Available online at www.sciencedirect.com

ScienceDirect

International Journal of Project Management 33 (2015) 576–588

International Journal of Project Management

www.elsevier.com/locate/ijproman

Environmental and social challenges for urban subway construction: An empirical study in China

Xiaolong Xue [a,*], Ruixue Zhang [a], Xiaoling Zhang [b], Rebecca Jing Yang [c], Hong Li [d]

[a] School of Management, Harbin Institute of Technology, Harbin 150001, China
[b] Department of Public and Social Administration, City University of Hong Kong, Hong Kong, China
[c] RMIT University, School of Project, Construction and Property Management, Australia
[d] China Construction Development (South Pacific) Co Pte. Ltd., Singapore

Received 19 December 2013; received in revised form 17 August 2014; accepted 9 September 2014
Available online 27 September 2014

Abstract

With rapid urban development in China, investments on subway projects are increasing. Although the type of projects can relieve transportation pressure in cities and make citizen's life easier, it raises many environmental and social problems during the construction process, in particular, problems about residents' daily life. Therefore, it is necessary to identify key environmental and social impacts of urban subway constructions and adjust construction programs and urban transportation programs to reduce negative impacts on citizen's daily life during construction. This paper analyzes the key factors for measuring environmental and social influences of subway construction and their interrelationships by using structural equation modeling (SEM) method. Four major impact factors are identified, namely, the impact on residents' travel, transportation, environment and daily life. Then some suggestions are made accordingly. These findings can be used as references for governments, contractors and other parties to develop more rational construction programs to minimize negative impacts of subway construction in urban development.

Keywords: Subway construction; Environmental and social impacts; Structural equation modeling; Factor analysis

1. Introduction

Urban subway project is considered as a safe and environmental friendly transportation mode. It has evolved considerably since its inception in the late 19th century when the first underground opened in London in 1863 (Jain et al., 2008). With the development of metropolitan economics, the conflicts caused by traffic congestions have become more significant than ever. The choice of traveling by private car invites more traffic jams, thus reducing the efficiency of public transport and the quality of life in urban districts. Hence, to alleviate the pressure of urban transportation, large cities in China have been actively constructing urban subway systems. By December 2009, ten cities including Beijing, Shanghai, Guangzhou, Shenzhen and many others have constructed 31 urban railway transportation lines, which add up to 835.5 km (People's Daily, 2009). The highly developed economic and demographic progress of China have caused a heightened demand for subway systems, which helped it spread across cities in China faster than a high-speed train. The subway lines in China are expected to grow from 48 in 2010, to 96 in 2015 and 289 in 2050 (Guangming Daily, 2011).

The subway projects play an important role in urban cities nowadays. There are many benefits to own subway projects for a modern city. In many cities, subway systems appear as the optimal solution to achieve a sustainable mobility for the growing urban population. Subway has a reputation of "green transport" for its rapid, efficient, low pollution, convenient and

* Corresponding author.
E-mail addresses: xlxue@hit.edu.cn (X. Xue), asnow1860@163.com (R. Zhang), xiaoling.zhang@cityu.edu.hk (X. Zhang), rebecca.yang@rmit.edu.au (R.J. Yang).

http://dx.doi.org/10.1016/j.ijproman.2014.09.003
0263-7863/00/

comfortable services and becomes one of the effective methods to alleviate problems in urban development (Ieda, 2010). They can provide many benefits including 'fast', 'regular', 'safe' and 'comfortable' services (La Vigne, 1997). Some other benefits include 'reduced traffic congestion', 'increased property values', and 'stimulated urban development' (Frisken, 1991; Mackett and Edwards, 1998). However, the subway projects also lead to many negative impacts on environment and society. For example, it may bring about disturbance to neighborhoods' daily life and challenges the existing urban transportation system as the construction is usually located in the central areas of a city. Sustainable construction has therefore become a global issue. Subway as an important infrastructure is a kind of public good in which government policy plays an important role to influence the effects of the project on economic development and social needs. The promotion of subway projects has been making significant contributions to the economic, social and environmental development in the developing country. In line with the promotion of the principle of sustainable development, subway projects should be developed to bring along benefits across all aspects, including economic, social, and environmental issues.

While there are many literatures that have conducted studies on the impacts of construction projects from economic, social and environment perspectives (Shen et al., 2005; Zhang et al., 2014), a few of them have investigated the dark side or challenges from those impacts in the developing countries, such as China. In China, subway construction site usually lies in the most prosperous business district. Construction caused part of the traffic jams, brought about negative influence on the benefit of the shops around, and inconvenience to urban residents. Life sewage and rubbish of the construction workers also had negative effect on city appearance. Mechanical activities in the construction process produced a lot of noise and vibration, which also disturbed the residents nearby. However, those countries with railways being constructed regarded the sustainable construction as the key issue for railways to avoid those negative impacts. For example, during the period of construction and operation, Hong Kong adopted technology innovation in terms of greenhouse gas emission, preserving non-renewable resources, vibration control and noise reduction to preserve the environment (Paul and Sun, 2008). It offered better service and security to the public and established a series of supervision system of transportation security that maintained the subway in a high level in terms of transportation intension, security, reliability, efficiency and benefit (Arthur, 2004). Comparing with the developed countries, the sustainable development of subway construction in China has fallen behind. To a larger extent, the subway projects are classified into infrastructure projects. It is therefore interesting to investigate the environment and social impacts of infrastructure projects in the context of China.

The aim of this paper is to investigate the environmental and social challenges for the construction of urban subway projects in China. This is followed by a brief review of the literatures that have studied the environment and social impacts of the construction projects. A quantitative structural equation model (SEM) is introduced to identify the key indicators that bring about negative impacts from environmental and social aspects. Results from the case study in the Harbin Subway project are presented to better understand the quantitative impacts of discovering environmental and social contamination on a project site. Finally, recommendations are given to guide the government, operating companies, designers, and contractors on how to deal with this issue.

2. Literature review on environmental and social impacts of construction projects

According to the Brundtland Report on the definition of sustainable development, where sustainable development is seen as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987), it has been commonly accepted that sustainable urban infrastructure projects emphasized on the prevention of unnecessary consumption of natural resources (especially non-renewable ones) and mitigation of harmful emissions. The social, economic and environmental indicators of sustainable development are drawing attention on the sustainable infrastructure projects. Many publications provide a generic classification on the types of environment and social impact. Environment impact includes high-energy consumption, solid waste generation, global greenhouse gas emissions, external air pollution, environmental damage and resource depletion and so on (Melchert, 2005; Zimmermann et al., 2005). Social impacts refer to both quantifiable variables such as numbers of immigrants (newcomers), and qualitative indicators such as cultural impacts involving changes to people's norms, values, beliefs, and perceptions about the society in which they live (Vanclay, 2002).

2.1. Environmental impact

Construction projects have been considered to cause environmental problems ranging from excessive consumption of global resources both in terms of construction and building operation and the pollution to the urban environment. For example, Guggemos and Horvath (2006) indicated that the construction of commercial buildings consumed significant amounts of energy and produced lots of emissions and waste and the major contributors were the inappropriate equipment used in the construction phase. Jaselskis and Anderson (1994) identified the need to use automated construction remediation techniques for site exploration, cleanup, and long-term monitoring of hazardous-waste sites. Siow et al. (2003) identified the modeling framework to assess the construction impacts during the major construction phases in the construction of George Bush Intercontinental Airport/Houston project. Guggemos (2003) conducted a research on environmental impacts of on-site construction processes with emphasis on structural frames. A construction environmental decision support tool was proposed to calculate the quantities of energy use and air emissions during the construction process of a building. Until now, there are many environmental assessment tools that have been developed to help evaluate the environmental loadings among the world. The