INTERNATIONAL REAL ESTATE REVIEW

2014 Vol. 17 No. 01: pp. 63 – 107

The Market Valuation of Interior Design and Developer Strategies: A Simple Theory and Some Evidence

Charles Ka Yui LEUNG *

Department of Economics and Finance, City University of Hong Kong, Kowloon Tong, Hong Kong. Phone: (852) 2788-9604; Email: kycleung@cityu.edu.hk.

Wai Yip MA

Chinese University of Hong Kong

Jun ZHANG

City University of Hong Kong

How much do the market values of housing reflect its interior design? Does the interior design interact with other housing attributes? By following recent research based on the "graph theory," this paper confirms the importance of internal design variables in a hedonic pricing model, which is applied to a large dataset of high-rise apartment buildings in Asia. The evidence is consistent with a simple theory in that developers strategically use interior design to "dilute" the effect of location, which leads to a form of endogenous multicollinearity. Directions for future research are also discussed.

Keywords:

Endogenous Multicollinearity; Interior Design; Market Valuation; Dummy Variables; Interaction Terms

* Corresponding author

The practice of interior design is like the practice of medicine in two important ways: first, design begins with problem identification and diagnosis; and second, it develops a solution (in medicine, a "treatment") derived from an understanding of the specific context and needs. However, interior design departs from medicine in one crucial way: it rarely conducts research to find out whether its "treatments" work.

Judith Heerwagen, in Interior Design: Handbook of Professional Practice, ed. by Cindy Coleman

Economic considerations can be expected to play an important role in any building program. The solution in a particular situation is usually one that is financially advantageous.

Victoria Kloss Ball, The Art of Interior Design.

1. Introduction

While the internal design of housing units is usually perceived to be influential on house valuation by ordinary people as well as real estate brokers, it is typically "absent" from the hedonic pricing model, and thus economists have little information about their quantitative importance.[1] In fact, practitioners are also aware that there is a lack of research on the price impact of design, as reflected in the quotations above. There seems to be a "missing link" between "conventional wisdom" and the academic literature.

While introducing architectural variables into the pricing equation is not totally new in real estate economics,[2] it seems to be an under-explored topic. The research efforts on how architecture design affects high-rise apartments are even fewer, if any. The reasons may not be surprising. Many existing research are based on datasets of detached housing units in North America.[3] Even in Tokyo, where land is expensive, detached houses still constitute a large share of residential property. Since the "external layout" of detached houses is *not* as "standardized" as that of apartment buildings, and since the "interior design" may be correlated to the "external layout," the effect of the "interior design" on detached house prices is difficult to quantify. On the other hand, for countries which depend on apartment buildings, such as China, data accessibility and transparency may create difficulties for "outside researchers". Thus, the research on the price effect of physical layouts may not be an easy task.

This study attempts to fill the knowledge gap, and studies how some dimensions of the interior design can affect apartment price. The importance of apartment research is clear. First, cities such as New York, Chicago, etc., seem to be increasingly depending on apartment buildings to house their population.[4] While some of them are often classified as "commercial real estate" (rather than "residential") due to their rental nature, how the designs affect the price (or the rental value) is still an important issue for both academic and practical reasons.

---

[1] For instance, see Malpezzi (2003) for a survey.

[2] For instance, Asabere et al. (1989) analyzes whether there are any partial effects due to architecture on home value. Smith and Moorhouse (1993) have estimated the hedonic price index after considering the detailed design features of more than 3,500 row houses in Boston.

[3] Among others, see Green and Malpezzi (2003) for a detailed analysis of the U.S. housing market, where detached housing is the norm.

[4] The demand for apartment buildings may be even larger in other parts of the world with faster population growth and in general, less land per capita. According to the World Bank (2006), the (annual) population growth rate in "East Asia and Pacific" is 1.2% during the period 1990-2004, while for their counterparts in the "high-income regions", it is 0.8%. In the "Middle East and North Africa," it is 2.1% and even 2.5% in "Sub-Saharan Africa."

In addition, *apartments may provide us with a natural setting to study the pricing of housing attributes*. Unlike detached houses, the physical layout in apartment units can hardly be changed. Potential buyers rationally anticipate that and therefore would likely “price in” the effect of the design. In addition, apartment units are easy to compare. For instance, apartment units within the same real estate development usually have very similar geographical attributes; they share the same public facilities, the same school district, etc. Moreover, the management, construction materials of the units, maintenance, etc. are typically identical. Thus, apartment units may provide a natural setting for the study of the price effect of physical layout.

Methodologically, this paper follows Nakata and Asami (2006), who apply the “graph theory” in their predictions of the floor layouts of detached houses in Tokyo based on the site conditions.[5] In their analysis, floor layouts of houses are transformed into “access graph” and “adjacency graph.” By adopting their idea, we create dummy variables such as *kitchen accessible to living room*, *kitchen adjacent to bedroom*, and *toilet adjacent to bedroom*. In addition, we divide the “shapes” of the living room in our sample into 4 classes, and represent them by 4 dummy variables. More details will be provided later.

To our knowledge, this paper is the first attempt to examine the market valuations toward different floor plan features in an active Asian market, based on a large number of transactions between Q1 1992 to Q4 2005. The Hong Kong residential property market is chosen for several reasons. With 7 million people and only 1,108 km^2 (about 428 square miles), Hong Kong is one of the most densely populated cities in the world (as a comparison, New York City, which is considered a very dense city in the United States, has about 19 million people and its size is about 6,720 square miles). As a result, the Hong Kong housing market is dominated by apartment buildings. The housing units within an estate[6] are *homogenous enough* for comparison, and at the same time, *heterogeneous enough* to highlight the role of different interior designs. The housing estates chosen in this study are frequently traded and thus a certain degree of “liquidity” is ensured. Second, the information on the floor plans[7] of large housing estates is accessible from property agents.[8] We

[5] “Graph theory” is a branch of “discrete mathematics”. For a review of its application, see Gross and Yellen (2005), among others.

[6] An “estate” is a collection of apartment buildings located closely and typically developed by the same real estate developer (or the same group of real estate developers). This is similar to “apartment complex” in the US, except that in Hong Kong, most estates are for sale while many apartments units are for rental in the US.

[7] A floor plan in architecture is a diagram of the relationships between rooms and other physical features at one level of a structure. It is similar to a map in that the orientation of the view is downward from above.

[8] One of the co-authors actually pretended to be an interested buyer and visited real estate agents in different districts and confirms that it is relatively easy to obtain the information of physical layout.

visit many property agents in Hong Kong and construct a comprehensive set of variables according to the floor plan information.

This paper focuses on the physical layout and leaves other aspects of "interior design" for future studies for a variety of reasons. First, physical layouts are relatively invariant while other aspects of "interior design" can be removed through renovation and remodeling. Second, the information about the layout in different estates are available from real estate agents, while other aspects of "interior design" are more idiosyncratic in nature and virtually impossible to be collected in a systematic manner. Third, while the physical layout of a housing unit can be objectively measured, other aspects of "interior design" may not be easily quantified. In fact, whether all of the "modern artistic features" add value to the housing units is controversial.

Perhaps more importantly, it seems that *other aspects* of "interior design" are not typically included in bank loan considerations. Observations suggest that the estimation of apartment value among the major banks, which are usually available within a day and without any site visit, deviate from one another by less than 5%.[9] Moreover, since the Hong Kong Monetary Authority restricts mortgage loans to not exceed 70% of the estimated value, the estimation of property value from banks essentially determine the upper bound of the amount of a mortgage loan that a potential home-buyer can obtain. It is likely that major banks in Hong Kong share some kind of "model" or "formula" in estimating the estate value.

The following section provides a literature review and description of the variables used. The dataset and the methodology will then be described, followed by the empirical findings and corresponding interpretations. A simple model is proposed to shed further light on the results. The final section concludes.

2. Literature Review

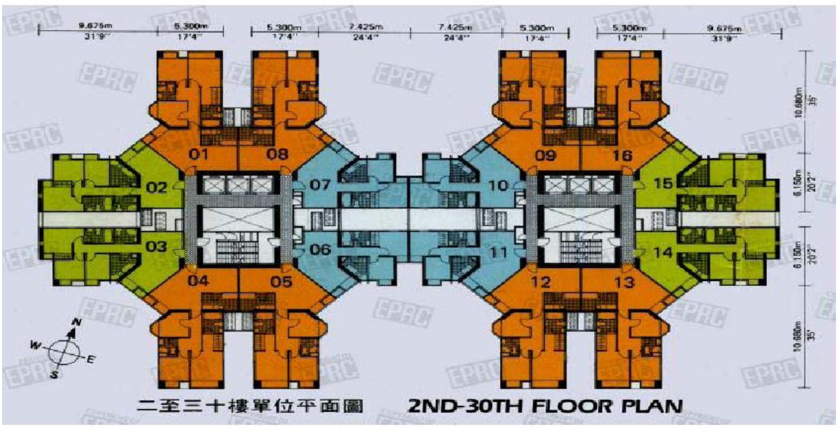
As in the case of other research, this paper is built on the work of several pioneers. For instance, Vandell and Lane (1989) have studied how the design quality can affect the rent for a set of 102 Class A office buildings in Boston and Cambridge. Vandell (1994) considers the design and style of housing as one of the subsets in site characteristics. Asabere et al. (1989) show that premium prices are associated with historical architectural styles. Smith and Moorhouse (1993) argue that architecture style and feature account for 14% of the house price in Boston. These findings all focus on how the *outer or external* architectural style of the real estate affect its corresponding rent or price.

[9] One of the co-authors actually pretended to be an interested buyer and asked for "loan quotations" from different banks, and finds that the valuation differences are typically small.

On the other hand, the floor plan features as well as the interior arrangement of various rooms ***within*** a house or an apartment are not explored. This paper will formally test whether (and how) the internal design of a housing unit would affect its market valuation. Thus, we naturally focus on the second-hand market where the transaction price is arguably determined by the market.

More specifically, we attempt to "characterize" the interior design in the following manner.[10] First, the location arrangement of different rooms are "measured" by accessibility and adjacency, such as "kitchen accessible to living room" or not, "kitchen adjacent to bedroom" or not, etc. Second, the shape of the living room is categorized into four types, namely, "Diamond," "Rectangular," "L," and "Two-rectangles," and Figure 1 shows an example of each type. The diamond-shaped living room can be a double-edged sword in design. On the one hand, it precludes the inter-visibility among the living rooms with the adjacent flats, and hence provides a higher degree of privacy in the midst of a highly crowded environment.[11] On the other hand, its non-rectangularity shape makes it difficult to place furniture without wasting some space.[12] All of these dummy variables contribute to quantifying the implicit prices of floor layout attributes, or, the so-called "premium of design".

Figure 1a Diamond Shaped Living Room from the Estate "Kornhill"



[10] Notice that the data from Vandell and Lane (1989) on "design quality" are based on detailed evaluations of each structure by a panel of architects, while the measures employed in this paper can be mechanically measured given the definitions.
[11] For details, "Wo de jia" [videorecording] / jian zhi Gu Qihui ; bian dao Deng Minmei ; Xianggang jian zhu xue hui lian he zhi zuo. Xianggang: Xianggang dian tai dian shi bu, 1997. UC Local TV Programme.
[12] These tradeoffs are well recognized. In practice, the size of living rooms that are "diamond-shaped" is larger in general. Residents place some specially designed furniture in those living rooms. We will get back to the "pros" and "cons" of "diamond-shaped" living rooms in a later section.

Figure 1b Rectangular Shaped Living Room from the Estate "Nam Fung Sun Chuen"

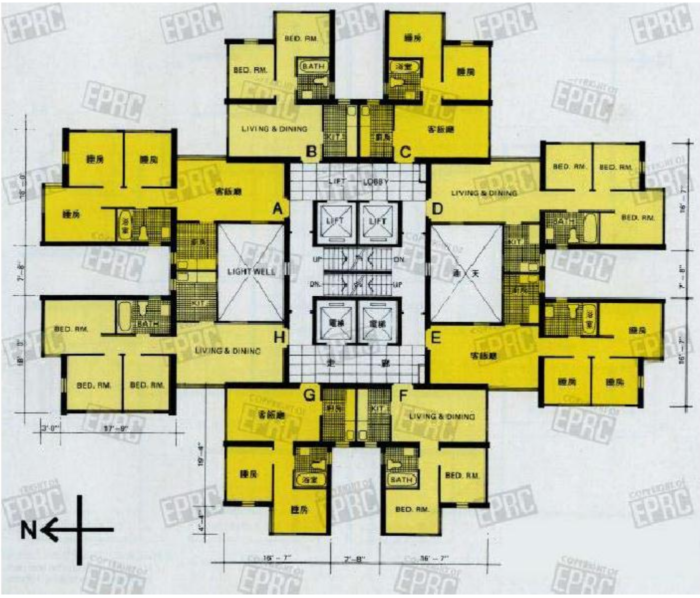


Figure 1c L-shaped Living Room from the Estate "Heung Fa Chuen" (Apts. 2, 3, 6, 7)

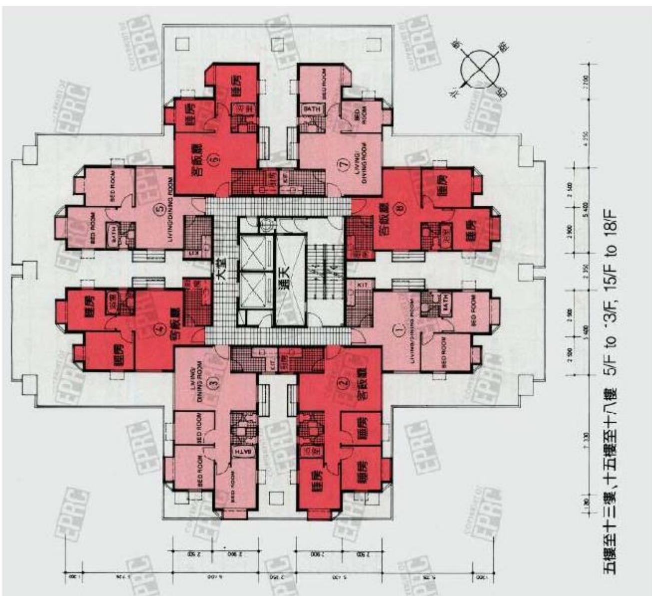
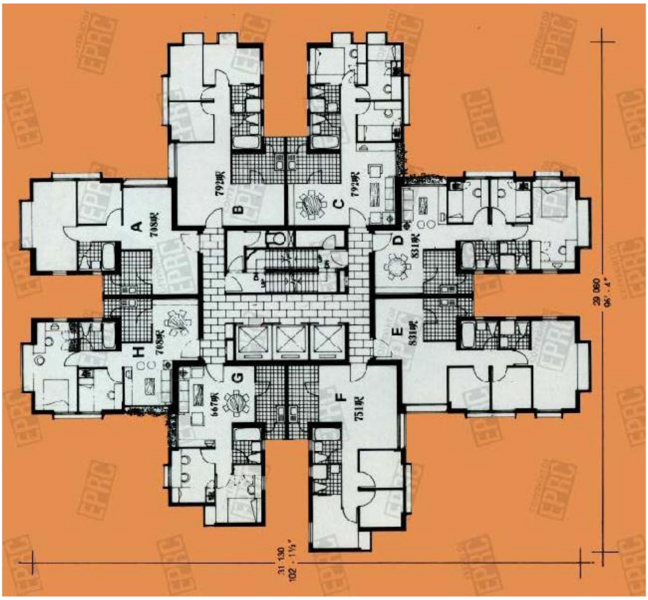


Figure 1d Living Rooms Shaped like "Two-rectangles" from the Estate "Taikoo Shing" (Apts. A, D, E, H)



Following the practice in the literature, we include the "number of bedrooms" and "number of toilets" in the regression, [13] with other floor layout features, such as the foyer[14], corridor[15] and balcony[16], which are also included in the analysis. Distance from the central business district (CBD)[17] is a proxy of the time for commuting. [18]

---

[13] In Hong Kong, although residents do not need to apply for government permission to adjust the number of bedrooms in their flats, it is very costly to do so.

[14] The foyer is the space in a flat which is used for entry from the outside. http://en.wikipedia.org/wiki/Foyer.

[15] The corridor is a path or guided way which usually refers to an interior passageway in a modern building. http://en.wikipedia.org/wiki/Corridor.

[16] The balcony is a kind of platform that projects from the wall of a building, and supported by columns or console brackets. http://en.wikipedia.org/wiki/Balcony.

[17] In Hong Kong, the CBD refers to Central and Tsim Sha Tsui.

[18] The relationship between the land rent or land value and the distance from the city center can be at least traced back to the work of Ricardo, which is then extended to form the rent gradient literature. Obviously, it is beyond the scope of this paper to review that literature. Among others, see Bertaud and Malpezzi (2003). Among others, Hanushek and Yilmaz (2007a, b) provide a general equilibrium formulation which will endogenously generate a rent gradient, among other stylized facts found in the public finance and urban economics literature. Mok et al. (1995) find that a distance decay mechanism appears in the Hong Kong residential property market.

In addition, we include variables that may add value to the houses, such as "view"[19] (classified by type of view, including roads, parks, large parks, open spaces, hills, sea, and partial sea view from building), accessibility to public transportation (which include the Mass Transit Railway or MTR, i.e. the subway, and the Kowloon-Canton Railway or the KCR, i.e. the railway[20]), availability of a clubhouse, proximity of urban park, open space, [21] and "lucky numbers" (i.e. "8").[22] Furthermore, we follow Kwok and Tse (2006a, b) in using "estate scale" as a measure of "liquidity" in the empirical analysis.[23]

3. Data Description

We compile our dataset from different sources. The housing transaction dataset is purchased from the Economic Property Research Center (EPRC).[24]

---

[19] Among others, Darling (1973), Brown and Pollakowski (1977), Benson et al. (1998), and Chau et al. (2005) all find that "view" is important in determining the property values. In this paper, a partial sea view is defined as a housing unit which has a sea view with some obstruction by buildings.

[20] The MTR provides the metro service for the northern part of the Hong Kong Island, Kowloon Peninsula, and southern part of the New Territories as well as the Hong Kong International Airport. See http://www.mtr.com.hk/prehome/index.html for details. The KCR operates four train lines, namely, the East Rail (connecting Lo Wu to East Tsim Sha Tsui), Ma On Shan Rail (connecting Wu Kai Sha to Tai Wai), West Rail (connecting Tuen Mun to Nam Cheong) and Light Rail (serving the northwest New Territories). See www.kcrc.com for details. The two companies have recently merged. However, this merger is only limited to financial purposes. The operations of the two lines are still independent.
Previous studies such as those by Grass (1992), and Bowes and Ihlanfeldt (2001) show that proximity to railway stations is one of the desirable factors for both high and low income residential neighborhoods. For evidence on the importance of public transportation on the Hong Kong housing market, see Mok et al. (1995), Leung et al. (2002), among others.

[21] Open space includes neighborhood parks, greenbelts, country parks and golf courses. Do and Grudnitski (1995) find that the premium paid for the properties on golf courses is approximately 7.6%. See Do and Grudnitski (1995), Soren and Sarah (2006), Dehring and Dunse (2006) on how proximity to open space can add value to houses.

[22] For instance, in New Zealand, Bourassa and Peng (1999) show that there is a premium for housing with lucky numbers in areas that have high percentages of Chinese. On the other hand, Leung et al. (2006, 2007) do not confirm this finding in Hong Kong.

[23] Kwok and Tse (2006a, b) find that there is a positive relationship between housing liquidity and estate scale, as there is more trading in larger estates, thus generating an *informational externality* in pricing *other* housing units in the same estate. For more discussion on how the liquidity of housing units affects their pricing, see Anglin (2006), Anglin et al. (2003), and the reference therein.

[24] EPRC, a subsidiary of the Hong Kong Economic Times, purchases all property market transaction records from the Hong Kong Land Registry Department. Then, the EPRC reorganizes those records and sells them to commercial and educational users.

In addition, we collect the floor plans of all thirty-three housing estates by visiting many different property agents.[25] To take into consideration all of the variations in the floor layout features, we study *all of the floor plans.* Table 1 provides a summary of the sample and more details can be found in the Appendix.

Table 1 Summary Statistics of the Samples

Regions	Number of “real estate developments”	Average number of buildings in each "real estate development"	Average number of units in each "real estate development"
Hong Kong Island	9	28	5,312
Kowloon Peninsula	8	39	6,150
The New Territories	16	19	4,585

Many efforts have been put forth to enhance the accuracy of the data. In the case of “view”, we combine both the satellite map as well as site investigations.[26] The information on the “distance from CBD” is acquired from measuring the distance of the shortest link, instead of the actual distance, between the housing estate and CBD, in order to take into consideration the presence of natural barriers, for instance, hills, gulfs, etc., between the two points. In addition, the values for dummy variables such as “Open Space 500”, “MTR500” and “KCR500” are similarly acquired.[27] We also visit the websites of various property agents for cross-checking, especially with respect to the presence of clubhouses and the estate scale. Tables 2 and 3 provide more information about the dataset. The Appendix further shows that the simple correlations among the variables are not that high. If we ignore all of the self-correlations (which attain the value of unity), there are in total, 171 correlations. There are 121 of them (i.e. 70%) that have an absolute value below 0.2. Another 36 (i.e. 21%) attain values between 0.2 and 0.4. Among the remaining 14 correlations, only one is above 0.6. Multicollinearity does not seem to be an important issue (this point will be discussed later).

The EPRC data base contains information on transaction price, corresponding gross and net size, as well as its address. In the EPRC, some details of each transaction, for example, the transaction price, corresponding gross square-footage, floor, year-built, etc. are provided.

[25] For instance, Centaline, Midland, Ricacorp, etc.

[26] For instance, the flats in an estate located on elevated land may have a sea view, despite the distance from the sea. On the other hand, Allways Garden in Tsuen Wan is far away from the sea, but some of the flats in some of the blocks also have sea-views. One of the co-authors actually spent a significant amount of time in the summer of 2006 to collect the information.

[27] Table 2 provides the definition of all the variables.

Table 2 Description of Research Variables

Variable	Description	Expected sign
Dependent Variable		
ln Price	Log selling price of a housing unit (in HK$million)	
Independent Variables		
Structural Attributes		
Age	Age of the housing unit (in years)	-
Age2	Square of age	+
Floor	Floor level of the housing unit	+
Floor2	Square of floor level	-
Gross size	Total gross area of the flat (sq-footage)	+
Gross size2	Square of gross size	-
Net ratio	The ratio of net size to gross size	+
Clubhouse	If clubhouse is available within the estate, this dummy is 1, otherwise=0	+
Lucky Number	If the floor level is 8,18,28, 38 or 48, LuckyNumber=1, otherwise=0	+
Estate scale	The total number of apartments in this housing estate	+
Neighborhood Attributes		
MTR 500	If MTR is available within 0-500 metres, MTR500=1, otherwise=0	+
KCR 500	If KCR is available within 0-500 metres, KCR500=1, otherwise=0	+
Open Space 500	If distance from open space within 0-500 metres, this dummy=1, otherwise=0	+
Water 500	If distance from waters within 0-500 metres, this dummy=1, otherwise=0	+
Locational Attributes		
Distance from CBD	Distance to the Central Business District	-
Distance from CBD2	Square of distance to the Central Business District	+
Hong Kong Island	If the housing unit is located on Hong Kong Island, this dummy=1, otherwise=0	+
Kowloon	If the housing unit is located on Kowloon peninsula, this dummy=1, otherwise=0	+

(Continued…)

(Table 2 Continued)

Variable	**Description**	**Expected sign**
Floor Layout Attributes		
Foyer	Presence of foyer=1, otherwise=0	-
Corridor	Presence of corridor=1, otherwise=0	-
Balcony	Presence of balcony=1, otherwise=0	-/+
No. of bedrooms	Total number of bedrooms of the apartment	-
No. of toilets	Total number of toilets of the apartment	-
Kitchen accessible to living room	If kitchen is accessible to living room, the dummy=1, otherwise=0	-/+
Kitchen adjacent to bedroom	If kitchen is adjacent to bedroom, the dummy=1, otherwise=0	-
Toilet adjacent to bedroom	If toilet is adjacent to bedroom, this dummy=1,otherwise=0	-/+
Diamond	Presence of diamond-shape living room=1, otherwise=0	-/+
L-shaped	Presence of L shape living room=1, otherwise=0	-/+
Rectangular	Presence of rectangular living room=1, otherwise=0	-/+
Store room	Presence of store room=1, otherwise=0	+
Roof	Presence of roof =1, otherwise=0	+
Deck	Presence of deck=1, otherwise=0	+
Views Attributes		
Sea-view	Sea view=1, otherwise=0	+
Interactive terms		
Age & Diamond	Variable "Age" times variable "Diamond"	-/+
Gross Size & Diamond	Variable "Gross size" times variable "Diamond"	-/+
Net Ratio & Diamond	Variable "Net Ratio" times variable "Diamond"	-/+
Distance from CBD & Diamond	Variable "Distance from CBD" times variable "Diamond"	-/+
Estate Scale & Diamond	Variable "Estate Scale" times variable "Diamond"	-/+
Age & L-shaped	Variable "Age" times variable "L-shaped"	-/+
Gross Size & L-shaped	Variable "Gross size" times variable "L-shaped"	-/+

(Continued…)

(Table 2 Continued)

Variable	**Description**	**Expected sign**
Interactive terms		
Net Ratio & L-shaped	Variable "Net Ratio" times variable "L-shaped"	-/+
Distance from CBD & L-shaped	Variable "Distance from CBD" times variable "L-shaped"	-/+
Estate Scale & L-shaped	Variable "Estate Scale" times variable "L-shaped"	-/+
Age & Rectangular-shaped	Variable "Age" times variable "Rectangular"	-/+
Gross Size & Rectangular-shape	Variable "Gross size" times variable "Rectangular"	-/+
Net Ratio & Rectangular-shaped	Variable "Net Ratio" times variable "Rectangular"	-/+
Distance from CBD & Rectangular-shaped	Variable "Distance from CBD" times variable "Rectangular"	-/+
Estate Scale & Rectangular-shaped	Variable "Estate Scale" times variable "Rectangular"	-/+

The sample period starts from the first quarter of 1992 to the fourth quarter of 2005. The sample is split into 56 sub-samples according to the transaction quarter.[28] In our sample, there are a total of more than two hundred thousand transactions. Figure 2 shows that the transaction volume significantly varies over time. The minimum number of transactions in one quarter is 1,399 and the average number of transactions is about 4,000 in each quarter (see Table 3a for more details), and thus we have “enough” degree of freedom for our regressions. All of the estates studied in this paper are apartment buildings.[29] To avoid double-counting, only the transactions with official housing sale and purchase agreements are considered.

[28] In the context of the Hong Kong housing market, the choosing of quarters as a period may be a constrained-optimal choice. It is not too short so that we have enough transactions in each period. It is not too long or else time aggregation bias may occur. Moreover, Leung, Leong and Chan (2002) explain that most transactions (from listing to the final contract signing) close in a quarter.

[29] Detached houses or low-density properties are removed from the data set for a variety of reasons. For instance, the buyers in this segment of the market may have different preferences. For instance, some buyers use the ground floor for retail and the upper floors for residential purposes. The transactions in this segment of market are usually thin. Perhaps more importantly, the shapes of the living rooms in this segment of the market may not be easily categorized into the four types mentioned above. Also, Leung et al. (2006) use both high-rise and detached properties to study the pricing of properties in Hong Kong, and there is no need to repeat their work in this paper.

Table 3 Descriptive Statistics

	Mean	Standard Deviation	Min	Max	Median
Dependent Variables					
ln_price	0.7985	0.5258	-5.30	3.37	0.7839016
Independent Variables					
Structural Attributes					
Age	10.3581	7.5638	0	37	9
Age2	164.5004	210.6440	0	1369	81
Floor	15.6399	9.4016	0	45	15
Floor2	332.9954	345.2236	0	2025	225
Gross size	676.8731	178.8206	273	2166	666
Gross size 2	490133.8000	276226.8000	74529.00	4691556.00	443556
Net ratio	0.8170	0.0456	0.42	0.99	0.81
Clubhouse	0.7766	0.4165	0	1	1
Lucky Number	0.0941	0.2920	0	1	0
Estate scale	8087.5670	4530.6620	11220.00	15836.00	8071
Neighborhood Attributes					
MTR 500	0.3653	0.4815	0	1	0
KCR 500	0.0631	0.2432	0	1	0
Open Space 500	0.7060	0.4556	0	1	0
Water 500	0.4034	0.4906	0	1	0
Locational Attributes					
Distance from CBD	14.4215	10.8346	1.80	36.60	11

(Continued…)

(Table 3 Continued)

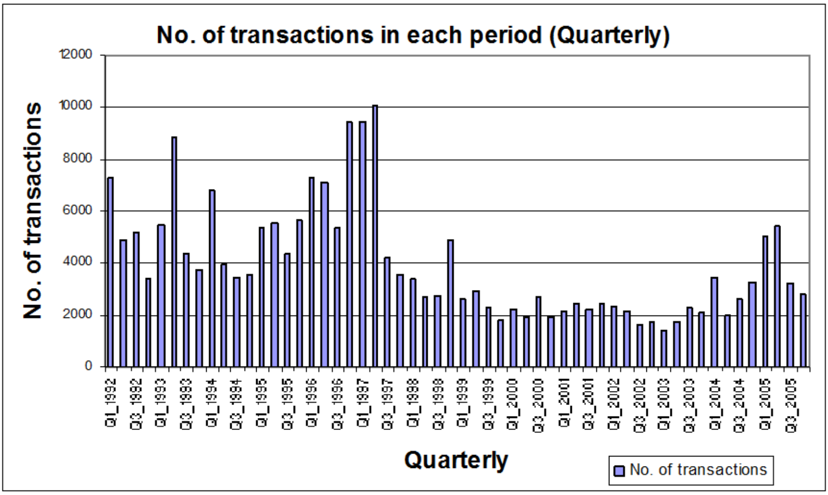
	Mean	Standard Deviation	Min	Max	Median
Locational Attributes					
Distance from CBD 2	325.3690	452.4455	3.24	1339.56	121
Hong Kong Island	0.2680	0.4429	0	1	0
Kowloon	0.2936	0.4554	0	1	0
Floor Layout Attributes					
Foyer	0.2052	0.4038	0	1	0
Corridor	0.8228	0.3818	0	1	1
Balcony	0.0829	0.2758	0	1	0
No. of bedrooms	2.4719	0.5521	1	5	2
No. of toilets	1.2996	0.4707	1	3	1
Kitchen accessible to living room	0.7683	0.4219	0	1	1
Kitchen adjacent to bedroom	0.0939	0.2916	0	1	0
Toilet adjacent to bedroom	0.9846	0.1233	0	1	1
Diamond	0.4062	0.4911	0	1	0
L-shaped	0.1950	0.3962	0	1	0
Rectangular	0.2948	0.4559	0	1	0
Store room	0.0978	0.2971	0	1	0
Roof	0.0444	0.2059	0	1	0
Deck	0.0020	0.0446	0	1	0
Views Attributes					
Sea-view	0.0741	0.2620	0	1	0

(Continued…)

(Table 3 Continued)

	Mean	**Standard Deviation**	**Min**	**Max**	**Median**
Interactive terms					
Age & Diamond	2.3363	4.2417	0	25	0
Gross Size & Diamond	307.8255	384.2294	0	2166	0
Net Ratio & Diamond	0.3301	0.3997	0	0.97	0
Distance from CBD & Diamond	6.9300	12.1950	0	36.60	0
Estate Scale & Diamond	4393.8660	5854.5870	0	1584	0
Age & L-shaped	2.6008	6.3973	0	37	0
Gross Size & L-shaped	134.2034	284.0552	0	1688	0
Net Ratio & L-shaped	0.1626	0.3309	0	0.99	0
Distance from CBD & L-shaped	2.6498	6.5456	0	31	0
Estate Scale & L-shaped	1289.6370	3197.4830	0	13063	0
Age & Rectangular-shaped	3.8435	7.1649	0	37	0
Gross Size & Rectangular-shaped	168.5468	274.4680	0	1494	0
Net Ratio & Rectangular-shaped	0.2378	0.3690	0	0.98	0
Distance from CBD & Rectangular-shaped	3.8612	7.2167	0	31	0
Estate Scale & Rectangular-shaped	1700.4730	3356.6140	0	13063	0
No. of observations	222562				

Figure 2 Number of Transactions in Each Quarter (1992~2005)



4. Methodology

Housing units typically differ in many dimensions. To "properly" estimate the value of houses, this paper employs the hedonic approach.[1] Among others, Leung et al. (2007) confirm that the implicit prices of housing attributes are not constant over time. Thus, it may not be appropriate to pool all the data into one regression. To avoid time aggregation bias[2], we divide the full sample into 56 sub-samples on a quarterly basis. As a comparison, we also have a complementary regression with all the data pooled together. By following Malpezzi (2003), a semi-log specification is estimated for each quarter:

$$\ln(P_i) = \beta_{i0} + \beta_{i1}S + \beta_{i2}N + \beta_{i3}L + \beta_{i4}F + \beta_{i5}V + \varepsilon_i \quad , i = 0, 1, 2\ldots, 56$$

where P represents the transaction price of an apartment, S represents structural attributes (such as age of the building), N represents neighborhood attributes (such as proximity to the MTR station), L stands for locational attributes (such as distance from the CBD or the district where the estate is located), F represents floor layout attributes (such as the foyer, corridor, balcony), V represents view attributes (such as a road view, open space view, etc.), and ε represents the error term in the regression model.

[1] It was introduced by Court (1939) and then elaborated by a static model of Rosen (1974), and dynamic model of Leung et al. (2007). For instance, see Rosen (1974), Leung et al. (2007), and Malpezzi (2003) for a review of the literature.

[2] For instance, see Christano, Eichenbaum and Marshall (1991).

5. Empirical Results

This section presents the results based on a series of cross-sectional hedonic price regressions. As we explained earlier, we separately estimate the implicit prices of the housing attributes in each quarter, which will avoid the potential of time-aggregation bias.[3] There are in total, 56 quarterly sub-samples. The expected signs for all variables are summarized in Table 2 and a more detailed discussion can be found in the Appendix. Clearly, the results in all of these 56 regressions do not need to be identical, as hedonic regression coefficients should fluctuate over time (Leung et al., 2007).

Due to space limitations, we only present the mean values of the coefficients in Table 4a and leave the details in the Appendix.[4] The first two columns present the results from basic models which do not include the physical layout variables. The third and the fourth columns present the results when the physical layout variables are included. The difference between the two columns is that some "outlier transactions" are eliminated in the restricted sample and thus, the fourth column is meant to be a type of "robustness check". The fifth and sixth columns report the estimates when both physical layout and the interaction terms between physical layout and other location variables are included. Again, the sixth column presents the results when "outlier transactions" are excluded. In general, the difference between the full sample and the restricted sample is very minor.

Most estimates deliver the expected sign. For instance, an increase in age and distance from the CBD will lead to a decrease in the house value (negative coefficient). An increase in the floor (i.e. units located at higher levels in the buildings), size and net ratio, the presence of a clubhouse, accessibility to the subway, train, waterfront, etc. will all increase the house value. All of these are consistent with the previous research.

Our focus, however, is on the interior design (or the physical layout), and hence we shift the attention to the third to sixth columns. The existence of a roof and deck, in which the area is not included in "area", provide extra value

---

[3] It will also contain the "statistical outliers" in the regression within the corresponding quarter and not spread out the effect of the potential contamination to the whole sample.

[4] Notice that the 56 hedonic equations for the 56 sub-samples are separately estimated, and therefore it is impossible to assess whether the mean values of these coefficients are statistically significant or not.

For robustness, we report the results on "restricted samples" in Columns 4 and 6. Basically, we drop the observations which are suspected outliers (in terms of transaction prices). In this case, it means transactions in which the square-feet price is lower than HK$500. The justification is that some of them may be traded among related parties, including trade among divorce couples. Therefore, it is possible that the transaction price is far below the market price. Unfortunately, such information is provided by neither the EPRC nor the government.

and hence the corresponding coefficients are positive. By controlling the size and location, an increase in the number of bedrooms or toilets would actually lead to a decrease in the house value. This may seem to be puzzling at first. However, given that the mean size in the sample is less than 700 square feet (or 70 square meters), an increase in the number of rooms will imply a reduction of "useable space".

We also find that the location of the kitchen next to either the living room or bedroom would negatively affect the house value. Asian cooking tends to create a lot of smoke in the process, which may contribute to this empirical finding.

The coefficients on the shape of the living rooms, which have not been discussed in the previous literature, may deserve more discussion. With "Two-Rectangles" as the control, we find that a "Diamond," "L-" or "Rectangular" shaped living room all add value (3^{rd} and 4^{th} columns in Table 4a). However, once we take into consideration the interaction terms and re-calculate the total effect, some of our conclusions may change. Table 4b shows the total effect of a selected group of variables (the rationale and computation of the total effect are detailed in the Appendix). While the total effect of having a "Diamond" shaped living room has roughly the same effect on the house price across different models, the measured contribution of an "L-" shaped living room would be under-estimated if the interaction terms are ignored. Over different sub-sampling periods, the average total effect of "L-" shaped living rooms increase almost 100% after the interaction terms are taken into consideration (the numbers in Models 5 and 6 are compared with those in Models 3 and 4). On the other hand, the contribution from a "Rectangular" shaped living room will be over-estimated, as the average total effect turns from positive (Models 3 and 4) to slightly negative (Models 5 and 6). Interaction terms matter.

At the same time, the estimated effects of the "district dummies" are also affected. The estimated effects of the "Hong Kong Island" district dummy diminish further from about 0.22 (Models 3 and 4) to about 0.19 (Models 5 and 6). The case for the "Kowloon" district coefficient is much more dramatic. The estimated effects decrease 75%, from about 0.08 (Models 3 and 4) to about 0.02 (Models 3 and 4). Again, this suggests that the interaction terms which involve interior design variables matter, and they tend to "dilute" the importance of the district dummies.

Now we show that the results are robust to alternative econometric strategies. More specifically, we run a complementary regression, which pool *all* the transactions in one sample, with time dummies for each quarter included. A merit of pooling all data into one regression is that we can easily check for the statistical significance.

Table 4a Estimated Results from Several Models (Mean Value of Coefficients)

	Basic Model 1	Basic Model 2	Model with "Design Variables"	Model using restricted sample	Model with "interactive terms and design"	Model with "interactive terms and design" using restricted sample
Constant	-1.4987	-1.5095	-1.5523	-1.5515	-2.1716	-2.1667
Age	0.0460	-0.0083	-0.0044	-0.0046	-0.0033	-0.0032
Age2	-0.0017	-0.0003	-0.0004	-0.0004	-0.0005	-0.0005
Floor	0.0078	0.0092	0.0094	0.0094	0.0093	0.0093
Floor2	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002
Gross size	0.0030	0.0024	0.0025	0.0025	0.0025	0.0025
Gross size 2	-8.42E-07	-5.96E-07	-5.90E-07	-5.89E-07	-5.31E-07	-5.34E-07
Net ratio		1.1352	1.1181	1.1123	1.8867	1.8767
Clubhouse	0.0654	0.0641	0.0617	0.0614	0.0431	0.0430
Lucky Number	0.0073	0.0076	0.0084	0.0086	0.0083	0.0085
MTR 500	-0.0200	0.0993	0.1026	0.1020	0.1399	0.1392
KCR 500	0.2214	0.2180	0.2263	0.2249	0.2439	0.2421
Open Space 500	-0.0523	-0.0100	-0.0113	-0.0116	-0.0058	-0.0062
Water 500	0.0382	0.0795	0.0654	0.0743	0.0690	0.0769
Distance from CBD		-0.0165	-0.0155	-0.0153	-0.0149	-0.0145
Distance from CBD 2		4.43E-06	-1.98E-05	-2.56E-05	1.97E-04	1.81E-04
Hong Kong Island	0.4622	0.2356	0.2215	0.2201	0.1941	0.1927

(Continued…)

(Table 4a Continued)

	Basic Model 1	Basic Model 2	Model with "Design Variables"	Model using restricted sample	Model with "interactive terms and design"	Model with "interactive terms and design" using restricted sample
Kowloon	0.3125	0.0949	0.0862	0.0859	0.0230	0.0235
Estate scale		9.77E-06	8.76E-06	8.84E-06	4.10E-06	4.42E-06
Foyer			-0.0227	-0.0234	-0.0108	-0.0114
Corridor			0.0035	0.0029	-0.0156	-0.0164
Balcony			-0.0189	-0.0199	-0.0235	-0.0242
No. of bedrooms			-0.0163	-0.0152	-0.0182	-0.0171
No. of toilets			-0.0430	-0.0454	-0.0381	-0.0407
Kitchen accessible to living room			-0.0034	-0.0045	0.0009	-0.0003
Kitchen adjacent to bedroom			-0.0204	-0.0220	-0.0360	-0.0373
Toilet adjacent to bedroom			0.0333	0.0337	0.0145	0.0153
Diamond			0.0247	0.0254	1.4922	1.4827
L-shaped			0.0129	0.0121	1.0303	1.0182
Rectangular			0.0043	0.0047	0.6284	0.6147
Store room			-0.0050	-0.0048	-0.0119	-0.0118
Roof			0.0429	0.0427	0.0411	0.0415
Deck			0.1395	0.1389	0.1379	0.1375
Sea-view			0.0166	0.0088	0.0191	0.0125

(Continued…)

(Table 4a Continued)

	Basic Model 1	Basic Model 2	Model with "Design Variables"	Model using restricted sample	Model with "interactive terms and design"	Model with "interactive terms and design" using restricted sample
Age & Diamond					-0.0030	-0.0031
Gross Size & Diamond					-0.0002	-0.0002
Net Ratio & Diamond					-1.5095	-1.4981
Distance from CBD & Diamond					-0.0153	-0.0152
Estate Scale & Diamond					1.16E-05	1.18E-05
Age & L-shaped					-0.0024	-0.0023
Gross Size & L-shaped					-0.0001	-0.0001
Net Ratio & L-shaped					-1.0734	-1.0608
Distance from CBD & L-shaped					-0.0089	-0.0089
Estate Scale & L-shaped					8.14E-06	7.84E-06
Age & Rectangular-shape					0.0056	0.0056
Gross Size & Rectangular-shaped					-1.09E-05	-1.12E-05
Net Ratio & Rectangular-shaped					-0.8300	-0.8092
Distance from CBD & Rectangular-shaped					-0.0051	-0.0051
Estate Scale & Rectangular-shaped					4.42E-06	3.91E-06

Table 4b A Comparison of the Total Effect of Selected Variables
(Average point estimates from quarterly regressions)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
(Locational)						
HK Island	0.462	0.236	0.221	0.220	0.194	0.193
Kowloon	0.312	0.095	0.086	0.086	0.023	0.024
(Structural)						
Diamond	N.A.	N.A.	0.0247	0.0254	0.025	0.026
L-shaped	N.A.	N.A.	0.0129	0.0121	0.020	0.019
Rectangular	N.A.	N.A.	0.0043	0.0047	-0.023	-0.023

Note: *N.A.* means *Not Available*, as that variable is not included in the regression.

Table 4c shows the same pattern. The coefficient of the "Hong Kong Island" dummy slightly drops when Models 3 and 4 (without interaction terms) are compared to Models 5 and 6 (when interaction terms are taken into account). The change in the "Kowloon" dummy is very dramatic. The decrease is around 80%, from about 0.057 (Models 3 and 4) to about 0.011 (Models 5 and 6). Not surprisingly, we also find that many interaction terms are themselves statistically significant at the 1% level.

In sum, Tables 4a to 4c demonstrate that the introducing of interaction terms only marginally increases the R^2 and mean adjusted R^2. On the other hand, both the results from the quarterly subsamples and pooled data show that once the interior design variables and their related interaction terms are included, the explanatory power of the district variables would sharply decrease. One potential explanation of this result is the existence of multicollinearity. However, we show in the Appendix that the simple correlations are not high: 121 of the 171 correlations (i.e. 70%) have an absolute value below 0.2, and another 36 (i.e. 21%) attain values between 0.2 and 0.4. Thus, we may need an alternative explanation.

Our explanation stems from simple economics. In Hong Kong, land ownership belongs to the government, who sells lots of land from time to time. The lot size, height limit, location, etc., are in some sense, exogenous. The developers can only choose "to bid" or "not to bid". On the other hand, conditional upon obtaining land from an auction, a developer can choose the "interior design" variables, including the shape of the living room, whether the kitchen is adjacent to the bedroom, etc. Thus, it seems reasonable to conjecture that the structural characteristics (determined by the developers) would depend on the location characteristics (which are "given" from the perspective of the developers). In other words, there is the possibility of *endogenous multicollinearity*. In particular, in our regression, the effect of the "district", such as "Hong Kong Island" or "Kowloon" would be significantly "diluted" after we include the interior design variables, and the corresponding interaction terms in the regression. This also explains why interaction terms like "Distance from CBD and Diamond," "Distance from CBD and L-shaped," "Distance from CBD and Rectangular" are all statistically significant. Notice that the "Distance from CBD" is a location characteristic and not subject to the choice of the developer, but this is not the case for the shape of the living room, which is a structural characteristic. Thus, the decision of the shape of the living room in an estate may be influenced by its location ("distance from CBD"). To formalize this idea, the next section will provide a simple theoretical model.

Table 4c **Estimated Results From Pooling Regression**

(All time dummies are statistically significant; details are in the Appendix)

	Basic Model 1	Basic Model 2	Model with "Design Variables"	Model using restricted sample	Model with "interactive terms and design"	Model with "interactive terms and design" using restricted sample
Constant	-1.36091***	-1.72331***	-1.72923***	-1.72844***	-2.34086***	-2.34001***
Age	0.02176***	-0.01681***	-0.01538***	-0.01545***	-0.01726***	-0.01718***
Age2	-0.00076***	-0.00008***	-0.00010***	-0.00010***	0.00000***	0.00001***
Floor	0.00764***	0.00945***	0.00976***	0.00977***	0.00974***	0.00975***
Floor2	-0.00017***	-0.00020***	-0.00021***	-0.00021***	-0.00021***	-0.00021***
Gross size	0.00275***	0.00232***	0.00241***	0.00241***	0.00239***	0.00239***
Gross size 2	-7.56E-07***	-5.94E-07***	-5.63E-07***	-5.62E-07***	-5.09E-07***	-5.09E-07***
Net ratio		1.21077***	1.19732***	1.19692***	1.95834***	1.95469***
Clubhouse	0.10895***	0.08863***	0.08805***	0.08818***	0.06992***	0.07011***
Lucky Number	0.00470***	0.00609***	0.00716***	0.00693***	0.00751***	0.00728***
MTR 500	-0.00841***	0.11416***	0.11752***	0.11730***	0.14582***	0.14569***
KCR 500	0.22106***	0.18042***	0.18549***	0.18459***	0.18695***	0.18608***
Open Space 500	-0.06175***	-0.00514***	-0.00675***	-0.00613***	0.00076	0.00138
Water 500	0.05225***	0.07430***	0.08425***	0.08527***	0.09086***	0.09186***
Distance from CBD		-0.01722***	-0.01695***	-0.01694***	-0.01534***	-0.01525***
Distance from CBD 2		-0.00002***	-0.00003***	-0.00003***	0.00015***	0.00014***
Hong Kong Island	0.44745***	0.18405***	0.16998***	0.17006***	0.15346***	0.15343***

(Continued…)

(Table 4c Continued)

	Basic Model 1	Basic Model 2	Model with "Design Variables"	Model using restricted sample	Model with "interactive terms and design"	Model with "interactive terms and design" using restricted sample
Kowloon	0.31425***	0.06716***	0.05686***	0.05691***	0.01121***	0.01129***
Estate scale		9.21E-06***	8.08E-06***	8.05E-06***	3.90E-06***	3.96E-06***
Foyer			-0.02412***	-0.02417***	-0.02069***	-0.02057***
Corridor			0.00559***	0.00586***	-0.01199***	-0.01162***
Balcony			-0.02643***	-0.02625***	-0.03985***	-0.03964***
No. of bedrooms			-0.01203***	-0.01204***	-0.00891***	-0.00903***
No. of toilets			-0.04255***	-0.04242***	-0.03608***	-0.03604***
Kitchen accessible to living room			-0.00145	-0.00146	-0.00170	-0.00159
Kitchen adjacent to bedroom			-0.01904***	-0.01910***	-0.03720***	-0.03709***
Toilet adjacent to bedroom			0.03752***	0.03807***	0.01158***	0.01228***
Diamond			0.01366***	0.01296***	1.43408***	1.42993***
L-shaped			0.01101***	0.01033***	1.12251***	1.12346***
Rectangular			-0.00510***	-0.00568***	0.67702***	0.67644***
Store room			-0.01045***	-0.01080***	-0.01162***	-0.01198***
Roof			0.05058***	0.05078***	0.04572***	0.04585***
Deck			0.16122***	0.16094***	0.15554***	0.15532***
Sea-view			-0.00667	-0.00778	-0.00596	-0.00714
Age & Diamond					0.00224***	0.00208***

(Continued…)

(Table 4c Continued)

	Basic Model 1	Basic Model 2	Model with "Design Variables"	Model using restricted sample	Model with "interactive terms and design"	Model with "interactive terms and design" using restricted sample
Gross Size & Diamond					-0.00014***	-0.00014***
Net Ratio & Diamond					-1.51267***	-1.50740***
Distance from CBD & Diamond					-0.01319***	-0.01323***
Estate Scale & Diamond					0.00001***	0.00001***
Age & L-shaped					-0.00418***	-0.00437***
Gross Size & L-shaped					-0.00006***	-0.00006***
Net Ratio & L-shaped					-1.19567***	-1.19366***
Distance from CBD & L-shaped					-0.00820***	-0.00827***
Estate Scale & L-shaped					0.00001***	0.00001***
Age & Rectangular-shaped					0.00056***	0.0042
Gross Size & Rectangular-shaped					0.0000	0.0000
Net Ratio & Rectangular-shaped					-0.80794***	-0.80582***
Distance from CBD & Rectangular-shaped					-0.00579***	-0.00583***
Estate Scale & Rectangular-shaped					5.14E-06***	5.07E-06***
R-square	85.5%	91.1%	91.3%	91.5%	91.6%	91.8%
Adj R-square	85.4%	91.1%	91.3%	91.5%	91.6%	91.8%

6. Endogenous Multicollinearity

In the previous section, we have provided an explanation of "endogenous multicollinearity," which is based on the incentive for the developers to adjust the structural attributes given the location of the land. It may be more important for places like Hong Kong where the land ownership belongs to the government and the private market for land re-sale does not exist.[1] This section attempts to formalize the ideas through a simple theoretical model.

To elucidate the idea, consider a developer who maximizes profit from selling a housing unit that faces a competitive environment. We assume that the potential buyers can always purchase from other developers in the market, or stay with the original dwelling unit and obtain a "reservation utility level" $\overline{U}$. We further assume that the market can competitively price each attribute and the developer takes these "hedonic prices" or "implicit housing attribute prices" P_i, i = L, S as given. To simplify the exposition, assume that there are only two attributes, a location attribute, L, and a structural attribute, S. Households (potential buyers) exhibit a concave preference to these attributes. Formally, this means that the utility function of the household, $U(L,S)$, has the usual properties:

$$U_i > 0, U_{ii} < 0, U_{ij} \geq 0,$$

where, $U_i = \partial U / \partial i, U_{ij} = \partial^2 U / \partial i \partial j$, and i, j = L, S. The cost function of the developer $C(L,S)$ is one that is typically found in microeconomics, which is at least weakly convex,[2] $C_i > 0, C_{ii} \geq 0, C_{ij} \geq 0,$ where $C_i = \partial C / \partial i, C_{ij} = \partial^2 C / \partial i \partial j$, and i, j = L, S. Thus, the maximization problem of the developer can be formulated as:

$$\max_{L,S} [P_L L + P_S S - C(L,S)],$$

subject to the "competition constraint," $U(L,S) \geq \overline{U}$. Let λ be the Lagrange multiplier of the competition constraint, then it is easy to derive $P_i - C_i + \lambda U_i = 0$, i = L, S. It can be further simplified as $\frac{U_L}{U_S} = \frac{C_L - P_L}{C_S - P_S}$. This means that the utility gain of an additional unit of each attribute should be balanced by the "net additional cost" of an additional unit of the same attribute. The last expression can be re-arranged as

$$U_L (C_S - P_S) - U_S (C_L - P_L) = 0.$$

---

[1] Most, if not all, of the land in many countries including the United Kingdom, Singapore, China, etc. belong to the government.

[2] See Mas-Colell et al. (1995) for justifications on the concavity of the utility function and the convexity of the cost function.

Since this expression always holds at the optimal, we can take the total differential. Assume that prices are invariant to the developer's decisions, i.e., $dP_i = 0$, i = L, S (this assumption can always be relaxed without changing the principal conclusion), we then have:

$$\begin{aligned}&(C_S - P_S)(U_{LL}dL + U_{LS}dS) + U_L(C_{SL}dL + C_{SS}dS)\\&-(C_L - P_L)(U_{LS}dL + U_{SS}dS) - U_S(C_{LL}dL + C_{SL}dS) = 0\end{aligned},$$

where we have assumed that both the utility function U and cost function C are smooth, and hence $U_{ij} = U_{ji}, C_{ij} = C_{ji}$, i, j = L, S. We can then re-arrange the terms and obtain the expression:

$$\frac{dS}{dL} = \frac{(C_L - P_L)U_{LS} + U_S C_{LL} - (C_S - P_S)U_{LL} - U_L C_{SL}}{(C_S - P_S)U_{LS} + U_L C_{SS} - (C_L - P_L)U_{SS} - U_S C_{SL}}.$$

Notice that even if both the utility and the cost functions are separable so that $U_{LS} = C_{SL} = 0$, this expression will be *non-zero* in general. This simply shows that the decision on location and structural attributes are in general *interdependent*. It is also clear that with more different attributes introduced into the utility and the cost functions, the above expression would only become more complicated and would not alter the basic conclusion that the location and the structural attributes are interdependent, which may be shown as a form of "*endogenous multicollinearity*".

The intuition is clear. From the viewpoint of the real estate developer, the *composition of structural attributes is endogenous*, and rational developers will adjust the composition according to the location and neighborhood features. All of these attributes in a hedonic pricing regression, such as the one adopted in this paper, are placed onto the right hand side of the equation in a parallel manner, which inevitably leads to *endogenous multicollinearity*".

7. Concluding Remarks

Other things being equal, does the interior design of a housing unit matter? "Street wisdom" would suggest a positive answer. This paper takes the first step to scientifically examining such street wisdom. In particular, we have chosen a collection of the most frequently traded real estate developments from Hong Kong. Since they are all apartment buildings, there will be many identically designed units on different floors with different views, which facilitate the comparison. In addition, racial discrimination virtually does not exist in Hong Kong. All of the public facilities, including schools, police, etc. are funded by the Hong Kong government, and district governments within Hong Kong virtually do not exist and hence local public finance will not be a concern. [3] All of these features in the market create a very desirable environment to investigating the value of interior design.

We find that the "design variables" are statistically significant. Perhaps more importantly, the interaction terms between the "design variables" on the one hand, and structural variables such as the "Distance from CBD" on the other hand, are statistically significant. The interaction terms among design variables, such as the shape of the living room on the one hand, and the net ratio or the estate scale on the other hand (all of these can be decided by the developers) are also statistically significant. We provide a simple theoretical model to account for such "endogenous multicollinearity".

Thus, one potential direction for future research would be to provide more theoretical modeling and empirical studies on the development process, and its interaction with the subsequent pricing of the housing units.[4] It will also be interesting to compare the results reported here with other cities, such as Singapore or even New York Manhattan, where apartment buildings play a dominant role in providing residence to the population. Also, the sampling period for future research should extend beyond 2005. Recent studies such as those by Leung et al. (2012), and Leung and Tang (2012) show that the housing market and the domestic economy in general reacted very differently during the recent global financial crisis, as compared to the earlier Asian financial crisis. It is possible that the market valuations for different types of physical layouts have changed as well. Last but not least, more cross-disciplinary research between real estate and architecture may prove to be mutually beneficial. We believe that research along these lines would eventually provide academic value as well as practical implications for property developers and architectural firms.

Acknowledgement

The authors are very grateful to Cheng Cheng, Kam Hon Lee, Saya Nakata, Tim Riddiough, Edward Tang, Kevin Wong, and especially Wai Kin Leung, seminar participants from the Chinese University of Hong Kong, City University of Hong Kong, as well as the American Real Estate Society, and Global Chinese Real Estate Congress, for many helpful comments and discussion. The research support from the City University of Hong Kong is gratefully acknowledged. The usual disclaimer applies.

---

[3] Among others, see Hanushek and Yilmaz (2007a, b) for a discussion on how the local public finance issue can significantly impact the housing price.
[4] Among others, see Lentz and Wang (1998) for some earlier efforts.

References

Archer, W. R., Gatzlaff, D. H. and D. C. Ling (1996), Measuring the Importance of Location in House Price Appreciation, *Journal of Urban Economics*, 40(3), 334 – 353

Anglin, P. (2006). Value and liquidity under Changing Market Conditions, *Journal of Housing Economics*, 15, 293-304.

Anglin, P, Rutherford, R. and Springer, T. (2003). The Trade-off Between the Selling Price of Residential Properties and Time-on-the-Market: The Impact of Price Setting, *Journal of Real Estate Finance and Economics,* 26, 95-111.

Asabere, P. K., Hachey, G. and Grubaugh, S. (1989), Architecture, historic zoning, and the value of homes, *Journal of Real Estate Finance and Economics,* 2, 181-195.

Ball, V. K. (1982), The Art of Interior Design, 2nd ed., New York: John Wiley.

Beaton, W. P., and Pollock, M. (1992), Economic Impact of Growth Management Policies Surrounding the Chesapeake Bay, *Land Economics*, 68, 434-453.

Benson, E. D., Hansen, J. L., Schwartz, A. L., Jr. and Smersh, G. T. (1998), Pricing Residential Amenities: The Value of a View, *Journal of Real Estate Finance and Economics*, 16, .

Bertaud, A. and Malpezzi, S. (2003), The spatial distribution of population in 48 world cities: implications for economies in transition, Univ. of Wisconsin, Madison, working paper.

Bowes, D. and Ihlanfeldt, K. (2001), Identifying the Impacts of Rail Transit Stations on Residential Property Values, *Journal of Urban Economics*, Vol. 50, 1-25.

Can, A. and Megbolugbe, I. (1997), Spatial Dependence and House Price Index Construction, *Journal of Real Estate Finance and Economics*, 14(1-2), 203 – 222.

Christano, L., M. Eichenbaum and D. Marshall (1991), The Permanent Income Hypothesis Revisited, *Econometrica*, 59, 397-424.

Coleman, C. ed. (2002), Interior Design: Handbook of Professional Practice, New York: McGraw-Hill.

Court, A. T. (1939) Hedonic Price Indexes with Automotive Examples, *The Dynamics of Automobile Demand*. General Motors, New York.

Dehring, C. and Dunse, N. (2006), Housing Density and the Effect of Proximity to Public Open Space in Aberdeen, Scotland, *Real Estate Economics*, 34, 553-566.

Diamond, P. (1982a), Wage determination and efficiency in search equilibrium, *Review of Economic Studies*, 49, 217-227.

Diamond, P. (1982b), Aggregate Demand Management in Search Equilibrium, *Journal of Political Economy*, 90(5), 881-94.

Diamond, P. (1984), Money in search equilibrium, *Econometrica*, 52, 1-20.

Grass, R. G. (1992), The Estimation of Residential Property Values around Transit Station Sites in Washington, D.C., *Journal of Economics and Finance*, 16, 139-146.

Green, R. K. and Malpezzi, S. (2003), A Primer on U.S. Housing Markers and Housing Policy, Washington, D.C.: Urban Institute Press.

Hanushek, E. and Yilmaz, K. (2007a), The complementarity of Alonso and Tiebout, *Journal of Housing Economics*, 16, 243-61.

Hanushek, E. and K. Yilmaz (2007b), Schools and location: Tiebout, Alonso, and government policy, NBER Working Paper 12960.

Jefferis, A. and Madsen, M. (2001), Architectural Drafting and Design, 4th ed., Albany: Delmar, Thomas Learning.

Kask, S. B., Maani, S. A. (1992), Uncertainty, Information, and Hedonic Pricing, *Land Economics*, 68, 170-184.

Kwok, H. H. and Tse, C. Y. (2006a), Estimating Liquidity Effects in the Housing Market, University of Hong Kong, mimeo.

Kwok, H. H. and Tse, C. Y. (2006b), Search in the Housing Market, University of Hong Kong, mimeo.

Leung, C. K. Y.; Cheung, P. W. Y. and Tang, E. C. H. (2012), Financial Crisis and the Comovements of Housing Sub-markets: Do relationships change after a crisis? forthcoming in *International Real Estate Review*.

Leung, C. K. Y., Lau, G. C. K., Leong, Y. C. F. (2002), Testing Alternative Theories of the Property Price-Trading Volume Correlation, *Journal of Real Estate Research*, 23:253-263.

Leung, C. K. Y.; Leong, Y. C. F.; Chan, I. Y. S. (2002), TOM: why isn't price enough? *International Real Estate Review*, 5(1), 91-115.

Leung, C. K. Y., Leong, Y. C. F., Wong, S. K. (2006), Housing Price Dispersion: An Empirical Investigation, *Journal of Real Estate Finance and Economics*, 32:357-385.

Leung, C. K. Y. and Tang, E. C. H. (2012), Comparing two financial crises: the case of Hong Kong Real Estate Markets, in *Global Housing Markets: Crises, Institutions and Policies*, eds. by A. Bardhan, R. Edelstein and C. Kroll, New York: John Wiley & Sons, chapter 17, 377-398.

Leung, C. K. Y.; Wong, S. K. and Cheung, P. W. Y. (2007), On the stability of the implicit prices of housing attributes: a dynamic theory and some evidence, *International Real Estate Review,* 10(2), 65-91.

Lentz, G. H., and Wang, K. (1998), Residential Appraisal and the Lending Process: A Survey of Issues, *Journal of Real Estate Research*, 15(1/2), 11-39.

Malpezzi, S. (2003), Hedonic pricing models: a selective and applied review, In: O'Sullivan, T., Gibb, K. (eds.), *Housing Economics and Public Policy*. Blackwell, Malder, MA.

Mas-Colell, A.; Whinston, M. and Green, J. (1995), *Microeconomic Theory*, New York: Oxford University Press.

Mingche, M., Li, H., Brown, J. (1980), Micro-Neighborhood Externalities and Hedonic Housing Prices, *Land Economics*, 56(2), 125-141.

Mok, H. M. K., Chan, P. P. K. and Cho, Y. S. (1995), Hedonic Price Model for Private Properties in Hong Kong, *Journal of Real Estate Finance and Economics*, 10(1), 37-48

Mok, H. M. K. (1995), A Hedonic Approach to Pricing of Residential Properties in Hong Kong, *Hong Kong Journal of Business Management*, 13, 1-15.

Nakata, S. and Asami, Y. (2006), Prediction of floor layouts of houses using data of houses newly supplied in Tokyo Metropolitan area, *working paper*, University of Tokyo.

Petrongolo, B.; Pissarides, C. (2001), Looking into the Black Box: A Survey of the Matching Function, *Journal of Economic Literature*, 39(2), 390-431.

Portnov, B. A., Fleishman, L. and Odish, Y. (2006), Changes and Modifications in Residential Neighborhoods as a Factor of Housing Pricing: Jerusalem and Haifa as Case Studies, *Journal of Real Estate Literature*, 14(3), 347-380.

Ricardo, D. (1817; 1965), The Principles of Political Economy and Taxation, London: J. M. Dent and Son.

Rogerson, R.; Shimer, R.; Wright, R. (2005), Search-Theoretic Models of the Labor Market: A Survey, *Journal of Economic Literature*, 43(4), 959-88.

Rosen, S. (1974), Hedonic prices and implicit markets: Product differentiation in pure competition, *Journal of Political Economy*, 82(1), 35-55.

Smith, M. S.; Moorhouse, J. C. (1993), Architecture and the Housing Market: Nineteenth Century Row Housing in Boston's South End, *Journal of the Society of Architectural Historians*, Jun., Vol. 52, No. 2, 159-178.

Strand, J., Vågnes, M. (2001), The relationship between property values and railroad proximity: a study based on hedonic prices and real estate brokers' appraisals, *Transportation*, Vol. 28, 137-56.

Vandell, K. D. (1995), Market Factors affecting Spatial Heterogeneity among Urban Neighborhoods, *Housing Policy Debate, Fannie Mae*, 1995, Vol. 6, Issue 1, 103-139.

Vandell, K. D. and Lane, J. (1989), The economics of architecture and urban design: some preliminary findings, *AREUEA Journal*, 17(2), 235-260.

Williams, C. W. (2008), An United Nation Report on demography and housing; presented as a keynote speech at the 2008 Asian Real Estate Society Meeting.

World Bank (2006), World Development Indicators, available from http://devdata.worldbank.org/wdi2006/contents/Section2_1.htm#f3

Appendix

The appendix is divided into several sections. Appendix I will provide some justifications on why the repeated sale method is not used. Appendix II provides some discussion on the expected signs of different coefficients. Appendix III provides supplementary results that are not included in the main text due to limitation in space. Appendix IV discusses how the "total effect" used in the text is measured.

Appendix I The Reason That The Repeated Sale Method Is Not Used

The repeated sale method is undoubtedly a very good method in controlling the quality of the housing units that are being traded and hence identifies "real changes" in prices. However, it may not serve the purpose of this paper, which is to examine whether the "interior design variables" have any significant effect on the property value. This can be easily illustrated in the following example. To simplify the exposition, consider the case with only one housing characteristic. In this case, the housing price can be expressed by the following equation:

$$\ln p_t = a_0 + a_{1t} x_t + D_t + u_t,$$

where p_t is the housing price, a_0 is a "fixed effect," a_{1t} is the time-varying coefficient for the characteristics x_t, D_t is the time-dummy for period t, and u_t is the stochastic disturbance term. The first-difference term can be re-written as:

$$\Delta \ln p_t = \Delta\left(a_{1t} x_t\right) + \Delta D_t + \Delta u_t,$$

as the "fixed effect" is eliminated, and the characteristics are assumed to be invariant over time. If we regress on this equation, we cannot identify a_{1t}, which is the focus of this study, but only its first-difference, $\Delta\left(a_{1t} x_t\right)$.

Appendix II Expected Signs of Variables

The expected signs for all variables are summarized in Table 2 and we attempt to provide a brief justification for them here. [5] As the maintenance cost and the age of the property are positively related, a negative coefficient of age is expected. Buyers typically prefer flats on higher floors for potentially better

---

[5] Some of them have been discussed in previous sections. For instance, we have explained that the sign for the coefficient of "clubhouse" is uncertain. We have also explained that the statistical significance of "lucky number" is also uncertain.

view and less noise from the streets, which lead to a positive sign for “floor”. In order to capture the potentially non-linear effect, the squared term of these variables are also added into the model.

The coefficient of net ratio is expected to be positive, as this ratio indicates the actual percentage of usable area given the “size”. Notice from Table 2 that the mean gross size of the apartment units in the sample is less than 680 square feet (or 68 square meters), which is relatively small compared to the average housing units in the United States, and hence the net ratio becomes very important. The mean net ratio is only about 0.8. This means that on average, housing units have less than 600 square feet (or 60 square meters) as “usable space”. Space is very precious in Hong Kong and the interior design may become very important, which is an issue to be further discussed in later sections.

According to Kwok and Tse (2006a, b), the estate scale, which is measured by the total number of apartment units in a certain housing estate, will have a positive impact on the housing unit price. Thus, we expect a positive coefficient from our regression.

Distance matters, even when the public transport system in Hong Kong is quite efficient in international standards. Thus, the coefficient of the variable “Distance from CBD” is expected to be negative.

Hong Kong can be divided into three parts: the Hong Kong Island, Kowloon Peninsula, and New Territories. The former two have relatively limited supply in land for residential use; therefore, both of their estimated coefficients are expected to be positive. The variable “Open Space 500” is expected to be positive, as the residents can access the area for leisure within 500 meters from their home.

For the floor layout attributes, the “foyer” and “corridor” may occupy precious space in Hong Kong flats and hence would tend to decrease the property values. Having the “kitchen adjacent to bedroom” may not be desirable for hygienic considerations. Many people complain that it is quite difficult to place furniture in a diamond-shaped living, and hence some living room space would be wasted. On the other hand, a diamond-shaped living room does provide more privacy. Thus, the sign of the variable “diamond” is not clear.

If the flat has a roof, which is the top covering of a building, or a deck, which is an outdoor area connected to the flat, then the flat price is expectedly higher. Roof and deck can be used in a number of ways, for instance, garden landscaping, storing goods, placing a drying rack, etc.[6] It also seems natural

---

[6] However, under the existence regulations, residents cannot use the roof or deck to extend the living areas of a flat.

to conjecture that more bedrooms are preferred to fewer, as it would allow for more privacy for individual family members. Therefore, the sign of the coefficient for the “number of bedrooms” is expected to be positive. On the other hand, it is always costly to construct an extra toilet in an apartment, so the coefficient of number of toilets is expected to be positive.

For the view variables, sea views and open space views are expected to add value to the housing units, thus resulting in positive coefficients in the regressions. On the other hand, due to the noise and the visual pollution, highway views are expected to decrease property values. Therefore, the coefficient of the highway view should be negative.

Appendix III Supplementary Results

This appendix provides more detailed information on the data set.

Table A-0 Some Basic Information of the Real Estate Developments Studied in This Paper.

	Number of Units	Number of Buildings	Number of floors
Hong Kong Island			
Chi Fu Fa Yuen	4326	27	27
City Garden	2393	14	28
Heng Fu Chuen	6311	48	18-22
Kornhill	6615	32	19-31
Lei King Wan	2295	17	17-19
Nan Fung Sun Chuen	2826	12	28-32
Pokfulan Garden	1120	6	28
South Horizons	9232	34	40-42
Tai Koo Shing	12690	61	28
Total	47808	251	
Kowloon			
Amoy Garden	4896	19	26-36
Laguna City	8071	38	25-28
Mei Foo Sun Chuen	13063	99	20
Sceneway Garden	4112	17	28-34
Tak Bo Graden	1888	8	33-40
Telford Garden	4065	21	10-26
Whampoa Garden	10287	88	15
Whampoa Estate	2820	25	15
Total	49202	315	
the New Territories			
Allway Garden	3418	16	33-36
Belvedere Garden	6016	19	35-45
City One Shatin	10642	52	27-33
Fanling Centre	2200	11	20-25
Kingswood Villas	15836	58	27-38
Luk Yueng Sun Chuen	3624	16	30
Miami Beach Towers	1272	6	37
Riviera Garden	5636	20	30-40
Tai Hing Garden	3740	15	34
Tai Po Center	4080	18	33
Tsuen King Garden	2968	12	32-34
Tsuen Wan Center	4454	19	28-36
Tuen Mun Town Center	2258	8	30-32
Sun Tuen Mun Centre	3520	10	44
Uptown Plaza	1240	6	29
Serenity Park	2450	15	23
Total	73354	301	

Table A-1 Correlation Coefficients of Structural and Neighborhood Attributes

	Age	Floor	Gross size	Net ratio	Clubhouse	Lucky Number	MTR500	KCR500	Open Space 500	Water 500	Distance from CBD	Hong Kong Island	Kowloon	New Territories	Estate Scale	Diamond	L-shape	Rectangular	Two Rectangle
Age	1																		
Floor	-0.1248	1																	
Gross size	-0.0974	-0.045	1																
Net ratio	0.3008	-0.1337	0.3984	1															
Clubhouse	-0.4473	0.069	0.1607	-0.1239	1														
Lucky Number	0.0076	0.0384	0.0009	0.0041	-0.0006	1													
MTR500	0.4753	-0.1275	0.0656	0.3322	-0.2997	0.0195	1												
KCR500	0.1035	-0.0664	-0.0673	-0.1288	-0.0838	0.0016	-0.0655	1											
Open Space 500	-0.0837	0.0506	-0.106	-0.1517	0.0796	-0.0003	-0.1073	-0.0683	1										
Water 500	-0.1097	0.0271	0.3376	0.0794	0.1351	0.0016	-0.0089	-0.0751	-0.1021	1									
Distance from CBD	-0.4688	0.1677	-0.0803	-0.4385	0.1646	0.0011	-0.4103	0.0327	0.3066	-0.0374	1								
Hong Kong Island	0.0422	-0.0271	0.3243	0.3629	0.2593	0.0185	0.3516	-0.1566	-0.1273	0.1578	-0.315	1							
Kowloon	0.2627	-0.1779	0.0024	-0.0008	-0.2794	-0.0169	0.3055	-0.0285	-0.136	-0.0382	-0.4419	-0.3896	1						
New Territories	-0.2786	0.1874	-0.2916	-0.3232	0.0249	-0.001	-0.594	0.166	0.2384	-0.1058	0.6864	-0.5352	-0.5694	1					
Estate Scale	-0.0427	-0.0095	0.1413	-0.0268	0.2486	-0.0066	-0.1888	-0.1192	0.2115	-0.0948	0.2603	-0.0657	-0.1053	0.1552	1				
Diamond	-0.5039	-0.0149	0.3749	-0.0773	0.4286	-0.015	-0.2815	-0.2142	0.0933	0.1009	0.2016	0.1295	0.0703	-0.1801	0.3456	1			
L-shape	0.1935	-0.0025	0.0315	0.1817	-0.2325	0.0033	0.1143	0.1056	-0.0567	0.0077	-0.0376	-0.0466	-0.0291	0.0683	-0.1257	-0.4071	1		
Rectangular	0.2299	0.0303	-0.3806	-0.1487	-0.1293	0.0098	0.0069	0.188	-0.0157	-0.0594	-0.0794	-0.1495	-0.0944	0.22	-0.1822	-0.5351	-0.318	1	
Two Rectangle	0.2164	-0.018	-0.0757	0.1108	-0.195	0.0052	0.2946	-0.0732	-0.0532	-0.0835	-0.1572	0.0753	0.0657	-0.1275	-0.121	-0.2818	-0.1675	-0.2201	1

Table A-2 Correlation Coefficients (Living Room Shape and Other Explanatory Variables)

	Diamond	L-Shaped	Rectangular	Two-rectangles
Age	-0.5039	0.1934	0.23	0.2164
Age2	-0.4194	0.1863	0.1844	0.1577
Floor	-0.0149	-0.0025	0.0303	-0.0181
Floor2	-0.0049	-0.003	0.0246	-0.025
Gross size	0.3749	0.0315	-0.3806	-0.0757
Gross size2	0.3196	0.0286	-0.324	-0.0675
Net ratio	-0.0773	0.1817	-0.1487	0.1108
Clubhouse	0.4286	-0.2325	-0.1293	-0.1951
Lucky Number	-0.015	0.0033	0.0099	0.0052
MTR500	-0.2816	0.1143	0.0069	0.2946
KCR500	-0.2142	0.1056	0.1881	-0.0733
Open Space 500	0.2542	-0.0375	-0.1177	-0.1847
Water 500	0.1998	0.002	-0.2073	-0.0144
Distance from CBD	0.2017	-0.0377	-0.0794	-0.1572
Distance from CBD2	0.2909	-0.0757	-0.1407	-0.1598
Hong Kong Island	0.1295	-0.0466	-0.1495	0.0754
Kowloon	0.0703	-0.0291	-0.0944	0.0657
Estate Scale	0.4988	-0.1605	-0.3312	-0.0997
Foyer	-0.4191	0.0852	0.3023	0.1124
Corridor	0.384	0.0171	-0.3626	-0.0985
Balcony	-0.0765	0.1259	0.0112	-0.0571
No. of bedrooms	0.3008	-0.0429	-0.2221	-0.0966
No. of toilets	0.3029	-0.0176	-0.2272	-0.1254
Kitchen accessible to living room	0.3746	-0.065	-0.2461	-0.151
Kitchen adjacent to bedroom	-0.1498	0.0658	0.0478	0.0845
Toilet adjacent to bedroom	0.1037	-0.1254	-0.0268	0.036
Store room	0.1197	0.0205	-0.1761	0.0438
Roof	-0.1316	-0.0414	0.2072	-0.044
Deck	-0.0348	-0.0029	0.0491	-0.0136
Sea-view	0.1236	0.0093	-0.0819	-0.0886

Table A-3 No. of Transactions in Each Sampling Period (Quarterly)

Quarter	No. of transact-ions	Quarter	No. of transact-ions	Quarter	No. of transact-ions	Quarter	No. of transact-ions
Q1-1992	7269	Q3-1995	4364	Q1-1999	2620	Q3-2002	1640
Q2-1992	4869	Q4-1995	5666	Q2-1999	2901	Q4-2002	1737
Q3-1992	5165	Q1-1996	7261	Q3-1999	2246	Q1-2003	1399
Q4-1992	3379	Q2-1996	7086	Q4-1999	1783	Q2-2003	1721
Q1-1993	5474	Q3-1996	5388	Q1-2000	2229	Q3-2003	2247
Q2-1993	8877	Q4-1996	9458	Q2-2000	1902	Q4-2003	2111
Q3-1993	4386	Q1-1997	9423	Q3-2000	2668	Q1-2004	3436
Q4-1993	3732	Q2-1997	10049	Q4-2000	1903	Q2-2004	2000
Q1-1994	6832	Q3-1997	4192	Q1-2001	2171	Q3-2004	2622
Q2-1994	3948	Q4-1997	3573	Q2-2001	2428	Q4-2004	3288
Q3-1994	3433	Q1-1998	3360	Q3-2001	2234	Q1-2005	4987
Q4-1994	3569	Q2-1998	2674	Q4-2001	2461	Q2-2005	5420
Q1-1995	5346	Q3-1998	2750	Q1-2002	2314	Q3-2005	3208
Q2-1995	5533	Q4-1998	4909	Q2-2002	2146	Q4-2005	2775
No. of observations = 222562							

Table A-4 Detailed Regression Results of The Pooled Sample

	Basic Model 1	Basic Model 2	Model with "Design Variables"	Model using restricted sample	Model with "interactive terms and design"	Model with "interactive terms and design" using restricted sample
Constant	-1.36091***	-1.72331***	-1.72923***	-1.72844***	-2.34086***	-2.31430***
Age	0.02176***	-0.01681***	-0.01538***	-0.01545***	-0.01726***	-0.01687***
Age^2	-0.00076***	-0.00008***	-0.00010***	-0.00010***	0.00000	0.00000
Floor	0.00764***	0.00945***	0.00976***	0.00977***	0.00974***	0.00976***
Floor^2	-0.00017***	-0.00020***	-0.00021***	-0.00021***	-0.00021***	-0.00021***
Gross size	0.00275***	0.00232***	0.00241***	0.00241***	0.00239***	0.00237***
Gross size^2	0.00000***	0.00000***	0.00000***	0.00000***	0.00000***	0.00000***
Net ratio		1.21077***	1.19732***	1.19692***	1.95834***	1.93228***
Clubhouse	0.10895***	0.08863***	0.08805***	0.08818***	0.06992***	0.07047***
Lucky Number	0.00470***	0.00609***	0.00716***	0.00693***	0.00751***	0.00735***
MTR500	-0.00841***	0.11416***	0.11752***	0.11730***	0.14582***	0.14588***
KCR500	0.22106***	0.18042***	0.18549***	0.18459***	0.18695***	0.18497***
Open Space 500	-0.06175***	-0.00514***	-0.00675***	-0.00613***	0.00076	0.00120
Water 500	0.05225***	0.07430***	0.08425***	0.08527***	0.09086***	0.09138***
Distance from CBD		-0.01722***	-0.01695***	-0.01694***	-0.01534***	-0.01544***
Distance from CBD^2		-0.00002***	-0.00003***	-0.00003***	0.00015***	0.00014***
Hong Kong Island	0.44745***	0.18405***	0.16998***	0.17006***	0.15346***	0.15257***
Kowloon	0.31425***	0.06716***	0.05686***	0.05691***	0.01121***	0.01142***
Estate Scale		0.00001***	0.00001***	0.00001***	0.00000***	0.00000***
Foyer			-0.02412***	-0.02417***	-0.02069***	-0.02027***
Corridor			0.00559***	0.00586***	-0.01199***	-0.01227***
Balcony			-0.02643***	-0.02625***	-0.03985***	-0.03953***
No. of bedrooms			-0.01203***	-0.01204***	-0.00891***	-0.00850***
No. of toilet			-0.04255***	-0.04242***	-0.03608***	-0.03612***
Kitchen accessible to living room			-0.00145	-0.00146	-0.00170	-0.00180
Kitchen adjacent to bedrooms			-0.01904***	-0.01910***	-0.03720***	-0.03680***
Toilet adjacent to bedrooms			0.03752***	0.03807***	0.01158***	0.01161***
Diamond			0.01366***	0.01296***	1.43408***	1.40917***
L-shape			0.01101***	0.01033***	1.12251***	1.10069***
Rectangular			-0.00510***	-0.00568***	0.67702***	0.65039***
Store room			-0.01045***	-0.01080***	-0.01162***	-0.01153***
Roof			0.05058***	0.05078***	0.04572***	0.04623***
Deck			0.16122***	0.16094***	0.15554***	0.15318***
Sea-view			-0.00667	-0.00778*	-0.00596	-0.00738*
Age & Diamond					0.00224***	0.00172***
Gross size & Diamond					-0.00014***	-0.00014***
Net ratio & Diamond					-1.51267***	-1.48251***
Distance from CBD & Diamond					-0.01319***	-0.01300***
Estate Scale & Diamond					0.00001***	0.00001***
Age & L-shape					-0.00418***	-0.00450***
Gross size & L-shape					-0.00006***	-0.00005***
Net ratio & L-shape					-1.19567***	-1.16956***
Distance from CBD & L-shape					-0.00820***	-0.00799***
Estate Scale & L-shape					0.00001***	0.00001***
Age & Rectangular					0.00056**	0.00032
Gross size & Rectangular					0.00000	0.00001
Net ratio & Rectangular					-0.80794***	-0.77761***
Distance from CBD & Rectangular					-0.00579***	-0.00560***
Estate Scale & Rectangular					0.00001***	0.00000***
R-square	85.5%	91.1%	91.3%	91.5%	91.6%	92.3%
Adj. R-square	85.4%	91.1%	91.3%	91.5%	91.6%	92.3%
y92Q2	0.12636***	0.13639***	0.13784***	0.13782***	0.12733***	0.12746***
y92Q3	0.12006***	0.17408***	0.17224***	0.17227***	0.17340***	0.17323***
y92Q4	0.09402***	0.13887***	0.13556***	0.13555***	0.11630***	0.11616***
y93Q1	0.04439***	0.09597***	0.09514***	0.09521***	0.09711***	0.09689***
y93Q2	0.09358***	0.11701***	0.11846***	0.11848***	0.11642***	0.11643***
y93Q3	0.20986***	0.24628***	0.24509***	0.24510***	0.24257***	0.24245***
y93Q4	0.24079***	0.26501***	0.26342***	0.26344***	0.26025***	0.26018***
y94Q1	0.34219***	0.41224***	0.40945***	0.40946***	0.40735***	0.40711***
y94Q2	0.46817***	0.52049***	0.51562***	0.51556***	0.51465***	0.51427***
y94Q3	0.39329***	0.45113***	0.44726***	0.44723***	0.44239***	0.44228***
y94Q4	0.39888***	0.45431***	0.44807***	0.44804***	0.44305***	0.44299***
y95Q1	0.32669***	0.38880***	0.38381***	0.38381***	0.38024***	0.38009***
y95Q2	0.28322***	0.37233***	0.36745***	0.36748***	0.36609***	0.36589***
y95Q3	0.17108***	0.27229***	0.26952***	0.26958***	0.27106***	0.27074***
y95Q4	0.20306***	0.28864***	0.28490***	0.28491***	0.28345***	0.28323***
y96Q1	0.24697***	0.35040***	0.34637***	0.34637***	0.34295***	0.34263***
y96Q2	0.33415***	0.43944***	0.43467***	0.43468***	0.43243***	0.43206***
y96Q3	0.36294***	0.47417***	0.46957***	0.46959***	0.46655***	0.46620***
y96Q4	0.44570***	0.55311***	0.54845***	0.54850***	0.54540***	0.54517***
y97Q1	0.60948***	0.74582***	0.74028***	0.74031***	0.73703***	0.73673***
y97Q2	0.74603***	0.87867***	0.87271***	0.87272***	0.87050***	0.87007***
y97Q3	0.77125***	0.89864***	0.89315***	0.89315***	0.89026***	0.88988***
y97Q4	0.73516***	0.86147***	0.85527***	0.85527***	0.85285***	0.85288***
y98Q1	0.49059***	0.64563***	0.63849***	0.63851***	0.63455***	0.63414***
y98Q2	0.37700***	0.53192***	0.52485***	0.52488***	0.52128***	0.52100***
y98Q3	0.17456***	0.32484***	0.31752***	0.31817***	0.31360***	0.31389***
y98Q4	0.13760***	0.29600***	0.28984***	0.28985***	0.28861***	0.28821***
y99Q1	0.18640***	0.37044***	0.36219***	0.36211***	0.35689***	0.35646***
y99Q2	0.20512***	0.38560***	0.37822***	0.37815***	0.37349***	0.37361***
y99Q3	0.17766***	0.36474***	0.35746***	0.35739***	0.35283***	0.35317***
y99Q4	0.05737***	0.24330***	0.23583***	0.23808***	0.23089***	0.24069***
y00Q1	0.09049***	0.31179***	0.30266***	0.30394***	0.29860***	0.30293***
y00Q2	0.00429	0.22158***	0.21159***	0.21268***	0.20700***	0.21248***
y00Q3	-0.03789***	0.18674***	0.17767***	0.17754***	0.17373***	0.18010***
y00Q4	-0.06170***	0.15757***	0.14918***	0.14904***	0.14436***	0.15004***
y01Q1	-0.10641***	0.12704***	0.11739***	0.11907***	0.11108***	0.12098***
y01Q2	-0.12000***	0.12310***	0.11450***	0.11517***	0.11020***	0.11602***
y01Q3	-0.15573***	0.08184***	0.07203***	0.07408***	0.06649***	0.07296***
y01Q4	-0.20980***	0.03423***	0.02458***	0.02651***	0.01923***	0.02424***
y02Q1	-0.20177***	0.05499***	0.04517***	0.04494***	0.04048***	0.04171***
y02Q2	-0.20952***	0.04363***	0.03427***	0.03405***	0.02743***	0.03023***
y02Q3	-0.26137***	-0.01459***	-0.02294***	-0.02178***	-0.02962***	-0.01894***
y02Q4	-0.33593***	-0.07641***	-0.08476***	-0.08265***	-0.09245***	-0.08443***
y03Q1	-0.37126***	-0.10508***	-0.11498***	-0.11263***	-0.12280***	-0.11679***
y03Q2	-0.43506***	-0.16434***	-0.17526***	-0.17488***	-0.18624***	-0.17899***
y03Q3	-0.42063***	-0.15210***	-0.16277***	-0.16147***	-0.17091***	-0.16188***
y03Q4	-0.29368***	-0.03757***	-0.04690***	-0.04515***	-0.05589***	-0.04977***
y04Q1	-0.15938***	0.10669***	0.09544***	0.09560***	0.08404***	0.08768***
y04Q2	-0.09991***	0.16578***	0.15507***	0.15643***	0.14481***	0.15437***
y04Q3	-0.11751***	0.14914***	0.13872***	0.14017***	0.12810***	0.13684***
y04Q4	-0.03748***	0.22762***	0.21589***	0.21601***	0.20529***	0.20916***
y05Q1	-0.02097***	0.27101***	0.25861***	0.25936***	0.24624***	0.25132***
y05Q2	0.03372***	0.33671***	0.32335***	0.32414***	0.30954***	0.31323***
y05Q3	0.06109***	0.35772***	0.34503***	0.34476***	0.33171***	0.33705***
y05Q4	0.03901***	0.33137***	0.31863***	0.31836***	0.30440***	0.31094***

Note: y92Q1 is controlled

* represents 10%, **represents 5% and *** represents 1% significance

Figure A-1a Time Series Plot of R-squared Coefficients from Different Models[41]

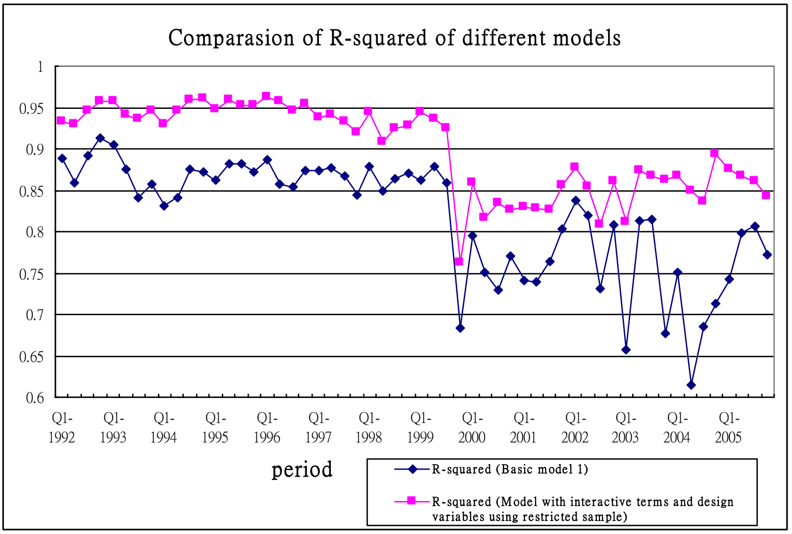
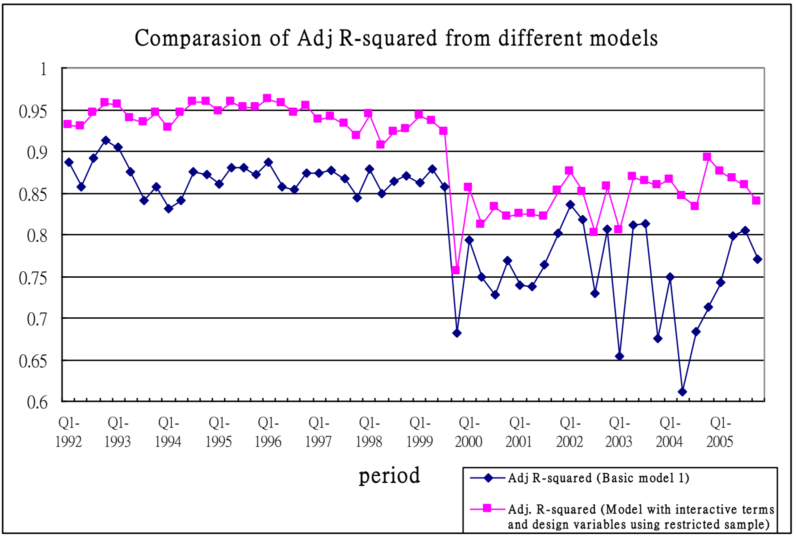


Figure A-1b Time Series Plot of adj. R-squared Coefficients of Different Models



Appendix IV Measuring the total effect

To illustrate the idea of measuring the total effect, let us consider the following simple regression,

---

[41] Basic model refers to the model shown in Table 4.

$$y = a_0 + a_1 x_1 + a_2 x_2 + a_{12} x_1 x_2 + u$$

Then,

$$\frac{\partial y}{\partial x_1} = a_1 + a_{12} x_2, \frac{\partial y}{\partial x_2} = a_2 + a_{12} x_1$$

Thus, we define the "total effect of x_1 on y" to be b_1, which is defined as:

$$b_1 = \left.\frac{\partial y}{\partial x_1}\right|_{x_i = \bar{x}_i, \forall i}$$

Similarly, we define the "total effect of x_2 on y" to be b_2, $b_2 = \left.\frac{\partial y}{\partial x_2}\right|_{x_i = \bar{x}_i, \forall i}$.

Thus, in general, for a regression model of the form $y = a_0 + \sum_i a_i x_i + \sum_{i,j} a_{ij} x_i x_j + u$, we define the "total effect of x_j on y" to be b_j, $b_j = \left.\frac{\partial y}{\partial x_j}\right|_{x_i = \bar{x}_i, \forall i}$. Clearly, for the case without interaction terms, $a_{ij} = 0, \forall i, \forall j, b_j = a_j$.

We can now provide a table which summarizes the total effects of the set of variables used in the main text and we will explain how we have come up with these numbers.

(Average point estimates from quarterly regressions)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Age	0.046	-0.008	-0.004	-0.005	-0.003	-0.003
Gross-size	0.003	0.002	0.003	0.002	0.003	0.003
Net-Ratio	N.A.	1.135	1.118	1.123	1.887	1.877
(Locational)						
HK Island	0.462	0.236	0.221	0.220	0.194	0.193
Kowloon	0.312	0.095	0.086	0.086	0.023	0.024
Distance from CBD	N.A.	-0.016	-0.016	-0.015	-0.015	-0.014
Estate Scale	N.A.	$9.77*10^{-6}$	$8.76*10^{-6}$	$8.83*10^{-6}$	$4.10*10^{-6}$	$4.42*10^{-6}$
MTR 500	-0.020	0.099	0.103	0.102	0.140	0.139
KCR 500	0.221	0.218	0.226	0.225	0.244	0.242
(Structural)						
Diamond	N.A.	N.A.	0.0247	0.0254	0.025	0.026
L-shaped	N.A.	N.A.	0.0129	0.0121	0.020	0.019
Rectangular	N.A.	N.A.	0.0043	0.0047	-0.023	-0.023

Note: *N.A.* means *Not Available*, as that variable is not included in the regression.

To compute the total effect, we first need to list all of the interaction terms used in this paper.

	Diamond	L-shaped	Rectangular
Age	Age & Diamond	Age & L-shaped	Age & Rectangular
Gross-size	Gross-size & Diamond	Gross-size & L-shaped	Gross-size & Rectangular
Net-ratio	Net-ratio & Diamond	Net-ratio & L-shaped	Net-ratio & Rectangular
Distance from CBD	Distance from CBD & Diamond	Distance from CBD & L-shaped	Distance from CBD & Rectangular
Estate scale	Estate scale & Diamond	Estate scale & L-shaped	Estate scale & Rectangular

Let us say that the regression equation is:

Ln(price) = … + a1*(age) + a2*(gross size) + a3* (net ratio) + a4* (distance from CBD) +a5*(estate scale)
+ c1* (diamond) + c2*(L-shaped) + c3*(Rectangular)
+d1*(Age & Diamond) + d2*(Gross-size & Diamond) + d3*(Net-ratio & Diamond) +d4*(Distance from CBD & Diamond) +d5*(Estate scale & Diamond)
+ e1*(Age & L-shaped) + e2*(Gross-size & L-shaped) + e3*(Net-ratio & L-shaped) + e4*(Distance from CBD & L-shaped) + e5*(Estate scale & L-shaped)
+ f1*(Age & Rectangular) + f2*(Gross-size & Rectangular) + f3*(Net-ratio & Rectangular) + f4*(Distance from CBD & Rectangular) + f5*(Estate scale & Rectangular)
+…

Then,

the total effect for Diamond = c1 + d1 *(mean of age) + d2* (mean of gross size) + … + d5* (mean of estate scale)
Similarly, the total effect for (distance from CBD) = a4 + d4 * (mean of Diamond) + e4 * (mean of L-shaped) + f4 * (mean of Rectangular).