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Barriers to the adoption of energy-saving technologies in the building sector: A survey study of Jing-jin-tang, China

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HIGHLIGHTS

- Fifteen barriers to the adoption of energy-saving technologies are discussed.
- Surveys are conducted in one of China's most technologically developed area.
- The barriers are divided into 5 groups according to the results of factor analysis.
- Barriers related to profitability greatly hamper the adoption of the technologies.
- Comparative analyses show the background of respondents influence their viewpoints.

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ABSTRACT

The building sector of China currently consumes 20% of the total energy consumption. Studies on barriers to the adoption of building energy-saving technologies are of great significance on implementing policies related to achieving energy-saving goals. This paper studied 15 barriers with the aid of information collected through questionnaires and semi-structured interviews. The respondents were 135 employees working in the Jing-jin-tang area. Based on the results of the factor analysis, the barriers were categorized into five groups: attitudes of stakeholders, policies and regulations, auxiliary resources, profitability, and adaptability of the technologies. Analysis of the entire sample showed that the *stakeholders' reluctance to use* was the largest barrier, followed by *high initial investment* and *low profitability*. Further analysis showed that the occupation and designation of the respondents and the size of the enterprises that they served influenced their perspectives on the barriers. It was found that architects attributed more importance to the adoption of energy-saving technologies than contractors; barriers confronted by employees of large enterprises and small enterprises were different; managers perceived weaker barriers than frontline employees and were more optimistic about the prospect of building energy-saving technologies. Finally, policy recommendations were proposed based on these in-depth and targeted analyses.

1. Introduction

The building sector of China consumes a lot of energy, both in the construction stage and in the operation stage, resulting in large-scale environmental pollution (He et al., 2013; Tan et al., 2011). In the past two decades, China's building energy consumption has grown rapidly (Cai et al., 2009; Chen et al., 2013), reaching 678 million ton of standard coal equivalent (tce) in 2011, which was nearly 20% of the nation's total energy consumption (THUBERC, 2013). In 2013, the government announced the launch of its new round of “urbanization” construction plans. As a consequence, energy consumption of the building sector was projected to grow continuously in the decades to follow. However, China faces enormous pressure to reduce its carbon emissions in light of the debates pertaining to global warming and environmental pollution related issues at the international arena. One way of contributing towards this cause would be for China to limit its building energy consumption below 1.1 billion tce by 2020. This is likely to be one of the most pragmatic measures to attain the emission reduction targets promised in 2009 at the Copenhagen United Nations Climate Change Conference (IEA, 2012). Since the choice of materials and processes have long-term consequences on energy consumption during the buildings' whole lifecycle (Morrissey and

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Horne, 2011), adopting energy-saving technologies is considered to be one of the most effective ways to achieve energy conservation goals. Therefore, it is essential to employ energy-saving technologies in the building sector and to explore the key factors affecting their adoption in specific projects. Since private sector involvement will not come about without strong political will to establish more favorable grounds (IEA, 2008), the promotion of governmental interventions is also very important.

Beginning in the early 1980s, China's government has developed a variety of energy codes to improve building energy efficiency (Yu et al., 2014). The series of policies to encourage the use of energy-saving technologies were among them, including enforcing energy consumption constraints on new projects, increasing the budget for energy consumption control, and providing financial support for energy-saving refurbishment and renewable energy. According to a survey conducted in 2006, 95.7% and 53.8% of China's new buildings complied with the Two-step Energy-saving Standard (i.e. energy consumption of new heating residential buildings should be at least 50% lower than the general designed level of local buildings in 1980–1981) in the design stage and the construction stage respectively. The corresponding proportions increased to 99.4% and 95.4%, respectively, by the end of 2010. A broad array of widely accessible and cost-effective energy-saving technologies have been adopted in the process (Zhang and Wang, 2013). However, the adoption of new energy-saving technologies may impede architects from using existing stylized design schemes and increase their workload. Moreover, these technologies would cut energy consumption primarily in the operation stage of a building instead of in the construction stage. Not only do they not bring direct benefits to the "producer" of the buildings, i.e. the contractors, but they also lead to an increase in the cost of the project. Several studies indicated that the adoption of energy-saving technologies among firms has taken place slowly and sometimes has shown no signs of progress at all, even in cases where the potential private gains outweighed the associated costs (Arvanitis and Ley, 2012). It is therefore evident that barriers to the adoption of building energy-saving technologies exist. This paper will explore some of these barriers, identify those that play major roles and then propose targeted policy recommendations.

The topic of barriers to energy saving is not a particularly new one, as a large body of literature on the subject can be found dated as far back as the late 1970s (Cagno and Trianni, 2013). Schipper (1978) and Chiogioji (1979) were two representative researchers active in the early periods. Several scholars have contributed to these studies by classifying the barriers into different groups. In our study, we shall refer to the methodology of Schipper. The first attempt of such classification, to the best of our knowledge, was made by Blumstein et al. (1980). They classified the barriers into six categories: misplaced incentives, lack of information, regulation, market structure, financing, and custom. Other categories include: structural and behavioral barriers, suggested by Hirst and Brown (1990); institutional, market, organizational, and behavioral barriers, suggested by Weber (1997); economic, behavioral and organization (Sorrell et al., 2000, 2004); knowledge, financial, and motivation barriers, suggested by Yik and Lee (2002) and so on. The research by Montalvo (2008) was one of the very few attempts in systematically classifying the factors affecting the adoption of cleaner technologies, although it did not clearly distinguish barriers from incentives. His study expressed the view that the factors could be either positive or negative, depending on the circumstances, time, and contexts in which they were considered. Furthermore, Cagno et al. (2013) studied the barriers to energy saving in terms of energy efficiency by designing a new taxonomy that had clear distinction between external and internal barriers with respect to the firm.

In addition to the above theoretical classification of barriers, there is lots of empirical research incorporating survey studies as well. As the background and characteristics of the respondents largely determines their viewpoints (Masselink, 2008), a popular method was to divide the building sector practitioners into several groups, for example architects and contractors. Some studies focused on specific target groups while the others deduced their conclusions through comparative studies. Osmani et al. (2006) compared the attitude of architects with that of the contractors on waste minimization. Chan et al. (2009) held the view that architects provided a link between the end-users, government and the market with a more objective viewpoint. They carried out their studies on green buildings from the perspective of these building designers. Despite the numerous benefits in implementing sustainable practices, including enhancing shareholder value, protecting enterprises' reputations and strengthening their competitive advantage (Tan et al., 2011), Wong et al. (2013) suggested that the cumulative experience of an organization would lead to the development of a set of beliefs and routines within their operations that could result in the delay by contractors in transforming carbon reduction strategies into actions.

Some researchers have studied the differences between the results from respondents who worked in enterprises of different sizes. Groot et al. (2001) suggested that the respondents from large firms attached a relatively heavy weight to general barriers such as "no sufficient importance imposed on energy costs", "low priority imposed on energy efficiency" and, the existence of "other priorities". The study of Rohdin et al. (2007) confirmed that firm size served as an influencing factor for energy efficiency in the foundry industry. Thollander et al. (2007) suggested that policy instruments which involve mandatory routines to be adopted could be argued to be a sound approach towards energy-intensive larger firms, while information programs may be a better choice for SMEs. Akadiri and Fadiya (2013) probed into the construction industry by conducting a questionnaire survey study among the UK's construction industry practitioners, including architects, designers, structural engineers, construction managers and quantity surveyors. Their survey results showed that significant relationships existed between firm size and the adoption of sustainable construction practices. Zhu and Geng (2013), on the contrary, held a different viewpoint on the effect of firm size. They indicated that firm size had absolutely no impact on the barriers to extended supply chain practices for energy-saving and emission-reduction goals.

Another method of classification is based on the designation of the respondents at their office. Some studies sampled only one person from each of the sample enterprises to represent their viewpoints, thereby ignoring the influence of designation on the barriers. The studies of Osmani and O'Reilly (2009), Davies and Osmani (2011), Kostka et al. (2013), and Wang et al. (2014) are examples of such studies. Osmani et al. (2006) chose intermediate and senior managers as respondents. Partners and associates of architectural offices, and sustainability and environmental managers of contracting firms were chosen due to their abundant experience in working on plenty of projects. Few studies have studied the opinions of frontline employees who directly participate in the design and construction of the buildings. It appeared that differences between their opinions and those of the intermediate and senior managers have long been ignored.

It is clear from the literature review that people have reached a consensus on the significance of research in energy-saving technologies for building sector as a number of theoretical and empirical studies can be found on this topic. However, there still exists a large scope for further research in this area. For example, until now, the methods of classifying barriers to energy saving are mostly based on experience and subjective judgment. Although