CONCORDANCE IN GLOBAL OFFICE MARKET CYCLES*

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ABSTRACT

A large proportion of international real estate investment is concentrated in the office markets of the world's largest cities. However, many of these global cities are also key financial services centres, highlighting the possibility of reduced economic diversification from an investor's perspective. This paper assesses the degree of synchronization in cycles across twenty of the world's largest office markets, finding evidence of significant concordance across a large number of markets. The results highlight the problems associated with commonalities in the underlying economic bases of the markets. The concentration of investment also raises the possibility of common flow of funds effects that may further reduce diversification opportunities.

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1 INTRODUCTION

The last decade has seen a large increase in cross-border investment in real estate. As recently as the mid-1990s, relatively little international investment occurred in the property sector, particularly in comparison with capital market assets such as equities and bonds.[1] To illustrate the dearth of international investment, Worzala (1994) found that 55% of institutional real estate investors held no overseas assets.[2] However, since the turn of the millennium, cross-border investment in real estate has risen at a remarkable rate. In Europe alone, annual cross-border investment increased from less than €25 billion in 2000 to over €150 billion in 2006 and 2007 (Jones Lang LaSalle 2007, 2008). While the broad principles of international diversification can be seen to lend justification to this broadening of the asset base, the case in real estate warrants a closer examination.

The underlying rationale behind international diversification is that as asset performance is interconnected with economic fundamentals; if an investor diversifies globally they are subject to fewer common underlying driving forces. This should therefore feed through to reduced correlations across assets and markets and lead to increased diversification benefits. Indeed, in a real estate context the rationale is particularly attractive. As a privately traded asset, real estate is more closely tied with underlying fundamentals than capital market assets such as equities, and a large literature has clearly illustrated the importance of economic fundamentals in the determination of both rental and capital values (for example Giussani et al. 1993, D'Arcy et al. 1997, Quan & Titman 1999, De Wit & Van Dijk 2003). One would therefore expect that the benefits of diversifying internationally would be enhanced in a real estate context. Indeed, some empirical work would seem to imply that this is the case. Conner & Liang (2005), for example, show that the average correlation between the US stock market and foreign markets has increased and has been consistently above 0.70 since 1988. In contrast, the corresponding average correlation in terms of US gross domestic product (GDP) is only 0.19. This would imply that a real estate fund manager would observe enhanced diversification benefits in a global setting in comparison with a corresponding equity manager.

However, this initial analysis fails to take into account one key element, namely that global real estate investment is not evenly distributed. Rather, it is highly concentrated – not only in a small number of countries, but also in a limited range of metropolitan areas within those countries. In particular, those markets in which investment is concentrated are largely the major global financial centres. This paper considers the degree to which the office markets of global cities display evidence of synchronisation in their cycles.

1 Throughout, when the paper refers to investment, it is considering capital investment in rental income producing standing investments. It does not consider investment in real estate development.

2 The institutional investors were from the following markets: Germany, Japan, Netherlands, Sweden, UK and USA.

The empirical analysis considers 20 of the world's largest office markets and is based upon the concordance measure proposed by Harding & Pagan (2006). The results reveal that many large office markets are indeed synchronised to a statistically significant degree. There is, however, evidence of segmentation with respect to continental European markets, and to some extent with Asia-Pacific markets. The findings broadly show that many of the primary destinations for real estate investment are synchronised, thereby implying reduced international diversification benefits. This applies not only in the context of real estate-only portfolios; multi-asset class portfolio managers are also potentially affected due to the linkages between the global office markets and the broad capital markets. Such funds managers may not be reaping the diversification benefits that are commonly seen as being one of the key advantages of real estate as an asset class. The remainder of the paper is structured as follows. Section 2 discusses in more depth the relevant literature, Section 3 details the data used in the empirical analysis which in turn is presented in Section 4. The final section provides concluding comments.

2 LITERATURE REVIEW

Despite the large amount of literature devoted to real estate portfolio management, remarkably little has concentrated on cross-border investment. This lack of research is in part due to a combination of data limitations and the fact that until the last decade the vast majority of real estate investment was domestic in nature. The relative lack of long-term data has meant that the majority of the empirical work to have considered real estate in an international context has in fact concentrated on a small number of markets, particularly the US and UK and to some degree Japan.[3] Furthermore, many of these papers have focused upon the issue of foreign exchange exposure. (for example Ziobrowski & Curcio 1991, Ziobrowski & Ziobrowski 1993, Ziobrowski et al. 1997). In fact, very few papers have considered the role that international real estate can play in a portfolio context. Chua (1999) considers the portfolio diversification benefits of real estate in a mixed asset context for France, Germany, Japan, the UK and the USA. The results support the view that overseas real estate, in addition to domestic, plays a role in an optimal portfolio. Hoesli et al. (2004) consider seven markets (US, UK, France, the Netherlands, Sweden, Switzerland and Australia) and provide supporting evidence to Chua (1999). In each case, not only does domestic real estate obtain an optimal allocation, but also does international real estate. Using a different methodological approach, Liow (2010) also provides empirical evidence on the diversification potential available internationally. The author uses the Gregory & Hansen (1996) test for co-integration in the presence

3 Sirmans & Worzala (2003) provide a review of those studies that have examined international real estate investment and portfolio diversification.

of structural breaks. In the majority of the systems there is no evidence of co-integration, implying long-term diversification benefits. However, this finding is weakest when considering the USA, the UK and Australia. This is a broadly consistently finding in terms of Myer et al. (1997) who find evidence of co-integration, and therefore a common long-term trend in the case of the USA, the UK and Canada.

However, the conventional portfolio papers that have looked at cross-border investment have largely utilized data at a national level. This raises two issues. Firstly, due to the heterogeneous nature of the asset, it is well established that it is very difficult for a real estate fund manager naively to diversify their portfolio to the extent that they can replicate the performance of national indices (for example Brown & Matysiak 2001, Byrne & Lee 2000). Secondly, global investment in real estate is extremely concentrated in a small number of key centres. Whilst Webb & O'Keefe (2002) note that there are only fourteen countries globally that can support real estate as a separate asset class, the level of concentration is effectively at a metropolitan level. To illustrate this, Jones Lang LaSalle (2007, 2008, 2009*a*,*b*, 2010) estimate that within a European context, the UK is consistently the largest single destination for cross-border investment in property. In 2005, 45% of all cross-border investment was into the UK, although this declined to 25% in 2008. Furthermore, this investment itself is further concentrated. According to Jones Lang LaSalle, in the first nine months of 2008, 53% of overseas purchases in UK real estate were in the London office market; and Lizieri & Kutsch (2006) note that foreign ownership of office properties in the City of London exceeds 45%. Lizieri (2009*a*) shows that over 40% of major office deals completed in 2007 and 2008 were concentrated in just five metropolitan areas: New York, London, Tokyo, Paris and Singapore. This has wide-ranging implications. Firstly, it highlights the limitations in relying on national data to consider effectively the diversification potential of global real estate. Secondly, the markets in which the investment is concentrated have similar economic bases; specifically, they are the major global financial services centres. Indeed, to illustrate this point further, Lizieri (2009*a*) notes that 72% of all office deals took place in cities ranked in the Z/Yen Global Financial Centers Index.

It is evident that this concentration of investment in global financial centres has a number of implications for real estate investors. The economic geography literature has long been concerned with the concept of world cities, with a large literature considering the growth and development of a world city network. An important element of this literature is that many of the global cities share a common feature in their acting a major financial services centres. This means that global real estate investment is concentrated in cities around the world that have common economic driving forces. The importance of economic concentration has been clearly demonstrated in a real estate context, and this implies that such a portfolio approach may be economically undiversified (for example Goetzmann & Wachter 1995). This

has potential implications for mixed-asset fund managers. The concentration of property investment in markets that have strong linkages with capital market assets could lead to a reduction in the diversification benefits a multi-asset manager obtains. This consequence arises from two issues. Firstly, that an investment strategy that is effectively economically undiversified may lead to a foregoing of diversification benefits. Secondly, the linkages between the global city office markets and the capital markets may result in a strategy that does not yield the diversification benefits associated with property as an asset class.

It is interesting to consider the broader implications of the majority of international investment being concentrated in financial centres. During the course of the last thirty years, a large literature has developed in economic geography relating to the concept of world cities and internationalization. A key issue in this literature is that many of the world's global cities are financial services centres. Kindleberger (1974) links the role of global cities with their function as financial services centres, and Friedmann (1986, 1995) argues that such metropolitan areas act as 'control centres'for capital accumulation. Sassen (1991, 1994) also highlights the importance of financial services in an analysis of London, New York and Tokyo, although Sassen adopts a slightly different emphasis in that the analysis focuses upon the servicing of global capital rather than its management. Amin & Thrift (1997) cite key areas with respect to globalization, the first being globalization of money and capital. A number of papers have also considered the importance of skilled migration across world cities and the importance in terms of connectivity that this provides and the role that a global network of corporate offices play in facilitating this (for example Friedmann & Wolff 1982, Sassen 1988, 1994, Beaverstock 1994, Findlay et al. 1996). Taylor et al. (2002) describe their role as providing 'a skeletal structure for globalisation'. Beaverstock & Boardwell (2000) note that professional skilled migration increased since the 1980s, and highlight the importance of global financial services firms and their role in the interlinkages between key global centres.[4]

The role of real estate in the context of global cities is an under-researched area in both the economic geography and real estate literatures.[5] The economic base dominated by financial services has the effect that such cities will have a large number of property tenants – not only in the same industry, but also in many cases they will be the same firms. Lizieri et al. (2000) highlight the importance of financial services tenants in the context of London; by 1997, 50% of City of London office space was occupied by the financial services sector. If this is extended to include all finance, insurance and real

4 With respect to broader issues relating to connectivity, see also Derudder et al. (2003), Derudder & Taylor (2005), and Taylor & Aranya (2008).

5 Lizieri (2009*b*) is an honourable exception in this regard and builds on a continuing stream of work to highlight the linkages between globalization, financial services and property markets. In addition, Friedmann & Wolff (1982) discussed the importance of a property infrastructure and its importance for global cities. Furthermore, they noted that such markets may act as a destination for real estate investment.

estate (FIRE) firms and other business services, 87% of City occupation is included. Lizieri et al. also note that over one-third of City offices were occupied by foreign tenants. However, what is important is not only that real estate investment is concentrated in such markets, but also that global financial activity is concentrated in the same markets. Beaverstock et al. (2000) note that London's corporate connections in the banking and finance industry are concentrated in seven centres: New York, Hong Kong, Singapore, Tokyo, Frankfurt, Paris and Zurich. Beaverstock & Smith (1996) highlight this in the context of employment in the investment banking sector, with one-third of London's employment flows heading to New York and nearly 75% to just six centres: New York, Tokyo, Hong Kong, Paris, Sydney and Madrid. In addition, research by Kern (2010) reveals that more than 75% of all global investment banking revenue occurs in the United States and European Union, and the main equity markets of the United States, European Union, Japan, Singapore and Hong Kong still comprise 79% of equity trading. Furthermore, 70% of all fixed-income securities are registered in the European Union and United States and over half of global foreign exchange trading takes place in the UK and the USA.

The influence of the capital markets may be enhanced due to their role as a key demand factor in the office sector. The evidence of increased integration in the capital markets has the implication of further increasing the risk to which real estate investors are potentially open (for example, Lin et al. 1994, Bekaert & Harvey 1995, Richards 1995, Ammer & Mei 1996, Bekaert et al. 2002, 2005, 2006). The integration of global financial markets may also lead to increasing convergence in the corporate performance of tenants in such markets. Dehesh & Pugh (1999, 2000) note that changes in the global economic system have, amongst other things, led to a process of deregulation, one consequence of which has been increased capital flows. They argue that during periods of domestic economic stability, property cycles are largely endogenous and primarily driven by disequilibrium in the sector. However, in times of economic instability they are exogenous. As global integration increases so does the risk of foreign shocks impacting upon real estate. It could also be argued that the deregulation that occurred in many markets in the financial services industry from the late 1970s onwards contributed to this exposure by aiding in the development and growth of the global financial services firms.

The importance of the economic base of the specific metropolitan area has been long established in the real estate literature. The role of economic driving forces in the determination of property returns is clearly established in a domestic localized context in the modelling literature (for example Wheaton 1999). This influence has also been illustrated in an international framework. Giussani et al. (1993) and D'Arcy et al. (1997) consider European markets and show the importance of GDP in the determination of rental values. In a global context, Quan & Titman (1999) consider seventeen global markets and find that not only rents, but also capital values are significantly re-

lated to economic variables such as GDP. Case et al. (2000) and De Wit & Van Dijk (2003) specifically consider metropolitan markets, and both papers confirm the importance of economic variables such as GDP or gross national product (GNP). The implications of such findings in a portfolio context are widespread. The importance of economic performance means that markets with similar underlying economic bases, and therefore similar systematic effects, may behave in a similar manner. This has the implication that simple geographic diversification – at both national and international levels – may not guarantee diversification. A number of domestic studies in the UK and USA have considered the portfolio implications, and as an extension have sought to group together markets with a similar economic base (for example Miles & McCue 1982, Goetzmann & Wachter 1995, Hoesli et al. 1997, Hamelink et al. 2000, Jackson 2002). In a global setting, evidence has been more limited. Goetzmann & Wachter (2001) undertake a similar analysis to that contained in the domestic study of Goetzmann & Wachter (1995). However, the global analysis is constrained due to its concentration on the crash of the late 1980s and early 1990s; their findings of strong international and continental affects must be viewed in this context.

The few empirical papers that have considered the implications of such effects from the perspective of a portfolio manager have reported largely consistent findings. Jackson et al. (2008) and Brooks & Tsolacos (2008) report evidence of co-integration with respect to the London and New York office markets and – in Brooks & Tsolacos (2008) – Tokyo as well. A recent paper by Lizieri (2009*a*) analyses twenty-eight global cities using principal components analysis. The results provide evidence of a global factor, with the first component explaining 38% of the variation in the rental data analysed, and all but eight of the markets having loadings in excess of 0.50.

The combination of both common economic driving forces and possible flow of funds effects may have the effect of constraining the diversification opportunities available. The final implication relates to the role of real estate in a mixed-asset portfolio. If the major global office markets are dominated by financial services firms as occupants, then this could result in (or contribute to) a strong correlation between real estate assets and financial assets. Froland et al. (1986) was one of the earliest papers to highlight the increased link between real estate markets (such as New York) and the stock market, and therefore reduced diversification in a multi-asset context. More recently, Stevenson & Young (2011) highlight the relation between the financial markets and the London office markets in a vector autoregression framework. A paper by Heathcote & Perri (2004), which considers financial and economic integration, is also of interest in this regard. They note that whilst real economic integration has weakened in recent decades, financial integration has strengthened. Such findings may initially appear to be beneficial in terms of the diversification potential inherent in real estate. However, the linkages between financial services and the capital markets and the primary global office market means that investors in such markets do not necessar-

ily benefit from reduced real economic integration. In addition, Heathcote & Perri argue that through increased capital flows, financial globalization reduces correlations in GDP, whilst at the same time financial globalization is endogenous to real shocks.

3 DATA AND METHODOLOGICAL FRAMEWORK

The data used in this study consist of rental and capital value figures for twenty of the largest office markets globally. The markets include a selection of key centres in Europe, the United States and the Asia-Pacific region. In Europe the markets examined are: Paris, Frankfurt, Milan, Amsterdam, Barcelona, Madrid, City of London, West End of London and Edinburgh. For the United States the following major cities are included in the analysis: Boston, Chicago, Los Angeles, New York, San Francisco, Seattle and Washington, DC. Lastly, the following cities are included from the Asia-Pacific region: Hong Kong, Singapore, Tokyo and Sydney. As Table 1 illustrates, seven of the cities selected are in the 2010 GFCI 8 (Global Financial Centres Index) top-ten ranked global financial services centres. In many cases, the choice of cities analysed was dictated to by the availability of data. The data are quarterly and extend from 1990 to 2009. Unavailability of data for markets such as Geneva, Zurich, Toronto and the Chinese markets necessitated their exclusion from the sample. However, the final sample does include the majority of the world's major global financial services centres.

Table 1: Global Financial Centres Index (GFCI) rankings of global financial centres

	GFCI 8 rank	GFCI 7 rank
London	1	=1
New York	2	=1
Hong Kong	3	3
Singapore	4	4
Tokyo	5	5
Shanghai	6	11
Chicago	7	6
Zurich	8	7
Geneva	9	8
Sydney	10	=9

Note: Rankings of the GFCI were produced by the Qatar Financial Centre.

There is a fundamental difficulty in the analysis of direct commercial property performance in a global context caused by the lack of long-term data series and the lack of a consistent global property dataset. A database of capital value and rental indexes for offices from various data providers was compiled in order to make a global analysis possible. The data sources are CBRE for Europe, Jones Lang LaSalle (JLL) for the Asia-Pacific region and Property & Portfolio Research (PPR) for the United States. All variables are in local currency. The differences in definitions of rents and capital

values reflect local market practices. The rent and capital value data for Europe and the Asia-Pacific region are for prime office property, while for the United States they reflect average transacted rent and capital values. In many of the European and Asian property markets prime rents and capital values are the only data available over more than the last ten years. Prime rents are recorded as at the end of each quarter, and are based on an opinion of the rent that would normally be achieved for high-quality space in the central business district (CBD) based on market transactions in the absence of special circumstances. Capital values data in the Asia-Pacific region are based on transactions observed for prime office space in the CBD in each time period. Capital values for Europe are derived from prime rents and prime initial yields observed on transactions. The US capital values, from PPR, are derived from net operating income (NOI) and cap rates.

Table 2 provides details of the average returns of both the rental and capital value series. These summary statistics are provided in both nominal and real terms. The rationale behind considering both nominal and real returns is that whilst real returns may provide insights into underlying fundamentals, nominal returns are what investors actually obtain. It is quite clear that (particularly in real terms) the markets in general have not delivered impressive performance during the last two decades. With respect to rents, only Amsterdam, New York, San Francisco and Hong Kong have seen positive average real returns. In the case of capital values, only six cities have seen positive average real returns: Amsterdam, the West End of London, Edinburgh, Hong Kong, Tokyo and Sydney. These results are in part due to the extreme falls observed since 2007. This also explains why even in nominal terms some markets have seen negative average figures. For example, the City of London market saw nominal capital values fall by 55% in the two years to June 2009.

The methodology adopted in this paper, however, is not biased by extreme movements as it uses state variables that merely consider whether a market is in a state of expansion or contraction. The methodological approach is based upon a measurement of concordance that has been empirically used in the context of business cycles. Harding & Pagan (2002) propose a non-parametric approach to estimating the level of concordance between two growth rate series. The growth rates are expressed as two binary random variables, S_{it} and S_{jt}, which are the state variables for cycles for markets i and j. The state variables are defined as dummy variables equalling unity when the cycle is on an upward trend, so in the case of the real estate data used in this study a positive period return, and zero otherwise. The average values of the state variables for each market are displayed in Table 3. Using these two state variables, the index of concordance (IC) between two cities

provides the information about the proportion of time two cycles spend in the same phase. The simple index can be calculated as follows:

$$IC = T^{-1} \sum_{t=1}^{T} \left(S_{jt} S_{it} + (1 - S_{jt})(1 - S_{it}) \right) \tag{1}$$

This statistic can also be adapted in what has been referred to as the mean-corrected index of concordance (MCIC). This adaptation, proposed by Harding & Pagan (2001), is designed to adjust the initial indicator for potential biases. Harding and Pagan note that the original IC measure might be overstated in the case of two variables that experience prolonged expansion during the period of study. Prolonged growth over a number of consecutive periods is a common feature of real estate and economic cycles' data. Therefore, with regard to a possible bias in the CI statistic, the authors propose the MCIC under the assumption of no relation between two series. In comparison with the original IC statistic, the MCIC measures the proportion of time that two series are expected to share in the same phase under an assumption of independence. The adapted MCIC measure is as follows:

$$MCIC = 2T^{-1} \sum_{t=1}^{T} \left((S_{it} - \bar{S}_i)(S_{jt} - \bar{S}_j) \right) \tag{2}$$

where

$$\bar{S}_i = T^{-1} \sum_{t=1}^{T} S_{it} \tag{3}$$

$$\bar{S}_j = T^{-1} \sum_{t=1}^{T} S_{jt} \tag{4}$$

This methodology has been widely used not only in the context of business cycles (for example Altavilla 2004, Harding & Pagan 2001, 2002), but also in office markets (Jackson et al. 2008). However, both concordance measures can be difficult to assess and interpret. The MCIC is unlikely to exceed 0.5, whilst the assumption of independence is a strong assumption to make. The original IC values lie within the interval $[0, 1]$, where 1 implies perfect synchronization. In this case, the value of 0.5 would mean no particular relation between two series. However, the values that exceed 0.5 cannot be interpreted as statistically meaningful based on the index value information. To overcome such limitations, Harding & Pagan (2006) propose an alternative MCIC ($\hat{I}_t$), which also allows inferences to be drawn about the concordance index values.

Harding and Pagan show that $\hat{I}_t$ and the empirical correlation between two series($\hat{\rho}_s$)are monotonically related and the significance of $\hat{\rho}_s$ implies significance of $\hat{I}_t$. They express the revised concordance index as follows:

$$\hat{I}_t = 1 + 2\hat{\rho}_s \sigma_{s_x} \sigma_{s_y} + 2\mu_{s_x} \mu_{s_y} - \mu_{s_x} - \mu_{s_y} \tag{5}$$

Table 2: Average returns (%)

	Nominal Rents	**Real Rents**	**Nominal Capital Values**	**Real Capital Values**
Paris	0.219%	-0.194%	-0.111%	-0.520%
Frankfurt	0.012%	-0.450%	-0.263%	-0.720%
Milan	0.500%	-0.226%	0.470%	-0.258%
Amsterdam	0.754%	0.202%	0.813%	0.262%
Barcelona	-0.179%	-0.986%	-0.220%	-1.025%
Madrid	0.041%	-0.770%	-0.156%	-0.963%
London: City	-0.278%	-0.820%	-0.181%	-0.722%
London: West End	0.444%	-0.108%	0.897%	0.341%
Edinburgh	0.452%	-0.101%	0.630%	0.073%
Boston	0.293%	-0.345%	0.007%	-0.627%
Chicago	0.548%	-0.088%	-0.561%	-1.190%
Los Angeles	-0.048%	-0.682%	-0.917%	-1.544%
New York	0.736%	0.097%	-0.249%	-0.881%
San Francisco	1.077%	0.434%	0.205%	-0.430%
Seattle	0.618%	-0.020%	0.348%	-0.288%
Washington D.C.	0.273%	-0.361%	-0.048%	-0.681%
Hong Kong	0.732%	0.064%	1.714%	1.036%
Singapore	0.234%	-0.164%	0.387%	-0.013%
Tokyo	-0.759%	-0.800%	0.678%	0.752%
Sydney	0.516%	-0.107%	0.642%	0.019%

Notes: Table 2 presents the average quarterly returns for each of the twenty office markets are presented. Both rental and capital value returns are reported and in both nominal and real terms.

Table 3: Average figures for state variables

	Nominal Rents	**Real Rents**	**Nominal Capital Values**	**Real Capital Values**
Paris	0.240	0.240	0.347	0.347
Frankfurt	0.173	0.213	0.200	0.240
Milan	0.253	0.280	0.307	0.307
Amsterdam	0.227	0.293	0.280	0.307
Barcelona	0.280	0.293	0.373	0.360
Madrid	0.373	0.373	0.427	0.413
London: City	0.427	0.427	0.453	0.467
London: West End	0.373	0.400	0.467	0.480
Edinburgh	0.267	0.293	0.387	0.373
Boston	0.573	0.533	0.533	0.533
Chicago	0.600	0.440	0.427	0.320
Los Angeles	0.480	0.347	0.480	0.387
New York	0.693	0.613	0.640	0.493
San Francisco	0.613	0.587	0.533	0.533
Seattle	0.573	0.453	0.533	0.493
Washington D.C.	0.520	0.467	0.533	0.440
Hong Kong	0.547	0.520	0.587	0.600
Singapore	0.440	0.427	0.280	0.320
Tokyo	0.320	0.333	0.564	0.590
Sydney	0.580	0.420	0.696	0.551

Note: Average figures for the state variables for each of the twenty office markets are presented. Both rental and capital value returns are reported and in both nominal and real terms.

where μ_{s_i} and σ_{s_i} are the average and standard deviation (SD) of the state variables $S_i (i = x, y)$; and $\hat{\rho}_s$ is the correlation between σ_{s_x} and σ_{s_y}. The value of $\hat{\rho}_s$ and inferences concerning it can be derived using the following ordinary least squares (OLS) regression:

$$\frac{S_{y_t}}{\sigma_{s_x}\sigma_{s_y}} = \hat{\alpha} + \hat{\rho}_s \frac{S_{x_t}}{\sigma_{s_x}\sigma_{s_y}} + \epsilon_t \tag{6}$$

In order to control for positive serial correlation inherent in S_{y_t}, the $\hat{\rho}_s$ test-statistics are estimated using robust standard errors obtained via the HAC (heteroskedasticity and autocorrelation consistent) procedure. Harding and Pagan also note that the alternative estimation of the index via $\hat{\rho}_s$ provides an alternative MCIC. Since the assumption is that the concordance of two independent series is measured, the regression helps one to identify which relations between two series are significant and validate the information about the degree of their synchronization. In a case when $\hat{\rho}_s$ is insignificant, the high concordance between two series might be caused by the prolonged expansion phase in both series during the time period under examination, which is a common feature of both real estate and macroeconomic data. The empirical analysis is conducted on a pairwise basis across all twenty markets. Both the rental and capital value series are considered and in both real and nominal terms.

4 EMPIRICAL ANALYSIS

This section initially concentrates upon the empirical findings with respect to the rental series; it then expands this to consider the changes in property values. The rationale behind this is that the economic diversification argument would intuitively be expected to impact upon rental values. The common economic driving forces, relating to the role of financial services, would be expected to have a common effect upon occupier demand, and therefore possibly lead to increased synchronization across the markets. Any common movement in capital values adds to this impact the effect of common investor behaviour.

Table 4 presents the modified concordance indicators using the Harding & Pagan (2006) methodology; and the estimates of rho from each of the pairwise regressions are reported in Table 5. As noted in the third section, these provide information regarding the significance of the concordance indicators. In both Tables 4 and 5 the upper triangle reports the nominal results, and the lower one presents the findings with respect to changes in real rents. The results show a high degree of concordance, and more importantly, a level of synchronization that is statistically significant. In addition, whilst the majority of the markets display a significant level of concordance, there are also indications of continental effects – consistent with findings in papers such as Goetzmann & Wachter (2001).

Within each continental area there is substantial evidence of concordance. This is particularly evident in the case of the United States. In both nominal and real terms, every pairing provides a significant result. This is also the case with respect to the Asian markets of Hong Kong, Singapore and Tokyo. Sydney appears to be slightly discordant with these markets, the only significant finding being that for nominal rents when it is paired with Singapore. Europe, however, provides a greater intra-continental level of variation. Of the thirty-six European pairings, fourteen are not significant in nominal terms and eight in real terms. To some degree there appears to a level of differentiation between the major global cities and remaining markets. The City of London market, for example, is not significantly synchronized with Frankfurt or Amsterdam in nominal terms, while the West End of London adds Paris, Milan and Edinburgh to this list. In contrast, as an example of a smaller centre, Edinburgh has significant results with respect to every European market with the exception of the West End of London. There are also a large number of markets for which Paris does not report significant findings. Indeed, in nominal terms the only significant rhos are with reference to the pairings with Madrid, the City of London and Edinburgh.[6] The overall inconsistency in the European findings is of interest particularly in the context of monetary union.

On a global level, there are a number of interesting findings. Whilst London's two markets are not synchronized with most of other European markets, they are with many markets elsewhere. The City of London's office market is significantly synchronized with all non-European markets in real terms and all but Hong Kong in nominal terms. The West End of London is synchronized with all markets with the exception of Hong Kong (nominal and real) and Sydney (real). This effect is also clearly evident with respect to Paris, which has significant rhos for every non-European market with the exception of Sydney in nominal terms, whilst Boston and Chicago are also not significant in real terms. In contrast, some of the other European markets, particularly Frankfurt, Milan and Amsterdam, show very few significant rhos. The lack of significant results with respect to the Asian cities, particularly in relation to a number of the US markets, is striking. No significance is reported for pairings that include Hong Kong, and neither Chicago nor Los Angeles are synchronized with Singapore or Tokyo. However, it is notable that Sydney rental values seem to behave similarly in terms of concordance with all of the American metropolitan areas.

6 An initial concern with the European data was related to the use of quarterly data. For a number of quarters in the first half of the sample the figures with respect to some of the European markets had a zero change. This comes into consideration as the state variables define an expansion as a return greater than zero. As a robustness check, all the tests were run with an alternative definition. In this case an expansion was defined as a return equal to or greater than zero. The results do not differ substantially in terms of the significance reported. They are available from the authors upon request.

Table 4: Concordance indicator rents

	Par	Fran	Mil	Ams	Bar	Mad	City	LWE	Edin	Bos	Chi	LA	NYC	SF	Sea	DC	HK	Sing	Tok	Syd
Paris	-	0.757	0.692	0.694	0.689	0.714	0.661	0.667	0.704	0.547	0.522	0.633	0.511	0.557	0.547	0.618	0.571	0.648	0.746	0.548
Frankfurt	0.765	-	0.770	0.680	0.809	0.711	0.598	0.648	0.733	0.524	0.542	0.609	0.417	0.489	0.565	0.573	0.488	0.586	0.657	0.480
Milan	0.689	0.760	-	0.709	0.807	0.728	0.627	0.608	0.771	0.537	0.560	0.670	0.501	0.500	0.537	0.586	0.468	0.591	0.637	0.552
Amsterdam	0.676	0.674	0.692	-	0.676	0.607	0.580	0.584	0.766	0.533	0.578	0.619	0.448	0.474	0.556	0.560	0.445	0.522	0.588	0.499
Barcelona	0.701	0.794	0.797	0.680	-	0.782	0.654	0.659	0.776	0.588	0.588	0.699	0.530	0.551	0.612	0.637	0.516	0.641	0.715	0.539
Madrid	0.714	0.709	0.708	0.622	0.798	-	0.755	0.787	0.750	0.741	0.691	0.804	0.691	0.758	0.741	0.764	0.610	0.715	0.823	0.587
London: City	0.661	0.612	0.557	0.570	0.644	0.755	-	0.684	0.667	0.773	0.776	0.810	0.752	0.764	0.773	0.823	0.533	0.693	0.746	0.705
London: West End	0.664	0.660	0.583	0.596	0.645	0.757	0.762	-	0.662	0.715	0.612	0.726	0.663	0.679	0.689	0.687	0.558	0.637	0.685	0.558
Edinburgh	0.701	0.818	0.745	0.680	0.760	0.773	0.722	0.719	-	0.622	0.574	0.660	0.541	0.610	0.645	0.623	0.527	0.628	0.675	0.525
Boston	0.560	0.579	0.529	0.590	0.590	0.726	0.758	0.755	0.639	-	0.816	0.850	0.906	0.940	0.947	0.863	0.573	0.732	0.650	0.705
Chicago	0.602	0.710	0.641	0.655	0.582	0.637	0.666	0.691	0.679	0.775	-	0.820	0.788	0.775	0.863	0.807	0.441	0.599	0.565	0.707
Los Angeles	0.694	0.736	0.661	0.700	0.751	0.845	0.769	0.794	0.777	0.829	0.729	-	0.811	0.794	0.857	0.853	0.533	0.641	0.635	0.723
New York	0.557	0.507	0.478	0.491	0.566	0.652	0.764	0.735	0.566	0.875	0.725	0.701	-	0.900	0.806	0.777	0.631	0.703	0.624	0.651
San Francisco	0.581	0.530	0.527	0.540	0.590	0.729	0.788	0.732	0.639	0.925	0.749	0.750	0.889	-	0.874	0.819	0.611	0.716	0.662	0.642
Seattle	0.635	0.675	0.604	0.642	0.642	0.779	0.785	0.730	0.691	0.867	0.852	0.826	0.780	0.836	-	0.863	0.546	0.706	0.650	0.676
Washington D.C.	0.691	0.618	0.615	0.653	0.629	0.739	0.797	0.742	0.629	0.800	0.812	0.761	0.819	0.822	0.906	-	0.520	0.654	0.679	0.737
Hong Kong	0.618	0.482	0.469	0.481	0.578	0.661	0.639	0.611	0.554	0.587	0.387	0.557	0.611	0.612	0.533	0.547	-	0.707	0.736	0.460
Singapore	0.661	0.568	0.582	0.545	0.668	0.703	0.707	0.652	0.619	0.709	0.507	0.648	0.677	0.732	0.627	0.614	0.722	-	0.846	0.637
Tokyo	0.732	0.634	0.624	0.612	0.741	0.807	0.758	0.700	0.663	0.621	0.520	0.668	0.618	0.675	0.675	0.690	0.748	0.842	-	0.556
Sydney	0.603	0.611	0.652	0.667	0.660	0.652	0.673	0.585	0.671	0.718	0.684	0.750	0.673	0.687	0.728	0.702	0.539	0.627	0.540	-

Note: Concordance indicators were estimated using the methodology of Harding & Pagan (2006). The upper triangle provides the results in nominal terms and the lower in real terms. The concordance indicator was estimated using the following formula:

$$\hat{I}_t = 1 + 2\hat{\rho}_s \sigma_{s_x} \sigma_{s_y} + 2\mu_{s_x} \mu_{s_y} - \mu_{s_x} - \mu_{s_y}$$

Table 5: Estimates of $\hat{\rho}_s$ with rental data

	Par	Fran	Mil	Ams	Bar	Mad	City	LWE	Edin	Bos	Chi	LA	NYC	SF	Sea	DC	HK	Sing	Tok	Syd
Paris	-	0.268	0.172	0.146	0.196	0.358***	0.290**	0.244	0.218*	0.201*	0.178*	0.286**	0.283***	0.279***	0.201*	0.301***	0.224**	0.275**	0.382***	0.212
Frankfurt	0.331**	-	0.332**	0.004	0.487***	0.350***	0.134	0.179	0.241*	0.193*	0.289***	0.254**	0.125	0.170	0.302***	0.226**	0.048	0.123	0.113	0.087
Milan	0.196	0.365***	-	0.205	0.508***	0.394***	0.212*	0.109	0.405***	0.169	0.256**	0.368***	0.240**	0.132	0.169	0.220*	-0.021	0.143	0.118	0.212
Amsterdam	0.175	0.148*	0.247*	-	0.148*	0.094	0.095	0.037	0.373***	0.177*	0.322***	0.259***	0.139	0.088	0.232***	0.169*	-0.070	-0.026	-0.027	0.103
Barcelona	0.239**	0.470***	0.504***	0.228**	-	0.522***	0.275**	0.237**	0.436***	0.270**	0.300**	0.423***	0.278**	0.232*	0.325***	0.325***	0.082	0.258**	0.324**	0.168
Madrid	0.358***	0.343***	0.351***	0.159	0.558***	-	0.493***	0.544***	0.445***	0.542***	0.456***	0.618***	0.538***	0.609***	0.542***	0.558***	0.253	0.416***	0.615***	0.224
London: City	0.290**	0.173	0.057	0.088	0.251*	0.493***	-	0.345***	0.305**	0.581***	0.600***	0.622***	0.615***	0.583***	0.581***	0.660***	0.081	0.374***	0.475***	0.443***
London: West End	0.267*	0.256**	0.089	0.122	0.233**	0.489***	0.511***	-	0.241	0.488***	0.289**	0.457***	0.476***	0.440***	0.433***	0.397***	0.145	0.253*	0.309**	0.165
Edinburgh	0.239*	0.534***	0.376***	0.228**	0.421***	0.501***	0.425***	0.399***	-	0.356***	0.278**	0.342***	0.322***	0.379***	0.411***	0.299***	0.111	0.227*	0.221	0.143
Boston	0.182	0.239**	0.096	0.229**	0.229*	0.486***	0.532***	0.536***	0.336**	-	0.622***	0.714***	0.827***	0.879***	0.891***	0.729***	0.134	0.491***	0.382**	0.396***
Chicago	0.167	0.431***	0.258*	0.288***	0.126	0.253*	0.320**	0.368***	0.342**	0.563***	-	0.662***	0.552***	0.528***	0.719***	0.620***	-0.140	0.227	0.221	0.396***
Los Angeles	0.280**	0.380***	0.219*	0.316***	0.434***	0.665***	0.524***	0.565***	0.493***	0.714***	0.445***	-	0.692***	0.614***	0.728***	0.709***	0.071	0.279	0.275	0.459***
New York	0.279**	0.179	0.063	0.085	0.253**	0.384***	0.583***	0.540***	0.253**	0.757***	0.493***	0.509***	-	0.793***	0.610***	0.585***	0.246	0.494***	0.451***	0.264*
San Francisco	0.299***	0.199*	0.147	0.170*	0.280**	0.526***	0.617***	0.517***	0.390***	0.854***	0.530***	0.591***	0.771***	-	0.743***	0.645***	0.207	0.474***	0.446***	0.258*
Seattle	0.260**	0.363***	0.187	0.270***	0.270**	0.555***	0.565***	0.452***	0.378***	0.746***	0.702***	0.657***	0.600***	0.702***	-	0.729***	0.080	0.437***	0.382**	0.336**
Washington D.C.	0.407***	0.243**	0.225*	0.307***	0.254*	0.479***	0.593***	0.482***	0.254*	0.607***	0.621***	0.529***	0.671***	0.668***	0.811***	-	0.037	0.316*	0.400**	0.474***
Hong Kong	0.301***	-0.017	-0.049	-0.024	0.190	0.344**	0.286*	0.235*	0.137	0.171	-0.222	0.132	0.218	0.220	0.071	0.096	-	0.431***	0.544***	-0.096
Singapore	0.290**	0.064	0.111	0.033	0.306**	0.384***	0.400***	0.283**	0.197	0.432**	-0.004	0.267	0.402***	0.503***	0.245	0.222	0.456***	-	0.701***	0.299**
Tokyo	0.360***	0.100	0.120	0.100	0.400***	0.580***	0.500***	0.360***	0.220	0.280	0.000	0.260	0.340**	0.440***	0.340*	0.380**	0.540***	0.680***	-	0.184
Sydney	0.145	0.160	0.264**	0.298**	0.283*	0.277*	0.330**	0.142	0.308**	0.453***	0.355***	0.480***	0.397***	0.412***	0.449***	0.399***	0.086	0.236	0.029	-

Note: Estimates of $\hat{\rho}_s$ were based on the following ordinary least squares (OLS) specification:

$$\frac{S_{y_t}}{\sigma_{s_x}\sigma_{s_y}} = \hat{\alpha} + \hat{\rho}_s \frac{S_{x_t}}{\sigma_{s_x}\sigma_{s_y}} + \epsilon_t$$

The results reported are with respect to rental data. The upper triangle provides the results in nominal terms and the lower in real terms. *Significance at the 10% level, **significance at the 5% level and ***significance at the 1% level.

The corresponding findings with respect to capital values are reported in Tables 6 and 7. The results are broadly similar to those relating to rents. As with the rental figures, London and Paris have a higher degree of concordance with American and Asia-Pacific markets than with other European markets. Indeed, the City of London is synchronized with every US and Asia-Pacific market. Similar results as reported with regard to rents are also found in terms of the interlinkages across Asian and US markets, Hong Kong's relative lack of concordance with other markets, and Sydney's strong connections with the United States. Whilst the results do reveal some evidence of continental discordance, the overall degree of concordance is quite evident. This is particularly so in the case of London and to some degree Paris and also New York. This is consistent not only with their roles as three of the largest office markets, but also with the global cities literature – which generally place London and New York as the two core global cities.

The similarities in the cyclical behaviour of the majority of the world's office markets raises the question as to why, if diversification opportunities are reduced, investors pursue a portfolio strategy that involves such a degree of concentration in a small number of interconnected markets. The concentration of investment can be viewed in the context of a constraint property investors continually face, namely one of availability of product. Real estate is a relatively small asset class; this can be seen by comparing the overall values of real estate with that of other asset classes. Chin et al. (2007) estimates that in 2006 the value of all invested real estate globally was $7.8 trillion. If the definition is extended to consider all investable real estate, thereby including owner-occupied properties, the figure rises to $12.4 trillion. Compared with the total value of other asset classes, this is a relatively small amount. For example, the World Federation of Exchanges estimates that at the end of 2009, the total market capitalization of global stock exchanges stood at $49 trillion, of which $15 trillion was in the US markets alone. The Securities Industry and Financial Markets Association (SIFMA) estimates that in 2009 the total amount of fixed-income securities outstanding in the United States alone was $34 trillion.[7]

Furthermore, the nature of real estate as an indivisible asset that is held for relatively long holding periods also has an impact. As only a small proportion will be available for transaction at any one time, transaction volume is relatively low. This can be illustrated using stock and flow figures. Chin et al. (2007) estimates that the value of European real estate in 2006 was $2.4 trillion; and Jones Lang LaSalle (2010) estimates that annual investment volume in European real estate averaged only €138 billion during the 2000s, reaching a peak of over €250 billion in 2006. In contrast, capital market assets are highly divisible and highly liquid, and huge volumes are traded each year. Whereas World Federation of Exchanges' data reveals that the

7 The data cited from the World Federation of Exchanges and the Securities Industry and Financial Markets Association were obtained from their respective websites (see http://www.world-exchanges.org/ and http://www.sifma.org).

market capitalization of the US equity markets stood at $15 trillion in 2009, trading volume during the year was in excess of $46 trillion. During the ten years from 2000, the ratio of trading volume to market capitalization averaged 2.31, and has been consistently above 1.0 since 1998. With respect to the fixed-income market, SIFMA data illustrate that trading volume in the US bond market has exceeded $200 trillion in each year since 2004, and that the average ratio of trading volume to debt outstanding was in excess of 7 during the last decade. These figures highlight that not only is real estate a relatively small asset class, but also that there is far less trading activity in real estate compared with financial assets. The global office markets, however, have a major advantage relative to smaller property markets: enhanced availability of product and higher liquidity. Liquidity risk is the most important primary risk factor for institutional investors in the context of property investment, as illustrated by Dhar & Goetzmann (2005). It may therefore be that global investors view the possible benefits from investing in deeper and more liquid markets sufficient to offset any loss of diversification benefit.

The concentration of investment may also lead to further risk factors. If global investors are increasingly dominating investment in major office markets, then it is possible that such centres are subject to flow-of-funds effects. This means that not only do such markets have common characteristics with respect to the occupier market and therefore rental income, but also with respect to yield movements. This is an important point as it provides an additional degree of integration between the markets. Whilst substantial differences between the results using rental and capital value data are not seen here, the study of Jackson et al. (2008) does provide supporting empirical evidence in the context of New York and London. Indeed, in some respects this can also be linked back to the global cities literature. Castells (1996) argues that issues such as the flow of information and capital through the global cities is more important than their fixed attributes. Lizieri (2009*a*) makes a similar, but not identical, point. He argues that the fact that so many investors are also financial services firms can lead to increased risk and volatility.

It may be the case that that investors would be better served by expanding their investment portfolio into smaller regional markets. However, this is subject to two key issues being satisfied. Firstly, that regional markets behave sufficiently differently from the major centres; and secondly, that investors are prepared to alter their investment strategies in such a way. In relation to the first point, the current study does not explicitly consider the behaviour of regional provincial markets and, furthermore, the existing empirical evidence in the context of most major markets is relatively limited. However, the available evidence suggests that the degree of divergence varies from country to country; whereas in some markets such benefits may be observed, it may not be the case in others. In relation to investor behaviour, real estate is a relatively small asset class, and it is also an illiquid one. Investors value the importance of both the size and depth of a market

and its relative liquidity (Dhar & Goetzmann 2005). The problem that many smaller regional markets face is that they are potentially insufficiently liquid to attract institutional interest. The combined effect for a major institutional investor is a trade-off between economic diversification and liquidity. If an investor has a preference for enhanced liquidity then this leaves them with the challenge of achieving diversification within an integrated system of office markets.

5 CONCLUSIONS

This paper has considered the level of concordance between twenty of the largest office markets globally. The results highlight the degree of synchronization in the cyclical behaviour of the markets considered. The importance of these findings is in relation to the diversification benefits available to international real estate fund managers, especially in light of the fact that such a high proportion of cross-border investment is concentrated in key markets such as London and New York. The combination of common underlying economic driving forces and common investors effectively means that global real estate investors are gaining little in terms of diversification, and are therefore also increasing their risk by concentrating investment in these markets. This paper highlights that whilst institutional investors may be constrained due to risk factors such as liquidity, the pursuit of an investment strategy that is concentrated in global cities has its own consequences. It is clearly shown here that there are previously unrecognized risks involved in such a strategy. This applies not only in the context of real estate-only portfolios. Multi-asset class portfolio managers are also potentially affected due to the linkages between the global office markets and the broad capital markets. This means that such managers may not be obtaining the asset-class diversification benefits associated with real estate investment.

Table 6: Concordance indicator capital values

	Par	Fran	Mil	Ams	Bar	Mad	City	LWE	Edin	Bos	Chi	LA	NYC	SF	Sea	DC	HK	Sing	Tok	Syd
Paris	-	0.713	0.615	0.644	0.704	0.648	0.596	0.634	0.716	0.595	0.674	0.697	0.572	0.595	0.595	0.671	0.518	0.701	0.663	0.599
Frankfurt	0.751	-	0.695	0.651	0.717	0.643	0.511	0.541	0.594	0.566	0.665	0.614	0.469	0.566	0.566	0.566	0.474	0.746	0.582	0.397
Milan	0.643	0.686	-	0.628	0.661	0.657	0.557	0.544	0.597	0.554	0.632	0.581	0.479	0.554	0.554	0.554	0.454	0.655	0.522	0.416
Amsterdam	0.670	0.662	0.627	-	0.708	0.582	0.556	0.543	0.621	0.601	0.678	0.627	0.527	0.601	0.601	0.601	0.454	0.653	0.648	0.425
Barcelona	0.718	0.751	0.649	0.726	-	0.729	0.597	0.610	0.639	0.726	0.781	0.752	0.655	0.726	0.726	0.726	0.572	0.733	0.733	0.497
Madrid	0.662	0.627	0.671	0.596	0.728	-	0.705	0.745	0.669	0.811	0.787	0.705	0.741	0.811	0.811	0.678	0.547	0.739	0.767	0.525
London: City	0.609	0.508	0.519	0.569	0.571	0.704	-	0.746	0.670	0.680	0.627	0.573	0.577	0.680	0.680	0.520	0.574	0.712	0.699	0.640
London: West End	0.646	0.541	0.531	0.581	0.609	0.717	0.826	-	0.793	0.747	0.695	0.720	0.674	0.747	0.747	0.693	0.615	0.698	0.746	0.624
Edinburgh	0.704	0.643	0.610	0.610	0.639	0.696	0.699	0.796	-	0.636	0.691	0.689	0.588	0.636	0.636	0.663	0.533	0.691	0.585	0.524
Boston	0.620	0.583	0.554	0.604	0.711	0.796	0.720	0.760	0.648	-	0.897	0.840	0.908	1.000	1.000	0.787	0.628	0.687	0.902	0.676
Chicago	0.764	0.746	0.692	0.745	0.835	0.731	0.677	0.749	0.796	0.807	-	0.837	0.796	0.890	0.890	0.784	0.520	0.768	0.796	0.557
Los Angeles	0.742	0.724	0.648	0.673	0.783	0.736	0.657	0.753	0.745	0.835	0.815	-	0.854	0.840	0.840	0.947	0.602	0.655	0.831	0.680
New York	0.659	0.620	0.617	0.617	0.724	0.651	0.626	0.693	0.661	0.826	0.805	0.857	-	0.879	0.879	0.879	0.546	0.568	0.727	0.724
San Francisco	0.620	0.583	0.554	0.604	0.711	0.796	0.720	0.760	0.648	1.000	0.767	0.819	0.827	-	1.000	0.787	0.628	0.687	0.902	0.676
Seattle	0.659	0.620	0.568	0.642	0.750	0.756	0.733	0.773	0.713	0.932	0.805	0.883	0.893	0.932	-	0.787	0.628	0.687	0.902	0.676
Washington D.C.	0.712	0.671	0.595	0.619	0.752	0.705	0.627	0.721	0.689	0.802	0.783	0.938	0.896	0.802	0.869	-	0.547	0.598	0.721	0.676
Hong Kong	0.532	0.453	0.466	0.466	0.571	0.547	0.602	0.588	0.480	0.615	0.505	0.599	0.602	0.615	0.657	0.629	-	0.540	0.789	0.549
Singapore	0.737	0.673	0.666	0.666	0.697	0.731	0.677	0.692	0.685	0.693	0.707	0.756	0.621	0.693	0.678	0.704	0.537	-	0.688	0.538
Tokyo	0.661	0.547	0.540	0.626	0.683	0.740	0.701	0.725	0.565	0.881	0.658	0.816	0.804	0.881	0.844	0.792	0.756	0.738	-	0.741
Sydney	0.617	0.465	0.424	0.558	0.545	0.547	0.708	0.636	0.575	0.619	0.585	0.603	0.692	0.619	0.692	0.634	0.564	0.612	0.554	-

Note: Concordance indicators were estimated using the methodology of Harding & Pagan (2006). The upper triangle provides the results in nominal terms and the lower in real terms. The concordance indicator was estimated using the following formula:

$$\hat{I}_t = 1 + 2\hat{\rho}_s \sigma_{s_x} \sigma_{s_y} + 2\mu_{s_x} \mu_{s_y} - \mu_{s_x} - \mu_{s_y}$$

Table 7: Estimates of $\hat{\rho}_s$ with capital value data

	Par	Fran	Mil	Ams	Bar	Mad	City	LWE	Edin	Bos	Chi	LA	NYC	SF	Sea	DC	HK	Sing	Tok	Syd
Paris	-	0.317**	0.127	0.180*	0.359***	0.267**	0.173	0.261*	0.391***	0.221*	0.322***	0.402***	0.252**	0.221*	0.221*	0.382***	0.096	0.312***	0.388***	0.363***
Frankfurt	0.421***	-	0.213*	0.053	0.365***	0.251**	-0.043	0.054	0.067	0.214**	0.305***	0.256**	0.139	0.214**	0.214**	0.214**	0.066	0.317**	0.305**	0.039
Milan	0.190	0.218*	-	0.103	0.252**	0.283**	0.085	0.068	0.118	0.146	0.228*	0.158	0.074	0.146	0.146	0.146	-0.027	0.169	0.102	-0.021
Amsterdam	0.253***	0.156	0.122	-	0.351***	0.111	0.080	0.064	0.162	0.257***	0.329***	0.263**	0.206*	0.257***	0.257***	0.257**	-0.018	0.140	0.396***	0.027
Barcelona	0.384***	0.435***	0.215*	0.389***	-	0.439***	0.178	0.211*	0.235*	0.486***	0.548***	0.511***	0.410***	0.486***	0.486***	0.486***	0.196*	0.407**	0.519***	0.104
Madrid	0.289**	0.196*	0.302**	0.137	0.431***	-	0.403***	0.486***	0.316**	0.639***	0.564***	0.408***	0.551***	0.639***	0.639***	0.371**	0.122	0.466***	0.564***	0.119
London: City	0.207	-0.021	0.014	0.121	0.129	0.404***	-	0.489***	0.329***	0.368***	0.245*	0.143	0.188	0.368***	0.368***	0.046	0.168	0.429***	0.414***	0.345***
London: West End	0.295**	0.073	0.051	0.158	0.216**	0.434***	0.652***	-	0.588***	0.500***	0.385***	0.438***	0.382***	0.500***	0.500***	0.393***	0.246**	0.410***	0.505***	0.298**
Edinburgh	0.359***	0.187*	0.138	0.138	0.223*	0.366***	0.395***	0.602***	-	0.296**	0.361***	0.378***	0.257*	0.296**	0.296**	0.350***	0.109	0.323**	0.206	0.152
Boston	0.275**	0.236**	0.146	0.254**	0.461***	0.614***	0.446***	0.525***	0.325**	-	0.814***	0.684***	0.833***	1.000***	1.000***	0.571***	0.249	0.450***	0.805***	0.354**
Chicago	0.471***	0.382***	0.284**	0.407***	0.635***	0.434***	0.355***	0.520***	0.554***	0.686***	-	0.675***	0.667***	0.800***	0.800***	0.586***	0.067	0.532***	0.623***	0.188
Los Angeles	0.447***	0.396***	0.231*	0.287***	0.537***	0.451***	0.307**	0.510***	0.460***	0.705***	0.603***	-	0.750***	0.686***	0.686***	0.900***	0.213	0.325*	0.674***	0.408***
New York	0.329***	0.273**	0.248**	0.248**	0.463***	0.304**	0.252*	0.386***	0.330**	0.654***	0.649***	0.730***	-	0.771***	0.771***	0.771***	0.046	0.302*	0.439**	0.384**
San Francisco	0.275**	0.236**	0.146	0.254**	0.461***	0.614***	0.446***	0.525***	0.325**	1.000***	0.600***	0.671***	0.657***	-	1.000***	0.571***	0.249	0.450***	0.805***	0.354**
Seattle	0.329***	0.273**	0.142	0.302***	0.516***	0.518***	0.466***	0.546***	0.437***	0.868***	0.649***	0.784***	0.787***	0.868***	-	0.571***	0.249	0.450***	0.805***	0.354**
Washington D.C.	0.409***	0.329***	0.156	0.210*	0.494***	0.398***	0.249*	0.442***	0.361***	0.617***	0.565***	0.879***	0.797***	0.617***	0.742***	-	0.084	0.251	0.439**	0.354**
Hong Kong	0.133	0.011	0.011	0.011	0.211*	0.133	0.222*	0.189	0.011	0.222	0.089	0.256	0.211	0.222	0.322*	0.289*	-	0.177	0.570***	0.033
Singapore	0.409***	0.199	0.223**	0.223	0.328**	0.434***	0.355***	0.397***	0.309**	0.441***	0.326*	0.473***	0.255	0.441***	0.377**	0.395**	0.159	-	0.487***	0.301***
Tokyo	0.402***	0.223*	0.166	0.353***	0.440***	0.527***	0.421**	0.465***	0.185	0.764***	0.416***	0.701***	0.620***	0.764***	0.701***	0.620***	0.495***	0.590***	-	0.474*
Sydney	0.280***	-0.021	-0.124	0.169	0.125	0.113	0.426***	0.277**	0.183*	0.233	0.222*	0.236	0.388***	0.233	0.388**	0.283*	0.110	0.280**	0.091	-

Note: Estimates of $\hat{\rho}_s$ were based on the following ordinary least squares (OLS) specification:

$$\frac{S_{y_t}}{\sigma_{s_x}\sigma_{s_y}} = \hat{\alpha} + \hat{\rho}_s \frac{S_{x_t}}{\sigma_{s_x}\sigma_{s_y}} + \epsilon_t$$

The results reported are with respect to rental data. The upper triangle provides the results in nominal terms and the lower in real terms. *Significance at the 10% level, **significance at the 5% level and ***significance at the 1% level.

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