



Analysis

The role of public information in increasing homebuyers' willingness-to-pay for green housing: Evidence from Beijing



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ABSTRACT

To explain the weak demand for green housing in Chinese cities, researchers point to the lack of reliable and accurate information to convince owners to invest, yet there is little concrete evidence that such information would in fact promote homebuyers' investment in green housing. We implement an information experiment in Beijing. We select two pairs of residential complexes – each pair has two complexes located in the same housing submarket, and one is green while the other is not. We ask the respondents' willingness to buy a new green housing unit, and, if yes, the price premium they are willing to pay. Then we show them an information card that documents that green apartments outperform their non-green counterparts in terms of several indoor environmental indicators, and then ask them the same two questions. We find that dwellers living in green complexes present a significantly higher initial willingness-to-pay for greenness, but this difference narrows significantly after our information treatment, as the non-green-complex dwellers' willingness-to-pay for greenness increases dramatically. This inspiring result suggests that Chinese urban households will be encouraged to purchase green housing if they are provided more reliable and concrete information.

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1. Introduction

The excessive energy consumption and greenhouse gas emissions in the building sector leads to many environmental impacts in the life cycle of every building. Promoting green buildings is thought to be an ideal solution to mitigating these environmental impacts. The Chinese government has prioritized addressing such environment and energy problems, recognizing that energy consumption and environmental impacts resulting from construction, operation and demolition of buildings are particularly severe in China. For instance, in Beijing, where the situation of building energy efficiency is relatively better in present China, the residential buildings are estimated to consume 1.5–2.0 times as much energy for winter heating as residential buildings in similar cold climates in Western Europe or North America and still provide far less comfort (Zhu and Lin, 2004). The energy consumption of building sector may further increase as urban households see their incomes rise and subsequently demand higher living standards. The Chinese State Government issued the Green Building Action Plan on January 1, 2013, setting the goal that by 2015, 20% of all new buildings should be green. However, the market has shown very weak response to such policies. By the end of 2013, the floor space of new residential

buildings certified by the Chinese Green Building Label system only accounted for about 0.8% of the gross floor space under construction that year.

While the promotion of green housing depends on the supply-side, the main driving force is from the demand-side – whether and how much urban households are willing to pay for green housing. If this willingness-to-pay (WTP) exceeds the incremental costs of building such green housing, developers will be incentivized to supply this green product in the market. To date, limited empirical evidence has demonstrated Chinese urban households' preference for green housing. In fact, based on a conjoint survey conducted in Nanjing, Hu et al. (2014) find that in China only the rich are willing to pay a price premium for green apartments. Zheng et al. (2012) investigate homebuyers' revealed preference for “green” housing based on the transaction prices and rents of residential complexes in Beijing between 2003 and 2008, and find that the self-advertised “green” residential complexes could sell for a price premium at the presale stage but subsequently resell or rent for a price discount due to false advertising or overselling the benefits of their “green” housing. They then argue that Beijing urbanites' demand for green housing is rising, but the lack of reliable information regarding the complex's true “greenness” (defined to include energy savings and improvements in living comfort) has substantially hindered development of the green housing market. It is true that no official certification system for green buildings was available in China until recently. Even after the launch of the official “Chinese Green Building

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Label (CGBL)” system in 2008, public knowledge of this official certification system has not been widespread (Zhou, 2015). Our survey reveals that around 90% of respondents know very little or nothing about the certification system. The dominant information source about green buildings is still from developers' advertisements.

Research has been conducted in other countries regarding the role of information provision in stimulating energy-efficiency investment. There is a widespread perception that better information can alleviate underinvestment in energy efficiency (Hausman, 1979; Achtenicht, 2011; Davis and Metcalf, 2014; Allcott and Taubinsky, forthcoming). Information plays a more crucial role in the real estate market than the markets of products whose attributes are perfectly observable prior to purchase, as buildings are a typical experience good – it is difficult to directly observe a full bundle of a building's quality attributes in advance (Nelson, 1970; Shapiro, 1983). Furthermore, the problems of information asymmetry and adverse selection are more serious in the green building sector than ordinary buildings (Heinzle et al., 2013), because the attributes of green buildings, consisting mainly of living comfort and energy efficiency (Kahn and Kok, 2014; Zuo and Zhao, 2014; Zhou, 2015), are revealed gradually over time as one physically lives in a building (Zheng et al., 2012). Most users lack specialized knowledge or sufficient information to evaluate a building's energy efficiency; in particular, such “energy literacy” has been found to be especially low in the residential sector (Brounen et al., 2013). In addition to this, some recent studies also suggest that consumers' low awareness of residential buildings' energy efficiency may be rational as the energy costs are too small (or lack of flexibility) to justify the effort (Brounen et al., 2013; Davis and Metcalf, 2014; Allcott and Taubinsky, forthcoming). Moreover, the environmental externalities may be another reason for households' inattention to green building's benefit of energy efficiency. Our paper will not explore all these factors in details, but mainly focuses on the role of information about green buildings' superior performance in terms of living comfort. Specifically, we investigate the added value achieved by providing more useful information and its impact on increasing potential homebuyers' willingness-to-pay for green housing units.

To achieve our research goal, we implemented an experiment in Beijing, China's capital. We select two pairs of residential complexes, and each pair consists of a green complex and a non-green complex located in the same housing submarket (a small geographic area). Therefore, the location and building quality of the two complexes within the pair are similar except for the “greenness” attribute. The two green complexes are developed by the same developer – MOMA,¹ which is widely acknowledged as one of the most famous “green” developers in China. This developer adopted the same green technologies in the two complexes we select. However, one of the two green complexes is officially certified while the other one is not.² Our partner, Department of Building Science at Tsinghua University, conducted a field test of indoor environmental quality (temperature, relative humidity, background noise, and luminance under natural lighting) in December 2014, and designed an information card based on the test results, which demonstrated that green apartments perform much better than their non-green counterparts in terms of the four indoor environmental indicators above. We use this information card to conduct a before–after information-provision survey in the two complex pairs. Before showing this information card to the respondents, we ask about their willingness to buy a new green housing unit, and, if they answer yes, the price premium they are willing to pay. Then we ask the same two questions after showing them the information card. The

design of our experiment ensures that the WTP change is solely due to the information treatment.

The results from our experiment show that those who live in green complexes either have a higher preference for green buildings, or have more pre-experiment knowledge about green buildings (the official green certification system), or both. We do find that those green housing dwellers have a higher initial WTP for greenness (329 RMB/m², compared to 225 RMB/m² for non-green housing dwellers), even after controlling for household attributes. But their incremental WTP compared with non-green housing dwellers becomes much smaller after our information treatment since the net gain from such information is marginal for them (the after-information treatment WTP is 317 RMB/m² and 285 RMB/m² for green and non-green housing dwellers, respectively). Furthermore, the comparison of the certified and non-certified green complexes (both developed by MOMA) reveals that there is little difference in these dwellers' WTP for greenness, either before or after our information treatment. Therefore the developer's “spillover” strategy is effective: it builds its “green” image by certifying some of its projects, and then enjoys the spillover effect to other projects under the brand name. Altogether, our experiment results highlight the important role of public information in promoting green housing development, and suggest that in addition to the green building certification, more concrete information is needed to improve dwellers' preference for green housing.

The remainder of this paper is organized as follows. We briefly introduce the institutional background of information dissemination regarding green buildings in China in Section 2. We present how we design our experiment and the basic findings from the experiment in Section 3. In Section 4, econometric models are estimated to better understand the before–after information-treatment WTP change and how such change varies between the dwellers in green and non-green residential complexes after controlling for location and other physical attributes. Section 5 concludes.

2. Information Sources of Green Housing in China

There are three common information sources about green buildings: knowledge cumulated by living in green buildings; non-official information from developers (mostly self-advertisements); and official information from the government (always in the form of green building certifications). Here we introduce the institutional context of the last two information sources in China.

As “greenness” is quite a new concept for most Chinese households and no official certification existed until recently, the primary information source has been developers' self-advertisements. Some real estate developers differentiate their housing products from others by actively advertising the green technologies used in their buildings, such as solar systems, ground source heat pump systems, appliances for natural ventilation and Low-E insulation windows (Zhang et al., 2011), and use words such as “green (*lv-se*)”, “energy-saving (*jie-neng*)” or “environmentally friendly (*huan-bao*)” in their advertisements (Zheng et al., 2012). Sometimes this becomes the developer's key selling point to attract those homebuyers who prefer to buy houses with superior energy efficiency performance or higher living comfort. The presale arrangement in China's real estate market, which allows developers to sell units when they are still under construction, exacerbates the asymmetry information problem for “greenness” – developers may have an incentive to oversell their “greenness” or even cheat on this, while homebuyers can only learn about the true “greenness” (energy efficiency and living comfort) of their units by living in them for a relatively long period of time. This uncertainty in the presale process may reduce homebuyers' incentive to invest in green buildings.

It is widely believed that reliable market signals, such as green building certifications provided by third parties like governments or independent institutions, are a relatively low-cost way to overcome the information problems in the green real estate market, and thus

¹ This developer's website: <http://www.modernland.hk/en-us/index.php?m=page&a=index&id=210>.

² Since this developer is regarded as a “green” developer by the public, people tend to believe that all residential complexes built by it are green, and thus this developer wants to enjoy this spillover effect and save the certification cost.

enable consumers to make rational investment in green properties (Coad et al., 2009; Heinzle et al., 2013; Kahn and Kok, 2014). Over the last several decades, green building certifications have proliferated in many countries. Examples include LEED and Energy Star in the US, BREEAM in the UK, Greenstar in Australia, and Green Mark in Singapore.³ Many studies conducted in these countries have concluded that, compared with their “brown” counterparts, officially certified green properties command a significant price premium in rental and sale markets (Eichholtz et al., 2010; Brounen and Kok, 2011; Fuerst and McAllister, 2011; Deng et al., 2012; Kok and Jennen, 2012; Chegut et al., 2014; Deng and Wu, 2014; Kahn and Kok, 2014).

Although the importance of green buildings has been widely recognized in mainland China, no official certification system for green buildings existed until 2008. Such absence of official certification created opportunities for developers to over-advertise or even falsely advertise the greenness of their buildings (Zheng et al., 2012). Many developer/owners of buildings in China also pursue LEED certification, which is the most internationally prestigious green building certification, but the vast majority of LEED-certified buildings in China are upscale office buildings and commercial complexes housing foreign corporations and high-end clientele (Zhou, 2015). To facilitate the development of green buildings, a nationwide program – the “Chinese Green Building Label” (CGBL) – was launched by the Ministry of Housing and Urban-Rural Development in 2008, based on the Evaluation Standards for Green Buildings. The CGBL rates buildings from one to three stars, with three-star being the highest level.⁴ Developers can apply for the certification at the design and/or operation stages.

Central and local governments in China have published a wide variety of specifications and policies related to the green building certification, but they have made little real effort to disseminate this certification to the public. Although the Ministry puts all CGBL-certified projects on its website,⁵ homebuyers' or renters' exposure to the CGBL rating system is still limited as most people rarely browse these websites. The Chinese government has also tried to educate the public about green buildings by constructing some demonstration buildings featuring CGBL design and technology, such as those in the 2010 World Expo in Shanghai (Zhou, 2015). However, these buildings are always equipped with high-tech systems to impress the audience, instead of providing practical information for common people to learn about the benefits of affordable green housing units. Thus the influence of this green building certification on common homebuyers is rather limited. From our survey, it is striking to find that the share of respondents who have heard of CGBL is only 31.7%, and only 2.1% of the respondents have detailed knowledge of this system such as knowing its rating criteria. The lack of public information about this official certification reduces dwellers' preference for green housing and in turn reduces developers' incentive to supply them (Davis and Metcalf, 2014).

The promotion of CGBL was sluggish at its outset, with only 19 residential complexes certified by the CGBL rating system in Beijing by the end of 2013. Besides the weak demand that may partly result from the lack of public information, another explanation may be that the financial incentive for developers to invest in green buildings is insufficient. Developers are not sure whether the price premium they can charge will be large enough to offset the incremental costs of adopting green practices. The skill shortages, higher risk, and lack of public confidence in the program also lead to slow diffusion of green buildings (Zheng et al., 2012; Fuerst et al., 2014). Another minor reason for the very small number of CGBL-certified residential complexes is the high application fee charged to developers. In 2013, this consultation and

application fee was one million RMB for a CGBL-certified project.⁶ As a Chinese real estate developer typically develops several residential projects in a city or in multiple cities, a common strategy for a developer engaged in green building development is to apply for the CGBL certification for some but not all of its projects. Since all its projects are under the umbrella of its brand, homebuyers will regard all the projects developed by the developer as “green”. This is exactly what MOMA did for the two residential complexes we include in this study. This strategy of developers also gives us an opportunity to test whether it is the official certification or consumers' subjective perception that actually generates the significant green price premium indicated by previously mentioned studies.

MOMA (China) Company Limited, established in 2000, is one of the most well-known developers for energy-efficient and environmentally friendly real estate development. MOMA has set up its own research and development center for green building technologies. As of 2014, MOMA had more than forty patents and ten CGBL-certified residential complexes,⁷ and became the only developer with two three-star CGBL certifications at the operation stage. However, it is noteworthy that some MOMA projects did not seek green building certification.

3. Experiment Design and Data

3.1. Experiment Design

To conduct our experiment, we chose two green residential complexes (G1, G2) developed by MOMA. Complex G1 is awarded a three-star CGBL certification at the operation stage. According to the Evaluation Standards for Green Buildings, this certification indicates that the energy consumed by this residential building for heating and cooling is less than 80% of the energy consumed by a conventional residential building that just meets the energy efficiency level prescribed by building codes. Yip et al. (2013) also document that the energy saved by three-star CGBL-certified residential buildings is 9.0–18.2 kWh/m² per year. Although Complex G2 is not CGBL-certified, it adopts the same technologies as Complex G1, such as ground source heat pump systems, ceiling radiant heating-cooling systems, exterior insulation systems, and natural ventilation systems. A test by China Academy of Building Research shows that the energy consumption of residential buildings developed by MOMA in Beijing is 74.4% as much as that of conventional residential buildings in Beijing.⁸

In addition, they are located in quite different neighborhoods in Beijing. Complex G1 is located in Dongcheng District, in the core area of Beijing, while Complex G2 is located in Haidian District, close to several university campuses. To find a non-green counterpart for each, we matched each with a comparable non-green residential complex (N1, N2) in the same housing submarket with similar locational attributes, as depicted in Fig. 1. These four complexes are all high-rise condominium buildings. We sort the dwellers in Complexes G1 and N1 into Group 1, and the dwellers in Complexes G2 and N2 into Group 2. Within each group, the two complexes are similar in both locational and physical attributes, with the only big variation being the complexes' “greenness”.

Our questionnaire consists of three parts: household and personal characteristics, current apartment's attributes, and specific questions regarding the respondents' knowledge, attitude and willingness-to-pay for green buildings. In Appendix A we list the specific green building questions. Q1 and Q2 investigate the respondents' pre-experiment

³ See Deng et al. (2012) for more details.

⁴ The certification inspects the buildings' performance in six categories: land savings and outdoor environment, energy savings, water savings, material savings, indoor environmental quality, and operational management. A building seeking to be CGBL-certified has to meet all of the mandatory items first, and its rating level is then determined based on how well it meets the general and preferred item requirements.

⁵ <http://ginfo.mohurd.gov.cn/index.aspx?tabid=1&infocate=35>.

⁶ Source: <http://news.dichan.sina.com.cn/2011/12/12/417720.html>.

⁷ Only one of these projects is located in Beijing and the others are located in Jiangxi, Hubei and Hunan provinces. These CGBL-certified projects include two three-star and six two-star projects certified at the design stage, and two three-star projects certified at the operation stage.

⁸ The residential buildings developed by MOMA in Beijing consume 12.8 kWh/m² for heating and 15.1 kWh/m² for cooling per year, while the corresponding levels of conventional residential buildings in Beijing are 14.9 kWh/m² and 22.5 kWh/m² respectively.



Note: Triangles represent green complexes and squares represent non-green complexes.

Fig. 1. The complexes in the experiment.

knowledge about the green building certification and their reasons for buying or not buying green apartments. The most novel feature of our experiment is the before–after information–treatment survey. Our design follows the experiments described in previous studies (MacMillan et al., 2006; Davis and Metcalf, 2014; Allcott and Taubinsky, forthcoming). We prepare an information card that contains information about several key indoor environmental indicators for green and non-green buildings and shows how they compare (Fig. 2). This information card was developed by Department of Building Science at Tsinghua University, following an indoor environmental test they conducted in these four complexes in December 2014. The card clearly shows that green buildings perform significantly better than non-green ones in terms of temperature, relative humidity, background noise, and luminance under natural lighting conditions. Before showing the information card to the respondent, we ask him/her two questions (Q3 in the Appendix A): (1) If you were going to buy a new apartment, would you buy a green apartment? (A binary variable, *BUY*) (2) If yes, how much would you be willing to pay for a green apartment compared to its non-green counterpart (*WTP*)? We then provide him/her with the information card. After he/she reads it, we ask the above two questions again. The changes in the respondents' two answers can only be attributed to the information treatment.

The benefits of green housing include both energy savings and improvements in living comfort. We do not include the former on the information card due to two considerations. First, in the pre-survey interviews, we find that more than half of the interviewees have no idea about their monthly electricity costs, which is consistent with the findings in several recent studies that households are inattention to the utility costs, especially in China where residential utilities are highly subsidized (Zheng et al., 2012; Brounen et al., 2013; Davis and Metcalf, 2014; Allcott and Taubinsky, forthcoming). Second, the largest utility cost, the winter heating fee, is fixed at around 30 RMB per square

meter per winter, no matter how much heat a household actually consumes. Given these facts, it is hard to obtain meaningful answers regarding people's *WTP* for the possible savings in utility bills of green buildings. We acknowledge that ignoring the energy-saving information on the information card may induce an under-estimation of the increase in people's *WTP* for green buildings after the information treatment.

3.2. Data Collection

We conducted the experiment in the four complexes in December 2014. We randomly selected 100 households in each of the four complexes and visited them for questionnaire survey. Only one respondent was interviewed per household. This survey yielded 240 valid questionnaires, consisting of 44 from Complex G1, 56 from Complex G2, 71 from Complex N1 and 69 from Complex N2. Our respondents consist of 162 homeowners and 78 renters. We include both homeowners and renters in our analysis because we focus on asking about their future home purchase decision rather than their current situation homes. We also expect that homeowners and renters have different preferences for green buildings, as the former are always richer and thus may have a higher demand for living comfort. In terms of socio-economic characteristics, the respondents are dominated by people with Bachelor's degree. 55.4% of the respondents are less than 40 years of age and 81.8% report annual household income between 100 and 500 thousand RMB. Table 1 further compares the socio-economic characteristics of respondents in the green and non-green complexes, revealing that the dwellers of green apartments are older and wealthier. The variable of *PRE_GOVNT_INFO* measures the respondents' knowledge about CGBL, with '1' denoting the least familiarity and '5' the most. The result indicates that the green-complex dwellers have more knowledge about CGBL.

Indoor Environmental Quality of Green and Non-Green Housing

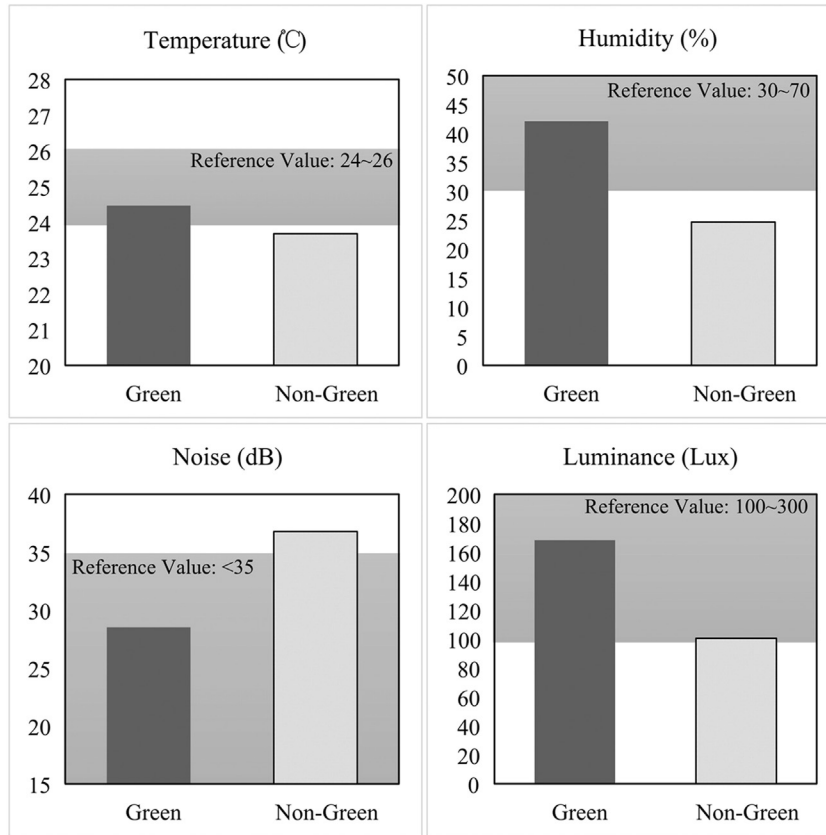


Fig. 2. Information card. Indoor environmental quality of green and non-green housing. Data source: Tests conducted by the Department of Building Science, Tsinghua University, in December, 2014. Note: Shadow areas reflect empirical values for comfortable indoor environment, according to *Heating, Ventilation and Air Conditioning Design Specifications of Civil Buildings* (GB50736-2012).

Table 1
Descriptive statistics of respondents' socio-economic characteristics.

Observations	Green	Non-green	Total
Total	100	140	240
1.1.Male	49	51	100
1.2.Female	51	89	140
2.1.Owner	69	93	162
2.2.Renter	31	47	78

Variables	Green (μ_1)	Non-green (μ_2)	t-test ($H_0: \mu_2 = \mu_1$)
AGE (year)	45.15 (10.65)	38.89 (9.37)	-4.82***
<30	0.16 (0.37)	0.31 (0.47)	2.75***
30-40	0.22 (0.42)	0.31 (0.47)	1.61*
40-50	0.19 (0.39)	0.23 (0.42)	0.72
50-60	0.34 (0.48)	0.08 (0.27)	-5.40***
>60	0.06 (0.25)	0.09 (0.29)	-0.74
EDUCATION (year)	15.49 (3.06)	16.21 (2.38)	2.06**
Junior high school	0.09 (0.29)	0.04 (0.19)	-1.77*
Senior high school	0.15 (0.36)	0.07 (0.26)	-1.97**
Bachelor	0.55 (0.50)	0.67 (0.47)	1.92*
Master	0.18 (0.39)	0.19 (0.40)	0.25
PhD	0.03 (0.17)	0.03 (0.17)	-0.06
INCOME (10 ⁴ RMB/year)	34.33 (23.05)	28.05 (17.41)	-2.40**
<10	0.00 (0.00)	0.08 (0.27)	2.91***
10-15	0.27 (0.45)	0.19 (0.39)	-1.55
15-25	0.21 (0.41)	0.31 (0.47)	1.80*
25-50	0.34 (0.48)	0.35 (0.48)	0.16
50-100	0.16 (0.37)	0.06 (0.25)	-2.41**
>100	0.02 (0.14)	0.01 (0.08)	-0.88
PRE_GOVNT_INFO (1-5)	1.56 (0.81)	1.32 (0.60)	-2.62***

Notes: For the options of age, education and income, 1 = yes, 0 = o/w. Standard deviations in parentheses.

4. Results

4.1. Pre-Experiment Knowledge of Green Buildings

Respondents' pre-experiment knowledge of CGBL is illustrated in Fig. 3. The result shows that dwellers in green complexes are more familiar with CGBL than dwellers in non-green complexes. It is striking that more than 60% of the respondents do not know about CGBL, and around 20% have only heard of it. 11% of the respondents in the green

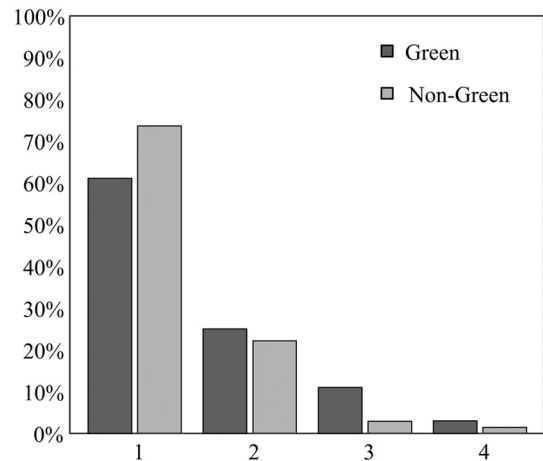


Fig. 3. Respondents' knowledge of Chinese green building label. Notes: 1 = "Do not know it"; 2 = "Only heard of it"; 3 = "Familiar. Know its logo"; 4 = "Very familiar. Has specialized knowledge about it".

complexes know the CGBL logo, while only 3% of the respondents in non-green complexes do. Consumers' minimal knowledge about CGBL helps to explain developers' unenthusiastic participation in this program.

Understanding why dwellers might choose to buy or not buy green apartments and the large variation in reasons among residents in different complexes, as presented graphically in Fig. 4, is important. The most common reason for buying green apartments is to improve living comfort and health, and this is the main reason for buying the apartments in Complex G2, a building that has no official green certification. Notably, around 40% of the homebuyers in Complex G1 claim that they were attracted by other apartment characteristics such as high quality architectural design, without caring about the green characteristic, but no surveyed homebuyer in Complex G2 chooses this option. One explanation may be that given the inferior location of Complex G2, the developer uses “greenness” as an important selling point to attract homebuyers, thus those homebuyers in Complex G2 have received more information about the greenness of their apartments. For the dwellers in non-green complexes, lack of knowledge about green buildings dominates the reasons for not buying green apartments, followed by the worry of developers' exaggerative or false advertisement about greenness. Overall, lack of reliable information about green buildings impacts their decision to not buy green apartments. “Green technologies are immature” and “Green buildings are too expensive” rank as third and fourth respectively in the reasons for not buying green apartments.

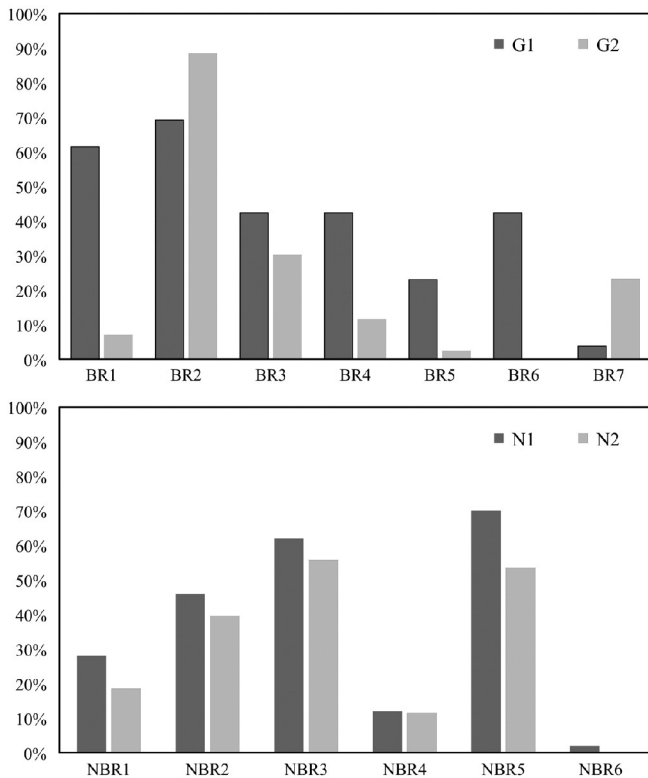


Fig. 4. Reasons for buying/not buying green apartments. Notes: Reasons for buying green apartments (multiple choice): BR1 = “To save operation expenses.” BR2 = “To improve living comfort and health.” BR3 = “To make a contribution to sustainable development.” BR4 = “To enjoy incentives from the government.” BR5 = “To follow the fashion of the time.” BR6 = “Being attracted by other characteristics without knowing its greenness.” BR7 = “Other reasons.” Reasons for not buying green apartments (multiple choice): NBR1 = “Green buildings are too expensive.” NBR2 = “Green technologies are still immature.” NBR3 = “False or over-advertising of green buildings is common.” NBR4 = “There are few government incentives.” NBR5 = “Without much knowledge about green buildings, greenness was not a factor in choosing to buy.” NBR6 = “Other reasons.”

4.2. Willingness-to-Pay for Green Housing before Information Treatment

In the same housing submarket, people sort themselves into green complexes and non-green ones based on their preference for greenness (quality of life and/or environmental ideology) and their existing knowledge of green buildings. We first explore the individuals who self-select into those green complexes, and investigate whether this group has a higher WTP for future purchase of green housing before introducing our information treatment. We adopt the logit models to analyze factors influencing respondents' current housing choices. The model is specified in Eq. (1):

$$\text{Prob}(LIVING_GREEN_i = 1) = f(\text{AGE}_i, \text{INCOME}_i, \text{EDUCATION}_i, \text{PRE_GOVNT_INFO}_i, G_i) \tag{1}$$

Where *LIVING_GREEN* indicates whether the respondent lives in a green apartment now; *G* is the group dummy, so we can make a within-group (submarket) comparison. We only keep those respondents who are accurately aware of their apartments' green status,⁹ because otherwise greenness was not considered when they made their home purchase choices. The results are listed in Table 2. In Column (1), we find that for homeowners, those who are older and more knowledgeable about CGBL (higher *PRE_GOVNT_INFO*) are more likely to buy green apartments. The income effect is insignificant. The positive effect of CGBL knowledge loses its significance in Group 2 as presented in Column (3). This is understandable given that Complex G2 is not officially certified but is just developed by a “green” developer. Within Group 2, elderly people are more likely to buy into the green Complex G2. The elderly are usually supposed to be reluctant to accept new things such as green buildings. However, in our survey, some elderly people told us that their children bought the green apartments for them. Considering that living comfort and health benefits are precisely the selling points made by “green” developers, this may attract homebuyers who want to provide a better living environment for their parents. For renters, the result in Column (4) suggests that wealthier renters are more likely to live in green apartments. As renters are less affluent than homeowners, only the wealthier among them may consider the issue of housing quality such as greenness.

We further use the Heckman two-step to estimate a respondent's intention to buy a new green apartment and his/her willingness-to-pay (in money terms) for this green apartment if he/she intends to buy it. We first show an intuitive chart presenting the probability distributions of current green-complex and non-green-complex dwellers' WTP for purchasing green apartments in the future (Fig. 5). Clearly the green-complex dwellers' WTP curve is to the right of the non-green-complex dwellers' one, indicating that the former group has an on-average higher WTP for green apartments due to their stronger preference and better existing knowledge.

Since in Table 1 we find the dwellers in green and non-green complexes differ to some extent in terms of household attributes and knowledge of green buildings, we control for as many such variables as we can. We estimate a first stage probit model:

$$\text{Prob}(BUY_i = 1) = f(\text{RENTER}_i, \text{FEMALE}_i, \text{AGE}_i, \text{INCOME}_i, \text{EDUCATION}_i, \text{PRE_GOVNT_INFO}_i, \text{LIVING_GREEN}_i, G_i) \tag{2}$$

⁹ For instance, some respondents had no idea about whether their current apartments are green or not, and some respondents in non-green complexes even though their apartments are green.

Table 2
Households' self-selection into green apartments.

Dependent variable	<i>LIVING_GREEN</i>				<i>BUY</i> ^a	<i>WTP BUY = 1</i> ^b	<i>BUY</i> ^a	<i>WTP BUY = 1</i> ^b
	Owners			Renters	All		All	
	All	G1&N1	G2&N2	All	(5)	(6)	(7)	(8)
<i>AGE</i>	0.073*** (3.46)	0.033 (0.86)	0.090*** (3.28)	-0.001 (-0.03)	-0.036** (-2.36)		-0.035** (-2.33)	
<i>INCOME</i>	0.004 (0.43)	0.014 (0.97)	-0.009 (-0.56)	0.081*** (2.96)	0.002 (0.32)		0.003 (0.40)	
<i>EDUCATION</i>	-0.042 (-0.52)	0.049 (0.32)	-0.042 (-0.42)	-0.248* (-1.70)	-0.071 (-1.28)	15.194*** (3.06)	-0.062 (-1.12)	15.387*** (3.11)
<i>PRE_GOVNT_INFO</i>	0.469* (1.74)	1.204*** (2.87)	-0.108 (-0.30)	1.119 (1.42)	0.285 (1.41)	54.505*** (2.69)	0.334 (1.57)	56.542*** (2.69)
<i>RENTER</i>					-0.087 (-0.35)	-74.236*** (-2.59)	-0.020 (-0.08)	-71.450*** (-2.48)
<i>FEMALE</i>					0.663*** (2.76)		0.692*** (2.85)	
<i>LIVING_GREEN</i>					0.141 (0.54)	110.304*** (4.04)	0.523 (1.15)	120.256*** (3.31)
<i>LIVING_CERTIFIED</i>							-0.585 (-1.06)	-21.506 (-0.38)
Group fixed effects	Yes	-	-	Yes	Yes	Yes	Yes	Yes
Constant	-3.727** (-2.02)	-5.313 (-1.55)	-2.972 (-1.27)	-0.136 (-0.04)	2.555* (1.94)	-158.012 (-1.61)	2.329* (1.75)	-160.514 (-1.64)
N	143	65	78	55	240		240	
Significance	Pseudo R ² = 0.134	Pseudo R ² = 0.196	Pseudo R ² = 0.164	Pseudo R ² = 0.254	rho = 0.972 sigma = 197.2 lambda = 191.7		rho = 0.971 sigma = 196.7 lambda = 191.0	

Notes:

* $p < 0.10$.

** $p < 0.05$.

*** $p < 0.01$.

^a z-statistics in parentheses.

^b t-statistics in parentheses.

In the second stage, we estimate the respondent's WTP for a green apartment conditional on his/her deciding to buy a green apartment.¹⁰

$$WTP_i|BUY_i = 1 \quad (3)$$

$$= f(RENTER_i, EDUCATION_i, PRE_GOVNT_INFO_i, LIVING_GREEN_i, G_i)$$

The results are reported in Columns (5) and (6) in Table 2. It seems that elderly people would actually be reluctant to buy green buildings in the future. Renters who may be relatively poor are less willing to pay for greenness. Interestingly, females are more likely to choose a green apartment. One possible interpretation may be that females pay more attention to living comfort or energy savings. Higher-educated people are willing to pay a significantly higher price premium for green apartments if they decide to buy. These highly-educated people may have a stronger environmental ideology so they value green buildings more, as is consistent with findings from previous studies (Kahn, 2002; De Silva and Pownall, 2014). Knowledge about CGBL seems to play an important role in increasing dwellers' WTP for green housing. The regression results also reveal that dwellers already living in green apartments have a much higher WTP for greenness than those living in non-green complexes. One explanation for this may be that the variable of *LIVING_GREEN* consists of some unobservable individual characteristics increasing dwellers' WTP for green housing. Another possible reason is that their personal experience of living in a green apartment may increase their knowledge about the benefits of green housing or they may have been more exposed to "green" advertisements from the developer. In Columns (7) and (8), we add the dummy of *LIVING_CERTIFIED* to indicate whether the residential complex is CGBL-certified and thus distinguish Complex G1 and G2.

¹⁰ We did an OLS regression of WTP including all the variables as the first stage and found *AGE*, *INCOME* and *FEMALE* to be insignificant, so we exclude them in the second stage estimation.

However, we find that dwellers of CGBL-certified Complex G1 do not present stronger willingness to choose or higher WTP for green housing than do dwellers of non-certified Complex G2.

4.3. Changes in Willingness-to-Pay for Green Housing after Information Treatment

The novel feature of our experiment is the information treatment and the before–after WTP comparison. To facilitate this comparison, we assume that one's WTP equals zero if he/she answers that he/she is not willing to buy a green apartment. In this way we can calculate ΔWTP for each respondent induced by the provided information card. We regress ΔWTP on respondents' characteristics, whether they live in green apartments now (dummy *LIVING_GREEN*), whether they live in CGBL-certified green apartments now (dummy *LIVING_CERTIFIED*), and whether they have more knowledge of the official green certification

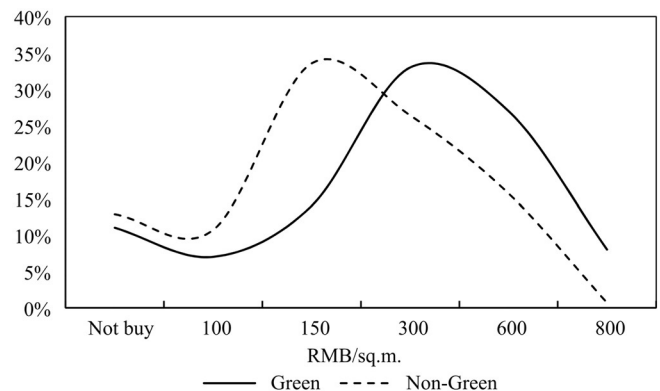


Fig. 5. Respondents' WTP for green housing.

Table 3
WTP change after information treatment.

Models	OLS			Tobit	
	ΔWTP			WTP	
	(1)	(2)	(3)	(4)	(5)
<i>LIVING_GREEN</i>	−73.194*** (−3.46)		−75.292*** (−3.35)	105.290*** (3.44)	115.248*** (2.96)
<i>LIVING_CERTIFIED</i>	23.479 (0.74)		24.332 (0.73)		−22.558 (−0.41)
<i>PRE_GOVNT_INFO</i>	−18.780 (−1.57)		−18.186 (−1.47)	52.626*** (3.31)	54.568*** (3.31)
<i>RENTER</i>		4.689 (0.27)	1.846 (0.11)	−63.754*** (−2.80)	−62.221*** (−2.70)
<i>FEMALE</i>		23.416 (1.42)	13.491 (0.83)	11.717 (0.54)	12.616 (0.58)
<i>AGE</i>		−0.035 (−0.04)	0.912 (1.02)	0.610 (0.51)	0.557 (0.47)
<i>INCOME</i>		−0.263 (−0.64)	0.014 (0.04)	−0.825 (−1.53)	−0.787 (−1.45)
<i>EDUCATION</i>		3.565 (1.08)	3.119 (0.97)	17.726*** (4.15)	17.673*** (4.13)
<i>INFO_TREATMENT</i>				59.324** (2.21)	59.313** (2.21)
<i>INFO_TREATMENT*LIVING_GREEN</i>				−71.020* (−1.71)	−72.814 (−1.46)
<i>INFO_TREATMENT*LIVING_CERTIFIED</i>					4.274 (0.07)
Group fixed effects	Yes	Yes	Yes	Yes	Yes
Constant	72.930*** (3.34)	−38.865 (−0.50)	−21.934 (−0.29)	−218.433** (−2.11)	−216.702** (−2.09)
N	240	240	240	480	480
R ²	0.085	0.019	0.094	0.020	0.020

Notes: *t*-statistics in parentheses.

* $p < 0.10$.

** $p < 0.05$.

*** $p < 0.01$.

before our treatment (*PRE_GOVNT_INFO*). We also control for the group fixed effect.

$$\Delta WTP = f(LIVING_GREEN_i, LIVING_CERTIFIED_i, PRE_GOVNT_INFO_i, RENTER_i, FEMALE_i, AGE_i, INCOME_i, EDUCATION_i, G_i) \quad (4)$$

Table 3 presents the regression results. We find that whether the respondent now lives in a green apartment dominates his/her ΔWTP following the information treatment. According to the result in Column (1), those who currently live in non-green complexes have a much larger increase in WTP after our information treatment (72.93 RMB/m²), while dwellers in green complexes show almost zero increase (or even a small decrease) in their WTP (72.93–73.19 = −0.26 RMB/m²). Recall the results in Table 2 we found before the information treatment: those green-complex dwellers have a much higher initial WTP than those in non-green complexes. This before–after comparison indicates that the newly-provided information only has an impact (in terms of improving their WTP for future green housing purchase) on dwellers living in non-green complexes. One explanation is that the information we provide has already been acquired by green-complex dwellers before our information treatment. These findings are consistent with the results of MacMillan et al. (2006) that affording participants with more information is an appropriate methodology for valuing unfamiliar environmental goods but less important for familiar goods. As we have controlled for the variable of knowledge about official green building certification, green-complex dwellers' better awareness of green housing features may result from the developer's advertisements or their own experience with green housing. The difference of ΔWTP induced by the information card is not significant between dwellers in Complexes G1 and G2, once again suggesting that certified and non-certified green apartments developed by the same "green" developer are nearly equivalent for homebuyers. The results in Columns (2) and

(3) imply that in terms of the response to the information card, there is no difference among people of different attributes, such as gender, age and income.

We provide an intuitive analysis tool for this before–after information-treatment WTP change in Fig. 6. The initial WTP gap before the information treatment between green-complex and non-green-complex dwellers comes mainly from the differences in these two groups' preference for greenness and the information they have known about green buildings, which can be regarded as a function of demographics and information access. Non-green-complex dwellers' WTP for a future green housing purchase increases dramatically after the information treatment because their initial information level is low. For green-complex dwellers, their WTP may increase (but much less than that for non-green-complex dwellers) if the information card contains some information new to them; or remain constant if the information card has no information new to them; or even decrease if they find their original knowledge obtained from developers' self-advertisement or other sources is too optimistic about the benefits of green buildings.

To quantify Fig. 6, we estimate a difference-in-differences Tobit model,¹¹ specified in Eq. (5):

$$WTP_i = f(\mathbf{X}_i, LIVING_GREEN_i, INFO_TREATMENT_i, LIVING_GREEN_i * INFO_TREATMENT_i) \quad (5)$$

Where: \mathbf{X}_i is a vector of control variables consistent with those in Eq. (4); and *INFO_TREATMENT* indicates whether the answer is after the information treatment. The regression result is shown in Column

¹¹ For residents whose WTPs for green housing are negative, we cannot observe their WTPs in questionnaires and set them to zero, so the WTP is censored. Thus the Tobit model is adopted to solve the problem of endogeneity and inconsistency of OLS for such censored sample.

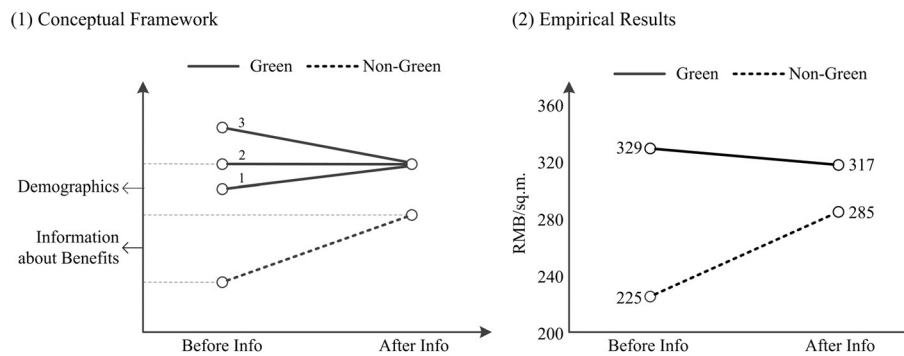


Fig. 6. Changes in WTP following information treatment for green housing.

(4) of Table 3. We can see that green-complex dwellers have a significantly higher initial WTP: about 105.3 RMB/m² higher than the non-green-complex dwellers. The information card increases non-green-complex dwellers' WTP by 59.3 RMB/m², while it slightly decreases green-complex dwellers' WTP by 11.7 RMB/m². In Column (5), we further introduce *LIVING_CERTIFIED* and the cross term of *INFO_TREATMENT* and *LIVING_CERTIFIED* into the model to analyze the difference between before- and after-treatment WTPs between dwellers in Complexes G1 and G2. The result suggests that living in officially certified green apartments does not effectively increase dwellers' WTP for green housing or influence their response to our information card. In other words, certified and non-certified complexes of MOMA have similar capacity to increase homebuyers' WTP as the developer enjoys the "green" reputation by developing several green-certified complexes. This result is consistent with the analysis by Shapiro (1983) that in an imperfect information market where product attributes are difficult to observe prior to purchase, consumers may plausibly use the quality of products produced by the firm in the past as an indicator of present or future quality. Thus reputable firms command a "goodwill" value of their brand names.

Based on those coefficients, we substitute the mean values of X for green-complex and non-green-complex dwellers respectively into Eq. (4) to calculate the green-complex and non-green-complex dwellers' before- and after-information WTPs for future green housing purchase. The result is graphically shown in Fig. 6, suggesting that the gap between green-complex and non-green-complex dwellers' WTPs greatly narrows after all dwellers have been exposed to the information card treatment. This narrowing can mainly be attributed to the large increase in non-green-complex dwellers' WTP after they receive new information about green building benefits (from 225 RMB/m² to 285 RMB/m²). In our survey, green-complex dwellers seem to be somewhat over-optimistic about such benefits, so their WTP drops a little (from 329 RMB/m² to 317 RMB/m²) after our information treatment. This result is not unique to our analysis, Allcott and Sweeney (forthcoming) also suggest that the majority of consumers who bought the Energy Star products may even overestimate its benefits. Note that after the information treatment, the non-green-complex dwellers' WTP is still about 32 RMB/m² lower than that of the green-complex dwellers. This after-treatment gap in WTP can be attributed to the preference difference (self-selection) and the knowledge gap between these two groups (that is, the knowledge possessed by green complex dwellers that exceeds the knowledge provided on our information card).

5. Conclusion

While it is widely acknowledged that lack of reliable and accurate information regarding green buildings' energy efficiency and living comfort hinders the development of the green building market, there is little concrete evidence of the role information plays in promoting

consumers' investment in energy-efficient and environmentally friendly buildings. Based on our experiment conducted in Beijing, this paper contributes to our understanding of households' present knowledge about green buildings as well as the influence of new information on purchasing decisions and WTP for green buildings.

It is striking that the overwhelming majority of our respondents are ignorant of the green building certification and only a small number consider greenness when buying apartments. Those respondents who take into account living comfort and health or weight energy and environmental issues as more important, as well as those with better access to information about green buildings, may self-select to purchase green apartments. Dwellers living in green complexes present a significantly higher initial WTP for greenness, but this difference narrows significantly after our information treatment that compares the indoor environmental indicators of green and non-green apartments, as the non-green-complex dwellers' WTP for greenness increases dramatically after the information treatment. This encouraging result suggests that households will be encouraged to buy green apartments by more concrete information. We also find that the officially certified and non-certified complexes have similar capacity to increase homebuyers' WTP if they are under the same "green" developer's name, suggesting that developers may enjoy the benefits of being seen as "green" and commensurate spillover effects by only having some of their projects certified.

Although respondents in our experiment learned only about living comfort benefits, the pronounced effects here already demonstrate that we can influence decision-making through information provision and nudge people towards investing in green housing. The lack of demand for green housing in China's current housing market cannot be attributed solely to Chinese households' lack of environmental ideology. Instead, a major reason is the lack of public information about green buildings. The impact of the official green building certification is still limited, as it has not been well translated into public knowledge about the benefits of green buildings. In fact, the certification only creates some vague impression on most people about the sustainability and energy-efficiency of some developers. To promote green buildings in the private sector in China, the government must provide more reliable and tangible information and help common people get a better understanding of green buildings.

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Appendix A. Related Survey Questions

Q1 Are you familiar with the Chinese Green Building Label certification system?

- (1) No. I do not know.
- (2) I only heard of it.
- (3) Yes. I know its logo.
- (4) Yes. I have specialized knowledge about it.

Q2 (For green-complex dwellers) Why did you buy/rent a green apartment (multiple choices)?

- (1) To save operation expense.
- (2) To improve living comfort and health.
- (3) To contribute to sustainable development.
- (4) To enjoy the government incentives.
- (5) To follow the fashion.
- (6) Being attracted by other characteristics without knowing its greenness.
- (7) Other reasons.

(For non-green-complex dwellers) Why did you not buy/rent a green apartment (multiple choices)?

- (1) Green buildings are too expensive.
- (2) Green technologies are still immature.
- (3) False or over-advertising of green buildings is common.
- (4) There are few government incentives.
- (5) Without much knowledge about green buildings, greenness was not a factor in choosing to buy.
- (6) Other reasons.

Q3 If you were going to buy a new apartment, would you buy a green apartment?

- (1) No.
- (2) Yes. How much would you be willing to pay for a green apartment compared to its non-green counterpart?
 - 1) <100 RMB/m²
 - 2) 100–200 RMB/m²
 - 3) 200–400 RMB/m²
 - 4) 400–800 RMB/m²
 - 5) >800 RMB/m²

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