al., 2014; Zheng et al., 2016). However, the key relationship between TOD and urban economic efficiency (in this thesis defined in terms of labour productivity) is not covered by previous studies. Filling this knowledge gap is important for two main reasons: 1) knowing how TOD relates to labour productivity, as an illustrative example, is helpful for exploring the relationships between TOD and other indirect effects (e.g., effects on the employment rate, land prices, or spatial equity); and 2) improved understanding of this connection can enhance urban planning and other policies aimed at achieving higher labour productivity in urban
areas (an important urban planning goal for many cities). The research sub-question (RQ3) for this part is defined as follows:

**RQ3:** Is labour productivity significantly higher in a more transit oriented developed area, and how do the specific TOD characteristics contribute to the clustering of labour productivity?

These three specific research sub-questions (RQ1, RQ2, and RQ3) are answered in Chapters 2, 3, and 4, respectively. The necessary theoretical and methodological tools are also developed, altogether constituting the main body of this thesis.

**1.5 Introduction of the selected case city: Beijing**

This section provides audiences with a brief introduction to Beijing, the reasons why the author chose Beijing as the case study city, and how this choice is related to the research sub-questions in the thesis.

In the last four decades, China’s capital city has seen rapid urbanisation and urban sprawl (Pesaresi and Freire, 2016, also see Figure 1-1). In 2014, the total urban and rural population in Beijing municipality reached 21.5 million, with 86.4% living in its urban areas (Beijing Municipal Statistics Bureau, 2015). Beijing is a relatively dense city, with urban population density of 8,975 persons per square kilometre in the built-up areas (2,217.40 km²) in 2015.

![Figure 1-1 Urban expansion in Beijing (1975-2014)](image)

*Map is drawn by Robbin-Jan van Duijne*
Chapter 1 Introduction

*Data is derived from Global Human Settlement Layer city centres database* (Pesaresi and Freire, 2016)

Beijing provides an excellent study case for the following reasons. First, TOD strategies, based on the metro system, have been implemented for many years (Beijing municipal government, 2003). The travel share of public transport (especially metro) has increased rapidly since the TOD policy was proposed, while the travel share of private cars has stabilised (see Figure 1-2). However, there is no study or report that has systematically assessed the actual implementation of TOD policy at the station area level in Beijing (especially, a TOD typology). Therefore, it is interesting and relevant to examine the TOD policy and undertake a systematic assessment of the implementation, by developing a TOD typology for Beijing’s metro station areas and providing a few insights from Beijing’s TOD experience to the world (in Chapter 2).

![Figure 1-2. The share of transport mode (not including walking) since 1986 in Beijing city](image)


Second, since TOD strategies were officially proposed in Beijing’s Urban Master Plan 2004–2020, metro-based TOD strategies have been considered as one of the key policy tools for increasing public transit use, reducing carbon emissions and air pollution, and channelling urban growth along mass transit corridors (Beijing municipal commission of transport, 2012, 2016; Beijing municipal commission of urban planning, 2009; Beijing municipal government, 2003). The expected benefits of TOD are all related to the enhancement of accessibility. A close examination of the relationship between TOD and accessibility is therefore warranted. Furthermore, the official Urban Master Plan 2016–2030 (Beijing municipal commission of planning and
land resource management, 2017) emphasised TOD as a policy for bringing jobs and housing closer to each other within each urban district, but it did not provide the specific strategies how to achieve this planning goal. This focus of Beijing’s urban planning professionals further demands careful investigation of the relationship between TOD and accessibility to jobs and inhabitants (to be addressed through the second research sub-questions in Chapter 3).

Third, TOD strategies are also considered as one of the key tools for intensive and cost-effective urban land use (Beijing municipal commission of urban planning, 2009) and boosting the urban economy (e.g., Yang et al., 2016b; Zhang et al., 2014). The official Urban Master Plan 2016–2030 (Beijing municipal commission of planning and land resource management, 2017) uses labour productivity as an important indicator to measure the efficiency of Beijing’s economy. It proposes increasing labour productivity in Beijing from 196,000 Chinese Yuan per worker in 2015 to 230,000 Chinese Yuan per worker in 2020; however, it does not provide any specific strategies how to achieve this planning goal. A study of the relationship between TOD and labour productivity of an area (the focus of the third research sub-question in Chapter 4) could be a useful contribution to this effort.

1.6 Outline of the thesis

This thesis is based on a series of papers that were published or submitted to international peer-reviewed journals.

Chapter 2: Developing a TOD typology for Beijing metro station areas

Brief Introduction:

This chapter develops a TOD typology for metro station areas in Beijing. The approach is based on the node-place model, which charts ‘Transit’ and ‘Development’ characteristics of metro station areas, expanding it with a third, ‘Oriented’, dimension to quantify 1) proximity between a metro node and developments and 2) walkability within metro areas. This chapter generates context-based TOD indicators by reviewing the main TOD indicators in the international literature and selecting those appropriate for the Beijing context with the help of local TOD experts. It evaluates TOD characteristics of each metro station area, classifies them into six types via cluster analysis and characterises each cluster.

Chapter 3: How does Transit Oriented Development contribute to station area accessibility? A study of Beijing

Brief Introduction:
Chapter 1 Introduction

This chapter develops a methodology to explore how specific TOD characteristics are related to accessibility as well as their relative contribution to accessibility. It first assesses the accessibility of any given metro station area in Beijing. Then, it studies how the specific TOD characteristics are related to accessibility at the metro station area’s one-hour travel time catchment level. The results highlight that in the Beijing context a station area’s location relative to the city centre and the land use pattern (e.g., a relatively lower average residential density; a relatively higher average all-job density; a relatively lower average job density in the sector of retail, accommodation, and catering; a relatively higher average job density in the sector of education, health, and culture; and a relatively lower average degree of functional mixes) around all the stations within the targeted station’s one-hour travel catchment are relatively more important for enhancing the area’s accessibility than improving the area’s transit performance. This outcome provides insights for developing area-specific and targeted strategies to enhance the accessibility of a given metro station area in Beijing.

Chapter 4: Is labour productivity higher in Transit Oriented Development areas? A study of Beijing

Brief Introduction:
This chapter operationalizes economic efficiency as labour productivity and develops a methodology to assess the values of labour productivities and their clustering (derived from a hotspot analysis) in different area types (according to distance from a metro station) across different types of industries. Furthermore, the study explores the relationships between the specific TOD characteristics and the clustering of labour productivities in certain industry sectors. The results show that in most industry sectors, the distribution of labour productivity has no significant association with TOD. However, the results suggest that within certain tertiary industry sectors (i.e. wholesale and retail trades; accommodation and catering; and culture, sports, and entertainment), labour productivity is significantly higher in a more transit oriented developed area. Furthermore, the paper has identified specific TOD components that are related to the clustering of labour productivities in certain industry sectors and the extent of the effect (e.g., in Beijing, the densification and diversification of development around a station area or along the transit network is more relevant than the transport connection of an area). These outcomes provide insights for developing targeted strategies to foster the clustering of labour productivities in certain industries at a given station area in Beijing.

Chapter 5: Conclusion and discussion
This chapter brings together the findings and contributions of the entire thesis, reflects on the limitations of the study, and discusses potential directions for TOD research.
Chapter 1 Introduction

References of Chapter 1


TOD and its effects: studies in Beijing, China

Institute of Urban and Regional Development, University of California at Berkeley.


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Table 1-1
The overview of TOD studies in the Chinese context

<table>
<thead>
<tr>
<th>Theme/topic</th>
<th>Study case/focus</th>
<th>What has been done or what is the main finding?</th>
<th>What is missing, has been neglected?</th>
<th>Literature reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Review of TOD studies in the American and Chinese contexts</td>
<td>TOD studies in the American and Chinese contexts</td>
<td>TOD principles and its interpretation in the Chinese context were reviewed</td>
<td>A review of TOD practices (e.g. TOD plan for cities or for neighbourhoods) in the Chinese context was neglected</td>
<td>(Wang et al., 2007)</td>
</tr>
<tr>
<td>The mechanism why TOD can deliver many benefits</td>
<td>Metro corridors in Beijing city</td>
<td>The mechanism by which TOD can deliver many benefits was discussed. And a guideline for TOD planning in the Chinese context was proposed</td>
<td>Empirical studies which can support the mechanism by which TOD can deliver many benefits were neglected</td>
<td>(Wang, 2013)</td>
</tr>
<tr>
<td>TOD practice in a city</td>
<td>A TOD plan in Dalian city</td>
<td>TOD principles and a TOD plan for Dalian city was introduced</td>
<td>Empirical studies which can support the expectation that TOD can deliver many benefits were neglected</td>
<td>(Yang and Li, 2004)</td>
</tr>
<tr>
<td>TOD principles for Chinese cities</td>
<td>TOD practices in Shanghai, Hong Kong, and Taipei</td>
<td>The TOD principles based on the Chinese context were generalised</td>
<td>China is a large and diverse country. Regions or cities demand more context-specific principles for</td>
<td>(Zhang and Liu, 2007)</td>
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<tr>
<td>TOD and its effects: studies in Beijing, China</td>
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<td>---------------------------------------------</td>
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<tr>
<td><strong>Multi-objective optimisation models for sustainable developments</strong></td>
<td>A station area in Shenzhen city</td>
<td>A TOD planning paradigm to ensure a multi-objective optimisation on sustainable developments was provided (Li et al., 2010)</td>
<td>Developing TOD. The mechanism of optimisation has not been supported by relevant empirical studies</td>
<td></td>
</tr>
<tr>
<td><strong>Multi-objective optimisation models for TOD planning</strong></td>
<td>Station areas in Beijing city</td>
<td>The key issues of TOD planning in the Chinese context were identified and a multi-objective optimisation model for TOD planning at the neighbourhood level was proposed (Lu and Zhao, 2008)</td>
<td>The mechanism of optimisation has not been supported by relevant empirical studies</td>
<td></td>
</tr>
<tr>
<td><strong>TOD’s principles and typology</strong></td>
<td>TOD studies in the American and Chinese contexts</td>
<td>TOD principles and several classical types of TOD areas were reviewed (Li et al., 2015)</td>
<td>No Chinese TOD typology was discussed or developed</td>
<td></td>
</tr>
<tr>
<td><strong>Travel behaviours</strong></td>
<td>Individuals within three neighbourhoods in Shanghai city</td>
<td>Due to the residential relocation from urban centre to the periphery, job accessibility decreases, but TOD moderates such losses in job accessibility. And TOD encourages transit commuting (Cervero and Day, 2008)</td>
<td>A comprehensive evaluation of TOD characteristics of the three sampled locations was neglected</td>
<td></td>
</tr>
<tr>
<td><strong>Travel behaviours</strong></td>
<td>Individuals within 19</td>
<td>People walk farther to transit 21 (Jiang et al., 2012)</td>
<td>Inter-dependency of</td>
<td></td>
</tr>
</tbody>
</table>
station areas in Jinan city stations when the walking environment has certain TOD characteristics TOD variables and some factors related to walk distance were neglected

Travel behaviours

Individuals in two station areas in the periphery of Shanghai city TOD does not effectively reduce car ownership and use in the urban periphery

Travel behaviours

Individuals in several sampled metro station areas in Shanghai city People’s intention to use metro has negative effects on mode choice of driving and car ownership; denser road network and more mixed land use at workplaces may result in less car purchasing; residents are more likely to commute by metro instead of car if the ratio of access time from homes/jobs to a station is smaller

A systematic evaluation of TOD characteristics (e.g. parking in the TOD’s residential areas, pedestrian- or cycling-friendly developments) of station areas was neglected

(Pan et al., 2011)
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<table>
<thead>
<tr>
<th>Attitudes and travel behaviours</th>
<th>Individuals within five neighbourhoods in Xi'an city</th>
<th>Individuals with a strong propensity to use transit commute by transit no matter whether they live near metro transit. Living near metro transit tends to promote transit commute for those with a weak propensity to use transit.</th>
<th>The TOD characteristics (e.g. walkability, urban diversity) of studied residential areas were neglected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accessibility and carbon emissions in different TOD scenarios</td>
<td>A TOD network in Shanghai city</td>
<td>TOD enhances accessibility and reduces urban carbon emissions</td>
<td>The relationship between TOD and travel behavioural change was neglected</td>
</tr>
<tr>
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<td>Land use change after TOD planning</td>
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<td>TOD land use becomes denser but less diverse and urban economy is expected to be fostered</td>
<td>The actual changes on land use were neglected</td>
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</table>

(Huang et al., 2016)  
(Dou et al., 2016)  
(Cervero and Murakami, 2009)  
(Li et al., 2011)
| TOD’s impacts on land expansion | 50 cities in China | The second- and third-class cities will probably have greater potential to achieve large urban form impacts from TOD than the first-class cities in China. Some factors (e.g., human decisions that lead to spread of urban areas) are not considered into the cellular automaton model. (Xu et al., 2017) |
| TOD and land transaction price | Land parcels nearby transit stations in Shenzhen city | Transit stations were likely planned/designe d at the less-developed areas of the city for the potential development of the areas. A positive correlation between TOD implementation and land transaction price was identified. The relationships between land transaction price and more specific TOD characteristics (e.g., land use density, diversity, walkability) were neglected. (Yang, Chen, et al., 2016) |
| TOD and land transaction price | Land parcels nearby transit stations within Beijing city | A positive correlation between TOD characteristics and land transaction price over time was identified. The barriers to reaching the higher economic potential development of TOD were identified. More specific TOD characteristics (e.g., land use diversity and walkability) were neglected in the spatial regression model. (Yang, Quan, et al., 2016) |
### TOD and its effects: studies in Beijing, China

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<th>TOD and housing price</th>
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