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Factors influencing the service lifespan of buildings: An improved hedonic model

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ABSTRACT

A large number of existing buildings were demolished indiscriminately during the urban renewal process in China, significantly shortening the average lifespan of buildings. This paper measures the average service life of existing buildings based on the investigation of 1732 demolished buildings in seven communities of Jiangbei District in Chongqing from 2008 to 2010, and then explores the influencing factors for a building's lifespan with an improved Hedonic model. It is found that the average lifespan of buildings is 34 years which is much shorter than the designed lifespan. The buildings with features such as small scale, near business centers, railway station, riverside and colleges, far away from the highway, and with high speed development of economy and high level social investment in fixed assets are more likely to be demolished and hence generally short-lived. The external influencing factors are more important than the internal influencing factors. And the internal factors, other than the floor area, are less important than expected. At last, this paper concludes some suggestions for prolonging the building's lifespan from the aspects of the demolition decision making system, maintenance and adaptive reuse of the existing buildings.

Introduction

With the implementation of the reform and opening-up policy in 1978, China has been experiencing rapid modernization and urbanization process. By the end of 2011, China's urbanization rate had reached 51.3%, and nearly 60% of population will live in urban areas by 2020 (see the report by NPFPCC, 2012). The urbanization growth in conjunction with the pursuit of more comfortable living environment has resulted in great amount of new housing demands and therefore huge number of construction projects (Chang, Ries, & Wang, 2013). The demands are commonly met through urban sprawl and urban renewal strategies. As urban sprawl has limits due to the strategy is at the expense of the loss of agricultural and ecological land, urban renewal strategy plays a major role in the process of urbanization (Shen, Yuan, & Kong, 2013).

China has been implementing huge plans of urban renewal in recent years. During the urban renewal process, massive demolition and reconstruction works have been undertaken. According to the report by Wang (2010), the land vacated from building demolition in China annually constitutes about 40% of the total land area acquired for construction. It is estimated that 4.2 million m^2 of housing have been demolished in the old district of Beijing from 1990 to 1998 (He & Wu, 2007). From 1995 to 2004, more than 745 thousand households were relocated and over 33 million m^2 of housing were demolished in Shanghai (see the report by SSB, 2005). The scale of demolition in China is much larger than that of the urban renewal period in US cities (He & Wu, 2007).

The demolition and reconstruction of existing buildings have always been considered as the phenomenon of urban renewal. However, the large scale of demolition works is undertaken indiscriminately in China, leading to the premature demise of existing buildings. Qiu Baoxing, the Vice Minister of the Ministry of Housing and Urban Construction of China commented that buildings in China can only last for approximately 30 years on average which is much shorter than their designed service life Wang (2010). Furthermore, it is estimated by some Chinese experts that the lifespan of the urban buildings constructed in the 1970s and 1980s is 30–40 years (Hu, Bergsdal, van der Voet, Huppes, & Müller, 2010). Buildings, as a carrier of culture, could store the memory of city development. They play an important role in urban cultural transmission and innovation. The merit of architectural structures and its significant historical value will get lost after the demolition (He & Wu, 2007), and the

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physical coherence of neighborhoods could be destroyed afterward (Zhai & Ng, 2013). Followed by these, the potential social contradictions are accompanied by the massive demolition activities. It is inevitable that the old community will be torn down to rebuild a new one and the original residents have to be relocated after having built a relatively stable social network (Zhang, Hu, Skitmore, & Leung, 2014). In this context, social conflicts occurred (He & Wu, 2007; Yau & Chan, 2008). According to Shan and Yai (2011), land expropriation and dismantling of existing buildings are among the major causes of social conflicts in China. The reduced building's lifespan also causes tremendous waste of resources and the aggravation of environment pollution (Bullen & Love, 2010; Ellison, Sayce, & Smith, 2007; Thormark, 2002). Buildings are responsible for more than 40% of global energy use, 12% of water consumption, one third of global greenhouse gas emissions (Conejos, Langston, & Smith, 2013), and account for approximately 136 million tons of waste, nearly half of which is from demolition (Fu, Pan, Ma, & Li, 2013). The waste produces a lot of hazardous substances and a bad effect on the water and soil surface due to the lack of waste-disposal technologies (Huang, Shi, Tanikawa, Fei, & Han, 2013). Moreover, demolition and rebuilding will increase the life cycle cost of buildings from the perspective of overall costs (Dong, Kennedy, & Pressnail, 2005). Every year, new building construction in China amounts to 2 billion m^2 and consumes approximately 40% of the world's cement and steel, and the construction waste accounts for 30–40% of the total amount of the urban waste (Gilbert, 2012). DeSimone and Popoff (1998) appreciated that one way of extending resource productivity is by prolonging the service life of products, and prolonging the existing building's lifespan is one of the effective approaches to the energy saving (Power, 2008). The volume of construction and demolition waste from future construction in China depends largely on the lifespan of the existing buildings (Hu, 2010). As the building's lifespan is considered as a contributor to sustainable urban development (Laure & Gerda, 2007; Lee, Lim, & Kim, 2013), the issue that concerns about the lifespan of existing buildings has attracted widespread attention and intense debate in China. However, it appears that little effort was made to investigate the determinants of the building's lifespan through analyzing a large number of exemplar buildings in previous studies.

As an effort contributing to sustainable urban development, the focus of this paper is to measure the service lifespan of buildings in China based on the investigation of a large number of demolished buildings, and then explores the key factors influencing the service lifespan of the existing buildings with a case study in Jiangbei District, Chongqing. The influencing factors are considered from five aspects which include building characteristics, location characteristics, neighborhood characteristics, economic variables and politic variables based on an improved Hedonic model. The outcome of this research is considered as the scientific foundation for developing the effective and efficient strategies for prolonging the building's lifespan.

Literature review

The reasons for demolishing buildings in the process of urban renewal have been investigated in previous studies (Bender, 1979; Golton, 1997; O'Connor, 2004). Golton (1997) indicated the reasons for the demolition of existing buildings are complex. Thus, the factors influencing building's lifespan are multiplex. According to the survey conducted by Japanese researchers, 47% of short-lived buildings are caused by aging of the building, 7% are caused by facilities update and others are caused by the social and economic factors in Japan (Song, 2004). All of the influencing factors for the building's lifespan can be grouped into internal and external factors, as shown in Table 1.

The physical condition of a building is an index to estimate the potential for adaptive reuse of the existing building (Langston, Wong, Hui, & Shen, 2008). So the variables of building condition are factors influencing the decision making of building demolition in the urban renewal process, such as the construction quality, and the aging of building structure and components. The poor conditions of existing buildings, including the inadequate architecture design, poor construction quality and unconformity to building standards and regulations, caused by the lack of construction supervision and jerry-build are generally considered to be the major internal factors for the short life of buildings in China (Shen et al., 2013). Moreover, the number of stories and the total floor area of building reflect the efficiency of land use (Weber, Doussard, Bhatta, & McGrath, 2006). Therefore, the low floor-area ratio buildings are more likely be demolished as it is one kind of "spatial fix" that prepares land for conversion to higher density and better use (Harvey, 1989; Smith, 1996).

The previous studies reveal that buildings are demolished not only because they are old or in a bad condition but also because proprietors or developers want to demolish them (Hzoka, 1988). The external factors are over-riding reason for the decision making of building demolition and determinants of building's service lifespan (Liu, Xu, & Zhang, 2012). Braid (2001), Brueckner (1980) and Wheaton (1982) found that the changes in a city's population density and housing preferences directly drive the building demolition. As a city seeks to house more people, the ground rents rise and landlords or developers replace small buildings with larger ones to get more profit (Hufbauer & Severn, 1973). However, Harvey (1989) and Smith (1996) indicated that the rent gap is the major reason for building demolition. Economists have found widespread evidence that the value differential accounts for renovation activity. Using data on single-family home sales in Vancouver, Rosenthal and Helsley (1994), the evidence for the hypothesis that demolition takes place when the sale price of a property that is purchased specifically for renovation is equal to the price of vacant land (plus the cost of demolition). According to Ravetz (2008), it is shown that much of the reinvestment in the existing buildings depends on perception of value and quality at the neighborhood scale, cultural heritage and landscape are two determinants for value. Moreover, some researchers have hypothesized answers to the determinants of demolition and renovation of urban existing buildings in their case studies of gentrified neighborhoods, and the common characteristics of these buildings are easily identifiable (Clay, 1979; Helms, 2003; Johnson, Drew, Keisler, & Turcotte, 2012; Zahirovic-Herbert & Chatterjee, 2011), which are presented in Table 1.

In spite of these results, this paper plans to test different hypotheses put forth in the literature based on a case study of structures in Jiangbei District, Chongqing. Empirically, the effects of five aspects of influencing factors (most of which are measured at

Table 1
Key factors influencing the building's lifespan in previous studies.

Groups	Aspects	Factors
Internal factors	Physical condition	Construction quality (building structure) Number of stories Floor area
External factors	Location condition	Distance to CBD Convenient to mass transit
	Neighborhood characteristics	Population density Distance to disamenities (public housing project, highway) Distance to pleasant views (park, lake, university campus)
	Economic variables	Land value
	Politic variables	Urban planning Political jurisdiction