Title	Floor-level premiums in high-rise and low-rise buildings
Author(s)	Wong, SK; Chau, KW; Yau, Y; Cheung, KC
Citation	The 12th Annual Conference of the Pacific Rim Real Estate Society, Auckland, New Zealand, 22-25 January 2006
Issued Date	2006
URL	http://hdl.handle.net/10722/115922
Rights	This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License.

Floor-level premiums in high-rise and low-rise buildings

WONG, Siu Kei,[1] CHAU, Kwong Wing,[2] YAU, Yung[3] and CHEUNG, Alex King Chung[3]

[1] Assistant Professor
[2] Chair Professor
[3] PhD Candidate

All in Department of Real Estate and Construction, The University of Hong Kong

Paper submitted to

The 12th Annual Conference of the Pacific Rim Real Estate Society

22-25 January 2006

Auckland, New Zealand

*Please send comments to:

Dr. S.K. Wong
Department of Real Estate and Construction
The University of Hong Kong
Pokfulam Road,
Hong Kong

Fax No.: (852) 2559 9457
E-mail: skwongb@hku.hk

Floor-level premiums in high-rise and low-rise buildings

Abstract

This paper examines a unique feature of multi-storey buildings – floor-level premiums. Floor-level premiums refer to the price paid for the vertical location of a flat, measured by its floor level. Previous hedonic price studies unequivocally showed that floor-level premiums are positive. However, they were often based on the assumptions that floor-level premiums are constant 1) across different floor levels within the same building and/or 2) across different buildings given the same floor level. This second assumption is particularly interesting because it begs the question of whether the same premium is paid for high-rise and low-rise buildings. For instance, do we pay the same for the 5th floor of a low-rise building and that of a high-rise building? Based on a sample of highly homogeneous buildings (except for their heights), we found that floor-level premiums were not constant but diminishing with respect to floor levels. Moreover, there was no significant difference in the pattern of floor-level premiums between high-rise and low-rise buildings. Finally, there was a positive and significant premium for shorter buildings over taller buildings.

Keywords

Floor level, Building density, Property price, Hedonic price model, Hong Kong

1. Introduction

Multi-storey buildings are ubiquitous in most metropolitan cities, such as New York, London, Paris, Tokyo, and Hong Kong. In the core areas of these cities, population is high and the supply of developable land is scarce. The resulting high property prices give developers strong financial incentives to develop tall and dense buildings in order to reap maximum development profits.

This paper examines a unique feature of multi-storey buildings – floor-level premiums. A floor-level premium refers to the price paid for the vertical location of a flat, measured by its floor level. In a hedonic pricing framework, it is the marginal effect of a floor level variable (*FL*) on property prices (*P*).[1] Previous hedonic price studies unequivocally showed that floor-level premiums are positive (i.e. ?*P*/?*FL*>0) – the price of a flat varies positively with its floor level. Chau *et al.* (2004, p.255), for instance, reasoned that "units on upper floors have better views, less noise, and fresher air". However, the models used by previous studies often made some of the following assumptions:

1) Floor-level premiums are constant across different floor levels within the same building (or, more generally, buildings of the same height, *H*):

$$\left.\frac{\partial P}{\partial FL}\right|_{FL=i;H=m} = \left.\frac{\partial P}{\partial FL}\right|_{FL=j;H=m} \qquad \forall i \neq j \tag{1}$$

2) Given the same floor level, floor-level premiums are constant across buildings with different heights:

$$\left.\frac{\partial P}{\partial FL}\right|_{FL=i;H=m} = \left.\frac{\partial P}{\partial FL}\right|_{FL=i;H=n} \qquad \forall m \neq n \tag{2}$$

This paper treats these assumptions as (null) hypotheses and empirically tests their validity. The first assumption may not be valid because the marginal benefit of locating

[1] To be precise, this paper defines property prices as the price of a flat located on a particular floor of a multi-storey building.

up one floor tends to be smaller on higher floors. For instance, in avoiding street-level noise, the benefit of moving from the 10^{th} floor to the 11^{th} floor may be much smaller than that of moving from the 4^{th} floor to the 5^{th} floor. This is not necessary the sole result of diminishing marginal utility. The inverse square law governing sound transmission may also play a part. We will test whether floor-level premiums are floor-varying or not.

The second assumption is particularly interesting in the context of high-rise and low-rise buildings. It begs the question of whether the same floor-level premium is paid for high-rise and low-rise buildings. For instance, given two otherwise identical buildings, do we pay the same floor-level premium for the 5^{th} floor of a 6-storey building and that of a 36-storey building? "Of course" seems to be the intuitive answer, but the picture would become different if one considers the 5^{th} floor as a top floor in the 6-storey building but a low floor in the 36-storey one. In fact, it is a common practice in the marketing (e.g. advertisement) of apartment units to use floor zones (e.g. low, mid or high-zone) rather than exact floor levels. Some previous studies also applied this logic in their hedonic pricing models. If the market values relative floor levels rather than absolute levels, then one would expect different patterns of floor-level premiums in low-rise and high-rise buildings. This is the second test we will perform.

Irrespective of its correctness, the above "relative" thinking brings us another important dimension of multi-storey buildings – building height.[2] Hitherto, little is known about how building height affects property prices. Previous hedonic studies normally ignored the effect of building height, thus assuming that:

$$\frac{\partial P}{\partial H} = 0 \tag{3}$$

However, there should be a discount on high-rise buildings because of their higher population density (assuming identical footprint area). There are three supporting arguments for this. First, residents may feel overcrowded and stressful. A number of theoretical studies showed that living in places with a high population density would

[2] Floor levels and building height are two different concepts that should not be mixed up. A floor level refers to the vertical location of a unit (or flat), whereas building height refers to the vertical dimension of a building.

likely to have a variety of negative effects, including physical, psychological, and social illnesses (Zlutnick and Altman 1972); stress and stress-related illnesses (Calhoun 1957); and crime and intergroup violence (Hartley 1972). Yet, empirical findings were mixed – some studies confirmed the negative effects (Galle *et al.* 1972; Tanaka *et al.* 1996), while others found a weak or even no association (Mitchell 1972; Schmitt *et al.* 1978; Millar 1979). Second, a high-density building reduces one's sense of privacy and tranquility. It is not unusual to see conflicts among residents over the sharing of communal facilities, like staircases, corridors, lifts, and lobbies in condominiums. Forced social interaction between non-relatives as a result of flat-sharing tended to create stress and tensions (Mitchell 1972). Third, the Severe Acute Respiratory Syndrome (SARS) outbreak in 2003 further highlighted the danger of transmitting communicable diseases through a high living density environment (Department of Health 2003; World Health Organization 2003). All these suggest lower property prices for flats in high-rise buildings when compared to those in low-rise buildings (i.e. a low-rise premium), all other things being equal. This becomes the third test of this paper.

The next section will outline how we test the aforesaid assumptions. Hong Kong is chosen as the place of empirical study in view of its high population density, its abundance of multi-storey buildings, and its active property market. With a total land area of 1,100 km^2 and a present population of 6.7 million, its overall population density is about 6,100 persons per km^2. When considering urban areas alone, the gross population density is four times higher – about 26,000 persons per km^2. To house this huge population within the small land area, a large number of multi-storey buildings have been developed. The government estimated that there are around 42,000 private buildings territory-wide (Housing, Planning and Lands Bureau, 2004). Chau *et al.* (2005) further stated that Hong Kong's property market has generated around 100,000 transactions per year since the 1990s, making it one of the most active markets in the world. These competitive advantages make Hong Kong a highly favorable laboratory to gauge the effect of floor levels and building height on property prices

2. Methodology

Before carrying out any analysis, a workable definition for the density of a building is needed. In this paper, we suppose that there are two groups of building that are exactly the same except for their heights (i.e., one group is high-rise and the other is low-rise). Since they have the same number of flats and the same floor area on each storey, a taller building would have a higher population density than the shorter one. This means we can simply measure building density by building height. In the following sections, we will use the terms building density and building height interchangeably.

To evaluate how floor levels and building height are priced, hedonic pricing analysis is applied. According to Rosen's (1974) seminal work, hedonic pricing models can extract the implicit price of property attributes from property transaction prices. As such, they can be used to estimate the implicit price of floor levels and building height. But in the real world, buildings with variations in height usually have very different designs and location characteristics, rendering the separation of the implicit price of height from other design and location attributes difficult.

To solve this problem, we identified a housing estate (Telford Gardens) in Kowloon that has buildings with highly homogenous attributes except for their heights (ranging from 11 to 26 storeys). Telford consists of 41 apartment building blocks with the same typical floor plan and building services systems. While the majority of the blocks are 11 or 12-storeys tall (low-rise), there are 10 blocks that are 25 or 26 storeys (high-rise). This unique housing development offers us a very good sample to study the relationship between property prices and floor levels and building height.

In the sample, the transaction data of flats on or below the 10/F was collected. We excluded units on or above the 12/F, as their transactions were only available for the taller buildings only. Flats on the 11/F were also truncated because they are located just beneath the roof and are more prone to water leakage and noises and vibrations generated by lifts. The quality of the top floor is therefore likely to be different from that of intermediate floors. After sample truncation, a total of 671 transactions remained, covering the period from January 2000 to October 2004. Table 1 presents the descriptive statistics of the data.

Table 1: Descriptive statistics of the property transaction data

	Mean	Std. dev.	Min	Max
Telford Gardens (No. of Transactions = 671)				
Property price (HK$mil)	1.48	0.26	0.60	2.28
Age (months)	255.48	17.96	216.00	292.00
Flat size (ft^2)	601.85	29.03	392	681
Floor level	5.37	2.85	1.00	10.00
MTR distance (m)	168.10	56.36	64.35	248.70
Street view (%)	0.29	-	-	-
Podium Garden view (%)	0.34	-	-	-
MTR depot view (%)	0.09	-	-	-
Low-rise building (%)	0.82	-	-	-

To estimate the implicit price of building density, a linear hedonic pricing model was set as follows:

$$
\begin{aligned}
P_{it} = b_1 LR_i + g_1 FLR_i + g_2 FLR_i^{\,2} + a_0 + a_1 AGE_i + a_2 SIZE_i + a_3 ST\_V_i + \\
a_4 GDN\_V_i + a_5 DPT\_V_i + a_6 MTR\_D_i + \sum_{k=1}^{T} c_k TIME_{ik} + e_{it}
\end{aligned}
\qquad (4a)
$$

The variables used in Eq. (4a) are defined in Table 2. Variables like building age, flat size, views, distance to the MTR station, and time factors are control factors.[3] Our first focus is on *ß*$_1$, which measures the relative price of a low-rise building to a high-rise building (i.e. a test of assumption 3). Its sign is expected to be positive because, as aforementioned, living in a dense environment may lead to crowding and a higher risk of health problems (mentally and physically). Our second interest lies in the coefficients of floor levels, $?_1$ and $?_2$. A square term for floor levels was added to cater for any non-linear effect (i.e. a test of assumption 1).[4] It is expected that $?_1$ is positive and $?_2$ negative. In fact, a more flexible specification for the price-floor relationship was to use floor

[3] The base period for the time dummies is January 2000. The base view type for the view dummies is a building view.

[4] We tried to add the square terms of *AGE* and *SIZE* to the equation, but they were insignificant.

dummies, *FLR_D* (see Table 2 for its definition). Building upon Eq. (4a), we replaced the continuous floor variable with floor dummies, as shown below:

$$P_{it} = b_1 LR_i + \sum_{j=2}^{10} g_j FLR\_D_{ij} + a_0 + a_1 AGE_i + a_2 SIZE_i + a_3 ST\_V_i + a_4 GDN\_V_i + a_5 DPT\_V_i + a_6 MTR\_D_i + \sum_{k=1}^{T} c_k TIME_{ik} + e_{it} \quad (4b)$$

The first floor is taken as the base floor level. As such, the coefficients of the floor dummies should be positive and increasing with floor levels.

Table 2. Definition of the variables

Variable	**Definition**
P_{it}	The transaction price (in HK$ million) of property *i* at time *t*
LR_i	A building height dummy that equals 1 when property *i* is low-rise, and zero when it is high-rise
FLR_i	The floor level of property *i*
FLR_D_{ij}	A floor dummy that equals 1 when property *i* is on the j^{th} floor, and zero if otherwise (base floor = 1/F)
AGE_i	The building age of property *i* in months
$SIZE_i$	The gross floor area of property *i* in square feet
ST_V_i	A view dummy that equals 1 when property *i* possesses a view facing the street, and zero if otherwise
GDN_V_i	A view dummy that equals 1 when property *i* possesses a view facing the podium garden, and zero if otherwise
DPT_V_i	A view dummy that equals 1 when property *i* possesses a view facing the MTR depot, and zero if otherwise
MTR_D_i	The distance between property *i* and the MTR station in metres
$TIME_{ik}$	A monthly time dummy that equals 1 when property *i* was transacted at time *k*, and zero if otherwise
a, *ß*, *?* and ?	Coefficients to be estimated
e_{it}	The error term capturing all unmeasured effect

To test assumption 2, we have to relax the assumption in Eqs. (4a) and (4b) that the patterns of floor-level premiums are the same for both low-rise and high-rise buildings. We added an interaction term of the low-rise dummy (*LR*) and floor levels (*FLR* and *FLR_D*) to Eqs. (4a) and (4b). The resulting equations were:

$$P_{it} = b_1 LR_i + b_2 LR_i \times FLR_i + b_3 LR_i \times FLR_i^2 + g_1 FLR_i + g_2 FLR_i^2 + a_0 + a_1 AGE_i + a_2 SIZE_i + a_3 ST\_V_i + a_4 GDN\_V_i + a_5 DOT\_V_i + a_6 MTR\_D_i + \sum_{k=1}^{T} c_k TIME_{ik} + e_{it} \quad (5a)$$

$$P_{it} = b_1 LR_i + \sum_{j=2}^{10} b_j LR_i \times FLR_{ij} + \sum_{j=2}^{10} g_j FLR_{ij} + a_0 + a_1 AGE_i + a_2 SIZE_i + a_3 ST\_V_i + a_4 GDN\_V_i + a_5 DPT\_V_i + a_6 MTR\_D_i + \sum_{k=1}^{T} c_k TIME_{ik} + e_{it} \quad (5b)$$

If the coefficients of these interaction terms are significant, then different patterns of floor-level premiums is implied. All the results will be presented and discussed in the next section.

3. Results

Based on the hedonic pricing analysis, the results of the two models without interaction terms (i.e. Eqs. (4a) and (4b)) are shown in Column 1 and 2 of Table 3. The R-squared values of these models were around 80%, with the value in Eq. (4b) slightly higher than Eq. (4a). This indicated that our models successfully explained a great deal of variability in the data. It should be noted that apart from the floor specification, the two models were similarly structured. For both models, most of the coefficients of control variables (except *MTR_D*) were highly significant with expected signs. The magnitudes of the coefficients estimated were also very close to each other. Most importantly, we found that:

- In Eq. (4a), both $?_1$ and $?_2$ were significant at the 1% level, with opposite signs. Over the sample range, the floor-level premium decreased strictly from HK$81,364 on the 1^{st} floor to –HK$30,488 on the 10^{th} floor. This rejects assumption 1 and confirms that floor-level premiums diminished with respect to floor levels. Obtaining unexpected negative floor-level premiums (starting from the 8^{th} floor) was likely due to the use of a quadratic functional form. As shown in Eq. (4b), when a more flexible form (i.e. floor dummies) was used, the floor-level premiums from the 8^{th} to 10^{th} floor indeed exhibited a rising trend.

- Units in taller (and thus denser) buildings were sold at a discount compared to those in shorter buildings, *ceteris paribus*. The estimated price differentials, captured by the coefficient of *LR*, were HK$28,073 in Eq. (4a) and HK$19,469 in Eq. (4b), representing about 1-2% of the mean transaction price in the sample. They were significant at the 5% and 10% levels, respectively. This rejects assumption 3 and confirms that there was a positive and significant premium for shorter buildings over taller buildings.

Next, Eqs. (5a) and (5b) were estimated to test whether floor-level premiums are constant across buildings of different heights. The regression results of Eqs. (5a) and (5b) are shown in Column 3 and 4 of Table 3. Central to these equations are the interaction terms of *LR* with floor levels. All their coefficients, however, were insignificant. There is no evidence to support the "relative" logic that floor-level premiums varied with buildings of different heights. Hence, assumption 2 cannot be rejected. As in Eq. (4a), assumption 1 is rejected again in Eq. (5a) in favour of the existence of diminishing floor premiums. But contrary to the findings in Eqs. (4a) and (4b), the low-rise premium became insignificant. This is probably because more correlated interaction terms were added. The coefficients of other control variables were largely the same as before.

Table 3. Estimation results

	Eq (4a)		Eq (4b)		Eq (5a)		Eq (5b)	
Variable	Coefficient		Coefficient		Coefficient		Coefficient	
LR	0.028073	**	0.019469	*	0.005513		0.045620	
FLR	0.093792	***	-	-	0.079172	***	-	-
FLR^2	-0.006214	***	-	-	-0.004554	***	-	-
FLR_D_2	-	-	0.221088	***	-	-	0.279765	***
FLR_D_3	-	-	0.276484	***	-	-	0.333099	***
FLR_D_4	-	-	0.269176	***	-	-	0.306244	***
FLR_D_5	-	-	0.279909	***	-	-	0.257462	***
FLR_D_6	-	-	0.295252	***	-	-	0.319566	***
FLR_D_7	-	-	0.325746	***	-	-	0.327751	***
FLR_D_8	-	-	0.315682	***	-	-	0.320130	***
FLR_D_9	-	-	0.325992	***	-	-	0.347470	***
FLR_D_{10}	-	-	0.341126	***	-	-	0.409844	***
*LR*FLR*	-	-	-	-	0.018865		-	-
$LR*FLR^2$	-	-	-	-	-0.002122		-	-
$LR*FLR\_D_2$	-	-	-	-	-	-	-0.069473	
$LR*FLR\_D_3$	-	-	-	-	-	-	-0.064560	
$LR*FLR\_D_4$	-	-	-	-	-	-	-0.045489	
$LR*FLR\_D_5$	-	-	-	-	-	-	0.029682	
$LR*FLR\_D_6$	-	-	-	-	-	-	-0.029519	
$LR*FLR\_D_7$	-	-	-	-	-	-	0.001041	
$LR*FLR\_D_8$	-	-	-	-	-	-	-0.007631	
$LR*FLR\_D_9$	-	-	-	-	-	-	-0.028094	
$LR*FLR\_D_{10}$	-	-	-	-	-	-	-0.087369	
CONSTANT	0.735229	***	0.734827	***	0.764767	***	0.776275	***
AGE	-0.003161	***	-0.002629	***	-0.003167	***	-0.002837	***
SIZE	0.002603	***	0.002461	***	0.002588	***	0.002433	***
ST_V	-0.035492	***	-0.041425	***	-0.035511	***	-0.041232	***
GDN_V	0.070449	***	0.072914	***	0.070331	***	0.073595	***
DPT_V	-0.059584	***	-0.061142	***	-0.058634	***	-0.058060	***
MTR_D	6.35E-05		-4.03E-05		5.98E-05		-2.88E-05	
R-squared	0.817323		0.842351		0.818150		0.844757	
Adj. R-squared	0.797362		0.823073		0.797609		0.823108	

White's standard errors were used to adjust for heteroskedasticity

*significant at the 10% level; **significant at the 5% level; ***significant at the 1% level

Notes: Time dummy results are not reported here, but available upon request.

4. Conclusion

In a city where multi-storey buildings as human habitats are common, we have evaluated three assumptions on floor levels and building height in Hong Kong based on the hedonic pricing analysis. First, we found that floor-level premiums were not constant but diminished with respect to floor levels in all equations. Second, although high-rise high-density living is the norm, the results from Eqs. (4a) and (4b) suggest that people still preferred living in shorter, hence less dense, buildings. Third, there was no significant difference in the pattern of floor-level premiums between high-rise and low-rise buildings and the notion that the market values relative floor levels rather than absolute levels was not supported.

One implication is that while developers build higher buildings for better returns, they should be reminded that this also comes with a decrease in sales for units on the lower levels. Although the current data set did not allow us to determine an optimum building height, we believe that revenue will not strictly increase with building height, but rather comes down.

Acknowledgments

We gratefully acknowledge the financial support provided by the Research Group on Sustainable Cities of The University of Hong Kong.

References

Calhoun, J.B. (1957) 'Social welfare as a variable in population dynamics", *Cold Spring Harbor symposia on quantitative biology*, **22**, 339-356.

Chau, K.W., Wong, S.K. and Yiu, C.Y. (2004) "The value of the provision of a balcony in apartments in Hong Kong", *Property Management*, **22**(3), 250-264.

Chau, K.W., Wong, S.K., Yiu, C.Y. and Leung, H.F. (2005) "Real estate price indices in Hong Kong", *Journal of Real Estate Literature*, forthcoming.

Department of Health (2003) *Main Findings of an Investigation into the Outbreak of SARS at Amoy Gardens*, http://www.info.gov.hk/info/ap/.

Galle, O.R., Gove, W.R. and McPherson J.M. (1972) "Population density and pathology: what are the relations for man?" *Science*, **176**, 23-30.

Hartley, S.F. (1972) *Population: quantity vs. quality: a sociological examination of the causes and consequences of the population explosion*, Prentice-Hall, Englewood Cliffs, N.J.

Housing, Planning and Lands Bureau (2004) *Building Management and Maintenance – Consultation Paper*. Hong Kong Government Printer, Hong Kong.

Millar, S. E. (1979) *The biosocial survey in Hong Kong*, Centre for Resource and Environmental Studies, Australian National University, Canberra.

Mitchell, R.E. (1972) *Levels of Emotional Strain in Southeast Asian Cities*, Orient Cultural Service, Taipei.

Rosen, S. (1974) "Hedonic prices and implicit markets: product differentiation in pure competition", *The Journal of Political Economy*, **82**, 34-55.

Schmitt, R.C., Zane, L.Y. and Nishi, S. (1978) "Density, health, and social disorganization revisited", *Journal of American Institute of Planners*, **44**, 209-211.

Tanaka, A., Takano, T., Nakamura, K. and Etkeuchi, S. (1996) "Health levels influenced by urban residential conditions in a megacity – Tokyo", *Urban Studies*, **33**, 879-894.

World Health Organization (2003) *Final Report - Amoy Gardens - WHO Environmental Investigation*, http://www.iapmo.org.

Zlutnick, S. and Altman, I. (1972) "Crowding and human behaviour" in J.F. Wohlwill and D.H. Carson (Eds.) *Behavioural Science and the Problems of Our Environment*, American Psychologists Association, 300.