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The spatial distribution of green buildings in China: Regional imbalance, economic fundamentals, and policy incentives

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ABSTRACT

Since China released its 3-Star green building rating system in 2006, the number of certified green buildings in the country has increased sharply. The concentrations of green buildings, however, are not spread evenly across different provinces. Employing the comprehensive green building data as of February 2014, this paper attempts to analyze the spatial distribution of green buildings in China and examine its underlying determinants. The empirical results confirm that a regional imbalance does exist with regard to green building numbers. The paper also finds that local economic fundamentals and subsidy-based incentive policies can explain the presence of green buildings, but the performance of real estate market, energy efficiency, and two specific green policies (local green standard and green building committee) are not significantly associated with green building concentrations at the provincial level. Based on the empirical results, the paper also yields a number of implications, which suggest that the government can promoting more green buildings via the alleviation of economic inequality across different regions, the establishment of a market-oriented mechanism, and the improvement of public awareness regarding sustainability. These implications will help to guide the government in its efforts to establish and implement more efficient and effective green policies. From a spatial perspective, this study unveils a general picture regarding green building development in China.

1. Introduction

Over the past three decades, China has been experiencing rapid urbanization. From 1978 through 2012, China's rate of urbanization increased from 17.9% to 52.6%, with roughly 500 million people flocking to urban areas (The United Nations, 2013). Large-scale urbanization was followed by an unprecedented amount of building construction. For example, China added approximately 2 billion square meters of new buildings in 2014, topping other countries throughout the world (Sina Finance, 2015). The large volume of buildings contributes significantly to the country's energy consumption. China's relatively lax building codes make this problem worse (Connelly, 2013). In 2011, the building sector accounted for 28% of energy total use, and it generated more than 50% of CO_2 emissions in China (Khanna, Romankiewicz, Zhou, & Feng, 2014). Reducing buildings' energy usage and carbon emissions had become a serious challenge for the Chinese government.

As the world's largest energy consumer and contributor of CO_2 emissions, China has promised to take the responsibility of reducing the county's environmental footprint through the implementation of a series of programs, including the green building program. China has a long history of green building philosophy and ideas. For instance, Chinese vernacular architecture takes advantage of diverse low-cost techniques, such as passive heating/cooling systems, to improve inhabitants' quality of life and curb energy usage (Cidell, 2009a). However, until the end of 1990s, contemporary ideas regarding green buildings were not widely discussed by scholars or policymakers. It was not until its Ninth Five-Year Plan (1996–2000) that the Chinese government began to fund research pertaining to the Chinese green building system (Geng, Dong, Xue, & Fu, 2012). China's current Five-Year Plan (2011–2015) aims to reduce energy use by 16% and reduce CO_2 by 17% through the expansion of green buildings (Institute for Building Efficiency, 2013; McGrawhill Construction, 2013). In 2012, the Chinese government announced the country's first goal with regard to green building development; the country is requiring that 30% of new construction meet green building standards by 2020 (Walsh,

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Green buildings are intended to allow for healthier and more resource-efficient living situations, and this happens via systematic approach that takes into account local climates and materials, that incorporates technologies designed to reduce resource usage, and that lowers carbon footprints and costs associated with design, construction, operation, and maintenance periods (Cidell & Beata, 2009; Cidell & Cope, 2013; Heerwagen, 2011; Kok, McGraw, & Quigley, 2011; Simons, Choi, & Simons, 2009). A number of extant studies have examined the benefits of green buildings (Brounen & Kok, 2011; Dwaikat & Ali, 2016; Fuerst & McAllister, 2009, 2011; Pivo, 2010). The benefits can be grouped into three categories – ecological, economic, and social. First, ecological benefits include conservation of natural resources and a reduction of overall environmental impact (Geng et al., 2012). Green buildings yield significant energy-saving benefits. According to Kats (2003), green buildings with the LEED (Leadership in Energy and Environment Design) label were on average 25% to 30% more energy efficient than conventional buildings. Second, the economic benefits include higher sales/rent premiums, higher occupancy rates and productivity, and a reduction in long-term costs (Choi & Miller, 2011; Cidell, 2009b; Miller, Spivey, & Florance, 2008). Empirical evidence has shown that market can price the benefits of green investment – in the U.S., LEED-labeled green buildings can garner 5% to 17% higher rents and 11% to 25% higher sale prices (Khanna et al., 2014; Simons et al., 2009; Watson, 2011). Third, green buildings represent an indispensable aspect of a healthy and just society. For instance, green buildings' healthier indoor environments – through, for example, better ventilation, cleaner indoor air and better natural light – bring about improved public health. Green buildings also serve to emphasize fairness and justice for all the stakeholders. A green building is not only a product; rather, it is also a life-cycle process involving many stakeholders, such as designers, construction workers, material suppliers, occupants, and the surrounding community, all of whom are influenced, directly or indirectly, by green buildings. While green buildings occupants can enjoy enhanced life quality, and construction workers can enjoy a healthier work environment during the construction process, the green buildings can also be of benefit to the surrounding community due to lower levels of pollutants and carbon emission. A green building is not only evaluated via environmental metrics, but also by indicators of social justice. For example, USGBC released new LEED social equity credits, which have been designed to address the inequality suffered by those who are affected by the construction of a green building (USGBC, 2014). This perspective suggests that green buildings might contribute to improved social justice.

Although local governments have recognized the significant green benefits or spillovers of green buildings, the concentration of green buildings varies across jurisdictions. As China is a country with a vast territory that covers differentiated climate zones, it is critical to examine its green buildings from a spatial perspective. Examining this from a spatial perspective can not only help policymakers to better understand green buildings practices across different places, but it can also help them to create place-based policies to promote the development of more green buildings (Cidell & Beata, 2009; Cidell, 2009a). The issue regarding green building spatial distribution has been of concern to those who have contributed to the existing literature. For instance, Cidell (2009a) examines the geographic distribution of LEED-certified buildings and accredited professionals across the U.S. Emerging literature began to study and address China's green building technologies, practices, and policies (Geng et al., 2012; Khanna et al., 2014; Walsh, 2012); the literature pertaining to the geography associated with green buildings, however, remains scarce. Today, green buildings in China attract more and more attention worldwide, but the world knows little about these buildings' spatial distribution.

This paper empirically examines the spatial distribution of green buildings and its determinants in China. The paper attempts to answer what factors promote the development of green building at the provincial level, with purposes of shedding light on the mechanisms underlying the spatial pattern of green buildings and assisting local governments to make more effective green policies. The paper is organized as follows: The next section provides a literature review, which focuses on the factors that may influence green building spatial distribution and tries to develop a theoretical framework for the following empirical investigation. The third section analyzes green building development in China, focusing on the green building rating systems. The fourth section discusses the empirical studies conducted. The fifth section provides policy and discuss limitations and future research. The sixth section concludes.

2. Literature review

Much of the existing literature emphasizes the role of geography in green building studies. Researchers not only confirm that green buildings can cluster in some places, but they also explore the dynamics, both demand-side and supply-side, underlying the spatial patterns (Kaza et al., 2013). As the dynamics of green buildings are geographically different, the concentration of green buildings can indicate spatial variation across different places (Cidell, 2009a). The geographic dynamics include factors rooted in physical and climatic conditions, culture, demographics, economics, and policy.

First, the difference in regional physical and climatic conditions, the cultural environment, and demographic composition may lead to spatial variation with regard to the concentration of green buildings (Cidell & Beata, 2009). The availability and proximity of natural resources vary across spaces, and the differences in geographical constraints as well as local environment shape green building spatial patterns (Cidell & Beata, 2009; Prum & Kobayashi, 2014). Climate conditions will also impact the design and construction of green buildings, as one of the principles of achieving green building is to respond to the local climate (Cidell, 2009a; Prum & Kobayashi, 2014). Culture also plays a role in promoting green buildings (Wu, Fan, & Chen, 2016). For instance, some regions have rich traditions in vernacular and sustainable architecture, which is consistent with many ideas associated with green buildings, such as employing native material and low-techniques in the buildings' ventilation and thermal insulation systems. Influenced by this kind of culture, the regions are inclined to cultivate more green buildings. In addition, the demographic composition of a region may influence the pattern of green buildings. For example, compared to those with older, more conservative population, regions with younger, more progressive populations are more likely to embrace and promote the development of green buildings.

Second, regional economic factors are tied closely to the level of green building activities (Cidell & Cope, 2013; Kaza et al., 2013; Kok et al., 2001; Allen & Potiowsky, 2008). Kok et al. (2001) provide evidence that metropolitan areas with higher incomes and with sound real estate market are likely to have more green buildings. Choi and Miller (2011) also find that the strongest factor affecting LEED-certified green buildings is the local economy. The economic factors work on the demand-side and supply-side of the green building market. On the demand side, regional economic structure drives the demand for green buildings, as regions with active economies can attract high-income consumers who can afford better quality buildings, or well-educated and environmentally aware consumers who prefer green buildings and greener lifestyles (Kaza et al., 2013). In addition, when local economies are strong, people are more likely to act on the social responsibility of pursuing