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Evaluation on the utility efficiency of metro infrastructure projects in China from sustainable development perspective

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Abstract

The development of metro infrastructure projects (MIP) has been playing an important role in the economic growth in China through improving urban transportation condition. The economic benefits from MIP in China have been well appreciated. However, concerns on the utility efficiency and the impacts of MIP on social and environmental aspects have been increasingly raised. It is anticipated that a large number of metro infrastructure projects will be built in the near future in China. There is a need for a method to guide the development of MIP towards achieving better utility efficiency and collective benefits between economic, social and environmental dimensions. Previous studies have provided various methods for evaluating economic performance of MIP, but it appears that there is no existing method for studying the utility efficiency of a metro infrastructure project particularly from sustainable development perspective. This paper presents a model for evaluating the utility efficiency of MIP with reference to the Chinese context, which is called utility efficiency evaluation index (UEEI) model. Population of city (POP), length of Metro systems (LEN), annual ridership of Metro systems (RID), ticket price (FAR) and Gross Domestic Product (GDP) are selected as the variables for developing the UEEI model. The utility efficiency of the 17 MIPs is analyzed by using the data collected from 17 cities in China.

Keywords: Metro infrastructure project; Sustainable performance; China; Utility efficiency

1. Introduction

Metro infrastructure project (MIP) is a common means in cities for improving transportation condition thus contributing to the urban economic development. Francesca and Enrica (2011) opined that light rail, metro and other urban rail transit systems can play a significant role in improving the attractiveness and quality of urban public transport. There are over 180 cities in the world which have developed the metro system (http://mic-ro.com/metro/). At present, the development of metro system in China is still at the primary stage compared to that in other developed countries. From 1978 to 2010, China's urban population increased from 80 million to about 640 million. By the end of 2010, there are 124 cities in China with a population of more than 1 million (China Statistical Yearbook, 2011). However currently there are only 17 cities which have a metro system in China. Compared with developed countries, for instance, UK, USA, France and others, the development level of metro system in China is still very low in terms of both scale and management performance.

The development of a metro system is a major strategy globally to drive social and economic development. The implementation of metro infrastructure projects has contributed significantly to the development of urbanization in China. The study by Zhou (2004) suggests that the investment of 1 Yuan on metro in Chongqing will lead to the increase of GDP by 2.63 Yuan, and currently the Chongqing Metro has provided 8466 jobs. It is estimated that the number of MIP will continue to grow globally particularly in those developing countries such as China where there are huge plans for urbanization. According

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to "the 12th five year plan transportation system", the total distance of urban rail transit in China will reach 3000 km, and 21 more cities will develop metro systems in the country (National Development and Reform Commission, NDRC, 2012).

The implementation of MIPs involves huge amount of social, financial and environmental resources. Previous studies demonstrate that the installation of metro systems requires large amount of capital investment, generally ranging from US$15 to 300 million per route-km with no guarantee of sound financial returns (Allport, 1990; Halcrow, 2000; Loo and Li, 2006). In the "Shanghai urban rail transit network planning", 210 billion Yuan will be invested to build 880 km of Shanghai urban rail transit, accounting for about 239 million Yuan per route-km (Song and Wang, 2009). Therefore, good performance of an MIP is expected from all stakeholders, including government, public, investor and other professional groups.

However, the performance of MIP varies between different cities and countries due to various reasons such as technical skill, management level and others. For example, New York City Subway, Paris Metro, London Underground, Tokyo Metro, and MTR of Hong Kong are commonly referred to as good examples. Both New York City and Hong Kong have well established rail systems, characterized by an extensive network structure and high transit ridership (Becky et al., 2010). London has the most advanced metro system, which has the first metro line in the history. This metro system is still the biggest one in Europe (Xi, 2008). Similarly, metro in Paris has been used for more than 110 years since its development in early 1900s and this system is well appreciated by the public for its convenience and time-saving (http://www.ccmetro.com/newsite/readnews.aspx?id=267). Tokyo is the first Asian city to use an urban rail transit. According to the study by Shu and Shi (2008) the metro system in Tokyo has made great contribution to the development of the city.

Other studies have examined the performance of metro system from different perspectives. Mohring (1972) pointed out that investments in rail transit infrastructure divert marginal automobile travellers away from their vehicles, resulting in a traffic diversion effect, and thereby reducing air pollution. Huang and Xia (2011) argue that metro system has direct and indirect effect on social and economic development and suggests that urban rail transit has become important for developing urban economy, improving industrial infrastructure and raising people living standard. The research work conducted by Francesca and Enrica (2011) presents the correlation between land-use plan and utility efficiency of urban rail system in a specific city. It emphasizes the proper land plan in order to have better efficiency in operating metro system. In examining the characteristic of city' rail networks, Guo and Zhu (2003) have built a more effective evaluation system by using a quantitative method, and studied the Beijing Metro Line 5 from the perspective of social benefit, the economic benefit and the utility capacity of the metro line. Liu and Hu (2007) investigated the Chongqing metro system, and found that there is a good correlation between real estate price and the location of individual stations of the metro system. The real estate nearby the stations will generally enjoy better price. Wang and Xi (2012) presented an assessment model for examining the benefit of air pollution reduction from the development of metro system. Stokesa and MacDonald, 2008developed a model to assess the potential cost savings in public health from a new light rail transit system in US.

In fact, a metro system is closely associated with people's life and work. The efficiency of using this type of infrastructure plays an important role in contribution to urban sustainable development. Nevertheless, there is little study on the utility efficiency of an urban metro system from a sustainable development perspective. Previous studies focus on studying economic performance of metro infrastructure projects. In fact, the implementation of a metro infrastructure project has significant impacts to social and environmental performance. Litman (2007) pointed out that high quality performance of metro system can reduce urban traffic congestion, and the metro system improvements can be cost effective investments when all economic impacts are considered. Xiao (2013) considers that urban rail transit plays an important role in not only improving the urban transportation contradiction, but also optimizing the use of urban land resources. Jiang and Bai (2010) compared the metro system with other traffic systems, and found obvious advantage from using the metro system in saving energy and reducing the air pollution in cities. Some other studies suggest that metro is "green transport" because of its high speed, punctuality, large carrying-capacity, independence from the ground traffic, use of clean energy, and low energy consumption. Therefore, this kind of traffic system is very important and necessary for implementing the principle of urban sustainable development (Bi, 2008). Although a number of cities in China have introduced a metro system, it appears that their utility efficiency is not good from the perspective of urban sustainable development. Some researchers have pointed out the weak areas in operating metro systems in China compared with other overseas cities. Liu and Chen (2008) found that the proportion of passengers who choose metro as means of transportation in China is less than that in Tokyo, London and Moscow. The urban rail transit in China has experienced more than four decades of development. Nevertheless, many problems are appreciated, for example, the lack of overall consideration on sustainable urban development during design and planning stages, giving the focus only on engineering technologies and network design, the lack of consideration on the future development of rail transit in urban planning, lack of an evaluation system to assess the utility efficiency of metro system and thus not being able to provide information for further improvement of the systems (Li and Xu, 2007). It is therefore considered essential to assess the metro infrastructure project (MIP) utility efficiency that integrates economic, social and environmental horizons from a sustainable perspective. Allport (1990) has pointed early the importance of evaluating the efficiency of metro system from the finding that there is no yardstick to compare the efficiency of metro system at both regional and global level. Metro lines and stations provide passengers more choices in urban areas where there are diversified sectors including business, hospital, education, and others. There is an urgent need for a method that can assist