IPF Research Programme 2006-2009

Real Estate's Role in the Mixed Asset Portfolio: A Re-examination

Working Paper 4
Real Estate Returns and Financial Assets in Extreme Markets

May 2012

This research was commissioned by the IPF Research Programme 2006–2009

IPF Investment Property Forum

This research was funded and commissioned through the IPF Research Programme 2006–2009, funded by a cross-section of 24 businesses, representing key market participants, together with a contribution from the Barkshire Committee.

This Programme has supported the IPF's wider goals of enhancing the knowledge, understanding and efficiency of property as an investment class. The initiative has provided the UK property investment market with the ability to deliver substantial, objective and high-quality analysis on a structured basis. It will enable the whole industry to engage with other financial markets, the wider business community and government on a range of complementary issues.

The IPF gratefully acknowledges the support of the following contributing organisations of the Research Programme 2006–2009.

Addleshaw Goddard
British Land
Credit Suisse
Deloitte.
DLA Piper
DTZ
GIC Real Estate
Grosvenor
GVA
Hammerson
Helical Bar plc
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LandSecurities
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Nabarro Clarity Matters
PRUPIM
Quintain
Standard Life Investments
Strutt & Parker
Scottish Widows Investment Partnership

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Research team

Colin Lizieri, *University of Cambridge*

Jamie Alcock, *University of Cambridge*

Steve Satchell, *Trinity College, Cambridge and the University of Sydney*

Eva Steiner, *University of Cambridge*

Warapong Wongwachara, *University of East Anglia*

Research steering group

Asli Ball, *GIC*

Russell Chaplin, *Aberdeen Asset Management*

Pam Craddock, *Investment Property Forum*

Sue Forster, *Investment Property Forum*

Guy Morrell, *HSBC Global Asset Management (UK) Limited*

Ben Sanderson, *Hermes Fund Managers Limited*

CONTENTS

1. EXECUTIVE SUMMARY

- The benefits of diversification from including real estate in a mixed-asset portfolio are typically established on the basis of low average correlations with other asset classes, in line with modern portfolio theory. However, the existing literature suggests that correlations may vary through time. Correlations tend to be higher in periods of increased uncertainty and during bear markets.
- This evidence suggests that returns from real estate investments exhibit 'asymmetric dependence' with respect to equities and bonds. Tail dependence is defined as a disproportionately high probability of jointly occuring high or low returns. Asymmetric dependence refers to the situation where this occurs in one tail of the joint return distribution only, typically the negative tail. That might imply that the benefits of diversification commonly ascribed to real estate may vanish when they are in fact most needed to protect portfolio values from eroding in downturns.
- A statistically robust assessment of asymmetric dependence is therefore crucial for determining the benefits of diversification associated with including real estate in mixed-asset portfolios. However, analysing asymmetric dependence is a complex, multi-dimensional problem. Existing studies of asymmetric dependence often rely solely on correlations, which may be an incomplete description of dependence, or employ methodologies that are unable to distinguish between different dimensions of dependence. They may, therefore, produce misleading results.
- Using Monte Carlo simulations, the research team identifies the most suitable metric of asymmetric dependence out of a range of methods commonly employed in real estate finance: the adjusted-J statistic. This metric is used in combination with the CAPM beta to provide a comprehensive assessment of dependence between the returns on real estate investments and other asset classes.
- This set of statistics is employed to empirically examine the dependence structures in a large sample of return data for direct and indirect UK real estate investments, and a range of benchmark assets over the period 1990–2010.
- When we control for linear dependence and focus on the strength, direction and statistical significance of higher-order, asymmetric dependence, the benefits of diversification offered by real estate appear stronger than sometimes reported in recent studies. There are asymmetric dependence relationships between real estate and equities. However, these seem to be a high-frequency phenomenon – relevant only to securities funds that are frequently rebalanced – and the effects reduce rapidly with lower frequency.
- By contrast, dependence between bonds and real estate appears to be more complex than previously assumed. The relationship re-emphasises the importance of gearing and credit conditions in affecting property performance.
- These finding highlights the importance of employing a statistically robust metric of asymmetric dependence. It may be possible to develop portfolio strategies based on such measures that can limit the downside risk while not adversely affecting the upside. As yet, though, such models are confined to listed securities and would be hard to implement in private real estate.

2. INTRODUCTION

This is the fourth working paper from the Investment Property Forum funded project re-examining the role commercial property can play in multi-asset portfolios. The project seeks to explore the nature of commercial real estate returns in the light of the performance of the asset class over the recent financial turmoil and the apparent failure of property to provide the diversification gains hoped for in mixed-asset portfolios. The project focuses on the dimensions of risk in property markets, the factors that drive returns, the relationship between real estate and other investment assets and the extent to which those relationships vary over time and are asymmetric in nature.

The second working paper revisited the valuation process and its implications for measures of real estate market performance. It suggested that valuation smoothing effects vary over time and that there is a link between performance in the equity market, real estate returns and valuation smoothing. In particular, it seemed that the behaviour of the real estate market and the extent of valuation smoothing were sharply different when the equity market was performing badly. Working Paper 3 considered the interaction between real estate returns and other asset classes and the extent to which that interaction changes over time. The influence of stocks and bonds on real estate changed over time and, once again, it appeared that negative shocks in the equity market feed into real estate markets, albeit with a lag. While there was evidence that property offers diversification benefits, the strength of those benefits shifts over time. This fourth paper develops that analysis by focussing on the relationship between real estate and other financial assets in 'extreme' market conditions.

The recent global financial crisis has materially altered investors' perception of real estate as an asset class. Traditionally, the rationale for investing in real estate is a combination of attractive risk-adjusted returns, inflation hedging qualities and benefits of diversification (Baum, 2002). The diversification benefits attributed to real estate are typically established on the basis that, on average, the correlation between real estate and other asset classes is low (Georgiev, Gupta and Kunkel, 2003). Consequently, adding real estate to a portfolio of stocks and bonds is expected to enhance risk-adjusted portfolio returns and insulate portfolios against drawdown during bear markets in accordance with Markowitz's (1952) modern portfolio theory.

However, during the recent global financial crisis, real estate performed exceptionally poorly across different property types and locations. Moreover, correlations between real estate and other asset classes appear to have increased more than during other recent crises, such as the 1997–1998 Russian and Asian financial panics or the immediate aftermath of the terrorist attacks on the US in 2001 (Gordon, 2009). The fact that the dependence between real estate returns and the returns from other asset classes varies with the prevailing state of the market and, in particular, the phenomenon that dependence increases during bad states of the market, is referred to as asymmetric dependence.

If the benefits of diversification offered by real estate dissipate because dependence with other asset classes increases during bear markets, this phenomenon has important implications for the effectiveness of mean–variance portfolio management techniques. In the presence of asymmetric dependence, the efficient frontier suggested by modern portfolio theory and typically used for capital allocation purposes is misleading: expected asset returns are systematically overstated while risk is understated. As a result, frequent rebalancing of investment positions is required to maintain a chosen target level of risk, with substantial consequences for transaction costs (Hatherley and Alcock, 2007; Alcock and Hatherley, 2009). In summary, asymmetric dependence can render the traditional, mean–variance-based strategies of diversification ineffective in the protection of portfolio values during bear markets.

2. INTRODUCTION

In other words, investors may not be able to rely on their portfolio being well diversified and thus insulated from value erosion during bad states of the market, when asymmetric dependence is not accounted for in the portfolio construction and management process.

Research into complex dependence structures in real estate and its consequences for portfolios managed under the traditional mean–variance approach is developing rapidly, especially since the onset of the global financial crisis. In this working paper, we explore the empirical evidence for asymmetric dependence in the returns from UK real estate assets, with a focus on the relationships between direct as well as indirect real estate investments and a broad range of benchmark assets from the stock and bond markets.

This paper is structured as follows. Section 3 reviews the existing empirical evidence for asymmetric dependence in the returns from direct and indirect real estate investments. Section 4 focuses on the different methods that have been proposed to assess asymmetric dependence. It is argued that investors have to be cautious in the interpretation of results based on some of these methods. Section 5 presents the data set and methodology that were chosen to adopt in this study. Section 6 discusses the empirical results and Section 7 concludes with a summary of key findings and an outline of the major implications for investors.

3. THE EXISTING EVIDENCE

Standard portfolio theory approaches to asset allocation typically rely on a measure of correlation between assets which is estimated from historical data and assumed to be constant over time. Empirical evidence generally suggests that, in practice, correlation varies across time, with significant implications for portfolio strategy.

The benefits of diversification associated with including real estate in a mixed-asset portfolio are typically established on the basis of low average correlation, in line with modern portfolio theory (Baum, 2002; Georgiev, Gupta and Kunkel, 2003). Consistently, listed real estate appears to display levels of systematic risk that are below those of the market as a whole, as measured by the familiar CAPM beta (Howe and Shilling, 1990; Chan, Henderschott and Sanders, 1990; Glascock and Hughes, 1995). The returns on listed real estate respond less than fully proportionally to variation in the return on the general stock market, suggesting a stabilising effect on the performance of a mixed-asset portfolio containing real estate securities.

Studies that allow for time variation in correlations provide a more sophisticated view on the evolution of dependence patterns in the returns from listed real estate. The sensitivity of listed real estate returns to the returns on stocks, bonds and direct real estate appears to be cyclical (Clayton and McKinnon, 2001). This finding implies that the benefits of diversification offered by real estate securities vary through time, and may be substantially reduced in some periods. Correlations may fluctuate around a positive trend, as reported in Cotter and Stevenson (2006) for US markets – that is, over time the correlation between REIT and general equity returns has increased. Further, structural breaks in the REIT history, such as the introduction of REITs into broader stock market indices, may demarcate different correlation regimes (Case, Yang and Yildirim, 2010). These results provide evidence for significant time variation in correlations and, therefore, in the benefits of diversification.

More specifically, time variation in correlations appears to be a function of the prevailing level of volatility in the market. Chong, Miffre and Stevenson (2009) present evidence that the correlations between US REITs and stocks as well as bonds respond positively to higher volatility in those markets. These findings suggest that, not only are benefits of diversification time-variant, but they appear to dissipate in periods of higher uncertainty.

Asymmetry in correlations of listed real estate securities refer to disproportionately stronger responses in correlations to negative return shocks than to positive ones. This notion implies that the benefits of diversification may be substantially reduced in bear market periods – precisely the time when investors wish to rely on their portfolio being well diversified and, thus, protected from negative shocks in a certain segment of the market.

Interestingly, the empirical evidence for asymmetry in correlations appears to become stronger with higher observation frequency (Fei, Ding and Deng, 2010; Liow, 2009; Yang, Zhou and Leung, 2010; Hoesli and Kustrim, 2011; Michayluk, Wilson and Zurbruegg, 2006). The technical reason for this is that when performance is evaluated on high-frequency data, such as daily geometric returns, which are then aggregated to a lower frequency, then the distribution of the resulting summation will approach normality with increasing time period[1] as a result of the central limit theorem. This relationship implies that asymmetric dependence may be more relevant for shorter investment time horizons and investment strategies that demand frequent rebalancing of portfolios. Returns from direct real estate investments are based on valuations that are typically available only on low frequencies and tend to be subject to valuation smoothing.

Therefore, higher-order, asymmetric components of dependence are likely to affect indirect real estate investments in listed securities that are held short-term more than long-term direct real estate investments.

[1] Or, indeed, with rising number of assets in a multivariate framework.

3. THE EXISTING EVIDENCE

Some authors approach the problem from a slightly different perspective. They do not focus on correlations as a measure of dependence, but analyse the likelihood of two securities experiencing negative returns at the same time.

This likelihood-based perspective is especially useful since the reliance on correlations as a complete measure of dependence is conceptually problematic because it makes a number of strict assumptions that are often not met by real-world data. Adopting the likelihood-based approach, several authors report a disproportionately high likelihood of joint negative return events between pairs of listed real estate market indices and between listed real estate and stocks (Knight, Lizieri and Satchell, 2005; Zhou and Gao, 2010; Hoesli and Kustrim, 2011).

Simon and Ng (2009) find that the likelihood of jointly negative return events between real estate securities and stocks has significantly increased following the onset of the sub-prime mortgage crisis in 2007. The results from studies adopting this different perspective on the problem of asymmetric dependence confirm that benefits of diversification commonly associated with portfolio exposure to real estate may be reduced substantially when they are most needed.

3.1 Key points

- Research often relies on average correlations to claim that real estate offers benefits of diversification;
- This perspective ignores time variation in correlations;
- Research confirms that the correlations between real estate securities and other asset classes increase with the degree of uncertainty in a market and that they are higher after negative return shocks;
- This means that the benefits of diversification offered by real estate securities may be substantially reduced when they are most needed;
- However, existing research focuses mainly on US and international REIT markets while substantially less evidence is available for UK direct and indirect real estate investments.

4. HOW SHOULD ASYMMETRIC DEPENDENCE BE MEASURED?

In this section, the report seeks to identify means of analysing the true nature of the relationship between returns from different asset classes and, in particular, of detecting the presence of asymmetric dependence – an increased probability of bad returns in one asset class coinciding with bad returns from another.

Measuring asymmetric dependence is a complex problem. Modelling dependence forms part of describing the joint distribution function of the assets under consideration. For example, modelling the dependence between the returns from listed real estate securities and the stock market means describing their joint distribution function – that is, the relationship between returns of real estate and equities. Simplifying, the joint probability distribution measures the probability that one variable (say, real estate securities) takes on the value x when another variable (say equities) takes on the value y.

This function consists of many different aspects that, in combination, fully determine the relationship between the two return series. One component or dimension of this distribution function is correlation (the 'scaled' version of covariance), which captures any common patterns of deviation from the mean or average value. But other components include co-skewness (which measures the extent to which both distributions have extreme values in one or other tail), co-kurtosis (which captures the extent to which distributions are peaked or have 'fat' tails – a higher probability of extreme outcomes) and other higher-order terms that have a less intuitive economic interpretation. The problem with measuring asymmetric dependence lies in identifying the exact dimensions of the joint distribution function that should be measured. These distinctions are highly relevant for portfolio construction because they determine the choice of the appropriate optimisation technique that will be employed to yield the desired risk–return trade-off.

In this paper, the research team distinguishes between linear dependence, measured by the familiar covariance metric and representing the basis for the traditional mean–variance portfolio optimisation, and higher-order components of dependence, such as co-skewness or co-kurtosis. This distinction is practical as linear dependence is adequately modelled in a mean–variance framework – the research interest focuses on the higher-order aspects of dependence, in other words, everything that determines the joint distribution function between the assets under consideration apart from linear dependence.

The research team therefore focuses its empirical analysis on two dependence metrics: the familiar CAPM beta, and the adjusted-J statistic. The CAPM beta between an asset (real estate securities) and the market is defined as

Equation 4.1: CAPM beta between an asset (real estate securities) and the market

$$\beta = \frac{\text{cov(asset,market)}}{\text{var(market)}}$$

The CAPM beta therefore measures the joint movement in the asset and the market per unit of variance in the market – in other words, it quantifies the variation in the asset for each unit of variation in the market. The CAPM beta is a measure of sensitivity of the asset returns to changes in the market returns.

4. HOW SHOULD ASYMMETRIC DEPENDENCE BE MEASURED?

However, the CAPM beta focuses only on the covariance of the asset with the market – it does not consider any of the other dimensions of the relationship between the asset and the market, such as common patterns of skewness or kurtosis.

This would not be a concern if there was a means of establishing that covariance is the only aspect of the relationship between the asset and the market that is relevant for portfolio construction and asset pricing but, unfortunately, this is not the case. This is the main issue surrounding mean–variance portfolio construction – it relies entirely on covariance as a complete metric of the dependence between assets. If this is not the case, then mean–variance optimisation yields sub-optimal outcomes, inefficient capital allocation and misleading information about the achieved risk–return trade-off.[2]

In sum, what is required is a measure that captures aspects of the dependence between assets that are distinct from covariance. This study proposes to use the adjusted-J statistic. Alcock and Hatherley (2011) propose the adjusted-J statistic to test for the existence of asymmetric dependence in a sample of return data. The statistic relies on the concept of 'exceedance correlations'. Exceedance correlations are a special case of conditional correlations – the correlation between two variables (assets) conditional on some common set of events or market conditions. Longin and Solnik (2001) define the exceedance correlation at a given level ϑ as the conditional correlation between two variables when both register shocks of more than ϑ standard deviations from their means.[3] Thus, the correlation between real estate and equities might be estimated when both experience returns that are more than one standard deviation from their average return. The exceedence correlation focuses on common movement in the tails of the return distribution and provides a measure of diversification potential in extreme periods.

The adjusted-J statistic[4] examines exceedance correlations in each tail of the assets' combined return distribution. The test statistic summarises the differences in the exceedance correlations in opposing regions of the joint distribution. If two random variables, such as return series, are jointly normally distributed, then the exceedance correlations in opposing regions of the distribution are equal since the normal distribution is symmetric (as in Panel (a) of Figure 4.1). In the presence of asymmetric dependence (Panel (b)), the exceedance correlations in one region are systematically different from those in the exactly opposing region, producing the familiar teardrop shape of asymmetric dependence that becomes increasingly distinct for higher levels of asymmetry. The adjusted-J statistic summarises deviations from the null hypothesis of no asymmetry at various levels of exceedances. It follows a $\chi^2(N)$ distribution where N is the number of exceedances. The greater the test statistic, the greater the departure from symmetry and, equivalently, the greater the strength of the asymmetry. The sign function means that the statistic will also display the direction of asymmetry by indicating whether, on balance, the differences in the exceedance correlations are positive or negative.

[2] A downside or lower partial moments beta can capture some sense of dependence in the lower tail, but does not make full use of available information and requires the assumption of a particular threshold value for the LPM.

[3] Formally, this can be expressed as

$$\bar{\rho}(\vartheta)= \begin{cases} \hat{\rho}(\vartheta^{+})=corr(\tilde{x},\tilde{y}|\tilde{x} > \vartheta,\tilde{y} > \vartheta;\rho) & \mathit{if}\ \vartheta\geq 0 \\ \hat{\rho}(\vartheta^{-})=corr(\tilde{x},\tilde{y}|\tilde{x} < \vartheta,\tilde{y} < \vartheta;\rho) & \text{if } \vartheta\leq 0 \end{cases}$$

that is the conditional correlation at level ϑ between two variables when both register shocks of more than ϑ standard deviations from their means.

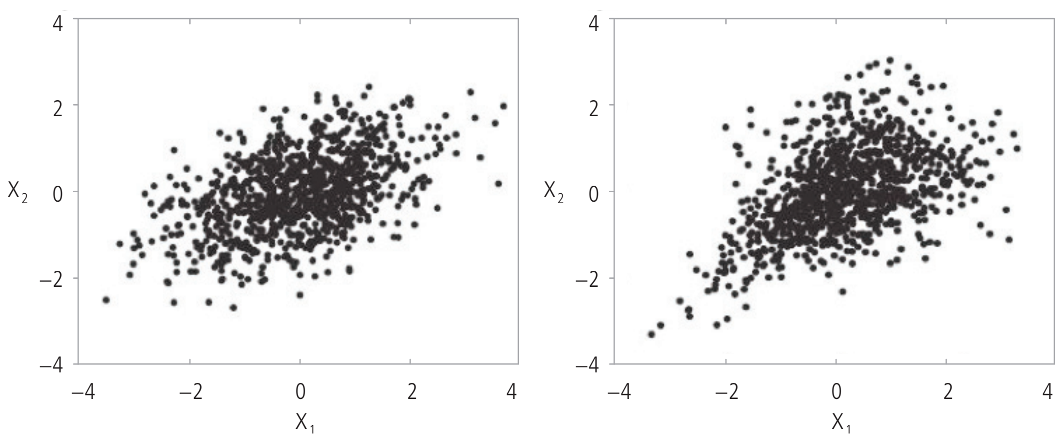
[4] Formally, adjusted-J is defined as

$$J^{Adj}:=[\mathrm{sgn}([\hat{\rho}^{+}-\hat{\rho}^{-}]\mathbf{1})]T(\hat{\rho}^{+}-\hat{\rho}^{-})'\,T(\hat{\rho}^{+}-\hat{\rho}^{-})$$

4. HOW SHOULD ASYMMETRIC DEPENDENCE BE MEASURED?

It must be stressed here that the focus of attention is on **asymmetric** tail dependence. The study does not seek to capture symmetrical tail dependence. Most investors will be most concerned with any dependence relationships in the lower tail. If real estate gives strong performance when equity markets are producing high positive returns, then that is beneficial; the concern occurs where poor equity and real estate returns coincide, when the diversification benefits are most needed. To capture symmetric tail dependence, a copula approach can be adopted, as in prior research. However, this has the disadvantage of being unable to identify the source of dependence nor distinguish between linear and tail dependence effects.

Figure 4.1: Scatter plots of simulated bivariate random variables



Panel (a): Multivariate normal distribution **Panel (b): Strong asymmetric dependence**

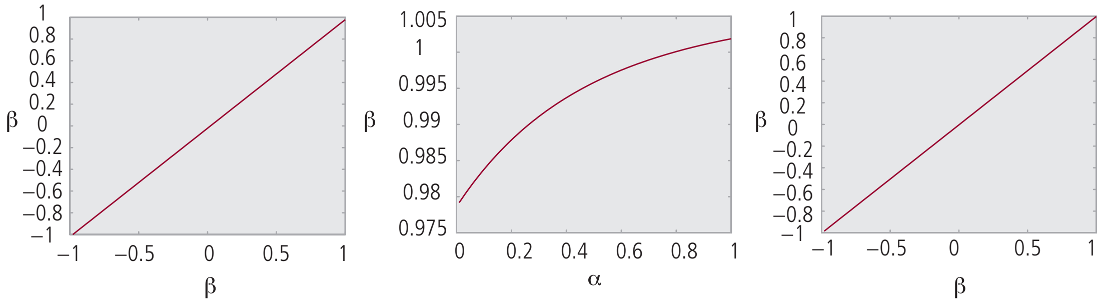
Note. Panel (a) shows multivariate normal (MVN) data of assets X_1 and X_2. Panel (b) shows a high degree of lower tail dependence (LTD), respectively. Multivariate normality results in a symmetric, elliptical dependence in which the occurrence of jointly positive returns is equal in likelihood and magnitude to that of jointly negative returns. In the presence of lower tail dependence, a disproportionate share of the probability mass is in the area of the joint distribution that represents joint negative returns.

Importantly, the arguments in the adjusted-J statistic are not the raw returns but a transformation of the raw returns. This modification makes the adjusted-J invariant to the level of linear (beta) dependence between the variables. Exceedance correlations are defined as correlations in areas of the return distributions demarcated by certain threshold values. If an observation falls into one of the areas defined by an exceedance level, this can be due to higher covariance of an asset with the market, but also due to higher-order, asymmetric dependence. The statistic has the potential to assess asymmetric dependence more accurately than competing metrics as changes in conditional correlations that are due to changes in beta caused by higher market volatility are controlled for.

It is possible to carry out a set of simulations in order to illustrate the point that the CAPM beta in combination with the adjusted-J statistic offers a comprehensive and informative as well as statistically robust assessment of dependence. The performance of the CAPM beta and the adjusted-J statistic can be assessed using three sets of simulated bivariate random variables (x, y). The first simulated data set exhibits no higher-order or asymmetric dependence and is given by $y_i = \beta x_i + \varepsilon_i$, where $x_i \sim N(0.25, 0.15)$ and $\varepsilon_i \sim N(0, 1)$. The parameter $\beta \in (-1, 1]$ describes the degree of linear dependence between x and y. The second simulated data set exhibits a fixed level of linear dependence of $\beta = 1$ and varying degrees of lower tail dependence. Lower tail dependence is introduced through heteroskedasticity in ε_i. Specifically, $y_i = \beta x_i + \varepsilon_i$, where $\varepsilon_i \sim N(0, \sigma^2 (x_i + 0.25)^\alpha$, $\alpha \in (0, 1]$.
The third simulated data set reflects a fixed degree of asymmetric dependence through $\alpha = 0.5$ and varying degrees of linear dependence with $\beta \in (-1, 1]$.

Scenario (a) in Figure 4.2 shows that in the presence of linear dependence only, the CAPM beta estimate increases monotonically with increasing linear dependence. However, beta by construction ignores the effects of higher-order, asymmetric components of dependence. In the presence of a fixed degree of linear dependence and varying asymmetric dependence (Scenario (b)), the beta estimate is broadly constant at the level of linear dependence. This finding is corroborated through the third simulation (Scenario (c)). The beta estimate increases monotonically with increasing linear dependence, irrespective of the degree of asymmetric dependence introduced into the data.

Figure 4.2: Evolution of the CAPM beta coefficient estimate in three different scenarios



(a) Linear dependence only

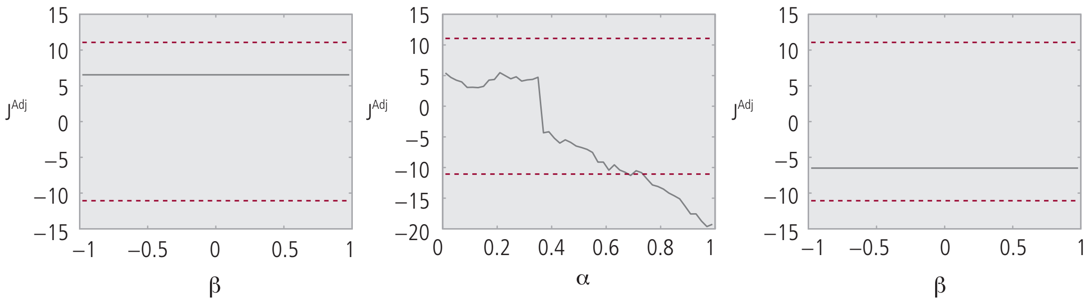
(b) Fixed linear dependence and varying lower tail dependence

(c) Fixed lower tail dependence and varying linear dependence

Note. In (a), the data is characterised by varying degrees of linear dependence from (−1, 1] only. In (b), the data displays a fixed level of linear dependence of unity, but varying degrees of lower tail dependence (LTD) from (0, 1]. Scenario (c) shows the evolution of beta as a function of fixed LTD and varying degrees of linear dependence as in (a). In each panel, the x-axis shows the evolution of the dimension of dependence that varies in the respective scenario. The results are based on simulations with n = 10,000.

The adjusted-J assesses the presence and strength of asymmetric dependence. Importantly, the adjusted-J recognises whether any higher-order dimensions of dependence, beyond linear dependence, are significant in the overall dependence structure characterising the data at hand. The adjusted-J is calculated based on transformed returns to control for linear dependence. Therefore, the statistic gives an indication of dependence net of the influence from linear dependence. Consistently, the adjusted-J is constant and insignificant in the presence of linear dependence only. It is constant at a negative value in the presence of lower tail dependence and varying degrees of linear dependence. The adjusted-J decreases with increasing lower tail dependence.

Figure 4.3: Evolution of the adjusted-J statistic in three different scenarios



(a) Linear dependence only

(b) Fixed linear dependence and varying lower tail dependence

(c) Fixed lower tail dependence and varying linear dependence

Note. In scenario (a), the data is characterised by varying degrees of linear dependence from (–1, 1] only. In (b), the data displays a fixed level of linear dependence of unity, but varying degrees of lower-tail dependence (LTD) from (0, 1]. Scenario (c) shows the evolution of beta as a function of fixed LTD and varying degrees of linear dependence as in (a). In each scenario, the x-axis shows the evolution of the dimension of dependence that varies in the respective scenario. The results are based on simulations with n = 10,000. The dotted line represents the positive and negative χ^2 critical values at 5% significance.

4.1 Key points

- Measuring asymmetric dependence is a complex problem as methods need to distinguish between linear and higher-order aspects or dimensions of dependence;
- Linear dependence and higher-order aspects of dependence need to be managed differently;
- Existing studies of asymmetric dependence tend to either focus on linear dependence (correlations) or employ methods that are unable to distinguish between different dimensions of dependence – these methods may produce misleading results that are not statistically robust;
- Use of the CAPM beta is suggested as a metric of linear dependence in combination with the adjusted-J statistic, a metric of asymmetric dependence that is robust to the prevailing level of linear dependence;
- In combination, these two methods provide a comprehensive, informative and statistically robust assessment of dependence between the returns from different assets.

5. METHODOLOGY AND DATA SET EMPLOYED

5.1 Data set

In the study a large sample of listed real estate firms is analysed, summarised in the FTSE EPRA UK index. For direct real estate, the IPD monthly total return index is included as well as two de-smoothed series based on this index. The first de-smoothed series is generated from a conventional filtering de-smoothing technique,[5] whereas the second series is obtained using the threshold autoregression technique as set out in Working Paper 2. In the analysis, a range of benchmark assets is considered. As a proxy for UK stocks, the FTSE All Share index and the FTSE Small Cap index are included. For fixed income, we include the 10-year UK Government Benchmark Bond is included.

Existing studies on the dependence structure of returns from listed real estate securities focus on a variety of observation frequencies. For completeness, data observed on a daily and monthly frequency are analysed.

Most studies into the dependence structure of real estate focus on total returns, but some researchers choose to study price returns. This analysis is conducted on the basis of total returns as well as price returns to control for confounding effects stemming from the inclusion of dividend payments. As far as the direct real estate data is concerned, the analysis is based on monthly total returns only.

The study period begins in January 1990 as the FTSE EPRA UK index data is unavailable prior to that date, and ends in December 2010.

5.2 Empirical method

The central objective of this paper is to isolate the linear dependence of real estate assets and the chosen set of benchmark assets from higher-order, asymmetric dependence between them. Linear dependence is assessed by estimating the traditional CAPM equation

Equation 5.1: CAPM equation

$$R_{it} = \alpha + \beta R_{mt}$$

where R_{it} is the return on real estate asset i at time t, α is a constant term, and R_{mt} is the return on the benchmark at time t. The estimate of the coefficient β reflects the ratio of the covariance between the test asset with the benchmark and the variance of the benchmark. Heteroskedasticity- and autocorrelation-consistent (HAC) standard errors with automatic lag selection (Newey and West, 1987, 1994).

The adjusted-J is calculated over the exceedances, $\vartheta = [0,0.2,0.4,0.6,0.8,1\ \}$.[6] The adjusted-J analyses the difference in correlation beyond certain exceedances, and the occurrence of net upper - or lower-tail dependence is likely to be contingent on a small number of tail events.

Therefore, the adjusted-J is likely to be prone to some likelihood of Type II error, and any evidence for the existence of asymmetric dependence on the basis of this statistic is conservative.

60-month rolling estimates of the CAPM beta and the adjusted-J are also caculated on the basis of continuously compounded monthly total returns to explore the evolution of these metrics over time.

[5] Following prior IPF research, the IPD monthly index is de-smoothed using an alpha of 0.8. The published valuation series has a serial correlation of 0.9, indicating very high levels of smoothing.

[6] The Bartlett kernel is used for the estimation of the variance–covariance matrix, Ω (Alcock and Hatherley, 2011; Hong, Tu and Zhou, 2007).

5.3 Descriptive statistics

Table 5.1 shows the main descriptive statistics for the return series studied. The daily price return series include information on the FTSE/EPRA UK index (FEUTDKL), the FTSE All Share (FTALLSH), the Small Cap index (FTSESCO) and the 10-year UK government bond (BMUK10Y). Mean values are close to zero for all series, but the FTSE/EPRA UK index as well as the FTSE All Share index have significantly higher standard deviation values than the Small Cap index and, of course, UK bonds. Values of skewness and kurtosis suggest highly non-normal distributions.

Mean values for daily total returns are higher than daily price returns, due to the inclusion of dividends and coupons, with comparable values of standard deviations as well as skewness and kurtosis, suggesting that the series are distributed in a similar fashion, but shifted slightly due to the influence of dividends and coupons.

The monthly total return series also include information on the IPD total return index (IPD) and two de-smoothed series, one obtained using the conventional de-smoothing technique (CONV) and one obtained from the threshold auto-regression (TAR) procedure. The mean values of the two de-smoothed series are similar to the mean of the IPD series but their standard deviations are substantially higher, reflecting the effects of de-smoothing. The TAR technique also produces stronger negative skewness and kurtosis.

The linear association between real estate securities and the benchmarks is negative for government bonds for the daily price and total returns as well as the monthly total returns. The highest correlations are observed between listed real estate and the UK stock market indices. The lowest correlations are observed between listed real estate securities and government bonds, suggesting that a portfolio containing these assets may offer some benefits of diversification.

As for direct real estate, the two unsmoothed series produce a fairly close replica of the IPD returns, with correlations generally above 60%. Unsurprisingly, the correlations between the direct real estate series and the stock market indices are substantially lower than for listed real estate – but the general pattern remains the same, with negative correlations between real estate and government bonds, and positive (but generally less than 30%) correlations between real estate and stocks.

Table 5.1: Descriptive statistics of data employed

(a) Daily price return					
(decimal)	DESCR	Mean	Stdev	Skewness	Kurtosis
	FEUTDKL	0.0000	0.0127	−0.0598	10.5390
	FTALLSH	0.0002	0.0105	−0.1688	10.3507
	FTSESCO	0.0001	0.0065	−1.0733	12.9972
	BMUK10Y	0.0001	0.0041	0.0562	7.1975

(b) Daily total return					
(decimal)	DESCR	Mean	Stdev	Skewness	Kurtosis
	FEUTDKL	0.0001	0.0127	−0.0532	10.5047
	FTALLSH	0.0003	0.0105	−0.1719	10.3274
	FTSESCO	0.0002	0.0065	−1.0513	13.0714
	BMUK10Y	0.0003	0.0040	0.0802	7.2117

(c) Monthly total return					
(decimal)	DESCR	Mean	Stdev	Skewness	Kurtosis
	IPD	0.0058	0.0116	−1.8078	9.6981
	TAR	0.0044	0.0318	−8.2676	102.1454
	CONV	0.0056	0.0261	−1.3246	8.7621
	FEUTDKL	0.0030	0.0609	−0.4789	5.1253
	FTALLSH	0.0067	0.0432	−0.6302	3.7288
	FTSESCO	0.0053	0.0544	−0.5533	5.9570
	BMUK10Y	0.0069	0.0196	0.0254	3.5409

Table 5.2: Unconditional correlations between the return series studied

(a) Daily price return							
	FEUTDKL	FTALLSH	FTSESCO	BMUK10Y			
FEUTDKL	1.0000						
FTALLSH	0.5631	1.0000					
FTSESCO	0.5617	0.6918	1.0000				
BMUK10Y	–0.0534	–0.0513	–0.0822	1.0000			

(b) Daily total return							
	FEUTDKL	FTALLSH	FTSESCO	BMUK10Y			
FEUTDKL	1.0000						
FTALLSH	0.5642	1.0000					
FTSESCO	0.5616	0.6927	1.0000				
BMUK10Y	–0.0552	–0.0536	–0.0843	1.0000			

(c) Monthly total return							
	FEUTDKL	FTALLSH	FTSESCO	BMUK10Y			
	IPD	TAR	CONV	FEUTDKL	FTALLSH	FTSESCO	BMUK10Y
IPD	1.0000						
TAR	0.5721	1.0000					
CONV	0.6318	0.7438	1.0000				
FEUTDKL	0.2906	0.2108	0.2652	1.0000			
FTALLSH	0.1562	0.2468	0.1542	0.6154	1.0000		
FTSESCO	0.1912	0.2610	0.2088	0.6267	0.8211	1.0000	
BMUK10Y	–0.2050	–0.1180	–0.1760	0.1910	0.1828	0.0393	1.0000

5.4 Key points

- Data from the United Kingdom commercial real estate, equity and bond markets between 1990 and 2010;
- Public market data – equity and bond series and securitised real estate returns – are analysed on a daily and on a monthly basis. Private real estate – the IPD monthly index and two de-smoothed series – are analysed on a monthly basis;
- Descriptive statistics for the series suggest that they are not normally distributed, with most series exhibiting high levels of kurtosis – that is, the series have 'fat tails' with a higher probability of extreme returns than would be expected from a normal distribution;
- An examination of the linear relationships suggests that real estate is positively linked to the equity market but negatively linked to bond returns. The private real estate series (smoothed and de-smoothed) have lower correlations with the financial assets than the public, property company and REIT returns.

6. EMPIRICAL RESULTS

This section presents results from the analysis of linear dependence (measured by CAPM beta) and asymmetric dependence (measured by the adjusted-J statistic) for the UK markets over the period 1990–2010.

Table 6.1 shows the main empirical results. The findings for indirect and direct UK real estate investments are discussed in turn.

Panel (a) reports the results from the CAPM beta estimation of the different types of UK real estate investments against the benchmarks. For listed real estate, the linear dependence with UK FTSE All Share and Small Cap stocks is significantly different from zero and similar in magnitude for the daily price and total return series (DPR and DTR, respectively), but slightly higher for the monthly total return series. However, from a risk management point of view, it is interesting to assess whether the linear dependence between real estate and the market is significantly different from one, since a CAPM beta coefficient smaller than one implies some risk-dampening influence of the stock on portfolio performance.

Panel (b) shows that, as far as the daily price return and total return series are concerned, there is some evidence that listed real estate exerts a risk-dampening influence on portfolio performance with beta coefficients significantly smaller than one with respect to the FTSE All Share index. However, the beta coefficient of listed real estate with respect to the Small Cap index is statistically indistinguishable from unity, implying that the FTSE/EPRA UK index follows variation in the Small Cap stock index fully proportionally. The evidence is reversed on the monthly frequency (for monthly total returns, MTR), where listed real estate appears to display some risk-dampening behaviour in relation to the Small Cap index, but not the FTSE All Share index. This finding suggests that the characteristics of monthly returns are significantly different from daily returns, as the aggregation to a lower frequency smoothes out some of the characteristics of the daily data.[7]

For unlisted real estate, panel (a) shows that the three monthly total return series (IPD and two unsmoothed series, TAR and CONV) appear to have insignificant linear association with the stock market indices (coefficients indistinguishable from zero and significantly lower than one). This finding implies substantial benefits of diversification and risk-dampening effects of direct real estate on a mixed-asset portfolio containing these assets. The linear association with government bonds is negative and has some statistical significance, corroborating the evidence for substantial benefits of diversification associated with direct real estate investments.

Empirical evidence for asymmetric dependence is assessed on the basis of the adjusted-J statistic (panel (c)). A value of the adjusted-J in excess of +/−10.6 is significant at the 5% level. When controlling for linear dependence, very little evidence is found for statistically significant asymmetric dependence between direct/indirect UK real estate investments and stocks or bonds.

These finding stands in contrast to studies reporting evidence for asymmetric dependence in international markets using a GARCH framework as well as (international) copula studies. As the results demonstrate, asymmetric dependence in listed real estate investments appears to be insignificant after linear dependence is appropriately controlled for.

The results presented here highlight the value of controlling for linear dependence in order to obtain a robust estimate of tail dependence. The lack of evidence for asymmetric dependence between UK real estate investments and the benchmark assets implies that conditional correlations should adequately capture the dependence structure of real estate investments with these benchmarks.

[7] As expected from the principles of central limit theorem.

Further, the results support the view that asymmetric dependence is less problematic in direct real estate investments. When performance is evaluated on high-frequency data, such as daily geometric returns, that are aggregated to a lower frequency, then the distribution of the resulting summation will approach normality with increasing numbers of observations, as a result of the central limit theorem. This relationship implies that higher-order moments of dependence are more relevant for shorter investment time horizons. Therefore, higher-order, asymmetric components of dependence are likely to affect indirect real estate investments into listed securities that are held short-term disproportionately more than long-term direct real estate investments.

Evidence is found for significant upper tail dependence between the returns on UK direct real estate investments and government bonds (panel (c)). Consider this finding in conjunction with the negative linear dependence between real estate and bonds: overlaying this inverse linear relationship with the significant upper-tail dependence suggests that when bonds perform well, real estate is likely to perform poorly. When bonds perform poorly, real estate is likely to perform relatively better, but the exact strength of the performance may vary significantly.

This might seem counter-intuitive, given that real estate is often said to have 'bond-like' characteristics, and that real estate and bond prices are both sensitive to interest rate shocks. Real estate is often assessed on the basis of yields that reflect all relevant risk factors, in line with the Gordon growth model (Baum, 2002). A risk premium is applied to the prevailing bond yield. If real bond yields fall,[8] real estate values may be expected to rise as yields may also fall, holding the risk premium constant. This situation would imply stronger returns on real estate.

However, bond returns are strong when bond prices rise and bond prices may rise in periods of financial turmoil when they are sought after as a safe haven for investors. This interpretation would imply that one of the occasions when bond prices rise is when the interest rate is reduced in order to stimulate the economy to overcome a slowdown. It may also be that the risk premium rises in such an environment, as higher uncertainty is more relevant for an asset class that shares some characteristics with a risky stock. This combination of factors may lead to an upward revision of risk premia and thus a net fall of real estate values, resulting in lower returns. Similarly, in an environment that is characterised by higher uncertainty, such as an economic slowdown that warrants reductions in the interest rate, it may become less likely that real options embedded in direct real estate investments may be exercised soon. Therefore, there may be an additional delay before investors can realise the value added through exercising these options. This factor may again cause downward revisions in real estate prices, triggering lower return observations when bond returns are strong.

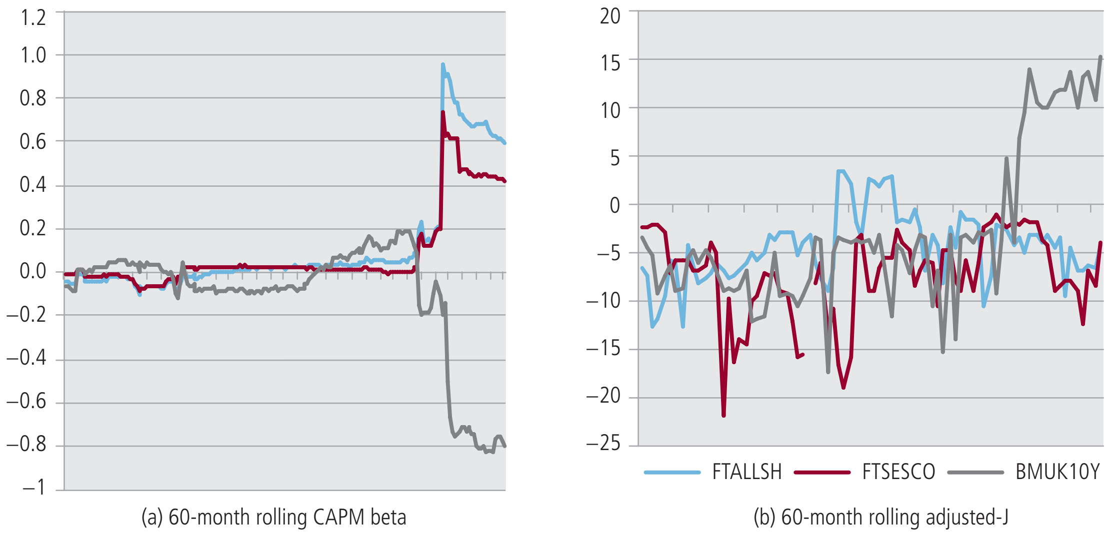
[8] A fall in nominal bond yields resulting from a fall in expected inflation may be offset by an equivalent fall in the expected nominal growth in rental values.

Table 6.1: Public market returns

(a)				(b)				(c)	
DPR	**Beta**	**Std err**	**t-stat**	**DPR**	**Beta**	**Std err**	**t-stat**	**Adj J**	**Value**
FEUTDKL	H0: beta = 0			FEUTDKL	H0: beta = 1			FEUTDKL	
FTALLSH	0.6810	0.0372	18.2872	FTALLSH	0.6810	0.0372	−8.5672	FTAL LSH	−8.5215
FTSESCO	1.0900	0.0565	19.3089	FTSESCO	1.0900	0.0565	1.5946	FTSESCO	−4.0106
BMUK10Y	−0.1650	0.0840	−1.9635	BMUK10Y	−0.1650	0.0840	−13.8618	BMUK10Y	−10.1888
DTR	**Beta**	**Std err**	**t-stat**	**DTR**	**Beta**	**Std err**	**t-stat**	**Adj J**	**Value**
FEUTDKL	H0: beta = 0			FEUTDKL	H0: beta = 1			FEUTDKL	
FTALLSH	0.6820	0.0373	18.2799	FTALLSH	0.6820	0.0373	−8.5250	FTALLSH	−9.8193
FTSESCO	1.0889	0.0566	19.2536	FTSESCO	1.0889	0.0566	1.5724	FTSESCO	−6.9990
BMUK10Y	−0.1728	0.0855	−2.0213	BMUK10Y	−0.1728	0.0855	−13.7194	BMUK10Y	−7.8881
MTR	**Beta**	**Std err**	**t-stat**	**MTR**	**Beta**	**Std err**	**t-stat**	**Adj J**	**Value**
FEUTDKL	H0: beta = 0			FEUTDKL	H0: beta = 1			FEUTDKL	
FTALLSH	0.8668	0.1035	8.3716	FTALLSH	0.8668	0.1035	−1.2870	FTALLSH	3.0627
FTSESCO	0.7010	0.0839	8.3534	FTSESCO	0.7010	0.0839	−3.5631	FTSESCO	2.6074
BMUK10Y	0.5944	0.2257	2.6336	BMUK10Y	0.5944	0.2257	−1.7974	BMUK10Y	2.4188
MTR	**Beta**	**Std err**	**t-stat**	**MTR**	**Beta**	**Std err**	**t-stat**	**Adj J**	**Value**
IPD	H0: beta = 0			IPD	H0: beta = 1			IPD	
FTALLSH	0.0420	0.0266	1.5773	FTALLSH	0.0420	0.0266	−36.0129	FTALLSH	−4.3770
FTSESCO	0.0408	0.0253	1.6122	FTSESCO	0.0408	0.0253	−37.9113	FTSESCO	−8.0714
BMUK10Y	−0.1217	0.0509	−2.3910	BMUK10Y	−0.1217	0.0509	−22.0361	BMUK10Y	−5.9198
MTR	**Beta**	**Std err**	**t-stat**	**MTR**	**Beta**	**Std err**	**t-stat**	**Adj J**	**Value**
TAR	H0: beta = 0			TAR	H0: beta = 1			TAR	
FTALLSH	0.1815	0.1373	1.3214	FTALLSH	0.1815	0.1373	−5.9606	FTALLSH	−4.8390
FTSESCO	0.1523	0.1040	1.4655	FTSESCO	0.1523	0.1040	−8.1540	FTSESCO	3.4885
BMUK10Y	−0.1917	0.1003	−1.9104	BMUK10Y	−0.1917	0.1003	−11.8786	BMUK10Y	12.8864
MTR	**Beta**	**Std err**	**t-stat**	**MTR**	**Beta**	**Std err**	**t-stat**	**Adj J**	**Value**
CONV	H0: beta = 0			CONV	H0: beta = 1			CONV	
FTALLSH	0.0931	0.0585	1.5917	FTALLSH	0.0931	0.0585	−15.5121	FTALLSH	−4.0046
FTSESCO	0.1001	0.0526	1.9021	FTSESCO	0.1001	0.0526	−17.1094	FTSESCO	−4.8223
BMUK10Y	−0.2346	0.1348	−1.7400	BMUK10Y	−0.2346	0.1348	−9.1569	BMUK10Y	4.0720

Figure 6.1 shows the evolution of 60-month rolling CAPM beta and adjusted-J values for monthly total returns of UK direct real estate investments (TAR series) and the benchmark assets over time.

Figure 6.1: Evolution of 60-month rolling CAPM beta and adjusted-J estimates for UK direct real estate (TAR series) and the benchmark assets



Note. The x-axis follows the dates of the study period, ranging from January 1990 to December 2010. The spike in the CAPM series corresponds to the events surrounding the Lehman Brothers collapse in September 2008. The same events appear to have less influence on the adjusted-J series, with the exception of the TAR series in relation to UK government bond returns.

While the CAPM beta series generally appear to exhibit a smooth constant evolution between –0.2 and 0.2, there is a spike in all of them following the collapse of Lehman Brothers in September 2008 – with the exception of the CAPM beta series tracking the relationship between real estate and bond returns; this relationship appears to experience a trough. At the same time, the adjusted-J series, while generally more volatile, appear to remain fairly unaffected by the turbulent events surrounding September 2008 – with the exception of government bond. The corresponding adjusted-J values reach unprecedented levels in that period. This finding suggests that linear and asymmetric dependence have to be taken into account separately in portfolio management, as they evolve relatively independently from each other.

6.1 Key points

- The evidence for asymmetric dependence in the returns from both public and private UK real estate investment is examined;
- The methodology makes it possible to provide a statistically robust estimate of asymmetric dependence taking into account the linear and time-varying relationships between real estate and equities explored in Working Paper 3;
- The results presented here suggest that tail dependence in UK real estate returns is not as pronounced a problem as might be expected on the basis of the previous literature on the subject. As the frequency of the returns falls from daily to weekly to monthly, so the significance of any tail dependence diminishes;

- This implies that for longer-term investors, real estate still offers clear diversification benefits when placed alongside equities in a mixed-asset portfolio. Managers who are required to revalue or rebalance their funds and manage their exposure on a frequent basis, by contrast, need to be aware of tail dependency effects and their impact on diversification;
- The relationship between real estate and government bonds is more nuanced than often assumed. Some evidence of positive tail dependence is detected – that high bond returns and high real estate returns coincide. The most likely explanation of this lies in the impact of interest rate shocks in both markets. This emphasises the need to be aware of the effect of leverage on delivered real estate returns.

7. CONCLUSION

The benefits of diversification associated with adding real estate to a mixed-asset portfolio are often established on the basis of low average correlations. However, research suggests that correlations vary through time. They tend to increase in periods of higher uncertainty and after negative return shocks. This finding opens up the possibility that the returns from real estate investments exhibit asymmetric dependence. This phenomenon, well documented in industrial equities, implies that jointly positive returns from real estate and other asset classes differ in likelihood and magnitude from jointly negative returns. The benefits of diversification often ascribed to real estate investments may vanish when they are most needed to protect investment portfolios from value erosion during downturns.

Measuring asymmetric dependence is a complex problem. The dependence structure between financial asset returns is characterised by many dimensions, including, but not restricted to, correlation, co-skewness, and co-kurtosis. Existing studies which suggest that real estate returns exhibit asymmetric dependence are often based on methods that either focus on correlations only or on methods that cannot distinguish between the different dimensions of dependence. The former type of method is unable to detect higher-order dimensions of dependence. The latter type is unable to attribute dependence patterns to any particular dimension. However, a clear distinction between the relevant dimensions of dependence is crucial for choosing the appropriate portfolio optimisation techniques.

A combination of methods is utilised in this study, which produces a comprehensive and, importantly, statistically robust description of the dependence structure between real estate and other asset classes. The CAPM beta is employed as a measure of linear dependence, and the adjusted-J statistic as a measure of asymmetric dependence that controls for linear dependence and focuses on higher-order dimensions of dependence only.

These dependence metrics are applied to a large sample of UK real estate investment returns from direct (smoothed/unsmoothed) and indirect real estate holdings. In summary, asymmetric dependence is found to be less universal a problem than sometimes suggested in the literature, especially for direct real estate investments that tend to be characterised by longer holding periods. This finding highlights the importance of distinguishing between different dimensions of dependence that need to be measured and, if found to be significant, managed separately.

This finding is of major importance to real estate investors since the benefits of diversification offered by real estate appear to be stronger than sometimes suggested in recent studies about asymmetric dependence. However, securitised real estate funds that must be rebalanced frequently may be vulnerable to an increase in co-movement between real estate and equity markets in extreme conditions.

It is also revealing that the relationship between government bond returns and real estate performance is more complex than often portrayed, resulting from the contradictory impacts of interest rates (with falling rates associated with rising bond and real estate prices, other things equal) and risk premia effects, where, in troubled markets, ‘flight to safety’ effects push bond prices (and returns) higher and other asset prices lower. Risk management processes need to account for these different effects.

The results presented above, then, suggest that asymmetric dependence is a potential issue for real estate securities but, due to longer holding periods and less frequent trading, less significant a problem than has been suggested for direct, private real estate. Nonetheless, the potential risks of clusters of poor returns across assets and asset classes must be considered in shaping portfolios and it is clear that the assumption that returns between real estate, equities and bonds hold the same relationship across all market conditions cannot be maintained. By implication, standard

7. CONCLUSION

mean–variance portfolio strategies may be sub-optimal in failing to account for periods when 'diversification does not work', where correlations between asset classes rise rapidly. This suggests the need to investigate risk management procedures that are more sensitive to these time-varying and conditional relationships between investment assets.

At this stage, however, little definitive can be said about the effects of asymmetric dependence on the optimal real estate portfolio, the appropriate efficient frontier or the performance of real estate portfolios in the long term. In the presence of asymmetric dependence, optimal portfolios must incorporate both information surrounding the marginal distributions of the assets and information about the dependence structure between assets. The majority of the finance literature to date on listed, traded securities presents conflicting results. In modelling marginal distributions that are non-normal functions alongside asymmetric dependency relationships, the effect of the dependence assumption becomes unclear. Notable exceptions to this include Hatherley and Alcock (2007) and Alcock and Hatherley (2009), who present a general methodology that can be used to determine the robustness of mean-variance-based portfolio theory to non-normal assumptions, focusing particularly on the effects of the assumption of asymmetric dependence. Assuming normal marginal distributions, they model asset dependence using copula functions and construct portfolios following the stochastic dominance paradigm. To this end, portfolios are constructed by minimizing conditional value-at-risk (or CVaR). For continuous distribution functions, CVaR is also known as expected shortfall or tail conditional expectation.

According to the Alcock and Hatherley work, controlling for lower tail dependence with this copula-CVaR method appears to provide significant economic benefit over mean-variance style portfolio selection. Negative returns can be reduced with little expense to upside risk. Controlling for lower tail dependence also reduces the size of any erosion in return relative to the normal portfolio. However, this does not imply that negative portfolio movements are eliminated all together. Hatherley and Alcock (2007) and Alcock and Hatherley (2009) demonstrate that for both portfolios of indices and for individual stocks, portfolio performance - as measured by the Sharpe Ratio, Maximum Drawdown and the Information Ratio - substantially improves by correcting for asymmetric dependence.

However, it must be stressed that these findings relate to the high-frequency data and listed securities and rely on relatively low transaction costs and liquidity in trading to permit portfolio rebalancing. The greater illiquidity, longer holding periods and substantially higher transaction costs make it problematic to apply such models in the private real estate market. Nonetheless, the overall findings from this research project make it clear that standard models of risk and return that rely solely on mean, variance and correlation measured over a single period do not adequately characterise the risks of investing in real estate, whether in private or public markets and that, therefore, researchers and practitioners need to develop models that help understand and manage these more complex inter-relationships between assets. The research team hopes it has contributed to that effort.

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Investment Property Forum
New Broad Street House
35 New Broad Street
London EC2M 1NH

Telephone: 020 7194 7920
Fax: 020 7194 7921
Email: ipfoffice@ipf.org.uk
Web: www.ipf.org.uk