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Policies to enhance the drivers of green housing development in China[☆]

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ABSTRACT

China's housing sector has a major impact on global energy consumption due to the rapid urbanization. Although the Chinese government launched a wide variety of policies to encourage green building practices, only 1592 housing projects had been green-certified by the end of 2015, representing a small percentage in China's booming housing market and with very uneven distribution across cities. Based on a panel dataset of all the cities at the prefecture level or above in China for the period from 2008 to 2015, this paper employs Tobit model and Cox proportional hazard model to investigate the drivers of green housing development. Besides the factors associated with economic returns to green investment, the empirical results suggest that some policy instruments have effectively stimulated green practices in the private housing sector, such as land-related policies, priority in enterprise qualification inspection and upgrade, and demand-side subsidies. This paper also highlights the spillover effects of the government's green practices in public housing, implying that governments can also influence the building sector as leading actors. These findings could help governments create more effective and efficient policies to boost green housing development.

1. Introduction

The construction, operation and demolition of buildings make a major contribution to global energy consumption and environmental pollution, resulting in increasing attention to going "green" in the building sector (Zuo and Zhao, 2014). Various standards for green buildings have proliferated around the world, which share three common pillars: efficient use of energy and other resources, improvement of indoor environmental quality, and minimization of negative impacts on the environment (Sedlacek and Maier, 2012; Zhang et al., 2018). Governments around the world have also adopted a range of policies to encourage such green building practices (Shi et al., 2014; Simcoe and Toffel, 2014; Kuo et al., 2016).

Green building development in China has profound global implications, due to the massive construction boom in the rapid urbanization (Cai et al., 2009; Zhang et al., 2017a). Green practices in the residential sector are especially important, as residential buildings now account for around 70% of building starts in China.[1] However, promoting green practices in residential buildings faces greater challenges than for implementation in commercial buildings. For commercial buildings (e.g., office and retail buildings), developers typically hold and operate buildings by themselves, and thus evaluate costs and benefits from the building life-cycle perspective. In contrast, housing units in China are always sold to households immediately after completion, or may even be presold before completion, making homebuyers' payment the only opportunity for developers to reap rewards from green investments (Zhang et al., 2017a). As most residents lack the skills to gather information and conduct life-cycle calculations, future benefits of green housing may not be fully capitalized in transaction prices (Allcott and Taubinsky, 2015). Such risks of benefit-cost mismatch significantly hindered housing developers from building green (Deng and Wu, 2014). This potential market failure makes government policy especially important in Chinese green housing sector. It is in this context that we investigate what policies can enhance the drivers of green housing development in urban China.

Although dozens of studies analyzed the drivers of green building development based on questionnaire surveys, case studies and interviews (Darko et al., 2017), only a few econometric studies had been conducted until very recently, and most of them concentrated on commercial properties in developed countries (Kahn and Vaughn, 2009; Kok et al., 2011; Cidell and Cope, 2014; Dippold et al., 2014; Fuerst et al., 2014). Besides the factors that have been well documented by

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[1] Source: National Bureau of Statistics of China (http://data.stats.gov.cn/).

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these studies (e.g., climate conditions, energy prices, economic status, environmental consciousness, real estate market conditions), this paper further examines the effectiveness of various policy instruments. This paper provides the first thorough empirical analysis on the drivers of green housing development by applying appropriate econometric techniques to analyze city-level panel data from China. We not only provide a comprehensive survey of various categories of policy instruments adopted by central and local governments in China, but also empirically investigate, compare, and discuss their effectiveness in stimulating the appearance and diffusion of green housing. This study also sheds light on the spillover effects of the government's own green practices in public housing.

The remainder of this paper is organized as follows. Section 2 reviews the related literature, and then an overview of green building development in China is provided in Section 3. Section 4 introduces the methodology and data, followed by a discussion of empirical results in Section 5. Section 6 concludes the paper.

2. Literature review

The past decade has witnessed quantities of studies examining the drivers of green building development (Darko et al., 2017). By surveying designers in Hong Kong and Singapore, Chan et al. (2009) found that economic force and government intervention were two strong forces to encourage green building development. Qi et al. (2010)'s survey on construction contractors identified managerial concern, government regulations and business size as the most important drivers for green practices. Berry et al. (2013)'s case study highlighted the exemplary leadership and spillover effects of niche events. While these survey and case studies provided valuable micro insights into corporates' green strategy, some recent studies began employing econometric methods to investigate the drivers of green building development at the national or regional level (Kahn and Vaughn, 2009; Kok et al., 2011; Cidell and Cope, 2014; Dippold et al., 2014; Fuerst et al., 2014; Zou et al., 2017). As summarized in Table 1, the major explanatory variables adopted by these studies include climate conditions, energy prices, economic status, environmental consciousness, real estate market conditions, policies, existing green buildings, market size, employment conditions, and LEED accredited professionals. These driving factors can be classified as *market drivers* and *policy drivers*, which are analyzed as follows by synthesizing the relevant literature of a wider range.

Market drivers are the focus of the existing studies, including economic returns and herding effects.

First, building owners and developers will be encouraged to build green if the economic returns are large enough to offset the incremental costs (Fuerst and McAllister, 2011; Eichholtz et al., 2013; Hyland et al., 2013; Zhang et al., 2017a). As green incremental costs are always unavailable and actually vary little among cities, the quantitative analyses have not taken them into analysis (Kok et al., 2011; Zhang et al., 2017a). Thus, economic returns are mainly determined by the base economic returns of developing general buildings and the green price premium (Jaffe and Stavins, 1994). The greater demand of the general real estate market will ease the absorption of green incremental costs and increase the potential gain of green housing investments (Oster and Quigley, 1977). The studies of office building market usually employ average rent and vacancy rate to indicate the market conditions, as presented in Table 1. The green premium relies on four main benefits of green buildings: (i) cost savings through reduced energy and other resource consumption; (ii) improved comfort, health and productivity; (iii) enhanced corporate reputation; (iv) environmental consciousness (Zhang et al., 2018). Cost saving potentials are usually measured by cooling and heating degree days and electricity prices (Kok et al., 2011; Dippold et al., 2014). Green buildings, which provide more comfortable built environment, are recognized as "luxury goods" that are more likely to be purchased by affluent consumers (Hu et al., 2014; Fuerst

Table 1
Variables included in the existing studies.

Author (Year):	Kahn and Vaughn (2009)	Kok et al. (2011)	Cidell and Cope (2014)	Dippold et al. (2014)	Fuerst et al. (2014)	Zou et al. (2017)
Country:	US	US	US	US	US	China
Building Type:	All buildings	Office buildings	All buildings	Office buildings	Office buildings	All buildings
Dependent Variable:	Number of green buildings	Annual change in the proportion of green office space	Number of green buildings	Whether the building is green-certified	Proportion of green office space	Number of green buildings
Independent Variables:						
(1) *Climate conditions*		Cooling/heating degree days		Cooling/heating degree days	Climate zones	
(2) *Energy prices*		Electricity price		Electricity price	Electricity price	
(3) *Economic status*	Income	Income		Income	GDP per capita	GDP
(4) *Environmental consciousness*	Political preference; Voting on environmental initiatives		Political preference	Education level; Political preference	Education level; Political affiliation of mayor	
(5) *Real estate market conditions*		Vacancy rate; Average rent		Vacancy rate; Average rent	Vacancy rate	Real estate price
(6) *Policies*		Number of policies	Climate Protection Agreement; Number of nearby cities with green building policies	Number of incentive policies	City-level/ state-level mandatory/ incentive policies	Subsidy policy; Local green building standard; Green building committee
(7) *Existing green buildings*				Existing share of green office buildings	Existing share of green office buildings	
(8) *Market size*	Population count		Population density	Population density; Total number of office buildings	Population count; Total floor space of office buildings	
(9) *Others*	Population age and race	Employment conditions; Office space per worker; LEED accredited professionals	Employment conditions; Population age; LEED accredited professionals	Employment conditions; Lease type; CO_2 emissions; Number of patents	Employment conditions; CO_2 emissions; LEED accredited professionals	Location; Energy efficiency