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The impacts of distance to CBD on housing prices in Shanghai: a hedonic analysis

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It is widely recognized that location is the primary determining factor of housing price. But to what extent the variation of housing price in Shanghai can be explained by the locational factor has not been empirically examined. In this paper, we examine the power of applying the hedonic method to the spatial-statistical analysis of housing prices in Shanghai. The data we use covers all new commercial residential housings sold in Shanghai during July 2004 and June 2006. The main focus in this paper is to examine the effect of geographical distance to city centre on the selling price of residential housings in Shanghai. We also discuss how the price gradient varies at different directions in Shanghai. Finally, we demonstrate the importance of applying quality control on the development of a housing price index. The statistical methodology and empirical results obtained in this paper carry interesting implications for other cities in China as well.

Keywords: hedonic analysis; Shanghai housing market; price gradient; constant-quality housing price index

JEL Classifications: R12; R14; R31

1. Introduction

Despite a burgeoning literature on China's urban housing system and real estate market, most existing studies focus mainly on the macro process of urban land use and housing market formation (Zhang, Mount, and Boisvert 2004; Quan 2006). There is generally a lack of micro understanding of spatial distribution of housing price, especially how housing price varies over the urban spatial pattern in Chinese cities. Also, very little is known about what are the main determinants of the market value of a particular property. This is probably because detailed information on real estate prices is not generally publicly available in a disaggregated format.

Typically, real estate researchers learn about the spatial distribution of property price through applying hedonic techniques. Although a hedonic study of housing price has been a standard analysis of real estate research worldwide, it is still almost an empty research area in mainland China. Two rare expectations are Yang (2001) and Yang and Shen (2006). Both are conducted for the housing market in Beijing.

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China has hundreds of cities of varying sizes (Huang, Kuo, and Kao 2003). As the biggest city and the leading industrial centre in China, Shanghai's real estate market attracts far more interest than any other. Although Shanghai's 13 million residents represent less than 1% of China's 1.3 billion population and less than 3% of China's total urban population, its market value accounted for a lion's share as high as 22% of the country's whole real estate market value in 2005.[1] Meanwhile, it is the most expensive housing market in China. At the end of 2006, the mean housing price for the whole metropolitan Shanghai was 7038 RMB/m^2 (US\$1 $\approx$ 8 RMB) while the price level in the central area of Shanghai stood well above 20,000 RMB/m^2. The relatively mature development of the real estate market in Shanghai provides an ideal context to study the micro-determining process of housing prices.

In addition to estimating the spatial distribution of housing prices, another key aim of this paper is to investigate how the hedonic price method can be applied to developing a constant-quality housing price index in Shanghai. Right now, nearly all housing price indexes in China are developed on the mean-price method and do not have explicit quality control. It is straightforward to see that the mean-price index is seriously biased in reflecting the true business trend in the housing market. In order to capture the real movement of demand and supply in the housing market, we must use the constant-quality housing price index that can isolate the effects due to the over-time variations in location structure of housing supply. The hedonic price method is well known for its robust strengths in this respect and has been widely applied in a number of countries (OECD 1997; Malpezzi 2005). Since our data spans July 2004 to June 2006 and is measured at a monthly frequency, it suffices for the construction of a housing price index. We then can show how much differences in the housing price index can yield with or without quality control.

The rest of this paper is organized as follows: Section 2 presents a brief description of the Shanghai housing market; Section 3 gives the conceptual and empirical framework of our analysis; Section 4 introduces the data sources and econometric model; Section 5 contains the empirical results; finally, Section 6 provides concluding remarks.

2. Background: the housing market in Shanghai

Residential dwelling was considered as a welfare good but not a commodity in China in the planned-economy era. Before 1978, most people in urban China lived under the welfare housing system in which the government produced and allocated nearly free dwellings. However, the single-channel state budgetary funding housing finance system could not be sustained on economic terms. Due to the continued financial deficit, investment on urban residential housing was consistently kept at a very low level.

Before the 1978 reform, residential dwelling shortage was extremely serious in Shanghai: between 1952 and 1978, housing investment on average accounted for only 5.8% of gross social investment in Shanghai; the accumulated increase of living space floor per capita over 27 years was a poor 1.2 m^2 (3.4 m^2 in 1952 and 4.5 m^2 in 1978). The acute situation of residential dwelling shortage in Shanghai did not get much improvement even after the economic reform. Between 1979 and 1997, the average annual salary of a worker in Shanghai achieved a threefold growth (after taking account of inflation) (784 RMB in 1979 vs. 11425 RMB in 1997). However, the living space floor per capita increased only from 4.5 m^2 to 9.3 m^2. Table 1 provides the basic information of the Shanghai housing market between 1995 and 2006.

Table 1. Overview of the residential real estate market in Shanghai, 1995–2006.

Year	Total construction space sold ($10{,}000\,m^2$)	Growth rate (%)	Total value sold (100 million RMB)	Growth rate (%)	Unit Price (RMB/m^2)	Growth rate (%)
1995	536.31		132.83		2477	
1996	528.56	−1.4	156.90	18.1	2968	19.8
1997	617.02	16.7	178.35	13.7	2891	−2.6
1998	1056.77	71.3	319.76	79.3	3026	4.7
1999	1243.33	17.7	385.64	20.6	3102	2.5
2000	1445.87	16.3	480.97	24.7	3326	7.2
2001	1681.48	16.3	615.17	27.9	3659	10.0
2002	1846.38	9.8	739.89	20.3	4200	14.8
2003	2224.47	20.5	1109.86	50.0	4989	18.8
2004	3233.74	45.4	2064.74	86.0	6385	28.0
2005	2845.69	−12.0	1906.05	−7.7	6698	4.9
2006	3025.40	6.3	2177.08	14.2	7038	5.1

Data source: *Shanghai Statistical Yearbook*, 1996–2006; *Shanghai Real Estate Yearbook*, 1997–2005.

The 1998 reform lifted the welfare housing system and paved the way for the development of a private real estate market. However, the Shanghai real estate market did not respond swiftly and a real estate boom did not arrive as expected. Instead, the market slumped into stagnation between 1998 and 1999. The Shanghai city government even had to create a variety of methods to stimulate the home purchasing enthusiasm (Chen and Hao 2006). The year of 2000 is the turning point. Since 2000, the Shanghai real estate market has shown a strong rebound. Between 2001 and May of 2005, the market can be described as scorching (cf. Figure 1). The average prices of new commodity residential real estates continuously achieved a double-digit growth rate over the previous year. There are people arguing that the fundamental strength of the Shanghai economy, alongside low interest rates, drove this phenomenon. However, quite a lot of media and researchers attributed property speculation as the major reason for the volatile upswing of real estate prices in Shanghai.

The skyrocketing of real estate prices in Shanghai and also some other major cities in China appeared out of control in early 2005. This imposed a severe threat to the financial stability and economic health of China's economy. To cool down the apparently overheated real estate market, the Chinese central government issued a series of new regulations. In spring 2005, the China cabinet decided to increase the interest rate and tighten the rules regarding down payments and real estate transactions. In a bid to crack down on real estate speculation, a transaction tax was imposed at the effective rate of more than 5% of the house transaction price for sellers who had owned their properties for less than two years. Meanwhile, the Central Bank twice raised interest rates on mortgages in 2005.

After this series of heavy-handed punches, the Shanghai real estate market was brought to a notable cooling-down and the price growth experienced a sharp halt after May 2005. Between May 2005 and April 2006, the real estate market struggled in recession, transaction volumes plummeted and price was on the down trend, although the size of the drop was small. When the real estate market in Shanghai and some other major cities in China exhibited renewed price vigor in the spring of 2006, the Central Bank responded promptly this time by a new increase in the mortgage rate in April 2006, sending out a strong

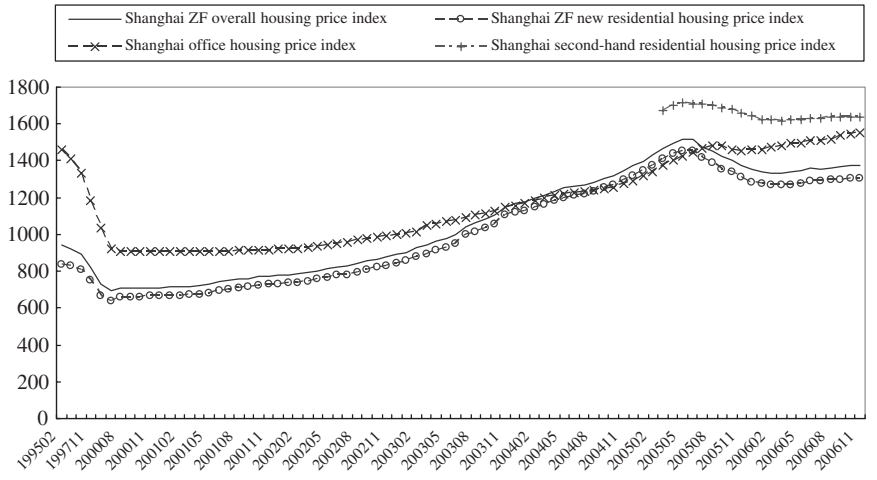

Figure 1. Shanghai ZF Monthly Housing Price Index (1995.02–2006.12).
Note: ZF (ZhongFang) real estate price index is compiled by *China Real Estate Price Research College* and computed for each major city in China. Although not quality-adjusted, it is currently well-recognized as a leading indicator of the China real estate market.

signal of the Chinese government's firm stand to stabilize the market and curb the real estate bubble. The movement of housing prices in Shanghai has been fairly stable since the middle of 2006.

3. Conceptual and empirical framework

In the literature, there are several statistical methods to analyze empirically the housing price, for example, the mean/median price method (possibly combined with a stratifying technique), the repeated-sale method, the hedonic price method, and the hybrid method, which combines the ideas of the repeated-sale and hedonic approach. However, indisputably the most popular one is the hedonic framework developed since Rosen (1974), which is widely applied not only in the academic community but also in commercial business (OECD 1997; Malpezzi 2005).

In Rosen (1974), housing is treated as a differentiated commodity in the sense that its market value is dependent on the vector of its characteristics (Lancaster 1966). The theory of hedonic price functions laid down the theoretic foundation for the analysis of differentiated goods and each individual characteristic can be implicitly priced. Commonly, characteristics that are important to the market value of housing are classified into three categories: (1) structural attributes, i.e. building material, floor space, number of bedrooms and bathrooms, inner structure, age of dwelling, floor level, direction, outside appearance; (2) neighborhood attributes, i.e. dwelling maintenance and management service, parking, safety, surrounding parks and leisure facilities, composition of neighbors in terms of ethnic, racial, age, educational background; (3) locational attributes, i.e. distance to CBD (Central Business District), travel and shopping convenience, accessibility to subway/underground and public transportation systems.

This paper mainly discusses the importance of location attributes on housing prices. Location attributes are widely regarded as the most important determinants of cross-sectional variations in housing prices. In many cases the distance to CBD alone accounts for a very large fraction of variations in housing prices. This is exactly what the classic model of the bid-rent curve of housing prices (Alonso 1964; Mills 1967; Muth 1969) predicted for a monocentric city.

Although the economic theory outlined by Rosen (1974) provides a general framework for the analysis of housing price through hedonic price functions, the theory has not yet provided standard guidelines on empirical issues such as the choice of functional form and the selection of particular housing characteristics to be included in the hedonic price function (Epple 1987). A long list of functional forms has been proposed and tested, including parametric and non-parametric approaches (Meese and Wallace 1991). However, recent discussions on the identification of hedonic price functions show that this issue is still open for further discussion (Ivar, Heckman, and Nesheim 2004). Maybe the most exciting breakthrough in hedonic price work during the last few decades is the increasing interest and growing application of newly developed spatial econometric techniques (Wihelmsson 2002). However, spatial econometric analysis requires very detailed data and is extremely technically complicated; we ignore the issue of spatial effects in this paper.

It is common in the literature to consider the following model where selling prices of housing are related to observable information about their attributes and transaction dates:

$$\log P_{it} = X_{it}\beta_{it} + D_{it}\gamma_{it} + \varepsilon_{it} \tag{1}$$

In this formulation, P_{it} is the price of housing i at time t, X_{it} is the observable characteristics of housing i at time t, D_{it} is the vector of time dummies. Correspondingly, β_{it} is the implicit hedonic price parameter of characteristics X_{it} and γ_{it} represents the time intercept coefficient. Linking the γ_{it} in a time series, we may obtain a hedonic/constant-quality index of housing price over the period under study.

Considering that the time period of the sample studied in this period is not long, only 2 years, we choose to apply a simple formulation of regression (1) where the vector of hedonic price coefficient is assumed to be time-invariant. This assumption is quite reasonable since it is not likely that the location effect would change substantially just within a 2 year time frame.

$$\log P_{it} = X_{it}\beta + D_{it}\gamma_{it} + \varepsilon_{it} \tag{2}$$

4. The data and econometric model

Usually, hedonic regressions are run on individual dwelling observations, where the prices of dwellings are linked to their locational and structural characteristics. Unfortunately, we do not have sufficient good-quality data on dwelling prices at this moment.

Nonetheless, the whole Shanghai housing market is administratively divided into 106 residential zones by the authority (cf. Figure 2). Although each zone has a varying size of area, the zone neighborhood is relatively homogeneous. The information regarding zone-level housing price and locational attributes is much easier to collect. As an illustration to show the usefulness of the hedonic price method on the analysis of housing prices in Shanghai, we apply our hedonic regression on the zone-level data. Such results are

Figure 2. The spatial distribution of zones in Shanghai.

Table 2. The distribution of zones by ring separation.

Ring separation	Within inner ring	Between inner and middle ring	Between middle and outside ring	Between outside ring and outskirt	Outskirt
Number of zones	23	20	19	27	17

preliminary and could not have straightforward business implication. However, it is still of interest to investigate whether there is a clear pattern of housing price and location attributes from aggregated data on the assumption that the zone neighborhood is fairly homogeneous, and ignoring the dwelling-level characteristics will not bias the coefficient parameters of zone-level characteristics too much. Meanwhile, as stated in the introduction, another purpose of our study is to develop a constant-quality housing price index. Our data has the potential to meet this purpose.

The data we use in this paper contains monthly zone-average housing prices spanning July 2004 to June 2006. It also contain the distance to CBD (Shanghai People's Square, where the Shanghai municipality office is located) measured at the zone-center, whether there is subway within the zone, conditions of public bus connection, and whether there is a famous landscape located inside the zone. We use the values of these zone characteristics measured at the same time period of housing prices.

Note that the urban area of Shanghai is separated by three major rings: inner ring, middle ring and outside ring. See Table 2 for the distribution of zones across the areas seperated by the three rings.

In total, we have data on housing prices and locational characteristics on 106 zones that are observed for 24 months. Some zones have missing information for a few months. The description of the data is given in Table 3.

Table 3. Data description ($N = 2412$, Zone = 106, $T = 24$ months).

Variable	Meaning (measured at zone level, monthly)	Mean	Std	Min	Max
ln *P*	ln(unit price of apartment, RMB/m^2)	8.87	0.64	6.89	10.98
D	Distance to CBD (kilometers)	16.86	13.19	1.17	57.89
R_ok	Availability with subway	0.23	0.42	0	1
T_good	Good bus connection (defined as with more than two bus lines directing to the CBD)	0.32	0.47	0	1
*T_bad**	Bad bus connection (defined as without any bus line directing to the CBD)	0.53	0.50	0	1
S	Famous Scenic View	0.14	0.35	0	1

*Note: The reference is with just one bus line directing to the CBD.

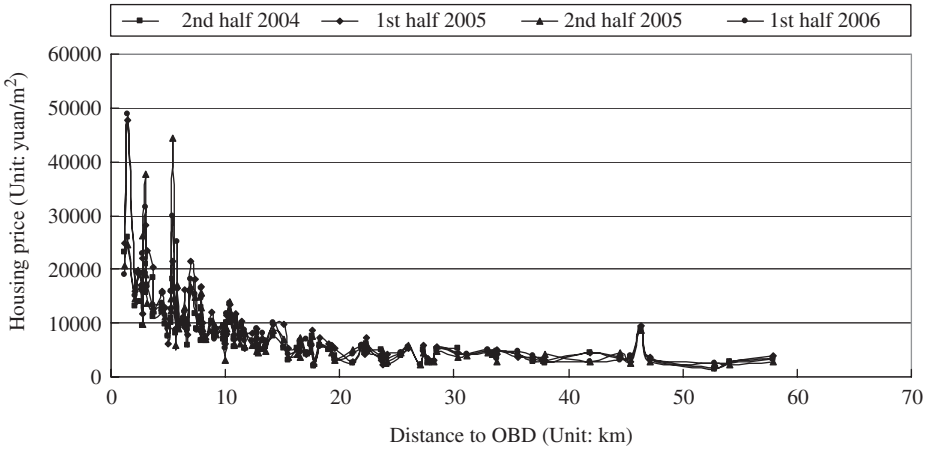

Figure 3. The distance gradient of housing prices in Shanghai.

Before the formal econometric analysis, we can have an intuitive impression, from Figure 3, about how the zone-level housing price declines as the zone's distance to CBD increases. The price gradient pattern is very obvious. The zone-level housing price clearly drops as the zone is further away from the CBD. Meanwhile, one can find that the declining speed is especially sharp at the first 5 km but slows after that.

The primary econometric model used in this paper is based on following equation:

$$\log P_{it} = \beta_0 + \beta_1 D + \beta_2 D^2 + \beta_3 R\_ok + \beta_4 T\_good + \beta_5 T\_bad + \beta_6 S + \varepsilon_{it} \quad (3)$$

where P_{it} is the mean housing price of each zone, D is the distance to CBD, which is measured in kilometers; D^2 is the square of distance and is included in the model to capture the nonlinear relationship between prices and distance to CBD; the meaning of other variables is explained in Table 3.

Submarket

The primary characteristic of housing is its heterogeneity. In particular, due to the spatial immobility of housing, there are no two identical houses in the world. House prices are influenced by a variety of land, structural, proximity, neighborhood and regional attributes. For this reason, some researchers have argued that a city's housing market may not be regarded as a uniform entity within this city's urban area; rather, each urban housing market should be considered as a collection of distinctive submarkets (Goodman and Thibodeau 2003). In the case of the Shanghai housing market, there is a strong indictor of submarket distinction based on the separation of the inner and outside rings. Therefore, it is of interest to test whether the submarkets exist and, if so, how the key parameters vary across different submarkets.

5. Empirical results

We run hedonic regressions for the whole city as well as for two assumed submarkets; one is the submarket that contains all the zones within the outside ring and another one is the submarket that contains only the zones outside of the outside ring. The three regression results are reported in Table 4.

From Table 4, for the city as a whole, we can say that the zone-level mean housing price on average drops 5% as the zone gets 1 km further away from the CBD. However, the dropping speed of housing price as a function of distance to CBD is much sharper within the outside ring than outside it. The coefficients of distance to CBD are statistically significant in all regressions.

Table 4. Hedonic regression results 1.

Variable	All city	Within the outside ring	Outside of the outside ring
D	−0.0527**	−0.0951**	−0.0153**
	(−31.78)	(−15.60)	(−4.23)
D^2	0.0005**	0.0021**	0.0000
	(20.38)	(6.51)	(0.08)
R_ok	0.2240**	0.1966**	0.2457**
	(23.08)	(15.52)	(10.81)
T_good	0.1778**	0.1279**	−0.0352
	(13.36)	(7.70)	(−0.86)
T_bad	−0.0245*	−0.0117	−0.0905**
	(−2.13)	(−0.75)	(−3.55)
S	0.2954**	0.2509**	0.6789**
	(23.33)	(16.14)	(7.23)
Constant	9.2593**	9.4990**	8.8319**
	(386.53)	(241.82)	(152.94)
Wald chi2(4)	14233.86	3243.11	1157.41
Log likelihood	−55.9916	−12.1557	−25.5161
Sample size	2412	1412	1000
Number of groups	106	62	44
Time effect control	Yes	Yes	Yes

Note: Figures in parentheses are t values. ** stands for significance at 1% level, * stands for significance at 5% level.

Meanwhile, we find availability of a subway increases housing prices very sharply. The conditions of bus connection also matter. Whether there is a scenic view makes a difference, too. However, we also find the submarkets within and outside the outside ring have substantial quantitative differences in their coefficients for nearly all parameters, although the signs of coefficients are basically the same. This finding reminds us that distinctive sub-segments exist in the housing market of Shanghai. That is to say, our predictions of the housing price pattern that are valid for certain parts of Shanghai may not hold true for other parts.

Further exploration: the directional price gradient

Usually, the literature assumes a uniform price gradient pattern in any direction outward from the city center. However, this may not be true in real life. For example, Soderberg and Janssen (2001) examined the real estate market in Stockholm, Sweden, and found an asymmetric price gradient. People familiar with Shanghai also know that the southern part of urban Shanghai tends to be much more flourishing than the northern part. To formally examine whether and how much the price gradient varies in different directions we estimate the following regression, where the west direction is used as a reference:

$$\begin{aligned}\log P_{it} = {} & \theta_0 + \theta_1 D + \theta_2 D^2 + \theta_3(Direction_{east}{}^{*}D) + \theta_4(Direction_{east}{}^{*}D^2) \\ & + \theta_5(Direction_{south}{}^{*}D) + \theta_6(Direction_{south}{}^{*}D^2) \\ & + \theta_7(Direction_{north}{}^{*}D) + \theta_8(Direction_{north}{}^{*}D^2) \\ & + \theta_9 R\_ok + \theta_{10} T\_good + \theta_{11} T\_bad + \theta_{12} S + \mu_3\end{aligned} \tag{4}$$

where $Direction_i$ here stands for the dummy of each direction.

Econometric regression estimation results presented in Table 5 suggest that the price gradient is flattest in the southern direction, significantly deeper in the western direction, the east is almost the same as the west, and sharpest in the northern direction. This finding is a useful addition to our knowledge of the spatial distribution pattern of housing prices in Shanghai.

Table 5. Hedonic regression results with directional price gradients.

	D	D^2	R_ok	T_good	T_bad	S	Cons
Refence (West)	−0.0813**	0.0001	0.1373**	0.1443**	0.055**	0.2051**	9.49**
	(−8.74)	(0.13)	(10.07)	(8.54)	(2.89)	(10.32)	(229.3)
D_East	0.0056	−0.0001					
	(0.74)	(−0.10)					
D_North	−0.0391**	0.0037**					
	(−5.44)	(4.97)					
D_South	0.0476**	−0.0018**					
	(7.07)	(−2.87)					

Wald chi2(19) = 3656.29 Prob > chi2 = 0.0000, Number of obs = 1412, Number of groups = 62.
Note: Figures in parentheses are t values. **stands for significance at 1% level;*stands for significance at 5% level.

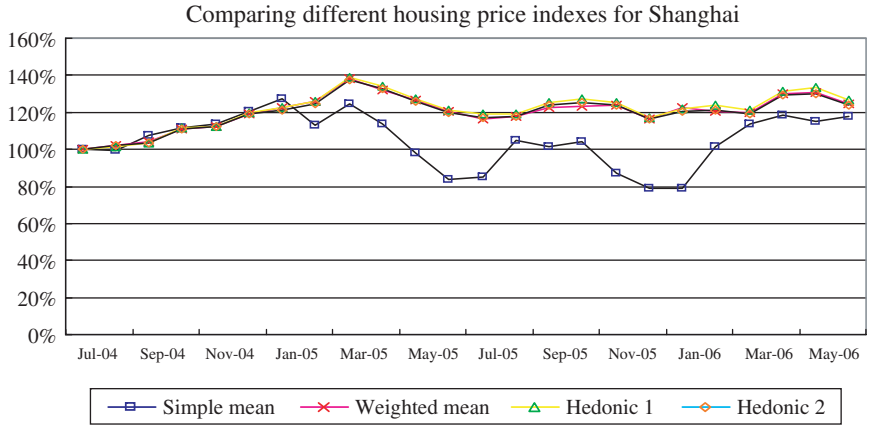

Figure 4. Four Shanghai monthly housing price indexes, July 2004–June 2006.

Hedonic price index

To demonstrate the importance of controlling quality and location when constructing the housing price index, we develop four different types of Shanghai monthly housing indexes based on the zone data for the period July 2004–June 2006 (cf. Figure 4).

The first one is the simple mean housing price index, where each month's mean price is obtained by dividing the city-level total sale price by city-level total sale space of that month. The second one is created when each month's mean price is weighted for zone sale volume. Two hedonic price indexes are constructed: Hedonic 1 is just keeping the control of the distance to CBD; Hedonic 2 adds additional controls of all variables included in the main regression model. The four monthly housing indexes are plotted below.

Using the weighted mean price index as the benchmark, we can see that the simple mean housing price index obviously overstates the market fluctuation and is seriously misleading. However, we did not detect significant disparity between hedonic price indexes and weighted mean price index. It is possible that the time length of two years and data aggregation at zone-level prevent showing the full power of the hedonic method in constructing the housing price index.

There may be concern about whether an inflation effect should be taken into account here.[2] We assume, however, that it should not be an important issue in this paper. This is because the CPI (consumer price index) was very low between July 2004 and June 2006 in Shanghai; in most times it was well below 2%. Therefore we feel there is not much need to deflate the nominal housing price by the general price index to obtain the real changes in housing prices. This is especially true when the focus is placed on the geographic pattern of housing price variations. Note that in all regressions estimated in Tables 4 and 5, the general time trend effect has been controlled for by employing a time dummy for each quarter.

6. Conclusions

How housing prices vary with locational characteristics has important policy and business implications. This paper provides the first attempt to use a hedonic analysis of housing prices in Shanghai. Our results suggest that, for the city as a whole, the zone-level mean

housing price on average drops 5% as the zone is gets 1 km further away from the CBD, *ceteris paribus*. However, the dropping speed is much sharper within the outside ring than outside that ring. The coefficients of distance to CBD are statistically significant in all regressions.

Meanwhile, we find that the availability of a subway increases the housing value very sharply. The bus connection conditions also matter. Whether there is a scenic view makes a difference too. But there is also evidence that distinctive sub-segments exist in the housing market of Shanghai. We also find the price gradient pattern varies substantially in different directions outward from the city center.

Finally, we argue that the hedonic price methodology is not only useful but also a necessary alternative to replace the current simple mean-price approach when constructing a housing price index in China. Our study shows that the simple mean housing price index is a seriously biased reflection of the true housing market trend in Shanghai, and that the hedonic price index reduces the biases significantly. Since the housing industry has become an increasingly important sector in China, accurate measurement of housing market trends is of great policy importance for not only Chinese housing investors and consumers but also for China's macroeconomic policy-makers.

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Notes

1. Note: all the data regarding Shanghai information in this paper are obtained from *Shanghai Statistics Yearbook* (1996–2006) and *Shanghai Real Estate Yearbook* (1997–2005) unless otherwise noted.
2. Thanks to Professor Shujie Yao for bringing our attention to this issue.

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