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Valuing external benefits of underground rail transit in monetary terms: A practical method applied to Changzhou City

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ABSTRACT

Underground rail transit is undergoing intense development across China. However, when it comes to cost-benefit analysis in the decision-making process, the benefit aspects, especially the external ones, of underground rail transit are still ambiguous when compared with the cost aspects. For one thing, the external benefits derived from underground rail transit is complicate to capture; for another, extensive research has not been represented in comparable monetary terms, which to some extent is impeding the urban development of some Chinese cities. This paper employed the service replacement cost method (SRCM) framework, after shedding particular light on the theoretical interpretation of SRCM from the perspective of marginal value theory for non-market goods and modifying it into three major steps, to translate the external benefits of underground rail transit into monetary terms. The method was then applied to Changzhou City, China as an illustrative case study. Results have shown that the development of underground rail transit could contribute an important portion for urban economy even though there remain gaps to fill in the method.

1. Introduction

Since the start of the century, China has been undergoing rapid development with regard to urban rail transit construction. As of 2015, the total operational length of urban rail transit lines has reached 3618 km (National Development and Reform Commission, 2017), with a further length of over 6500 km[1] being or to be constructed in 43 cities in the following years. In China, urban rail transit has been taken as a way to address pressing urban problems such as traffic congestion (Zhao and Deng, 2013), air pollution, etc., and also been deemed as an important stimulus for urban economy (Zhao et al., 2016). According to the report by the National Development and Reform Commission (2017), the completed urban rail transit has introduced a gross investment of over 2633 billion yuan (about 405 billion 2016 US$) to urban economy.

However, new trends have emerged in the approval process of urban rail transit projects. In August 2017, Metro Line 1 and Line 2 projects in Baotou City, Inner Mongolia Autonomous Region were called for immediate cessation just three months after the commencement of construction. The decision was made out of the consideration that the construction cost of the two lines was out of proportion to local financial resources available. Similar incidents also occurred in other cities and they are releasing the signals that China is tightening up the approval process of urban rail transit projects to avoid potential fiscal overburden.

By far the general decision-making process for rail transit planning in China is practicing following the procedures shown in Fig. 1. The qualified applicant cities for rail transit development should at least meet the requirements regarding local budget avenue, GDP and urban population. Prior to the final approval to the urban rail transit network planning, several rounds of discussions will be held between decision-making and planning revision process. Foremost among these concerns are cost-benefit analysis, e.g., whether the city's fiscal budget can afford the construction cost, whether the city can tolerate the disorder elicited by the large-scale construction, or what or how much benefit the city can derive if the planned rail transit network is implemented?

The aforementioned incidents reflect the fact that cost aspects weigh greater than benefit aspects in the trade-offs between fiscal expenditure and urban development. This fact is markedly evident when the decision-making process involves underground rail transit projects whose construction cost is generally 2–10 times that of aboveground projects (Kaliampakos et al., 2016). The cost issue has proved to be intuitively

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[1] Data were collected on the Internet according to the approvals of urban rail transit projects by the National Development and Reform Commission.

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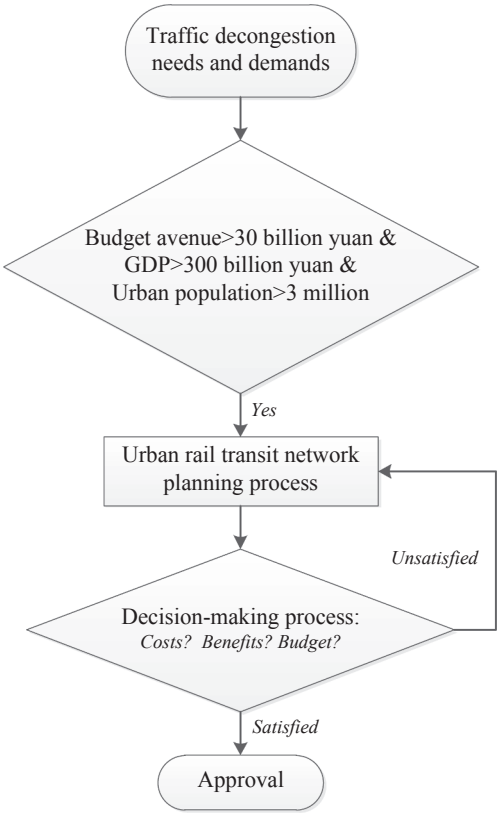

Fig. 1. General decision-making process for rail transit planning in China.

unfavorable to urban underground space development and has taught us lessons in such case like Lujiazui Business District, Shanghai which lost the best opportunity of inter-connecting major buildings in core business area via underground passageways (Qiao and Peng, 2016).

The turning point of underground rail transit development in the decision-making process would come if the external benefits of underground rail transit are taken into consideration (Godard and Sterling, 1995; Qiao et al., 2017). In this respect, considerable research efforts have been made to reveal what and how urban rail transit, underground rail transit included, is benefiting the city. However, most of the efforts just focused on single benefit derived from urban rail transit, i.e., the effect on land use (Calvo et al., 2013; Ahmad et al., 2016) or property price (Cervero, 1994; Debrezion et al., 2007; Bobylev, 2009; Hewitt and Hewitt, 2012; Anantsuksomsri and Tontisirin, 2015; Zhang et al., 2016), on traffic congestion (Li and Hensher, 2011), on air pollution (ITA Working Group, 1990; Hsu and Guo, 2005; Broere, 2016; Park and Sener, 2017), on greenhouse gas emission (Griswold et al., 2013; Sharma et al., 2014; Matute and Chester, 2015), on human health (Topalovic et al., 2012; Rissel et al., 2012; Kwan et al., 2016), etc., and could not provide an integral assessment method for strategic decision-making process of underground rail transit projects. Additionally, the existing literature provided merely the scale of differences occurring before and after urban rail transit projects were completed. Nevertheless, it is by no means an easy task to persuade the decision-makers to select underground rail transit solutions if you cannot give them a comparable result to the construction cost. Therefore, the monetary valuation of external benefits of underground rail transit, that is, the quantification of external benefits in monetary terms, may be literally the determining factor in the decision-making process.

When compared with aboveground rail transit, underground rail transit could benefit cities in a broader range of aspects, e.g., saving land (Hunt et al., 2016; Sterling, 1997; Broere, 2016; Admiraal and Cornaro, 2016), reducing noise (ITA Working Group, 1990; Sterling, 1997; Broere, 2016), mitigating disaster-caused loss, and so forth

Fig. 2. Location of Changzhou City. (Source: https://map.baidu.com/, modified by the authors).

(Sterling and Nelson, 2013; Hunt et al., 2016; Working Group No. 4, International Tunnelling Association, 2000; Ronka et al., 1998; Chestert, 1981; Broere, 2016; Sterling, 1997). Given that these 'externalities' are largely external to the market and thus not reflected in market prices (van der Heide et al., 2010), the monetary valuation of external benefits of underground rail transit would be a critical point for the development of underground rail transit. The aim of this paper is to develop a practical method for the monetary valuation of external benefit of underground rail transit. Given that the precise estimate is almost an impossible task, this paper can only provide a crude approximation of the value of urban underground space, but it is still valuable for awareness-raising and will further influence the trade-offs in the decision-making process (Marre et al., 2016) of underground rail transit development. This paper is an extension of Qiao et al. (2017) which introduced the idea of monetary valuation of underground benefits via service replacement cost method (SRCM). This paper will shed specific light on the theoretical interpretation of SRCM from the perspective of marginal value theory for non-market goods and develop the detailed three step procedures for application process. Section 2 sets the context for underground rail transit development in Changzhou City before detailing the methodological approach in Section 3. Results shows the contribution of underground rail transit to urban welfare and are further discussed in Section 4. Conclusions are drawn in Section 5.

2. Brief overview of Changzhou City and its underground rail transit

Changzhou City is a major city of Suzhou-Wuxi-Changzhou Metropolitan Area (Fig. 2) in the Yangtze River delta. As of 2016, its population has reached 4.71 million, of which 71% residents are living in urban areas[2]. Changzhou City is composed of five districts and one county, covering a total area of 4385 km^2. In 2016, the GDP of Changzhou City achieved 577.4 billion yuan, averaging 123,000 yuan per capita (about 18,923 2015 US$). The disposable personal income exceeded over 46,000 yuan.

The central urban area of Changzhou City covers an area of 700 km^2, with the population predicted to reach 1.80 million in 2020. According to the Master Planning of Changzhou City (2008–2020), the central urban area will be developed into ten urban clusters, hence underground rail transit will be of significant importance for the inter-connection among these urban clusters. Meanwhile, underground rail transit will play an important role in the integrated development process of regional transportation in the Yangtze River delta. Last but not least, underground

[2] Source: http://www.changzhou.gov.cn/