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# **The Market Valuation of Interior Design and Developers strategies: a simple Theory and some Evidence**

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## **Abstract**

How much do the market values of housing reflect its interior design? Does the interior design interact with other housing attributes? Following the recent research based on “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 that developers strategically use interior design to “dilute” the effect of location, which leads to a form of endogenous multi-collinearity. Directions for future research are also discussed.

JEL Classification: R10, R20, R21

Keywords: endogenous multi-collinearity, interior design, market valuation, dummy variables, interaction terms.

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*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 to its 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.<sup>1</sup> In fact, practitioners are also aware that the lacks of research on the price impact of design, as reflected in the quotation above. There seems to be a “missing link” between the “conventional wisdom” and the academic literature.

While introducing architectural variables into the pricing equation is not totally new in real estate economics,<sup>2</sup> it seems to be an under-explored topic. The research efforts on how architecture design affect high-rise apartments are even less, if any. The reasons may not be surprising. Many existing research are based on datasets of detached housing units in the North America.<sup>3</sup> Even for 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 in the case of apartment buildings, and since the “interior design” may be correlated to the “external layout,” the effect of “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 difficulty for “outside researchers”. Thus, the research on the price effect of physical layouts may not be an easy task.

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<sup>1</sup> For instance, see Malpezzi (2003) for a survey,.

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

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

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.<sup>4</sup> 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.

In addition, *apartment may provide us a natural setting for the study of 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; share the same public facilities, the same school district, etc. Moreover, the management, the construction materials of the units, the 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), which applies the “graph theory” in their predictions of the floor layouts of detached houses in Tokyo based on the site conditions.<sup>5</sup> In their analysis, floor layouts of houses are transformed into “access graph” and “adjacency graph.” Adopting their idea, we create dummy variables such as *kitchen accessible to living room*,

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<sup>4</sup> 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 the counterpart in “High-income region” is 0.8%. In “Middle East and North Africa,” it is 2.1% and even 2.5% in “Sub-Saharan Africa.”

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

*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 the different floor plan features in an active Asian market, based on a large number of transactions in between Q1 1992 to Q4 2005. The Hong Kong residential property market is chosen with 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 city in the world. (As a comparison, the 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<sup>6</sup> are *homogenous enough* for comparison, and at the same time *heterogeneous enough* to highlight the role of different interior design. The housing estates chosen in this study are frequently traded and thus a certain degree of “liquidity” is ensured. Second, the information about floor plan<sup>7</sup> of large housing estates is accessible from property agents.<sup>8</sup> We 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 the “interior design” for future studies for a variety of reasons. First, physical layouts are relatively invariant while other aspects of “interior design” can be

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<sup>6</sup> An “estate” is a collection of apartment buildings located closely and typically developed by the same real estate developer (or 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.

<sup>7</sup> 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 that the orientation of the view is downward from above.

<sup>8</sup> One of the co-authors actually pretends to be interested buyers and visited real estate agents in different districts and confirms that it is relatively easy to obtain the information of physical layout.

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 the 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 values to the housing units is controversial.

Perhaps more importantly, it seems that *other aspects* of “interior design” typically are not included in the bank loan consideration. Observation suggests that the estimation of the apartment value among major banks, which are usually available within a day and without any site visit, deviate from one another by less than 5%.<sup>9</sup> And since the Hong Kong monetary authority restricts that the mortgage loan cannot exceed 70% of the estimated value, the estimation of property value from banks essentially determine the upper bound of the amount of 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 literatures review and description of the variables used. The data set 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.

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<sup>9</sup> One of the co-authors actually pretends to be interested buyers and asks for “loan quotations” from different banks and finds that the valuation differences are typically small.

## 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 subset in the site characteristics. Asabere et al. (1989) show that premium prices are associated with the historical architectural styles. Smith and Moorhouse (1993) argue that architecture style and feature accounts for 14% of price of the house in Boston. These findings all focus on how the *outer or external* architectural style of the real estate affect its corresponding rent or price.

On the other hand, the floor plan features as well as the interior arrangement of various rooms *within* a house or an apartment is 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.<sup>17</sup> 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 living room is categorized into four types, namely, “Diamond,” “Rectangular,” “L,” and “Two-rectangle,” and figure 1 provides example of each type. The Diamond-shape living room can be a double-edged sword in the design. On the one hand, it precludes the inter-visibility among the living rooms with the

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<sup>17</sup> Notice that Vandell and Lane (1989)’s data on “design quality” is based on detailed evaluation of each structure by a panel of architects, while the measures employed in this paper can be mechanically measured given the definitions.



adjacent flats, and hence provides a higher degree of privacy in the midst of a highly crowded environment.<sup>18</sup> On the other hand, its non-rectangularity shape makes it difficult to place furniture without wasting some space.<sup>19</sup> All these dummy variables contribute to quantify the implicit prices of floor layout attributes, or, the so-called “premium of design.”

(Figure 1 about here)

Following the practice of the literature, we include the “number of bedrooms” and “number of toilets” in the regression,<sup>20</sup> with other floor layout features such as foyer<sup>21</sup>, corridor<sup>22</sup> and balcony<sup>23</sup> also included in the analysis. Distance from the Central Business District<sup>24</sup> is a proxy of the time for commutes.<sup>25</sup>

In addition, we include variables that may add values to the houses, such as “views”<sup>26</sup> (classified by type of view-road, park, large park, open space, hill, sea, partial sea view of building), the accessibility to the public transportation (which include the Mass Transit Railway, or MTR, (i.e. the subway) and the

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<sup>18</sup> 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.

<sup>19</sup> These tradeoffs are well recognized. In practice, the size of living rooms of “diamond-shape” is larger in general. Residents place some specially designed furniture in those living rooms. We will get back to these “pros” and “cons” of the “Diamond-shape” living room in the later section.

<sup>20</sup> In Hong Kong, although residents do not need to apply for government permissions to adjust the number of bedrooms in their flats, it is very costly to do so.

<sup>21</sup> Foyer is a space in a flat which is used for entry from the outside. <http://en.wikipedia.org/wiki/Foyer>.

<sup>22</sup> Corridor is a path or guided way which is usually referring to an interior passageway in modern building. <http://en.wikipedia.org/wiki/Corridor>.

<sup>23</sup> Balcony is a kind of platform projecting from the wall of a building, supported by columns or console brackets. <http://en.wikipedia.org/wiki/Balcony>.

<sup>24</sup> In Hong Kong, C.B.D. refers to Central and Tsim Sha Tsui.

<sup>25</sup> 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 generate a rent gradient endogenously, among other stylized facts found in the public finance and urban economics literature. Mok et al. (1995) find that distance decay mechanism appears in Hong Kong residential property market.

<sup>26</sup> Among others, Darling (1973), Brown and Pollakowski (1977), Benson et al (1998), Chau et al (2005) all find that “view” is important in determining the property values. In this paper, partial sea view is defined as the housing unit has a sea view with some obstruction by buildings.

Kowloon-Canton Railway, or KCR, (i.e. the railway)<sup>27</sup>), the presence of clubhouse, the proximity of urban park, open space,<sup>28</sup> the “lucky number” (i.e. “8”).<sup>29</sup> Furthermore, we follow Kwok and Tse (2006a, b) to use the “estate scale” as a measure of the “liquidity” in the empirical analysis.<sup>30</sup>

### **3. Data Description**

We compile our dataset from different sources. The housing transaction data set is purchased from the Economic Property Research Center (EPRC).<sup>31</sup> In addition, we collect the floor plans of all thirty three housing estates by visiting many different property agents<sup>32</sup>. To take into consideration of all the variations of 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 about here)

A lot of efforts have been put to enhance the accuracy of the data. In the

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<sup>27</sup> MTR provides metro service on northern part of Hong Kong Island, Kowloon Peninsula, and southern part of the New Territories as well as the Hong Kong International airport. <http://www.mtr.com.hk/prehome/index.html> for detail. KCR operates four train lines, namely, 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). [www.kcrc.com](http://www.kcrc.com) for detail. The two companies are recently merged. However, this merger is only limited to the financial dimension. The whole operation systems of the two lines are still independent.

Previous studies such as Grass (1992), Bowes and Ihlanfeldt (2001) show proximity to railway station is one of the desirable factors for both high income and low income residential neighborhoods. For the evidence on the importance of public transportation in Hong Kong housing market, see Mok et al. (1995), Leung et al. (2002), among others.

<sup>28</sup> 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 course is approximately 7.6%. See Do and Grudnitski (1995), Soren and Sarah (2006), Dehring and Dunse (2006) on how proximity of open space can add values to the house.

<sup>29</sup> For instance, Bourassa and Peng (1999) show there is a premium for the housing with lucky number in the society with high percentage of Chinese in New Zealand. On the other hand, Leung et al (2006, 2007) do not confirm this finding in Hong Kong.

<sup>30</sup> Kwok and Tse (2006a, b) find that there is a positive relationship between the housing liquidity and the estate scale, as there are more trading in larger estates, generating an *informational externality* in pricing *other* housing units in the same estate. For more discussion on how the liquidity of the housing units affects their pricing, see Anglin (2006), Anglin et al (2003), and the reference therein.

<sup>31</sup> EPRC, a subsidiary of the Hong Kong Economic Times, purchases all property market transaction records from Hong Kong Land Registry Department. Then the EPRC re-organizes those records and sell them to commercial and educational users. EPRC data base contains information of transaction price, corresponding gross and net size, as well as the address of it. In the EPRC, some details of each transaction, for example, the transaction price, the corresponding gross square-footage, floor, year-built, etc. are provided.

<sup>32</sup> For instance, Centaline, Midland, Ricacorp etc.

case of “view,” we combine both the satellite map as well as and site investigations.<sup>33</sup> The information about the “distance from CBD” is acquired from measuring distance of the shortest link, instead of the actual distance, between the housing estate and CBD, in order to take into consideration of the presence of natural barriers, for instance, a hill, a gulf etc, between the two points. In addition, values for dummy variables such as “Open Space500”, “MTR500” and “KCR500” are acquired similarly.<sup>34</sup> We also visit the websites of some property agents for cross-checking, especially concerning the presence of clubhouse and the estate scale. Table 2 and 3 provide more information about the dataset. The appendix further shows that the simple correlations among variables are not that high. If we ignore all those self-correlations (which attain the value of unity), there are totally 171 correlations there. 121 of them (i.e. 70%) have absolute value below 0.2. Another 36 of them (i.e. 21%) attain values between 0.2 and 0.4. Among the remaining 14 correlations, only one of them is above 0.6. Multi-collinearity seems to be not an important issue. (We will get back to this point later).

(Table 2, Table 3 about here)

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 quarter of transaction.<sup>35</sup> In our sample, there are totally more than two hundred thousand transactions. Figure 2 shows that the transaction volume varies

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<sup>33</sup> For instance, the flats in an estate located on elevated land can have 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 flats in some blocks can have sea-view also. One of the co-authors actually spend some significant of time in the summer of 2006 to collect such information.

<sup>34</sup> Table 2 provides the definition of all the variables.

<sup>35</sup> In the context of Hong Kong housing market, choosing a quarter as a period may be a constrained-optimal choice. It is not too short so that we have enough transaction in each period. It is not too long or else the time aggregation bias may occur. Moreover, Leung, Leong and Chan (2002) explained that most transactions (from listing to the final contract signing) close in a quarter.

significantly over time. The minimum number of transaction in one quarter is 1,399 and the average number of transaction 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 estates studied in this paper are apartment buildings.<sup>36</sup> To avoid double-counting, only the transactions with official housing sale and purchase agreement are considered.

(Figure 2 about here)

#### 4. Methodology

Housing units typically differ in many dimensions. To estimate the value of houses “properly,” this paper employs the hedonic approach.<sup>37</sup> Among others, Leung et al (2007) confirmed 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 the time aggregation bias<sup>38</sup>, we split 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. Following Malpezzi (2003), a semi-log specification is estimated for each quarter:

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

, where P represents the transaction price of apartment, S represents structural attributes (such as age of the building), N represents neighborhood attributes

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<sup>36</sup> Detached house 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 preference. 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) uses both high-rise and detached properties to study the pricing of properties in Hong Kong, and there is no need for repeating in this paper.

<sup>37</sup> It was introduced by Court (1939) and then elaborated by the static model of Rosen’s (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.

<sup>38</sup> For instance, see Christano, Eichenbaum and Marshall (1991).

(such as proximity to MTR station), L stands for locational attributes (such as distance from CBD or the district where the estate is located), F represents floor layout attributes (such as foyer, corridor, balcony), V represents view attributes (such as road view, open space view, etc.), and  $\varepsilon$  represents the error term in the regression model.

## 5. Empirical Results

This section presents the results based on a series of cross-sectional hedonic price regression. As we have explained earlier, we estimate the implicit prices of the housing attributes in each quarter separately, which will avoid the time-aggregation bias that may occur.<sup>39</sup> There are totally 56 quarterly sub-samples. The expected signs for all variables are summarized in table 2 and more detailed discussion can be found in the appendix. Clearly, the results in all these 56 regressions need not be identical, as hedonic regression coefficients should fluctuate over time (Leung et al., 2007).

Due to the space limit, we only present the mean values of those coefficients in table 4a and leave the details in the appendix.<sup>40</sup> The first two columns present the results from basic models which does not include the physical layout variables. The third and the fourth column 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 a kind of “robustness check.” The fifth

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<sup>39</sup> It will also contain the “statistical outliers” in the regression within the corresponding quarter and not spreading out the effect of the potential contamination to the whole sample.

<sup>40</sup> Notice that the 56 hedonic equations for the 56 sub-samples are estimated separately, and therefore it is impossible to assess whether the mean values of those coefficients are statistically significant or not. For robustness, we report the results on “restricted samples” in column 4 and 6. Basically, we drop the observations which are suspected outliers (in terms of transaction prices). In this case, it means transactions whose square-feet price is lower than HK\$500. The justification is that some of them may be trade 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 the sixth column 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.

(Table 4a about here)

Most estimates deliver the expected sign. For instance, an increase in age, an increase of distance from the CBD will lead to a decrease in the house value (negative coefficient). An increase in the floor (i.e. units located in higher level of the buildings), an increase in the size, an increase in the net ratio, the presence of clubhouse, the accessibility to the subway, train, waterfront, etc. will all increase the house values. All 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 roof and deck, whose area are not included in the “area” provide extra value and hence the corresponding coefficients are positive. 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 in the first sight. 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 kitchen being located next to either the living room or bedroom would damage the house value. The Asian cooking style, which tends to create a lot more smoke in the process, 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 “double-rectangular” as the control, we find that having a “Diamond,” “L-Shape” or “rectangular” shape living room all add values (3<sup>rd</sup> and 4<sup>th</sup> column in the table 4a). However, once we take into consideration of 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 the computation of the total effect are detailed in the appendix). While the total effect of having a “Diamond” shape living room has roughly the same effect on the house price across different models, the measured contribution of “L-shape” would be under-estimated if the interaction terms are ignored. Over different sub-sampling periods, the average total effect of “L-shape” increase almost 100% after the interaction terms are taken into consideration (compare the numbers in the model 5 and 6, versus those come from model 3 and 4). On the other hand, the contribution of having a “rectangular” living room will be over-estimated, as the average total effect turns from positive (model 3 and 4) to slightly negative (model 5 and 6). Interaction terms matter.

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

(Table 4b about here)

Now we would 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 4c about here)

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

In sum, table 4a to 4c demonstrate that introducing the interaction terms only increase the  $R^2$  and mean adjusted  $R^2$  marginally. On the other hand, both the results from quarterly subsample or pooling-all-data shows that once 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 multi-collinearity. However, we show in the appendix that the simple correlations are not high: 121 of 171 correlations (i.e. 70%) have absolute value below 0.2, and another 36 of them (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, which sells slots of land from time to time. The lot size, the height limit, the location, etc., are in some sense exogenous. The developers can only choose “to bid” or “not to bid.” On the



other hand, conditioning on obtaining the land from auction, the 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 developers). In other words, there is a possibility of *endogenous multi-collinearity*. In particular, in our regression, the effect of “districts” 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. It also explains why the interaction term like “Distance from CBD and Diamond,” “Distance from CBD and L-shape,” “Distance from CBD and Rectangular” are all statistically significant. Notice that the “distance from CBD” is a location characteristic is not subject to the choice of the developer, but the shape of the living room, which is a structural characteristic, is. 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.

## **6. Endogenous Multi-collinearity**

In the previous section, we provide an explanation of the “endogenous multi-collinearity,” which is based on the incentive for the developers adjusting 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 private market for land re-sale does not exist.<sup>41</sup> This section attempts to formalize the ideas through a simple theoretical model.

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<sup>41</sup> Many countries including the United Kingdom, Singapore, China, etc. have most, if not all, their land belonging to the government.

To fix the idea, consider a developer who maximizes the profit from selling a housing unit facing a competitive environment. We assume that the potential buyers can always purchase from other developers from the market, or stay with the original dwelling unit and attains a “reservation utility level”  $\bar{U}$ . We further assume that the market can price each attribute competitively 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, the location attribute  $L$  and structural attribute  $S$ . Households (potential buyers) exhibit a concave preference on the attributes. Formally, it means that the utility function of the household,  $U(L, S)$ , possesses 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 the typical type in microeconomics, which is at least weakly convex,<sup>42</sup>  $C_i > 0, C_{ii} \geq 0, C_{ij} \geq 0$ , 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,”  $U(L, S) \geq \bar{U}$ . Let  $\lambda$  be the Lagrange multiplier of the competition constraint, it is easy to derive that  $P_i - C_i + \lambda U_i = 0$ ,  $i = L, S$ . It can be further simplified as  $\frac{U_L}{U_S} = \frac{C_L - P_L}{C_S - P_S}$ . It 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-

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<sup>42</sup> See Mas-Colell et al. (1995) for the justifications for the concavity of the utility function and the convexity of the cost function.

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

Since this expression always holds at the optimal, we can take the total differential. Assume that the 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

$$(C_S - P_S)(U_{LL}dL + U_{LS}dS) + U_L(C_{SL}dL + C_{SS}dS) - (C_L - P_L)(U_{LS}dL + U_{SS}dS) - U_S(C_{LL}dL + C_{SL}dS) = 0$$
, 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 function and the cost function are separable so that  $U_{LS} = C_{SL} = 0$ , this expression will be *non-zero* in general. It simply shows that the decision on location attribute and structural attribute are in general *inter-dependent*. It is also clear that with more different attributes introduced into the utility function and the cost function, the above expression would only get more complicated and it would not alter the basic conclusion that the location attribute and structural attribute are inter-dependent, which may exhibit as a form of “*endogenous multi-collinearity*.”

The intuition is clear. From the real estate developer point of view, the *composition of structural attributes is endogenous*, and rational developers will adjust the composition according to the location and neighborhood features. In

the hedonic pricing regression such as the one adopted in this paper, all those attributes are put in the right hand side of the equation in a parallel manner, which inevitably leads to *endogenous multi-collinearity*.”

## 7. **Concluding Remarks**

Other things being equal, does the interior design of a housing unit matter? The “street wisdom” would suggest a positive answer. This paper takes a step to examine such street wisdom scientifically. In particular, we have chosen a collection of most frequently traded real estate developments from Hong Kong. Since they are all apartment buildings, there will be many identically designed units at different floors and with different views, which facilitates the comparison. In addition, racial discrimination problem virtually does not exist in Hong Kong. All 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.<sup>43</sup> All these features of the market create a very desirable environment to investigate 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” 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 these can be decided by the developers) are also statistically significant. We provide a simple theoretical model to account for such “endogenous multi-collinearity.”

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<sup>43</sup> Among others, see Hanushek and Yilmaz (2007a, b) for a discussion on how the local public finance issue can significantly impact the housing price.

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.<sup>44</sup> It will also be interesting to compare the results reported here with other cities, such as Singapore or even the 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 Leung et al (2012), Leung and Tang (2012) show that the housing market and the domestic economy in general react 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 layout have changed as well. Last but not the 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.

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<sup>44</sup> Among others, see Lentz and Wang (1998) for some earlier efforts.

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Table 1 Summary Statistics of the sample

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

Table 2 Description of Research Variables

Variable	Description	Expected sign
Dependent Variable		
In 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 size 2	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 CBD 2	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, otherwis=0.	+
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 toilet	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 bedrooms	If kitchen is adjacent to bedroom, the dummy=1, otherwise=0.	-
Toilet adjacent to bedrooms	If toilet is adjacent to bedroom, this dummy=1, otherwise=0.	-/+
Diamond	Presence of diamond-shape living room=1, otherwise=0.	-/+
L-shape	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-shape	Variable "Age" times variable "L-shape"	-/+
Gross Size & L-shape	Variable "Gross size" times variable "L-shape"	-/+
Net Ratio & L-shape	Variable "Net Ratio" times variable "L-shape"	-/+
Distance from CBD & L-shape	Variable "Distance from CBD" times variable "L-shape"	-/+
Estate Scale & L-shape	Variable "Estate Scale" times variable "L-shape"	-/+
Age & Rectangular-shape	Variable "Age" times variable "Rectangular"	-/+
Gross Size & Rectangular-shape	Variable "Gross size" times variable "Rectangular"	-/+
Net Ratio & Rectangular-shape	Variable "Net Ratio" times variable "Rectangular"	-/+
Distance from CBD & Rectangular-shape	Variable "Distance from CBD" times variable "Rectangular"	-/+
Estate Scale & Rectangular-shape	Variable "Estate Scale" times variable "Rectangular"	-/+

Table 3 Descriptive Statistics

	Mean	Standard Deviation	Min	Max	Median
<b>Dependent Variables</b>					
ln_price	0.7985	0.5258	-5.298317	3.367296	0.7839016
<b>Independent Variables</b>					
<b>Structural Attributes</b>					
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	4691556	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	1120	15836	8071
<b>Neighborhood Attributes</b>					
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
<b>Locational Attributes</b>					
Distance from CBD	14.4215	10.8346	1.8	36.6	11
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
<b>Floor Layout Attributes</b>					
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 toilet	1.2996	0.4707	1	3	1
Kitchen accessible to living room	0.7683	0.4219	0	1	1
Kitchen adjacent to bedrooms	0.0939	0.2916	0	1	0
Toilet adjacent to bedrooms	0.9846	0.1233	0	1	1
Diamond	0.4062	0.4911	0	1	0
L-shape	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
<b>Views Attributes</b>					
Sea-view	0.0741	0.2620	0	1	0
<b>Interactive terms</b>					
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	36.6	0
Estate Scale & Diamond	4393.8660	5854.5870	0	15836	0
Age & L-shape	2.6008	6.3973	0	37	0
Gross Size & L-shape	134.2034	284.0552	0	1688	0
Net Ratio & L-shape	0.1626	0.3309	0	0.99	0
Distance from CBD & L-shape	2.6498	6.5456	0	31	0
Estate Scale & L-shape	1289.6370	3197.4830	0	13063	0
Age & Rectangular-shape	3.8435	7.1649	0	37	0
Gross Size & Rectangular-shape	168.5468	274.4680	0	1494	0
Net Ratio & Rectangular-shape	0.2378	0.3690	0	0.98	0
Distance from CBD & Rectangular-shape	3.8612	7.2167	0	31	0
Estate Scale & Rectangular-shape	1700.4730	3356.6140	0	13063	0
No. of observations	222562				

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
Age <sup>2</sup>	-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
Floor <sup>2</sup>	-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 <sup>2</sup>	-8.42E-07	-5.96E-07	-5.90E-07	-5.89E-07	-5.31E-07	-5.34E-07
Net ratio		1.1352	1.1181	1.1227	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
MTR500	-0.0200	0.0993	0.1026	0.1020	0.1399	0.1392
KCR500	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 <sup>2</sup>		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
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 toilet			-0.0430	-0.0454	-0.0381	-0.0407
Kitchen accessible to living room			-0.0034	-0.0045	0.0009	-0.0003
Kitchen adjacent to bedrooms			-0.0204	-0.0220	-0.0360	-0.0373
Toilet adjacent to bedrooms			0.0333	0.0337	0.0145	0.0153
Diamond			0.0247	0.0254	1.4922	1.4827
L-shape			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
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-shape					-0.0024	-0.0023
Gross size & L-shape					-0.0001	-0.0001
Net ratio & L-shape					-1.0734	-1.0608
Distance from CBD & L-shape					-0.0089	-0.0089
Estate Scale & L-shape					8.14E-06	7.84E-06
Age & Rectangular					0.0056	0.0056
Gross size & Rectangular					-1.09E-05	-1.12E-05
Net ratio & Rectangular					-0.8300	-0.8092
Distance from CBD & Rectangular					-0.0051	-0.0051
Estate Scale & Rectangular					4.42E-06	3.91E-06

Table 4b: A comparison of 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-shape	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

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

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***
Age <sup>2</sup>	-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***
Floor <sup>2</sup>	-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 <sup>2</sup>	-7.5600E-07***	-5.9400E-07***	-5.6300E-07***	-5.6200E-07***	-5.0900E-07***	-5.0900E-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***
MTR500	-0.00841***	0.11416***	0.11752***	0.11730***	0.14582***	0.14569***
KCR500	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 <sup>2</sup>		-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***
Kowloon	0.31425***	0.06716***	0.05686***	0.05691***	0.01121***	0.01129***
Estate Scale		9.2100E-06***	8.0800E-06***	8.0500E-06***	3.9000E-06***	3.9600E-06***
Foyer		-0.02412***	-0.02412***	-0.02417***	-0.02069***	-0.02057***
Corridor		0.00559***	0.00586***	0.00586***	-0.01199***	-0.01162***
Balcony		-0.02643***	-0.02625***	-0.02625***	-0.03985***	-0.03964***
No. of bedrooms		-0.01203***	-0.01204***	-0.01204***	-0.00891***	-0.00903***
No. of toilet		-0.04255***	-0.04242***	-0.04242***	-0.03608***	-0.03604***
Kitchen accessible to living room		-0.00145	-0.00146	-0.00146	-0.00170	-0.00159
Kitchen adjacent to bedrooms		-0.01904***	-0.01910***	-0.01910***	-0.03720***	-0.03709***
Toilet adjacent to bedrooms		0.03752***	0.03807***	0.03807***	0.01158***	0.01228***
Diamond		0.01366***	0.01296***	0.01296***	1.43408***	1.42993***
L-shape		0.01101***	0.01033***	0.01033***	1.12251***	1.12346***
Rectangular		-0.00510***	-0.00568***	-0.00568***	0.67702***	0.67644***
Store room		-0.01045***	-0.01080***	-0.01080***	-0.01162***	-0.01198***
Roof		0.05058***	0.05078***	0.05078***	0.04572***	0.04585***
Deck		0.16122***	0.16094***	0.16094***	0.15554***	0.15532***
Sea-view		-0.00667	-0.00778	-0.00778	-0.00596	-0.00714
Age & Diamond					0.00224***	0.00208***
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-shape					-0.00418***	-0.00437***
Gross size & L-shape					-0.00006***	-0.00006***
Net ratio & L-shape					-1.19567***	-1.19366***
Distance from CBD & L-shape					-0.00820***	-0.00827***
Estate Scale & L-shape					0.00001***	0.00001***
Age & Rectangular					0.00056***	0.00042
Gross size & Rectangular					0.00000	0.00000
Net ratio & Rectangular					-0.80794***	-0.80582***
Distance from CBD & Rectangular					-0.00579***	-0.00583***
Estate Scale & Rectangular					5.1400E-06***	5.0700E-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%

Figure 1a: Diamond Shape Living Room from the estate “Kornhill”

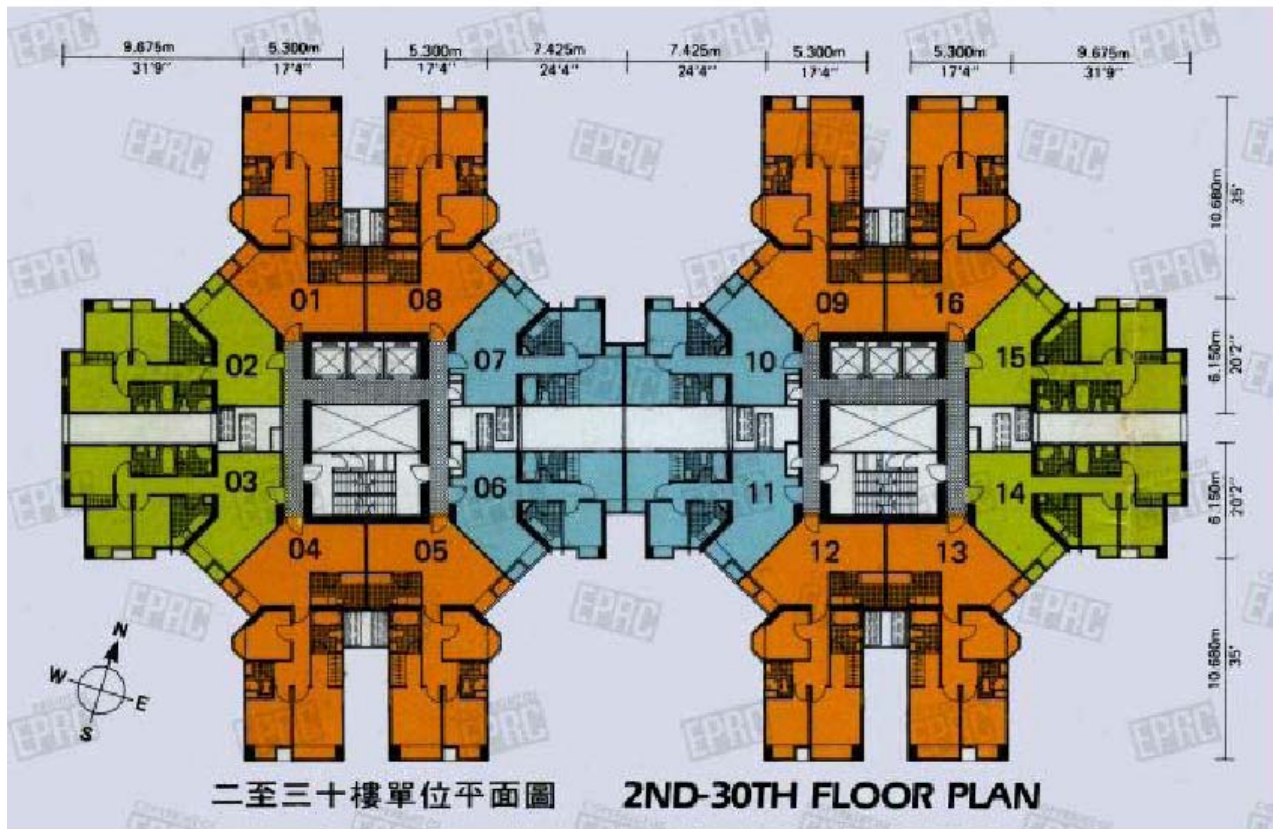


Figure 1b: Rectangle Shape Living Room from the estate “Nam Fung Sun Chuen”

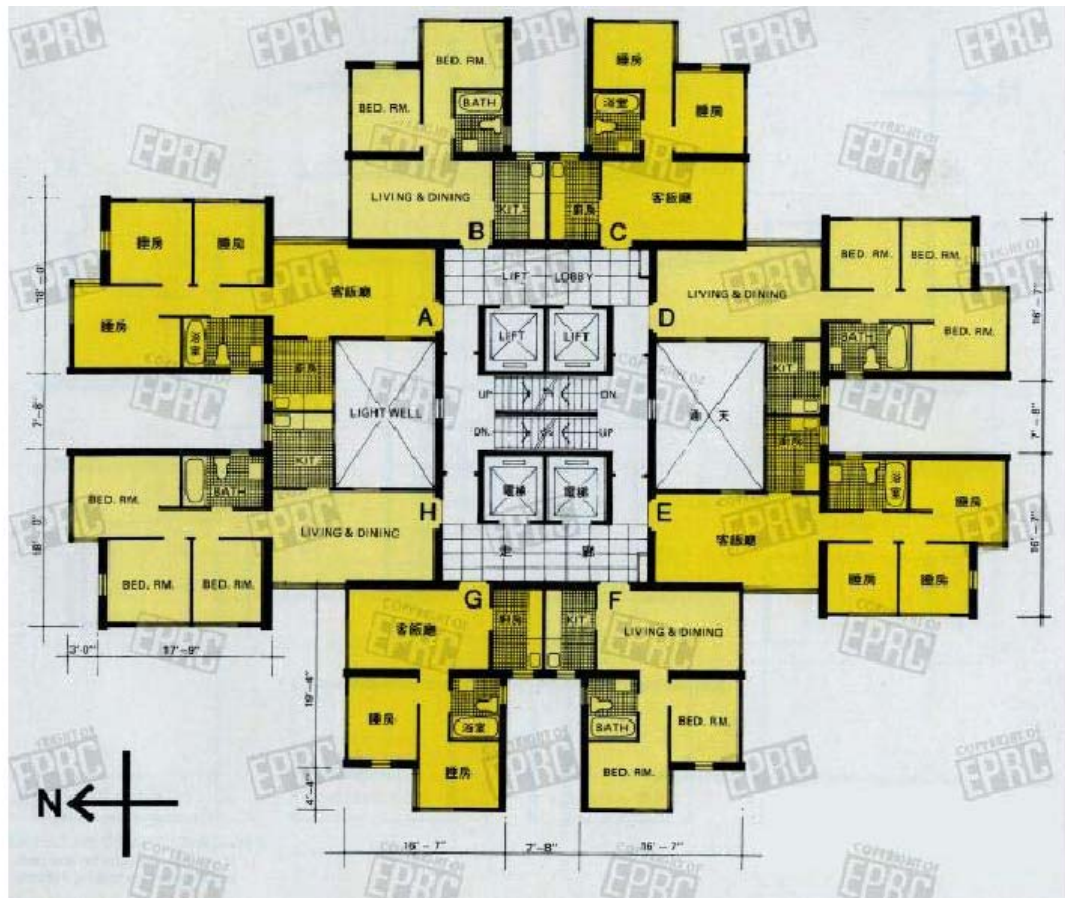






Figure 1d: "Two-rectangle" Shape Living Room from the estate "Taikoo Shing" (apt A, D, E, H)

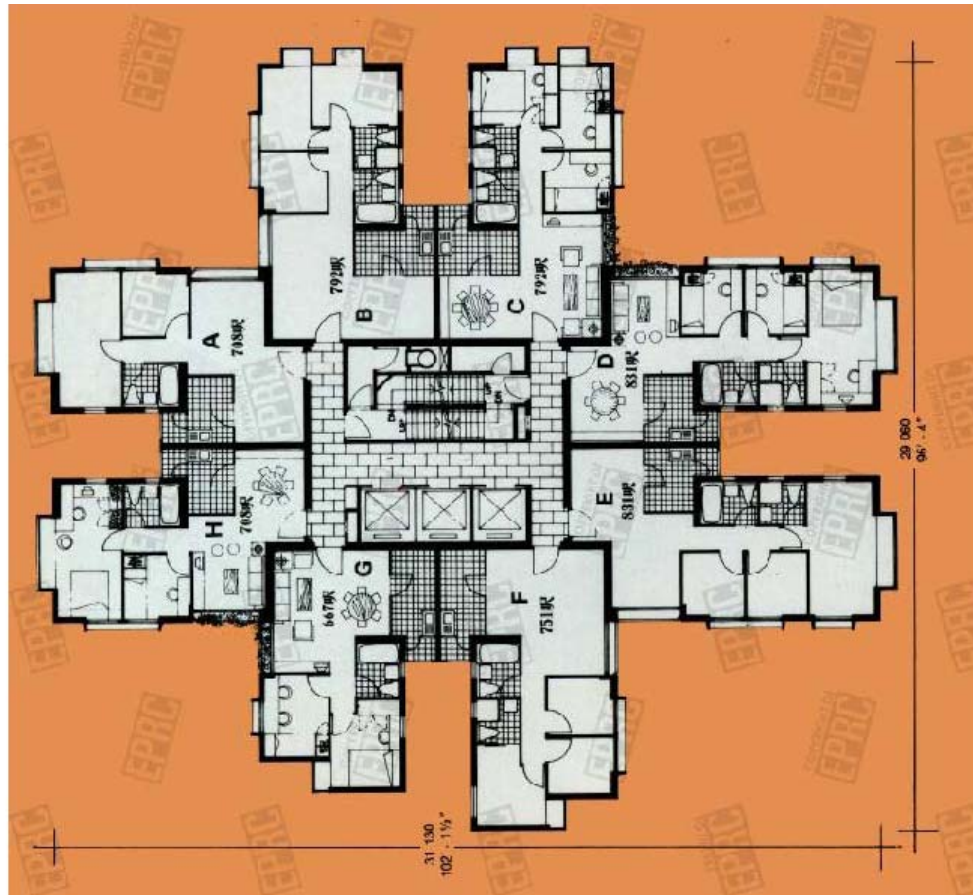
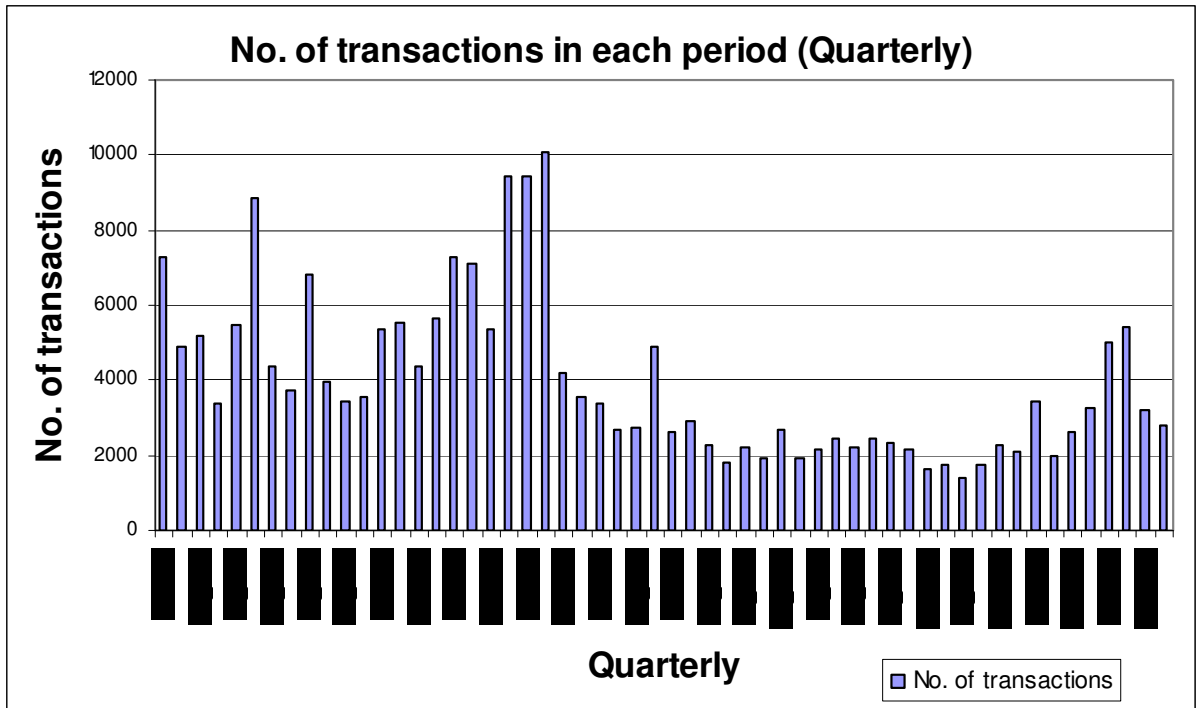


Figure 2 Number of transaction in each quarter (1992~2005).



## **APPENDIX**

The appendix is divided into several sections. Appendix I will provide some justifications of why 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 the limit of space. Appendix IV discusses how the “total effect” used in the text was measured.

### **Appendix I: why we did not use repeated sale method**

*The repeated-sale method is doubtlessly a very good method in controlling the quality of the housing units being traded and hence identifies the “real changes” in prices. On the other hand, 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. It can be easily illustrated in the following example. To simplify the exposition, consider the case with only one housing characteristics. 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 kind of “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. In first-difference term, it can be re-written as

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

as the “fixed effect” is eliminated, and the characteristics is 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 the first-difference of it,  $\Delta(a_{1t}x_t)$ .

## **Appendix II: Expected Sign of variables**

The expected signs for all variables are summarized in table 2 and we attempt to provide a brief justification for them here.<sup>45</sup> As the maintenance cost and the age of the property are positively related, negative coefficient of age is expected. Buyers typically prefer flats on higher floor for potentially better view and less noise from the street, which leads 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 relative 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. It means that on average housing units have less than 600 square feet (or 60 square meters) in “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 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 the international standard. 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, the Kowloon Peninsula, and the 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 those residents can access the area for leisure within 500 meters from their home.

For the floor layout attributes, “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 the hygienic consideration. Many people complain it is quite difficult to place furniture in diamond-shape 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 stuff, placing drying rack, etc.<sup>46</sup> It also seems natural to conjecture that more bedroom is preferred to few, as it would allow 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 toilet is expected to be positive.

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

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<sup>45</sup> 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.

<sup>46</sup> However, under the existence regulations, residents can not use the roof or deck to extend living areas of the flat.

### Appendix III: Supplementary results

*This appendix provides more detailed information of the dataset.*

Table A-0: Some basic information of the real estate developments studied in this paper.

	Number of Units	Number of Buildings	Number of floors
<u>Hong Kong Island</u>			
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	
<u>Kowloon</u>			
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	
<u>the New Territories</u>			
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 shapes and other explanatory variables)

	Diamond	L-shape	Rectangular	Two-rectangle
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 toilet	0.3029	-0.0176	-0.2272	-0.1254
Kitchen accessible to living room	0.3746	-0.065	-0.2461	-0.151
Kitchen adjacent to bedrooms	-0.1498	0.0658	0.0478	0.0845
Toilet adjacent to bedrooms	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 transaction in each sampling period (Quarterly)

Quarter	No. of transaction	Quarter	No. of transaction	Quarter	No. of transaction	Quarter	No. of transaction
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 observation = 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 <sup>2</sup>	-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 <sup>2</sup>	-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 <sup>2</sup>	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 <sup>2</sup>		-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-square's coefficients from different models<sup>47</sup>

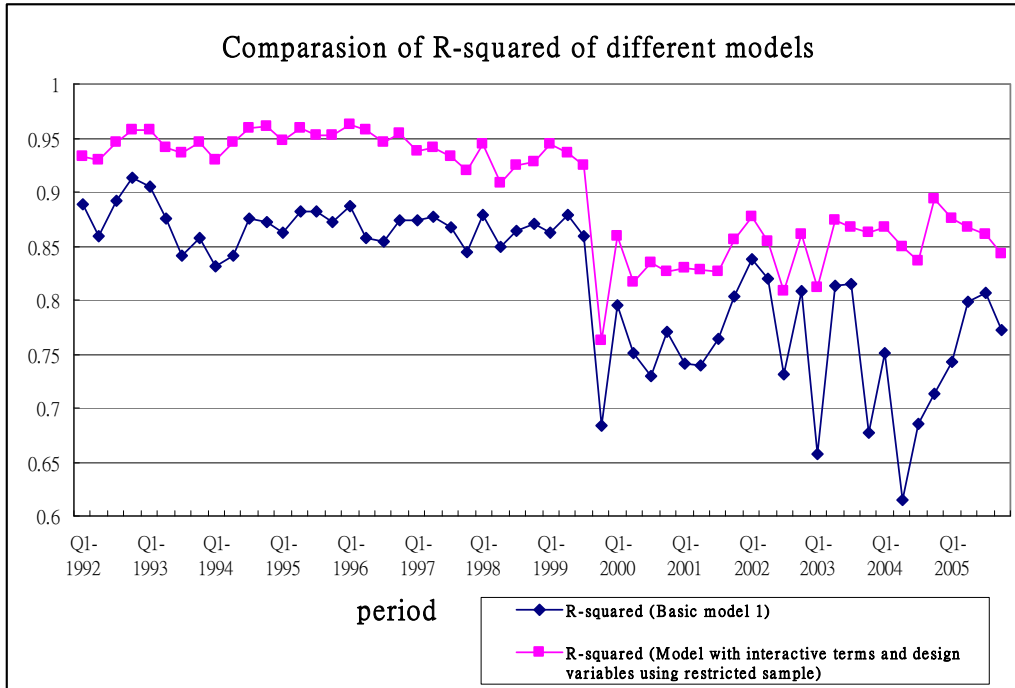
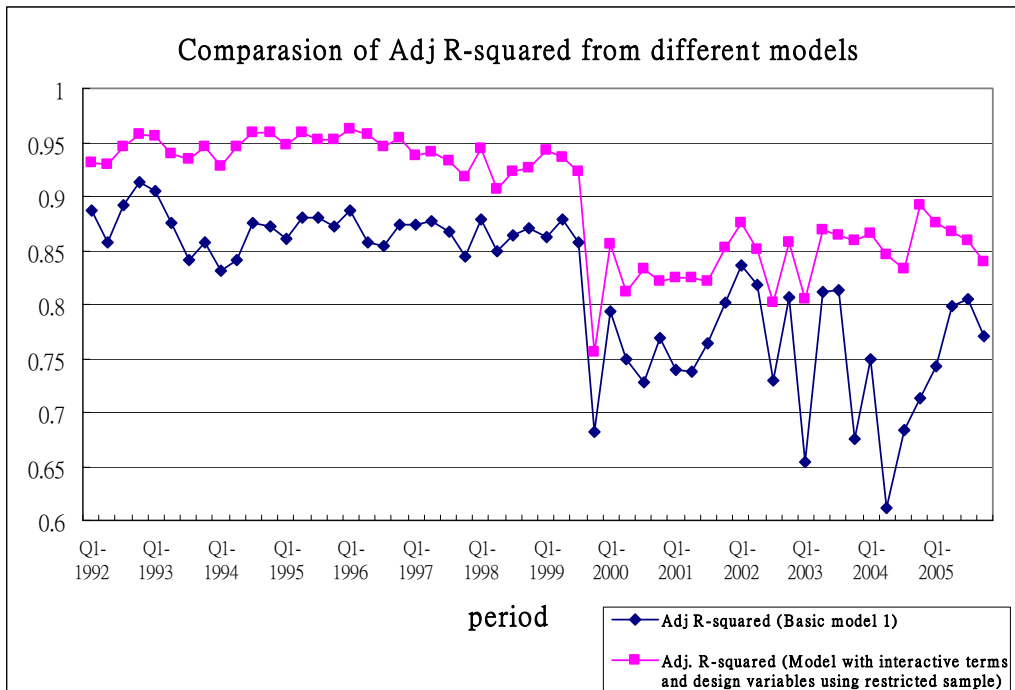


Figure A-1b: (Time series plot of Adj. R-square's coefficients from different models)



<sup>47</sup> Basic mode refers to the model shown in table 4.

Appendix IV: Measuring the total effect

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

$$y = a_0 + a_1x_1 + a_2x_2 + a_{12}x_1x_2 + u$$

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

$$b_1 = \frac{\partial y}{\partial x_1}_{x_j = \bar{x}_j, \forall j}$$

Similarly, we define the “total effect of  $x_2$  on  $y$ ” to be  $b_2$ ,  $b_2 = \frac{\partial y}{\partial x_2}_{x_j = \bar{x}_j, \forall j}$ . 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  $b_j$ ,  $b_j = \frac{\partial y}{\partial x_j}_{x_i = \bar{x}_i, \forall i}$ . 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 a set of variables used in the main text and we will explain how we 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-shape	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

Key: *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 the interaction terms used in this paper.

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

Let us say the regression equation is

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

Then,

$$\text{the total effect for Diamond} = c1 + d1 *(\text{mean of age}) + d2*(\text{mean of gross size}) + \dots + d5*(\text{mean of estate scale})$$

$$\text{Similarly, the total effect for (distance from CBD)} = a4 + d4 *(\text{mean of Diamond}) + e4 *(\text{mean of L-shape}) + f4 *(\text{mean of Rectangular}).$$