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Measuring House Prices in China's Emerging Residential Housing Market

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Abstract: The recent house price surge in several major cities in China has attracted global interest, which makes an improved understanding of accurate measurement of house prices in China as well as in other emerging markets an important and timely issue. The three most common methods of price measurement are applied to both the newly-built and resale housing market in China: the simple average method without quality adjustment, the hedonic modeling approach, and the matching approach with the repeat sales modeling framework. The theoretical and empirical analyses suggest that in the emerging residential housing market in China, the hedonic method is preferable in measuring the house price level and its movement when applied to the newly-built housing market, while the repeat sales method with matching approach performs better for the newly emerged resale market for houses. The results also indicate that the two official house price indices published and widely used in China both suffer from downward bias, which implies that the current Chinese housing market may be even more overheated than is reported in existing metrics.

1. Introduction

The dramatic rise of housing prices in several major cities in China has generated global interest among investors, policy makers, scholars and journalists. Due to China's rising economic importance, there has been growing concern that a house price bubble in China and its aftermath would be a catastrophe not only to China but also to the world economy.¹ Accordingly recent researches have sought to provide a more rigorous test of the sustainability of Chinese housing prices by detecting and measuring potential mispricing.²

These analyses depend on the accurate measurement of the level and movement of Chinese house prices. Currently two official house price indices are regularly updated in China, namely, the "Average Selling Price of Newly-Built Residential Buildings" (abbreviated as the "Average Price Indices" henceforth), and the "Price Indices for Real Estate in 35/70 Large and Medium-sized Cities" (abbreviated as the "35/70 Cities Indices" henceforth), both calculated and reported by the National Bureau of Statistics of China. They provide almost the only consistent source for description and analysis of Chinese house prices.³

However, these indices are widely mistrusted – simply because the price movements suggested by these indices deviate significantly from common experience in the market. For example, while the government and the general public in China were highly concerned with the apparent surge in house prices in 2009, the "35/70 Cities Indices" suggested that nominal house prices increased by 1.5% in 2009 compared with the preceding year. This generated great suspicion and criticism.⁴ Furthermore, problems in the consistency of data also puzzle researchers. For instance, in their attempt to detect the house price bubble in major Chinese cities, Ahuja *et al* (2010) point out that these two indices largely diverged during 2004-2009, and thus could lead to totally different results in the bubble gauge. For these reasons, the Chinese statistics agency announced in February 2011 that it would systematically adjust the house price statistics system, including suspending reporting any house price indicator in the national level.⁵

In the Chinese context, the accurate measurement of house price is also of especially enormous importance for policy makers. Even after the transition from a housing allocation system to private housing markets in the late 1990s, the Chinese government retains strong and direct influence on the housing market via a number of direct market intervention policies. Since

¹ As a recent example, in IMF's report of "Global Economic Prospects and Policy Challenges" prepared for the meetings of G-20 finance ministers and central bank governors in February 2011, "a potentially steep price correction in Chinese property markets" is listed as one major risk for global recovery.

² Among others, see Hui and Shen (2006), Wu, Gyourko and Deng (2011), Ahuja *et al* (2010), and Dreger and Zhang (2010) for example. There are also a large number of related studies published in Chinese.

³ Some researchers also try to independently construct house price indices and conduct researches based on these indices, such as Wu, Gyourko and Deng (2011) and several articles and reports in Chinese by Institute of Real Estate Studies at Tsinghua University. But the difficulty in collecting micro-level transaction data in China restricts the usage of this research strategy.

⁴ See the reports from *Financial Times* ("Fears of China Property Bubble Grow", Mar 10, 2010) or *China Daily* ("Doubts over Increase in Property Price", Feb 27, 2010) for more details.

⁵ See the reports from *Wall Street Journal* ("China Scraps High-profile Property Data", Feb 17, 2011) for more details.

2003 the State Council in China has explicitly listed the “relative stabilization of house prices” as the key objective of its intervention, and hence the Council frequently adjusts the policy instruments according to the level and growth rate of house prices.⁶ The appropriateness of such direct and volatile government intervention is well beyond the scope of this research, but it highlights the importance of a reliable house price index – the incorrect signal from systematic errors in measurement may lead to improper intervention policies and could cause great damage to the market.

In this paper we thus focus on the appropriate measurement of house prices in China. Instead of seeking to invent a “new” approach to measurement and estimation, we follow the comparative research strategy initiated by Case, Pallakowski and Wachter (1991), Case and Szymanoski (1995), and implemented recently by Hill, Melser and Syed (2009), Dorsey *et al* (2010), Nagaraja, Brown and Wachter (2010). We apply the major price index construction methods developed in the existing literature to Chinese housing markets, and compare their performance in theory and also in practice. Our purpose is to evaluate the accuracy of the two official house price indices currently used in China, and to suggest the methods for the development of price measurement in Chinese housing market.

Three general price estimation methodologies are included in our analysis. The first includes simple average methods without any adjustment for quality change or variability among housing units. These methods are seldom discussed in scientific research, but they have been widely used in practice in China, due to constraints on data availability. The latter two are traditional quality-adjusted approaches, the hedonic method and the repeat-sales method. The procedures we adopt to use the hedonic method are generally consistent with those employed in other countries like U.S. However, due to data limitations, we could not directly apply the repeat sales method to Chinese housing markets. Accordingly, the matching approach developed by McMillen (2008), Deng, McMillen and Sing (2010) is adopted: each observation on the sale of a unit is matched with the most similar unit sold previously; the classical weighted repeat sales procedure is then applied to these matched pairs.

All these three methodologies are compared using two unique large transaction dataset from both the newly-built and the resale housing market in a typical Chinese city. The results indicate that, since in most Chinese housing markets (both newly-built and resale) the housing qualities keep continuously changing during recent years, the simple methods without quality adjustment are always biased. Meanwhile, although the matching approach with the repeat sales modeling framework works best among all candidates in the resale housing market, it tends to be downward biased when adopted in the newly-built housing market, due to some unique features in newly-built units’ selling process in China. These leave the hedonic method the only

⁶ For example, the Chinese government switched the direction of housing market intervention from constraint to stimulus within a few months in mid-2008 when house prices started to stagnate or even fall in some major cities, but then shifted back to the opposite direction again in the second half of 2009 when the house price again surged.

reasonable choice in measuring house price levels and movements in the newly-built housing sector, while the matching approach is a preferable option in the recently emerged resale market.

More importantly, because the “Average Price Indices” is currently calculated by the weighted average formula without quality adjustment, and the “35/70 Cities Indices” with a method very similar with the matching approach discussed in the paper, the above findings imply that these two official indices are both problematic, especially in the newly-built housing market. As an initial attempt to correct such potential bias and reveal the true path of house price, we apply the hedonic modeling method to the newly-built housing market in 4 major Chinese cities. Recent house price growth rates are significantly higher according to our results than in the two official indicators.

The paper proceeds as follows. The next section describes some key features of Chinese housing markets which could affect house price index estimation and introduces the two official house price indices. Section 3 briefly reviews the three major house price indices and discusses their advantages and potential problems when adopted in Chinese housing markets. These three methodologies are then applied in a typical Chinese housing market in Section 4. Section 5 concludes.

2. Chinese Housing Markets and House Price Indices

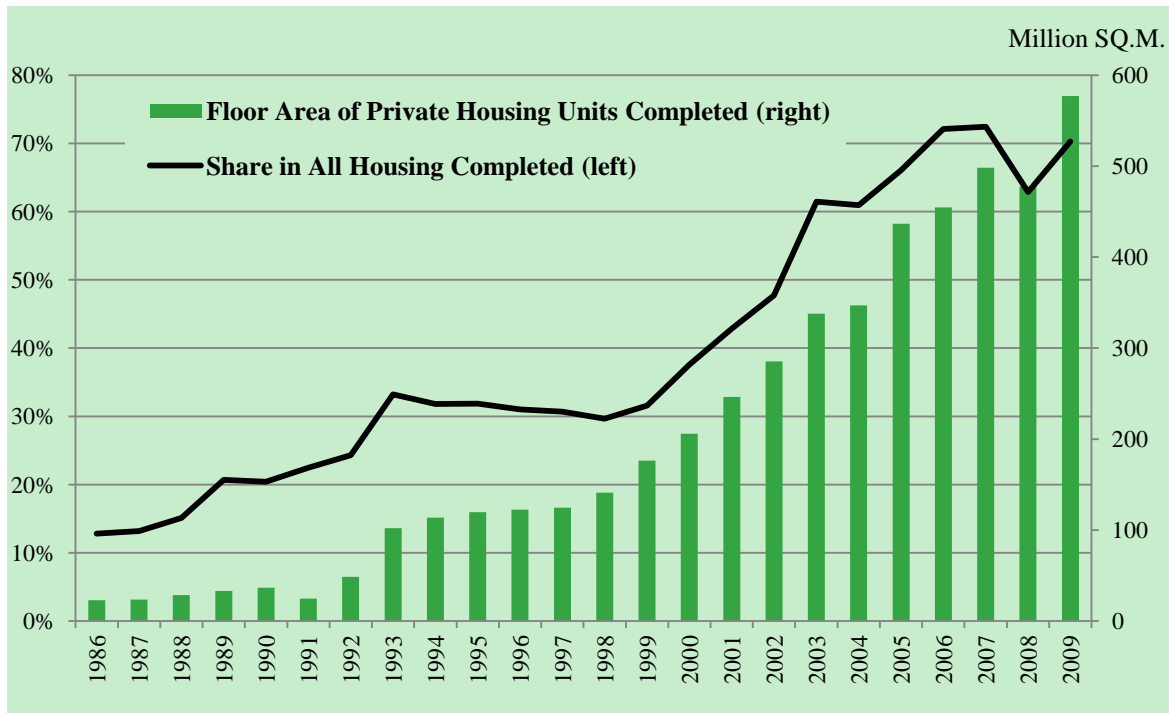
2.1 Major Features of Chinese Housing Markets

In most Chinese cities there has only been a truly private market for housing units since the late 1990s. For the three decades after the founding of People’s Republic of China in 1949, the urban housing sector was dominated by a housing allocation system, in which almost all urban housing units were developed and owned by the work units (*dan wei*), and then allocated to individual households at low rent. A private housing market did not exist during that period, nor did any concept related to a market price.

The Chinese government embarked on housing reforms in the early 1980s, which expanded and advanced step by step in the following two decades. The work units were required to terminate gradually the direct housing allocation system, and sell the housing units they owned to the resident workers. Finally in 1998, the State Council in China issued the 23rd Decree, a milestone in Chinese housing reform. Work units were no longer allowed to develop new residential housing units for their employees in any form. Instead, they had to integrate any implicit housing benefits into employees’ salaries, and the households had to buy or rent their residential housing units in the private housing market (or public housing system for low income households). This led to a rapid development of the private housing sector in China since the end of 1990s. As depicted in Figure 1, the annual volume of private housing units completed

increased from 140 million square meters in 1998 to near 580 million in 2009, while its share in all housing units completed more than doubled from 30% to over 70% during the same interval, with the rest mainly from the public housing system.

Figure 1: Floor Area of Private Housing Units Supplied and the Share in Total Annual Flow Supply, 1986-2009



Source: Calculated based on statistics published by National Bureau of Statistics of China in “Statistics Yearbook of China.”

Due to such a large volume of annual new supply, currently housing markets in most Chinese cities are still dominated by the newly-built sector, instead of the resale market. According to the statistics provided by the Ministry of Housing and Urban-Rural Development in China, in 2009 the newly-built units accounted for over 60 percent of floor area of all housing units sold in 40 major cities. This makes the accurate measurement of newly-built houses an especially important issue in China.

The rapid expanding in new private housing supply also leads to a continuous decentralization in housing units’ locational pattern. On the one hand, in most Chinese cities, especially the large and developed cities, there is little land left in the central regions available for housing development, and hence most of the new housing complexes locate in the suburban area.⁷ On the other hand, the surging house prices force more households to choose houses farther from the city center. Considering location is a most important housing attribute in determining transaction price, this structure change in house quality may make the

⁷ Among others, see Wu, Xu and Yeh (2007) for a literature review on housing suburbanization in major Chinese cities.

measurement in long-run house price growth misleading if not adjusted properly. Besides such suburbanization trend, in general the existing literature has not reported other apparent housing quality changing over time in recent Chinese housing markets.

The third distinguishing feature of Chinese housing markets is that, instead of detached or attached houses that are popular in many countries, the current urban housing sector in China is dominated by condominium units.⁸ A typical condominium complex in China typically contains hundreds (or even thousands) of units located in dozens of high-rise residential buildings on a contiguous land parcel. Therefore the attributes of dwellings can be grouped into two levels, the complex level and the unit level. Although housing units within the same complex may still differ in some unit-level characteristics, such as unit size, floor level, and specific environment attributes (*e.g.*, noise, view of green space, accessibility to sunshine, *etc.*), they obviously share the same complex-level attributes including location characteristics and neighborhood amenities, and could also be very similar or exactly the same in other unit-level attributes like construction type and building age. This inherent similarity or homogeneity of dwelling characteristics within the same complex can be helpful for quality control during estimating Chinese house price indices.

Finally, newly-built housing units' selling process in China is unique and quite different with that of the resale housing units discussed in literature. Typically, the developer of a newly-built housing complex lists all the units included when it receives the selling permit from local government.⁹ The developer sets the listing price for each unit, and can adjust listing price for any unsold unit according to changed market conditions. The potential buyers come to visit the complex and choose their preferred units. In most cases, the potential buyers cannot bargain with the developer - a household that is interested in certain unit can only choose to purchase at the given listing price, or reject the price and turn to other units/complexes. Thus a newly-built unit's transaction price always equals its listing price set by the developer.

Such selling process could affect the price measurement in the newly-built housing market via at least the following two aspects. Firstly, it leads to a shift in quality of the dwellings within the complex. When all units within the same complex are simultaneously listed and open to select, it is natural that units with the highest quality are picked and purchased first, following by units with lower quality, and units with lowest quality are sold last; in other words, within the same complex units' unit-level attributes always degrade over time. Secondly, the complex-level price path will be greatly affected by its developer's pricing behavior, since units' transaction prices always equal the listing prices. We will discuss their impacts on house price measurement more detailed in the next section.

⁸ According to the statistics published by National Bureau of Statistics of China in the "Statistics Yearbook of China", the percentage of condominium units in newly-built housing market kept around 94%-96% during the past decade. For example, in 2009 condominium units accounted for 94.6% in floor area of all newly-built housing units sold in the national level.

⁹ Note that presale of newly-built housing units is permitted in China, which means that developers can get the permit and sell housing units to households before the units are completed and ready to deliver.

2.2 *Current House Price Indices in China*

Currently there are two official nationwide indices in China that track house price movements, both calculated and reported by the National Bureau of Statistics of China (NBSC). Almost all analyses and research focusing on the Chinese housing market, as well as policy makers' decisions on housing market interventions, rely on these two indicators.

The first house price index is the "Average Selling Price of Newly-Built Residential Buildings" ("Average Price Indices"). Since mid-1990s, all real estate developers in China are required to report regularly a variety of business indicators to the government statistics bureau, including the total volume (in floor area) of newly-built housing units sold and the total price of these units.¹⁰ By aggregating these reported figures at various levels, and dividing the total price by total floor area of the transacted units, the weighted average house prices are calculated and reported at the city, province, and national level, respectively. House price indices could be further calculated based on these average prices if needed.

In 1997 the NBSC started to publish a second house price indicator, the "Price Indices for Real Estate in 35/70 Large and Medium-sized Cities" ("35/70 Cities Indices"), which originally covered 35 major cities and was then expanded to 70 cities in July, 2005. This index seeks to control for quality change by taking advantage of the homogeneity of units within the same complex. For each sampled housing complex,¹¹ the average transaction price is calculated in each month and compared with that of the same complex in the preceding month. The monthly house price growth rate at city level is calculated as the weighted average of the growth rates of all sampled complexes in the corresponding month. Although the calculation within complexes is still not quality adjusted, the complex-level quality change could be at least partly controlled through the above procedures. Consequently, the "35/70 Cities Indices" are much more influential than "Average Price Indices" in China.¹²

Figure 2 provides the real quarterly price series for newly-built houses suggested by these two indices. Due to the difference in city coverage (the "Average Price Indices" include all cities in mainland China, while the "35/70 Cities Indices" only cover 35 major cities before 2005 and 70 cities after that), a direct comparison of their national level series is ambiguous. Hence we focus on the city level comparison, using four major Chinese cities (Beijing, Shanghai, Guangzhou and

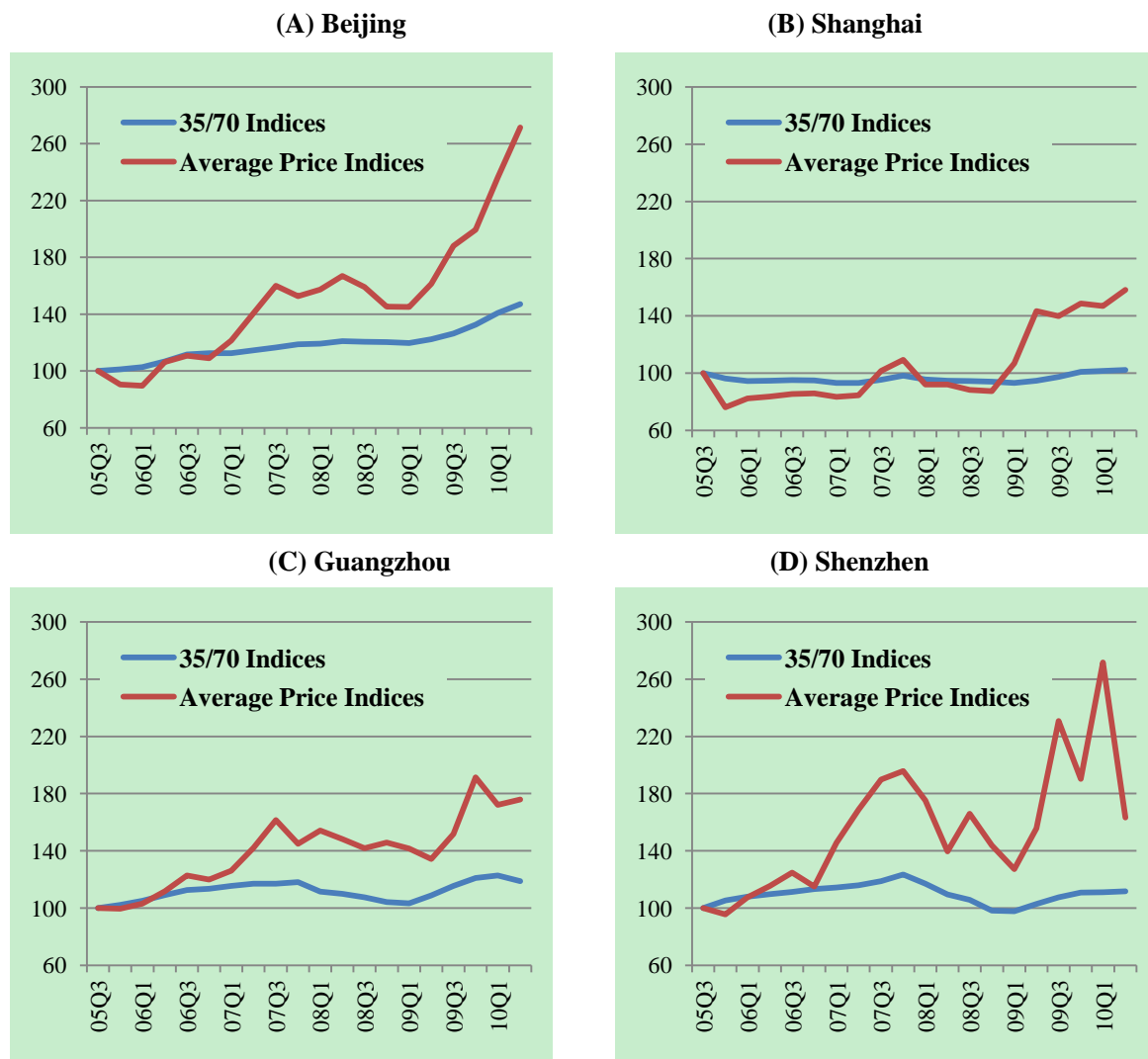
¹⁰ Note that the definition of "selling out" is not consistent in the series. As introduced earlier, in China's newly-built housing market the housing units are always presold before construction complete. For a long period since mid-1990s, these presold units were only accounted in the calculation of the "Average Price Indices" when they were completed and delivered to the households, which might be several months (or even over one year) after the presale transaction. Such definition was believed to lead to a lag in price movement, and hence since the 3rd quarter in 2005 the NBSC adjusted the definition of "selling out", according to which the presold housing units are included in the calculation immediately when the transactions are achieved.

¹¹ For the purpose of calculating the "35/70 Cities Indices", in each month technicians from local statistics authorities are sent to sampled housing complexes (both newly-built and existing) to collect raw information on house transaction price. Thus the "35/70 Cities Indices" include sub-indices for both newly-built housing price and resale price.

¹² Another important reason is the NBSC publicly reports the updated series of the "35/70 Indices" each month, but in most cities only publishes the annual series of the "Average Price Indices".

Shenzhen) as the example.¹³ Since the “Average Price Indices” adjusted the sample definition in the 3rd quarter of 2005, only the series after that are displayed here.

Figure 2: Real Quarterly Series of Two Official House Price Indices in China, Newly-Built Housing Market (2005Q3-2010Q2; 2005Q3=100)



Source: Calculated based on statistics published by local statistics authorities in corresponding cities.

Although these two indices generally show similar movement patterns in this interval, there are two obvious differences between them. First, the magnitude of real price growth suggested by the “35/70 Cities Indices” is much smaller than that indicated by the “Average Price Indices”. The “35/70 Cities Indices” do not provide any evidence on house price surges in Shanghai, Guangzhou, and Shenzhen, with average real quarterly price growth rates of only 0.14%, 0.95%,

¹³ As introduced earlier, neither of the two indices directly reports the fixed base series: the “Average Price Indices” report the average price level, and the “35/70 Indices” report the growth rate compared with the preceding reporting period. But both could be transferred to the fixed base series by simple calculation. The CPI series is then applied to deflate the nominal fixed base series to get the real series.

and 0.65% in these three cities, respectively. Beijing is the only exception, with an average real quarterly growth rate of 2.07% during these 5 years. However, the “Average Price Indices” reflects a significantly larger house price growth in all these four cities (especially in 2007 and 2009-2010). The average real quarterly price growth rate reaches 5.79% in Beijing, 3.19% in Shanghai, 3.39% in Guangzhou, and 4.89% in Shenzhen.

Secondly, the series of “35/70 Cities Indices” is much smoother than the “Average Price Indices”, without a significant shift between booms and recessions in these years. The standard deviations of the real quarterly price growth rate suggested by the “35/70 Cities Indices” are 1.97% (Beijing), 1.98% (Shanghai), 3.13% (Guangzhou), and 3.73% (Shenzhen), respectively, compared with 9.28% (Beijing), 12.79% (Shanghai), 9.17% (Guangzhou), and 22.06% (Shenzhen) by the “Average Price Indices”.

The rather different pictures suggested by these two series could co-exist only if the quality of newly-built housing units sold in the market greatly improved and heavily fluctuated during these years, which is unlikely given the rapid housing suburbanization in most Chinese cities discussed above.¹⁴ Accordingly, at least one of the two indicators is seriously deficient.

3. House Price Index Estimation in Chinese Housing Markets

The key challenge in house price construction is quality adjustment – controlling for the potential effect of quality change, which is always confounded with the movement of house price. The relationship between housing characteristics and transaction prices is usually expressed by the hedonic model. Given the features of the Chinese housing market discussed in last section, housing attributes can be grouped in unit-level and complex-level, respectively, and the hedonic model for the Chinese housing market can be expressed as:

$$P_{ijt} = \alpha \cdot U_{it} + \beta \cdot P_{jt} + \delta_t \cdot D_{ijt} + \mu_{ijt} \quad (1)$$

Where: P_{ijt} is the transaction price of housing unit i in complex j sold at time t ; U_{it} and P_{jt} are sets of unit-level and complex-level characteristics, respectively; D_{ijt} is a set of dummies indicating the timing of transactions (equals 1 in period t , and 0 in other periods); μ_{ijt} is an i.i.d. error term. While other parameters might also be of interest, the key task of house price index construction is the accurate estimation of time dummies' coefficient, δ_t .

3.1 The Simple Methods

The simplest house price index construction method is to direct calculate the unweighted or weighted average of transactions prices. In the hedonic model framework described in eq.(1),

¹⁴ The divergence could also be explained from the raw data perspective if developers systematically report higher prices (than the real transaction prices) to the statistics bureau. But we could not find any evidence on this, or imagine any incentives for developers to do so.

this equals only to include the time dummies as explanatory of house price, leaving all effects of housing attributes as the error term (eq.(2)).

$$P_{ijt} = \delta'_t \cdot D_{ijt} + \varepsilon_{ijt}, \quad (2)$$

Where, $\varepsilon_{ijt} = \alpha \cdot U_{it} + \beta \cdot P_{jt} + \mu_{ijt}$

According to eq.(1) and eq.(2), if neither of the characteristics that affect housing units' price (observed or not) keep changing over time, and the sample volume is large enough to offset the units' quality variance in each period, the new error term ε_{ijt} can still meets i.i.d., and hence the coefficients of δ'_t could be an unbiased estimate of δ_t , although the variance of ε_{ijt} should be larger than that of μ_{ijt} . In this case the simple methods could achieve in an unbiased house price index without any information on the characteristics of housing units. This advantage in feasibility makes these methods well suited to data conditions in emerging housing markets like China. As introduced in Section 2.2, the "Average Price Indices", one of the two official house price indices currently published in China, is calculated using a simple weighted average formula.

However, if any housing characteristic keeps changing over time, this will lead to a correlation between time dummies and error term in eq.(2), and hence a bias in the estimated δ'_t . As discussed earlier, one most apparent case of such quality change is the trend of housing suburbanization in most Chinese cities. This can be regarded as a continuous "degrading" of transacted units' quality in location aspect over time - units sold today in suburban area are compared with those sold yesterday in city center. Accordingly, without quality adjustment, this change could be expected to result in a downward bias in the results of simple methods, either in the newly-built sector or the resale sector.

3.2 The Hedonic Method

Considering the deficiencies of the simple methods, two quality-adjusted house price measurement methods have been developed in literature. The hedonic method seeks to incorporate the quality adjustment directly. In its most widely-used form, housing transactions from multiple periods are pooled into a single hedonic model, estimate the vector of coefficients δ_t . The house price index is based on δ_t (Kain and Quigley, 1970; Thibodeau, 1989; Kiel and Zabel, 1997; Gourieroux and Laferrere, 2010).

A major limitation of hedonic method is the high data requirement. Besides transaction price, detailed housing attribute information is required for the proper implementation of hedonic method. As pointed out by Clapham *et al* (2006), the lack of standard and extensive data sets of housing attributes in U.S. makes it difficult to apply the hedonic method in official statistics. Similar reasons also explain why the hedonic method has not been used in Chinese housing market yet.

But things started to change recently. In China all housing transaction contracts are required to register in local housing authorities, and since 2004 municipal housing authorities in major cities (originally 40 and then expanded to 90 cities) are required by the Ministry of Housing and Urban-Rural Development to electronically record key information for all transactions. Then in the “Technical Code for Real Estate Market Information System” released in April 2007, the Ministry of Housing and Urban-Rural Development provided detailed definition of such information. The housing characteristic variables listed in the Code include detailed address in the complex-level (which could be converted to more location variables), and room area, floor level, and total floor in the unit level. This makes the wide implementation of hedonic method feasible in China.

Nevertheless, these limited variables surely cannot capture all housing attributes that can affect housing price, and hence the omitted variable issue still matters. In this case the hedonic model in eq.(1) should be re-written as eq.(3), where all effects of unobserved housing characteristics are grouped into the error term.

$$P_{ijt} = \alpha \cdot OU_{it} + \beta \cdot OP_{jt} + \delta'_t \cdot D_{ijt} + s_{ijt}, \quad (3)$$

Where, $s_{ijt} = \gamma \cdot UU_{it} + \varphi \cdot UP_{jt} + \mu_{ijt}$

OU_{it} and OP_{jt} are sets of observed unit-level and complex-level characteristics, respectively, while UU_{it} and UP_{jt} are unit-level and complex-level characteristics not captured by available variables but could also affect housing units' price, respectively. Similar with the earlier discussion on eq.(2), any continuous change in unobserved attribute will lead to the correlation between error term s_{ijt} and time dummies, and hence a bias in estimate of δ_t (and then the house price index). But considering that the most important quality change in current Chinese housing market is the suburbanization in location aspect, and the available variable can well reflect this change, we believe the omitted variables would not significantly the results of hedonic method.¹⁵

3.3 *The Matching Approach with the Framework of Repeat Sales*

Method

Another quality-adjusted house price measurement method is the repeat sales method, which is more widely applied at present, especially in practices (Bailey, Muth and Nourse, 1963; Case and Shiller, 1987, 1989). By restricting the sample to housing units sold at least twice, and with the assumption of homogeneousness of the same unit between two sale dates, the repeat sales method can achieve in constant quality house price measurement without detailed information about housing units' attributes. Accordingly, although still believed to suffer from several

¹⁵ For example, the continuous change in unit-level attributes within the same complex and the effect of developers' pricing strategy can be offset among different complexes in the hedonic model.

problems,¹⁶ it is still the most widely applied house price indices construction methodology at present, especially in the U.S.¹⁷

But the repeat sales method cannot be easily applied to the Chinese housing market. Obviously there should not exist any repeat sales in the newly-built housing market. Even in the resale market, the volume of repeat sales is also quite limited, partly because of China's short history of private housing market, and partly due to the heavy tax on housing units resold within short interval.¹⁸

However, as suggested by McMillen (2008), Deng, McMillen and Sing (2010), the repeat sales method can be treated as an extreme version of a matching estimator. In other words, instead of a sample of repeat sales, we can match each housing unit sold with the most similar unit sold previously and apply the repeat sales approach to the matched pairs. Suppose that unit i in complex j sold in period t is matched with the unit k in complex l sold in period τ ($t > \tau$), their difference in transaction price is:

$$P_{ijt} - P_{kl\tau} = \alpha \cdot (OU_{it} - OU_{k\tau}) + \beta \cdot (OP_{jt} - OP_{l\tau}) + (\delta'_t D_{ijt} - \delta'_\tau D_{ij\tau}) + \gamma \cdot (UU_{it} - UU_{k\tau}) + \varphi \cdot (UP_{jt} - UP_{l\tau}) + (\mu_{ijt} - \mu_{ij\tau}) \quad (4)$$

If we allow for matching only within the same complex to increase homogeneity, then eq. (4) becomes:

$$P_{ijt} - P_{kj\tau} = \alpha \cdot (OU_{it} - OU_{k\tau}) + (\delta'_t D_{ijt} - \delta'_\tau D_{ij\tau}) + \gamma \cdot (UU_{it} - UU_{k\tau}) + (\mu_{ijt} - \mu_{ij\tau}) \quad (5)$$

In eq.(5) all complex-level characteristic terms (either observed or not) are dropped due to units' inherent homogeneousness within the same complex, which greatly avoids difficulties resulting from unobserved characteristics in location and neighborhood. The unit-level attributes (OU_{it} and $OU_{k\tau}$) are controlled to be homogeneous to the largest extent via the matching procedures, while the remained differences could also be offset if the sample volume is large enough. If the unobserved unit-level characteristic does not vary between units within the same complex (*i.e.*, $UU_{it} - UU_{k\tau} = 0$, like the construction type), or does not change over time (*i.e.*, $(UU_{it} - UU_{k\tau})$ and $(\delta'_t D_{ijt} - \delta'_\tau D_{ij\tau})$ are not correlated), we can estimate price change over time by applying the standard repeat sales method to these matched pairs.¹⁹ See Deng,

¹⁶ Among others, see Case, Pallakowski and Watcher (1991), Haurin and Hendershott (1991), Case and Szymanoski (1995), Deng and Quigley (2008) for a literature review.

¹⁷ See Nagaraja, Brown and Wachter (2010) for a detailed summary of the application of repeat sales method in U.S.

¹⁸ In order to restrict speculation in the housing market, if one housing unit is resold within 5 years, stated share (20% in most cities) of the price appreciation would be levied as a tax.

¹⁹ Theoretically, besides the repeat sales method, we could also apply the hybrid method developed by Case and Quigley (1991), Quigley (1995), Hill, Knight and Sirmans (1997) to the matched pairs, where information from both repeat sales and single sales are both utilized. However, since only few (if any) transactions are unmatched in the matching approach, which means that only little information is excluded in the estimation of repeat sales

McMillen and Sing (2010) for a house price index for Singapore estimated using a similar method.

As introduced in Section 2.2, a simplified form of this matching approach has been adopted in the “35/70 Cities Indices” (although the matching procedure is applied at the complex level by comparing the weighted average price of each complex in each month with that of the same complex in the preceding month). This complex-level matching approach could be expected to share the advantages of the unit-level matching approach discussed above.

However, due to the two distinct features of new units’ selling process in China discussed in Section 2.1, the matching approach (either unit-level matching or complex-level) could still be biased when adopted in Chinese newly-built housing markets. First, in Chinese newly-built housing market units’ qualities within the same complex always “degrade” over time since better units are always sold out earlier. Although part of this effect can be control via the matching procedure, there may still exist some unobserved (which could be “unobserved” by the available variables, but could be observed by the potential buyers) unit-level attributes. It implies the premise of no continuous change in unobserved unit-level attributes is very likely to be violated, and the term of $(UU_{it} - UU_{k\tau})$ in eq. (5) is negatively correlated with the $(\delta_t D_{ijt} - \delta_\tau D_{ij\tau})$ term. This negative correlation, if exists, will lead to a downward bias in the estimated price change.

Furthermore, the effect of developers’ pricing strategies may be another source of potential bias. On the one hand, because any new unit’s transaction price should equal to its listing price set by the developer, the complex-level price path is directly determined by its developer’s behavior in adjusting listing prices for unsold units. On the other hand, however, developers always hesitate to adjust the listing price in a large magnitude due to the following reasons. The existing literatures have provided lots of evidences that the anchoring effect plays an important role in market participants’ judge on properties’ price – peoples always irrationally anchor on properties’ earlier transaction prices, initial asking prices or so on.²⁰ This effect can be expected to be especially significant in China’s newly-built housing market, since transactions within the same new complex are always concentrated within a few months, and hence potential buyers can easily observe the complex’s past price path. Thus if a developer substantially raises the unsold units’ listing price, potential buyers are very likely to reject the new prices according to their judgments based on past price level, even if such adjustment does not exceed the magnitude of market price appreciation. This makes developers also tend to anchor on earlier

method, the hybrid method’s improvement compared with the repeat sales method could be expected to be very limited. Accordingly we do not discuss the hybrid method detailedly in this paper.

²⁰ Among others, see Northcraft and Neale (1987), Genesove and Mayer (2001), Leung and Tsang (2010) for example.

price level and reluctant to greatly raise the listing price, which will result in a downward bias in the matching approach during the market booming period.²¹

As a result of these two factors, the appropriateness of the matching approach when adopted in Chinese newly-built housing markets is still questionable. However, since both these two potential problems are induced by newly-built units' selling process, the matching approach may still work well in the resale housing market.

4. Empirical Tests

4.1 Data

One typical large Chinese city is selected for the empirical test,²² where micro-level transaction data in the newly-built sector and the resale sector are both included but collected from different sources. Full sample transaction data in the newly-built housing market is provided by local housing authority. During the period of 2004-2009, 539,067 newly-built housing units were sold in the city. These units were distributed in 2,534 complexes.

Although housing resale transactions are also required to be registered with housing authorities, currently this does not provide reliable information for house price construction in China. A large portion of buyers and sellers in the resale housing market choose to register a false transaction price (far lower) to evade transaction taxes.²³ Comparably, the transaction information provided by the brokers is more reliable. Thus we choose to collect the resale transaction data from one leading brokerage company in the city. 35 complexes are included in the analyses, with a total transaction volume of 19,791 units during the period of 2007-2009.²⁴

The variables included in these two data sets are similar. Besides the transaction date and price, the information on housing characteristics include room area, floor level, and total floor in the unit level, as well as information on distance to city center and distance to nearest subway station in the complex level. This is the typical housing attribute information available in most Chinese cities under current conditions. The variable definition and descriptive statistics are listed in Table 1.

²¹ Similar phenomenon also exists in the recession period. It is difficult for developers to lower the listing price of unsold units' even if the market conditions turn down, because the households that already purchased units in the same complex always strongly oppose, or even require to refund. As a combination of these effects, the method would over-smooth the price variance.

²² According to the requirement of raw information provider, we cannot explicitly report the name of the city.

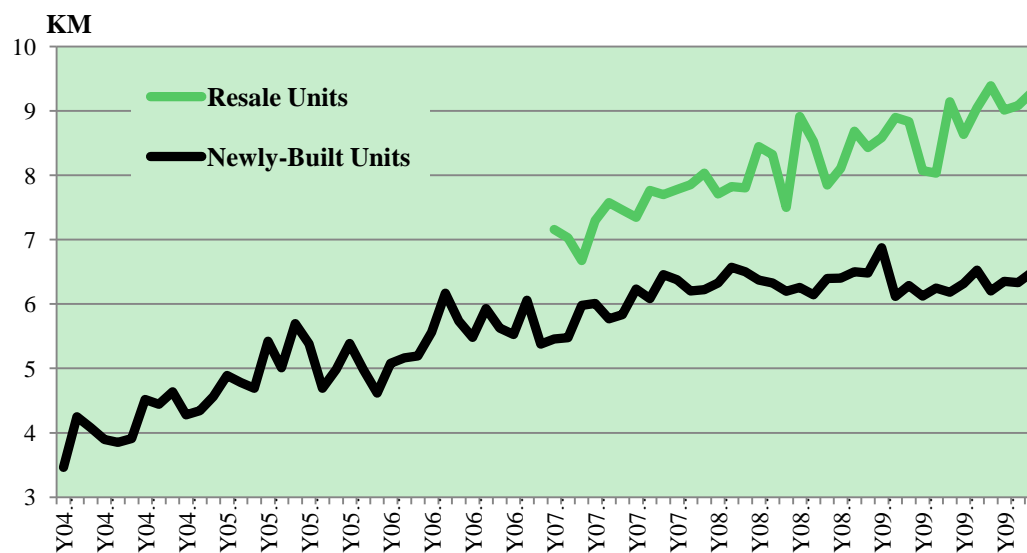
²³ This phenomenon does not exist in the newly-built housing market, because the developers have to receive audit for their accountings.

²⁴ Our major purpose here is to test the performance of the estimating methods based on this sample. The statistics resulted from the sample does not necessarily represent the full picture of the market.

Table 1: Descriptive Statistics of Variables

Variable	Description	Newly-Built		Resale	
		Mean	Std. Dev.	Mean	Std. Dev.
D_CENTER	Distance to the city center; in kilometers.	5.82	2.44	8.33	3.92
D_SUBWAY	Distance to the nearest subway station; in kilometers.	2.33	1.81	2.90	1.52
UAREA	Room area of the unit; in square meters.	98.05	37.50	130.62	53.84
UFLOOR	Floor level of the unit.	11.30	7.71	7.23	5.83
TFLOOR	Total floor of the building.	21.37	8.90	14.23	8.00

The change of units' location attributes, which is the most significant housing quality change in recent China as discussed above, could be reflected in these data. As depicted in Figure 3, the average distance of newly-built dwellings to the city center increased from 3.5 km in Jan, 2004 to 6.3 km in Dec, 2007, which provides a clear evidence of housing suburbanization during this period. The spatial pattern of the newly-built market generally remained stable after that. Similar change also occurs in the resale housing market (at least in our sample), with average distance to city center of sold dwellings increasing from 7.2 km in Jan, 2007 to 9.3 km in Dec, 2009.

Figure 3: Average of Transacted Housing Units' Distances to City Center

4.2 Method Specifications

All the three methods discussed in Section 3 are included in the empirical analysis; their specifications follow.

(1) Simple Method

Both unweighted and weighted average transaction prices are calculated relative to a fixed base. This weighted average index can be regarded as a proxy for the official indicator of “Average Price Indices”.

(2) Hedonic Method

The hedonic model of the form of eq. (1) is constructed and estimated separately in the newly-built market and the resale market; the log transaction price as the dependent variable and the housing attributes listed in Table 1 and the monthly dummies as the explanatory variables. The models are estimated by OLS.

(3) Matching Approach

Both the unit-level and complex-level matching approach discussed in last section are applied. As for the unit-level matching, a standard propensity score approach is adapted. For each period $t > 2$, all housing units sold in and before this period are pooled and the “nearest neighbor” is estimated (see Deng, McMillen and Sing (2010)).²⁵ 385,179 pairs of transactions are matched in the newly-built housing market, while 19,322 pairs are matched in the resale market. Finally the standard procedure of weighted repeat sales method developed by Case and Shiller (1987, 1989) is applied to these matched pairs to estimate the price index over time.

As for the complex-level matching, we replicate the method applied by the “35/70 Cities Indices” in a more formal way. Firstly the complex-level hedonic price index is calculated for each complex. Next for each period $t > 2$, one complex’s hedonic price index in that period is matched with the last period, and finally the standard repeat sales procedure is applied to the matched pairs. The result will work as the proxy of the “35/70 Cities Indices” in the following empirical test, although it could be expected to achieve a better performance because it also (at least partly) controls for the unit-level quality changes.

4.3 Comparison of Performance

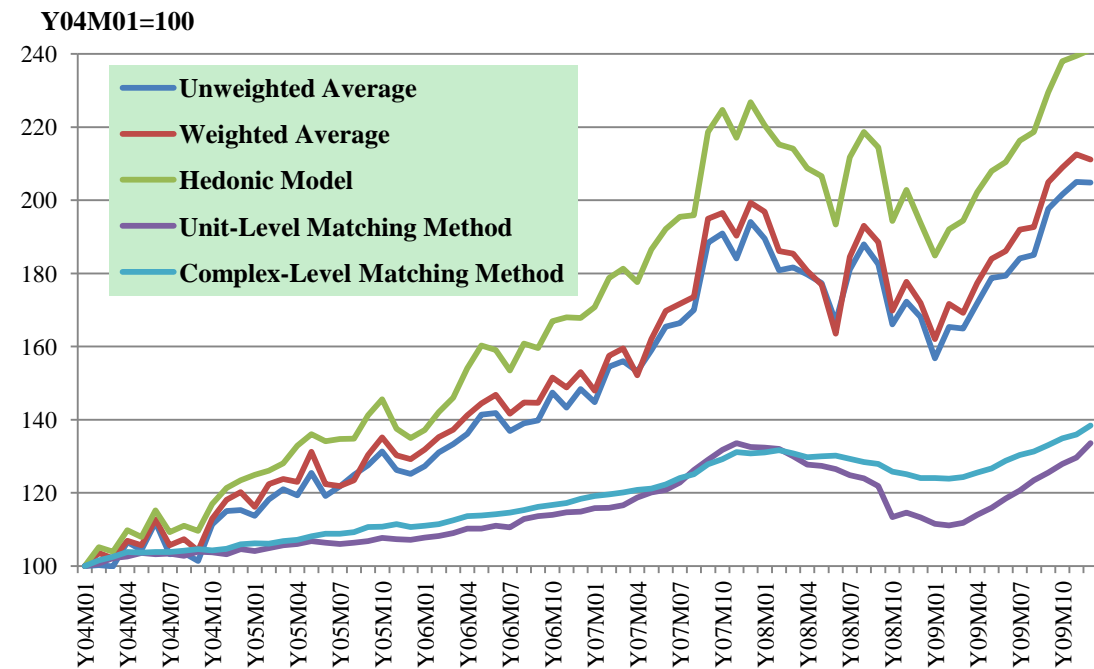
All the methods specified in Section 4.2 are applied in both the newly-built housing market and the resale housing market in this selected city. The house price indexes are depicted in Figure 4, and Table 2 further provides four indicators reflecting the performance of the methods which are applied in most literature (Case, Pallakowski and Wachter, 1991; Case and Szymanoski, 1995; Dorsey *et al*, 2010; Nagaraja, Brown and Wachter, 2010): (1) the average monthly growth; (2) the standard deviation of the monthly growth; (3) the average of width of 95% confidence interval; and (4) the standard deviation of error term in the model. The first two indicators reflect the divergence in long-term trend or short-term dynamics of the series, although can only serve as qualitative analysis since nobody knows what the “true” price path exactly is. The latter two are

²⁵ If more than one unit’s propensity scores share the same distance with the object unit, the unit latest sold would be chosen.

more quantitative – methods achieving in narrower confidence interval or smaller variance in error term are always seemed to be better.

Figure 4: House Price Indices in the Selected City

(A) Newly-Built House Price Indices



(B) Resale House Price Indices

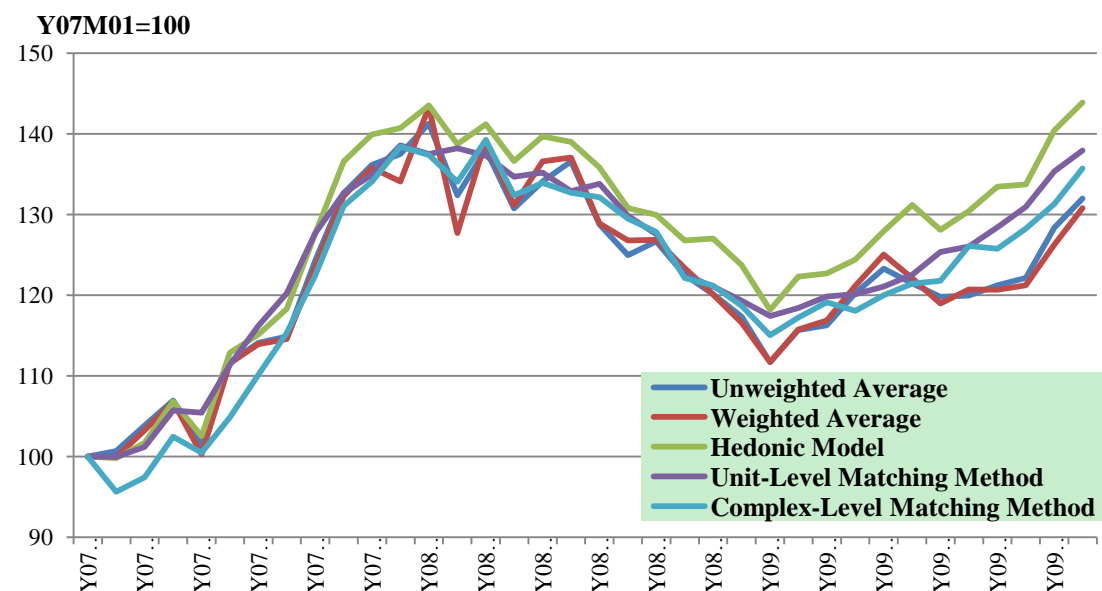


Table 2: Summary Statistics of the House Price Construction Methods

	Average Monthly Increase	Std. Dev. of Monthly Increase	Width of 95% Confidential Interval	Std. Dev. of Disturbance
(A) Newly-Built House Price Indices				
Unweighted Average	1.09%	3.95%	0.023	0.259
Weighted Average	1.15%	4.34%	0.025	0.259
Hedonic Method	1.31%	3.68%	0.019	0.215
Unit-Level Matching Method	0.42%	1.41%	0.016	0.125
Complex-Level Matching Method	0.46%	0.70%	0.329	0.086
(B) Resale House Price Indices				
Unweighted Average	0.87%	3.85%	0.073	0.291
Weighted Average	0.88%	4.68%	0.080	0.291
Hedonic Method	0.99%	2.81%	0.043	0.254
Unit-Level Matching Method	0.95%	2.37%	0.033	0.209
Complex-Level Matching Method	0.92%	3.10%	0.212	0.082

(1) Simple Methods and Quality Adjusted Methods

In general the average growth rate resulting from the simple methods is lower than that resulting from the quality adjusted methods, especially the hedonic method. For example, the average monthly growth rate by the weighted average formula is 0.16 percentage points (or 12.2%) lower than the hedonic method in the newly-built market. More precisely, the gap is especially significant during the period of rapid suburbanization in 2004-2007 (1.55% by weighted average formula and 1.81% by hedonic method), but negligible (0.34% and 0.36%) during the period of 2008-2009 when the spatial pattern kept generally stable. This again suggests that the existence and magnitude of non-constant-quality bias depends on the trend of quality change. However, the difference between the simple methods and the matching approaches is smaller in the resale market, while in the newly-built market the growth rates by the simple methods even exceed those by the matching approaches. We believe this results from the problem of the matching approaches.

Moreover, indices by the simple methods are more variable than both the hedonic method and the matching approaches judging by the indicator of monthly growth rates' standard deviation, which should result from the variance of units' characteristics in different periods (*e.g.*, the variance of distance to city center depicted in Figure 3). Due to the same factor, both the average width of 95% confidential interval and the standard deviation of the model error of the simple methods are larger than the hedonic method and the (unit-level) matching approach.

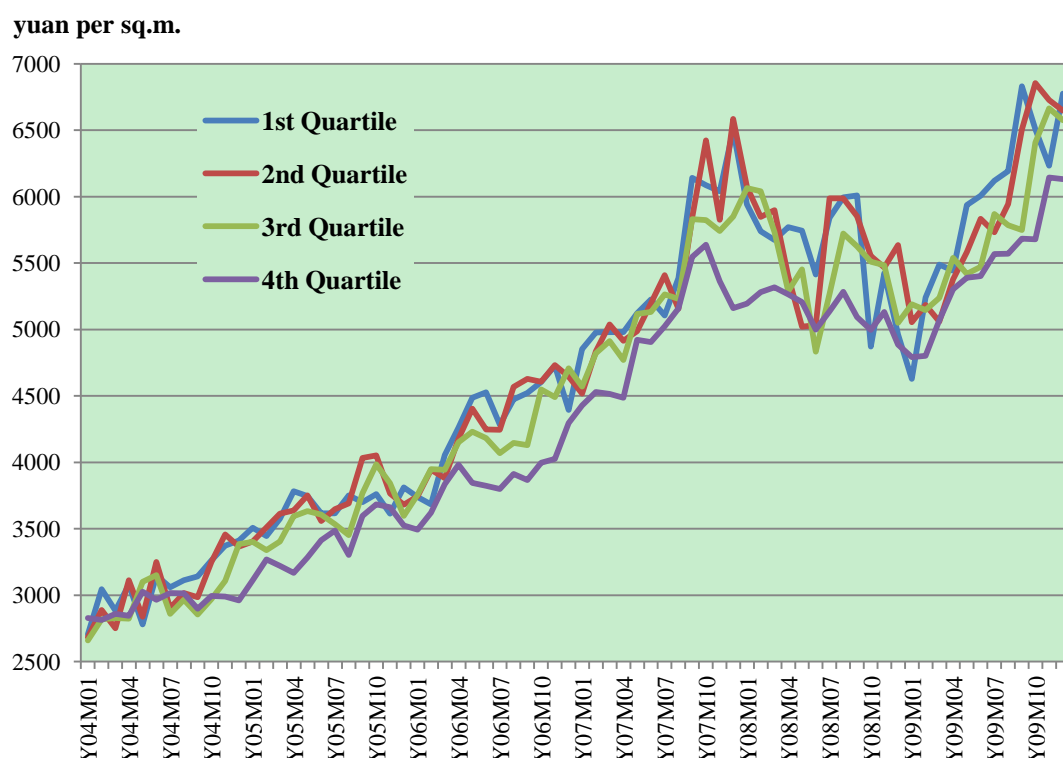
(2) Hedonic Method and Matching Approach

Despite the negligible difference in average monthly growth rate, the hedonic method and the matching approaches suggest a similar price path in the resale housing market, while the performance of the matching approaches still outpaces the hedonic method in two aspects. First, the indices by the matching approaches are less volatile than the hedonic method, while the volatility of hedonic index may at least partly be resulted from the effect of omitted variables as discussed in last section. Secondly, the matching approaches (especially the unit-level matching approach) also performance better in the 95% confidence interval indicator and the error term variance indicator. Furthermore, the matching approaches achieve in such performance based on less information, especially in the complex level.

However, the indices estimated by the different methods greatly diverge in the newly-built housing market. The largest gap exists in the magnitude of price increase – the average monthly growth rate by the matching approaches is only about one third of that by the hedonic model, and is even far lower than the growth rates of the average indices.

According to the analysis in Section 3.3, this results from the downward bias due to continuous change in unobserved unit-level attributes and developers' anchoring pricing behavior, which both result from the unique features of Chinese newly-built housing markets. We try to provide more evidences of these problems here. First, it is expected that units' unobserved unit-level attributes decrease with their sequences in being sold out. In order to test this effect, we divide the sample into four quartiles according to their transaction sequence in the complexes, and calculate the constant quality price level for the same typical unit in the four quartiles (using the average value of unit-level characteristics listed in Table 1). As depicted in Figure 5, controlling for the observed units' characteristics and time effect, units' sold out later (especially the last quartile) could only achieve a significantly lower price than units in the same complexes but sold earlier. Accordingly, it appears that the unobserved unit-level attributes of newly-built units do decrease over time, which will lead to a downward bias in the index by the matching method.

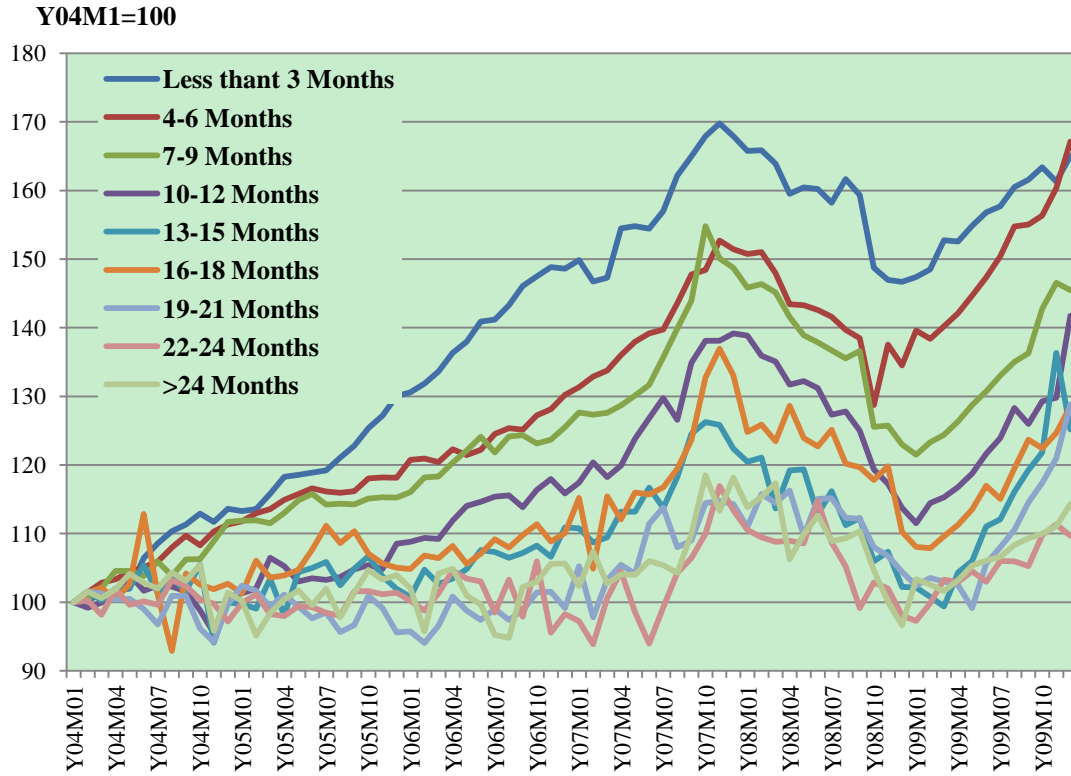
Figure 5: Typical Newly-Built Housing Unit's Price for Units Sold in Different Sequences



Moreover, although we cannot provide direct evidence on the effect of developers anchoring pricing behavior,²⁶ we can still test the existence of such an effect indirectly by dividing the matched pairs according to the time-on-market of the latter transactions in the pairs. If developers always adjust unsold units' listing prices in a smaller magnitude than market price change, the divergence between complex-level price growth and market price growth would be accumulated and hence expanded over time. In other words, the price increase calculated by the matching approach will be lower in the groups with larger time-on-market. The result depicted in Figure 6 is consistent with this expectation, where the house price growth rate significantly decreases when the time-on-market extends. Therefore, we could believe that both the two factors suggested in the theoretical analysis work in the newly-built housing market, which lead to the downward bias of the matching approaches.

²⁶ We try to empirically test the existence of anchoring effect, using the method developed by Beggs and Graddy (2009) in the arts market and then introduced to the housing market by Leung and Tsang (2010). The anchoring effect proxy is significantly positive in our model, although such result is less convincing than Beggs and Graddy (2009) and Leung and Tsang (2010) (and thus not reported here), because our analysis based on matched pairs, instead of real repeat sales, and so could not perfectly control the effect of unobserved characteristics. Detailed results are available on request.

Figure 6: Newly-Built House Price Indices for Units with Different Time-on-Market



4.4 Summary

(1) Discussion on Method Selection

According to the above analysis, the choice of house price index construction differs in the newly-built housing market and the resale housing market in China. As for the newly-built housing market, although the hedonic method still suffers from problems like unobserved characteristics, it is still the best choice, because the other two candidates suffer from more serious problems when adopted in Chinese newly-built housing markets – non-constant-quality bias (downward bias in most circumstance) for the simple methods, and the downward bias for the matching approaches due to both unobserved characteristics and developers’ pricing behavior. While adopting the hedonic method as a “no choice” solution, we should still try every effort to improve its accuracy by capture as much information as possible on housing characteristics, especially those probably undergoing continuous change. Besides, the choice of proper hedonic model form should also be an important issue for further research.

However, the matching approach developed from the traditional repeat sales method can be a preferable option in Chinese resale markets. First, the two potential biases of the matching approaches discussed above only exist in the newly-built sector, and there is no evidence on the bias of the matching method when adopted in the resale sector. Secondly, the theoretical and empirical analyses above suggest that the matching method outpaces the hedonic method in some performance indicators. Last but not least, the matching method does not require any

information on complex-level attributes, which not only improves its feasibility under current data conditions in China, but greatly avoids the potential biases due to omitted variables.

(2) Discussion of the Current Indices

The results could also help us understand the potential problem of the two official house price indices currently published in China. Despite any possible flaw in micro-level data underlining the calculation, in the newly-built housing market both the “Average Price Indices” and the “35/70 Cities Indices” could be expected to suffer from downward bias judged from the methodology aspect, since they are constructed via the weighted average method and the complex-level matching method, respectively, while the bias of the “35/70 Cities Indices” could be especially serious. This also well explains the divergent paths of these two indices as depicted in Figure 2, especially the extremely low price growth rate of the “35/70 Cities Indices”.

As an initial attempt to correct the potential bias in these two indices, we apply the hedonic method to transaction data on newly-built dwellings in four major cities, with the comparison of results listed in Table 3. The real quarterly price growth rate of the hedonic indices calculated is substantially larger than that by the “35/70 Cities Indices” in all the four cities, and is also 0.5-1.0 percentage points higher than the “Average Price Indices” in three of the four cities, with Shenzhen as the exception. Meanwhile, the hedonic indices are also less volatile than the “Average Price Indices” due to the control of units’ quality variance.

Table 3: Possible Correction of Two Official House Price Indices in Four Major Chinese Cities (2005Q3-2010Q2)

	“Average Price Indices”	“35/70 Cities Indices”	Authors’ Calculation Based on Hedonic Method
(A) Average of Real Quarterly Increase			
Beijing	5.79%	2.07%	6.48%
Shanghai	3.19%	0.14%	4.12%
Guangzhou	3.39%	0.95%	4.32%
Shenzhen	4.89%	0.65%	3.93%
(B) Standard Deviation of Real Quarterly Increase			
Beijing	9.28%	1.97%	6.43%
Shanghai	12.79%	1.98%	5.35%
Guangzhou	9.17%	3.13%	7.29%
Shenzhen	22.06%	3.73%	9.78%

5. Conclusion

As issues related to Chinese house prices gradually become an international concern, the accurate measurement of Chinese house prices will also become an important issue. In this paper, we apply three major house price indices methodologies to Chinese housing markets. It is

clear that the simple average methods without quality adjustment suffer from bias if the quality of housing units sold in the market keeps changing over time. They are also more likely to be downward biased in most Chinese cities considering the recent trend of rapid housing suburbanization. As for the quality adjusted methods, the matching approach developed from the repeat sales framework performance well in the newly emerged resale housing market, but when adopted in the newly-built housing market it would be downward biased due to the unique selling processes of newly-built housing units in China. This makes the hedonic method the only choice of house price index construction in the Chinese newly-built housing market.

These findings also suggest that, the current two official house price indices in China, the “Average Price Indices” which are calculated by the simple method (weighted average), and the “35/70 Cities Indices” which are calculated by the complex-level matching approach, both suffer from a downward bias; the bias in the “35/70 Cities Indices” could be particularly substantial. In other words, the risks in the Chinese housing market (especially the newly-built housing market) are even higher than revealed in existing analyses based on these two official indices. Both researchers and policy makers should pay attention to such bias and their potential effects on their analyses or policy design. Meanwhile, improving these two existed indices, or seeking to develop a new accurate measurement, should be of high priority.

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