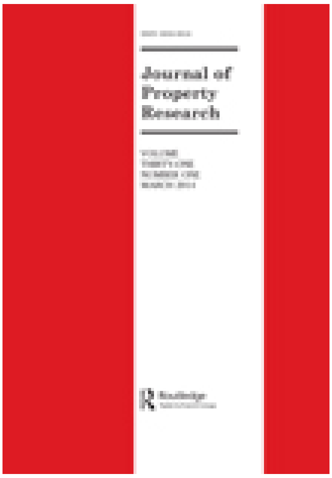


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# Investigating the dynamics of, and interactions between, Shanghai office submarkets

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# Investigating the dynamics of, and interactions between, Shanghai office submarkets

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The Shanghai office market has developed rapidly over the past two decades. As a consequence of this development, two, apparently distinct, office submarkets, Puxi and Pudong have developed in central Shanghai. This raises the issue as to whether the Shanghai office market can be viewed as a homogeneous entity or whether there is imperfect substitutability across office locations within the city. The latter case raises the possibility of the existence of office submarkets. In this paper, we examine intra-metropolitan rental dynamics in the Puxi and Pudong submarkets, identifying any interrelationships between these markets, and consider whether they form distinct office submarkets. We find no interaction between the two submarkets. Further, we find no evidence of lead–lag relationships between the two submarkets. Finally, when we test for convergence in rental performance between the two submarkets, the tests reveal that we can reject the null of no convergence.

**Keywords:** Shanghai; Pudong; Puxi; office rents; office submarkets

## Introduction

Studies on housing submarkets abound in the literature. However, the studies on office submarkets lag behind. Earlier office submarket studies have focused on rent/price differences between submarkets within given metropolitan areas (e.g. Glascock, Jahanian, & Sirmans, 1990; Mills, 1992; Wheaton & Torto, 1994) and the determining factors in explaining spatial variations in office rents (e.g. Bollinger, Keith, & Bowes, 1997; Clapp, Pollakowski, & Lynford, 1992). However, limited evidence remains on the interaction effects between office submarkets.

The issue of submarkets and their definition has become increasingly important. Submarkets might exist because certain types of office occupiers prefer to locate together perhaps reflecting agglomeration economies. As office markets develop this means that certain occupiers prefer one location over another within the same urban area, leading to imperfect substitutability across locations. If office submarkets are not substitutable then excess demand in one submarket cannot be met by new supply in another location. The former submarket would then provide a greater return performance for investors. Modelling of commercial real estate markets begins to address the issue of submarkets in the 1990s. (See, for example, the more

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sophisticated modelling of local office markets in Rabianski & Cheng, 1997; Taylor, Rubin, & Lynford, 2000.) Dunse, Leishman, and Watkins (2000) also argue that office markets are segmented across urban areas and thus that offices in one location in any given city cannot be seen as perfect substitutes for those located in another area.

The submarket literature has been well documented in housing market analysis. Studies on housing submarkets suggest that the stock could usefully be delineated by the extent to which a particular property was likely to represent a relatively close substitute to alternative properties when considered by potential purchasers or renters (Grigsby, 1963). Decreased vacancy in one submarket, for instance, might not stimulate rent growth in another even when there is space available in neighbouring submarkets. In other words, spatial substitution may be limited due to imperfect substitutability. Bourassa, Cantoni, and Hoesli (2007) indicate that consideration of submarkets significantly aids explanation of house price performance across urban areas. The special characteristics of real property, such as spatial fixity, durability and heterogeneity, together with the influence of information asymmetry, prevent demand and supply from responding instantly to local shocks, therefore, prevent urban property markets from reaching equilibrium and from operating as unitary entities. Supply is relatively static, particularly in the short term while intra-market demand can be more fluid. Even so, most residents will be unlikely to move from one submarket to another in response to small changes in submarket conditions. Thus in comparison to arbitrage in financial markets, spatial arbitrage is usually much less common.

Office occupiers also display spatial fixity and may not regard other locations in a local economy as perfectly substitutable. In London, for example, the occupier mix in the West End is different from The City or Docklands. The new supply generated by the creation of Docklands did not cause spatial substitution from the West End market. Instead, areas contiguous to the West End, however, have become attractive to occupiers who prefer a West End location but cannot afford the high rent levels.

These submarkets are the focus for investment, mainly due to these complex phenomena, the tendency for industries to co-locate and the presence of agglomeration economies. What is more, submarket forces within fragmented markets could create disparities in performance levels, growth and volatility across the geographic market (Taylor et al., 2000). Thus, it is more useful to conceptualise urban property markets in terms of a set of interrelated submarkets and study the interactive effects between these submarkets.

Many of the studies on office markets in the USA are at city level (Clapp 1980; Glascock et al., 1990; Mills, 1992; Wheaton & Torto, 1994). The issue of submarket existence was tested through the inclusion of locational submarket dummies. Most research on office markets in Europe and the UK has been conducted at city or regional level and has used a reduced form modelling approach (e.g. D'Arcy, McGough & Tsolacos, 1997, 1999; Gardiner & Henneberry, 1988, 1991; Guissani, Hsia, & Tsolacos, 1993). However, in these studies, submarket issues were not tested, partly reflecting the more aggregated data used and the focus on time series rather than spatial relationships.

In this paper, we investigate the dynamic and interactive effects between two key office submarkets in Shanghai. The Shanghai office market is of interest for a number of reasons. First of all, it is the second largest office market in terms of footage and investment behind the Beijing office market in China. Second, it comprises distinct submarkets the most important of which are Puxi and Pudong New District that are segmented spatially and administratively. The former is a traditional commercial area while the latter is a specially built functional area driven by the government development planning policy (from the early 1990s) rather than market demand. These two key submarkets contain over half of the prime office stock in Shanghai. The structural fragmentation of these two submarkets may be hard to identify, since most office buildings were built since the early 1990s in both locations, but there is distinct spatial fragmentation and difference in tenant profile between the two. These submarkets provide an opportunity to test whether there are interaction effects in rent setting behaviour.

As one of the most appealing and dynamic emerging commercial property markets, Shanghai real estate has attracted domestic and foreign investors.[1] However, there is limited research on the Shanghai office market due to the short history of the commercial property market in China and unavailability of quality data. So far there is only one research paper by Ke and White (2009). Their study concentrated on the central Puxi office submarket and investigated the determinants of office rent and rental adjustment processes. They employed an error correction model and found that demand for space was both price and income elastic. Further, their results indicated that the office market displayed relatively slow adjustment to equilibrium. Foreign direct investment (FDI) had a significant impact on long-run rents while the vacancy rate affected short-run rental change.

This paper develops and essentially extends that work and investigates the rental adjustment process and the interrelationship, if any, between the two key Shanghai office submarkets. The study period runs from 1994 to 2010 and captures a period of economic growth and transition in Shanghai and the development of the two submarkets. The paper will contribute further to the understanding of the behaviour of the Shanghai commercial property market. It will be useful to academics and policy-makers, as well as to investors looking for new investment opportunities in China.

The paper is arranged as follows: a literature review is presented followed by a description of the two submarkets. Then, the methodological approach adopted and data are explained. The results of the analysis are then presented and conclusions are reached in the final section.

## Literature review

Studies on office rents in the USA by Glascock et al. (1990, 1993), Mills (1992), and Wheaton and Torto (1994) explicitly examine submarket location by using dichotomous variables in hedonic regression models. These studies document the existence of office submarkets and locational differences in office rents across individual metropolitan areas.

Glascock et al. (1990), for example, examine the rental differences in Baton Rouge, Louisiana. Six geographic submarkets with distinguishing features in terms of user profile and physical characteristics of buildings are included in their hedonic model. They find rents vary systematically across classes of buildings and locations. In their other paper, Glascock, Kim, and Sirmans (1993) re-examine office market rents with the same set of data, but employ different techniques, i.e. random effects and heteroscedastic autoregressive models. They find variations in rents over time, across different classes of buildings and geographical submarkets. Mills (1992) estimates office rents in Chicago using a hedonic model with 543 buildings scattered across 10 submarkets. He finds that the locational coefficients had expected signs and magnitudes.

Clapp et al. (1992) study the intra-metropolitan location and office market dynamics in the Boston area. They hypothesise that both cross-sectional (submarket) and dynamic variables are important to gain an understanding of the growth and location of office employment. They combine multi-equation neoclassical models of office space with descriptive techniques to evaluate spatial patterns of office agglomeration. They find that spatial concentrations by industry (agglomerations) are important determinants of growth in office demand and the demand for office space in submarkets is responsive to agglomerations by type of industry as well as to growth in finance, insurance and real estate employment. Bollinger et al. (1997) estimate the spatial variation in office rents within the Atlanta region using hedonic modelling techniques. Controlling for typical building characteristics and lease terms, they find that variables measuring locational differences in wage rates, transport rates and proximity to concentrations of support services and office workers play an important role in explaining the spatial variation in office rents.

Research on office markets in Europe and the UK has been conducted at national, regional and city level. At a regional level using UK data, Hendershott, MacGregor, and White (2002) construct an error correction mechanism linking a long-run equilibrium model to a short-run dynamic adjustment path for both office and retail markets. Their research constructs a panel model for the regions of the UK (except London). Their results show that the error correction is significant indicating that markets adjust back to their long-run equilibrium paths but that this process can be protracted.

Building upon the work of Hendershott, MacGregor, and Tse (2002) and Englund, Gunnelin, Hendershott, and Soderberg (2008), Hendershott, Lizieri, and MacGregor (2010) use an error correction modelling approach to examine the City of London office market. The paper considers asymmetric responses to shocks in employment and supply. Positive shocks were found to have significant effects on rental values but negative shocks had insignificant impacts.

Again, at the city level, Dunse, Watkins, Leishman, Hewines, and Fraser (2000) examine spatial submarkets and submarkets based on quality differences within Edinburgh and Glasgow using a hedonic estimation approach. The results of their study suggest that there is clear evidence of submarket existence in Glasgow, but Edinburgh appeared to operate as a unitary market.

In their separate research of office submarkets in Glasgow and Edinburgh, Dunse, Leishman, et al. (2000) adopt principal components analysis and cluster analysis. Their findings reveal that in both cities, spatial and structural characteristics have important influences on submarket structure. Dunse and Jones (2002) test the existence of submarkets in Glasgow with hedonic equations. A number of submarket specific hedonic equations are estimated and the implicit rental estimates in each submarket are compared with those of market-wide models. These studies test the existence of submarkets and raise the importance of studying submarkets, but they fail to test the relationship between the submarkets in terms of rental impact and substitutability in demand and supply.

A relatively recent study of office price is conducted by Nappi-Choulet, Maleyre, and Maury (2007). They adopt the hedonic approach to estimate the office transaction price in two main central business districts (CBDs) in Paris. They find that there is similarity in price trends in the two CBDs, which behave as if they were a single market, though the end-users of office buildings in these two submarkets are different. Hence they suggest that these two submarkets are complementary, rather than competing, and operate as a single functional centre.

In contrast to these studies, Stevenson (2007) innovatively adopts error correction modelling to examine the rental adjustment in the four primary submarkets in central London and to model the interactive effects among the submarkets. He extends the model to include not only the error correction term of the appropriate submarket, but also lets the error correction terms of other submarkets affect each submarket in the short-run models. If the error (or imbalance) in one submarket affects another submarket, then adjustment processes link the submarkets. He finds inter-linkages between the submarkets, and in particular the City of London market disequilibrium term affects the other submarkets.

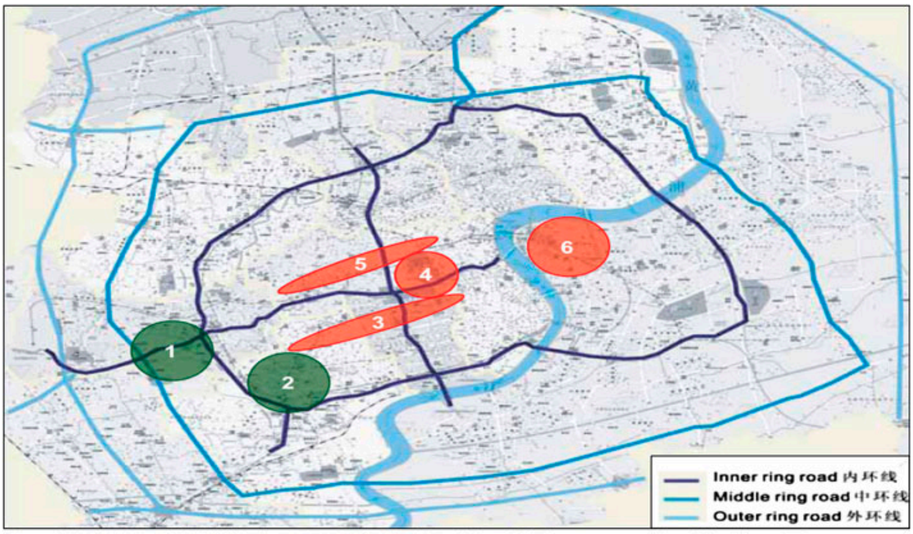
In contrast to housing market research, analysis of office submarkets has been relatively limited, the paper by Stevenson outlined above being one of only a small number. The approach adopted in this paper builds upon the work of Hendershott, MacGregor, and Tse (2002), Hendershott, MacGregor, and White (2002), Hendershott et al. (2010), Stevenson (2007), and Ke and White (2009) reviewed above using an error correction framework and testing for submarket interaction effects. We then test for convergence in submarket performance. To our knowledge, no other work has adopted these methods of analysis to examine different aspects of office submarket structure and behaviour.

## Shanghai office submarkets: central Puxi and Lujiazhui in Pudong New District

Puxi and Pudong are two distinct submarkets. They are physically separated by River Huangpu that runs through the urban part of Shanghai. They belong to different administrative districts and have different types of end-users.

The central Puxi commercial area, on the west bank of River Huangpu, was first established in the 1850s and quickly became the leading commercial district in Shanghai. Since the era of economic reform, particularly since the later 1980s, central Puxi was expanded further to the west from a traditional commercial core in Shanghai and has become a key CBD. The Grade A office buildings are located along Nanjing Road West, People's Square and Huaihai Road (see Figure 1), representing 30% of total prime office stock of Shanghai (DTZ, 2010). The central Puxi area was already approaching saturation, so Pudong New District, was designed and developed to relieve the spatial pressure on the old Shanghai central area. Pudong also provides Shanghai with a new CBD that can house a variety of business activities and, most importantly financial and business services.

In terms of the preference of end-uses, large office blocks in central Puxi are primarily occupied by regional headquarters (HQ) of multi-national companies and large professional services companies. This area has been historically regarded as providing the most prestigious address in the city representing the prime area of the market and has had the strongest occupier demand, greatest rental growth rates and lowest capitalisation rates.




Note: 1-Hongqiao and 2- Xujiahui are second tier business hubs (which are not considered in this study). 3- Huaihai Road, 4- People's Square and 5- Nanjing Road West are first tier business hubs in Puxi. 6 is Lujiazui in Pudong (first tier business hub).
Source: (DTZ, Shanghai).

Figure 1. Shanghai Grade A office hub distribution.

In contrast, the emergence and rapid expansion of Pudong New District on the east bank of River Huangpu is the outcome of central government strategic planning from the beginning of 1990. The plan was to develop Pudong as a pilot scheme in order to stimulate future economic development of coastal cities along the Yangtze River Delta and establish Shanghai as an international economic, financial and trading centre. Before 1990, Pudong comprised farm land and fishing villages, lagging behind Puxi in terms of economic activities. There were no bridges or tunnels connecting the two sides of the river. A ferry was the only means of transportation linking the east bank (Pudong) and west bank (Puxi) of the river.

On 18 April 1990, the State Council of the central government announced a decision to open up Pudong as a Special Economic Development Zone. The Shanghai Pudong New Zone permitted foreign companies to begin operating and specifically attracted financial institutions into the Lujiazui Finance and Trade Zone. The government objective has been to make this the main financial hub in China and East Asia. Pudong has also created areas for other industrial groups (e.g. export processing in Jinqiao). In 1993, Pudong New District Administration Committee was established. Subsequently, large-scale construction projects, including office buildings, commenced. In the past 19 years, Pudong has experienced rapid and substantial economy expansion. For example, in 1990, Pudong's Gross Domestic Product (GDP) was Renminbi (RMB) 6.02 billion (US$ .77 billion). This figure soared to RMB 92.06 billion (US$ 11.8 billion) 10 years later in 2000, increasing 14.3 times. In 2010, Pudong's GDP was RMB 470.75 billion (US$ 74.25 billion), representing 28% of Shanghai's total GDP. In terms of the growth rate of GDP, Pudong exceeded the average growth rate of Shanghai as a whole over the past 18 years (see Figure 2).

Pudong's Lujiazui CBD has been guided by the long-term ambitions of the city and facilitated by an international consultative planning process in which experts

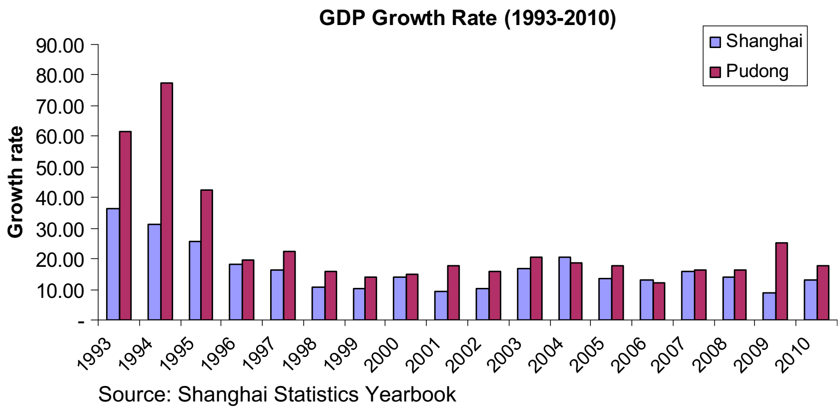



Figure 2. GDP growth rate (1993–2010).

from France, Britain, Italy and Japan have participated (Olds, 1997). It is the sole national development zone in the country named as the Financial and Trade Zone. It houses the Shanghai Stock Exchange and domestic and foreign financial institutions. So far, there are over 500 domestic and overseas financial and insurance organisations that have settled in this zone and these are the predominant office occupiers.

Today, four bridges and five tunnels connect the both sides of the river. There are also ferries for people, bicycles and other vehicles. The underground links Puxi and Pudong and the maglev line came into operation in 2006. All of these have greatly improved accessibility.

The rapid and large-scale development of the Pudong submarket was driven by government planning and development policy and the Shanghai Municipal government's promotion policy that attempted to influence the central government's decision in locating major national institutions in Shanghai. In 1980s and 1990s, Shanghai, especially Pudong, benefited from China's restriction on where foreign financial institutions and other foreign service providers might operate business (Zhang, 2003). For instance, foreign banks located in Pudong were the first to be allowed in 1996 to enter the Chinese currency business.[2] All these indicate that the institutional setting in Pudong may have impacted on the interaction and substitutability of these two submarkets.

In 1990, real estate investment in Pudong was only RMB 6 million (US$.77 million), with completed construction space of 1.45 million sqm. In 2000, it rose to RMB11.1 billion (US$ 1.42 billion), with complete construction space of 5.7 million sqm. In 2010, the investment in real estate was RMB 55.57 billion (US $8.85 billion). According to DTZ report, in 1994, total prime A office stock in Pudong was only about 38,000 sqm. Ten years later in 2004, it had increased to 972,668 sqm. By the end of 2010, it had 1582,770 sqm of prime A office stock, a dramatic increase compared with 1994. Now, Little Lujiazui CBD boasts a concentration of Grade A office space that is equal to 36% of total prime office stock in Shanghai (see Figure 3 for total stock and investment values in Pudong from 1993 to 2010).

Over the period from 1993 to 2010 there has been a general increase in property investment although this has been against a background of cyclicality with lower

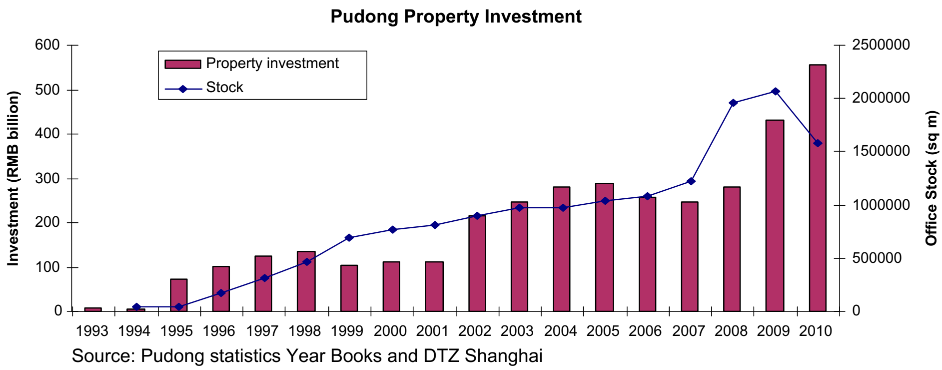



Figure 3. Pudong's property investment.

investment between 1999 and 2001 compared to 1996–1998. Investment dips in 2006–2007 compared with the immediately preceding period before increasing again in 2008. The vacancy rate of Pudong office buildings increased significantly during the 1990s and reached a peak in 1998 at over 50% (see Figure 5), resulting from the significant mismatch between supply and demand.

Economic growth since 2000 created high demand for space and the vacancy rate fell. Real estate investment started to pick up and in 2005, it reached another peak. On average, Pudong's office vacancy rate has been higher than Puxi's. So the investment boom may not have been entirely driven by the demand, but by the government planning and development policy, especially by the government's ambition to build Pudong as the Financial and Trade Centre of China.

Across the river, in central Puxi, due to the constraints of land supply, the limited supply of office buildings and strong demand, some companies may have to cross the river to Pudong. Furthermore, the high rents in central Puxi will also make some companies relocate to Pudong. The average rent in central Puxi by the end of 2010 was RMB 232 per sqm per month, while in Pudong it was RMB 215 per sqm per month (DTZ, 2010). The development and growth of the Pudong submarket is expected to have an impact on the central Puxi submarket. Puxi will continue to draw service providers and many multi-national companies' head quarter operations while Pudong's Lujiazui district will increasingly house companies from the financial sector.

## Data and methodology

The real estate data used in this paper were supplied by DTZ, Shanghai, China, for Class A office space. The economic data were collected from Shanghai Statistics Year Books and Pudong Statistics Year Books. The data-set employed is quarterly and covers the period from 1994 quarter four until 2010 quarter four. Full details are provided in the data appendix.

As there are no statistics on individual building characteristics, a hedonic regression approach cannot be employed. Data used provide information on asking rents in each submarket (Pudong and Puxi) over time, together with stock, vacancy rates, FDI and GDP.

We use an error correction framework to examine the importance of key exogenous variables and rental adjustment processes in the central Puxi office submarket.

The approach adopted below follows from Hendershott, MacGregor, and Tse (2002), Hendershott, MacGregor, and White (2002), and Hendershott et al. (2010). Demand for space depends upon occupier demand ($E$) and the cost of space captured in rent ($R$). Thus:

$$D = \lambda_0 E^{\lambda_1} R^{\lambda_2} \tag{1}$$

In this relationship, $\lambda_1$ and $\lambda_2$ are price and income elasticities, respectively. In equilibrium, demand for space will equal the stock of occupied space which is total space less vacant space. Hence:

$$D = (1 - v)\mathrm{SU} \tag{2}$$

where SU is the supply of space and $v$ is the vacancy rate. Substituting (2) into (1) and in log format we have:

$$\ln R = \gamma_0 \ln \lambda_0 + \gamma_1 \ln D + \gamma_2 \ln Stock + \gamma_2 \ln(1 - v) + u_t \tag{3}$$

$$\Delta \ln R_t = \phi_0 + \phi_1 \Delta \ln D_t + \phi_2 \Delta \ln Stock_t + \phi_3 \Delta \ln(1 - v_t) + \phi_4 u_{t-1} + \varepsilon_t \tag{4}$$

where $R$ is asking rent, $D$ represents the demand variable (e.g. GDP), *Stock* is the stock of floorspace of prime A offices, $v$ is the vacancy rate, $u$ is the error term and the $t$ subscript denotes the time period. Equation (3) represents the long-run model and the dynamic short-run adjustment is captured in Equation (4)[3] where the lagged residual from the long-run model is included and represents the error correction as the position of the market in the short run adjusts back towards its long-run equilibrium path.

In this paper, we are also interested in the interaction, if any, between the submarkets. Stevenson (2007) uses an error correction framework for London office submarkets and uses the residuals generated from the long-run models for each market as error correction terms in the short-run dynamic models. Hence he permits interaction between submarkets to be captured by the error correction term. As the error correction terms represent the deviation of observed rent from its long-run equilibrium, this deviation is then used to capture submarket interaction. If the deviation in one submarket is statistically significant in another submarket, it would suggest that there is some connection between the two submarkets. Thus in the case of the Shanghai submarkets, we permit the error correction term for Puxi to be a regressor in the short-run dynamic model for Pudong, and vice versa.

Thus Equation (4) can be rewritten as:

$$\begin{aligned}\Delta \ln R_{1,t} = \phi_0 &+ \phi_1 \Delta \ln D_{1,t} + \phi_2 \Delta \ln Stock_{1,t} + \phi_3 \Delta \ln(1 - v_{1,t}) + \phi_4 u_{1,t-1} \\ &+ \phi_5 u_{2,t-1} + \varepsilon_{1,t}\end{aligned} \tag{5}$$

where the subscripts 1 and 2 refer to the specific submarket. Testing in both directions implies:

$$\begin{aligned}\Delta \ln R_{2,t} = \phi_0 &+ \phi_1 \Delta \ln D_{2,t} + \phi_2 \Delta \ln Stock_{2,t} + \phi_3 \Delta \ln(1 - v_{2,t}) + \phi_4 u_{1,t-1} \\ &+ \phi_5 u_{2,t-1} + \varepsilon_{2,t}\end{aligned} \tag{6}$$

As is common practice, we begin by testing for the presence of unit roots in the time series used in the study. This is followed by estimating the long-run models for each submarket in Equation (1). The models are then tested for the presence of a cointegrating vector following Johansen (1991). After this short run, dynamic models as in Equations (5) and (6) are estimated.

Finally, it is also possible that the submarkets converge (or diverge) in terms of their behaviour over time. This possibility is discussed further below.

## Test results and analysis

We begin by examining the behaviour of rents and vacancy rates in the two submarkets. Figure 4 below shows the path of real rents in the Puxi and Pudong submarkets. Rents in Puxi, while higher in the 1990s, fall quite sharply from 1994 to 1999. Rents in both submarkets increase from the end of 2000. In Pudong, rents rise above Puxi until 2003 after which both rise at approximately the same rate. Both submarkets see rents beginning to fall in 2008.

Figure 5 displays the vacancy rate in each submarket. The patterns are very similar with extremely high vacancy rates peaking in 1998 at just under 50% in Puxi and over 60% in Pudong. Vacancy rates then fall to almost zero by 2007 but increase in 2008, especially in Pudong, to almost 27%, resulting from the new supply brought into the market and low demand in the economic downturn.

While these markets are still relatively new and data do not exist prior to the early 1990s, the graphs seem to indicate that there is increasingly similar performance in rents after the 1990s and patterns in vacancy rates also show a high degree of similarity. Hence, it is possible that the performance of these submarkets is converging. This too, may be tested within a cointegration framework.

Before estimating any of the models outlined above, it is necessary to test for stationarity. Augmented Dickey–Fuller (ADF) unit root tests were undertaken to discover the order of integration of each time series variable used and results are reported in Table 1.

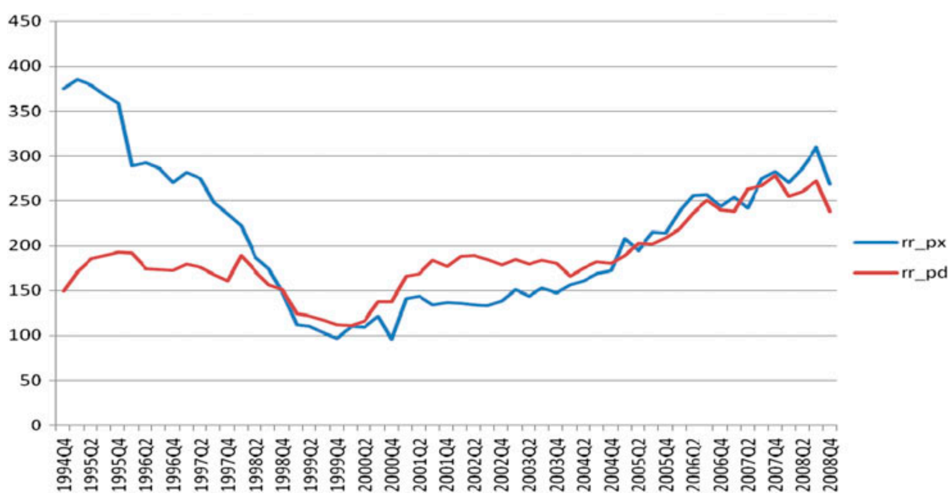



Figure 4. Real rents in Puxi and Pudong.

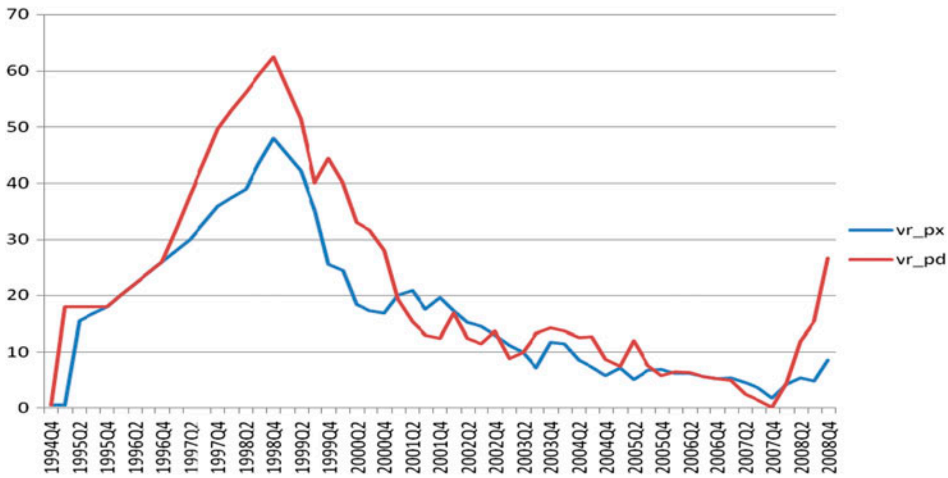



Figure 5. Vacancy rates (%) in Puxi and Pudong.

Table 1. Unit root tests.

| | ADF – Puxi | PP – Puxi | ADF – Pudong | PP – Pudong |
|---|---|---|---|---|
| Rent | $-11.138^{***}I(2)$ | $-4.302^{***}$ | $-4.175^{***}$ | $-6.895^{***}$ |
| GDP | $-33.404^{***}$ | $-33.376^{***}$ | $-9.134^{***}$ | $-3.692^{***}$ |
| Stock | $-3.082^{**}$ | $-3.071^{**}$ | $-2.801^{*}$ | $-2.687^{*}$ |
| Vacancy rate | $-5.583^{***}$ | $-5.883^{***}$ | $-6.312^{***}$ | $-3.939^{***}$ |
| FDI | $-4.693^{***}I(0)$ | $-9.766^{***}I(0)$ | $-3.104^{**}I(0)$ | $-2.834^{*}I(0)$ |
| Real interest rate | $-3.507^{**}I(0)$ | $-7.546^{***}$ | | |

Note: All variables are $I(1)$ unless stated otherwise.
$^{*}$, $^{**}$ and $^{***}$ stand for the 10, 5 and 1% significance levels, respectively.

The standard regression for this approach is:

$$\Delta x_t = \alpha + \beta_1 x_{t-1} + \sum_{i=1}^{\rho-1} \delta_i \Delta x_{t-i} + \mu_t \tag{7}$$

where the chosen value for $\rho$ is such that $\mu_t$ will be a white noise error term. The $t$-statistic on $\beta_1$ is compared with the critical values found in Fuller (1976). When only the lagged value of $x$ is present, the test is referred to as a DF test. When lagged difference terms are added, the resulting test is an ADF test. An alternative approach to adding lagged values of the dependent variable has been suggested by Phillips (1987) and extended by Perron (1988) and Phillips and Perron (1988). They suggest adding a non-parametric correction to the $t$-test statistic. This accounts for autocorrelation that may be present.

The unit root tests indicate that the order of integration of most variables is the same across the two submarkets. Next, both long- and short-run models are estimated for each submarket where the long-run model is based upon Equation (3) and the short-run models are based upon Equations (5) and (6). Table 2 presents results from the long-run models for both submarkets.

Table 2. Long-run model results.

| | Puxi | Pudong |
|---|---|---|
| Constant | 11.445 (15.568) | 6.483 (21.167) |
| GDP | .462 (2.401) | .004 (.039) |
| Stock | −.604 (−9.109) | −.135 (−3.545) |
| FDI | .200 (1.231) | .136 (3.258) |
| $(1 - v)$ | .285 (4.744) | .205 (4.938) |
| Adjusted $R^2$ | .736 | .676 |
| Durban-Watson (DW) | .578 | .775 |
| Prob of $F$-statistic | .000 | .000 |

Note: $t$-statistics are in parentheses.

Table 3. Johansen cointegration test results for Puxi office submarket.

| Hypothesised no. of CE(s) | Eigen value | Trace Statistic | .05 Critical value | Prob.** |
|---|---|---|---|---|
| None* | .637015 | 133.6739 | 69.81889 | .0000 |
| At most 1* | .440913 | 72.87023 | 47.85613 | .0001 |
| At most 2* | .303362 | 37.98322 | 29.79707 | .0046 |
| At most 3* | .165607 | 16.29385 | 15.49471 | .0378 |
| At most 4* | .086538 | 5.430783 | 3.841466 | .0198 |

Trace test indicates five cointegrating equations at the .05 level.
*Rejection of the hypothesis at the .05 level.

Table 4. Johansen cointegration test results for Pudong office submarket.

| Hypothesised no. of CE(s) | Eigen value | Trace Statistic | .05 Critical value | Prob.** |
|---|---|---|---|---|
| None* | .493265 | 99.29040 | 69.81889 | .0000 |
| At most 1* | .367888 | 57.82466 | 47.85613 | .0044 |
| At most 2* | .274921 | 29.84468 | 29.79707 | .0494 |
| At most 3 | .101760 | 10.23474 | 15.49471 | .2631 |
| At most 4 | .058673 | 3.688325 | 3.841466 | .0548 |

Trace test indicates three cointegrating equations at the .05 level.
*Rejection of the no cointegration hypothesis at the .05 level.

The results for the long-run models show a positive impact of GDP on rent and the negative impact of supply (stock). However, GDP is not significant in Pudong. The Puxi market is more sensitive to both demand and supply side variables having (absolutely) larger coefficients. FDI (entered in the model as an additional explanatory demand-side variable) is significant in Pudong but is insignificant in Puxi. This could possibly be explained as Pudong has been seen as a destination for international companies entering China in the financial sector. Thus GDP would be less important and FDI more important in Pudong than in Puxi. The vacancy rate variable has the expected sign and is significant in both Puxi and Pudong.[4] These models are next tested for cointegration. Using both Engle and Granger (1987) and

Table 5. Short-run models.

| | Puxi | Pudong |
|---|---|---|
| Constant | −.007 (−.524) | −.004 (−.434) |
| ΔGDP | −.177 (−1.693) | .006 (.049) |
| ΔStock | −.243 (−1.908) | −.118 (−2.661) |
| ΔFDI | −.010 (−.137) | .038 (1.136) |
| $\Delta(1-v)$ | .078 (2.571) | .019 (1.162) |
| Error correction term – Puxi | −.209 (−3.309) | −.029 (−.548) |
| Error correction term – Pudong | .016 (.148) | −.173 (−2.028) |
| Adjusted $R^2$ | .259 | .136 |
| DW | 2.022 | 1.937 |
| Prob of $F$-statistic | .001 | .027 |

Note: $t$-statistics are in parentheses.

Johansen (1991) methodologies, we can reject the null of no cointegration in each submarket (Tables 3 and 4).

The next step is to estimate a short-run dynamic adjustment model for each of the submarkets. The short-run model with error correction terms from each submarket are reported in Table 5.

The short-run model results for Puxi show that the change in stock and the error correction term are statistically significant with the correct signs. In the model for Pudong, the change in stock, the change in the vacancy rate and the error correction term are significant and correctly signed. The change in GDP is insignificant at the 5% level in both submarkets. In neither model is the error correction term of the other submarket significant. Thus disequilibrium in one submarket does not have a significant impact on the other submarket. Rental differences therefore do not cause significant spatial reallocation. The results may reflect differences in the occupier base, their characteristics and their locational preferences. Further as particular types of occupiers concentrate within particular submarkets, agglomeration economies may reinforce locational inertia.

However, given that Pudong is a newer development it may be the case that there are lead–lag relationships between the submarkets. Rental change in one submarket may cause rental change to happen in the other submarket. This can be investigated using Granger-casuality tests following Granger (1969). The test is based on the following vector autoregressive model.

$$r_t^{Px} = \alpha + \sum \gamma_i r_{t-i}^{Px} + \sum \beta_i r_{t-i}^{Pd} \tag{8}$$

where the rent in Puxi is regressed on its own past values and the past values of rents in Pudong. The model is then run with Pudong rent as the dependent variable. Results for this Granger-causality test are presented in Table 6.

The results indicate that it is not possible to reject the null hypothesis of no Granger-causality between the submarkets in either direction. Such a result would be consistent with a policy-led development of a new office area like Pudong.

Given that both submarkets are attractive to investors and contain large stocks of grade A office accommodation this result may be surprising. However, it may also be the case that occupiers do not view the submarkets as good substitutes for each other, and given the results above this view has persisted. There may also be other more qualitative or policy-driven factors that are not captured by the

Table 6. Granger-causality test between Puxi and Pudong submarkets.

| Null hypothesis | Obs | $F$-Statistic | Probability |
|---|---|---|---|
| Pudong does not granger cause Puxi | 61 | 1.006 | .413 |
| Puxi does not granger cause Pudong | | .393 | .813 |

regression models. The expansion of Pudong's Lujiazui Financial and Trade Zone has not had a negative impact on the Puxi market as both localities largely house different types of businesses. Lujiazui has attracted companies related to the financial industry due to policy and incentive driven agglomeration. Puxi, alternatively, has remained attractive for service providers and for the HQ operations of many multi-national companies due to good connectivity and excellent amenities. Therefore, these submarkets do not compete with each other for tenants.

It is also possible that since the markets are still immature that there is uncertainty in the market and changes in one location do not directly affect the other. Since Pudong was developed because of government policy and not market forces, then policy variables may be more important than rent and value signals. Also data quality may be adversely affected in an immature market. Data collection proved difficult and problems with the data may have impacted on the results. Longer time series may be needed before clearer effects can be discovered.

However, Figures 4 and 5 suggested that Puxi and Pudong behaved in a similar way in relation to rents and vacancy rates. Does this provide any evidence of convergence in submarket performance?

A necessary condition for convergence is no cointegration since cointegration implies a constant equilibrium difference between the submarkets. Table 7 provides evidence of no cointegration in rental performance in the two submarkets. This would be consistent with the pattern in rents displayed in Figure 4. Similarity in rents by itself does not necessarily imply perfect substitutability if agglomeration effects are present reflecting concentrations of particular occupier groups.

Gallet (2004) examines housing markets and tests for convergence. He suggests that 'convergence in housing prices between two regions is indicative of a shared

Table 7. Cointegration test between Puxi and Pudong office submarkets.

| *Unrestricted cointegration rank test* (*trace*) | | | | |
|---|---|---|---|---|
| Hypothesised No. of CE(s) | Eigen value | Trace Statistic | .05 Critical value | Prob.** |
| None | .170094 | 14.11628 | 15.49471 | .0798 |
| At most 1 | .040400 | 2.556831 | 3.841466 | .1098 |
| *Unrestricted cointegration rank test* (*maximum Eigen value*) | | | | |
| Hypothesised No. of CE(s) | Eigenvalue | Max-Eigen Statistic | .05 Critical value | Prob.** |
| None | .170094 | 11.55945 | 14.26460 | .1283 |
| At most 1 | .040400 | 2.556831 | 3.841466 | .1098 |

Trace test indicates no cointegration at the .05 level.Max-Eigen value test indicates no cointegration at the .05 level.

*Rejection of the hypothesis at the .05 level.

**MacKinnon–Haug–Michelis (1999) $p$-values.

market …' (p. 552). Following Gallet (2004), and Carlino and Mills (1993, 1996), we examine the movements in relative rents between the two submarkets, i.e. the log of rent in Puxi relative to Pudong. The relative rent is written as a function of long-run equilibrium differential and deviations around this. Thus:

$$\mathrm{rr}_t = \mathrm{rr}^e + \mu_t \tag{9}$$

where rr is the relative rent in Puxi to Pudong, $\mathrm{rr}^e$ is the equilibrium differential and $\mu$ is the deviation. This can be written as:

$$\mu = v_0 + \beta t + v_t \tag{10}$$

where $v_0$ is the initial deviation from equilibrium, $\beta$ is the rate of convergence and $t$ is a time trend. Combining (9) and (10) gives:

$$\mathrm{rr}_t = \mu + \beta t + v_t \tag{11}$$

Thus rents converge if the deviations, $v_t$, are non-permanent. The convergence test can be based upon the ADF procedure as described in Equation (7) above. Rewriting (7) and adding a time trend we have:

$$\Delta \mathrm{rr}_t = \mu + \beta t + \alpha \mathrm{rr}_{t-1} + \sum_{m=1}^{k} \delta_m \Delta \mathrm{rr}_{t-m} + \varepsilon_t \tag{12}$$

Similar to the unit root test, the coefficient on $\alpha$ is examined. If $\alpha$ is statistically insignificantly different from zero, then there is a unit root in relative rents such that shocks to one market will be permanent and there will not be convergence. Estimating (12) with trend and two lags on the dependent variable (to whiten the residuals) produces the results in Table 8.

In this model, $\alpha$ is −.089 and is statistically significant. Hence we find convergence in the performance of the two submarkets. Gallet (2004) argues that such convergence is indicative of a shared market. However, the earlier tests suggest that the submarkets are not related to each other. The fact that there has been rental convergence may not in itself imply that the submarkets form one market. Differences in the occupier mix and sources of agglomeration benefits can still

Table 8. ADF test for convergence.

| Variable | Coefficient | Std. error | $t$-statistic | Prob. |
|---|---|---|---|---|
| Constant | .078 | .046 | 1.696 | .0954 |
| Time trend | .001 | .000 | 1.814 | .0750 |
| Lagged relative rent (−1) | −.089 | .043 | −2.033 | .0467 |
| Δ Lagged relative rent (−1) | −.358 | .126 | −2.821 | .0066 |
| Δ lagged relative rent (−2) | −.142 | .127 | −1.118 | .2684 |
| $R$-squared | .224 | Mean dependent var | | −.002 |
| Adjusted $R$-squared | .169 | SD dependent var | | .018 |
| Standard Error of regression | .017 | Akaike info criterion | | −5.240 |
| Sum squared resid | .016 | Schwarz criterion | | −5.068 |
| Log likelihood | 167.449 | Hannan–Quinn criter. | | −5.173 |
| $F$-statistic | 4.105 | Durbin–Watson stat | | 1.992 |
| Prob ($F$-statistic) | .005 | | | |

imply that occupiers regard the submarkets as imperfect substitutes. Convergence in rents may still be consistent with imperfect substitutability whilst underlying demand and supply conditions have resulted in rental performance becoming more similar in the two markets.

## Conclusions

This paper has extended earlier research to extend analysis of the Shanghai office market, specifically to examine the behaviour of two important office submarkets, central Puxi and Lujiazui, Pudong. The results suggest that there is no interaction between the two submarkets unlike the results that Stevenson (2007) found between London office submarkets. Further, there is no evidence of lead–lag relationships between the two submarkets. This may imply that is has been limited spatial interaction. As the disequilibrium terms in one submarket did not affect the other submarket, these results together imply a lack of integration between these two submarkets. Finally we test for convergence in rental performance between the two submarkets. These tests suggest that rental convergence cannot be rejected, although this does not in itself suggest the markets are perfect substitutes for each other from the occupiers' perspective.

The results highlight the importance of going beyond a descriptive graphical analysis. Such an approach might suggest that the submarkets are not distinct. However, the statistical tests more accurately reveal the disconnection between the two submarkets. For example, the role of FDI differs between the two submarkets as does GDP. This is not obvious from the graphs but is clear in the estimation results. Such differences may reflect the occupier mix, and overseas investment location choice. In addition, this occurs against a background of significant changes in supply and given the supply lags in development, significant market imbalances. If policy impacts on location choice then this may limit any degree of adjustment between the submarkets within the city. This is important in a market in which a policy of Special Economic Zones can create incentives for particular occupiers to locate in specific submarkets.

It is important to note that the Pudong market is relatively new and the Puxi market has experienced significant redevelopment and both have seen significant new supply. The occupier mix is also different. These factors together with a relatively short time series for data analysis may lead to the findings above. As the markets become more established it may be the case that there will be more interaction between them and that their rental performance may or may not continue to converge. However, it will be worthwhile revisiting this relationship between these two important submarkets in the future when further empirical information becomes available.

## Notes

1. FDI in real estate is restrained by the Chinese Government.
2. The government placed upon them restrictions had to be removed in 2006 under the conditions and terms of China's new World Trade Organisation membership.
3. Where $\Delta$ denotes the first difference.
4. Due to the endogeneity of the vacancy rate, the variable for the vacancy rate is the predicted value from an Autoregressive Moving Average (2, 1) model. This model was the best fit for the vacancy rate in each submarket.

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## Data appendix

### *Definition of data*

Unlike other mature markets in Western developed countries, the 'emerging' nature of Chinese real estate market affects the availability of quality and long time series of office data. The office data we apply in the paper are supplied by DTZ, Shanghai. DTZ, China started to collect Chinese property market data and publish quarterly office rent indices for four Chinese cities; Beijing, Shanghai, Guangzhou and Shenzhen in December 1991. They also provide quarterly office market reports providing such information as vacancy rates and supply. But there were only a few transactions in these cities prior to 1993. In addition, the Pudong office market emerged after 1993. Given this fact, the study period in the paper starts from the second half of 1994. The relatively short time series of the office data could complicate analysis and application of sophisticated statistical models.

Our data-set covers rent, stock and the vacancy rate of grade A office buildings for two most important Shanghai office submarkets. According to a DTZ report, the Puxi office market is composed of seven submarkets spreading across the Puxi area. Four of them are located outside the central Puxi area and have shorter time series data; therefore are excluded from the study. Our study focuses on the central Puxi area along People's Square, Nanjing Road West and Huaihai Road (see Figure 1), where there are three submarkets; Huangpu, Luwan and Jing'an. While the size of each individual submarket is small; they aggregate to some 30% of total Shanghai grade A office stock, about the same size of Lujiazui CBD in Pudong. Because of the proximity of these submarkets to each other, they are usually regarded as one CBD, i.e. the central Puxi CBD. In our study, these comprise the Puxi CBD submarket. The rent is deflated by Consumer Price Index (CPI). An office building can define itself as grade A office only after satisfying a number of standards such as ceiling height, finishing, floor layout, etc. Grade A office stock is the total amount of grade A office space available within a given area. Buildings being renovated or buildings under construction and not available to the market are excluded. It includes buildings for owner occupation in addition to those for leasing. The vacancy rate is the ratio of vacant grade A office space to total grade A office stock in the market.

Demand variables for the Pudong submarket are Pudong New District's GDP, total employment and actual FDI, while the demand variables for central Puxi submarkets are total Shanghai value deducted by Pudong's value. For instance, GDP for the Puxi submarket is total Shanghai GDP deducted by the one of Pudong. Another demand variable for Puxi submarket, employment, is total employment of Shanghai deducted by Pudong employment. There are no data of employment breakdown by industry. GDP and FDI are also deflated by CPI.