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Abstract

In recent years, formal certification programs for rating and evaluating the sustainability and energy efficiency of buildings have proliferated around the world. Developers recognize that such "green labels" differentiate products and allow them to charge a price premium. China has not formally adopted such rating standards. In the absence of such standards, developers are competing with each other based on their own self-reported indicators of their buildings' "greenness". We create an index using Google search to rank housing complexes in Beijing with respect to their "marketing greenness" and document that these "green" units sell for a price premium at the presale stage but they subsequently resell or rent for a price discount. An introduction of a standardized official certification program would help "green" demanders to acquire units that they desire and would accelerate the advance of China's nascent green real estate market.

Key words: green building; energy efficiency; environmental sustainability; information asymmetry; China housing market

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1. Introduction

Buildings and their associated construction activities account for almost a third of world greenhouse gas emissions, and the construction and operation of buildings account for about forty percent of worldwide consumption of raw materials and energy (Deng, Li and Quigley, 2011). Given that building is a long lasting durable good, choices made today in fast growing urban cities will have long run effects influencing an economy's overall energy efficiency for decades to come.

In China's booming cities, thousands of new housing complexes are being built. To meet soaring electricity demand, China is building a large number of new coal fired power plants. Environmentalists are worried that an unintended consequence of such growth is sharply increasing greenhouse gas emissions and worse local air quality. According to a recent calculation by Zheng, Wang, Kahn and Glaeser (2011), the average household in the least "green" Chinese city produces only one-fifth greenhouse gas emissions of that in the "greenest" city in U.S. This fact implies that if Chinese households' energy consumption rises to U.S. levels, the global carbon emissions would increase by more than fifty per cent. Engel curve studies from around the world have documented that energy consumption rises with household income (Dargay, Gately and Sommer, 2007). Anticipating that aggregate energy demand in China will rise sharply, China's Premier has launched an initiative to reduce energy intensity (energy consumption per dollar of GDP) over the next five years (Decree 26th of State Council in 2011).

Raising residential electricity prices would be one direct incentive for encouraging conservation. But the Chinese government has chosen to keep such prices low. In Beijing, since the electricity pricing reform in 2003, industrial and commercial electricity prices have increased by more than residential electricity prices. Commercial electricity prices have increased from 0.63 yuan to 0.76 yuan per kWh and industrial-use electricity prices have increased from 0.42 yuan to 0.55 yuan per kWh. However, the rate of residential-use electricity only increased once in 2004 from 0.44 yuan to 0.48 yuan per kWh.

Rising consumer demand for green real estate offers an alternative pathway. U.S studies have documented that more educated households are more likely to be environmentalists (Kahn, 2002). As China's major cities enjoy rising levels of educational attainment, it is likely that the demand for living in "green" housing will rise. The net effect of rising demand is that developers will have an incentive to innovate and supply such building complexes.[1]

In many developed economies, such as United States, Western Europe and Singapore, *etc.*, formal certification programs have been developed that objectively rank buildings with respect to their environmental impact and performance, hence encouraging real estate developers to supply more energy efficient and environmental friendly building complex projects. Developers recognize that such "green labels" differentiate products and allow them to charge a price premium that some consumers are willing to pay. Examples of such ratings include the U.S. Energy Star program, LEED certification and Singapore's Green Mark Schemes.[2]

China has not adopted a well-functioning green rating standard for its booming residential sector. In the absence of a trusted certification provider, some developers of new housing complexes are still advertising their new housing using "green" words as a marketing strategy. We use Google search to create a new data base that allows us to identify the subset of new housing complexes that are advertised as "green" in Beijing. Less well-known developers (new entrants) are more likely to market their buildings as "green", as well as developers of complexes in less desirable locations.

Apartment buyers in hot property markets in China, such as Beijing, often purchase the property at the presale stage and thus cannot verify the claims made by developers. Given the rapidly rising demand for apartments, many of these buyers are often novices

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[1] See, for example, Acemoglu and Linn (2004).
[2] Energy Star was created by the EPA in 1992 and provides commercial building owners with strategic energy management plans designed to benefit both the environment and the property owners. LEED operates through the U.S Green Building Council and takes a broader approach considering people, planet and profit, not just energy use. Green Mark Scheme was launched by Singapore government's Building and Construction Authority in January 2005 as an initiative to drive Singapore's construction industry towards more environment-friendly buildings.

who have not purchased a housing unit before. In addition, seventy percent of the new developers in our sample period (six years) only built one project. Apartment buyers will have no access to a track record for these one-time developers. An information problem arises if developers are building apartment complexes and advertising them as "green" when in fact these buildings are not going to deliver the expected energy reducing savings. This could arise due to some developers' engaging in "deceptive advertising" while in other cases, some of them may simply be ignorant about how the "green" building will actually perform due to the immaturity of the green technology it adopted.

Using hedonic pricing methods for new-unit buyers, subsequent resale-unit buyers, as well as subsequent tenants, we document that all else equal, buildings that score high on this green index sell for a price premium at the presale stage, but they are subsequently leased or resold for a price discount. We attribute such a sign flip to the lack of transparent data on the green performance of the new apartment units sold on the market, and the inexperienced buyers who lack knowledge on how the new "green" apartments will affect their future residential utility bills.

Our paper contributes to a growing literature examining the price premium for green residential and commercial real estate properties. For example, hedonic analyses set in Beijing (Zheng and Kahn, 2008) and across Chinese cities (Zheng, Fu and Liu, 2009; Zheng, Cao and Kahn, 2011) indicate that residential real estate sells for a higher price in the areas that are objectively greener. This price premium is rising over time. Deng, Li, and Quigley (2011) study 697 individual complexes and 36,512 transactions in the Singapore housing market and find substantial price premium for the Green Mark certified buildings. Eichholtz, Kok and Quigley (2009, 2010) find that the intangible effects of the label itself seem to play a role in determining the value of green buildings in the marketplace. They also find that though not all of a building's energy use measured by the Energy Star label is directly linked to the ultimate energy bill, the label still yields positive effects on a building's value. However, Yoshida and Sugiura (2010) study Tokyo green condominium market and find a negative value effect related to the green label. More recently, Brounen, Kok and Quigley (2011) investigate how the introduction of residential energy labels in Holland has affected the price premium for "green" real estate. They find that the introduction of residential energy labels has led to a capitalization of energy efficient homes into the hedonic price gradient.

Our analysis also adds to recent works on information problems that arise in presale (or pre-construction transaction) housing markets. Chau, Wong and Yiu (2007) and Deng and Liu (2009) examine the moral hazard problem in presale markets in Hong Kong and China, respectively. They find that the market is able to capitalize developers' reputations into future prices, so the optimal strategy for well-established developers is to commit to the quality level implied by their reputations. However, they also find that the pre-sale practice significantly lowers the barrier of entry in the real estate industry in China, thus encouraging new comers to become involved in residential housing development.

This paper offers an innovative approach to study the nascent market for "green" real estate in Beijing. In section 2 below, we propose a new green index to measure residential complex's "greenness" in Beijing. In section 3, we evaluate the price premium for the "green" buildings in the nascent "green" housing market in Beijing. In section 4, we examine these "green" building's price premium during the subsequent resale and rental stages. Section 5 concludes.

2. Measuring a Residential Complex's "Greenness" in Beijing

Before 1980s, urban housing in China was allocated to urban residents as a welfare good by their employer (the work unit or "*dan-wei*") through the central planning system. Since 1980s, most of the work-unit housing has been privatized. By the end of the 1990s, housing procurement by work units for their employees had officially ended and new homes would be built and sold in the market.[3]

Beijing has one of the largest housing markets in China. In 2009, the quantity of newly completed residential construction reached 16.1 million square meters.[4] Home price started to surge since 2005. The average price of newly-built housing units in Beijing have been growing at an annual rate of 25 per cent during 2004~2010. This

[3] See Deng, Zheng and Ling (2005) and Zheng, Fu and Liu (2006) for more elaborated discussions.
[4] The statistics in this paragraph are from the "Chinese Statistics Yearbook" by the National Bureau of Statistics.

market's growth has led to a fast expansion of the real estate development industry. The number of real estate developers in Beijing has increased from 893 in 2000 to 3,190 in 2010. Most of the new entrants are small developers.[5] Those small developers need more marketing tools to compete with more established (famous) developers. As we discuss below, small developers have highlight "greenness" in their advertisements as marketing strategy to compete with famous developers in the market.

At present, potential apartment buyers in Beijing do not know how the energy efficiency housing units are performed. Since 2007, the Ministry of Housing and Urban-Rural Development in China has been seeking to create a nationwide program called the "China Green Building Evaluation Label".[6] Developers are encouraged to have their buildings evaluated in this program, and labeled with one to three stars according to the building's energy efficiency. However, few developers have participated in this program. For instance in 2009 only about twenty buildings across the whole country were evaluated and ranked, and less than ten of them were residential buildings. The slow implementation of such a rating program may be attributed to the lack of public confidence to the program, and insufficient institutional and financial mechanism to reward those who achieved higher scores for energy efficiency.

Since China's government has not developed a well-functioning green rating system like the standardized "LEED", "Energy Star", or "Green Mark", we construct an innovative "green" ranking in this study. To build our residential complex "green" metric, we rely on Google search. In particular, we use Google to search for each residential complex's name. Google reports back the total number of entries, and this serves as the denominator in our index.[7] To construct the numerator, we search for the residential complex's name plus three key words which are usually adopted when Chinese real estate developers advertise the green technologies used in their residential projects: "green (*lv-*

[5] In China, real estate developers are rated from grades I to V (Grade I is the highest ranking) by the government authorities, largely based on the company's scale and experience. In 2010, only 686 real estate developers in Beijing are rated at or above Grade III by the local housing authority, accounting for just 21.5 per cent in the total number.

[6] See the Ministry of Housing and Urban-Rural Development's website of the program for more details (www.cngb.org.cn).

[7] No filter is imposed in this keyword search, and we directly record the total number of hits yielded as the denominator. If the identical advertisement appears in multiple distinct websites, each of these websites will be counted. These rules also apply to the numerator.

se) technology", "energy-saving (*jie-neng*) technology" and "environmentally-friendly (*huan-bao*) technology". Dividing this count of joint searches by the total number of Google entries per residential complex and then multiplying by 100 yields our Google Green Index (*GREENINDEX*). The Index varies between 0 and 100. We use this ratio as the green metric instead of directly applying the absolute number of joint search outcomes in order to adjust for the pure scale effect of the complexes with different sizes on their marketing intensity.

During the period from 2003 to 2008, 1,567 non-landed newly-built housing complexes were listed and transacted in Beijing (See Figure 1 for the spatial distribution). From local housing authorities we collect information on presale price (*HP*) and major housing attributes for each complex, including the building complex's size (*PAREA*, measured as the total floor area), floor to area ratio (*FAR,* as a measure of density), green space ratio (*GREENRATE*, measured as the ratio between green space area and total land area of the complex), whether the units are sold with interior decoration on delivery or not (*DECORATION*), duration between presale year and expected completion year (*PRESALE_LENGTH*), distance to CBD (*D_CBD*), distance to the closest subway stop (*D_SUBWAY*), and whether it is built by a famous developer (*FAME*).[8] The definitions and summary statistics of the variables are listed in Table 1. Besides, we also calculate the Google Green Index for all these 1,567 complexes.[9] The distribution and major statistics of this index is provided in Figure 2. The average of the index is 9.47. The "greenest" complex in the sample achieves a Google Green Index of 46.5, which implies that the green technologies are mentioned in nearly half of the entries of this project in Google search. On the other hand, if a real estate developer does not take any action to advertise the residential building's energy efficiency, the numerator will be close to zero, so this complex will have a very low Green Index. Four complexes in our sample scored

[8] A well-known real estate research institute in China (*ZhongZhi* Real Estate Institute) publishes the list of "Top 100 Real Estate Developers in China" annually. We identify the developers who appear in the list for at least three years as "famous developers" in our study with *FAME* equaling to 1. There are altogether 36 famous developers in the over 1,200 developers in our sample.

[9] One weakness with our green index is that it is based on Google searches in calendar year 2010. Ideally, we could go back in time and conduct the Google search in the year when the apartments were presold. We use the ratio term to mitigate this problem—the denominator and numerator are both generated from using a Google search conducted in calendar year 2010. Besides, as the robustness check, we also re-run all the regressions listed in Table 3 to Table 6 only using the complexes presold between 2005 and 2008, and the results are generally consistent.

a zero on this “green” index metric.

**** Insert Table 1 about here ****

**** Insert Figure 1 about here ****

**** Insert Figure 2 about here ****

To verify whether our Google Green Index can effectively capture the application of green technologies in complexes, we use information collected from one of the leading real estate websites for newly-built housing complexes in China (www.soufun.com). This website lists the basic information of selected complexes which contains a brief introduction (typically 800 - 1,200 Chinese characters) provided by its developer and verified by the website. We are able to find 157 complexes in our sample (around ten per cent of the whole sample) on this website. We check the brief introduction carefully to see whether any green technology (for example, the central air conditioning system, “low-e” window glass) is emphasized for that complex. 32 of these 157 complexes emphasize the usage of at least one green technology in the brief introduction, and their average Google Green index reaches 13.7. Meanwhile, the average Google Green index for the left 125 complexes without any green technology mentioned is only 9.0, which is significantly lower than the first group based on the ANOVA test. This significant difference suggests that our Google Green Index does measure the usage of green technologies.[10] Nevertheless, it is important to note that our Index is not designed to measure the true energy performance of such technologies. Alternative metrics measuring the building’s actual “greenness”, for example, a measure of the average electricity consumption or heating consumption per square foot after the building is put into use, however, are not currently available in China.

We posit that home buyers believe that “green technology” does have a superior energy consumption performance. Sellers anticipate this and are catering their marketing (as revealed by Google) to meet this demand. The degree of asymmetry with regards to

[10] Due to data availability constraint, we are unable to expand this test to the full sample. We leave this for future studies.

information about the true energy performance remains an open question. The profit maximizing developers may know that they are selling a “lemon” or they may also not know but simply hope that their claims are true. The lack of public knowledge is further strengthened by the presale arrangement. In Chinese cities, developers often list the condominium units when the complexes are still under construction in order to reduce their financial and development risk.[11] The presold units are delivered to the buyers after the construction is completed, which is typically several months or even over one year after the presale transactions. Since prospective buyers cannot inspect the property before they make their purchase decision, the presales mechanism provides developers incentives to lie about or overstate quality of the building, for example, the effectiveness of the “green” feature of the building. In a hot market, sellers recognize that they can make claims that are difficult to substantiate, and while buyers will know that they cannot cross-check such claims, such claims may be effective in boosting the value of the differentiated product.[12]

It is also easier for a developer to engage in potentially exaggerating an apartment’s greenness, compared with other physical and neighborhood attributes. Consider an attribute vector including unit size, transportation accessibility (such as distance to subway), structure quality, view, community amenities (such as green space), and greenness. Unit size is clearly stated in the presale contract and is regulated by government so developers will not lie about it. Transportation accessibility and community amenities are not stated in the contract but they are both easy to be visually verified so developers do not have a significant information advantage. Asymmetric information is more likely to be an issue for attributes such as the structure’s quality, view and greenness. It is harder to verify them and thus this gives the seller an information edge. Among them greenness may be the one with the highest degree of incomplete information for buyers. “Greenness” is quite a new concept for most Chinese households.

[11] According to the statistics in 40 major cities by the Ministry of Housing and Urban-Rural Development in China, in 2009, 95.6 per cent of the transactions in the newly-built housing market were presold. In our sample city of Beijing, this percentage was 93 per cent.

[12] Zinman and Zitzewitz (2009) document that U.S ski resorts self-report 23 per cent more snowfall on weekends. Resorts that plausibly reap greater benefits from exaggerating do it more. Such false advertising helps these firms to attract more customers. One might conjecture that skiing represents repeated business and thus due to reputational concerns that resorts would not engage in such lying. In the case of a housing complex, such reputational concerns. Their study also surveys recent empirical work on false advertising in differentiated product markets.

Neither the apartment's "nominal" greenness (in terms of technologies used) nor its true greenness (in terms of performance) is included in presale contract and these attributes are not regulated by the government. A complex resident only can learn his unit's "greenness" after living in it for months and receiving energy bills. Therefore, at the presale stage developers have an incentive to engage in overselling with regards to "greenness".

We also compute the correlations between Google Green Index and other housing complex attributes (Table 2). Overall, Google Green Index is not highly correlated to other attributes. An interesting finding is that, in general, the complexes with less desirable hedonic attributes, less favorable marketing period, or higher environmental hazard risk (for example, the building located further away from the city center or subway stop, in the area with bad air quality, non-decorated at delivery, or pre-sold much earlier before completion) are more likely to be advertised as a "green" project. Non-famous developers are also more likely to adopt "green" strategy in their marketing. One possible explanation is that, recognizing their complexes have those negative attributes, the developers attempt to use "greenness" as a selling point to differentiate their products to command possible price premium.

**** Insert Table 2 about here ****

3. "Green" Buildings' Price Premium at the Presale Stage

In this section, we test the effect of the green advertising at the presale stage based on a set of hedonic pricing regressions. Our strategy is, after controlling for presale condominium complexes' other characteristics and the effect of market conditions (via the time dummies), whether a complex with higher Google Green Index could command a "green premium" as expected. If buyers believe that those green buildings can actually save energy and thus reduce utility bills, they are willing to pay a price premium. Since buyers are unable to test these "green" technology of the residential complexes at the presale stage, their knowledge mainly comes from public information and developers' advertising. Given that no green rating system has been formally set up in China and academic research on green buildings has not diffused widely to the public, the public is not well informed about the performance of such "green" technologies. The hedonic model is specified below:

$$\log(HP_{it}) = constant + \alpha_{ps}GREENINDEX_i + \beta_{ps}X_{it} + \gamma_{ps}T_t + \varphi_{ps}D_i + \mu_{it}, \qquad (1)$$

where the subscript "*ps*" denotes "presale". The average presale transaction price per square meter by building complex (*HP*; in natural logarithm term,) is adopted as the dependent variable of the hedonic model. The presale processes in some complexes lasted for more than one year. For these complexes the average prices by year are treated as independent observations in the model, and this is why the total sample size in this presale stage hedonic model is larger than the total number of complexes. The explanatory variables include Google Green Index (*GREENINDEX*) as well as a vector of the major housing attributes (*X*) listed in Table 1. We also include a vector of district fixed effects (*D*) to control for unobservable district-level attributes (there are 11 districts altogether), and control for year fixed effects (*T*).

The results of our hedonic pricing analyses are reported in Table 3. In all the five specifications, the coefficient of the Google Green Index we construct (α_{ps}) is positive and is statistically significant.[13] Taking Column (5) as an example, controlling for other factors, the "greenest" complex in our sample (with a Google Green Index of 46.5) are able to claim a price premium of about 17.7 per cent compared to the brownest complex with Google Green Index of 0. Therefore, at the presale stage, those developers who adopt green technologies in their complexes do receive a substantial reward, regardless of the real performance of such green technologies.

Besides the greenness measure, the coefficients of control variables are also consistent with expectation. In Column (1) we control for year dummies and the location

[13] We are aware of the potential concern that the Google Green Index might be correlated with some other housing attributes. To address such concern, we compute the variance inflation factor (VIF) of *GREENINDEX*. Our result shows that the VIF of *GREENINDEX* is only 1.03, far below the conventional threshold of 5.0, which mitigates the concern over multicollinearity in our specification.

attributes. We find a significant negative price gradient of minus 0.6 per cent with respect to the distance to CBD. In Column (2) we add in the air quality measure (PM10 concentration in that year in the district where the complex locates). It has a negative sign and is marginally significant. In Column (3) we further include four indicators of a complex's physical attributes. Interiorly decorated units are 4.3 per cent more expensive than those un-decorated. We introduce the time length between presale start date and completion date in Column (4). Those complexes presold much earlier before the real completion suffer from a significant price discount due to higher uncertainty. We include a developer's fame measure in Column (5). Famous developers enjoy a significant price premium of about ten per cent comparing to their counterparts.

From the above findings we can see that the complexes with better (physical and location) quality, or lower environmental hazard, or complexes developed by famous developers enjoy price premiums. Recall that the correlation matrix in Table 2 shows such complexes are less likely to be advertised as "green" complexes. A possible explanation is that, those developers who build complexes with less desirable attributes listed above or less famous developers have to explore other strategies to charge higher prices, and pursuing "green buildings" may be one. Our hedonic regressions show that this strategy does bring a significant price premium for the developers.

**** Insert Table 3 about here ****

To address the potential concern that our hedonic results may suffer from the problem of omitted variables, we further run a matching regression. Via the GIS software, each housing complex in our sample is matched with the closest complex sold in the same year, with a maximal distance allowed of 500 meters. We also impose the constraint that the size gap between the two complexes in a pair should not be very big (*i.e.*, the size of the smaller complex should be no smaller than one quarter of the larger complex), since some omitted physical attributes may be correlated with complex size. We finally have 654 pairs based on the above criterions. In Table 4, the price gap between the two complexes' prices within the same pair is regressed on the gap of the Google Green Indexes and other physical attributes (location attributes are dropped out because the two complexes are geographically close enough). The Google Green Index is positive and still holds the statistical significance at 1 per cent level.

**** Insert Table 4 about here ****

We acknowledge that the current specification of the matching regression only addresses the problem of omitted location attributes, but not omitted physical attributes. A developer who exaggerates the greenness of a complex is also likely to promote other physical features that we are unable to observe. This is a common challenge that most papers studying the green premium face. However, it is important to note that a unique feature of the Beijing's housing market is that complexes in a geographically small submarket are quite similar in terms of architecture design, structure type, and internal landscape design style. The uniqueness of the Beijing housing market partially mitigates the challenges of addressing the issue of unobservable physical attributes.

4. "Green" Buildings' Price Premium at the Subsequent Resale and Rental Stages

In Beijing, resale and rental markets for existing housing units are just starting to emerge.[14] Nevertheless, the resale and rental markets offer us an important test of the information asymmetry hypothesis concerning the objective greenness of "Google green" buildings. If the buildings that score high on the Google Green Index with a price premium (at the presale stage) are objectively green, this initial price premium will persist and will be capitalized into subsequent resale and rental prices. Conversely, if later it is found that the "green" technologies require high maintenance cost, or do not save energy at all, in other words, these "green" technologies induce higher life-cycle use costs, resale and rental units in such buildings should lose that price premium or even sell for a price discount.

The hedonic models are generally consistent with that for the presale stage (Eq. (2)

[14] According to the statistics by the Ministry of Housing and Urban-Rural Development in China, in 2009 the resale section accounted for 47.4 per cent in all housing transactions in Beijing, while the other 52.6 per cent comes from the newly-built section. According to the 2010 Urban Household Survey conducted by National Bureau of Statistics in China, only 22 per cent of the households in Beijing are tenants.

for resale price and Eq. (3) for rental price, respectively. The subscripts "*rs*" and "*rt*" denote "resale" and "rent", respectively). The resale and rental transaction data were collected in April 2011. For each housing complex in our sample, 10 resale transactions and 10 rental transactions in that month are randomly collected from a major broker in Beijing (we are unable to access historical transaction data). We calculate the average resale price (*RP*) and rental price (*RENT*) for each complex which are the dependent variables (in natural logarithm) in hedonic regressions.[15] The explanatory variables are generally the same with those in Table 3, while the year dummies are dropped since all transactions occurred in the same month. A new variable of *HAGE* captures the age of the complex (between the completion year and year 2011 when the resale and rental data was collected). The results are listed in Table 5.

$$\log(RP_{i,2011}) = constant + \alpha_{rs}GREENINDEX_i + \beta_{rs}X_i + \varphi_{rs}D_i + \upsilon_i, \qquad (2)$$

$$\log(RENT_{i,2011}) = constant + \alpha_{rt}GREENINDEX_i + \beta_{rt}X_i + \varphi_{rt}D_i + \theta_i. \qquad (3)$$

**** Insert Table 5 about here ****

In Column (1) and (3) we include district-specific air quality measure (PM10 concentration) in the year when the data was collected, so we are unable to further add in district dummies (complete collinearity). In Column (2) and (4) we replace this variable with district dummies to fully control for district-specific attributes. Complexes with larger green space have higher resale prices but do not have significantly higher rents. We observe significant price and rent premiums for clean air without controlling for district fixed effects. Renters are more sensitive to subway accessibility. It is an open question for us that high-density complexes have higher rents while the resale prices are lower.

The most important finding is that, unlike in the presale price hedonic, the coefficient of *GREENINDEX* (α_{rs}) is negative and statistically significant at the 1 per cent level in the resale price model, and α_{rt} is also negative (marginally significant) in the rental price

[15] We could not access enough information on unit-level attributes for these sample units, and thus could only calculate the average prices, instead of the constant-quality prices adjusted by methods like hedonic models. However, since the Google Green Index is a complex-level variable in our analysis, it would not be correlated with the omitted unit-level attributes. Therefore we believe the use of average price indicator here will not result in a biased estimation on Google Green Index's coefficient.

model, which implies that resale and rental units in the “green” buildings suffer from a price discount. Holding other factors constant, the “greenest” complex’s subsequent resale and rental prices are 11 per cent and 8.5 per cent lower compared with the complexes with zero Google Green Index respectively. Given that the “greenest” complex has a 17.7 per cent price premium at the presale stage, it faces a “value loss” of about 30 per cent when moving to the resale stage. We also duplicate the matching approach for the resale and rental samples (Table 6), and the results are robust– the green discounts for resale and rental prices are both significant (at 5 and 1 per cent level, respectively).

**** Insert Table 6 about here ****

One explanation for this is that the “green” technologies adopted in “green” buildings might require high maintenance cost or actually consume more energy. China’s residential construction sector is far from being a mature sector. Most of the so-called “green technologies” currently used in some residential complexes are simply adopted from the office building sector. Relatively little is known about the actual performance of such technology in residential buildings. Recent building energy engineering research shows that the stated “greenness” (by counting green technologies) and real energy efficiency diverge.

An alternative explanation is that households living in the “green” residential complexes using centrally controlled “energy-saving technologies” tend to consume more energy due to the central system and the current cost sharing mechanism lack of incentive for individuals to save. For example, the most popular “energy-saving technique” adopted in almost every “green” residential complex in China is the central air conditioning system, while most “non-green” residential buildings use the split air conditioning system.[16] According to a recent survey of 1,000 housing units in Beijing by Tsinghua University (Jiang *et al*, 2009), the average electricity consumption for the split air conditioning system is about 2 kWh per square meters of floor area per year, while that of the central air conditioning system reaches over 20 kWh – ten times as much as the

[16] In the split air conditioning system, one small air conditioning unit (with its own external machine) is installed in each bedroom/living room, and thus could be controlled separately.

traditional split system, due to the inflexible temperature control.

The original buyers who bought at the presale stage are unable to observe the true energy performance of an uncompleted building and thus may overestimate the energy consumption performance of these “green technologies”. However, once the construction completes and the presale-stage buyers move in and begin to pay energy bills, information on this particular building’s real “greenness” spreads. Subsequent buyers and tenants are able to visit the buildings and learn the truth, and finally the information is capitalized into resale and rental prices.[17]

Do our hedonic analysis outcomes indicate that the Beijing residential “nascent green market” is stuck in bad equilibrium such that new apartment buyers seeking “green” units will be lured into “overpaying” for an apartment relative to its true quality? We acknowledge that we cannot definitively answer this question. An optimist could argue that over time, China’s engineers will make progress so that newer vintages of housing complexes are more likely to be objectively energy efficient. If this claim is true, then future research will document that the price discount for marketed “green buildings” that have been built more recently should vanish over time because these “green marketed” buildings will be objectively greener than the average building. A pessimist might counter that fast urbanization in China brings millions of new home buyers to the market who have very little knowledge about green buildings and are susceptible to overpaying in the presale markets. If this is the case, then developers can consistently oversell the “greenness” of their projects to novices even though the completed green buildings elsewhere are already proven to be brown.

In China’s residential construction sector, there are plenty of “green” technologies which a developer can choose from. Therefore, knowledge about any specific residential project’s energy efficiency may not provide useful information about the energy efficiency of another residential complex. This inability to learn from experience lowers the likelihood that the market can engage in efficient product differentiation without government trusted certification. Up until today, China’s government has not developed a

[17] A significant price discount for green condominiums is also reported in Yoshida and Sugiura (2010) based on the Tokyo condominium market data. They attribute such negative effect to the high life-cycle costs of green housing units.

well-functioning green rating system, while the free market has not yet found a coordination device for objectively signaling which housing complexes are green.

5. Conclusion

As China builds more real estate assets, could a growing share of such new capital be "green"? There are two dimensions of "green" real estate. First a housing complex can be built in a city or a neighborhood within a larger district that has especially good local air quality and has access to ample green space. Residential real estate sells for a higher price in the areas that are objectively greener. A second dimension of real estate "greenness" focuses on a building's energy efficiency. A growing literature has examined using data from around the world to test whether such real estate commands a price premium.

Our new empirical work not only contributes to the literature on the second dimension of real estate "greenness", it also highlights an information problem that will hinder the growth of Beijing's nascent green building market.

Using Google search, we documented that some real estate developers are actively marketing their new residential complexes with so-called "green" technologies as "green buildings" to presale buyers. All else equal, our empirical estimates highlight that these buildings do sell for a price premium at the presale stage. But, we also document that these "green" properties subsequently resell and rent for a price discount. Our findings of this sign flip corroborate the findings of studies conducted by Chinese engineers who have reported that housing units in the "green buildings" embedded with the technologies such as central air conditioning actually consume more electricity. As this building-specific information is revealed only after the residential building complex is completed and the electricity bill arrives, the units in this complex actually resell and rent for a price discount.

We recognize that a limitation of our study is that we cannot extrapolate about the objective "greenness" of future apartment complexes based on the recent past experience. Ideally, the "green" real estate market in China will mature, so that there is a positive correlation between a building's "marketed greenness" and its objective energy efficiency.

The development of green real estate market will be further accelerated if a trusted "green rating" system could be introduced. Consumers who want to buy a "green" housing unit would be able to distinguish "green" from "brown". Private developers who seek to collect a price premium for building "green" real estate would be required to meet specific building requirements. Government labeling can help to create a trusted system for rating building "greenness". Furthermore, if the population of environmentalists in China's cities is willing to vote their pocketbook and is able to identify objectively "green" real estate, then for profit developers will have an incentive to supply such real estate and the nascent true green building market will emerge.

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Figure 1: Spatial Distribution of Residential Complexes in Beijing

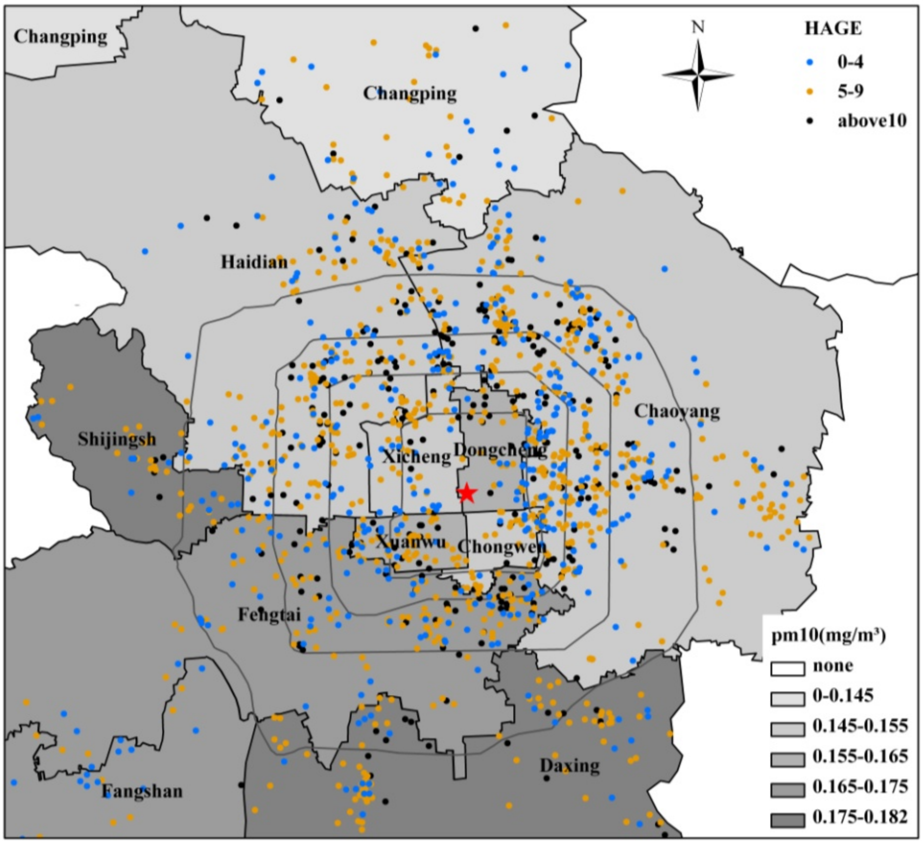

Figure 2: Distribution of the Google Green Index

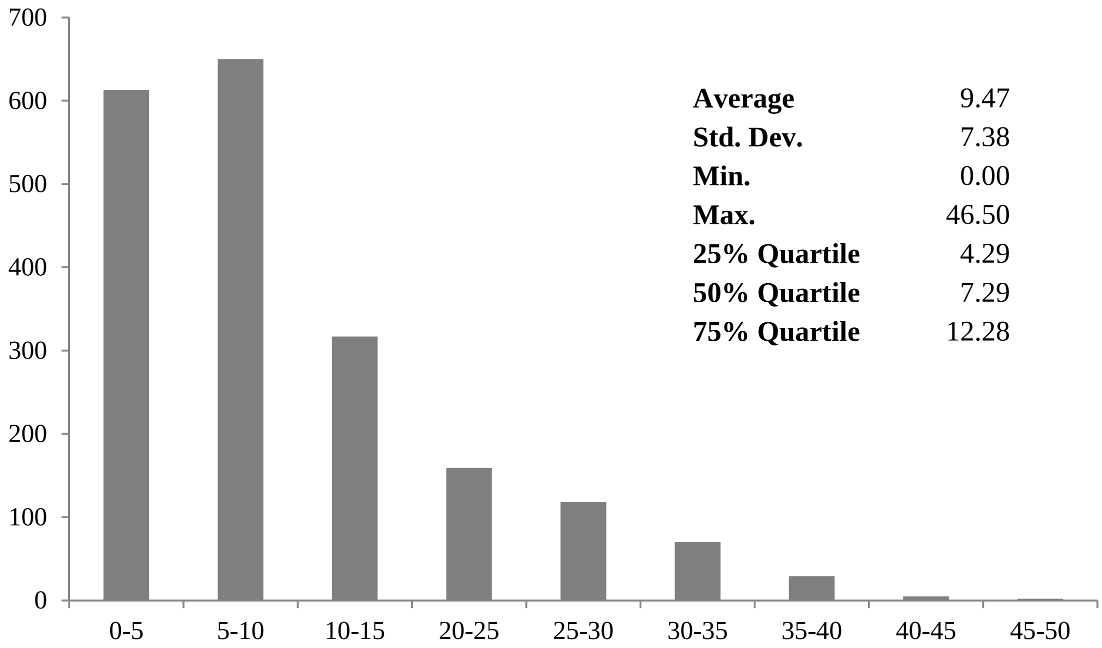

Table 1: Variable Definitions and Summary Statistics

Variable	Definition	No. of Obs.	Mean	Std. Dev.
HP	Average transaction price, by complex-year; in yuan per square meter.	3,330	8,982.33	6,454.46
RP	Average reselling price in April 2011; in yuan per square meter.	1,441	27,482.36	9,572.09
RENT	Average rent in April 2011; in yuan per square meter per month.	1,404	53.25	30.57
D_CBD	Distance to CBD (Tiananmen); in kilometer.	1,567	12.55	9.72
D_SUBWAY	Distance to the closest subway station; in kilometer.	1,567	4.14	7.45
AIRQUALITY	PM10 concentration (ug/m^3) of the district where the complex locates, by district-year.	1,567	0.17	0.03
PAREA	Total floor area of the complex; in million square meters.	1,497	0.19	0.34
FAR	Floor area ratio.	1,499	3.07	2.25
GREENRATE	Ratio between green space area and total land area of the complex.	1,567	0.35	0.08
DECORATION	Whether units included in the complex are decorated on delivery; 1=yes, 0=o/w.	1,519	0.30	0.46
PRESALE_LENGTH	Time length between presale and expected completion of the complex; in years.	1,514	1.85	2.21
FAME	Whether the complex is developed by a well-known developer (see the text for detailed definition); 1=yes, 0=o/w.	1,563	0.07	0.25
HAGE	Age of the complex (between the completion year and year 2011 when the resale and rental data was collected); in years.	1,514	6.72	3.11

Table 2: Correlation Matrix of Key Variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) *GRRENINDEX*	1.000	-	-	-	-	-	-	-	-	-
(2) *D_CBD*	0.058	1.000	-	-	-	-	-	-	-	-
(3) *D_SUBWAY*	0.067	0.943	1.000	-	-	-	-	-	-	-
(4) *AIRQUALITY*	0.113	0.047	0.088	1.000	-	-	-	-	-	-
(5) *PAREA*	-0.095	0.021	-0.002	-0.023	1.000	-	-	-	-	-
(6) *FAR*	-0.001	-0.372	-0.303	-0.046	-0.051	1.000	-	-	-	-
(7) *GREENRATE*	0.040	0.240	0.222	0.008	0.021	-0.198	1.000	-	-	-
(8) *DECORATION*	-0.031	-0.180	-0.141	-0.144	0.012	0.203	-0.032	1.000	-	-
(9) *PRESALE_LENGTH*	0.056	-0.142	-0.138	-0.271	-0.036	0.145	0.028	0.060	1.000	-
(10) *FAME*	-0.072	-0.060	-0.053	0.010	0.135	-0.004	-0.038	0.013	-0.031	1.000

Table 3: Home Presale Price Hedonics and the "Green" Premium

	(1) log(*HP*)	(2) log(*HP*)	(3) log(*HP*)	(4) log(*HP*)	(5) log(*HP*)
GREENINDEX	0.0029** (2.12)	0.0029** (2.13)	0.0026* (1.85)	0.0031** (2.16)	0.0035** (2.33)
D_CBD	-0.0056*** (-2.80)	-0.0056*** (-2.82)	-0.0051** (-2.46)	-0.0052** (-2.45)	-0.0051** (-2.43)
log*(D_SUBWAY)*	0.0001 (0.00)	0.0002 (0.02)	0.0019 (0.14)	0.0014 (0.10)	0.0008 (0.06)
AIRQUALITY	-	-1.0653 (-1.09)	-1.1490 (-1.12)	-1.2239 (-1.19)	-1.2156 (-1.18)
FAR	-	-	0.0126** (2.55)	0.0144*** (2.86)	0.0146*** (2.90)
PAREA	-	-	0.0027 (0.08)	-0.0013 (-0.04)	-0.0136 (-0.39)
GREENRATE	-	-	-0.1470 (-1.11)	-0.0945 (-0.70)	-0.0940 (-0.70)
DECORATION	-	-	0.0425* (1.78)	0.0401* (1.67)	0.0418* (1.73)
PRESALE_LENGTH	-	-	-	-0.0116** (-2.42)	-0.0115** (-2.39)
FAME	-	-	-	-	0.0995** (2.49)
Constant	8.5288*** (109.11)	8.7302*** (43.34)	8.7752*** (40.71)	8.7751*** (40.51)	8.7695*** (40.43)
District Dummies	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes
Observations	3288	3288	2997	2949	2940
R^2	0.21	0.21	0.21	0.21	0.22

Notes: (1) t-statistics are reported in parentheses.

(2) ***: significant at the 1% level; **: significant at the 5% level; *: significant at the 10% level.

(3) See Table 1 for variable definitions.

Table 4: A Home Presale Price Hedonic Regression Based on a Matching Approach

	(1) △log(*HP*)
△*GREENINDEX*	0.0065* (1.81)
△*FAR*	-0.0094 (-1.01)
△*PAREA*	0.6473*** (3.13)
△*GREENRATE*	-0.2347 (-0.88)
△*DECORATION*	-0.1335*** (-2.64)
△*PRESALE_LENGTH*	-0.0024 (-0.34)
△*FAME*	0.0713 (0.85)
Observations	654 (pairs)
R^2	0.03

Notes: (1) t-statistics are reported in parentheses.

(2) ***: significant at the 1% level; **: significant at the 5% level; *: significant at the 10% level.

(3) See Table 1 for variable definitions.

Table 5: Hedonic Regressions for Resale Price and Rent

	(1) log(*RP*)	(2) log(*RP*)	(3) log(*RENT*)	(4) log(*RENT*)
GREENINDEX	-0.0036*** (-2.90)	-0.0025** (-2.36)	-0.0024 (-1.62)	-0.0019 (-1.46)
D_CBD	-0.0126*** (-9.99)	-0.0050*** (-3.62)	-0.0108*** (-6.86)	-0.0022 (-1.21)
log(*D_SUBWAY)*	-0.0901*** (-9.23)	-0.0336*** (-3.59)	-0.1133*** (-9.69)	-0.0587*** (-5.08)
AIRQUALITY	-0.9214*** (-2.90)	-	-0.8392** (-2.19)	-
FAR	-0.0040 (-0.95)	-0.0053 (-1.48)	0.0123** (2.43)	0.0108** (2.41)
PAREA	-0.0364 (-1.48)	-0.0102 (-0.49)	-0.0792*** (-2.72)	-0.0532** (-2.09)
GREENRATE	0.2664** (2.39)	0.3195*** (3.37)	0.2422* (1.76)	0.2469** (2.04)
DECORATION	0.0668*** (3.54)	0.0490*** (2.99)	0.1925*** (8.49)	0.1488*** (7.36)
FAME	0.0665** (2.04)	0.0486* (1.75)	0.0677* (1.74)	0.0369 (1.08)
HAGE	-0.0038 (-1.36)	-0.0085*** (-3.57)	-0.0096*** (-2.88)	-0.0144*** (-4.89)
Constant	10.4762*** (145.59)	9.9678*** (159.97)	4.1070*** (47.03)	3.588*** (46.31)
District Dummies	No	Yes	No	Yes
Observations	1293	1293	1258	1258
R^2	0.36	0.55	0.37	0.52

Notes: (1) t-statistics are reported in parentheses.

(2) ***: significant at the 1% level; **: significant at the 5% level; *: significant at the 10% level.

(3) See Table 1 for variable definitions.

Table 6: Hedonic Regressions for Resale Price and Rent Using a Matching Approach

	(1) △log(*RP*)	(2) △log(*RENT*)
△*GREENINDEX*	-0.0030** (-2.11)	-0.0065*** (-3.69)
△*FAR*	-0.0042 (-1.13)	0.0138*** (3.00)
△*PAREA*	0.1421* (1.73)	0.0152 (0.15)
△*GREENRATE*	0.0963 (0.91)	0.0447 (0.34)
△*DECORATION*	-0.0035 (-0.17)	0.0221 (0.88)
△*FAME*	0.0009 (0.03)	0.0415 (1.00)
△*HAGE*	-0.0035 (-1.30)	-0.0133*** (-3.95)
Observations	654 (pairs)	654 (pairs)
R^2	0.02	0.06

Notes: (1) t-statistics are reported in parentheses.

(2) ***: significant at the 1% level; **: significant at the 5% level; *: significant at the 10% level.

(3) See Table 1 for variable definitions.