INTERNATIONAL REAL ESTATE REVIEW

2008 Vol. 11 No. 2: pp. 47 – 74

Intra-metropolitan Office Price and Trading Volume Dynamics: Evidence from Hong Kong

Charles Ka Yui Leung*
Department of Economics and Finance, City University of Hong Kong, Kowloon Tong, Hong Kong; Tel: 852-2788-9604; E-mail: kycleung@cityu.edu.hk

Patrick Wai Yin Cheung
Department of Economics, Chinese University of Hong Kong, Shatin, Hong Kong; Tel: 852-2609-8190; E-mail: economics@cuhk.edu.hk

Erica Jiajia Ding
Department of Economics, Chinese University of Hong Kong, Shatin, Hong Kong; Tel: 852-2609-8190; E-mail: economics@cuhk.edu.hk

Previous studies of the office market have tended to focus on either the rental market or the aggregate sales market. This paper focuses on the intra-metropolitan sales market and on office price and trading volume dynamics in Hong Kong. According to our findings, buildings trading at higher prices are not necessarily traded more often than those trading at lower prices. In addition, the price of offices in different categories does not necessarily move in tandem. The trading volumes of higher priced buildings tend to Granger cause the lower priced buildings, and this conclusion is robust to alternative classifications. The paper contrasts several existing theories. Suggestions for future research are also discussed.

Keywords

Commercial property; Correlation

---

* Corresponding author

1. Introduction

This paper studies the sales market of offices within a single metropolitan area. While many studies have been done on intra-metropolitan residential property prices, far fewer have been done on the sales market of offices within one metropolitan area.[1] Many of the studies that have been done tend to focus on the local or national-level (among others, see Eppli, Shilling and Vandell, 1998; Sivitanidou and Sivitanides, 2000; Wheaton, 1987; Wheaton and Torto, 1988; Wheaton et al, 1997).[2] In addition, previous studies of the office market have disproportionately emphasized the rental market (among others, see Sivitanidou and Sivitanides, 1999, 2000; Sivitanidou 2002, and the references therein). This may be partly due to the fact that the rental market dominates office properties in the United States.

Parallel studies in other countries may prove difficult. First, the rental market may not dominate. Second, the needed information for rental market studies may not be accessible. For instance, "side deals" such as rent-free periods, the inclusion of management fees, the inclusion of utilities, contract-completion rebates, conditional renewal agreements, etc., are very common in the Hong Kong office rental market,[3] and they also vary from firm to firm and over time. Unfortunately, information on such deals is not publicly available in Hong Kong. In addition, some commercial property rental contracts are quite lengthy, lasting as long as three to five years. Thus, the data set needs to cover a rather long period in order for contract renewal to be observable in the data. While such time series are available for the US market, it would be a considerable big challenge to analyze such data from other countries.

Given these limitations, this paper will instead focus on the sales market of offices.[4] In particular, this paper will study intra-metropolitan office price and trading volume dynamics. This is an important issue because several existing property market theories have implications for the dynamics of price and trading volume. As will become clear, some refinements of the existing theories are needed. The study of the sales market of offices may indeed be a promising approach, especially for cross-country comparisons as sales information is usually recorded by governments for tax and other purposes. While it is clear that a survey of the literature is beyond the scope of this paper, we will nevertheless tabulate our literature review in Appendix I to facilitate comparison. It suffices to say that this paper will be substantially different from the existing literature in terms of the dataset, the focus, and the results.

---

1 The literature on residential property price is too large to be reviewed here. Among others, see Chau et al (2004), Englund, Quigley and Redfearn (1998), Hwang and Quigley (2004).

2 Needless to say, there are also contract/loan level studies (among others, see Ambrose and Sanders, 2003; Fu et al, 2003; Gunnelin and Soderberg, 2003; Patel and Sing, 2000). Again, such detailed datasets are not common, making related and follow-up studies very difficult.

3 We confirm this statement with industry participants, who are unwilling to disclose their identities.

4 In terms of research ideas, this paper is also related to the "spatial-temporal approach" in the residential property literature, such as Tu et al (2004), and the reference therein. We consider the spatial dimension to be less important for commercial property, especially for a small geographical area like Hong Kong and we simply take office buildings as a given unit to start with.

In terms of research strategy, this paper will construct indices for different "classes" of office, based on all the information that we can access, which includes more than 24,000 transactions involving 601 office buildings. Note that a direct study of all these buildings is virtually impossible. First, we would need to find some metrics to compare more than 1,000 time series (each building has a time series of price as well as trading volume). Second, some buildings are less frequently traded than others, and it is possible that some "outliner transactions" might contaminate the dataset. Aggregating the office buildings into classes would "average out the noises". For this reason, aggregating the 601 office buildings into a much smaller number of classes seems to be a much preferred strategy (more discussion of this will follow). This paper will focus on the following questions: 1.) whether different classes of offices do in fact move together in terms of the transaction price and of the trading volume, and 2.) whether one particular class of office drives the rest.

Clearly, these questions carry important implications. For instance, if the price movement of different classes is very different, the construction of a city-level price index might be subject to serious aggregation bias. It might also mask the important intra-metropolitan dynamics among different classes of offices.

In principle, all of the office sales transactions taking place during the sample period should be included in the EPRC, which is the dataset that we have employed. If this is the case, then all of the office sales transactions in Hong Kong taking place during the sample period would be included in our dataset.

Note that these indices are transaction-based. For this reason, this paper is not subject to the appraisal-smoothing debate (see Geltner, 1991, and Lai and Wang, 1998, among others). Perhaps more importantly, the causality relationship among different classes of offices will shed light on the transmission mechanism of shock within the property market. To clarify this point further, it may be instructive to compare this with the case of residential properties. Ortalo-Magne and Rady (2004, 2006) have established that the causality goes from lower-priced to higher-priced units, which is consistent with the collateral-based theory of property market price and trading volume fluctuations. Thus, if the firms have some "consumption motives" for office space, and they are also subject to collateral constraints as with households, we would expect that the causality would go from the lower-priced to the higher-priced units. This would be the first possible relationship between lower and higher-priced units. It will be later referred to as the Hypothesis I.

Firms, however, might differ from households, facing less severe financial constraints, and hence the collateral-based mechanism would be significantly weakened (see Leung and Feng, 2005, for more discussion of this point). Moreover, the "consumption motive" may not exist in offices. Thus, the price of lower-priced units might not Granger cause their higher-priced counterparts. In fact, firms might want to "move down the ladder" by selling a higher-priced unit and move to a lower-priced one (which need not necessarily be a smaller one) and keep some of the cash for other purposes. In that case, we would expect the causality in price and trading volume to be from a higher-price unit to a lower-priced unit. This is the second possible relationship between the lower- and higher-priced units. It will later be referred to as Hypothesis II.

Needless to say, if the capital market is perfect and lower-priced and higher-priced units are perfect substitutes, we could expect the prices of small and large units to move together. This is the third possible relationship between the lower- and higher-priced units. It will later be referred to as Hypothesis III.

There is a fourth possibility. If the information is incomplete, less-traded properties might be difficult to price, and there might be an inclination for information on more-traded units to be used to adjust their price expectations.[5] The price causality should therefore go from office buildings that are being traded more frequently to those that are being traded less often. In this case, we should categorize office buildings according to their trading volume (or a proxy of the liquidity) rather than their price. And we should observe the causality from groups with higher trading volumes to those with lower trading volumes. This will later be referred to as Hypothesis IV.

In sum, price and trading volume dynamics in the office market can be very different from those in the residential market. More importantly, they can provide an indirect test of alternative theories of property market dynamics (see Kan et al, 2004, for a dynamic general equilibrium model that exhibits a similar pattern). Table 1a summarizes our discussion.

Table 1a Summary of Hypotheses

I	Lower-priced units causes higher-priced units
II	Higher-priced units causes lower-priced units
III	Higher-priced units and lower-priced units co-move
IV	Higher volume units causes lower volume units

The “spatial-temporal approach” found in residential property literature such as Tu et al (2004) and the references therein were taken into account when this paper’s research strategy was determined. We decided that in a city such as Hong Kong, where commercial properties are clustered in a relatively small geographical area, the spatial dimension was less relevant. We simply took office buildings as a convenient starting point.

[5] We have had private correspondence with several market practicing professionals, and they all support this theory.

Office buildings in Hong Kong are concentrated in a few prime locations – especially at the higher end. According to research by the Jones, Long and LaSalle, Tsang (2005), 29% of Grade A office space in Hong Kong is located in the city's Central Business District. The Wanchai/Causeway Bay corridor, which is just north of Central, holds another 21%. The island's Eastern District, which is right next to the Wanchai/Causeway Bay corridor, holds another 12%. Across the harbor is Kowloon's Tsimshatsui district, which accounts for another 14%.

Together, these four districts account for more than three-fourths of Hong Kong's Grade A office space. What is more, these districts are clustered geographically very close to one another. Therefore, a classification of office buildings based on geography would not yield very good results (see Leung et al, 2006). Furthermore, if prices are largely determined by geographical location, as in the case of the Ricardo model, and if price causality runs from better-located properties to those with less favorable locations, we would still observe price causality from higher- to lower-priced offices according to our classification (see Ricardo, 1817; 1965). Thus, our proposal to study the price and volume causality would still be a meaningful test of competing theories.

The Hong Kong government never formally announces which office buildings belong to grades A, B, and C and whether they adjust these classification over time. Because we are unable to use the government's classification of office buildings, we have decided to classify office buildings based on our own objective and quantitative criteria, differentiating office buildings into 10 classes instead of the three used by the Hong Kong government. More detailed explanations will be provided henceforth.

The Hong Kong market was chosen for several reasons. To start with, it is well known for having a simple tax system. Secondly, it has a fixed exchange rate in relation to the US dollar. Next, it treats foreign investors equally. There are no capital controls and no capital gains tax. The property market is relatively active (see Leung et al, 2007, for more evidence). Finally, the capital market is relatively well-developed.

The organization of this paper is as follows. The next section describes the dataset and the econometric tools. The following section presents the empirical findings and the interpretations. The final section is the conclusion.

2. Data Description and Econometric Method

2.1 Data Source

The dataset we employed was collected by the Economic Property Research Center (EPRC), which in turn collected all of the transactions recorded by the Land Registry Department of the Hong Kong Government. It contained information about building names, addresses, completion dates, transaction dates, and transaction prices as well as the corresponding gross feet, net feet, gross foot price, and net foot price. The sample period for the analysis ran from January 1992 to December 2004. Our research focused on the sales market of the Hong Kong office market, with more information and higher accuracy than the rental counterpart.

The research includes all buildings with more than four transactions from January 1992 to December 2004 and includes complete information on transaction dates and transaction prices as well as corresponding gross square footage and net square footage to construct the quarterly data employed in this study. For our entire sample, we have a total of 601 estates and have made more than 24,000 observations.

In order to examine the robustness of a full sample, a restricted sample was selected. These were composed of estates having had at least 52 transactions during the sampling period, i.e., on average, each selected estate had at least one transaction during the three-month period. We had a total of 120 estates in the restricted sample. Ding (2006) found that the results from the full sample and the restricted sample were essentially the same. For this reason, this paper will focus on the full sample. Tables 1 and 2 will provide more information about the dataset.

Table 1b Number of Estates in Each Sampling Group

Sample Group	No. of Estates
Full Sample (total no. of transactions >4)	601
Restricted Sample (total no. of transactions >=52)	120

Table 2a Summary Statistics of Volume, office buildings sorted by ROR (Full Sample)

Group	Min	Max	Mean	Std. Dev.
Group 1	19	300	71.55769	58.36747
Group 2	4	267	42.63462	49.07299
Group 3	9	190	46	36.26482
Group 4	11	358	61.21154	62.61126
Group 5	14	345	64.96154	71.32911
Group 6	15	180	44.71154	34.15095
Group 7	12	115	49.80769	26.71787
Group 8	10	88	32.30769	18.99901
Group 9	13	81	29.53846	14.08443
Group 10	6	35	18.15385	7.437016

Table 2b Summary Statistics of Volume, office buildings sorted by Volume (Full Sample)

Group	Min	Max	Mean	Std. Dev.
Group 1	63	799	219.6538	175.6225
Group 2	22	283	75.98077	55.99842
Group 3	12	161	46.38462	32.79057
Group 4	3	139	32.61538	24.93612
Group 5	7	73	25.13462	15.07631
Group 6	5	75	19.48077	12.4782
Group 7	2	49	14.96154	8.659035
Group 8	2	36	11.67308	7.00342
Group 9	1	33	8.576923	5.248141
Group 10	0	17	6.423077	3.862064

2.2 Measurement of Trading Volume and Office Prices

In this study, as in many related studies, trading volumes were measured according to the number of times an estate had been transacted in a given quarter (See Leung et al, 2002, and Leung and Feng, 2005, among others, and the references therein). When it came to calculating the price of an office, we employed the realized rate of return as the de-trended office price and used the relative transaction value as a weight to create an index. The transacted value was calculated as the product of price per square foot and the construction area. Since some estates only had gross areas, some only had net areas, and some had both, we chose the net area as a priority The idea was that a higher value transaction (relative to other transactions in the same estate and period) would contain more information about the market. Formally, the index is constructed as follows:

$$W_i = P_{ij} Q_{ij} \Big/ \sum P_{ij} Q_{ij}$$
$$\sum W_i P_i = \tilde{P}$$

where i is the index of the estate, j is the number of transactions of the i estate per quarter, P is the nominal price per square foot, Q is the constructed area, and $\tilde{P}$ is the weighted average price per quarter. To facilitate cross-period comparisons, the weighted average price per quarter is deflated by the quarterly composite consumer price index (CPI) (1992=1). The real rate of return (*ROR*) is the change of percentage of the real price. That is,

$$P*_i = \tilde{P}_i \big/ CPI$$

$$ROR_t = \left(P*_t - P*_{t-1}\right)/P*_{t-1}$$

where P^* is the real office price per quarter of a specified estate and ROR_t the realized rate of return, which can also be interpreted as the real de-trended office price or simple *real office price*. From this point on, we will use the term “real office price” and “ROR” interchangeably. This study focused on the effective sampling period, which starts with the first actual transaction period for each estate. After the effective sampling period begins, if another other zero transaction period follows, in order to avoid uninformative zero ROR , for that zero transacted period, $ROR_t = ROR_{t-1}$.

3. Econometric Method

As we discussed in the introduction, we will split the sample into 10 equal-sized groups twice: first by descending order of the total trading volume (as a proxy of liquidity) and secondly by descending weighted average office price (as a proxy of quality). The last group will always have 61 buildings, with the others having 60.

Clearly, the use of alternative sorting methods highlights different dimensions of the market and so can also help to improve the robustness of the results. Notice that although the number 10 is somewhat arbitrary, the results do not seem to be very sensitive to this. And it is already much better than the government’s classification, which has only three categories. Perhaps more importantly, the four hypotheses outlined *do not depend on the number of classes* in the data and should therefore hold true in general. Without any *a priori* knowledge, this choice seems to be acceptable. As we have split the sample into 10 categories, there should have been enough trading for each type within each period.

A simple correlation test and Granger causality tests of group volumes and prices were conducted. Similar methods were applied to the restricted sample (see Ding, 2006) for more details. Tables 3a and 3b provide some basic statistics of the 10 categories under different classifications. We also computed the correlation of prices between groups falling into different classifications. Table 4 shows that the correlation is far from being uniform. This confirms that the two classification methods do, in fact, rank office buildings differently. In particular, the correlation of prices between group i (ranked by price) and group i (ranked by volume), i = 1, 2, 3 are, in general, very low. *In other words, office buildings with higher prices are not necessarily being traded more often.* The price and the trading volume of the building level are not as correlated as in the aggregate. On the other hand, the correlation of volumes is positively significant, reflecting some kind of consistency. We will have more to say on this issue later.

Table 3a Summary Statistics of ROR, office buildings sorted by ROR (Full Sample)

Group	Min	Max	Mean	Std. Dev.
Group 1	-0.5876	1.95204	0.034406	0.329773
Group 2	-0.4059	0.764871	0.013924	0.190167
Group 3	-0.36961	0.83092	0.008961	0.215808
Group 4	-0.45428	0.403183	-0.00028	0.135383
Group 5	-0.2832	0.387924	-0.00169	0.138188
Group 6	-0.66969	1.30954	0.016486	0.251244
Group 7	-0.57738	1.475486	0.011802	0.255855
Group 8	-0.47721	1.192872	0.013125	0.23779
Group 9	-0.51321	0.566973	0.011208	0.204498
Group 10	-0.52022	0.960298	0.018369	0.269945

Table 3b Summary Statistics of ROR, office buildings sorted by Volume (Full Sample)

Group	Min	Max	Mean	Std. Dev.
Group 1	-0.60818	1.982352	0.034265	0.332764
Group 2	-0.68537	2.022708	0.050003	0.387081
Group 3	-0.62344	0.787426	0.057204	0.33792
Group 4	-0.61867	1.660154	0.058072	0.417386
Group 5	-0.38094	0.83926	0.024309	0.273031
Group 6	-0.60545	2.885353	0.07618	0.552682
Group 7	-0.47299	1.047905	0.046027	0.34612
Group 8	-0.57793	1.338889	0.066384	0.370358
Group 9	-0.5541	1.405929	0.067872	0.40459
Group	-0.71249	5.173311	0.165256	0.828395

One may object to this way of classifying office buildings because it does not explicitly take the location factor into account. As we have already explained, while location may be important in other places, it is not necessarily important in Hong Kong. First, Hong Kong is geographically small. Leung et al Wong (2006) found that the geographical factor might not be important in determining the “substitutability” of office buildings in different districts. Second, the location of office buildings is endogenous. In particular, as Tsang (2005) has shown, most of the quality office buildings are concentrated in Central and Tsimshatsui, making separate identification of different factors difficult to determine. Third, the way the Hong Kong government classifies offices buildings is neither transparent nor refined. They are simply divided into three broad categories. Nevertheless, to address the potential concerns that we anticipate, we will also conduct a district-level analysis, which will yield a similar pattern. Owing to space limitations, we will present this analysis in Appendix III. In the main text; we will focus on the classifications of office buildings based on price and trading volume.

Table 4 Correlation of Volume and Price, office buildings sorted by Volume and Price Separately (Full Sample)

Group	Correlation of Volume(Volume sorted, ROR sorted)	Correlation of Price(Volume sorted, ROR sorted)
Group1	0.7648*	0.8908*
Group 2	0.7391*	-0.1169
Group 3	0.7943*	0.053
Group 4	0.7495*	0.4325*
Group 5	0.7178*	0.2297
Group 6	0.6054*	0.0983
Group 7	0.6499*	-0.3586*
Group 8	0.6791*	0.1611
Group 9	0.4668*	0.1884
Group 10	0.5452*	0.1326

Note: * denotes that the correlation is significant at the 1% confidence level.

4. Empirical Results

The empirical results will be presented in the following order. First, the matrix of correlation coefficients of the volume and ROR of groups will be illustrated for both full and restricted samples. Second, we will calculate the correlation coefficients of volume and ROR ranked by volume and real price separately within each group. Third, in order to examine the lead-lag relationship of volume and real price separately, we will check the Granger causality for volume and the ROR for each group for both full and restricted samples.

4.1 Correlation of Volume and ROR

Table 5a displays the matrix of correlation coefficients of volume when the buildings are ranked by real office price for the full sample. It is clear that every group is highly correlated with the other groups. And a similar pattern emerges when the buildings are ranked by trading volume (see Table 6b). It seems safe to conclude that the trading volumes among different groups are highly correlated. One might be tempted to interpret this in terms of substitution among different office buildings. However, the correlation coefficients among groups do not display any monotonic patterns, suggesting that the "substitution effect" may not be the driving force in this sample.

Table 5a Correlation of Volume, office buildings sorted by ROR (Full Sample)

Group	gp1	gp2	gp3	gp4	gp5	gp6	gp7	gp8	gp9	gp10
gp1	1									
gp2	0.7110*	1								
gp3	0.8061*	0.8847*	1							
gp4	0.5675*	0.5978*	0.6390*	1						
gp5	0.5821*	0.7876*	0.7210*	0.7164*	1					
gp6	0.4629*	0.5204*	0.6013*	0.6827*	0.6211*	1				
gp7	0.5945*	0.7249*	0.7618*	0.6897*	0.7362*	0.6608*	1			
gp8	0.6219*	0.5415*	0.6686*	0.7879*	0.6171*	0.6966*	0.6673*	1		
gp9	0.5396*	0.4764*	0.5212*	0.8032*	0.5830*	0.6932*	0.6508*	0.8099*	1	
gp10	0.5426*	0.4188*	0.5163*	0.6088*	0.4743*	0.6074*	0.6061*	0.7106*	0.6684*	1

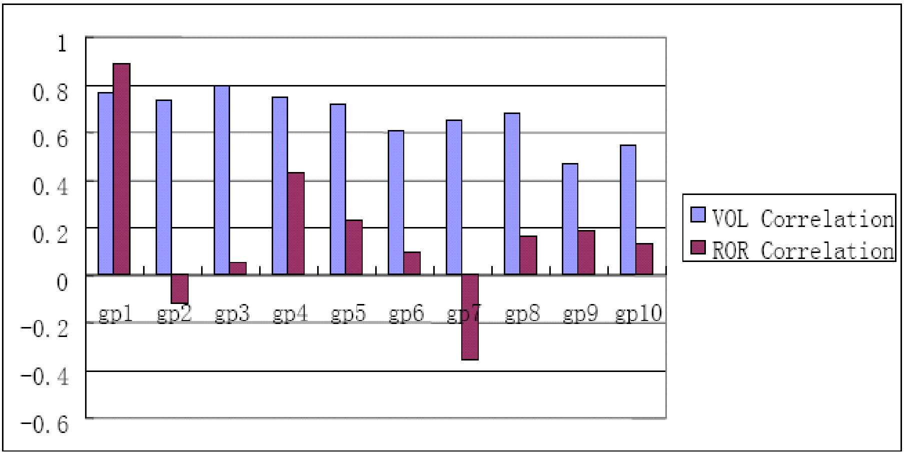
Note: * denote that it is significant at the 1% confidence level.

Table 5b Correlation of Volume, office buildings sorted by Volume (Full Sample)

Group	gp1	gp2	gp3	gp4	gp5	gp6	gp7	gp8	gp9	gp10
gp1	1									
gp2	0.8155*	1								
gp3	0.8820*	0.8732*	1							
gp4	0.8535*	0.8062*	0.9278*	1						
gp5	0.7232*	0.7961*	0.7297*	0.6908*	1					
gp6	0.8229*	0.7950*	0.8175*	0.8285*	0.6684*	1				
gp7	0.7266*	0.7679*	0.8256*	0.8611*	0.5779*	0.7515*	1			
gp8	0.6454*	0.7292*	0.7424*	0.7507*	0.6584*	0.7497*	0.6694*	1		
gp9	0.7389*	0.6415*	0.7588*	0.8069*	0.4768*	0.8179*	0.7081*	0.6427*	1	
gp10	0.6312*	0.6320*	0.5773*	0.5763*	0.5523*	0.5836*	0.5241*	0.5431*	0.5440*	1

Note: * denote that it is significant at the 1% confidence level.

Figure 1 VOL Correlation versus ROR Correlation for Each Group (Full Sample)



The results of the de-trended office price, or ROR, pose a further challenge to the hypotheses outlined above. Table 6a displays the matrix of correlation coefficients of ROR when the buildings are ranked by real office price for the full sample. We find that only five pairs of significant correlations are examined, which is in sharp contrast to Table 5a. The same conclusion holds when the buildings are ranked by trading volume, as in Table 6b. It is shown that when the buildings are sorted by district, the correlation of the ROR is even more absurd, with only three significantly high correlations.

4.2 Granger Causality Tests

Interaction among office buildings need not be contemporary. To entertain the possibility of dynamic interactions, especially to test the different hypotheses concerning the lead-lag relationships among “higher groups” and “lower groups,” we conducted the Granger causality tests of volume and ROR ranked by real office prices, volumes, and district prices separately. Table 7a displays the results of the Granger tests of volume when the buildings are ranked by real price in descending order. We can see that group one only significantly Granger causes the volume trends of groups two, four, and six. Groups two, four, five, eight, and nine Granger cause several other groups. However, the ordering is not uniform, and the pattern is not clear.

Table 6a Correlation of ROR, office buildings sorted by ROR(Full Sample)

Group	gp1	gp2	gp3	gp4	gp5	gp6	gp7	gp8	gp9	gp10
gp1	1									
gp2	0.1352	1								
gp3	-0.1411	0.0363	1							
gp4	0.4999*	0.3627*	0.1262	1						
gp5	0.1547	0.4933*	0.1998	0.3385	1					
gp6	0.2126	0.0898	0.1223	0.325	0.296	1				
gp7	-0.0147	-0.0544	0.0182	-0.0573	-0.0613	-0.1236	1			
gp8	0.111	0.3205	0.1655	0.4657*	0.2092	0.003	-0.1181	1		
gp9	-0.1969	0.2154	0.4717*	0.2927	0.1884	0.0949	-0.0458	0.2324	1	
gp10	0.0566	0.1919	-0.1949	0.265	-0.033	0.1217	-0.1418	0.2098	0.1322	1

Note: * denote that it is significant at the 1% confidence level.

Table 6b Correlation of ROR, office buildings sorted by Volume (Full Sample)

Group	gp1	gp2	gp3	gp4	gp5	gp6	gp7	gp8	gp9	gp10
gp1	1									
gp2	0.1441	1								
gp3	0.1529	0.2902	1							
gp4	0.2262	0.1599	0.096	1						
gp5	-0.2049	-0.1351	-0.2638	0.078	1					
gp6	0.0511	-0.0062	0.0169	0.102	0.1749	1				
gp7	-0.2024	-0.1393	-0.0162	0.2573	0.2435	0.1149	1			
gp8	0.2185	-0.184	0.0516	0.1172	0.1125	-0.0198	0.5345*	1		
gp9	0.0728	-0.0206	0.3538	-0.0048	0.1144	-0.1314	0.1873	0.4109*	1	
gp10	0.0032	-0.0451	0.1139	0.0743	0.0805	0.0913	0.4189*	0.4341*	0.3669*	1

Note: * denote that it is significant at the 1% confidence level.

On the contrary, when the groups are volume-ranked, Table 7b shows that group one Granger causes all other groups. Group two exhibits a similar pattern except for group six. In general, higher-ranked groups tend to Granger cause the lower-ranked groups in trading volume. Thus, the results in the office market are in sharp contrast to the residential market. It is consistent with the explanation that when collateral constraints and up-trading incentives are less important, the causality from the lower-priced units to the higher-priced units disappears. On the other hand, it is puzzling that the causality is from higher-ranked to lower ranked units in trading volume when the office buildings are volume-ranked, but not when they are price-ranked. *These patterns are not completely consistent with the hypotheses outlined before* (see Table 1a). Clearly, more refinement in the theoretical aspects is needed.

Table 7a Granger Causality of Volume, office buildings sorted by ROR (Full Sample)

Group	gp1	Gp2	gp3	gp4	gp5	gp6	gp7	gp8	gp9	gp1
gp1		Y	N	Y	N	Y	N	N	N	N
gp2	Y		Y	Y	Y	N	N	N	Y	Y
gp3	Y	N		N	Y	N	N	N	Y	N
gp4	Y	N	Y		Y	N	N	N	Y	N
gp5	Y	Y	Y	Y		N	Y	N	Y	Y
gp6	N	N	N	N	N		N	N	N	N
gp7	N	N	N	Y	N	N		N	Y	N
gp8	N	Y	Y	N	Y	Y	Y		Y	N
gp9	N	N	Y	Y	Y	Y	Y	Y		Y
gp10	N	N	N	N	N	Y	Y	Y	Y	

Table 7b Granger Causality of Volume, office buildings sorted by Volume (Full Sample)

Group	gp1	gp2	gp3	gp4	gp5	gp6	gp7	gp8	gp9	gp10
gp1		Y	Y	Y	Y	Y	Y	Y	Y	Y
gp2	Y		Y	Y	Y	N	Y	Y	Y	Y
gp3	N	N		Y	Y	Y	Y	Y	N	Y
gp4	N	Y	Y		N	Y	Y	Y	N	N
gp5	Y	Y	Y	Y		Y	Y	Y	Y	Y
gp6	Y	N	N	N	N		Y	N	N	N
gp7	N	Y	N	N	N	Y		N	N	N
gp8	N	N	N	N	N	N	N		N	N
gp9	Y	N	N	N	N	Y	N	N		N
gp10	N	N	N	N	Y	N	Y	N	N	

Table 9 summarizes the Granger causality tests of volume for both full and restricted samples. The results are similar. Almost half of the Granger causality results of volume exhibit a significant lead-lag relationship among groups by the three grouping methods.

By the same token, we conducted the Granger causality tests on pricing among different groups. The results were *very* different. For our full sample, no matter how the office buildings were categorized, almost none of the groups showed a significant causality effect on the other groups. The only exception was group three (price ranked) Granger caused four other groups. In particular, while in general the higher-ranked office buildings Granger caused the lower-ranked in trading volume, they failed to carry the same causality in terms of office prices. *None* of the hypotheses discussed above could account for this phenomenon (again, see Table 1a).

Table 8 Summary of Granger Causality in Volume

	Full Sample		Restricted Sample	
sorted by Price	42	(Total) 90	14	(Total) 30
	46.67%	100%	46.67%	100%
sorted by Volume	45	(Total) 90	14	(Total) 30
	50%	100%	46.67%	100%
sorted by District	24	(Total) 42	16	(Total) 30
	57.14%	100%	53.33%	100%

Table 9a Granger Causality of ROR, office buildings sorted by ROR (Full Sample)

Group	gp1	gp2	gp3	gp4	gp5	gp6	gp7	gp8	gp9	gp10
gp1		N	N	N	N	N	Y	N	N	N
gp2	Y		N	Y	N	N	Y	N	N	N
gp3	N	N		Y	N	N	Y	Y	Y	N
gp4	N	N	N		N	N	N	Y	N	Y
gp5	Y	N	N	N		N	N	N	N	N
gp6	N	N	N	N	N		N	N	N	N
gp7	N	Y	N	N	N	Y		N	N	N
gp8	N	N	N	Y	N	N	Y		Y	Y
gp9	N	Y	N	N	N	Y	N	N		N
gp10	N	N	Y	N	N	N	N	N	Y	

Table 9b Granger Causality of ROR, office buildings sorted by Volume (Full Sample)

Group	gp1	gp2	gp3	gp4	gp5	gp6	gp7	gp8	gp9	gp10
Gp1		N	N	N	Y	N	N	N	N	Y
Gp2	N		N	N	N	N	Y	N	N	N
Gp3	N	Y		Y	N	N	N	N	N	Y
Gp4	N	N	N		N	N	N	N	N	N
Gp5	Y	N	N	N		N	N	N	N	N
gp6	Y	N	N	N	Y		Y	N	N	N
gp7	Y	Y	N	N	N	N		Y	N	Y
gp8	N	Y	N	N	N	N	Y		N	N
gp9	N	N	N	N	N	N	N	N		N
gp10	N	N	Y	N	N	N	N	N	Y	

In Table 10, which summarizes all of the results, we can see that no more than 30% of the tests are significant, which is in sharp contrast to what happens with volume. Perhaps more importantly, no group seems to be the "benchmark" of the others. Again, these results suggest that a serious refinement of the office market theory is needed.

Table 10 Summary of Granger Causality in ROR

	Full Sample		Restricted Sample	
sorted by Price	21	(Total) 90	7	(Total) 30
	23.33%	100%	23.33%	100%
sorted by Volume	18	(Total) 90	4	(Total) 30
	20%	100%	13.33%	100%
sorted by District	5	(Total) 42	8	(Total) 30
	11.90%	100%	26.67%	100%

5. Estimation of Markov Chain Model Estimation

One possible explanation of the "negative results" identified in the previous sections is that office buildings frequently move up and down across groups, making all of the correlation and Granger tests difficult to interpret. To entertain this concern, we also estimated a Markov chain model on our restricted sample to study the persistence of the return performance of estates. Since the first year of the whole period contains limited information, we started with the year 1993. The office buildings were categorized as follows: first we ranked the buildings in each and every quarter according to their corresponding real price in descending order. There were 84 office buildings with transactions throughout the12-year sampling period, and they were put into six groups. A Markov chain was then estimated.

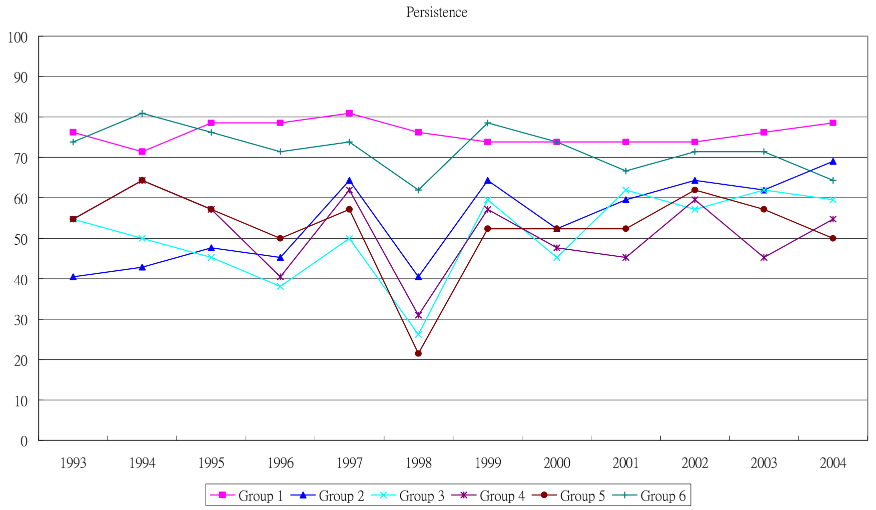
Given the limits of space, we could only focus on the principal diagonal elements (see Table 11a). They indicated the probability of an office building staying in the original group for another period, which in some sense indicated the “stability” of the relative price/return performance of different office buildings (see Young and Graff (1996, 1997). For example, in 1993, there was a 76.19% chance of an office building that was ranked in the first group in the time period *t* remaining in the same group the following year. Clearly, the principal diagonal elements of each group were usually larger than the non-diagonal elements of the corresponding row so the return performance of each group could be considered persistent. Moreover, the buildings in the polar groups (i.e. groups 1 and 6) had a very high probability of remaining in their original group, showing that mobility at the two ends of the office building distribution were relatively low, which is consistent with some previous research (for instance, see Lee & Ward, 2000).

Table 11a Within-Group ROR Persistence of Office Buildings from 1993 to 2004

Year	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
1993	76.19	40.48	54.76	54.76	54.76	73.81
1994	71.43	42.86	50	64.29	64.29	80.95
1995	78.57	47.62	45.24	57.14	57.14	76.19
1996	78.57	45.24	38.1	40.48	50	71.43
1997	80.95	64.29	50	61.9	57.14	73.81
1998	76.19	40.48	26.19	30.95	21.43	61.9
1999	73.81	64.29	59.52	57.14	52.38	78.57
2000	73.81	52.38	45.24	47.62	52.38	73.81
2001	73.81	59.52	61.9	45.24	52.38	66.67
2002	73.81	64.29	57.14	59.52	61.9	71.43
2003	76.19	61.9	61.9	45.24	57.14	71.43
2004	78.57	69.05	59.52	54.76	50	64.29
Whole Sample	76.29	54.71	51.06	52.28	53.5	72.04

On the other hand, Figure 2 shows that the persistence of the in-between groups significantly (and only temporarily) dropped in 1998 (i.e., during the Asian financial crisis). It seems to suggest that a crisis does have an impact on the intra-metropolitan price dynamics of an office market. It seems to be a research topic to be further explored

Figure 2 Within-Group Price Persistence of Office Buildings from 1993 to 2004



For comparison, we performed the same analysis on the real housing price of residential estates in Hong Kong. In Hong Kong, the term "estate" refers to a group of buildings – usually quite tall – that are built in the same neighborhood, at about the same time, usually by the samee developer. There is no exact parallel in the United States. The closest thing might be a housing development. In Hong Kong, the population of some large estates is huge, which means that some of them constitute distinct communities. For details of the data used, see Leung and Cheung (2006).

Table 11b represents the elements of the principal diagonal from 1992 to 2004, which indicates the probability of a residential estate remaining in the original group for the following month (Ding, 2006, provides all transition matrices in each year). As in the case of office buildings, the principal diagonal elements of each group were always larger than the non-diagonal elements of the corresponding row, indicating a high degree of persistence. In addition, the estates in the polar groups also had a very high probability of remaining in their original group (although there were some exceptional situations in the early part of the sampling period). This demonstrates that the relatively low mobility at the two ends of the distribution of residential estates was applicable for both kinds of real estate asset.

On the other hand, both Table 11b and Figure 3 suggest a drop in the persistence of the relative ranking of prices after the Asian Financial Crisis in 1998, especially the polar groups (one and six), which seems to be in sharp contrast with what happened with office buildings.[6] Unlike office buildings, the drop in those two groups did not show any "rebound". The dramatic V-shaped drop of the persistence for most groups of office buildings in the year 1998 was not found in the residential property market. Instead, the year 1998 was just at the midway point of decreasing within group price persistence.

In general, the six time frames for the analysis of office buildings seemed to fluctuate around some group-specific constant. However, the six time frames for the residential market exhibited a break, or level drop, in the persistence level in 1998. It seems to be another piece of evidence that even when we stuck to the sales market, the office and residential property markets did, in fact, behave very differently.

5.1 Robustness Checks

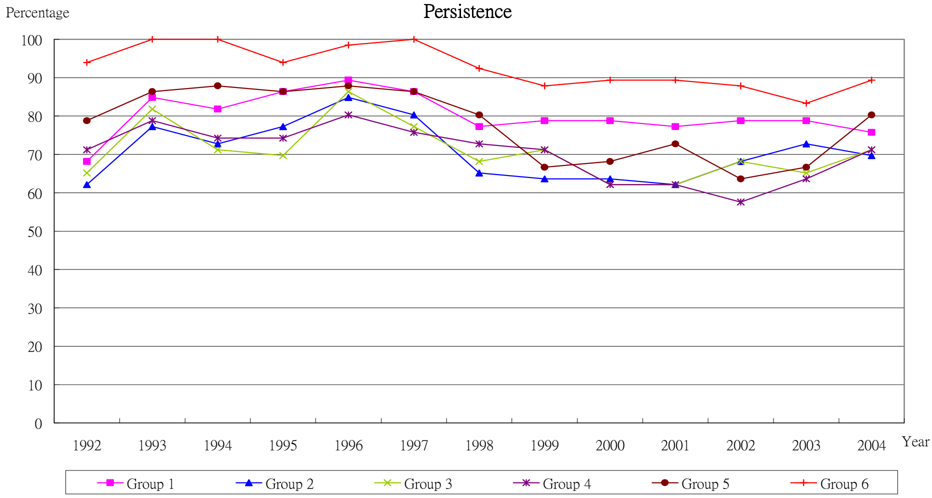
As an earlier draft of this paper was being circulated, serious doubts were forwarded to the authors. To address some of these doubts, we have performed some robustness tests. Owing to space limitations, we will briefly explain them in this section.

Table 11b Within-Group ROR Persistence of Residential Estates from 1992 to 2004

Year	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
1992	68.18	62.12	65.15	71.21	78.79	93.94
1993	84.85	77.27	81.82	78.79	86.36	100
1994	81.82	72.73	71.21	74.24	87.88	100
1995	86.36	77.27	69.7	74.24	86.36	93.94
1996	89.39	84.85	86.36	80.3	87.88	98.48
1997	86.36	80.3	77.27	75.76	86.36	100
1998	77.27	65.15	68.18	72.73	80.3	92.42
1999	78.79	63.64	71.21	71.21	66.67	87.88
2000	78.79	63.64	62.12	62.12	68.18	89.39
2001	77.27	62.12	62.12	62.12	72.73	89.39
2002	78.79	68.18	68.18	57.58	63.64	87.88
2003	78.79	72.73	65.15	63.64	66.67	83.33
2004	75.76	69.7	71.21	71.21	80.3	89.39
Whole Sample	80.11	70.75	70.75	70.43	78.17	92.9

[6] Limited by the sample size (13), we are unable to conduct a meaningful structural break test formally.

Figure 3 Within-Group Price Persistence of Residential Estates from 1992 to 2004



One of the serious objections was that the draft ignored the possibility of a structural change in 1997, the year when Hong Kong was handed over to China and when the Asian financial crisis began. We therefore split the samples into two sub-samples: 1992 Q1 through 1997 Q4 and 1998 Q1 through 2004 Q4. A clear consequence of sample-splitting was the reduction of the sample size, which might have had an impact on the significance of the test statistics, especially for Granger causality. The correlations and causality were in general weak, but the basic pattern was sustained. There was no clear pattern in terms of the price across different groups, while the causality in volume was in general from the "higher groups" (higher-priced or more frequently traded) to the "lower" ones.

Another objection that caught our attention was the potential bias owing to the existence of seasonal factors. Theoretically, it is *not* clear why seasonal factor would lead to more significant causality in volume than in price. Nevertheless, to address this concern, we ran a simple regression with a constant term, an autoregressive term, and three seasonal dummies. None of the volume-regressions displayed any significance for seasonality. For price-regression, seasonal dummies were significant in only two groups when the buildings were sorted by volume. It seems safe to conclude that the seasonal factors were not important in our samples.

6. Conclusions

Although the exercises conducted in this paper are technically simple, they contain important messages. One important finding of this research is that the trading volume of commercial property displays a clear lead-lag relationship. There is also a significant correlation – in general, from higher volume groups to lower ones) – while the majority of office estates shows neither a significant correlation nor a lead-lag relationship in price. Almost half of the Granger causality results of volume exhibit a lead-lag relationship among groups. The results are almost the same for both full and restricted samples. These findings are in sharp contrast to the case of residential properties, where the price and volume of lower-priced properties typically drive their counterparts in the higher-priced sector (for examples, see Ortalo-Magne and S. Rady, 1999, 2005, and the references therein).

The results further indicate that the widely cited "benchmarking hypothesis," which is a form of "informational friction," may not be strong enough to be statistically significant. It then leads to the question of what determines the price and trading volume dynamics among different classes of office building. Existing search-theoretic models are silent on the issue of dynamics between higher and lower priced office markets. In other words, existing hypotheses of office market dynamics are either silent on or inconsistent with the stylized facts established in this paper. Clearly, more effort on theoretical and empirical works is needed to solve this empirical puzzle.

This paper carries implications for the construction of a city-level index. Regardless of the sorting method used, real office prices are not always significantly correlated. It leads to the concern that an "aggregate" city-level price index may not be a very informative device although it is a widely used practice. On the other hand, the trading volumes among different classes are highly correlated. Thus, it may indeed be appropriate to construct a city-level trading volume index.

This observation leads to one possible direction for future research. Macroeconomists have long been aware that the regional dynamics (in terms of output and other macroeconomic variables) may be significantly different from the aggregate counterpart (for an example, see Quah, 1996a). They go further and derive methods to test whether there is any trend of convergence among different "regions" to the "aggregate" (for an example, see Quah 1996b, c). Alternatively, they derive methods to characterize the "distributional dynamics" and how they are related to the "aggregate dynamics" (for an example, see Quah, 1997). If the office prices of different classes do not move together, now is perhaps the time for real estate economists to examine the "convergence" issue and the "distributional dynamics" issue in the context of the office market.

Needless to say, the econometric methods used here are relatively simple. It is possible that to revisit these conclusions with more non-linear models. Our current sample, however, has only 52 periods, or quarters, and may not be an ideal sample for those techniques. A dataset with a longer time horizon and more transactions is needed.

A comparison of the Markov chain model estimates of the office and housing markets reveals further differences between the two types of property. In particular, the persistence in relative price ranking in the office market seems to be more robust than in the residential market, especially when the market was impacted by the Asian financial crisis. It may be somehow counter-intuitive because we expect that the “neighborhood” (including the geographical location, the school district, the crime rate, etc.) is relatively stable and should be more important to residential property prices than to office property prices. The “polar groups” (the highest and lowest priced properties) in the office market seem to be more stable than the other groups in the office market. It seems to be the opposite for the residential market. Clearly, much more empirical as well as theoretical work is needed to understand the difference between the two markets.

Acknowledgements

The authors are very grateful to Paul Anglin, Yuming Fu, Francois Ortalo-Magne, S. E. Ong, Ko Wang, and the seminar participants of Chinese University of Hong Kong, Tsinghua University MBA class, NUS-HKU Symposium on Real Estate Research, for comments and discussion, Nelson Lee for capable research assistance, and City University of Hong Kong (Project No. 7200076) for financial support. The usual disclaimer applies.

References

Ambrose, B. and Sanders, A. (2003). Commercial mortgage-backed securities: Prepayment and default, *Journal of Real Estate Finance and Economics*, **26** (2-3), 179-196.

Bryson, J. (1997). Obsolescence and the process of creative reconstruction, *Urban Studies*, **34** (9), 1439-1458.

Chau, K. , Wong, S., Yiu; C., and Leung H. (2004). Real estate price indices in Hong Kong, *Journal of Real Estate Literature*, forthcoming.

Ding, J. (2006). Estimating the intra-metropolitan price and volume dynamics of commercial property: Empirical study of Hong Kong, Unpublished Master Thesis, Chinese University of Hong Kong.

Du, J.; Leung, K., and Chu, D. (2006). Corporate real estate and corporate governance, Chinese University of Hong Kong, mimeo.

Englund, P., Gunnelin, A., Hoesli, M., and Soderberg, B. (2004). Implicit forward rents as predictors of future rents, *Real Estate Economics*, **32** (2). 183-215.

Englund, P., Gunnelin, A.; Hoesli, M., and Soderberg B (2005). Adjustment in property space markets: Estimates from the Stockholm office market, *NBER Working Paper No. 11345*

Englund, P., Quigley, J., and Redfearn, C. (1998). Improved price indexes for real estate: Measuring the course of Swedish housing prices, *Journal of Urban Economics*, **44**, 171-196.

Eppli, M., Shilling, J., and Vandell, K. (1998). What moves retail property returns at the metropolitan level?, *Journal of Real Estate Finance and Economics*, 16 (3), 317-342.

Fu, Q., LaCour-Little, M., and Vandell, K. (2003). Commercial mortgage prepayments under heterogeneous prepayment penalty structures, *Journal of Real Estate Research*, **25** (3), 245-275.

Gabriel, S. and Nothaft, F. (1988). Rental housing market and natural vacancy rate, *AREUEA Journal*, **16** (4), 419-429.

Geltner, D. (1991). Smoothing in appraisal-based returns, *Journal of Real Estate Finance and Economics*, **4** (3), 327-345.

Hanushek, E., Rivkin, S., and Taylor, L. (1996). Aggregation and the estimated effects of school resources, *Review of Economics and Statistics*, **78**, 611-627.

Hendershott, P., Lizieri, C., and Matysiak G. (1999). The Working of the London Office Market, *Real Estate Economics*, 27 (2), 365-387.

Hwang, M. and Quigley. J. (2004). Selectivity, quality adjustment and mean reversion in the measurement of house values, *Journal of Real Estate Finance and Economics*, **28** (2/3), 191-214.

Kan, K.; Kwong, S., and Leung, C. (2004). The dynamics and volatility of commercial and residential property prices: theory and evidence, *Journal of Regional Science*, **44** (1), 95-123.

Kwong, S. and Leung, C. (2000). Price Volatility of commercial and residential property, *Journal of Real Estate Finance and Economics*, **20** (1), 25-36.

Lai, T. and Wang, K. (1998). Appraisal smoothing: The other side of the story, *Real Estate Economics*, **26** (3), 511-535.

Lee, S. and Ward, C. (2001). Persistence of UK real estate returns: A Markov chain analysis, *Journal of Asset Management*, **1** (3), 279-291.

Leung, C. and Cheung, P. (2006). Estimating and explaining extreme co-movements in Hong Kong residential property market, *City University of Hong Kong*, mimeo.

Leung, C. and Feng, D. (2005). What drives the price-volume correlation? Evidence from a commercial real estate market, *Journal of Real Estate Finance and Economics*, **31** (2), 241-255.

Leung, C., Lau. G.., and Leong. Y. (2002). Testing alternative theories of the property price-trading volume correlation, *Journal of Real Estate Research*, **23** (3), 253-263.

Leung, C., Wei, P., and Wong, S. (2006). Are the markets for factories and offices integrated? Evidence from Hong Kong, *International Real Estate Review*, **9**, 62-94.

Leung, C.; Wong, S., and Cheung, P. (2007). On the stability of the implicit prices of housing attributes: A dynamic theory and some evidence, forthcoming in *International Real Estate Review.*

Liu, H. and Chang, H. (2004). Variation of floor rent differentials of high-rise buildings, *Regional Science*, **83** (2), 495-503.

Mcqueen, G. and Thorley, S. (1991). Are stock returns predictable? A test using Markov chains, *Journal of Finance*, **46** (1), 239-263.

Mills, T. and Jordanov, J. (2003). The size effect and the random walk hypothesis: Evidence from the London Stock Exchange using Markov chains, *Applied Financial Economics*, **13**, 807-815.

Mun, S. and Hutchinson, B. (1995). Empirical analysis of office rent and agglomeration economies: A case study of Toronto, *Journal of Regional Science,* **35**, 437-455.

Nagai, K., Kondo, Y., and Ohta, M. (2000). A hedonic analysis of the rental office market in the Tokyo Central Business District: 1985-1994 fiscal years, *Japanese Economic Review*, **51** (1), 130-154.

Orr, A. and Jone, C. (2003). The analysis and prediction of urban office rents, *Urban Studies,* **40** (11), 2255-2284.

Ortalo-Magne, F. and Rady, S. (1999). Boom in, bust out: Young households and the housing price cycle, *European Economic Review,* **43** (4-6), 755-766.

Ortalo-Magne, F. and Rady, S. (2006) Housing Market Dynamics: On the contribution of income shocks and credit constraints, *Review of Economic Studies*, **73**, 459-485.

Patel, K. and Sing, T. (2000). Implied volatility in the U.K. commercial property market: Empirical evidence based on transaction data, *Journal of Real Estate Finance and Economics*, **20** (1), 5-24.

Quah, D. (1996a). Aggregate and regional disaggregate fluctuations, *Empirical Economics*, **21** (1), 137-159.

Quah, D. (1996b). Regional convergence clusters across Europe, *European Economic Review*, **40** (3-5), 951-958.

Quah, D. (1996c). Empirics for economic growth and convergence, *European Economic Review*, **40** (6), 1353-1375.

Quah, D. (1997). Empirics for growth and distribution: Stratification, polarization, and convergence clubs, *Journal of Economic Growth*, **2** (1), 27-59.

Ricardo, D. (1817; 1965). The principles of political economy and taxation, London: J. M. Dent and Son.

Rosen, K. and Smith, L. (1983). The price-adjustment process for rental housing and the natural vacancy rate, *The American Economic Review*, **73** (4), 779-786.

Shilling, J., Sirmans, C., and Corgel, J. (1987). Price adjustment for rental office space, *Journal of Urban Economics*, **22** (1), 90-100.

Sivitanidou, R. (1997). Are center access advantages weakening? The case of office – commercial markets, *Journal of Urban Economics*, **42** (1), 79-97.

Sivitanidou, R. and Sivitanides P. (1999). Office capitalization rates: Real estate and capital market influences, *Journal of Real Estate Finance and Economics*, **18** (3), 297-322.

Sivitanidou, R. and Sivitanides, P. (2000). Does the theory of irreversible investments help explain movements in office-commercial construction? *Real Estate Economics*, **28** (4), 623-661.

Sivitanidou, R. (2002). Office rent process: The case of US metropolitan markets, *Real Estate Economics*, **30** (2), 317-344.

Slade, B. (2000). Office rent determinants during market decline and recovery, *Journal of Real Estate Research*, **20** (3), 357-381.

Smith, L. (1974). A note on the price adjustment mechanism for rental housing, *American Economic Review*, **64** (3), 478-481.

Tsang, K. (2005). Hong Kong Grade A office market, Jones Lang LaSalle, mimeo.

Tu, Y., Yu. S., and Sun, H. (2004). Transaction-based office price indexes: A spatiotemporal modeling approach, *Real Estate Economics*, **32** (2), 297-328.

Wheaton, W. (1987). The cyclic behavior of the national office market, *Real Estate Economics*, **15** (4), 281-299.

Wheaton, W. (1990). Vacancy, search and price in A housing market matching model, *Journal of Political Economy*, **98** (6), 1293-1306.

Wheaton, W.， Torto, R., and Evans P. (1997). The cyclic behavior of great London office market, *Journal of Real Estate Finance and Economics*, **15** (1), 77-92.

Wheaton， W. (2005). Does location matter? Property fundamentals vary within markets and is this reflected in pricing?, *Journal of Portfolio Management*, Special Real Estate Issue, 100-107.

Young, M. and Graff, R. (1996). Systematic behavior in real estate investment risk: performance persistence in NCREIF returns, *Journal of Real Estate Research*, **12** (3), 369-381.

Young, M. and Graff, R. (1997). Performance persistence in equity real estate returns, *Real Estate Finance*, **14** (1), 37-42.