



Research
Programme
2006-2009

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



Working Paper 1
Real Estate Returns
and Other Asset Classes:
A Review of Literature

April 2012

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



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



Deloitte.



PRUPIM



Working Paper 1

IPF Research Programme 2006–2009

April 2012

REAL ESTATE'S ROLE IN THE MIXED-ASSET PORTFOLIO: A RE-EXAMINATION

Research team

Jamie Alcock, *University of Cambridge*

Colin Lizieri, *University of Cambridge*

Eva Steiner, *University of Cambridge*

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*

Disclaimer

This document is for information purposes only. The information herein is believed to be correct, but cannot be guaranteed, and the opinions expressed in it constitute our judgement as of this date but are subject to change. Reliance should not be placed on the information and opinions set out herein for the purposes of any particular transaction or advice. The IPF cannot accept any liability arising from any use of this document.

CONTENTS

1	Executive Summary	6
2	Introduction	7
3	The Conventional Mean–Variance Framework and Real Estate Returns	8
	3.1 Return Distributions and Portfolio Theory	9
	3.2 Summary	10
4	The Distribution of Real Estate Returns	11
	4.1 Return Distributions	11
	4.2 Asymmetric Behaviour in Property Markets	12
	4.3 Valuation Smoothing	12
	4.4 Summary	14
5	Evidence of Complex Dependence Structures in Real Estate	15
	5.1 Summary	17
6	Conclusions	18
	BIBLIOGRAPHY	19
	APPENDIX	24
	Appendix: Dependence as a Multi-dimensional Problem	24
	REFERENCES	25

1. EXECUTIVE SUMMARY

- This paper – the first of four working papers re-examining the role of real estate in mixed-asset portfolios for the Investment Property Forum – reviews the literature on the relationship between real estate returns and those of other asset classes.
- The use of standard portfolio optimiser techniques using equity, bond and real estate indices tends to point towards a large allocation to real estate – far greater than the proportion held by most professional investors in their mixed-asset portfolios.
- This result is driven by property's reported low standard deviation and low correlations with the other financial asset classes. However the allocation results hold even where property returns are desmoothed and illiquidity premia are added.
- Portfolio theory requires that asset returns follow a particular distributional form that means that risk can be fully characterised using just individual asset standard deviation and the covariance between assets.
- Research suggests that real estate does not meet the requirements of portfolio theory and the capital asset pricing model: skewness and excess kurtosis lead real estate to fail tests for normality.
- There is some evidence that return distributions are time-varying and that real estate is characterised by asymmetric and/or non-linear behaviour, with differences observed between bull and bear markets. This suggests that more complete risk management strategies are required.
- In particular, the nature of property returns cast doubt on the use of the standard deviation as the most effective measure of risk for property returns. Researchers have advocated the use of mean absolute deviation, downside risk and lower partial moments, drawdown and other ways of capturing the risk of the asset class.
- Much real estate performance data relies on valuations rather than transaction-based evidence. This is problematic since it is believed that valuers anchor on past valuations and thus report smoothed, moving average, returns. Methods that seek to desmooth valuation-based returns rely on a set of assumptions and there is no consensus as to the most appropriate method.
- Analysis of REIT returns suggests that the relationship between property and other asset classes is more complex than portrayed in standard mean–variance approaches. The sensitivity of REITs to the overall stock market and to bonds appears to be time varying or cyclical in nature, while the correlation between real estate and equities varies over time. There is some evidence that correlations increase when markets are more volatile, with implications for the benefits of diversification.
- Studies employing a copula approach have identified a higher than expected probability of pairs of negative returns, particularly between real estate and equity indices, which suggests the presence of lower-tail dependence.
- These findings suggest that the diversification benefits of including real estate in a portfolio vary over time – and may diminish in difficult market conditions.
- Most of the results found relate to relatively high frequency data – daily, weekly or monthly. As short-run returns are aggregated, the time varying effects become less evident. This might suggest that the impact of complex return relationships is more likely to be felt in public real estate markets than in private property.

2. INTRODUCTION

This is the first working paper from the Investment Property Forum funded project re-examining the benefits of including real estate 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. In particular, the research examines the extent to which real estate returns behave more like other asset classes in 'bad' economic environments. If that is the case, then conventional arguments on the role of property as a risk diversifier look less strong. However, if it can be shown that commercial real estate continues to behave in a distinctive manner in general asset market downturns and booms, then this provides useful evidence to shape multi-asset portfolio allocation strategies.

The project has generated four working papers. This first paper provides a general introduction to the topic and the state of existing research. Working Paper 2 focuses on the nature of valuation-based return data and attempts to assess whether the underlying return processes and the behaviour of valuers changes across different market environments. Working Paper 3 looks at the time-varying relationship between real estate returns and the returns of other asset classes. Working Paper 4 focuses on the asymmetry issue and seeks evidence of tail dependence between real estate returns and other asset classes: in brief, whether the correlation between property and equities or property and bonds increases when market conditions are poor. If that occurs, then the diversification benefits offered by real estate in the mixed-asset portfolio are diminished.

The aim of this paper is to examine the literature on real estate return distributions, the measurement of risk and asymmetric dependence structures in real estate investment. It should be noted that the approach here is to focus on 'conventional' financial approaches to risk, rather than to follow and duplicate the approach adopted in the IPF's **Risk Web 2.0 project** (Blundell, Frodsham & Martinez, 2011) which, in essence, focused on fund tracking error and the factors contributing to that. It also develops, rather than attempts to duplicate, the work contained in the 2007 IPF report **Asset Allocation in the Modern World**.

Section 2 of this paper considers the conventional mean–variance approach to portfolio allocation and discusses the assumptions that underpin the conventional model. The study next turns to commercial real estate returns. It begins with a discussion of the distribution of real estate returns. Three topics are covered: first, evidence on normality (or, more accurately, non-normality) of real estate returns; second, the research looks at evidence of asymmetric behaviour in property; third, the impact of the valuation basis of most direct property market indices is considered briefly, with smoothing being the subject of Working Paper 2. Finally, the available evidence on asymmetric behaviour and tail dependence in commercial real estate is considered, before drawing brief conclusions.

3. THE CONVENTIONAL MEAN–VARIANCE FRAMEWORK AND REAL ESTATE RETURNS

The standard arguments for the inclusion of real estate in mixed-asset portfolios draw on the mean–variance framework of modern portfolio theory (MPT) and the capital asset pricing model (CAPM). Is a focus on mean, standard deviation and correlation sufficient to characterise property risk?

Much of the existing research on real estate investment characteristics sits within a conventional or traditional finance framework drawing on MPT and the CAPM. Even where these do not directly drive policy, they continue to influence thinking, with the risk–return trade-off couched in terms of average or mean returns and the volatility of those returns captured by the standard deviation. CAPM concepts are implicit in risk attribution and performance measurement and in the pursuit of positive ‘alpha’ – significant outperformance after accounting for the systematic or market risk of the fund.

The original **Case for Property**¹ lies in the combination of apparently strong risk-adjusted returns and the low observed correlation between commercial real estate returns and those of other financial assets. Since any asset that is less than perfectly correlated with others reduces risk in a portfolio, placing real estate returns in a mean–variance portfolio optimiser alongside equities and bonds seemed to point to a very high allocation to real estate – far higher than typical institutional holdings – along much of the efficient frontier. While this was clearly an artefact of the real estate data and, in particular, the valuation-based index data, the standard portfolio model generated a huge body of research (see, for example, Hoesli and Lizieri, 2007; Bond et al. 2007b; or MacKinnon and Al Zaman, 2009 for recent reviews). Real estate returns were desmoothed in various ways, other asset classes were included, forecast or expected returns were substituted for ex post returns, downside risk measurements utilised, international perspectives adopted. Approaches drawn from CAPM and arbitrage pricing theory (APT) were used in an attempt to identify unique real estate factors and to examine the long-run behaviour of real estate as an asset class. Nonetheless, application of standard optimisation models, however adapted, tends to support a large allocation to real estate.

In their 2007 IPF study, Bond et al. concluded:

... there is strong support from the historical evidence to underlie the current trend towards the high and increasing allocations towards real estate. On a risk-adjusted basis, real estate has been one of the best performing asset classes ... and it is noted that real estate has a significantly better risk hedging characteristic than any of the other asset classes. On the question of whether these benefits could have been derived from substituting members of the alternative asset group in place of real estate in a portfolio, the emphatic answer was that no other asset class could deliver the same level of portfolio hedging benefits as real estate.

These fundamental portfolio ideas – from Markowitz’s modern portfolio theory, from the CAPM and its variants, and from APT – rest on a set of exacting assumptions about market structure and investor behaviour. The validity of many of the assumptions is questionable in general and particularly problematic in real estate markets. Assets are not all marketable; there are barriers to investment, investors face capital constraints, information is not freely available to all investors; there are transaction costs, and those costs differ by asset class. For the remainder of the paper, two key issues are examined. First, are asset class return distributions consistent with the assumptions of portfolio theory and, if not, what are the implications? Second, do the standard models have explanatory power across the cycle and do the results from the models hold in different market environments? These two questions are closely related and have implications for portfolio investment strategies.

¹ Within the UK, the familiarity of the term comes largely from the Richard Ellis reports of that name popularising portfolio theory and arguing for a higher allocation in institutional portfolios.

3. THE CONVENTIONAL MEAN–VARIANCE FRAMEWORK AND REAL ESTATE RETURNS

3.1 Return Distributions and Portfolio Theory

The seminal works of Markowitz (1952), Sharpe (1964) and Elton and Gruber (1977) highlight the concept of dependence between asset returns as fundamental to asset allocation, portfolio construction and asset pricing. For example, Elton and Gruber (1977) show that, as the number of assets in a portfolio increases, the total portfolio variance converges to the average covariance between assets rather than the risk characteristics of any individual asset. All of these theories assume that the dependence between assets can be fully characterised by the variance–covariance matrix, which includes the covariance (and hence the correlation) between returns. This assumption implies that asset returns follow a multivariate normal distribution (MVN). This forms the basis of conventional, Markowitz-style mean–variance portfolio selection models and the CAPM characterisation of asset risk into systematic (market) and specific (residual) risk components.

In addition, the MVN implies that the relationship between different asset return distributions is the same in **normal markets** and in extreme bull or bear markets – that the covariance is largely independent of the market environment. However, casual observation suggests that the dependence between asset returns during extreme bear markets tends to increase markedly, as seen for example during the global financial crisis that began in 2007. Returns may not be symmetrically independent during extreme events. Rather, the dependence between returns is asymmetric – with high correlations observed during down-states of the market and lower correlations observed during up-states of the market. As a result, investors may not get diversification when they need it most.

The major implication of these tail dependence and asymmetric effects is that models based just on mean, standard deviation and correlation may be inadequate in describing portfolio risk and, hence, their application may fail to generate efficient portfolio allocation. The Appendix sets out formally an approach to understanding portfolio risk based on the Edgeworth expansion. This provides a useful conceptual framework for critically reviewing the most common approaches to assessing dependence in real estate finance and asset markets in general.

Markowitz's portfolio theory relies on the mean and the covariance matrix of returns to derive optimal portfolios using a linear optimisation algorithm. The validity of this theory relies on a set of assumptions about investor behaviour and asset market behaviour. Formally, it requires that investors make choices in line with quadratic utility,² or that return distributions are multivariate normal, in order to justify the use of a symmetric risk measure such as variance and the choice of covariance as an adequate measure of the dependence relationship between assets (Feldstein, 1969; Tobin, 1958). The assumption of quadratic utility implies increasing absolute risk aversion (that is, the greater the risk, the greater the relative demand for return that compensates) and eventual satiation of investor appetite for risk (over a certain risk level, no amount of extra return can persuade investors to accept an investment), characteristics that seem inconsistent with observed behaviour even in the earliest assessments of investor decisions (Borch, 1969; Feldstein, 1969; Levy, 1974; Pratt, 1964; Sarnat, 1974; Wipperfurth, 1971). Moreover, there is increasing evidence for asymmetric risk preferences and especially downside risk aversion that challenge the appropriateness of a symmetric risk measure such as standard deviation and its use in portfolio selection and performance measurement (see the reviews in Alcock and Hatherley, 2009; Hatherley and Alcock, 2007).

² Or a similar utility function.

3. THE CONVENTIONAL MEAN–VARIANCE FRAMEWORK AND REAL ESTATE RETURNS

The assumption of multivariate normality is not well supported empirically. Skewness and excess kurtosis are commonly observed in financial asset returns (Harvey, 2010; Harvey et al. 2010). Furthermore, if the probability of two assets both having high positive returns is not equal to the probability of those assets both having negative or low returns, then the symmetric dependence implied in the variance–covariance matrix and standard portfolio models inadequately describes the true dependence between those assets. This would imply that asset allocation models may need to incorporate higher-order terms of dependence to minimise portfolio risk as intended in the Markowitz framework. The next section develops this theme in considering return distributions and measurement issues in real estate markets.

3.2 Summary

- Standard portfolio optimiser exercises using equity, bond and real estate indices tend to suggest a large allocation to real estate – far greater than the proportion held by most professional investors in their mixed-asset portfolios;
- This result is driven by property’s reported low property standard deviation and low correlations with the other financial asset classes. However, the allocation results hold even where property returns are desmoothed and illiquidity premia are added;
- Portfolio theory holds where returns follow a multivariate normal distribution and where the relationship between asset returns is constant across the return distribution. Given that, risk can be fully characterised using asset standard deviation and the covariance between assets;
- However, it has been suggested that in bear markets, correlations between assets increase. If this asymmetric tail dependence is present, then diversification benefits may diminish when they are most needed;
- There is also evidence of skewness and excess kurtosis in asset returns which casts doubt on the validity of the normality assumptions of portfolio theory. This suggests that more complete risk management strategies are required.

4. DISTRIBUTION OF REAL ESTATE RETURNS

The validity and effectiveness of portfolio optimiser techniques in shaping investment strategies is determined by the quality of the data input into the models. What does research tell us about the nature of real estate distributions and the robustness of reported commercial property returns?

In this brief section, the literature on real estate return distributions is reviewed and some key measurement problems in real estate markets highlighted – notably the issue of valuation or appraisal smoothing in private real estate markets. Working Paper 2 deals with the smoothing issue at more length. As noted in the previous section, many portfolio allocation and performance measurement models used in finance implicitly assume normal or log-normal returns. The available evidence suggests that this is not a sound assumption in real estate markets – a finding which suggests that careful consideration is needed in the choice of risk measures and the interpretation of results from standard portfolio optimisers. Furthermore, there is growing evidence that real estate performance differs depending on market environment. What are the implications of such time-varying behaviour? Finally, early portfolio analyses of real estate returns utilised smoothed valuation-based real estate returns which may bias asset allocation. The problems of index construction, the dampening of reported risk measures and the potential distortion of correlation measures between asset markets that result from the use of appraisal-based indices are explored.

4.1 Return Distributions

Many authors have examined real estate return distributions and questioned the assumption of normality, particularly for direct, private market investment and for indices based on valuation/appraisal measures. Myer and Webb (1993) found evidence of non-normality in US data in terms of both skewness and kurtosis. Lizieri and Ward (2000) found that UK monthly commercial property returns data were non-normal, while quarterly data appeared more normal. Maurer et al. (2004) compare the distributional properties of US, UK, and German direct real estate returns. Using quarterly data, they find that UK returns are normal, but not US and German returns. For German data, normality is rejected due to significant positive skewness, while the US data could not be classified as normal due to significant negative skewness and leptokurtosis (fat tails). Once the data were desmoothed, the results changed with normality being accepted for Germany, but rejected for the UK and the US data. Nonetheless, when annual data were used, the assumption of normality could not be rejected for any country, either using the appraisal-based or desmoothed data. Other authors, however, do reject normality at annual frequency. As noted above, in the US, directly-held real estate appears to be less normal than other asset classes, while in the UK normality is rejected for the IPD-based series but not for the public asset classes. Various attempts have been made to find a suitable return distribution for real estate returns. Lizieri and Ward (2000) test real estate returns for a variety of possible distributions. There is little evidence that supports an assumption of normality. They find that the best fitting distribution appears to be the logistic distribution, but that even this is rejected in most cases; Bond et al. (2007b), drawing on IPF research, use a negative exponential distribution to model volatility in the marketing period for commercial property research.

Young, Lee and Devaney et al. (2006) decisively reject normality for private UK real estate returns. They also find that the characteristics of return distributions – including skewness – are time-varying. Similar findings emerge for US real estate returns – see, for example, Young and Graff (1995); Cheng (2005); or Young (2008), and for Australia (Graff et al., 1997). Young (2008) argues that the heteroscedastic, non-normal nature of real estate returns means that asset diversification is far less effective at reducing the impact of non-systematic investment risk on real estate portfolios than in the case of assets with normally distributed investment risk.

4. DISTRIBUTION OF REAL ESTATE RETURNS

4.2 Asymmetric Behaviour in Property Markets

There is also some evidence of non-linearity and asymmetry in the behaviour of real estate returns. In the IPF portfolio study, Bond et al. (2007a), writing before the onset of the global financial crisis, concluded that “over the bull and bear market periods the relative performance of the asset groups changed dramatically. Equities, private equity and gilts were the best performing assets during the bull market. In the bear market period, real estate and infrastructure have performed strongly”. Both Lizieri et al. (1998) and Maitland-Smith and Brooks (1999) obtain results that suggest there are distinct ‘return regimes’ in which return processes vary. Lizieri et al. use a threshold autoregressive model conditioned on real interest rates to show that volatility increases sharply in high real interest rate environments compared to low real interest regimes. In the former, returns trend downwards sharply; in the latter there is a more erratic upward movement. Maitland-Smith and Brooks use a Markov switching model that implies periods of quite distinct performance in terms of returns and, in particular, of volatility. These results have implications for performance benchmarking and for the assessment of asset risk. Okunev and Wilson (1997) use non-linear statistical techniques to suggest that the REIT market and the general equity market are partially integrated but that, with weak mean reversion, differences may persist, providing diversification benefits. Hutson and Stevenson (2008) discuss asymmetry in the REIT market and find evidence of time-varying skewness. Lizieri, Satchel and Zhang (2007) examine REIT behaviour using an independent components analysis approach that focuses on kurtosis rather than on variance to identify statistical risk factors. There is a link here to recent research that identifies asymmetric behaviour in rental adjustment and return processes, such that positive supply or demand shocks have different impacts to negative shocks – see, for example, Barras (2005), Farrelly and Sanderson (2005), Englund et al. (2008), Brounen and Jennen (2009) or Hendershott, Lizieri and MacGregor (2010).

These characteristics of asset behaviour have led to suggestions that portfolio allocation models including real estate should use a risk measure other than (or in addition to) the variance. Thus Byrne and Lee (1997, 2004) discuss various risk metrics and propose use of a mean absolute deviation risk measure,³ Hamelink and Hoesli (2004) use a maximum drawdown function and others have suggested a semi-variance measure (for example Bond and Patel, 2003). Stevenson (2001) argues for the use of Bayes–Stein estimators to ‘shrink’ risk-adjusted returns for international real estate portfolio diversification to reduce the impact of estimation error and to reduce the problem of ‘corner solutions’ – where the mean–variance algorithm results in very high weightings to individual asset types, against intuitive understanding of diversification as a spread of assets. The literature, however, has not considered explicitly whether diversification benefits are uniform across the distribution. Knight, Lizieri and Satchel (2005) report preliminary evidence that both global and UK real estate stocks exhibit tail dependence with common equities – that is, that there are correlations in the presence of extreme events. The results for the UK in particular suggest that correlations are strongest in the negative tail – ie, that diversification is absent when it is needed most. Similarly, Liu and Mei (1998) observe that international real estate stocks show a higher correlation with US stocks when US markets are performing badly. This is examined further below.

4.3 Valuation Smoothing

The topic of valuation smoothing has been extensively debated in commercial real estate markets – not least in the IPF research report *Index Smoothing and the Volatility of UK Commercial Property* (Marcato and Key, 2007). This section does not attempt to provide a full review, but it is important to note that using valuation-based real estate data is not straightforward due to the significant presence of significant serial correlation in returns.⁴ This is generally attributed to the consequence of valuers using weighted averages of the contemporaneous information set and

³ However, the MAD approach would be directly equivalent to the mean–variance approach if the assets are multivariate normally distributed.

⁴ See Brown and Matysiak (2000a; 2000b, chapter 12); Geltner, MacGregor and Schwann (2003); Geltner et al. (2007, chapter 25).

4. DISTRIBUTION OF REAL ESTATE RETURNS

their own historical appraisals (see, e.g. Geltner, MacGregor and Schwann 2003) in the face of uncertainty as to true price and thin transaction volumes. Such behaviour has been documented empirically and experimentally. The results of Diaz and Wolverton (1998), for instance, support the hypothesis of insufficient adjustment from previous value judgments. Similarly, Clayton, Geltner and Hamilton (2001) find evidence that appraisers valuing the same property in consecutive periods anchor onto their previous appraised values. Transaction-based indices have also been shown to exhibit greater volatility and less lagging than appraisal-based indices (Fisher et al., 1999, 2003). The reported series may also be subject to temporal aggregation problems (that is, the valuations are actually carried out in a time window spread out around the particular valuation date – unlike, for example, an equity market index which, typically, uses end-of-day transaction prices. Smoothing will predominantly lead real estate indices to underestimate the volatility of real estate returns (see also Edelstein and Quan, 2006), although additionally it may impact on the correlation between real estate returns and the returns on other asset classes.

Numerous desmoothing approaches have been suggested. There is no clear consensus on what approach should be used, but two methods have been widely used in the literature. The first approach assumes that real estate markets are fully efficient, and hence that real estate returns should not exhibit any serial correlation. ‘True’ real estate returns are recovered as follows:

Equation 4.1: True real estate returns

$$r_t^u = \frac{(r_t^* - \alpha r_{t-1}^*)}{(1 - \alpha)}$$

where r_t^u is the desmoothed return in period t , r_t^* is the smoothed return in period t , α is the first-order serial correlation coefficient, and r_{t-1}^* is the smoothed return during the previous period. An alternative desmoothing method which has been widely used is that devised by Geltner (1993), which applies a similar reverse filtering model (see also Cho et al., 2003). The appealing property of this model is that it does not require the assumption that the real estate market is efficient, and hence does not get rid of all serial correlation. It does require, however, that some assumption be made regarding the standard deviation of real estate. The common assumption is to assume that real estate’s volatility is one-half that of stocks (Geltner, 1993; Corgel and de Roos, 1999). An alternative to this is to consider a target serial correlation level or to assume a priori a value for α . There have also been attempts to use a time-varying desmoothing parameter (see, eg, Brown and Matysiak, 2000b).

Although there is overwhelming support for smoothing in appraisal-based real estate returns, the smoothing assumption has been challenged by some authors. Lai and Wang (1998) argue that much of the smoothing literature starts from an assumption that smoothing exists. They argue that the favourable risk-adjusted returns observed for real estate can be explained much more by the fact that investors need to be compensated for the illiquidity and high information costs, than by the fact that the data are noisy. They analyse each of the smoothing arguments, and conclude that the variance of real estate returns can in fact be less than the variance of appraisal-based returns (some empirical evidence of this is found, eg, in Webb, Miles and Guilkey 1992). However, their view has not received widespread acceptance and the evidence of strong serial correlation – more than can be explained simply by stable rental cashflows – suggests that there is a valuation impact in reported returns.⁵

⁵ It is noted, but not discussed here, issues of client influence and agency problems resulting from the valuation process – see Crosby, Lizieri and McAllister (2010) for a discussion and evidence.

4. DISTRIBUTION OF REAL ESTATE RETURNS

The obvious implication of the existence of smoothing (and the lack of a definitive means of recovering the underlying return series) is that it creates uncertainty in the interpretation of analyses based on valuation-based return series. Clearly, any series that is, in effect, a moving average will understate the volatility of the underlying asset market and, hence, overstate the risk-adjusted return. The moving-average process will also mean that the reported return series will tend to lag those factors that are determining returns in the underlying markets and the returns from other asset classes. This makes it difficult to assess the attributes of commercial property as an asset class and its behaviour in relation to macro-economic and capital market shocks. This topic is addressed in much more depth in Working Paper 2. The more limited research on dependence in real estate that moves beyond the standard mean–variance approach is considered next.

4.4 Summary

- The literature on real estate return distributions generally rejects the assumption of normality for data with a frequency less than annual. Most research points to negative skewness and excess kurtosis (fat tails);
- There is some evidence that return distributions are time-varying and that real estate is characterised by asymmetric and/or non-linear behaviour, with differences observed between bull and bear markets;
- These distributional issues cast doubt on the use of the standard deviation as the most effective measure of risk for property returns. Researchers have advocated the use of mean absolute deviation, downside-risk measures and lower partial moments, draw down measures and other ways of capturing the risk of the asset class;
- Much real estate performance data relies on valuations rather than transaction-based evidence. This is problematic since it is believed that valuers anchor on past valuations and thus report smoothed, moving average, returns;
- Methods that seek to desmooth valuation-based returns rely on a set of assumptions and there is no consensus as to appropriate method. This casts doubt on the robustness of results based on private real estate returns.

5. EVIDENCE OF COMPLEX DEPENDENCE STRUCTURES IN REAL ESTATE

Are the relationships between real estate and other investment assets time-varying? Do correlations depend on the state of the investment market? In particular, is there tail dependence – an increase in common patterns of movement in the negative tails of real estate and equity market distributions? The evidence from research on REIT returns is examined next.

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 MPT (Baum, 2002; Georgiev, Gupta, and Kunkel, 2003). Consistently, REITs appear to display below market levels of systematic risk as measured by the familiar CAPM beta (Chan, Hendershott, and Sanders, 1990; Glascock and Hughes, 1995; Howe and Shilling, 1990). However, there is a growing body of research that questions whether the low correlations and high relative risk-adjusted returns hold across time and different market environments. As examples, the sensitivity of REIT returns to returns on stocks, bonds and direct real estate appears to be cyclical (Clayton and McKinnon, 2001). Some authors also suggest that REITs exhibit lower systematic risk in bear markets (Glascock, 1991; Glascock, Michayluk, and Neuhauser, 2004). If the relationship between real estate and other asset classes is time-varying; or, equivalently, if the cross-asset class dependence in returns is more complex than in the standard model, then conventional mean–variance approaches may not lead to portfolios that minimise risk for investors at a particular target return level.

Studies that allow for time variation in conditional correlations provide a more sophisticated view on the evolution of linear dependence patterns in returns from listed real estate securities. Evidence suggests that correlations, and thus benefits of diversification between listed real estate securities (such as REITs) and stocks, tend not to be time-invariant. Instead, they may fluctuate around a positive trend, as reported in Cotter and Stevenson (2006). Further, structural breaks in the REIT history, such as the introduction of REITs into broader stock market indices, appear to demarcate different correlation regimes (Case, Yang and Yildirim, 2010). These results provide evidence for significant time-variation in conditional correlations, and therefore in benefits of diversification. More specifically, time-variation in conditional correlations appears to be a function of the prevailing level of volatility. Chong, Miffre, and Stevenson (2009) present evidence that the pairwise correlations between US REITs and stocks as well as bonds respond positively to higher volatility in those markets, while the opposite appears to be the case for the relationships with government securities and commodities.

Liow et al. (2009) extend this analysis to pairs of international listed real estate securities markets as well as the relationships with the corresponding national stock markets. They confirm the positive relationship between conditional correlations of listed real estate securities and stocks and the prevailing level of volatility. These findings suggest that not only are benefits of diversification time-variant, but that they appear to dissipate in periods of higher uncertainty. Evidence for asymmetry in conditional correlations in returns from listed real estate securities, i.e. disproportionately stronger responses in correlations to negative than to positive return shocks, appears to become stronger with higher observation frequency (see for example Fei, Ding, and Deng, 2010; Liow, 2009; Yang, Zhou, and Leung, 2010). Evidence for asymmetry in daily returns is confirmed by Hoesli and Reka (2010) and Michayluk, Wilson and Zurbruegg (2006).

When performance is evaluated on high-frequency data, such as daily geometric returns, that are then aggregated to a lower frequency (monthly, quarterly, annual), then the distribution of the resulting summation will approach normality with increasing aggregation 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. Returns from direct real estate investments are based on valuations that are typically available 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 (such as listed securities that are held short-term) disproportionately more than long-term direct real estate investments such as private funds.

5. EVIDENCE OF COMPLEX DEPENDENCE STRUCTURES IN REAL ESTATE

Empirical evidence from studies using a copula approach⁶ suggests significant lower-tail dependence in the returns from listed real estate securities. 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 (Hoesli and Reka, 2010; Knight, Lizieri and Satchell, 2005; Zhou and Gao, 2010). Simon and Ng (2009) find significantly increased levels of lower-tail dependence between REITs and stocks following the onset of the sub-prime mortgage crisis in 2007. The benefits of diversification commonly associated with portfolio exposure to real estate may be reduced substantially when they are most needed. However, the estimation of the copula relies on the existence of extreme joint return events between the asset and the benchmark under consideration. For instance, as returns from direct property tend to be based on valuations that are often subject to smoothing, Knight, Lizieri and Satchell (2005) are unable to report any evidence for tail dependence in the returns from direct property. For a summary of the studies reviewed here, see Table 5.1.

Table 5.1: Summary of the literature into dynamic, asymmetric dependence structures in real estate

Method	Time period	Frequency	Data type	Authors
CAPM beta				
CAPM beta	1973–1987	Quarterly	Total return	Chan, Hendershott and Sanders, 1990
CAPM beta	1973–1987	Monthly	Total return	Howe and Shilling, 1990
CAPM beta	1965–1986	Monthly	Total return	GlascocK, 1991
CAPM beta	1972–1991	Daily	Total return	GlascocK and Hughes, 1995
CAPM beta	1978–1998	Quarterly	Total return	Clayton and McKinnon, 2001
CAPM beta	1997	Daily	Total return	GlascocK, Michayluk and Neuhauser, 2004
Multivariate GARCH				
BEKK GARCH	1999–2003	Daily	Total return	Cotter and Stevenson, 2006
DCC GARCH	1999–2005	Daily	Total return	Huang and Zhong, 2006
DCC GARCH	1999–2005	Daily	Total return	Chong, Miffre and Stevenson, 2009
DCC GARCH	1984–2006	Monthly	Total return	Liow, et al. 2009
DCC GARCH	1978–2008	Monthly	Total return	Case, Yang and Yildirim, 2010
AG DCC GARCH	1987–2008	Monthly	Total return	Fei, Ding and Deng, 2010
AG DCC GARCH	1995–2009	Weekly	Total return	Liow, 2009
AG DCC GARCH	1999–2008	Daily	Total return	Yang, Zhou and Leung, 2010
Copula frictions				
SJC copula	1986–2004	Monthly	Total return	Knight, Lizieri and Satchell, 2005
SJC copula	2000–2009	Daily	Price return	Zhou and Gao, 2010
Mixture	2004–2008	Daily	Total return	Simon and Ng, 2009
Various Copulas	2000–2009	Daily	Total return	Goorah, 2007
Various Copulas	1988–2008	Quarterly	Total return	Dulguerov, 2009
Mixture of methods				
SJC, asymmetric BEKK GARCH	1990–2009	Daily	Price return	Hoesli and Reka, 2010
ADC GARCH, J statistic	2000–2003	Daily	Total return	Michayluk, Wilson and Zurbrugg, 2006

The table shows an overview of the main studies into dynamic and asymmetric dependence structures in real estate. The table contains information about the methods employed as well as the time period and observation frequency considered.

⁶ A copula is a statistical procedure that measures the relationship or dependence between variables at different points on the distribution of returns – see Knight et al. (2005) for a general discussion in a property context.

5. EVIDENCE OF COMPLEX DEPENDENCE STRUCTURES IN REAL ESTATE

This growing body of research, then, suggests that the relationships between the asset returns of real estate and other, typically financial, assets are more complex than portrayed in conventional mean–variance approaches that rely on the covariance to capture common movements. However, it should be noted that the majority of studies have been conducted on public listed real estate securities: most studies use US REIT returns or an equivalent. This is a consequence of the data requirements of the techniques used to capture higher-order dependence between assets or conditional, time-varying relationships. It is thus possible that the results reported here reflect the effect of public listing on return performance; or that at lower frequency – the monthly and 16 quarterly returns that are more characteristic of private real estate – these relationships might lose their significance. This subject is returned to in Working Paper 3, which examines time-varying relationships between property and other asset classes, and Working Paper 4, which considers the evidence of asymmetric relationships and tail dependence. Both shed light on a key investment question: whether the diversification benefits of real estate are maintained in difficult market environments.

5.1 Summary

- Analysis of REIT returns suggests that the relationship between property and other asset classes is more complex than portrayed in standard mean–variance approaches;
- The sensitivity of REITs to the overall stock market and to bonds appears to be time-varying or cyclical in nature;
- Similarly, the correlation between real estate and equities varies over time. There is some evidence that correlations increase where markets are more volatile, with implications for the benefits of diversification;
- Studies employing a copula approach have identified a higher than expected probability of pairs of negative returns, particularly between real estate and equity indices, which suggests the presence of lower-tail dependence;
- These findings suggest that the diversification benefits of including real estate in a portfolio vary over time – and may diminish in difficult market conditions;
- Most of the results found relate to relatively high frequency data – daily, weekly or monthly. As short-run returns are aggregated, the time-varying effects become less evident. This might suggest that the impact of complex return relationships is more likely to be felt in public real estate markets than in private property.

6. CONCLUSIONS

Standard arguments for inclusion of real estate in the mixed-asset portfolio draw on conventional mean–variance-based portfolio theory. Placing real estate returns alongside equity, bond and other financial assets in a portfolio optimiser tends to produce high suggested allocations to property as real estate appears to have low correlations with other assets and low risk relative to its ex post returns.

It has long been recognised that there are significant problems with such an approach. There are major practical impediments to assembling a portfolio that tracks a market index like IPD with any sort of precision; many real estate indices are valuation-based, calling into question the validity of the statistical results; many argue that there should be an adjustment for the illiquidity of property. However, even correcting for these factors, most studies still identify a strong role for real estate in the mixed-asset portfolio.

This paper, the first of four reports for the Investment Property Forum, identifies a number of issues that need to be considered in evaluating the role property can play in managing investment risk. First, the standard models make strong assumptions about the distribution of returns. Second, the relationships between assets may vary over time and over the market environment. Third, there may be more complex dependencies between assets and asymmetric relationships which need to be factored into any risk management structure. In particular, given low average correlations between assets, if when equity or bond market returns were underperforming badly, real estate was found to produce weak returns – that is, if there was negative asymmetric dependence – then the diversification benefits of real estate would be diminished.

In reviewing the existing research, it seems that there is a body of research that casts doubt on the standard ‘case for property’. Real estate returns are not normal even correcting for valuation smoothing effects. The correlation between assets is not constant over time. There is some evidence of tail dependence effects. The remaining papers from this IPF research project consider these topics in more depth, examining UK public and private real estate returns and testing for more complex relationships between real estate and other asset classes.

BIBLIOGRAPHY

- Alcock, J. and Hatherley, A. (2009). **Asymmetric dependence between domestic equity indices and its effect on portfolio construction**, *Australian Actuarial Journal*, 15(1), 143–180.
- Barras, R. (2005). **A building cycle model for an imperfect world**, *Journal of Property Research*, 22, 63–96.
- Baum, A. (2002). **Commercial Real Estate Investment**, London, Estates Gazette Books.
- Blundell, G., Frodsham, M. and Martinez, R. (2011). **Risk Web 2.0: An Investigation into the Causes of Portfolio Risk**, London, Investment Property Forum, 54pp.
- Bond, S. A., Hwang, S., Lin, Z. and Vandell, K. D. (2007). **Marketing period risk in a portfolio context: theory and empirical estimates from the UK commercial real estate market**, *Journal of Real Estate Finance and Economics*, 34(4), 447–461.
- Bond, S. A., Hwang, S., Mitchell, P. and Satchell, S. (2007a). **Portfolio Allocation in the Modern World**, London, Investment Property Forum.
- Bond, S. A., Hwang, S., Mitchell, P. and Satchell, S. (2007b). **Will private equity and hedge funds replace real estate in mixed-asset portfolios?** *Journal of Portfolio Management*, 33, 74–84.
- Bond, S. and Patel, K. (2003). **The conditional distribution of real estate returns: are higher moments time varying?** *Journal of Real Estate Finance and Economics*, 26(2), 319–339.
- Borch, K. (1969). **A note on uncertainty and indifference curves**, *Review of Economic Studies*, 36, 1–4.
- Brounen, D. and Jennen, M. (2009). **Asymmetric properties of office rent adjustment**, *Journal of Real Estate Finance and Economics*, 39, 339–358.
- Byrne, P. J. and Lee, S. L. (2004). **Different risk measures: different portfolio compositions?** *Journal of Property Investment & Finance*, 22(6), 501–511.
- Case, B., Yang, Y. and Yildirim, Y. (2010). **Dynamic correlations among asset classes: REIT and stock returns**, *Journal of Real Estate Finance and Economics*, forthcoming.
- Chan, K. C., Hendershott, P. H. and Sanders, A. B. (1990). **Risk and return on real estate: Evidence from equity REITs**, *AREUEA Journal*, 18(4), 43–452.
- Cheng, P. (2005). **Asymmetric risk measures and real estate returns**, *Journal of Real Estate Finance and Economics*, 30(1), 89–102.
- Cheng, P. and Wolverton, M. L. (2001). **MPT and the downside risk framework: a comment on two recent studies**, *Journal of Real Estate Portfolio Management*, 7(2), 125–131.
- Cherubini, U., Luciano, E. and Vecchiato, W. (2004). **Copula Methods in Finance**, Wiley Finance.
- Cho, H., Kawaguchi, Y. and Shilling, J. D. (2003). **Unsmoothing commercial property returns: a revision to Fisher–Geltner–Webb’s unsmoothing methodology**, *Journal of Real Estate Finance and Economics*, 27(3), 393–405.
- Chong, J., Miffre, J. and Stevenson, S. (2009). **Conditional correlations and real estate investment trusts**, *Journal of Real Estate Portfolio Management*, 15(2), 173–184.
- Chung, Y. P., Johnson, H. and Schill, M. J. (2006). **Asset pricing when returns are non-normal: Fama–French factors vs. higher-order systematic co-moments**, *Journal of Business*, 72(2), 923–940.
- Clayton, J. and McKinnon, G. (2001). **The time-varying nature of the link between REIT, real estate and financial asset returns**, *Journal of Real Estate Portfolio Management*, 7(1), 43–54.

BIBLIOGRAPHY

- Clayton, J., Geltner, D. and Hamilton, S. W. (2001). Smoothing in commercial property valuations: evidence from individual appraisals, *Real Estate Economics*, 29(3), 337–360.
- Corgel, J. B. and de Roos, J. A. (1999). Recovery of real estate returns for portfolio allocation, *Journal of Real Estate Finance and Economics*, 18(3), 279–296.
- Cotter, J. and Stevenson, S. (2006). Multivariate modelling of daily REIT volatility, *Journal of Real Estate Finance and Economics*, 32, 305–325.
- Crosby, N., Lizieri, C. and McAllister, P. (2010). Means, Motive and Opportunity? Disentangling Client Influence on Performance Measurement Appraisals, *Journal of Property Research*, 27(2), 181–201.
- Diaz, J. III and Wolverton, M. (1998). A longitudinal examination of the appraisal smoothing hypothesis, *Real Estate Economics*, 26(2), 349–358.
- Elton, E. J. and Gruber, M. J. (1977). Risk reduction and portfolio size: an analytical solution, *Journal of Business*, 50, 415–437.
- Englund, P., Gunnelin, A., Hendershott, P. and Soderberg, B. (2008). Adjustment in commercial property space markets: taking long-term leases and transaction costs seriously, *Real Estate Economics*, 36, 81–109.
- Farrelly, K. and Sanderson, B. (2005). Modelling regime shifts in the City of London office rental cycle, *Journal of Property Research*, 22, 325–344.
- Fei, P., Ding, L. and Y. Deng (2010). Correlation and volatility dynamics in REIT returns: Performance and portfolio considerations, *Journal of Portfolio Management*, 36(2), 113–125.
- Feldstein, M. S. (1969). Mean–variance analysis in the theory of liquidity preference and portfolio selection, *Review of Economic Studies*, 36, 5–12.
- Fisher, J., Gatzlaff, D., Geltner, D. and Haurin, D. (2003). Controlling for the impact of variable liquidity in commercial real estate price indices, *Real Estate Economics*, 31(2), 269–303.
- Geltner, D. (1993). Estimating market values from appraised values without assuming an efficient market, *Journal of Real Estate Research*, 8(3), 325–346.
- Geltner, D., MacGregor, B. D. and Schwann, G. M. (2003). Appraisal smoothing and price discovery in real estate markets, *Urban Studies*, 40(5-6), 1047–1064.
- Graff, R., Harrington, A. and Young, M. (1997). The shape of Australian real estate return distributions and comparisons to the United States, *Journal of Real Estate Research*, 14(3), 291–308.
- Georgiev, G., Gupta, B. and Kunkel, T. (2003). Benefits of real estate investment, *Journal of Portfolio Management*, 29, 28–33.
- Glascok, J. L. (1991). Market conditions, risk, and real estate portfolio returns: Some empirical evidence, *Journal of Real Estate Finance and Economics*, 4(4), 367–373.
- Glascok, J. L. and Hughes, W. T. (1995). NAREIT identified exchange listed REITs and their performance characteristics: 1972–1991, *Journal of Real Estate Literature*, 3(1), 63–83.
- Glascok, J. L., Michayluk, D. and K. Neuhauser (2004). The riskiness of REITs surrounding the October 1997 stock market decline, *Journal of Real Estate Finance and Economics*, 28(4), 339–354.
- Hamelink, F. and Hoesli, M. (2004a). Maximum drawdown and the allocation to real estate, *Journal of Property Research*, 21(1), 5–29.

BIBLIOGRAPHY

- Harvey, A. (2010). **Tracking a changing copula**, *Journal of Empirical Finance*, 17, 485–500.
- Harvey, C. R., Liechty, J. C., Liechty, M. W. and Muller, P. (2010). **Portfolio selection with higher moments**, *Quantitative Finance*, 10(5), 469–485.
- Hatherley, A. and Alcock, J. (2007). **Portfolio construction incorporating asymmetric dependence structures: A user's guide**, *Accounting and Finance*, 47, 447–472.
- Hendershott, P., Lizieri, C. and MacGregor, B. (2010). **Asymmetric Adjustment in the London Office Market**, *Journal of Real Estate Finance and Economics*, 41, 80–101.
- Hoesli, M. and Lizieri, C. (2007). **Real estate in the investment portfolio: A report prepared for the Investment Strategy Council of the Royal Ministry of Finance, Norway**, [http://www.regjeringen.no/upload/FIN/Statens pensjonsfond/Norway Real Estate Final Report Revised May 31.pdf](http://www.regjeringen.no/upload/FIN/Statens_pensjonsfond/Norway%20Real%20Estate%20Final%20Report%20Revised%20May%2031.pdf).
- Hoesli, M. and Reka, K. (2010). **Volatility spillovers, asymmetry and extreme events in securitized real estate returns**, *Swiss Finance Institute Research Paper Series*, No.10-40.
- Howe, J. S. and Shilling, J. D. (1990). **REIT advisor performance**, *AREUEA Journal*, 18(4), 479–500.
- Hutson, E. and Stevenson, S. (2008). **Asymmetry in REIT Returns**, *Journal of Real Estate Portfolio Management*, 14(2), 105–123.
- Jondeau, E. and Rockinger, M. (2009). **The impact of shocks on higher moments**, *Journal of Financial Econometrics*, 7(2), 77–105.
- Knight, J., Lizieri, C. and Satchell, S. (2005). **Diversification when it hurts? The joint distribution of real estate and equity markets**, *Journal of Property Research*, 22(4), 309–323.
- Levy, H. (1974). **The rationale of the mean-standard deviation analysis: comment**, *American Economic Review*, 64, 434–441.
- Ling, D. C. and Naranjo, A. (1997). **Economic risk factors and commercial real estate returns**, *Journal of Real Estate Finance and Economics*, 14(3), 283–307.
- Ling, D. C. and Naranjo, A. (1999). **The integration of commercial real estate markets and stock markets**, *Real Estate Economics*, 27(3), 483–515.
- Ling, D. C. and Naranjo, A. (2002). **Commercial real estate return performance: a cross-country analysis**, *Journal of Real Estate Finance and Economics*, 24(1/2), 119–142.
- Lintner, J. (1965). **Security prices, risk and maximal gains from diversification**, *Journal of Finance*, 20(4), 587–615.
- Liow, K. H. (2009). **Co-movements and correlations across Asian securitised real estate and stock markets**, *IRES Working Paper Series*.
- Liow, K. H., Ho, K. H. D., Ibrahim, M. F. and Chen, Z. (2009). **Correlation and volatility dynamics in international real estate securities markets**, *Journal of Real Estate Finance and Economics*, 39(2), 202–223.
- Liu, C. H. and Mei, J. (1994). **An analysis of real-estate risk using the present value model**, *Journal of Real Estate Finance and Economics*, 8(1), 5–20.
- Lizieri, C. M. and Ward, C. W. R. (2000). **Commercial real estate return distributions: a review of the literature and empirical evidence**, in J. Knight and S. Satchell (Eds), *Return Distributions in Finance*, pp.47–74, Oxford, Butterworth-Heinemann.

BIBLIOGRAPHY

- Lizieri, C., Satchell, S., Worzala, E. and Dacco, R. (1998). Real interest regimes and real estate performance: a comparison of UK and US markets, *Journal of Real Estate Research*, 16(3), 339–356.
- Lizieri, C., Satchell, S. and Zhang, Q. (2007). The underlying return generating factors for REIT returns: an application of independent component analysis, *Real Estate Economics* 35(4) 569–598.
- MacKinnon, G. H. and Al Zaman, A. (2009). Real estate for the long term: The effect of return predictability on long-horizon allocations, *Real Estate Economics*, 37, 117–153.
- Maitland-Smith, J. and Brooks, C. (1999). Threshold autoregressive and Markov switching models: an Application to commercial real estate, *Journal of Property Research*, 16(1), 1–19.
- Marcato, G. and Key, T. (2007). Index smoothing and the volatility of commercial property, Technical Report, Investment Property Forum, London.
- Markowitz, H. (1952). Portfolio selection, *Journal of Finance*, 7(1), 77–91.
- Maurer, R., Reiner, F. and Sebastian, S. (2004). Characteristics of German real estate return distributions: evidence from Germany and comparisons to the US and UK, *Journal of Real Estate Portfolio Management*, 10(1), 59–76.
- Michayluk, D., Wilson, P. J. and Zurbruegg, R. (2006). Asymmetric volatility, correlation and returns dynamics between the US and UK securitized real estate markets, *Real Estate Economics*, 34(1), 109–131.
- Mossin, J. (1966). Equilibrium in a capital asset markets, *Econometrica*, 34, 768–783.
- Myer, F. C. N. and Webb, J. R. (1993). Return properties of equity REITs, common stocks and commercial real estate: a comparison, *Journal of Real Estate Research*, 8(1), 87–106.
- Pratt, J. W. (1964). Risk aversion in the small and in the large, *Econometrica*, 32, 122–136.
- Quan, D.C. and Quigley, J. (1991). Price formation and the appraisal function in real estate, *Journal of Real Estate Finance and Economics*, 4, 127–146.
- Richard Ellis (1990). *The Case for Property*, London, Richard Ellis.
- Sa-Aadu, J., Shilling, J. and Tiwari, A. (2010). On the portfolio properties of real estate in good times and in bad times, *Real Estate Economics*, 38, 529–565.
- Sarnat, M. (1974). A note on the implications of quadratic utility for portfolio theory, *Journal of Financial and Quantitative Analysis*, 9, 687–689.
- Sharpe, W. F. (1964). Capital asset prices: A theory of market equilibrium under conditions of risk, *Journal of Finance*, 19(3), 425–442.
- Simon, S. and Ng, W. L. (2009). The effect of the real estate downturn on the link between REITs and the stock market, *Journal of Real Estate Portfolio Management*, 15(3), 211–219.
- Stevenson, S. (2001). Bayes–Stein estimators and international real estate Asset Allocation, *Journal of Real Estate Research*, 21(1), 89–103.
- Webb, R. B., Miles, M. and Guilkey, D. (1992). Transactions-driven commercial real estate returns: the panacea to asset allocation models? *Journal of the American Real Estate and Urban Economics Association*, 20(2), 325–357.

BIBLIOGRAPHY

Wipperfurth, R. F. (1971). **Utility implications of portfolio selection and performance appraisal models**, *Journal of Financial and Quantitative Analysis*, 6, 913–924.

Yang, J., Zhou, Y. and Leung, W. K. (2010). **Asymmetric correlation and volatility dynamics among stock, bond, and securitized real estate markets**, *Journal of Real Estate Finance and Economics*, forthcoming.

Young, M. S. (2008). **Revisiting non-normal real estate return distributions by property type in the US**, *Journal of Real Estate Finance and Economics*, 36(2), 233–248.

Young, M. S. and Graff, R. A. (1995). **Real estate is not normal: a fresh look at real estate return distributions**, *Journal of Real Estate Finance and Economics*, 10(3), 225–259.

Young, M. S., Lee, S. L. and Devaney, S. P. (2006). **Non-normal real estate return distributions by property type in the UK**, *Journal of Property Research*, 23(2), 109–133.

Zhou, J. and Gao, Y. (2010). **Tail dependence in international real estate securities markets**, *Journal of Real Estate Finance and Economics*, forthcoming.

APPENDIX: DEPENDENCE AS A MULTI-DIMENSIONAL PROBLEM

Assessing the dependence between the returns from financial securities in a portfolio forms part of an attempt to understand the joint distribution of a combination of random variables. Consider the Edgeworth expansion to describe a bivariate distribution

$H(x, y)$ as

Equation

$$H(x, y) = \Phi(x, y; \rho) + \sum_{r+s \geq 3} (-1)^{r+s} \frac{A_{rs}}{r!s!} D_1^{r-1} D_2^{s-1} \phi(x, y; \rho)$$

where $(x, y; \rho)$ is a standard bivariate normal distribution with correlation coefficient ρ , $\phi(x, y; \rho)$ is the standard bivariate normal density function of random variables (x, y) , and $D_1 = \partial/\partial x$, $D_2 = \partial/\partial y$ and A_{rs} are functions of co-moments associated with X and Y that depend on the sum $r + s$ (Hall, 1992).

This representation illustrates that the joint distribution of any two random variables (X, Y) can be approximated by a combination of a standard bivariate normal distribution and a potentially infinite number of higher-order co-moments. In the standard normal distribution, the dependence between (X, Y) is described by the correlation coefficient ρ . This distribution is unique in that it is fully described by the first two moments. Any dependence model that relies solely on correlation to describe the relationships between assets in a portfolio implicitly assumes that either returns are multivariate normal and/or the dependence between them is symmetric (Cherubini, Luciano, and Vecchiato, 2004). Asymmetric dependence is defined as the unequal likelihood and scale of jointly positive and negative returns from two or more financial assets (Hatherley and Alcock, 2007).

The representation of a joint distribution as a combination of a potentially infinite number of co-moments highlights the multi-dimensionality of dependence. Financial theories such as modern portfolio theory (Markowitz, 1952) or the familiar CAPM (Lintner, 1965; Mossin, 1966; Sharpe, 1964) provide a theoretical rationale why covariance is a relevant dimension of dependence. At the same time, these theories implicitly consider any higher-order dimensions of dependence to be negligible. In other words, they effectively truncate the expansion in (1) after $r + s = 2$.

Some authors examine higher-order co-moments such as co-skewness or co-kurtosis (Chung, Johnson, and Schill, 2006; Jondeau and Rockinger, 2009). While there is an economic interpretation of higher-order co-moments up to co-kurtosis, the rationale for why these co-moments should be relevant for pricing and enter into portfolio construction decisions is unclear.

REFERENCES

- Cherubini, U., Luciano E. and Vecchiato W. (2004). *Copula methods in finance*, Wiley Finance.
- Chung, Y. P., Johnson, H. and Schill M. J. (2006). Asset pricing when returns are non-normal: Fama-French factors vs. higher-order systematic comoments, *Journal of Business*, 72(2), 923–940.
- Hall, P. (1992). *The bootstrap and Edgeworth expansion*, Springer, New York.
- Hatherley, A. and Alcock J. (2007). Portfolio construction incorporating asymmetric dependence structures: A user's guide, *Accounting and Finance*, 47, 447–472.
- Jondeau, E. and Rockinger M. (2009). The impact of shocks on higher moments, *Journal of Financial Econometrics*, 7(2), 77–105.
- Lintner, J. (1965). Security prices, risk and maximal gains from diversification, *Journal of Finance*, 20(4), 587–615.
- Markowitz, H. (1952). Portfolio selection, *Journal of Finance*, 7(1), 77–91.
- Mossin, J. (1966). Equilibrium in a capital asset markets, *Econometrica*, 34(4), 768–783.
- Sharpe, W. F. (1964). Capital asset prices: A theory of market equilibrium under conditions of risk, *Journal of Finance*, 19(3), 425–442.

NOTES

NOTES



Printed on recycled paper

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