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Doing well by doing good? The case of housing construction quality in China☆

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ABSTRACT

Construction quality is a major problem in China's housing market. We investigate whether the housing market could provide incentives to encourage developers to promote construction quality beyond the compulsory, minimum standards by testing the financial viability of efforts made in this field by developers. This study takes place in the city of Beijing, where the "Great Wall Award", granted by the local construction bureau, is used as an indicator of excellent performance in construction quality. Our analysis shows that, from 2005 to 2010, the transaction price in the housing resale market of a unit that received the award can be up to 7.0% higher than a similar unit that did not receive the award. This difference is due to both the higher possible rent and a lower capitalization rate. However, we find no meaningful price premium at the presale stage, while developers with a record of winning the award cannot use such reputation to obtain price premiums in later projects either. These findings indicate a mismatch between the costs and benefits that residential developers face when deciding to enhance the quality of their construction. This mismatch partially explains the current housing construction quality problems in China, and may also discourage future improvements in this field. More efforts from the government are required to correct such market failures.

1. Introduction

China's urban housing sector has developed rapidly since housing reforms in the late 1990s. Today, the largest number of new housing units in the world is produced in China (Fig. 1). According to the National Bureau of Statistics of China, 10.73 trillion m^2 of housing was completed in urban areas in 2012 in terms of floor area, with 73.7% contributed by the private housing sector. Accordingly, the per capita living space for urban households in China has increased from about 20 m^2 in 2000 to over 32 m^2 in 2012.

However, despite the substantial increase in the quantity of housing units, the quality of housing, especially construction quality, remains a major concern in China. According to China's Consumer Association, construction quality complaints are the most common issue among complaints about real estate development. Although most of these complaints concentrate on relatively "minor" defects such as leaking roofs, they still have a significant effect on the quality of life of the residents. In addition, construction quality is one of the major factors that determine the resilience of residential buildings to accidents, such as fires or explosions, and natural disasters, like earthquakes. After the Wenchuan earthquake in 2008, many researchers pointed out that the losses and number of deaths in the earthquake could have been significantly reduced if the overall construction quality in that area had been of a higher standard.[1] Finally, in some extreme cases, shoddy construction might directly cause great damage. As a latest example, on April 4, 2014, a 5-story residential building in Ningbo, Zhejiang Province, which was completed in 1994, crumbled to the ground, killing one resident and badly injuring several others.[2]

In addition to its direct impact on individual residents, the overall quality of construction in China's housing sector could indirectly but severely affect global sustainability. According to official estimates by the Ministry of Housing and Urban–Rural Development, the average life expectancy of residential buildings in China is only 25–30 years,

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[1] Among others, see Chen and Qian (2008) as an example for reviews of related research.

[2] See the report from China Daily (http://www.chinadaily.com.cn/china/2014-04/04/content_17407305.htm) for more details about this accident, as well as a summary of recent building collapses in China since 2009 (http://europe.chinadaily.com.cn/china/2014-04/04/content_17409025.htm).

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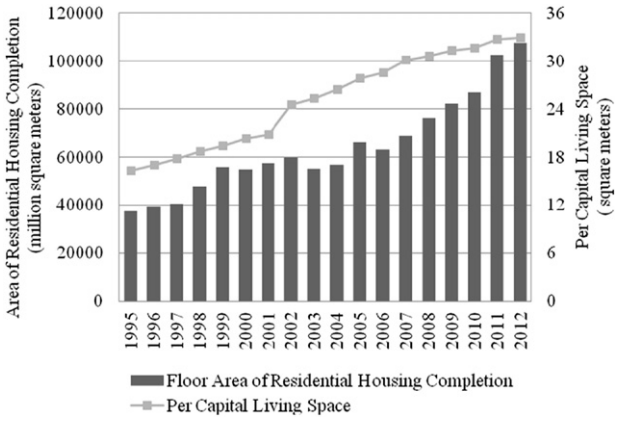

Fig. 1. Floor area of residential housing completions and per capita living space in urban China.
Source: National Bureau of Statistics.

less than half that of most developed countries.[3] Building construction and demolition consume a significant amount of raw materials and energy, and also substantially contribute to the production of carbon emissions and solid waste (Hendrickson & Horvath, 2000; Raymond & Kernan, 1996). The short life expectancy of the majority of Chinese residential buildings, which is at least partially due to poor construction quality, means that the environmental impact of building and demolishing them will largely offset China's other efforts in improving its sustainability.

Therefore, improving the construction quality of new residential buildings has become a major priority in the future development of China's real estate and construction industries. So far, most efforts have emphasized ensuring minimum levels of construction quality, such as construction quality inspections by government-sponsored institutes, or surety bonds/insurance of construction quality. In this study, by contrast, we focus on whether the housing market itself can provide enough incentives and encourage developers to spend additional efforts to promote construction quality beyond the minimum, compulsory standards. The key issue here is the financial sustainability of developers in pursuing outstanding construction quality: if dwelling units with extraordinarily good construction quality could be recognized and rewarded with a statistically and economically meaningful price premium in the market, which is large enough compared with the additional costs that the developers incurred, then they will have enough financial incentives to continue doing so. This kind of market mechanism has been shown to be effective in several other fields. A well-known example is the positive expected return that is thought to have driven the rapid development of green buildings in the past few years in several major economies (Eichholtz et al., 2010; Kok et al., 2011). If we can find evidence of a positive return associated with outstanding construction quality in China's housing market, a continuous improvement in housing construction quality in the near future can be expected, which might be even more important than government mandates.

While it is difficult to get enough micro-level data to directly calculate and compare the return rates associated with residential buildings with different levels of construction quality, we choose to test two preconditions for the effectiveness of such market mechanisms. First, a reliable signal indicating the construction quality of residential buildings should exist and be widely accepted by market participants, thus guaranteeing a price premium. Housing is a typical example of an experience good, whose quality is difficult to be directly observed or investigated in advance, but can only be tested gradually upon consumption (Nelson, 1970; Shapiro, 1983). In particular, the effects of some aspects of housing construction quality can only be revealed after a long period of occupancy, via their performance during disasters like earthquakes, or thorough inspections by professionals. The literature has pointed out that, for such experience goods, consumers need to rely on market signals such as price distortions, certifications, advertising, or warranties to distinguish their quality; therefore, a positive signal would typically be granted with a substantial price premium (Palfrey & Romer, 1983; Tirole, 1988).

Kain and Quigley (1970) provided the first attempt in the context of housing to evaluate the quality of dwelling units based on survey data, and conclude that some factors have significant effects on housing rental prices. Wieand (1983) uses data from the Annual Housing Survey to calculate the probability-to-defect ratio as a proxy of housing quality, and shows that housing quality is important in affecting rentals. Chen and Rutherford (2012) suggest that time-on-market, or the length of time a house takes to be sold, can serve as a signal of housing quality, although they do not directly test its effect on housing prices. Ooi et al. (2014) used the CONQUAS scoring metric in Singapore to measure housing construction quality, and find a significant premium for good workmanship quality in the new sale, sub-sale and resale housing markets.

The second precondition is that the price premium, if it exists, should be large enough to offset the additional costs of increasing construction quality.[4] At the very least, the party that is burdened with the additional costs should be rewarded with benefits from the price premium; otherwise a mismatch problem could occur. A similar mismatch problem was documented in the green housing market in Singapore by Deng and Wu (2014). Their empirical analysis pointed out that while developers have to pay most of the additional costs, they only obtain a small portion of the associated benefits since the price premium mainly come from the resale stage, which substantially discourages further development of green housing in Singapore. A similar mismatch problem may also exist in China. Currently, most new dwelling units in China are presold before completion, when developers find it difficult to claim any construction quality premium since the buildings are still under construction and their quality cannot be directly assessed. Potential alternatives through which developers can enjoy the benefits include committing to outstanding construction quality in advance to seek a premium during the presale stage, or taking advantage of the reputation around good construction quality to build a premium into future development projects (Chau et al., 2007). However, the effectiveness of such strategies remains an open question and can only be tested via empirical tests.

In this study, we use the capital city of Beijing in China as the example to test these two preconditions. The Great Wall Award (GW award), which is awarded by the local housing and construction authority in Beijing, is adopted as a signal of outstanding performance in construction quality. This award was introduced in 1997, and has been granted annually since 1999 to recently-completed construction projects with extraordinarily good construction quality.[5] Taking advantage of several unique datasets, we are able to merge the award data with micro-level transaction data in both the presale and resale sectors,

[3] Source: speech of Baoxing Qiu, Vice Minister of Ministry of Housing and Urban–Rural Development, in the Sixth International Conference on Green and Energy-Efficient Building in 2010.

[4] In the literature of quality management of construction projects, it is widely accepted that, besides contractors and consultant engineers, owners also play a key role in achieving high construction quality, by choosing contractors with better records in quality performances, setting higher and more specific quality requirements in the contracts, providing more daily quality inspections on site, etc. The owners, or housing developers in our case, typically need to pay additional efforts or expenses accordingly. See the review of Gransberg and Molenaar (Gransberg & Molenaar, 2004) and Kagioglou, Cooper and Aouad (Kagioglou et al., 2001) for example for more details.

[5] The "Great Wall Award" was firstly introduced in 1997, but at the beginning there was no standard assessment criteria. The formal evaluation standard was issued in 1999, and the evaluation exercise and award have been conducted annually since then.

and then construct empirical models in both sectors. The model in the resale sector is used to test the effectiveness of the signal and the existence of a construction quality premium, and the model in the presale sector is used to investigate whether such a premium is rewarded to the developers.

The empirical analysis leads to mixed findings. Encouragingly, the results for the resale sector suggest that the GW award has been well accepted by market participants, and can grant a significant price premium in the housing resale sector. Controlling for other factors, the resale price of a unit in a housing complex that received the award can be expected to be 7.0% higher than its non-awarded counterparts. Further analysis suggests that this premium comes from both the ability to charge a higher rent and a lower capitalization rate. The results are consistent across various robustness checks.

However, the analysis finds no evidence of any meaningful price premiums associated with the GW award at the presale stage. In addition, developers with a good record of winning the award cannot use such reputation to obtain a price premium in future development projects either. This reveals a typical mismatching problem: while developers have to pay additional costs to promote construction quality beyond the compulsory minimum standard, they do not receive any financial returns for doing so. We believe such dilemmas are at least one of the problems behind poor construction quality in the Chinese housing sector, and imply a need for the government to engage with the industry to correct such market failures.

The paper proceeds as follows. The next section describes the data used in this study. Section 3 empirically investigates the price premium in the housing resale sector associated with the GW award. Section 4 focuses on the premium for the award at the presale stage, and discusses the dilemma for housing developers accordingly. The final section concludes the study.

2. Data

2.1. The construction quality award in Beijing

We use the local construction quality award in Beijing; i.e., the GW award, as an indicator of excellent performance in construction quality in this study.[6] The GW award has been granted by the Beijing Municipal Commission of Housing and Urban–Rural Development, the local bureau in charge of the construction and real estate industries, since 1997 to both owners (i.e., developers of housing projects) and contractors of construction projects to promote quality management practices. According to the documents published by the Commission, the selection criteria for the GW award focus on the quality of the construction of the main structure, including the stability and robustness of the foundation, safety and durability of the main structure, high seismic fortification intensity, and the level of fire resistance. In addition, performance in decoration and technological innovation is also considered.

Typically, the selection and awarding of the GW award proceed as follows. All new buildings in Beijing that meet the compulsory minimum requirements on construction quality can voluntarily choose to apply for the award. Evaluation starts some time (typically one year) after the completion. In addition to reviewing documents, a team of 4 to 6 experts appointed by the Commission investigate and evaluate the building's specifics. They then submit an investigation and recommendation report to the Commission. At the final stage, the Commission forms a committee to review all the reports and vote for the winning projects.

By the end of 2011, 5001 construction projects in Beijing had won the GW award, including 2506 residential projects and 2495 commercial/public projects. Fig. 2 depicts the number of construction projects awarded annually between 1999 and 2011. In the early years (1999–2001), only 20–40 residential projects received the award each year. The number jumped to about 300 in 2002, and has fluctuated between 150 and 300 residential projects since then.[7]

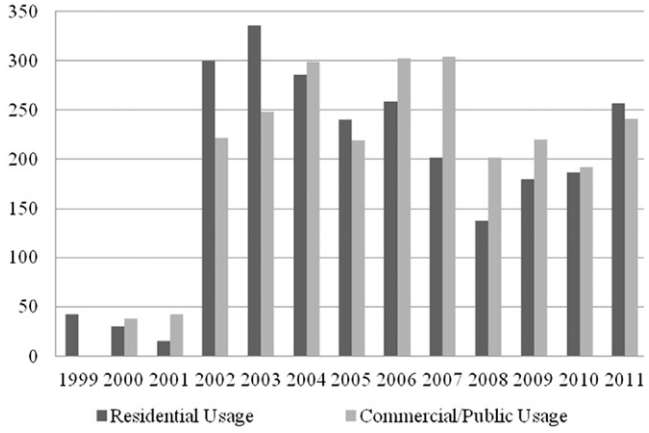

Fig. 2. Distribution of GW awarded construction projects over years. Source: Beijing Municipal Commission of Housing and Urban–Rural Development.

It is reasonable to consider that the GW award has been widely recognized as a signal of outstanding performance in construction quality in the market. Fig. 3 reports the volume of outcomes based on Bing searches with GW award-related keywords.[8] The number of GW award-related reports fluctuated between 1999 and 2007, and significantly increased since 2008. We also searched fang.com, the largest and most influential advertising platform for newly-built housing projects in mainland China, as well as the official websites of developers receiving the GW award. In almost all cases, developers highlighted the GW award information on either the website of the winning complex or its own official website.

2.2. Housing transaction data

To test the potential price premium associated with the GW award, we use micro-level housing transaction data from Beijing for both new and resale transactions.

The data for new sales transactions is provided by the local housing bureau in Beijing, and includes all 310,643 units sold between January 2006 and December 2009. For the resale sector, we, with the help of a leading brokerage company in Beijing, obtained information on 44,194 housing resale transactions in 1588 complexes between January 2005 and December 2010, accounting for about 10% of all resale transactions.[9] In addition, we obtained information on 131,813 rental transactions in the same period from the same brokerage company.[10] For each

[6] Besides the "Great Wall Award", there is also a national-level award for excellent construction quality, named "Luban Award", granted by the Ministry of Housing and Urban–Rural Development. By the end of 2010, only 192 construction projects in Beijing had won this award, of which only 16 were residential buildings.

[7] We cannot directly calculate and report the share of these awarded units in the housing market by year, since the volume of awarded units is reported in number of projects, while the total volume of housing completion and transaction is reported in number of floor area. According to the analysis based on our merged data, which will be discussed later, in general the awarded units would account for about 10% in the annual transaction volume of the newly-built housing market in Beijing. Therefore, the GW award can be perceived to be prestigious.

[8] For each year, we use the combination of "Beijing", "*GW award*" and the year, with the first two keywords in Chinese, and report the number of websites resulted via Bing search. We also tried other major internet search engine such as Baidu and Google, and the trend of results is generally consistent.

[9] As discussed in detail in Wu et al. (2014) and Zheng et al. (forthcoming), which adopted the same resale and rental dataset in their empirical analysis, this sample can be expected to reasonably reflect the whole market, without remarkable selection biases.

[10] In both the resale and rental samples, we exclude units in buildings completed before 1998, since the GW award was introduced in 1997, and the Beijing Municipal Commission of Housing and Urban–Rural Development began publishing the list of winning projects in 1998.

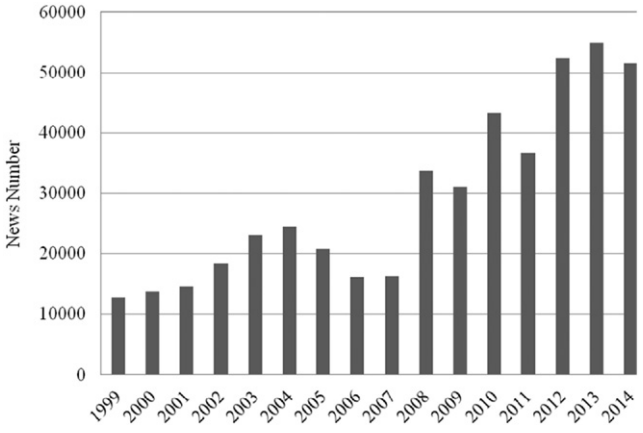

Fig. 3. The public news coverage on GW awards over years.
Source: authors' calculations; see the text for more details.

transaction, we have detailed information, including transaction date, transaction price, developer and the major hedonic attributes, such as location, unit size, and floor level. Building age information is also available for resale/rental transactions.

The GW award and housing transaction datasets are then merged. As listed in panel A of Table 1, 32,213 new sale units received the GW award, accounting for 10.38% of all the units. As discussed before, since most new units were presold and the GW award could only be granted some time after the completion of construction, all new units in this sample that received the GW award actually obtained it after being presold to households. The corresponding figure is 8.40% in the resale sector and 8.12% in the rental sector. This provides the treatment group in the following empirical analysis.

However, directly comparing GW-awarded units with non-GW-awarded units can still be misleading due to the potential omitted variable problem: the non-construction quality related housing characteristics of GW-awarded and non-GW-awarded units may be different, which may also lead to the housing prices differing across these two groups. Therefore, two methods are adopted here to define the control group in the empirical analysis.

First, we use propensity score matching (PSM), as proposed by Eichholtz et al. (2010), Deng et al. (2012), and Deng and Wu (2014), to match the GW-awarded units (the treatment group) with "similar" non-GW-awarded units (the control group) to mitigate any potential bias in estimating the construction quality premium. Dwelling units in non-GW-awarded complexes are first weighted according to their propensity scores, reflecting the probability that their non-GW-awarded related hedonic attributes are similar to units in the treatment group. We then match each unit in the treatment group with the unit in the non-GW-awarded complex that has the most similar propensity score (the"nearest one-to-one neighbor matching" criterion). The distribution of the matched sample is listed in panel B of Table 1. In the matched sample, 3695 non-GW awarded resale units are matched with the GW-awarded units, and the corresponding number is 31,583 in the presale sample and 10,662 in the rental sample. Table 2 provides the major statistics in each category for both the original and matched samples. The non-construction quality related characteristics of the GW-awarded and non-GW-awarded groups are generally more similar after the matching procedures. Fig. 4 depicts the annual average transaction price for the awarded- and matched non-awarded groups. This information provides some preliminary evidence on the existence of a price premium for the GW award in the resale sector (but less so for the presale sector), although a more conclusive analysis is carried out in the following empirical analysis.

Secondly, we choose to rule out the potential omitted variable bias by taking advantage of the co-existence of both GW-awarded and non-awarded units within the same complex. The GW award does not necessarily apply to all units/buildings in a housing complex; by contrast, in most cases, only a few buildings in a housing complex with multiple buildings are granted with the GW award. Units in the other buildings within the same complex are categorized as "non-awarded" in panel A of Table 1. For example, in the resale sector, besides the 3711 units in GW-awarded buildings, there are another 11,937 "non-GW-awarded units in complexes with GW-awarded buildings", leaving 28,546 units in complexes that have no relationship to the GW award. Within the same complex, units in these GW-awarded and non-awarded buildings should be expected to share exactly the same complex-level attributes (Wu et al., 2014), and, controlling for unit-level attributes and transaction time, their difference in transaction price should only reflect the effect of the GW award.

3. Existence of a construction quality premium in the resale sector

3.1. Empirical strategy

We start with the resale sector to explore whether the GW award is accepted by market participants as an effective market signal indicating construction quality in the residential buildings. Following the empirical strategy adopted by previous studies, we test the existence and magnitude of the construction quality premium associated with the GW award by directly relating the unit sale price to the units' GW labels and a set of structural, spatial and temporal control variables via a hedonic model.

The hedonic model is specified in Eq. (1):

$$\log P_{it} = c + a \cdot GW_i + \beta \cdot X_i + y \cdot R_i + \delta \cdot K_i + \varepsilon. \quad (1)$$

The dependent variable is the logarithm of the transaction price (RMB per square meter) of transaction i sold in month t, P_{it}. As for the explanatory variables, our major interest is whether the unit is located in a GW-awarded building, GW_i, which serves as a proxy of extraordinary construction quality. The basic hedonic variables (X_{it}) include: (1) unit size, whose effect on transaction price is uncertain and can only be revealed via empirical tests; (2) unit floor level; typically units

Table 1
Sample distribution.

		Resale	Presale	Rent	Sum
A. Original (unmatched) sample					
Awarded units		3711	32,213	10,702	46,626
Non-awarded units	Non-awarded units in complexes with awarded buildings	11,937	87,464	36,840	136,241
	Units in complexes without any awarded buildings	28,546	190,786	84,271	303,603
Total		44,194	310,463	131,813	486,470
B. Matched sample					
Awarded units		3695	31,583	10,662	45,940
Non-awarded units		3695	31,583	10,662	45,940
Total		7390	63,166	21,324	91,880

Table 2
Descriptive statistics of key variables.

	Awarded units				Non-awarded units (original)				Non-awarded units (matched)			
	Resale	Rent	Presale	Total	Resale	Rent	Presale	Total	Resale	Rent	Presale	Total
Distance to center (kilometers)	13.98	13.54	11.16	11.94	16.21	14.54	19.07	17.53	14.29	14.02	12.23	12.81
	(6.49)	(6.54)	(5.84)	(6.18)	(8.34)	(8.00)	(12.78)	(11.44)	(7.14)	(7.26)	(10.22)	(9.43)
Distance to subway (kilometers)	2.05	2.00	1.44	1.62	1.98	1.73	3.14	2.64	1.99	1.97	2.36	2.24
	(2.09)	(1.54)	(1.42)	(1.54)	(1.88)	(1.42)	(6.10)	(4.96)	(2.18)	(1.55)	(5.44)	(4.62)
Unit size (square meters)	102.72	84.78	116.98	108.36	94.68	79.23	120.22	106.44	103.68	87.15	117.92	109.63
	(46.97)	(39.45)	(56.77)	(54.19)	(44.02)	(36.73)	(86.53)	(74.8)	(53.04)	(41.85)	(73.63)	(67.22)
Unit floor	10.15	10.33	10.19	10.22	8.73	8.65	7.69	8.05	10.10	10.31	9.81	9.95
	(7.10)	(6.93)	(6.50)	(6.65)	(6.67)	(6.48)	(5.96)	(6.19)	(7.16)	(7.07)	(6.47)	(6.68)
Building age	4.86	4.63	–	4.69	5.73	5.57	–	5.61	4.91	4.67	–	4.73
	(2.21)	(2.33)		(2.30)	(2.46)	(2.68)		(2.63)	(2.29)	(2.63)		(2.55)

Note: standard deviations are reported in parentheses.

on higher floors have better views and are thus more desirable and expected to get higher prices; (3) building age, which is set as the length between the transaction year and the completion year; the unit transaction price is expected to be negatively correlated with building age, due to the vintage effect; (4) distance to city center, which is the complex's distance in kilometers to the center of the city (more

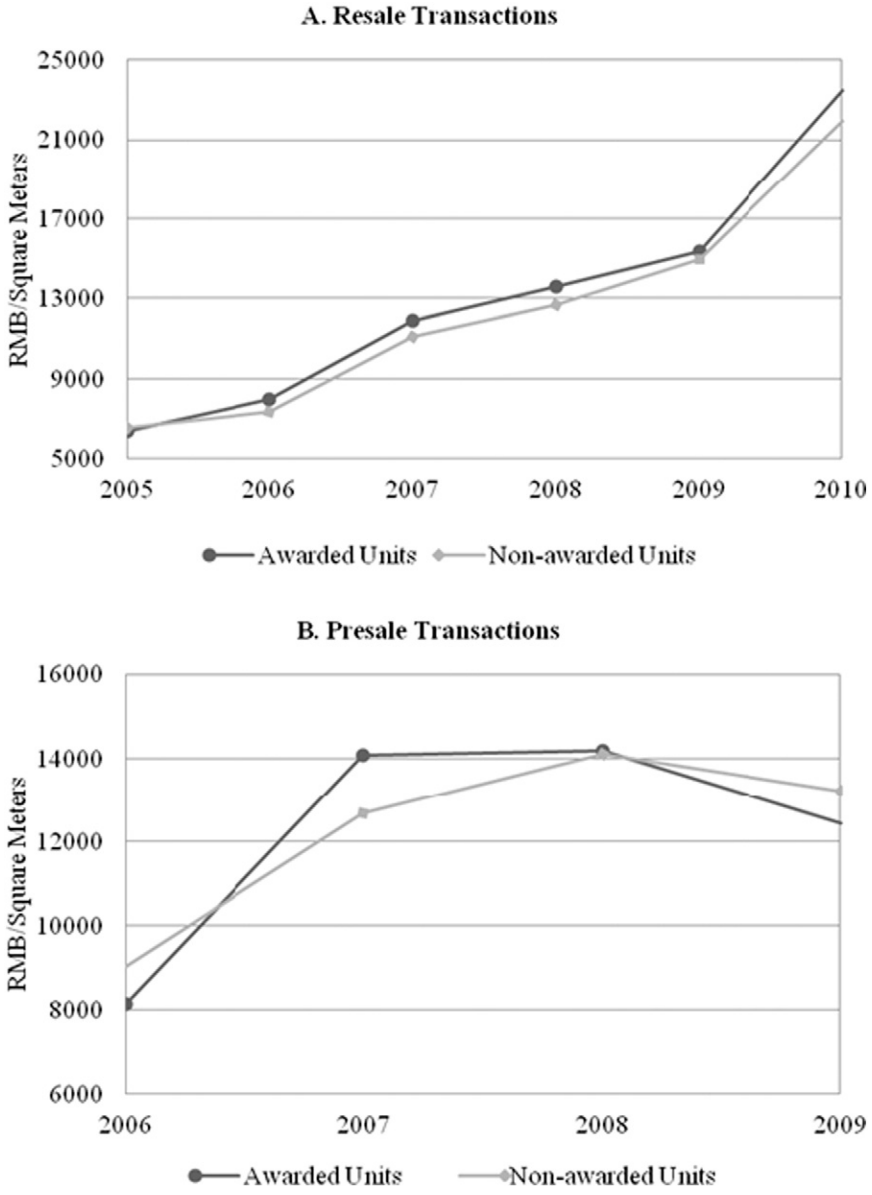

Fig. 4. Average transaction price and GW award over years.

specifically, Tian An Men Square in Beijing); units in complexes closer to the city center are expected to achieve higher prices; (5) distance to subway station, which is the complex's distance in kilometers to the nearest subway station in operation; units in complexes closer to subway stations are expected to achieve higher prices. In addition, we also include a set of district dummy variables (R_i) to capture other unobserved locational attributes of residential complexes, and a set of monthly dummies (D_i) to control for the effect of overall market conditions. Finally, we introduce a set of developer fixed effects (K_i) to control for unobserved developer characteristics that might also affect housing prices, such as developers' reputations that are not related to construction quality.

3.2. Evidence of a premium for construction quality in the resale sector

The results of the basic specification of the resale market are listed in Table 3, which are estimated with OLS. The first column indicates the price premium associated with resale units that received the GW award, with the non-awarded units matched via the PSM procedures as the control group. The coefficient for the GW award is positive in the model and statistically significant at 99%. According to the results, controlling for other factors, the transaction price of a GW-awarded unit is expected to be 7.0% higher than its non-GW-awarded counterparts. Moreover, the effects of all the control variables are generally consistent with our expectations. The overall explanation power of the model reaches as high as 82.3%.

In column (2) of Table 3, we introduce the units in the buildings that did not receive an award but are in the complexes where other buildings received the GW award as the control group. The results show that, compared with the non-awarded buildings, the GW-awarded buildings in the same complex do enjoy a significantly higher resale price, with the price premium being about 3.3%. It is worth noting that a spillover effect may have existed here, since some market participants may have failed to distinguish the awarded and non-awarded buildings within the same complex; in other words, it is very likely that the coefficient of the GW award dummy is dampened in column (2). Accordingly, in the following analysis we choose to adopt column (1) as the basic specification for the following analysis, although the results in column (2) still provide strong evidence that the GW award is associated with a remarkable price premium.[11]

Table 3
Effects of GW Award in the housing resale sector. Dependent variable: log(unit price per square meter).

Variables	(1) With matched non-awarded units via PSM procedures as the control group	(2) With non-awarded units in the same complexes as the control group
GW award	0.0679***	0.0327***
	(0.0121)	(0.0049)
Log(distance to city center)	−0.4009***	−0.3196***
	(0.0230)	(0.0073)
Log(distance to subway station)	−0.0165**	−0.0317***
	(0.0075)	(0.0030)
Unit size	−0.0002***	0.0003***
	(0.0001)	(0.0000)
Unit floor	0.0016***	0.0023***
	(0.0004)	(0.0003)
Building age	−0.0194***	−0.0258***
	(0.0022)	(0.0011)
Constant	13.5273***	12.7657***
	(0.2416)	(0.1023)
Year fixed effects	Yes	Yes
District fixed effects	Yes	Yes
Developer fixed effects	Yes	No
Observations	7390	15,603
R-squared	0.8238	0.6945

Note: standard errors are reported in parentheses.
*** Significant at the 1% level.

Table 4
Effects of GW award in the housing resale sector: rental and capitalization rate.

Variables	(1) Log(rental price)	(2) Log(rent-to-price ratio)
GW award	0.0240**	−0.0287**
	(0.0099)	(0.0122)
Log(distance to city center)	−0.4343***	0.4041***
	(0.0195)	(0.0232)
Log(distance to subway station)	−0.0588***	0.0141*
	(0.0065)	(0.0076)
Unit size	−0.0037***	−0.0040***
	(0.0001)	(0.0001)
Unit floor	0.0018***	−0.0007*
	(0.0003)	(0.0004)
Building age	−0.0193***	0.0196***
	(0.0019)	(0.0022)
Constant	8.9369***	−9.7623***
	(0.3644)	(0.2502)
Year fixed effects	Yes	Yes
District fixed effects	Yes	Yes
Developer fixed effects	Yes	Yes
Observations	21,324	7390
R-squared	0.5951	0.8235

Note: standard errors are reported in parentheses.
* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

We also shed more light on why households are willing to pay higher prices for GW-awarded units. According to the basic principle of the asset pricing model, we investigate the effect of construction quality on rental prices and the rent-to-price ratio (i.e., capitalization rate in the resale market). Column (1) in Table 4 uses rental transaction observations, with the monthly rental price (yuan per sq. m. per month; in logarithm terms) as the dependent variable, and the explanatory variables are consistent with Eq. (1). Again, controlling for other factors, the GW-award dummy is significantly positive in the model, implying a rental premium of 2.4%. The coefficients of the control variables are in general consistent with the results of column (1) in Table 3.

Column (2) in Table 4 uses the resale transaction observations again, but with the imputed rent-to-price ratio as the dependent variable. In order to obtain the dependent variable, we first use the hedonic model in the rental sector (i.e., column (1) in Table 4) to impute the rental price for each resale transaction, and then use the imputed rental price and actual resale price to calculate the rent-to-price ratio. The explanatory variables are consistent with Eq. (1). Holding other factors constant, the capitalization rate of GW-awarded units is 2.8 percentage points lower compared with the non-GW-awarded counterparts.

According to the above results, outstanding performance in construction quality affects two separate factors. First, the units that are well-constructed are preferable to residents, perhaps because they are expected to be safer, especially in terms of resilience to disasters such as earthquakes, or because they are less likely to suffer from defects such as roof leaks or wall cracks. Thus, the GW-awarded units were able to claim higher rental prices. Secondly, these well-constructed units are also expected to have lower maintenance costs, a lower depreciation rate, or lower risks, and thus have a lower capitalization rate (rent-to-price ratio in this case). These two effects together

[11] Besides the transaction price, we also test the effect of the GW award on residential units' time-on-market. More specifically, we use the duration between listing and transaction of a unit as the dependent variable (in logarithm term), with all the explanatory variables consistent with Eq. (1). The GW award dummy is negative, but statistically insignificant in the model. Such results suggest that the effect of the GW award concentrates in the price perspective. We only report these results in the footnote since we do not have information of sellers' listing prices, and thus our model on time-on-market cannot be as strict as suggested by Anglin et al. (2003) or Chen and Rutherford (2012).

Table 5
Effects of GW award in the housing resale sector: robustness check. Dependent variable: log(unit price per square meter).

Variables	(1) Sample: 2006–2009	(2) Sample: exclude central districts	(3) Sample: original sample
GW award	0.0806***	0.0539***	0.0540***
	(0.0119)	(0.0135)	(0.0048)
Log(distance to city center)	−0.4659***	−0.4319***	−0.3088***
	(0.0231)	(0.0271)	(0.0018)
Log(distance to subway station)	−0.0091	−0.0142***	−0.0425***
	(0.0077)	(0.0078)	(0.0018)
Unit size	−0.0001	−0.0003***	−0.0002***
	(0.0001)	(0.0001)	(0.0000)
Unit floor	0.0015***	0.0019***	0.0012***
	(0.0004)	(0.0004)	(0.0002)
Building age	−0.0189***	−0.0181***	−0.0295***
	(0.0022)	(0.0024)	(0.0006)
Constant	13.6891***	13.8614***	12.8677***
	(0.288)	(0.2886)	(0.0515)
Year fixed effects	Yes	Yes	Yes
District fixed effects	Yes	Yes	Yes
Developer fixed effects	Yes	Yes	Yes
Observations	5536	6792	44,021
R-squared	0.8138	0.8360	0.7068

Note: standard errors are reported in parentheses.
*** Significant at the 1% level.

Table 6
Effects of GW award at the housing presale stage. Dependent variable: log(unit price per square meter).

Variables	(1)	(2)	(3)
GW award	−0.0005	–	–
	(0.0024)	–	–
Previous award(s) since 1999	–	−0.0005	–
	–	(0.0003)	–
Previous award(s) during the previous 3 years	–	–	−0.0002
	–	–	(0.0003)
Log(distance to city center)	−0.2555***	−0.2524***	−0.2525***
	(0.0035)	(0.0017)	(0.0017)
Log(distance to subway station)	0.0011	−0.0297***	−0.0297***
	(0.0016)	(0.0007)	(0.0007)
Unit size	0.0010***	0.0013***	0.0013***
	(0.0000)	(0.0000)	(0.0000)
Unit floor	0.0029***	0.0024***	0.0024***
	(0.0002)	(0.0001)	(0.0001)
Constant	11.1276***	11.3222***	11.3217***
	(0.0422)	(0.0152)	(0.0152)
Year fixed effects	Yes	Yes	Yes
District fixed effects	Yes	Yes	Yes
Observations	63,164	308,045	308,045
R-squared	0.6538	0.6442	0.6442

Note: standard errors are reported in parentheses.
*** Significant at the 1% level.

result in a construction quality price premium of about 7.0% in the housing resale market in Beijing. These results indicate that the first precondition for the financial sustainability of developers' investment in improving construction quality is met.

3.3. Robustness checks

We start with the time-consistency of the results in the robustness checks. In particular, considering that for the presale stage, our transaction sample only covers the period 2006 to 2009, we use resale data between 2006 and 2009. As listed in column (1) in Table 5, the results remain consistent. Thus, the difference in the price premium discussed below does not result from the difference in the sample period. For similar purposes, considering that the presale units are mainly concentrated in the suburban areas, while the resale transactions are distributed in the whole city, in column (2) we exclude all resale units located in the four central districts (i.e., Dongcheng, Xicheng, Xuanwu and Chongwen). The coefficient for the GW award dummy is slightly smaller, but it is still significantly and economically significant. This implies that the difference in the price premium discussed below does not result from the difference in the sample area either.

In addition, column (3) provides the results using the original sample for the resale market; that is, we introduce all the units in the non-GW-awarded buildings (without PSM matching) as the control group. The results are consistent with the contents of Table 4, where the price premiums still significantly exist.

4. Dilemma for housing developers

4.1. Existence of construction quality premiums at the presale stage

The above analysis has provided evidence that households in Beijing evaluate the GW award as a reliable signal of good construction quality and are willing to pay a substantial premium for that. However, a positive price premium alone does not necessarily guarantee a positive economic return to residential property developers. For the financial sustainability of developers, the key issue here is whether such premium also exists in the new sales sector, and whether it is large enough to compensate for their additional efforts in promoting construction quality.

As discussed before, developers in China encounter a typical mismatch problem. On the one hand, most units are sold before the completion of the structure because of the presale arrangement. On the other hand, the performance in construction quality is only observable and measurable after the completion of construction and developers can only apply for the GW award several months after the completion. Therefore, in most cases, a developer cannot use the GW award as explicit evidence to indicate their construction quality at the presale stage. This does not necessarily prevent developers from sharing the benefits of good construction quality. For example, a developer can commit to make additional efforts and guarantee extraordinary performance in construction quality at the presale stage, and ask for a premium from the buyers. But whether such a commitment would work is an open question and can only be assessed empirically.

For this purpose, we use transactions in the presale sector in Beijing to test the existence of a construction quality premium at the presale stage. The dependent variable is the transaction price of the unit, and the explanatory variables are generally consistent with Eq. (1), although the control variable of building age is not applicable here. The results are listed in the first column of Table 6. According to the results, the dummy variable of the GW award is statistically insignificant in the model. The results suggest that, at least in Beijing during the sample period, developers were unable to obtain any benefit in advance for their future efforts in promoting construction quality.[12]

4.2. Contribution to developers' reputations

Even without an immediate price premium, developers still have other opportunities to seek reimbursements for their efforts to promote construction quality. In particular, a good record in construction quality may become an important part of a developer's reputation and help it obtain abnormal returns from future projects.

While it is difficult to quantitatively measure a developer's reputation in the Chinese housing market, we choose to directly test whether a developer's prior record in winning a GW award affects the transaction prices of new units in subsequent residential complexes. The results are listed in columns (2) and (3) in Table 6. In column (2), both

[12] We also try using the newly-built units' time-on-market as the dependent variable, and again the GW award dummy is statistically insignificant in the model.

the dependent and explanatory variables are generally consistent with those in column (1), and the only difference is that the GW award dummy is replaced with a variable measuring the number of times that the developer had been awarded the GW award between 1999 and the year before the transaction of the current complex. The results show that this variable is not statistically significant. Then in column (3) we only count the number of GW awards received in the previous three years, and this variable is still insignificant.[13] Thus, the lack of significance of previous records in winning GW awards does not result from the "short memories" of households.

An interesting question is why such a reputational enhancement mechanism does not work in Beijing when it works well in Hong Kong, as shown by Chau et al. (2007). One potential reason is that winning the GW award is more like an ad hoc event for Beijing developers, instead of being an outcome of their outstanding ability or good tradition of quality management. Between 1999 and 2011, there 2495 developers with 4703 buildings have won the GW award, among which 1713 developers (68.66%) won the award once, and 399 developers won it twice. Accordingly, a winning record cannot contribute to a developer's reputation. As evidence, we rarely find developers mentioning their record in winning a GW award in advisements for subsequent new housing complexes in Beijing.

The absence of a statistically and economically significant construction quality premium at the presale stage implies an economically important mismatch between developers' costs and benefits when investing in housing construction quality. While developers are burdened with the additional attention and costs of improving housing construction quality, they are not rewarded by any corresponding benefits, as the housing construction quality is only observable after developers have sold the units to households. This would make investing in housing construction quality unfeasible for residential developers, which, as we suggest earlier, may at least partially explain the current problem of the poor quality of housing construction in China and discourage further improvement.[14]

5. Conclusion

With the rapid development of the housing market, construction quality remains a major problem in China. It affects the quality of life of residents, as well as efforts to make China's development more sustainable. In this study, we focus on the financial viability of developers' investments in construction quality, with the hope that a positive financial return will encourage them to promote housing construction quality above the minimum compulsory requirements.

With Beijing as an example, we use the GW award as an indicator of outstanding performance in construction quality, and test the price premium of receiving it in both resale and presale sectors. The findings are twofold. On the one hand, there exists a significant and substantial price premium in the resale sector, which results both from higher rents and a lower capitalization rate. On the other hand, however, further analysis indicates that developers cannot share in these benefits in the presale sector, either in current or future projects.

We believe such a mismatch at least partially explains the current problem of construction quality in China's housing market, or may even discourage future improvement efforts. The findings imply that the government has to play a key role in addressing this market failure by promoting construction quality, either by issuing additional mandatory provisions, inspecting construction projects, or providing further direct or indirect incentives to developers to encourage them to build dwelling units of extraordinarily good quality. Meanwhile, developers can seek other channels to maximize the benefits from their investments in construction quality. For example, they can provide more explicit commitments of construction quality performance, and emphasize construction quality in their marketing efforts.

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[13] We also try one, two, four, or five years, and the results always remain robust.

[14] Ideally, we could provide further evidence to support the conclusion on mismatch problem here by introducing the repeat sales sample: if the premium does not exist during the presale stage, but only appear in the resale stage, one should expect a positive abnormal price growth rate associated with the GW-awarded units. Deng and Wu (2014) adopted this strategy in their research in Singapore's green housing market to prove that the green price premium mainly exists in the resale stage. Unfortunately, in our current dataset there are few repeat sales samples, and we leave it on the agenda for future research.