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Convergence in the UK Direct Real Estate Market

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Abstract

This study examines the issue of convergence in the monthly returns, rental growth and yields for 10 market segments in the UK direct real estate market, using principal component analysis, over the period from 1987 to 2014. The principal component approach provides an assessment of the extent to which the variance of the market segments can be represented by a single common factor, explaining their long-run behaviour, and the degree of independence between the market segments.

The results suggest that there is strong evidence of convergence over the entire sample period in relation to monthly returns and yields but less evidence of convergence in rental growth, which confirms the findings in previous studies in international securitised and direct markets markets. There is also an indication that convergence is period-specific and was particularly strong in the period of the Global Financial Crisis.

The convergence in returns has crucial implications for investors as it leaves investors exposed to the same structural shocks and so magnifies the importance of volatility spillover effects, limits their ability to create well-diversified portfolios, and make it more difficult for fund managers to outperform the market.

Keywords: *UK direct real estate, Returns, Rents, Yields, Principal Component Analysis, Convergence*

Convergence in the UK Direct Real Estate Market

Introduction

It can be shown that all financial assets are driven by a small number of risk factors, where a factor is any characteristic that is important in explaining the risk and return of a group of assets. The factor structure of asset returns has crucial implications for the success of portfolio performance. For instance, if assets display the same factor structure an investor's ability to create a well-diversified portfolio is severely limited. But, if assets display differing factor structures it is easier to develop a well-diversified portfolio. Indeed, Meucci (2009) contends that portfolio managers comprehend a portfolio to be well-diversified if it is not heavily exposed to individual shocks, or factors.

The oldest and most well-known factor model is the Capital Asset Pricing Model (CAPM) of Sharpe (1964), Lintner (1965) and Mossin (1966), which suggests that there is only one risk factor that arises from exposure to the market and is captured by beta, the sensitivity of an asset's return to the market. Ross (1976) proposed a different theory of what drives asset returns, the Arbitrage Pricing Theory (APT). This approach suggests that the expected return of assets can be modelled as a function of various macroeconomic factors or theoretical market indexes. Importantly, unlike the CAPM, APT does not explicitly identify the number of priced factors. But the number of priced factors explaining the long-run cross-sectional performance of asset returns can be extracted through principal component analysis (Roll and Ross, 1980).

Becker and Hall (2009a and 2009b) argue the extent of convergence in asset returns, explaining their long-run behaviour, can be assessed by the similarity in the factor loadings and the percentage R^2 of the first principle component. For instance, if the first principle component explains only a small amount of the return variance and the factor loadings are largely random, i.e. with different signs and differing sizes, this implies that the asset returns move largely independently of each other, indicating low or no convergence in their cross-section performance in the long-run. In contrast, if the first principle component explains a large amount of the return variance and the factors loadings are systematic, i.e. show the same sign and are of a similar size, the greater the degree of convergence in their cross-section performance in the long-run.

Several studies have examined the convergence of returns in international securitised real estate markets and find that for some regions convergence is present, while for others it is not evident, and that convergence is time-varying. A few studies have also examine convergence in international direct real estate market and conclude that convergence is more prevalent in returns and yields rather than rental levels. But as far as the author knows no study has examined convergence in the UK direct real estate market.

This study makes three contributions to the literature. First, we examine convergence of 10 market segments in the UK direct real estate market using monthly returns, rental growth and yields. Second, we use the principal component analysis approach of Becker and Hall (2009a and 2009b) to test whether the UK real estate market has converged over time and the degree of independence between the market segments. Lastly, we test whether any convergence is period-specific, especially in periods of boom and bust.

The results show strong evidence of convergence in returns and yields but less evidence for rental growth, which confirms the findings in previous studies in international securitised and direct markets. There is also evidence that the convergence is period-specific and was particularly strong in the period of the Global Financial Crisis, which also confirms the findings in previous studies.

The remainder of this paper is structured as follows. Section 2 provides a review of the previous studies of convergence in international securitised and direct real estate markets. The data is presented in Section 3, while Section 4 outlines the methodology we use to test for convergence. Section 5 presents the results of convergence in monthly returns, rents and yields, over the entire sample period, and also tests whether convergence is period-specific. The implications of the findings are presented in section 6. The final section provides a summary and conclusions.

Previous Studies

Securitised Real Estate

A few authors have examined whether the returns in international securitised real estate markets are more or less integrated than the wider stock markets. For instance, Eichholtz (1996) found that the correlations of real estate securities across countries are lower than cross-border correlations between common stocks. Grissom and Lizieri (2003); Lizieri *et al*. (2003) and McAllister and Lizieri (2006) studied the integration of European stock markets and securitised real estate markets before and after the establishment of European Monetary Union (EMU). Using monthly data and a battery of statistical tests the authors find that while the wider stock markets show evidence of convergence in returns, real estate security markets showed less and slower integration, which the authors attribute to the small size of the real estate markets and the local nature of the holdings in property company portfolios.

The number of common factors also varies from country to country. For instance, using a multifactor approach and data over the period 1986 to 2002 Cauchie and Hoesli (2006) find that Swiss real estate funds returns are described by four sources of systematic risk; the stock market, innovations in the term structure premium, the unemployment rate and unexpected inflation. Using factor analysis techniques Liow (2004) investigated the presence of common factors in securitized real estate markets using 10-year monthly return data of 142 real estate securities in four markets: US, UK, Hong Kong and Singapore. The author finds that the number of common securitized real estate market factors are 7, 7, 6 and 2 in the US, UK, Hong Kong and Singapore, respectively. In contrast, Liow and Schnidler (2014) examined the integration between nine securitised real estate and nine stock markets at the local, regional, and global levels, using monthly data from January 1990:1 to 2011:1. The results indicated that five common factors generate returns, namely, two real estate factors, two local stock market factors, and one regional common stock market factor.

The result of previous studies also indicates that convergence is time-varying. For instance, Hamelink and Hoesli (2002) found that while the average rolling correlation coefficients were stable during the period 1990-2002, in the period mid-1996 to mid-1998 there was a notable drop in rolling average correlation probably reflecting the increase in currency volatility in the period 1992-1995. Brounen and Huisman (2007) using monthly data from 1997 to 2007 find that while some countries have become more related to the European factor others have become less dependent on the European factor. Using time-varying parameter

modelling techniques and monthly data over the period 1990 to 2007 Lee (2009a) examined the extent of convergence of the UK real estate market with the other countries in Europe, relative to the US. The results showed that for some periods the UK was converging with its neighbours within Europe, while for other periods the UK was more influenced by the returns in the US. Yunus (2009) investigated the dynamic interdependence among the securitized real estate markets of Australia, France, Hong Kong, Japan, Netherlands, UK, and US for the period 1990-2007. Using the recursive co-integration test and common trends analysis, the author finds that international securitized real estate markets are becoming increasing integrated, which would be indicative of increasing convergence over time. Liow (2012) finds that the conditional securitised real estate-stock correlations at the local, regional and global levels are time-varying and asymmetric and are influenced by relative (real estate/stock) volatilities. A finding confirmed by Liow and Schnidler (2014) who found that that the levels of local, regional, and global real estate and stock market correlations are time-varying.

Studies also show that the extent of convergence has been substantially affected by structural changes and financial crises. For instance, Yang *et al*. (2005) evaluated the impact of the Monetary Union on linkages among nine European real estate markets. The authors found that the larger Eurozone countries (Germany, France and the Netherlands) showed greater integration than the smaller Eurozone countries (Belgium and Spain). In addition, the authors find that the countries outside the single currency (Denmark, Switzerland and the UK) exhibited little change in integration following the introduction of EMU. In a similar vein, McAllister and Lizieri (2006) find that there was more evidence of integration in the 'core' Eurozone countries relative to 'non-core' Eurozone countries and non-Eurozone countries following the introduction of the Euro. Liow and Schnidler (2014) found that the securitised real estate and stock markets became more correlated in the periods of high volatility, such as the period of the Global Financial Crisis. Liow (2012) however finds that while that the risk-return convergence of 12 developed securitised real estate markets with the global real estate portfolio remained fairly stable over the 1990-2011 period, most of the markets were more "divergent" as well as being more volatile, during the Asian Financial Crisis and the Global Financial Crisis periods. The Global Financial Crisis having a greater impact on divergence than the Asian Financial Crisis. In a similar vein, Hatemi-J *et al*. (2014) find that the US real estate market crisis made the US real estate market more integrated globally but resulted in the Japanese market becoming less integrated internationally.

There are also differences in the convergence of local securitised markets with the global securitised market. For instance, Liow (2010) found that 13 global developed securitized real estate markets are more integrated with their local stock market while only weakly integrated with the global stock and global real estate markets. Hatemi-J *et al*. (2014) tested the extent of integration with the world market of four real estate markets: Australia, Japan, the UK and the US. The authors find that the US and the UK are the most integrated, while Australia is the least integrated, with the world market. In other words, the integration of local markets with the world index is not a foregone conclusion. An assumption confirmed by Andrews and Lee (2008) who used the time-varying integration score approach of Akdogan (1996, 1997), as extended by Barari (2004), and monthly data over the period 1990:1 to 2007:12 to examine the extent of global and regional integration in nine European countries. The results' indicate that both the level of global and regional integration for real estate securitised markets in Europe has on average increased since 1990, although the effect varied from country to country.

A few authors have examined whether securitised real estate markets display a regional dimension. For instance, Eichholtz, *et al*. (1998) used monthly data over the period 1984 to 1996 and a multi-factor model to examine the extent to which real estate returns are driven by continental factors. The authors concluding that a continental factor clearly exists in Europe and North America, but not in the Asia-Pacific region. Liow (2012) and Liow and Schnidler (2014) also found two regional groups (Asia and non-Asia). Lee (2009b) found however that that the extent of convergence of the securitised real estate market within Asia is not a simple process, with some countries showing strong and lasting relationships while others show little, or no, evidence of convergence. More importantly, Chuangdomrongsomsuk and Lizieri (2013) argue that even if a national index is independent from, or co-integrated with, it's regional or the global market there is no guarantee that an individual firm's performance is similarly independent or co-integrated. The authors therefore examined the returns of individual firms with a high exposure to global cities, to see whether differences occur below the national level of analysis. The results demonstrate clearly that integration at the regional and national level differs across sectors; i.e. countries that are regionally co-integrated at the aggregate level may be independent at a sector level. Further, the results suggest that the impact of regional location in determining diversification benefits varies by sector. The office, retail and international financial centre portfolios are more driven by common global factors and the level of inter-regional co-integration is stronger. In other words, although the performance of a country may be globally driven at the aggregate level, particular sectors may be independent while other sectors or cities may be more co-integrated with other countries and convergent with the global market benchmark.

Direct Real Estate

Goetzmann and Wachter (1999) used principal component analysis on annual office returns for 24 countries for the period from 1985 to 1993 "in order to identify meaningful clusters of countries which moved together in the past, and which are likely to move together in the future." The authors found that the first principal component explained 44% of the variation in global office market returns. In other words, there appears to be at least one, strong, common factor that drove international office markets, suggestive of global market integration. Nonetheless, Goetzmann and Wachter (1999) find that country-specific GDP changes help explain more of the variation in real estate returns than the global factor.

Using the Johansen co-integration technique and quarterly total return data from the Property Portfolio Research (PPR) database over the period 1990:Q1 to 2007:Q4 Brookes and Tsolacos (2008) examined the co-integration in each of the pairs of the three CBD office markets in New York, London and Paris. The authors find that the Johansen test suggests that in the long-run the three cities move together and as such any diversification benefits will only be achieved in the short-run. The strongest link is between London and New York, while the Paris office market barely adjusts to movements in the other two markets.

Jackson *et al*. (2008) examined the total returns and rental data of the New York City and City of London office sub-markets to test the hypothesis that the two largest financial centres behave in a similar fashion. Using Johansen co-integration techniques, Granger causality tests and the Harding and Pagan (2002) concordance approach the authors find that total returns of the New York City and the City of London sub-markets display strong long run relationships and causal links, which suggest that a common economic factor plays an important role. In contrast, the same was not true for the rental series. The lack of significant findings in the rental data leading the authors to speculate that it is the yield movements

between the two markets which is influencing capital values, and therefore total returns, an argument that the authors could not pursue due to lack of yield data.

McAllister (2008) used the β-convergence and σ-convergence tests to examine the convergence in the rental levels for 24 European office markets from 1999 to 2006. The convergence tests were also performed on a sample of 27 US cities in order to provide a benchmark against which to compare the results in Europe. The author finds no significant decrease in the standard deviation of the rental levels, and hence no evidence of σ-convergence, over the study period. Similarly, the author finds no statistical evidence of β-convergence in the 2006 rental levels compared to the 1990 rental levels among all the 24 European office markets.

Using annual data from JLL and LaSalle Investment Management Lizieri (2009) analysed rental data for 28 global office markets for the period from 1990 to 2007. The results of a principal components analysis showed that the first component explained 38% of the variation in rents, with all but 8 of the markets having factor loadings in excess of 0.5. Asian cities however had lower factor loadings than European and North American cities, which suggest rental growth also displays a regional pattern. A supplementary analysis on the 11 highest ranked International Financial Centres (IFCs) showed that the first principal component explained 53% of the rental growth in these markets, and with the exception of Hong Kong and Sydney all IFCs had factor loadings of 0.62 or higher. The author concluding that rental growth in global office markets is mainly driven by a common factor, confirming the results of Goetzmann and Wachter (2001).

Using the β-convergence and σ-convergence methodologies, Srivatsa and Lee (2010) find that there is not enough statistical evidence of β-convergence in either rents or yields but evidence of significant σ-convergence in rents and yields in the European office markets under review. Additionally, the authors find some evidence that the introduction of the single currency in 1999 led to increasing signs of convergence, especially in the Continental European markets.

Suran (2013) used quarterly rental data from CBRE over the period from 2001:Q4 to 2012Q:4 for the 32 largest global office markets and finds that the first principal component explains 38% of the variance in the data. In other words, global office markets are largely driven by one common factor, supportive of the results of Goetzmann and Wachter, 2001 and Lizieri, 2009. Additionally, the author finds there is also a regional dimension in international real estate markets, especially in Asia, confirming the findings in previous studies in the international securitised and direct real estate markets.

Lastly, Stevenson *et al*. (2014) used quarterly rental and capital value data and the Harding and Pagan (2002) concordance approach to test for synchronisation in the cyclical behaviour of global office markets from 1990 to 2009. The authors find evidence of significant concordance across the 20 largest global office markets, raising the possibility that global real estate investors may experience only limited gains in terms of diversification and may be better served by expanding their investment portfolio in smaller regional markets; as suggested by the results of Lizieri (2009) and Suran (2013).

In summary, previous studies in the international securitised and direct real estate markets suggest that convergence in the UK direct real estate market is likely to show a number of results. First, like the results for regions, in the international research, convergence in the UK

is likely to show differences across property-types. Second, direct real estate market convergence is likely to be to be time-varying (period-specific) and particularly in the period of the Global Financial Crisis. Lastly, there are likely to be substantial differences in convergence between returns, rental growth and yields.

Data and Summary Statistics

The data used in this study are for the 10 market segments used by the Investment Property Databank (IPD) in their standard performance analysis reports to investors. The IPD monthly indices are based on the performance of 3,479 properties valued at £43 billion at the end of 2014. The data used in this study is essentially all standing investments in the monthly IPD database; i.e. properties that are held in portfolios and not bought or sold, or subject to development or significant improvement expenditure during the period.

Tests performed by IPD have suggested that this 10 segment categorisation maximises the explanatory variance in returns across individual properties and is the most effective split for asset allocation optimisation (Frodsham and Key, 1996). The 10 market segments are: Standard Retail Southeast (SRSE); Standard Retail Rest of UK (SRRUK); Shopping Centres (SC); Retail Warehouses (RW); City Offices (OC); West-End Offices (OW); Offices Rest of Southeast (ORSE); Offices Rest of UK (ORUK); Industrials Southern and Eastern (ISE) and Industrials Rest of UK (IRUK).

We use three monthly data series in order to assess the extent of convergence in the UK real estate market: return, rental growth and equivalent yields[1]. The data cover the period 1987:1 to 2014:12, a total of 336 observations. Summary statistics for the monthly return, rental growth and equivalent yield data for the entire sample period are presented in Table 1.

Table 1: Summary Statistics: Monthly Data 1987: to 2014:12

Panel A Returns	SRSE	SRRUK	SC	RW	OC	OW	ORSE	ORUK	ISE	IRUK
Average	0.71	0.60	0.65	0.89	0.56	0.84	0.66	0.72	0.87	0.93
Standard Deviation	0.97	0.97	1.26	1.32	1.59	1.52	1.13	1.17	1.10	1.13
Skewness	-1.36	-1.21	-2.26	-1.32	-1.46	-0.82	-0.89	-0.62	-0.98	-0.54
Kurtosis	7.56	6.58	9.69	6.12	5.64	3.23	3.76	4.59	4.75	5.93
Jarque-Bera	917.9	698.7	1620.7	629.8	571.9	186.1	245.2	320.7	373.9	515.8
Panel B Rents	**SRSE**	**SRRUK**	**SC**	**RW**	**OC**	**OW**	**ORSE**	**ORUK**	**ISE**	**IRUK**
Average	0.20	0.14	0.15	0.30	0.09	0.21	0.06	0.17	0.15	0.15
Standard Deviation	0.61	0.47	0.60	0.54	1.47	1.45	0.77	0.69	0.68	0.51
Skewness	2.41	1.21	2.05	0.62	-0.71	-0.50	-0.23*	2.47	1.67	2.11
Kurtosis	10.98	3.93	12.34	10.82	5.84	2.44	2.80	8.68	8.51	6.95
Jarque-Bera	2041.3	301.7	2398.3	1684.9	512.5	98.2	114.4	1417.1	1187.4	937.0
Panel C Yields	**SRSE**	**SRRUK**	**SC**	**RW**	**OC**	**OW**	**ORSE**	**ORUK**	**ISE**	**IRUK**
Average	6.85	6.97	9.29	7.70	7.98	7.16	8.90	8.95	9.13	9.71
Standard Deviation	0.94	0.79	1.71	1.73	1.46	1.20	1.09	1.11	1.54	1.62
Skewness	-0.10*	-0.35	-0.21*	0.50	-0.04*	-0.15*	-0.62	-0.89	-0.08*	0.26*
Kurtosis	-0.88	-0.22*	-0.32*	-0.31*	-0.70	-0.38*	0.62	1.25	-0.74	0.28*
Jarque-Bera	11.6	7.4	4.0*	15.8	7.0	3.4*	26.9	67.0	8.2	4.9*

Note: all the Skewness, Kurtosis and Jarque-Bera statistics are significant at the 5% level except *

[1] Equivalent yields are the main method for communicating the current level of return on commercial property in the UK as a result of its unique lease structure, with 5-year upward only rent reviews. That is, the value of property in the UK is estimated as the present value of two streams: the rent up to the rent review and then the market rent, assumed to be received in perpetuity starting from the time of the next rent review. In other words, neither the initial yield (current rent to capital value) nor the reversionary yield (market rental value divided by capital value) is deemed to be a reliable indicator of return potential, whereas equivalent yields, which are a weighted average of the initial and reversionary yields, provides a better picture.

The results in Panel A of Table 1 show that the market segment with the highest average return over the entire sample period was Industrials Rest of UK (IRUK) and the lowest in City Offices (OC). The volatility (measured by the standard deviation of monthly returns) was highest in City Offices (OC) and least in Standard Retail Rest of the UK (SRRUK). In addition, all segments show significant negative skewness and significant positive kurtosis, which implies the return data is non-normal; a view confirmed by the Jarque-Bera statistic.

The rental growth statistics in Panel B of Table 1 presents a somewhat different picture from that for returns. The market segment with the highest average rental growth over the sample period was West-End Offices (OW), while City Offices (OC) showed the least growth. The standard deviation of rental growth was highest in City Offices (OC) and least in Standard Retail Rest of UK (SRRUK). Furthermore, with the exception of Offices Rest of Southeast (ORSE), all the segments display significant skewness and all segments show significant positive kurtosis. Hence, the Jarque-Bera statistic shows the data is non-normal.

Finally, Panel C of Table 1 shows that the market segment with the highest average equivalent yield was Industrials Rest of UK (IRUK) and the lowest in West-End Offices (OW). The market segment with the lowest standard deviation was Offices Rest of Southeast (ORSE) and highest in Retail Warehouses (RW). However, only four segments display significant skewness (SRRUK, RW, ORSE, and ORUK), while only five segments display significant kurtosis (SRSE, OC, ORSE, ORUK and ISE). Nonetheless, with the exception of three segments (SC, OW and IRUK) all the market segments display non-normality on the Jarque-Bera test.

Methodology

This paper investigates the convergence in the UK real estate market using factor analysis. Factor analysis is an important tool for analysing datasets with large time series and cross-section dimensions, since it allows us to decompose the data series into a smaller number of common factors in a parsimonious way.

From an empirical point of view principle component analysis is preferred to factor analysis for two reasons. First, principle component analysis is simpler to apply mathematically since it makes no assumptions about the underlying properties of the data series (Stevens, 1992). Secondly, principle component analysis does not have to account for factor indeterminacy, which is a troublesome feature of common factor analysis (Steiger, 1979). Therefore we choose principle component analysis as our approach in test for convergence in the UK real estate market.

Let X represents a vector of returns, rental growth or yield data of the 10 market segments. Principle component analysis detects integration in the variables by converting a matrix of the data into a linear combination of unobserved principal components, which explain the complete variance of the data series and has the following form:

$$P = \lambda X \qquad (1)$$

where P is a vector of orthogonal factors, or principal components, which are a linear combination of the original data series X and λ is a matrix of coefficients, called factor loadings, with each coefficient representing the weight of the corresponding original variable

X in the relevant principle component (see Jolliffe, 2002; for more details on principal component analysis).

The transformation of variables can be accomplished by using either the correlation matrix or the covariance matrix. Since it is mean-cantered, the correlation matrix is particularly useful when the variables differ in scale (Jolliffe, 2002). Hence, in this paper we employ the transformation based on the correlation matrix.

Principle component analysis derives the principle components in such a way that they explain the variations in the set of original variables in a descending order. Thus, the first principle component accounts for the main part of the variation in X; the second principle component will explain the main part of the remaining variations in X after the effects of the first principle component has been removed, and so on.

Our use of principle component analysis is the same as that used by Becker and Hall (2009a and 2009b) in their analysis of exchange rate and inflation convergence in the European Union. Becker and Hall (2009a and 2009b) argue that a set of variables are convergent if the general factor representation given in Equation (1) is restricted to the first principle component. In other words, if the data of the UK market segments are converging, the correlation structure of each data series would be best described by one common factor explaining their long run behaviour.

The measure of convergence employed by Becker and Hall (2009a and 2009b) is the percentage R^2 of the first factor, which provides a measure of the total variation in the data series explained by the first principle component. The closer this value is to 1, the greater the degree of convergence in the data series. In addition, if the percentage R^2 over period 1 is less than that in some consequent period 2, then convergence has accelerated over the selected interval (Becker and Hall, 2009a and 2009b). In other words, even if there is no evidence of convergence over the entire sample period the methodology allows use to test for any period-specific convergence.

Principle component analysis also allows us to examine the extent to which the individual market segment data fluctuate about the common factor[2]. That is, with complete convergence, the factor loadings on the first principal component would be equal 1, for all market segments in our sample. However, even if the factor loadings do not equal 1 but are systematic, i.e. show the same sign and are of a similar size, the greater the degree of convergence[3]. On the other hand, if the factor loadings are largely random, i.e. with different signs and differing sizes, this implies that the data move largely independently of each other, indicating low or no convergence (Becker and Hall, 2009a and 2009b).

However, before any factor analysis can be undertaken we need to examine the sampling adequacy of the data. This is done using the Kaiser-Meyer-Olkin (KMO) statistic (Kaiser, 1970; Cerny and Kaiser, 1977; and Dziuban and Shirkey, 1974). The KMO statistic assesses the extent to which the variables belong together, i.e. a measure of the homogeneity of variables, by measuring how small the partial correlations are, relative to the original (zero-order) correlations. If the variables share common factor(s), then the partial correlations should be small and the KMO statistic should be close to 1.0.

[2] Note that the signs of the loadings are completely arbitrary (Joliffe, 2002).
[3] Factor loadings are usually considered significant if they are greater than 0.6, although many researchers have used 0.4 as a cut off (Sharma, 1996).

No statistical tests exist for the KMO measure, however, but Kaiser and Rice (1974) suggest the following guidelines in the interpretation: a KMO measure larger than 0.9 is marvellous, larger than 0.8 is meritorious, larger than 0.7 is middling, larger than 0.6 is mediocre, larger than 0.5 is miserable, and below 0.5 unacceptable.

Results

In this section we report our results from applying the principle component analysis approach to test for convergence in the UK direct real estate market returns, rental growth and equivalent yield data over the entire sample period (1987 to 2014) and for a number of sub-periods to test whether convergence is period-specific. The results reported in Tables 2 and 3.

Entire Sample Period

The final row of Column 2 of Table 2 shows that for the overall sample period shows that there is only 1 significant principal component, for returns in the UK direct real estate market[4], which is able to explain approximately 81% of the variance in the data, while the KMO statistic is marvellous (0.934). Additionally, the factor loadings, or weights, on the first principal component have the same sign and all the market segments display loadings that are greater than 0.79, with the majority above 0.9, suggestive of strong convergence in monthly returns.

Table 2: Percentage R^2 and Factor Loadings for the First Principal Component
Returns, Rents and Yields: Monthly Data 1987:1 to 2014:12

Data Series	Returns	Rents	Yields
Percentage R^2	81%	60%	80%
SRSE	0.943	0.882	0.929
SRRUK	0.935	0.883	0.866
SC	0.830	0.637	0.911
RW	0.894	0.507	0.885
OC	0.789	0.600	0.865
OW	0.880	0.744	0.879
ORSE	0.932	0.861	0.916
ORUK	0.915	0.791	0.897
ISE	0.953	0.893	0.933
IRUK	0.926	0.839	0.837
KMO Statistic	0.934	0.888	0.799
# Significant Factors	1	2	1

Column 3 in Table 2 shows that UK rents, over the entire sample period, were explained by 2 significant factors and that the first principal component is able to only explain 60% of the variance in the rental growth data. The KMO statistic is also very high at 0.888, which is meritorious. In addition, all the segments show the same factor loading sign and with the exception of the Retail Warehouse (RW) segment the factor loadings are all greater than 0.6. This implies that convergence in UK rental growth was somewhat less than that for returns but is still stronger than that in international markets (see, Goetzmann and Wachter, 2001; Lizieri, 2009 and Suran, 2013).

Lastly, Column 4 of Table 2 shows that there was only 1 significant principal component for the yield data, which is able to explain approximately 80% of the variance in UK equivalent yields. In addition, all the market segments display the same sign and show factor loadings

[4] To determine the number of significance principal components we applied the Kaiser rule of eigenvalues greater than or equal to 1 (Kaiser, 1960).

greater than 0.86, which implies that there has been a strong move to convergence in UK market segment yields, over the entire sample period, although the KMO statistic is only middling (0.799).

Period-specific Convergence

The clear implication is that there is strong evidence of convergence over the entire sample period for returns and yields, while the result for rents are marginally weaker. As a result, we next attempt to assess whether market segment convergence is period-specific, particularly in rising and falling markets. Therefore, in order to establish if convergence in the UK real estate market is different in times in rising markets compared to falling markets we break the data series into up-markets and down-markets; as defined by the returns of the Investment Property Databank Monthly Index (IPDMI)[5]. That is, if the return of the IPDMI in a particular month is negative we classify that month as a down-market and *vice versa*, the results shown in Columns 2 to 6 of Table 3.

Table 3: Percentage R^2 and Factor Loadings for the First Principal Component Up-markets and Down-markets: Monthly Data 1987:1 to 2014:12

Period	87:1 - 90:1	90:2 - 91:4	91:5 - 07:7	07:8 - 09:6	09:7 - 14:12
Panel A Returns	Up-market	Down-market	Up-market	Down-market	Up-market
Percentage R^2	43%	47%	67%	91%	83%
SRSE	0.634	0.870	0.894	0.966	0.951
SRRUK	0.763	0.860	0.874	0.983	0.932
SC	0.322	0.266	0.698	0.757	0.943
RW	0.586	0.826	0.822	0.978	0.860
OC	-0.099	0.184	0.598	0.958	0.786
OW	0.643	0.458	0.666	0.964	0.930
ORSE	0.819	0.684	0.855	0.972	0.866
ORUK	0.638	0.687	0.914	0.974	0.954
ISE	0.826	0.778	0.899	0.974	0.943
IRUK	0.830	0.827	0.929	0.977	0.911
KMO Statistic	0.733	0.793	0.899	0.880	0.903
# Significant Factors	3	2	2	1	1
Panel B Rents	Up-market	Down-market	Up-market	Down-market	Up-market
Percentage R^2	35%	64%	51%	84%	61%
SRSE	0.457	0.933	0.866	0.902	0.728
SRRUK	0.662	0.886	0.739	0.946	0.879
SC	0.149	0.606	0.294	0.890	0.584
RW	0.040	0.272	0.236	0.949	0.607
OC	-0.616	0.590	0.679	0.898	0.787
OW	0.070	0.886	0.743	0.854	0.799
ORSE	0.893	0.939	0.892	0.967	0.881
ORUK	0.591	0.858	0.732	0.935	0.852
ISE	0.783	0.906	0.900	0.892	0.828
IRUK	0.802	0.852	0.714	0.945	0.820
KMO Statistic	0.562	0.896	0.888	0.871	0.880
# Significant Factors	4	2	3	1	1
Panel C Yields	Up-market	Down-market	Up-market	Down-market	Up-market
Percentage R^2	66%	83%	91%	99%	87%
SRSE	0.042	0.996	0.984	0.999	0.948
SRRUK	-0.760	0.967	0.962	1.000	0.958
SC	-0.974	0.192	0.972	0.990	0.990
RW	0.711	0.828	0.935	0.996	0.959
OC	-0.489	0.945	0.865	0.997	0.922
OW	0.852	0.945	0.925	0.980	0.957
ORSE	0.969	0.985	0.984	0.999	0.873
ORUK	0.945	0.975	0.985	0.999	0.748
ISE	0.913	0.992	0.919	0.999	0.970
IRUK	0.974	0.965	0.988	1.000	0.977
KMO Statistic	0.799	0.864	0.883	0.897	0.876
# Significant Factors	2	2	1	1	1

[5] We recognise the just using the IPDMI to classify down-markets may be subject to error so we also expanded the down-markets by up to three months before and after that identified by the negative returns in the IPDMI with no change in the percentage R^2 explained by the first component and little change in the factor loadings.

The results in Table 3 show a number of features of interest. First, over the entire sample period there has been a general increase in convergence in returns and yields and to a lesser extent rents. For instance, the percentage R^2 of the first principal component for returns, rental growth and yields increased from 43% to 83%; 35% to 61% and 66% to 87%, respectively. In addition, after July 2007 the variance in all the data sets was explained by just 1 significant common factor.

Second, the property market boom period (87:1 to 90:1) displays a good deal of disparity in performance across the market segments, indicated by the relatively low R^2 values of the first principal component (43%, 35% and 66%, respectively). In addition, the results of the Kaiser rule indicate that returns were explained by 3 significant factors, rents by 4 significant factors and yields by 2 significant factors, respectively. Furthermore, the factor loadings display different signs and relatively low weightings in all data sets, which implies there was divergence rather than convergence in performance during this period. In particular, the factor loading of City Offices (OC) is substantially different in all data sets, while the Shopping Centre (SC) and Retail Warehouse (RW) segments displayed substantially different factor loadings on rents and yields. Additionally, the KMO statistic for rents is only 0.562 which according to Kaiser and Rice (1974) is miserable, while that for returns and yields is middling (0.733 and 0.799, respectively). Suggestive of large diversification benefits across the market segments in this period.

Third, in the period of the 90s property market crash (90:2 to 91:4) returns were explained by 2 significant factors, while the percentage R^2 of the first principal component only increased marginally from 43% to 47%, suggestive of only a little increase in convergence compared with the previous boom period. Furthermore, the KMO statistic is still middling (0.793). Nonetheless, all the market segments display the same sign and with the exception of City Offices (OC), West-End Offices (OW) and Shopping Centres (SC) all the segments have factor loadings greater than 0.6.

The rent data shows stronger evidence of acceleration in rental growth convergence, during the market crash of the 90s, than that for returns, as the percentage R^2 of the first principal component almost doubled from 35% to 64%. Additionally, all the segments show the same sign on the factor loadings and with the exception of City Offices (OC) and Retail Warehouses (RW) all the loadings are greater than 0.6, while the KMO statistic is now marvellous (0.896). This suggests that there was a strong move to convergence in rental growth in the market downturn. Nonetheless, the results show that rents, in this period, were still explained by 2 significant factors.

Lastly, convergence in yields, during the 90s property market crash, was even stronger than that for rents and returns, as the percentage R^2 of the first principal component rose from 66% to 83% and all the market segments display the same sign and all the factor loadings are greater than 0.83, with the exception of Shopping Centres (SC), while the KMO statistic is now marvellous (0.864). The results show however that there were 2 significant factors explaining yields in this period.

Fourth, following the property market crash of the 90s convergence accelerated in returns and yields, with the percentage R^2 of the first principal component increasing from 47% to 67% and 83% to 91%, respectively. The factor loadings showing the same sign and all are greater than 0.6, on both data sets, while the KMO statistics are meritorious (0.899 and 0.897,

respectively). In contrast, the percentage R^2 of the first principal component for rental growth fell from 64% to 51% and rents were explained by 3 significant factors. It is also noticeable that while all the factor loadings of the rent data display the same sign the factor loadings for the Shopping Centre (SC) and Retail Warehouse (RW) segments are substantially different from the rest (0.294 and 0.236, respectively). This implies that although diversification benefits were diminishing during this period there were still opportunities in certain segments, especially from investment into the Shopping Centre and Retail Warehouse segments. The KMO statistics is also meritorious (0.888).

Fifth, convergence peaked in the UK real estate market in the period of the Global Financial Crisis (07:8 to 09:6), as the percentage R^2 for the first principal component for returns, rents and yields was 91%, 84% and 99%, respectively. In addition, all the factor loadings show the same sign and are all greater than 0.7, with the majority above 0.9, while the KMO statistics are all meritorious (0.880, 0.871 and 0.897, respectively). This indicates that in this period the UK real estate market was completely integrated. In other words, the Global Financial Crisis triggered a "correlation breakdown" in the UK real estate market; the tendency of correlations to move towards one and so reducing diversification opportunities just when they were needed most.

The analysis also shows that the property market crash of the 90s and that in the Global Financial Crisis were very different in character. The 90s crash was explained by 2 significant factors, on all data sets, which indicates there was a good deal of diversity in performance across the market segments and that diversification possibilities still existed. In contrast, all the market segments were driven by 1 common factor during the Global Financial Crisis, which shows that this crash was systemic and so diversification benefits were not available in this period.

Lastly, in the period after the Global Financial Crisis, up to the end of the sample period (09:7 to 14:12), although there has been a fall in the percentage R^2 for the first principal component in all data sets, especially for rents, there is still only 1 significant common factor explaining the variance in returns, rents and yields in the UK direct real estate market. Additionally, the factors loadings all show the same sign and with the exception of rents in the Retail Warehouse (RW) segment are all above 0.6. The KMO statistics are also either marvellous (0.903 for returns) or meritorious (0.880 and 0.876 for rents and yields respectively), which suggests that the UK real estate market is still largely integrated and as a consequence the extent of diversification potential in the market is still severely limited.

Implications

The results above have crucial implications for investors; for at least three reasons. First, convergence in returns in the UK direct real estate market magnifies the importance of volatility spillover effects. Volatility spillovers imply that one large shock increases the volatilities not only in its own market segment, but also in other market segments as well. In other words, shocks, especially negative shocks, in one market segment can quickly spread to other segments and so to the market as a whole much faster, possibly leading to a market crash. The results above suggest that this is a real possibility in the UK direct real estate market as the market at present is driven by only 1 common factor with all the market segments displaying similar factor loadings.

Second, as Markowitz (1952) shows if investors spread their holdings across a number of assets that show less than perfect correlation the risk of the portfolio will decline without hurting returns. Ang (2012) argues however that "[A]ssets are bundles of different types of factors just as foods contain different combinations of nutrients." In other words, a meal consisting of different foods with very similar nutrients might not be considered balanced. This suggests that a portfolio that may appear to be well-diversified, due to being spread a large number of assets, may in fact be undiversified if is concentrated in assets that are essentially exposed to the same common factors (Ang, 2012). This implies that if there is a convergence in market segment performance it leaves investors exposed to the same structural shocks and so their portfolios may not be as diversified as thoroughly as they had believed.

The results above show that since the start of the Global Financial Crisis the performance of the UK direct real estate market has been driven by 1 common factor; as such the potential for creating a well-diversified portfolio is severely limited; even from spreading across all 10 market segments. This raises the question as to how well-diversified are current UK real estate portfolios. A situation that is likely to be maintained given the current low inflation and low growth environment in the UK.

Lastly, the case for the real estate fund management industry depends on them adding above-average performance (alpha) through active management. Underlying this is a presumption is that active fund managers over-weight assets that are expected to outperform the market and under-weight assets that are expected to underperform. Central to the fund manager ability to achieve above average performance is the extent of cross-sectional dispersion in returns. That is, the greater the cross-sectional dispersion in returns the greater the fund managers chance to outperform the market. In contrast, when returns are similar tilting the fund towards higher performers is of little advantage; as active bets cannot produce performance that differs discernibly from those of the market.

The convergence in market segment performance over time highlighted in Table 3 suggests that the ability of UK real estate fund manager to generating outperformance since the Global Financial Crisis has been severely limited and will remain so unless cross-sectional dispersion increases. As such investors may start to question the high fees charged by active fund managers for little or no potential outperformance.

Conclusions

This study examines the issue of convergence in monthly returns, rents and yields for 10 market segments in the UK private real estate market using principal component analysis over the period from 1987 to 2014. The principal components approach provides an assessment of the extent to which the variance of the market segments can be represented by a single common factor explaining their long-run behaviour and so indicates the extent of convergence in the UK.

The results show that the percentage R^2 of the first principal component for the entire sample period explains 81% of the variance in monthly returns, 80% of the variance in equivalent yields and 60% of variance in the rent data, suggestive of strong evidence of convergence in relation to monthly returns and yields but less evidence of convergence in rental growth, which confirms the findings in the previous studies in international direct real estate markets. There is also an indication that convergence is period-specific and was particularly strong in

the period of the Global Financial Crisis, confirming the results of previous studies in the international securitised real estate markets.

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