Heterogeneity in Housing Attribute Prices: An Interaction Approach between Housing Attributes, Absolute Location and Household Characteristics

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Abstract

Coefficients of housing attributes in most hedonic specifications are held constant under the assumption that each attribute has one unique marginal price throughout the entire market area. However, there's increasing evidence that the marginal prices of some key housing attributes do vary according to particular systematic patterns. In this paper, we employed expansion methods by incorporating both {X, Y} coordinates and buyer's characteristics to examine the spatial and socio-economic heterogeneities in housing attribute prices within the Shenzhen, China housing market. The results provide strong evidence that the marginal prices of key housing attributes are not constant but vary with household profile and absolute-location context. Besides, it is strongly proved that spatial expansion method with {X, Y} coordinates is also practicable to property assessment and urban studies of China.

Keywords: Absolute location, Expansion method, Hedonic model, Household profile, Shenzhen

1. Introduction

It has been widely recognized that the analysis of house prices using hedonic modelling makes it possible to estimate the marginal monetary contribution of property attributes and neighbourhood externalities (Rosen, 1974). Most empirical models have conceptualized a metropolitan area as a single unified market and the coefficients of housing attributes are held constant, which means each observed attribute is assumed to have one unique marginal price. However, various methods have been designed to challenge this assumption and presented that the marginal price of housing attributes may vary according to particular systematic pattern (Anselin, 1988; Casetti, 1972; Griffith, 1988). A number of housing market studies have used spatial expansion method which recognizes that functional relationships may not be constant but vary over space and explicitly allows parameter estimates to drift based on their spatial context (Jones and Casetti, 1992; Can, 1992). Besides, based on the hypothesis that the variability of the implicit prices of certain property and location attributes is partly linked to individual preferences, some studies have attempted to expand housing attributes with buyers' characteristics, allowing the marginal price to vary regarding household profiles (Kestens, 2006).

This paper seeks to perform an empirical case study analysing the spatial and socio-economic structures of Shenzhen's housing market by employing both sales data and household-level data. Two expansion models, social expansion model - housing attributes are interacted with household data- and spatial expansion model - housing attributes are interacted with {X,Y} coordinates- were applied to explain the house price variations in Shenzhen's housing market by examining the relationships between house prices and housing attributes, absolute location and household characteristics.

The remainder of the paper is organized as follows. We begin with a literature review of the previous hedonic approaches followed by an overview of the Shenzhen housing market in Section 3. Section 4 presents the data and modelling procedures, whereas the results are given in Section 5. Finally, a summary of the main findings and further research possibilities are presented in Section 6.

2. Background

Hedonic price method is a well established technique based on Lancaster's consumer theory, which states that utility is derived from the properties or characteristics of a good (Lancaster, 1966). After Rosen (1974) extended hedonic model to housing market, this method has been widely used as an important tool for property assessment and urban analysis. The most common approach to hedonic price method is to model house price directly as a function of various property specifics (floor area, building age, number of stories, etc.) and location descriptors (neighbourhood characteristics or accessibility) and to assume that the coefficients of the hedonic equation (also called implicit price or hedonic price) reflect buyers' willingness to pay (WTP) for those attributes.

2.1 Non-interactive Hedonic Price Models

In basic forms of hedonic house model, buyers are assumed to evaluate property specifics and location attributes separately when they purchase a home. This is a kind of "addictive" regression model, in which, house value is determined by property specifics plus location attributes and no interactive effect between these two parameters is considered in the model. In such an "addictive" regression, the marginal prices of property specifics are assumed constant throughout a metropolitan area. However, this assumption is quite inconsistent with the established theory that prices of housing attributes exhibit distinct spatial heterogeneity within housing markets (Michaels and Smith, 1990; Goodman, 1998). Thus, addictive regression fails to allow marginal value of property specifics to vary spatially over the city, which may result in biased coefficients and a loss of explanatory power.

2.2 Interaction approach by using {X, Y} coordinates

In order to allow housing attribute prices to vary over space, a number of housing market studies have employed expansion method pioneered by Casetti (1972, 1997). This method explicitly allows parameter estimates to "drift" based on their spatial context, that is, allows site, structural and other independent attributes to interact with location attributes (Jones and Casetti, 1992). In most models' specifications, the spatial context variables are usually related to neighbourhood and accessibility characteristics. Can (1990) utilized the expansion method to allow the marginal prices of property specifics to vary with neighbourhood quality and found that the neighbourhood interaction terms were significant for several variables: the type of exterior, the lot size, the presence of a two-car garage and the presence of a utility room. Thériaut et al. (2003) then improved this approach by incorporating both accessibility (computed with GIS) and neighbourhood attributes in the interaction terms. However, using location dummies (neighbourhood, submarket, etc.) to explain spatial variation is itself limited since house prices are averaged over discrete geographic boundaries. In order to explain the spatial variation for a continuous "price surface", absolute-location attribute - {X, Y} coordinates – was introduced into the spatial expansion model. As Fik et al. (2003) suggested, "with absolute-location variables, we can differentiate price with respect to location X (or Y) and obtain the geographic slope of house price in the vicinity of some location {X, Y}, taken along the X (or Y) axis. Besides, if we differentiate price with respect to a structural attribute, we can obtain a location-specific rate of change in price with respect to a unit change in the attribute." In his study of Tucson, Arizona, property specifics were interacted with both submarket dummies and {X, Y} coordinates in the form of a second order polynomial expansion which allowed the coefficients of property specifics to vary in a fully continuous manner over space. Another study of Tucson's housing market was performed by Bitter (2007) using absolute-location variables as well. Different from the former study, Bitter compared two approaches – spatial expansion method and geographically weighed regression (GWR) – to examine spatial heterogeneity in housing attribute prices and provided strong evidence that the marginal price of key housing attributes do vary over space.

Incorporating {X, Y} coordinates into hedonic models in the form of a polynomial expansion is appealing because location dummies, such as neighbourhoods or housing submarkets, are normally hard to define and it is usually difficult to accurately identify all locational influences that affect house prices (Orford, 1999). Moreover, the use of absolute location is especially attractive since the researchers are not required to master adequate local market knowledge about the division of neighbourhoods or submarkets.

2.3 Interaction approach by using buyer's attributes

Spatial expansion method is used to examine the spatial variation in housing attribute prices. However, expansion method can be applied more generally, by observing the heterogeneity of any parameter depending on the "context" variable (Kestens, 2006), in other words, you can expand property specifics with location attributes but you can also expand them with census data or household characteristics depending on which kind of variation you want to explain.

It is doubtless that house prices are mainly determined by structural specifics and location attributes. However, in an established housing market (second-hand housing market), the transactional characteristics of the market permit buyers to play an important role on transaction price determination (Horowitz, 1986; Yavas, 1992; Song, 1994). The home buyers affect selling price through their bargaining power relative to that of the home sellers (Song, 1998). In this sense, the socio-economic disparities between different home buyers may lead to heterogeneous implicit prices as well. The marginal price of a particular housing attribute, say floor area, may vary significantly with buyers' characteristics; due to different affordability and preferences, buyers with high occupation statuses or income levels may be willing to pay a premium for a large dwelling while common clerks are certainly unwilling to pay that much for such a luxurious living condition. Kestens (2006) introduced household-level data into hedonic models and found that marginal value given to certain property specifics and location attributes do vary regarding the characteristics of the buyer's household. For instance, highly-educated households would like to pay more for housing to fulfil their quest for social homogeneity.

To the best of our knowledge, although several studies have already employed hedonic model to analyse the price determinations or consumption preferences in the housing markets of Chinese cities (Ma and Li, 2003; Jim and Chen, 2007), no research has applied interaction approach to allow the marginal price of housing attributes to vary with location attributes or household profiles, largely due to the lack of official statistical data (In current China, housing transactions and household-level data are not well developed and not publicly available).

3 Shenzhen housing market

In most Chinese cities, residential buildings constructed before the housing reform in the 1990s were mainly monotonous rectangular ferro-concrete blocks of 6 storeys or less (Gaubatz, 1999). As a component of state welfare, dwellings were assigned to workers by work units according to service duration (Zhang, 2000b). The location and quality of housing, which are key concerns of home ownership in the western world, were largely ignored during the old planned and allocation period (Jim and Chen, 2007). However, the introduction of housing and land markets after the 1980s brought about great changes to residential structure. Commodity housing (new properties supplied through the market mode) has emerged as the leading residential type and households are encouraged to satisfy their housing demands from this commodity housing market. Two types of new housing estates have been built in Chinese cities: high-density multi-floor apartments (less than 7 storeys), medium high-rise apartments (8-12 storeys) and high-rise apartments (more than 12 storeys), and low-density villa style houses (Yan et al., 2001; Zhao, 2003).

Shenzhen is a small-sized metropolitan area situated in Guangdong Province of Southern

China. As China's first Special Economic Zone (SEZ), Shenzhen has been successfully transformed from an agriculture-based village into a national metropolis within only 30 years. Housing market in boomtown Shenzhen has been well developed and is extremely active and energic in recent years. Shenzhen's house prices have been growing at a breathtaking speed, rising from 5,000 RMB/m2 (USD 641) in 2004 to 10,000 RMB/m2 in 2006 (Li, 2007). In the past five years, median house prices of Shenzhen have been always among the highest in the country-wide.

The nature of SEZ required a physical boundary to identify the area where the special economic and social policies were applicable. Thus, in addition to the fenced First Border with Hong Kong, Shenzhen has a Second Border inside the city which divides the whole area into two parts: inner-SSEZ (Futian, Nanshan, Luohu and Yantian districts, 327.5 km2) and outer-SSEZ (Longgang and Bao'an districts, 1692.5 km2). Enjoying favoured economic and social policies, the levels of economic development, infrastructure condition and social status in inner-SSEZ are largely higher than the outer two districts. Influenced by this contrived segmentation, Shenzhen's housing market is distinctly divided into two submarkets, with the highest priced housing mainly located in inner areas, especially in Futian district (See Figure 1). The inner half of the city typically contains older, smaller but much more expensive housing while newly-built housing with larger size, lower density and cheaper price are generally found in outer districts.

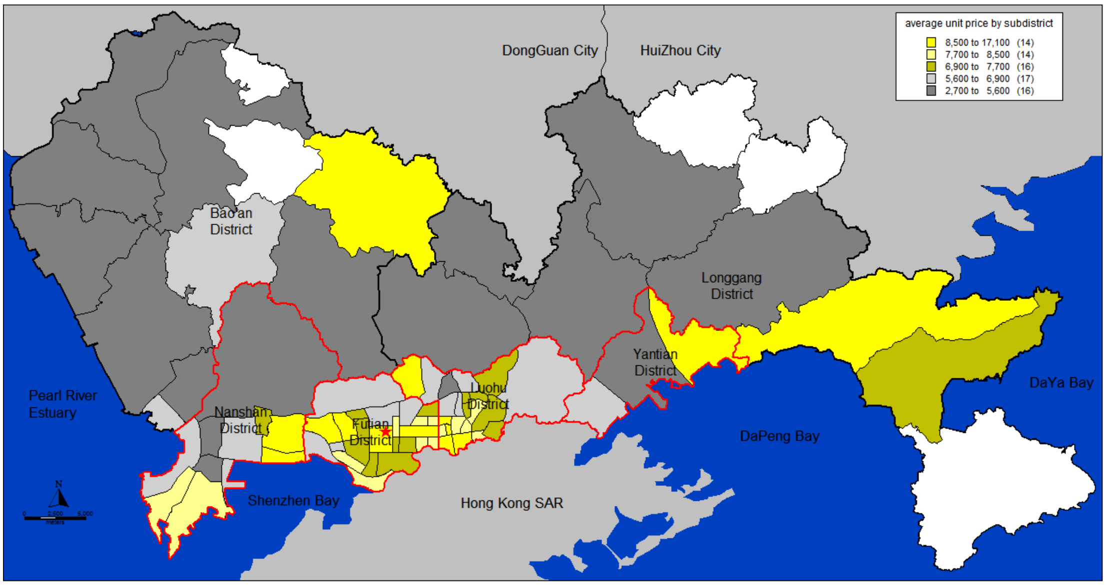

Figure 1 House price differentials between inner-SSEZ and outer-SSEZ

4. Methodology

4.1 Data collection

The official statistical system in China has not been well developed. Shenzhen Real–Estate Transaction Centre does hold some data, but only some basic descriptions of the transaction, such as transaction price, floor area, building material, address and the id number of the seller and buyer. In any case, even those data are confidential and not publicly available. Instead, we got data support from the two biggest property agency companies of Shenzhen: "World Union" and "Centaline". Transaction data was obtained through Centaline Property Agency Company. The master sales database contained 10,805 records which happened in the established housing market during year 2006. Those transaction data were then matched to a property "parcel" GIS coverage maintained by World Union Property Company and each property was attributed with the coordinates of its parcel centroid. This resulted in a total of 974 matched housing projects and 5,713 matched records. Development projects involved in the final database are all commodity housing projects developed by different types of developers, including state-owned companies, public-private joint-ventures and private enterprises. Nearly 76% (742 projects) of these projects locate in inner districts; however, as for the transaction cases, they are averagely distributed between inner and outer areas. Most of the projects are consist of high-density buildings while the percentage of detached house projects is relatively small. Other kinds of housing supply, such as low-rental residences (LianZuFang) and economy housing (JingJiShiYongFang) provided by the government as social welfare were not included in the study to avoid potential bias due to this provision diversity.

4.2 Models

Four models were estimated in the empirical analysis. All models use the natural log of sale price as the dependent variable and a semi-log equation was employed for hedonic regression procedure. The variables available for the study can be grouped as follows (Table 1):

(1)Transaction attribute;
(2)Property specifics;
(3)Location attributes;
(4)Buyer’s socio-economic characteristics.

Table 1: Definition of variables and descriptive statistics

Variable	Tyes	Definition	Unit or coding	Minimum	Maximum	Mean	Std.Dev.
Transaction attribute							
SPRICE	C	sale price of the property		30000	12630000	638284.66	612086.39
Structural specifics							
FAREA	C	floor area	m^2	20	639.87	83.89	39.29
BEDROOMS	C	number of bedrooms	count	1	8	2.38	0.92
LIVINGROOMS	C	number of livingrooms	count	0	5	1.75	0.48
STOREYS		number of storeys					
STOREY_7	B	<=7	1 if yes, 0 if no	0	1	0.16	0.37
STOREY_12	B	>12	1 if yes, 0 if no	0	1	0.62	0.48
UNITS		number of units on each storey					
UNITS_3	B	<=3	1 if yes, 0 if no	0	1	0.22	0.41
UNITS_9	B	>9	1 if yes, 0 if no	0	1	0.23	0.42
PAGE		age of the property					
PAGE_5	B	<=5years	1 if yes, 0 if no	0	1	0.52	0.50
PAGE_10	B	(5,10]years	1 if yes, 0 if no	0	1	0.47	0.50
PAGE_20	B	(10,20]years	1 if yes, 0 if no	0	1	0.17	0.37
COM_DEC	B	presence of a common decoration	1 if yes, 0 if no	0	1	0.75	0.44
LUX_DEC	B	presence of a luxurious decoration	1 if yes, 0 if no	0	1	0.16	0.36
location attributes							
INNER_DIS	B	located in inner districts	1 if yes, 0 if no	0	1	0.70	0.46
X	C	Cartesian coordinate_X		91067.7	150618.4	114588.70	9980.17
Y	C	Cartesian coordinate_Y		13455.5	44249.23	21947.13	5021.83
Buyer's attributes							
MORTGAGE	B	pay by mortgage	1 if yes, 0 if no	0	1	0.91	0.29
BAGE_30	B	buyer age<=30years	1 if yes, 0 if no	0	1	0.47	0.50
BAGE_50	B	buyer age>50years	1 if yes, 0 if no	0	1	0.03	0.16
SZ	B	buyer from shenzhen	1 if yes, 0 if no	0	1	0.37	0.48
HK	B	buyer from Hongkong	1 if yes, 0 if no	0	1	0.07	0.25
OTHERS	B	buyer from other Chinese cities	1 if yes, 0 if no	0	1	0.55	0.50
BM	B	boss and managers	1 if yes, 0 if no	0	1	0.23	0.42
CC	B	common clerks	1 if yes, 0 if no	0	1	0.41	0.49

* Type of variable: B binary, C continuous

The definition of transaction, property specifics, location and buyer’s socio-economic attributes is displayed in Table 1, together with their descriptive statistics. Consequently, a multi-step regression analysis is followed involving 4 steps (See Figure 2):

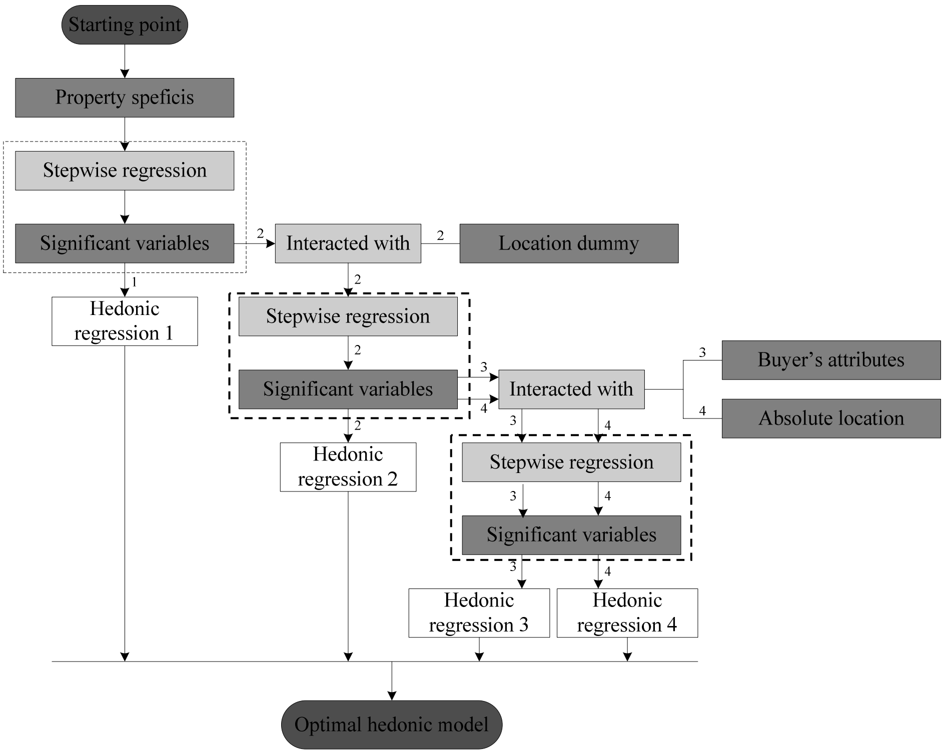

Figure 2: Multi-step regression procedure

Most significant property specifics are first selected using a stepwise regression procedure based on the original 12 property-related variables. As shown in Table 2, after withdrawal of multi-collinear variables, 9 significant attributes were retained for later steps;

Table 2: Model 1- Property specifics

Independent variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error			
(Constant)	11.7516	0.0275		427.6905	0.0000
FAREA	0.0097	0.0002	0.6070	46.1206	0.0000
STORE_12	0.3508	0.0114	0.2810	30.7530	0.0000
PAGE_5	0.2041	0.0095	0.1688	21.4487	0.0000
UNITS_3	0.0558	0.0129	0.0383	4.3335	0.0000
UNITS_9	-0.2089	0.0128	-0.1425	-16.3799	0.0000
COM_DEC	0.0930	0.0157	0.0672	5.9439	0.0000
LUX_DEC	0.1877	0.0179	0.1132	10.5042	0.0000
BEDROOMS	0.0428	0.0093	0.0638	4.6196	0.0000
LIVINGROOMS	0.0465	0.0120	0.0368	3.8728	0.0001

Dependent Variable: ln_price.Observations 5713. R 0.8383, R square 0.7028, Ajusted R-square 0.7023, Std. error 0.3296. Signifies statistical significance at the 5% level.

In step 2, dummy variables were added to control for the location of properties between discrete areas. Location dummies could be defined by district, neighbourhood or census tract. Since interactive specifications can quickly generate a large number of explanatory variables, we sought to use the least location dummies to get the most explanatory power. Due to the existence of the external physical boundary and the internal disparities in economic development and social status between inner and outer areas, Shenzhen's housing market can be exactly divided into two submarkets. Thus, INNER_DIS, together with the expansion terms (all property specifics being interacted with INNER_DIS) are added into the model to explain the price variation between inner and outer areas. As shown in Table 3, 11 variables were retained by the stepwise procedure;

Table 3: Model 2- Property and location dummy attributes

Independent variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error			
(Constant)	11.5352	0.0180		639.5644	0.0000
FAREA	0.0085	0.0002	0.5287	50.3941	0.0000
PAGE_5	0.2200	0.0076	0.1820	29.0210	0.0000
BEDROOMS	0.0742	0.0074	0.1106	9.9954	0.0000
LIVINGROOMS	0.1020	0.0097	0.0807	10.5525	0.0000
STORE_12	0.2152	0.0095	0.1724	22.6478	0.0000
UNITS_3	0.0523	0.0103	0.0359	5.0818	0.0000
UNITS_9	-0.2148	0.0164	-0.1466	-13.1169	0.0000
LUX_DEC	0.0592	0.0188	0.0357	3.1392	0.0017
INNER_DIS	0.4259	0.0097	0.3246	43.9019	0.0000
INNER_DIS*UNITS_9	0.1054	0.0187	0.0622	5.6516	0.0000
INNER_DIS*LUX_DEC	0.0534	0.0219	0.0285	2.4397	0.0147

Dependent Variable: ln_price.Observations 5713. R 0.9001, R square 0.8102, Ajusted R-square 0.8099, Std. error 0.2634. Signifies statistical significance at the 5% level.

Buyer's attributes are introduced in the model in Step 3. The 11 variables selected out from step 2 were used as basic parameters and expansion terms were also applied here allowing these basic parameters to vary with regard to the household profile. Three analysis scenarios were developed here. The first scenario included the whole urban area (see Table 4), while the other two tackled two distinct housing submarkets respectively (See Table 5). Variable INNER_DIS was excluded in the last two scenarios. As shown in Table 4, 13 expansion terms are significant, showing that the value given to certain property specifics or location attributes is indeed heterogeneous among buyers.

In step 4, absolute location was incorporated into the model in the form of Cartesian coordinates to accurately identify and specify locational influences that affect house prices. The 11 variables generated from step 2 are interacted with 9 absolute-location variables in the form of a third degree polynomial expansion of the parcel coordinates (X, Y, XY, X2Y, XY2, X2, Y2, X3, Y3) in order to allow the marginal price of the housing attributes to vary in a continuous manner over space (Table 6). Here, the raw coordinates were first standardized according to the mean X and Y values before imported into the regression equation.

5. Results

Different regression results are displayed in Table 7. It is indicated that model performances are quite satisfying, with R-squares ranging from 0.7028 to 0.8544 and standard errors of estimate decreasing from 32.96% to 23.14%.

(1) Property specifics

In spite of a lower performance, Model 1(step 1), with only property specifics as explanatory variables, still manages to explain about 70% of the price variations. Except for UNITS_9, which represents a kind of high density land using, the other significant property-related variables all contributed positively to house price. The positive effects of STOREY_12 and UNITS_3 indicate that high-rise buildings with less than 3 units on each floor are preferable and much more valuable in Shenzhen. High-rise buildings, which are commonly regarded as undesirable features in western cities, are popular and acceptable in most Chinese cities. In Shenzhen, living in higher apartment blocks connotes a better view, improved environment, and also a high social status since low-rise buildings are always linked to old poor-quality accommodation in people's opinions.

Table 4: Model 3- Property, location dummy and buyer's attributes

Independent variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error			
(Constant)	11.5784	0.0236		491.3741	0.0000
FAREA	0.0102	0.0004	0.6211	23.8717	0.0000
INNER_DIS	0.4243	0.0095	0.3233	44.7568	0.0000
PAGE_5	0.2203	0.0078	0.1807	28.2913	0.0000
LIVINGROOMS	0.0595	0.0203	0.0455	2.9297	0.0034
STORE_12	0.2113	0.0136	0.1685	15.4853	0.0000
UNITS_9	-0.1792	0.0128	-0.1197	-14.0343	0.0000
BEDROOMS	0.0978	0.0090	0.1430	10.8773	0.0000
LUX_DEC	0.0579	0.0192	0.0348	3.0218	0.0025
INNER_DIS*LUX_DEC	0.0473	0.0224	0.0250	2.1155	0.0344
OTHERS	-0.0886	0.0231	-0.0723	-3.8308	0.0001
BM*UNITS_3	0.1113	0.0154	0.0461	7.2103	0.0000
HK*INNER_DIS	0.1167	0.0341	0.0458	3.4233	0.0006
BAGE_30*STORE_12	-0.0327	0.0098	-0.0242	-3.3245	0.0009
CC*STOREY_12	-0.0306	0.0098	-0.0213	-3.1092	0.0019
MORTAGE*FAREA	-0.0013	0.0004	-0.0923	-3.4343	0.0006
MORTAGE*LIVINGROOMS	0.0552	0.0199	0.0603	2.7766	0.0055
BAGE_50*BEDROOMS	-0.0174	0.0078	-0.0135	-2.2369	0.0253
OTHERS*INNER_DIS*UNITS_9	0.0914	0.0189	0.0405	4.8417	0.0000
SZ*BEDROOMS	-0.0515	0.0110	-0.1155	-4.6968	0.0000
CC*UNITS_3	0.0398	0.0141	0.0180	2.8205	0.0048
HK*BEDROOMS	-0.0581	0.0156	-0.0623	-3.7186	0.0002
OTHERS*FAREA	-0.0010	0.0003	-0.0807	-3.6094	0.0003
OTHERS*STORE_12	0.0380	0.0157	0.0294	2.4169	0.0157

Dependent Variable: ln_price.Observations 5713. R 0.9054, R square 0.8198, Ajusted R-square 0.8190, Std. error 0.2591. Signifies statistical significance at the 5% level.

Table 5: Comparison between regression results for inner and outer areas

Independent variables	INNER		OUTER	
	Unstandardized Coefficients	Sig.	Unstandardized Coefficients	Sig.
(Constant)	11.9249	0.0000	11.5975	0.0000
FAREA	0.0083	0.0000	0.0132	0.0000
PAGE_5	0.2193	0.0000	0.2580	0.0000
BEDROOMS	0.0818	0.0000	———	———
LIVINGROOMS	0.1308	0.0000	———	———
STORE_12	0.2127	0.0000	———	———
UNITS_9	———	———	-0.2044	0.0000
LUX_DEC	0.1072	0.0000	———	———
HK*LIVINGROOMS	0.0524	0.0000	———	———
BAGE_30*FAREA	-0.0004	0.0003	———	———
BAGE_50*UNITS_3	-0.1411	0.0377	———	———
SZ*UNITS_9	-0.0564	0.0092	———	———
SZ*UNITS_3	0.0446	0.0120	———	———
CC*UNITS_3	———	———	0.0817	0.0004
CC*STOREY_12	-0.0255	0.0261	———	———
BM	———	———	-0.0916	0.0502
BM*FAREA	———	———	-0.0021	0.0099
BM*UNITS_3	0.0825	0.0001	0.1076	0.0002
BM*BEDROOMS	———	———	0.1177	0.0000
MORTGAGE* STOREY_12	———	———	0.1989	0.0000
MORTAGE*LIVINGROOMS	———	———	0.0752	0.0000
MORTAGE*FAREA	———	———	-0.0026	0.0000
MORTAGE*UNITS_9	-0.0943	0.0000	———	———
OTHERS*PAGE_5	———	———	-0.0687	0.0003
OTHERS*LUX_DEC	———	———	0.0908	0.0001
OTHERS*UNITS_3	———	———	-0.0514	0.0151

Table 6: Model 4- Property, location dummy and absolute location attributes

Independent variables	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients	t	Sig.
(Constant)	11.5891	0.0208		556.7930	0.0000
BEDROOMS	0.0811	0.0070	0.1209	11.6240	0.0000
FAREA	0.0083	0.0002	0.5149	48.3777	0.0000
LUX_DEC	0.0506	0.0169	0.0305	2.9988	0.0027
PAGE_5	0.1464	0.0111	0.1211	13.1439	0.0000
STORE_12	0.1529	0.0097	0.1225	15.7162	0.0000
UNITS_3	0.0231	0.0097	0.0158	2.3811	0.0173
UNITS_9	-0.2104	0.0272	-0.1436	-7.7267	0.0000
INNER_DIS	0.5292	0.0157	0.4033	33.7989	0.0000
INNER_DIS*LUX_DEC	0.0494	0.0196	0.0263	2.5173	0.0119
INNER_DIS*UNITS_9	0.0846	0.0202	0.0499	4.1782	0.0000
INNER_DIS*X2	-0.1717	0.0137	-0.2561	-12.5487	0.0000
INNER_DIS*X2Y	0.0805	0.0236	0.0971	3.4021	0.0007
INNER_DIS*X3	0.0454	0.0061	0.1429	7.4881	0.0000
INNER_DIS*XY	0.1381	0.0355	0.1117	3.8897	0.0001
INNER_DIS*XY2	-0.0970	0.0354	-0.0831	-2.7394	0.0062
INNER_DIS*Y	-0.4908	0.0260	-0.3510	-18.8503	0.0000
INNER_DIS*Y2	-0.3584	0.0271	-0.2542	-13.2244	0.0000
LIVINGROOMS	0.0929	0.0087	0.0734	10.6569	0.0000
X	-0.2255	0.0259	-0.3720	-8.7167	0.0000
X*BEDROOMS	0.1049	0.0123	0.4607	8.5475	0.0000
X*FEARA	-0.0014	0.0002	-0.2273	-6.1003	0.0000
X*LIVINGROOMS	-0.0265	0.0093	-0.0804	-2.8597	0.0043
X*LUX_DEC	0.0193	0.0088	0.0126	2.1966	0.0281
X*UNITS_9	0.1055	0.0261	0.0698	4.0352	0.0001
X2*PAGE_5	0.0487	0.0064	0.0854	7.5736	0.0000
X2*UNITS_9	0.0470	0.0128	0.0425	3.6688	0.0002
X2Y	0.0362	0.0088	0.1625	4.1326	0.0000
X2Y*BEDROOMS	-0.0105	0.0023	-0.1385	-4.6703	0.0000
X2Y*PAGE_5	-0.0320	0.0066	-0.1087	-4.8287	0.0000
X2Y*UNITS_3	-0.0288	0.0071	-0.0862	-4.0333	0.0001
X3	0.0744	0.0091	0.3757	8.1342	0.0000
X3*BEDROOMS	-0.0233	0.0044	-0.3515	-5.2753	0.0000
X3*FAREA	0.0001	0.0000	0.0694	2.1021	0.0356
X3*PAGE_5	0.0223	0.0030	0.0799	7.3503	0.0000
X3*UNITS_9	-0.0676	0.0100	-0.1172	-6.7860	0.0000
XY*FAREA	0.0004	0.0001	0.0881	5.7698	0.0000
XY*STORE_12	-0.0372	0.0111	-0.0361	-3.3604	0.0008
XY*UNITS_9	-0.0863	0.0198	-0.0497	-4.3614	0.0000
XY2*UNITS_9	0.0160	0.0079	0.0225	2.0165	0.0438
Y*FAREA	0.0010	0.0001	0.1572	6.7965	0.0000
Y2	-0.0524	0.0084	-0.1949	-6.2719	0.0000
Y2*PAGE_5	0.0523	0.0108	0.1567	4.8348	0.0000
Y2*UNITS_9	0.0368	0.0146	0.0322	2.5201	0.0118
Y3*PAGE_5	-0.0131	0.0039	-0.1337	-3.3262	0.0009
Y3*STORE_12	0.0069	0.0022	0.0279	3.1035	0.0019
Y3*UNITS_3	0.0084	0.0024	0.0742	3.4844	0.0005

Dependent Variable: ln_price.Observations 5713. R 0.9243, R square 0.8544, Ajusted R-square 0.8532, Std. error 0.2314. Signifies statistical significance at the 5% level.

Table 7: Results of hedonic regression models

		Model 1	Model 2	Model 3	Model 4
Model specifications	R	0.8383	0.9001	0.9054	0.9243
	R Square	0.7028	0.8102	0.8198	0.8544
	Adjusted R Square	0.7023	0.8099	0.8190	0.8532
	Std. Error of the Estimate	0.3296	0.2634	0.2591	0.2314
Variables in model	Property specifics	X	X	X	X
	location dummy		X	X	X
	Buyer's attributes			X	
	absolute location				X

(2) Introduction of location dummy INNER_DIS

Due to special economic and political policies, Shenzhen city is apparently segmented into two parts. The general environment in inner areas, including economic development, infrastructure construction and social status, is absolutely better than outer areas. Besides, with a serious limitation of land resource, house price inside SSEZ is dramatically higher than outer districts. In order to prove this spatial variation in house prices, spatial dummy descriptor INNER_DIS was added into the regression procedure in Model 2. The addition of INNER_DIS results in a modest improvement in explanatory power as the adjusted R-square was increased by nearly 10%. As expected, INNER_DIS contributed positively and significantly to house price and the house price would dramatically increase by 53.1% (e0.4259-1) for a location in inner districts.

(3) Introduction of socio-economic variables describing the household

The transactional characteristics of the housing market permit home buyers to play an important role on house price determination. In order to examine the relationship between buyer's characteristics and house prices, household-level variables, including age, hukou, occupation and payment type, were introduced into the model. Several interesting findings can be drawn from the analysis:

- Buyers migrating from other Chinese cities pay less for an improving of dwelling size but 3.87% (e0.0380-1) more for high-rise buildings and 9.57% (e0.0914-1) more for high-density designed buildings in inner districts than people from other places;
- Bosses and managers would like to pay 7.71% (e0.1113- e0.0398) more than common clerks for a presence of UNITS_3;
- Buyers from Hong Kong would like to pay 12.38% (e0.1167-1) more than other buyers for properties locating in inner districts, however, these "Hong Kong-buyers" pay 0.7% (e0.0581-e0.0515) less than native buyers and 5.98% (e0.0581-1) less than migrants for the same number of bedrooms;
- Partly-paid owners (mortgage payment) pay less than fully-paid owners for the same floor area;
- Old households, over 50 years of age, pay 1.76% (e0.0174-1) less than younger buyers for the same bedroom numbers.

Further comparison was pursued between inner and outer areas to explore the differences in buyer's preference over space. For inner districts, UNITS_9 is no longer a significant negative parameter to house price since most of the buildings are high-density designed in inner areas due to the limitation of land resource. Once you choose to live in inner SSEZ, building density is no longer one of the most important considerations. However, native buyers and those with high employment status (bosses and managers) still seek for low-density designed buildings in inner areas. Bosses and managers do not prefer a property in outer areas; however, if it is a low-density designed dwelling with more bedrooms, they are willing to pay a premium for it in order to get a better living environment.

(4) Introduction of Cartesian coordinates describing absolute locations

Absolute location variables were incorporated into the hedonic models using spatial expansion method. The inclusion of absolute-location interaction terms boasts an adjusted R-square of 0.8532 and a standard error of 0.2314. Obviously, Model 4 outperforms all prior specifications. The results indicate that:

- Although classic location-related parameters, such as neighbourhoods dummies and accessibility variables are not used in the model, Model 4 performed extremely well by solely using {X,Y} coordinates, which supports the contention that detailed knowledge of an urban housing market is not necessary when estimating house prices;
- Significant interaction terms involving both property specifics and absolute location indicate that distinct geographic and spatial differences in housing attribute prices does exit in terms of floor area, building age, number of bedrooms/livingrooms, number of storeys and building density, especially in the inner section of the city;
- Although it is already suggested in Model 2 that spatial variation in house price distinctly exists between inner and outer areas, the inclusion of interaction terms involving both discrete location dummy (INNER_DIS) and absolute location in Model 4 helps to uncover the directional aspects of price variation within inner submarket. For example, negative coefficients for both INNER_DIS*Y and INNER_DIS*Y2 suggest that in inner submarket, the increase of y value may negatively affect the house price, that is to say, a shorter distance to outer areas may lead to a lower house price (See Figure 3).

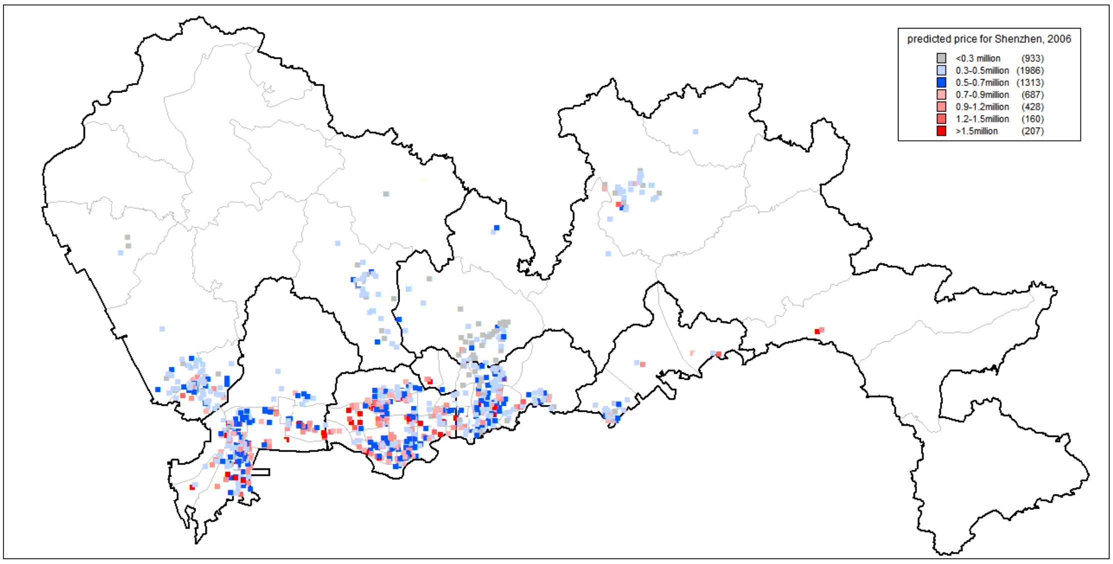

Figure 3 Predicted prices for full sample of 5713 transactions using Model 4

6. Conclusion

Overall, the empirical evidence of the study suggests that housing transaction price is tightly related to physical attribute, absolute location and household profile. Moreover, the study highlights the interactive nature of absolute location, household characteristics and housing attributes as they combine to explain variations of house price in Shenzhen market.

(1) Feasibility of spatial expansion model in China

High explanatory power of Model 4 indicates that spatial expansion method could also be applied to Shenzhen, China where housing market was just introduced after the 1980s. Although accessibility indices and well-subdivided location dummies were not included in the model, Model 4 still performed quite well by incorporating one location dummy and {X, Y} coordinates. As Fik et al. (2003) repeatedly insisted “this method is extremely useful and attractive for those real estate analysts who wish to uncover the importance of “location, location, location” in an absolute sense without having prior expert knowledge of the geographic markets”. Therefore, it may be possible for us to employ spatial expansion model for property valuation or urban studies of China.

(2) Heterogeneity in marginal prices

The focus of the study was not to compare the prediction accuracy of different models. Actually, the result of prediction accuracy tests for Model 3 and 4 is not that satisfying due to small data size. Anyway, the higher explanatory power of expansion models still provides strong evidence for the presence of heterogeneity in housing attribute prices within the Shenzhen market, indicating that the marginal prices of key housing attributes are not constant but vary with household profile and locational context. For example, the marginal prices given to particular housing attributes are different between several social groups: buyers from Hong Kong would like to pay a premium for dwellings inside SSEZ because it is close to Hong Kong and convenient for them to travel between the two cities; buyers with high employment status or income level, such as bosses and managers, are willing to give a higher marginal price for low density building in inner areas in order to seek for a better living condition; old households would not like to pay more for an improving of number of bedrooms or building density, this could be easily understood since most retired people cannot afford such a better housing and also they do not need such large dwellings due to the small family structure; people migrating from other Chinese cities would not like to pay a premium for a larger dwelling size but they much prefer high-density buildings, especially those locating in inner areas. Besides, spatial heterogeneity in housing attribute prices exists within Shenzhen's housing market as well; the marginal prices of housing attributes, including floor area, building age, number of bedrooms/livingrooms, number of storeys and building density, all distinctly vary over space.

(3) Improvement of the model

We only employ a cross-sectional hedonic model in the paper, with results pertaining to year 2006. However, the framework can be easily expanded by incorporating an interactive time variable and then it will be possible for us to explain the price variations over time.

According to the interaction terms involving both absolute location and discrete location dummy in Model 4, we can only get a general idea that spatial variation in house price also exists within SSEZ area. No obvious spatial pattern of the variation can be generated from the result. This is because only INNER_DIS was defined as the location dummy variable, which is too general for spatial analysis. In future studies, more well-subdivided location dummies which describe submarkets or neighbourhoods could be incorporated into the model.

In the paper, we only examined the relationship between house prices and buyer's characteristics, however, in a free housing market, house prices should reflect both supply- and demand-driven forces, thus, it would be interesting and necessary for us to incorporate information about the seller's profile in the future studies.

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