Dynamics of Commercial Real Estate Asset Markets, Return Volatility, and the Investment Horizon

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Abstract

The term structure of return volatility is estimated for UK and US direct and securitized commercial real estate using vector autoregressions. To capture the dynamics of the real estate asset markets it is important to account for a valuation ratio specific to the asset market analyzed. In the UK, direct real estate and property shares exhibit mean reversion, and unexpected returns are primarily driven by news about discount rates. US REIT returns are mean reverting, too. In contrast, US direct real estate shows a considerable mean aversion effect over short investment horizons. This can be explained by the positive correlation between cash-flow and discount rate news, which can be interpreted as underreaction to cash-flow news. In the UK, direct real estate returns remain more predictable than property share returns in the medium and long term, whereas US REIT returns appear to be equally predictable to US direct real estate returns at a ten-year investment horizon.

Keywords Commercial real estate investment - Investment horizon - Return volatility – Vector autoregression

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Introduction

A lot of research in real estate focuses on the problem of how to correct ("unsmooth") appraisal-based returns in order to obtain returns, which are closer to true market returns (e.g., Blundell and Ward 1987, Geltner 1993, Fisher et al. 1994). The unsmoothed returns are used to assess the volatility of real estate markets. The studies use quarterly or annual return data, however. Typically, real estate investors have longer investment horizons than a quarter or a year. With an average holding period of about ten years, direct commercial real estate investments are typically long-term investments (Collet et al. 2003, Fisher and Young 2000). The relationship between the short-term and the long-term return volatility is straightforward when returns are independently and identically distributed (IID) over time: The variance of (continuously compounded) returns increases in proportion to the investment horizon. When returns are predictable, however, there may be substantial horizon effects in the periodic (divided by the square root of the investment horizon) volatility of returns. For example, there is a lot of evidence suggesting that stock returns are mean reverting, i.e., that the periodic long-term volatility of stock returns is lower than the short-term volatility.[1]

The widespread view is that commercial real estate returns are predictable. Securitized real estate investments are often seen to exhibit similar dynamics as the general stock market. Conventional wisdom and empirical evidence (Clayton 1996, Geltner and Mei 1995, Scott and Judge 2000) suggest that direct real estate asset markets exhibit cyclicality. A series of high returns tends to be followed by a series of low returns, and vice versa. Hence, cyclicality implies that real estate returns are mean reverting over long investment horizons, making real estate relatively less risky in the long run. Cyclicality also implies that direct real estate exhibits return persistence over short investment horizons, so that we see mean aversion in the short run. The return persistence is typically attributed to the specific microstructure of the direct real estate asset market characterized by high transaction costs, low transaction frequency and heterogeneous goods, causing slow information diffusion (e.g., Geltner et al. 2007, Chapter 1). Thus, horizons effects in the volatility of returns are likely to be linked to the informational efficiency of an asset market.

The goal of this paper is to analyze how important mean aversion and mean reversion effects are in UK and US direct and securitized commercial real estate markets. Using vector autoregressions (VARs), the term structure of the annualized return volatility is estimated for

[1] Early references include Campbell (1991), Fama and French (1988a, 1988b), Kandel and Stambaugh (1987) and Porterba and Summers (1988).

direct and securitized real estate in these two countries. We explore the implications of the term structure of return volatility for the dependence of the degree of return predictability (R^2 statistics) on the investment horizon. In order to get deeper insights into the term structure of the return volatility of an asset, the variance of unexpected returns is decomposed into the variance of news about future cash flows, news about future returns, and their covariance.

We find that in the UK the results for direct real estate and property shares are similar to the results for the general stock market. Both UK direct and securitized real estate exhibit strong mean reversion, and unexpected returns are primarily driven by news about future returns. US REIT returns are strongly mean reverting, too. In contrast, US direct real estate returns are considerably mean averting over short investment horizons, after which the term structure of the annualized volatility is slightly decreasing. To estimate the long-term return volatility of the assets adequately, it is important to include a valuation ratio specific to the asset market analyzed in the VAR models. The low short-term standard deviation and the mean aversion of US direct real estate returns can be explained by the positive correlation between cash-flow and discount rate news, which can be interpreted as underreaction to cash-flow news. The choice of the parameter used to unsmooth appraisal-based returns has a large effect on the short-term, but not on the long-term volatility of direct real estate returns. In the UK, direct real estate returns remain more predictable than property share returns in the medium and long term, whereas US REIT returns appear to be equally predictable to US direct real estate returns at a ten-year investment horizon.

The remainder of the article is organized as follows. The next section contains a review of the literature and some background discussion. We proceed with a description of the VAR model and the data, and present the VAR estimates. The next section contains the discussion of the term structure of return volatilities and the multi-period R^2 statistics implied by the VARs. The variance decompositions are presented in the subsequent section. A discussion and further analysis with regard to the informational efficiency of the real estate asset markets follows. The final section concludes the article.

Background and literature review

How does return predictability induce horizon effects in the periodic volatility of returns? To address this issue, most recent studies use VAR models. In this framework, risk is based on the unpredictable component of returns, i.e., the return variance is computed relative to the conditional return expectation. The conditional periodic volatility of multi-period returns can be calculated from the VAR results and may increase or decrease with the investment horizon. The standard example of horizon effects in the return volatility is the mean reversion effect in stock returns induced by the dividend yield. The dividend yield has been found to positively predict stock returns (Campbell and Shiller 1988, Fama and French 1988a). In combination with the large negative correlation between shocks to the dividend yield – whose process is usually well described by an AR(1) process – and shocks to the stock return, mean reversion in stock returns emerges: A low realized stock return tends to be accompanied by a positive shock to the dividend yield, and a high dividend yield predicts high stock returns for the future, and vice versa. Campbell and Viceira (2005) show that this effect cuts the periodic long-term standard deviation of US stock returns to approximately 50% of the short-term standard deviation. In general (see Campbell and Viceira 2004), returns exhibit mean reversion if the sign of the parameter obtained from a regression of an asset's return on a lagged predictor variable has the opposite sign as the correlation between the contemporaneous shocks to the asset return and the predictor variable; mean aversion is induced if the regression parameter and the correlation of the residuals are of the same sign. The higher the persistence of the forecasting variable, the more important is this predictor for the long-term asset risk.[2]

There are a lot of studies suggesting that commercial real estate returns are not IID. Direct real estate returns appear to be positively related to lagged stock returns (Quan and Titman 1999) and more specifically to the lagged returns on property shares (e.g., Gyourko and Keim 1992, Barkham and Geltner 1995). Furthermore, direct real estate returns appear to be positively autocorrelated over short horizons (Geltner 1993, Fu and Ng 2001). Fu and Ng (2001), Ghysels et al. (2007) and Plazzi et al. (2010) show that the cap rate predicts commercial real estate returns positively. (The cap rate of the real estate market is like the dividend yield of the stock market – the ratio of the income to the price of an asset.) Variables that have been used to predict REIT returns include the dividend yield of the general stock market, the cap rate of the direct real estate market, and interest rate variables (e.g., Bharati and Gupta 1992, Liu and Mei 1992, 1994).

A few articles have looked at the implications of the predictability of commercial real estate returns for the term structure of return volatility. Geltner et al. (1995) calculate five-

[2] There is an additional effect, which always leads to an increase in the periodic conditional return variance. If the forecasting variable is very persistent, this effect – reflecting the variance of expected returns – may lead to a notable increase of the long-term return volatility, a point emphasized by Schotman et al. (2008).

year risk statistics based on regressions of real estate returns on contemporaneous and lagged asset returns. These authors find that the variance of US private real estate returns at a five-year horizon is higher than five times the annual variance – reflecting mean-aversion. Using a VAR model, Porras Prado and Verbeek (2008) also find that US direct real estate exhibits mean aversion. Hence, the existing evidence points towards mean-aversion in direct US real estate returns.[3] With regard to securitized real estate, the results are mixed. Fugazza et al. (2007) find that the standard deviation (per period) of European property shares is increasing with the investment horizon. Porras Prado and Verbeek (2008) find that returns of US property shares are mean averting. In contrast, Liu and Mei (1994) and Hoevenaars et al. (2008) find that US REIT returns exhibit mean-reversion, which is, however, weaker than the mean-reversion effect in the general stock market.

The VAR results can also be used to calculate the implied R^2 statistics of multi-period returns. Judging from regressions with quarterly or annual returns, direct real estate returns are more predictable than real estate share returns, but this may change with the investment horizon, because when expected returns are persistent, R^2 statistics can be much larger for longer horizons (Fama and French 1988a). Technically, persistence in expected returns makes the variance of expected multi-period returns increase faster than the total variance of multi-period returns. Chun et al. (2004) document rising R^2 statistics for US REITs over investment horizons of up to five years. Plazzi et al. (2010) find rising R^2 statistics over short investment horizons for US direct commercial real estate investments. More distant returns become less predictable, of course, so the R^2 statistics eventually decrease. Hence, we see a hump-shaped pattern of implied R^2 statistics in the general stock market (Kandel and Stambaugh 1987, Campbell 1991).

The variance of unexpected returns can be decomposed into the variance of news about future cash-flows, the variance of news about future returns (discount rates), and their covariance (Campbell 1991). This yields insights with regard to the return volatility. Discount rate news justify large changes in asset prices when expected returns are persistent. This mechanism induces mean reversion in returns: When discount rates increase, the price of the

[3] An exception is the article by MacKinnon and Al Zaman (2009), who find strong mean reversion in US direct real estate returns. The estimated long-term (25-year) return volatility of real returns on direct real estate is estimated to be slightly below 2.0% per annum, identical to the estimated long-term stock return volatility. All of the asset classes analyzed by MacKinnon and Al Zaman – including US REITs – exhibit very strong mean reversion, though. For example, MacKinnon and Al Zaman find that the annualized 25-year volatility of US real cash returns is only 0.3%, compared to estimates of about 3% by Campbell and Viceira (2005), Hoevenaars et al. (2008) and Porras Prado and Verbeek (2008). Therefore, the results can be regarded as unusual.

asset decreases, but expected returns are higher than before. In contrast, there is no such mechanism with regard to cash-flow news. Liu and Mei (1994) analyze US REITs and find that the variance of cash-flow news is larger than the variance of discount rate news, which results in a relatively weak mean-reversion effect, compared to the general stock market. Liu and Mei also find a positive correlation between cash-flow news and discount rate news, which attenuates the short-term return volatility. The reason is that positive cash-flow news increase prices, but positive discount rate news decrease prices. Though not employing Campbell’s (1991) variance decompositions, Geltner and Mei (1995) show that returns of US direct real estate investments are primarily driven by changing expected returns. In-sample forecasts of commercial real estate values track the market values closely when time-variation in discount rates is allowed for, whereas the forecasts are virtually constant over time and far removed from the actual market values when discount rates are held constant and only cash-flow forecasts are allowed to vary. Clayton (1996) analyzes the Canadian direct commercial real estate market and confirms the conclusion of Geltner and Mei that most of the volatility of direct real estate returns is caused by time-variation in discount rates.

In this paper, we compare the UK and US direct and securitized real estate markets with regard to their term structure of return volatility. The comparison of the UK and the US market is particularly interesting with regard the direct real estate market, because there is evidence that in the UK direct real estate market new information is timelier incorporated into prices than in the US. Specifically, annual appraisal-based US direct commercial real estate returns, unsmoothed with the Geltner (1993) method, still exhibit high autocorrelation, but in the case of the UK market, returns are virtually uncorrelated after unsmoothing (Barkham and Geltner 1994). Barkham and Geltner (1995) and Eichholtz and Hartzell (1996) find that in the UK direct real estate returns respond rather quickly to changes in securitized real estate returns, compared to the US. Thus, lag effects are more important in the US, whereas in the UK the contemporaneous relation between direct real estate and securitized real estate is stronger than in the US. For example, Barkham and Geltner (1995) find that the correlation between annual (unsmoothed) direct real estate returns and real estate stock returns is 61% in the UK, but only 19% in the US. These differences in the dynamics of the direct real estate markets should affect the term structure of the return volatility.

The high negative correlation between dividend yield and stock return residuals is crucial to capture mean reversion in stock returns (Campbell and Viceira 2005). Therefore, we include common valuation ratios specific to real estate asset markets in the VAR models, whose residuals are highly negatively correlated with the return residuals. In particular, the cap rate of the direct real estate market is used to predict the return of the direct real estate market, and a valuation ratio specific to the market for securitized real estate is used as a return predictor for the securitized real estate market. This point has been neglected by previous research on the term structure of the return volatility of real estate assets. (Previous studies on securitized real estate accounted for the dividend yield of the general stock market, but not for the dividend yield of the market for real estate stocks, or a similar valuation ratio specific to the real estate stocks market). Therefore, previous studies may have overestimated the long-term volatility of these assets. We link the results for the term structure of return volatilities to the variance decomposition of Campbell (1991), and use the VAR results to calculate multi-period R^2 statistics for real estate investments. Finally, we use the results of the variance decompositions to analyze the informational efficiency of the real estate asset markets.

VAR model and data

VAR specification

The results are based on separate VARs for each country using annual data from 1972 to 2008 (37 observations) for the UK market and from 1979 to 2008 (30 observations) for the US market.[4] Let $\mathbf{z}_{t+1}$ be a (5x1) vector, whose first two elements are log (continuously compounded) real asset returns, $r_{t+1} = \ln(1+R_{t+1}) - \ln(1+I_{t+1})$, where R_{t+1} is the simple nominal return on an asset and I_{t+1} is the inflation rate. The first element of the vector $\mathbf{z}_{t+1}$ is the log real return on direct real estate; the second element is the log real return on securitized real estate. Asset returns are measured in real terms, since real rather than nominal returns are relevant for investors who are concerned about the purchasing power of their investments. Three additional state variables that predict the asset returns are included in $\mathbf{z}_{t+1}$. All variables are mean-adjusted. Assume that a VAR(1) model captures the dynamic relationships of the variables:[5]

[4] The main results for the UK market remain qualitatively unchanged, if the shorter time span 1979 to 2008 is used (as for the US market).

[5] The VAR(1) framework is not restrictive since a VAR(p) model can be written as a VAR(1) model, see Campbell and Shiller (1988).

$$\boldsymbol{z}_{t+1} = \boldsymbol{\Phi}\boldsymbol{z}_t + \boldsymbol{v}_{t+1}. \quad (1)$$

$\boldsymbol{\Phi}$ is a (5x5) coefficient-matrix. The shocks are stacked in the (5x1) vector $\boldsymbol{v}_{t+1}$ with time-invariant (5x5) covariance-matrix $\boldsymbol{\Sigma}_v$.

Data

To calculate the log real total return on securitized real estate, a property share index is used for the UK market and a REIT index is used for the US market. For the UK market the log of the dividend yield of the property share index is used as a state variable to predict the return on property shares. In analogy, we considered the dividend yield of the REIT market for the US VAR. However, this variable is not a significant predictor of REIT returns at any conventional levels. In contrast, another valuation ratio, the price to cash-flow ratio of the REIT market is a significant predictor of REIT returns. Hence, this variable is included as a state variable in the US VAR model in form of the log of the inverse of the variable, i.e., the log of the cash-flow yield. US REITs are restricted in their dividend policy since they have to pay out at least 90% (formerly 95%) of their taxable income as dividends. This restriction links the dividend payments of REITs to their earnings. Lamont (1998) shows with regard to the general stock market that in a univariate regression the earnings yield is not – in contrast to the dividend yield – a significant predictor of stock returns. This suggests that the dividend restriction of REITs might explain why the cash-flow to price ratio is a better valuation ratio to forecast REIT returns than the dividend yield.[6] We also include the yield spread as a state variable that has been shown to predict asset returns (e.g., Campbell 1987, Fama and French 1989). The variable is computed as the difference of the log yield on a long-term bond minus the log yield of three-month treasury bills. Details on the data can be found in Appendix A.

Appraisal-based capital and income returns are the basis for the calculation of the total return series and the cap rate series of direct real estate. The indexes used are the NCREIF property index (NPI) for the US market and the IPD long-term index for the UK market. The appraisal-based returns are unsmoothed using the approach introduced by Geltner (1993) for the US market and applied by Barkham and Geltner (1994) for the UK market. This

[6] Chun et al. (2004) show that, after controlling for payout and book-to-market ratios, the price-dividend ratio is a significant predictor of excess US REIT returns.

unsmoothing approach does not presume that true real estate returns should be uncorrelated. Annual appraisal-based log real capital returns g_t^* are unsmoothed using the formula

$$g_t = \frac{g_t^* - (1-a)\cdot g_{t-1}^*}{a}, \tag{2}$$

where g_t is the true log real capital return (or growth), and a is the smoothing parameter. We use the value 0.40 (0.625) for unsmoothing annual US (UK) returns as favored by Geltner (1993) and Barkham and Geltner (1994), respectively. Total real estate returns and the cap rate series are constructed from the unsmoothed log real capital return and income return series as follows. The unsmoothed log real capital returns are converted to simple nominal capital returns (CRU_t). This series is used to construct an unsmoothed capital value index (UCV_t). The unsmoothed capital value index is calibrated such that the average of the capital values over time matches the corresponding average of the original index. A real estate income series (Inc_t) is obtained by multiplying the (original) income return (IR_t) with the (original) capital value index (CV_t): $Inc_t = IR_t \cdot CV_{t-1}$. New income returns are computed with regard to the unsmoothed capital value index: $IRU_t = Inc_t / UCV_{t-1}$. Total returns are obtained by adding the adjusted simple income and capital returns: $RER_t = CRU_t + IRU_t$. The cap rate series is calculated as $CR_t = Inc_t / UCV_t$. The variables included in the VAR are the log real total return, and the log of the cap rate.

As a robustness check for the UK market, we estimate additional VARs based on direct real estate return and cap rate series that result from using the smoothing parameters 0.50 and 0.75, which Barkham and Geltner (1994) consider as reasonable lower and upper bounds. In analogy, US results are recalculated for the alternative smoothing parameters 0.33 and 0.50 following Geltner (1993). To save space, we provide only the results concerning direct real estate from these additional VAR estimates, since the results for securitized real estate and the three state variables are not much affected by using the different real estate return and cap rate series resulting from the alternative smoothing parameters in the VARs.

Table 1 lists the standard deviations and first-order autocorrelations of the variables included in the benchmark UK VAR (a = 0.625) and the benchmark US VAR (a = 0.40). Direct real estate returns are much more volatile in the UK than in the US, and the UK returns exhibit less autocorrelation than the US returns. The returns of securitized real estate investments are also more volatile in the UK compared to the US. The additional three state variables all show notable positive autocorrelation.

Since the Center for Real Estate at MIT provides the Transaction-Based Index (TBI) for the US commercial real estate market, one might object the use of (unsmoothed) appraisal-based returns. The TBI is based on property transactions in the pool of properties that are used to construct the appraisal-based NPI (for details on the construction of the TBI see Fisher et al. 2007). It should be emphasized, however, that, while transaction-based indexes have the advantage to be based on transaction prices (instead of appraisal), they are not generally preferable to (unsmoothed) appraisal-based indexes, because they might be subject to other problems such as noise due to the relatively small amount of property transactions (in contrast to appraisals).[7] The NPI index has the advantage that it goes back further in time than the TBI. Nevertheless, to see how the unsmoothed NPI returns used in this paper compare to TBI returns, Table 2 provides some statistics of unsmoothed NPI and TBI returns for the period of overlap 1985 to 2008. TBI returns are reported for both the variable and the constant liquidity version of the TBI. (We compare appreciation returns instead of total returns, since the constant liquidity version is available as an appreciation return index only.) The construction of a constant liquidity transaction-based index is motivated by the fact that liquidity is time-varying and pro-cyclical in real estate markets (see Fisher et al. 2003 and Goetzmann and Peng 2006). While the variable liquidity TBI tracks the development of transaction prices in the commercial real estate markets, it reflects variable market liquidity. The constant liquidity TBI is an index that tracks the development of transaction prices under the assumption of constant liquidity.

As can be seen in Table 2, the constant liquidity returns show a higher volatility and lower autocorrelation than the variable liquidity returns. Unsmoothed NPI returns have correlations with TBI returns of about 80%, and the correlations are generally higher with regard to the constant liquidity version of the TBI than with the variable liquidity version. This is consistent with the view of Fisher et al. (1994, 2003) that unsmoothing procedures can be seen as an attempt to control for pro-cyclical variable liquidity. Constant liquidity returns are better comparable to stock returns, since well-developed stock markets offer (approximately) constant liquidity. Judging from the return standard deviations, the smoothing parameter $a = 0.40$ favored by Geltner (1993) indeed appears to be more reasonable than the values 0.33 and 0.50. Annual TBI returns show a similar autocorrelation

[7] See Geltner et al. (2007, Chapter 25) for a discussion of appraisal-based and transaction-based commercial real estate indexes.

as unsmoothed appraisal-based returns. Hence, the notable autocorrelation in annual returns of about 40% indeed seems to be a feature of the direct US real estate market.

VAR estimates

The results of the VARs, estimated by OLS, are given in Tables 3 (UK) and 4 (US). Panels A contain the coefficients. In square brackets are *t*-values. The rightmost column contains R^2 statistics and the *p*-value of the *F*-test of joint significance (in parentheses). With R^2 values of about 29 and 35% the degree of predictability of annual securitized real estate returns is similar in the two countries. With an R^2 value of 60% US direct real estate returns are much more predictable than US REIT returns and UK direct and securitized real estate returns. Direct real estate has a higher R^2 value than securitized real estate in the UK as well. The *p*-values of the test of joint significance are below or close to 5% and thus indicate that real returns of direct and securitized real estate are indeed predictable in both countries.

The dynamics of real estate returns in the UK and in the US are qualitatively similar. But there are notable differences with regard to the magnitude and significance of some coefficients. In particular, direct real estate returns in the US strongly depend positively and significantly on its own lag, which is not the case for direct real estate in the UK. The return on securitized real estate has a positive influence on direct real estate returns in both countries, but the influence is not significant in the UK. Direct real estate returns are significantly affected by the lagged cap rate in both countries. The lagged cap rate also has a positive (though not significant) influence on securitized real estate returns. The lagged dividend/cash-flow yield of the securitized real estate markets has a positive influence on securitized real estate returns. The coefficient is not significant in the UK, but in a regression of property share returns on the lagged dividend yield alone this is the case (*t*-value of 2.75). Finally, the lagged yield spread is positively related to direct and securitized real estate returns. The coefficients are never significantly different from zero at the 10% level, though. All three additional state variables show persistent behavior with coefficients on their own lags of between 0.356 and 0.795. Since these state variables predict asset returns, the persistency of the state variables carries over to expected asset returns, making expected returns positively autocorrelated. A shock to the expected return persists for some periods ahead, but eventually dies out. The dynamics of some of the state variables are more complex, however. In the UK, the lagged yield spread is also a significant predictor of the cap rate. In the US, lagged direct real estate returns and REIT returns have a significantly negative influence on the cap rate. Due to the positive autocorrelation in direct real estate returns, a price increase of direct real estate in period $t-1$ tends to be associated with a price increase in *t*, which lowers the cap rate in *t*. Similarly, the dependence of the cap rate on the lagged REIT return can be explained by the dependence of direct real estate returns on lagged REIT returns. The dynamics are very similar, when the results are based on the alternative smoothing parameter assumptions.

Panels B of Tables 3 and 4 contain the standard deviations (diagonal) and correlations (off-diagonals) of the VAR residuals. We see that the standard deviation of direct real estate return residuals is much lower in the US than in the UK. There are two reasons for this result. First, the total return variance is lower in the US, as seen in Table 1. Second, annual direct real estate returns are more predictable in the US, which means that the unexpected part of the total variance is smaller. The choice of the smoothing parameter has a notable influence on the residual standard deviation of UK direct real estate returns. When appraisal-based returns are assumed to exhibit relatively little smoothing ($a = 0.75$) the volatility is 11.4%, compared to 17.1% when it is assumed that there is a lot of smoothing ($a = 0.50$). Qualitatively, we see the same result in the US estimates. As with the total standard deviation, the residual standard deviation of US REIT returns is lower than the residual standard deviation of UK property shares. The correlation between direct and securitized real estate return residuals is positive and particularly strong in the UK (77%). US direct real estate and REIT residuals have a correlation of about 51%. The residual correlation between direct and securitized real estate is similar to the correlation between the real log return series itself in the UK, but in the US the residual correlation is higher. In the US, the correlation of the return variables is 33.6% $(a = 0.40)$ compared to the 51.3% residual correlation. This effect is similar to the result of Giliberto (1990), who finds that the residuals obtained from regressions of US direct real estate and REIT returns on other (contemporaneous) asset returns are significantly correlated, although the return series itself are not. The residual correlations between direct real estate returns and cap rates and between securitized real estate returns and dividend/cash-flow yields are highly negative. In the UK, the correlations are about -95% and in the US they are about -90%.

Multi-period volatility and R^2 statistics

Methodology

The term structure of an asset's conditional (i.e., taking predictability into account) standard deviation of real returns can be extracted from the conditional multi-period covariance matrix of the vector $\boldsymbol{z}_{t+1}$, scaled by the investment horizon k (see, e.g., Campbell and Viceira 2004):

$$
\begin{aligned}
\frac{1}{k} Var_t(\boldsymbol{z}_{t+1} + \ldots + \boldsymbol{z}_{t+k}) &= \frac{1}{k}\boldsymbol{W}(k) \\
&= \frac{1}{k}(\boldsymbol{\Sigma}_v + (\mathbf{I}+\boldsymbol{\Phi})\boldsymbol{\Sigma}_v(\mathbf{I}+\boldsymbol{\Phi})' \\
&\quad + (\mathbf{I}+\boldsymbol{\Phi}+\boldsymbol{\Phi}^2)\boldsymbol{\Sigma}_v(\mathbf{I}+\boldsymbol{\Phi}+\boldsymbol{\Phi}^2)' + \ldots \\
&\quad + (\mathbf{I}+\boldsymbol{\Phi}+\ldots+\boldsymbol{\Phi}^{k\text{-}1})\boldsymbol{\Sigma}_v(\mathbf{I}+\boldsymbol{\Phi}+\ldots+\boldsymbol{\Phi}^{k\text{-}1})'),
\end{aligned}
\tag{3}
$$

where **I** is the identity matrix.

Define **e1** (**e2**) as a (5x1) vector where the first (second) element is one and the other elements are zero. Then $\boldsymbol{e1}'\frac{1}{k}\boldsymbol{W}(k)\boldsymbol{e1}$ picks out the annualized conditional variance of real direct real estate returns, and $\boldsymbol{e2}'\frac{1}{k}\boldsymbol{W}(k)\boldsymbol{e2}$ picks out the annualized conditional variance of real securitized real estate returns, at horizon k.

The VAR results can also be used to calculate implied R^2 statistics for multi-period asset returns (see Hodrick 1992). The R^2 statistic can be expressed as one minus the ratio of the unexplained variance to the total variance of multi-period returns. $\boldsymbol{W}(k)$ contains the unexplained variance of k-period returns. To calculate the k-period total variance we need to calculate the unconditional variance of the vector $\boldsymbol{z}_{t+1}$, which is:[8]

$$
\boldsymbol{C}(0) = \sum_{j=0}^{\infty} \boldsymbol{\Phi}^j \boldsymbol{\Sigma} \boldsymbol{\Phi}^{j}{}'. \tag{4}
$$

The k-period matrix of total covariances is:

$$
\boldsymbol{V}(k) = k\boldsymbol{C}(0) + \sum_{j=1}^{k-1}(k-j)(\boldsymbol{C}(j)+\boldsymbol{C}(j)'), \tag{5}
$$

where $\boldsymbol{C}(j) = \boldsymbol{\Phi}^j\boldsymbol{C}(0)$ is the j-th order autocovariance of the vector $\boldsymbol{z}_{t+1}$. Hence, the k-period

[8] The infinite sum is truncated at j = 1000 in the calculations.

R^2 statistic of direct real estate returns, implied by the VAR estimates, is:

$$R^2(k) = 1 - \frac{\boldsymbol{e1}'\boldsymbol{W}(k)\boldsymbol{e1}}{\boldsymbol{e1}'\boldsymbol{V}(k)\boldsymbol{e1}}. \tag{6}$$

The k-period R^2 statistic of securitized real estate returns can be calculated in the same way using the vector **e2** instead of **e1**.

Results

Figure 1 shows the estimates of the term structure of the conditional standard deviation for direct and securitized real estate returns. Panel A shows the results for the UK, and Panel B shows the results for the US. The Panels contain the term structures for direct real estate for the three alternative smoothing parameters. The term structures for securitized real estate are obtained from the VARs with the benchmark smoothing parameter assumption.

In the UK, property share returns show strong mean reversion, which cuts the annualized standard deviation from 28.2% at the one-year horizon to 15.0% at the twenty-year horizon. Similarly, Campbell and Viceira (2005) report that the annualized volatility of US general stock market returns falls by about 50%. The level of the return volatility of the US general stock market is lower, though. The mean reversion of UK property share returns can be traced back to the positive dependence of the return on the lagged dividend yield of the property shares market, since return and dividend yield residuals are highly negatively correlated.

Direct UK real estate returns show a similar pattern as securitized real estate. For the $a = 0.625$ case, the annualized long-term standard deviation is only 56% of the one-year volatility. Over the short-term, however, the pattern is different from property shares. Depending on the assumed smoothing parameter, the term structure is slightly increasing ($a = 0.75$), flat ($a = 0.625$), or slightly decreasing ($a = 0.50$). The counteracting mean-aversion effect is due to the positive dependence of direct real estate returns on lagged securitized real estate returns in combination with the high positive correlation of direct and securitized real estate return residuals. When there is a positive shock to the property share return, the return on direct real estate tends to be high as well, and a high return on property shares predicts a high return on direct real estate, and vice versa. As noted above, the choice of the smoothing parameter has a strong effect on the one-year return volatility. In contrast, the choice of the smoothing parameter has little influence on the long-term volatility.

Depending on the smoothing parameter, the annualized twenty-year volatility is between 7.5% and 8.25%. Thus, for long-term direct real estate investment decisions the choice of the smoothing parameter is of minor importance. The cap rate is crucial to capture the long-term mean-reversion effect in direct UK real estate returns. When the cap rate is excluded form the five-variable VAR model, the returns still exhibit (slight) mean reversion, but the estimated annualized 20-year return volatility is much higher with values between 11.2% ($a = 0.75$) and 14.6% ($a = 0.50$). Thus, the cap rate captures mean reversion of direct real estate returns, just like the dividend yield of the property share market captures mean reversion in the securitized real estate market.

Looking at the estimates for US securitized real estate, we see a pattern similar to the UK results. The periodic long-term volatility of REIT returns is only about 55% of the one-year volatility. Thus, when a valuation ratio specific to the securitized real estate market is included in the VAR model, the mean reversion effect appears to be very similar to the general stock market.

Turning to US direct real estate, we see a strong mean aversion effect over short investment horizons. The annualized three-year return standard deviation is more than three percentage points higher than the one-year standard deviation (this is true for all three smoothing parameters). Thus, the short-term mean aversion effect is much stronger in the US than in the UK direct real estate market. As in the UK, the mean aversion effect can be attributed to the relationship with securitized real estate returns. Direct real estate returns are positively related to lagged REIT returns and the correlation of the residuals is also positive. In addition to that, direct real estate returns are positively autocorrelated in the US, which also induces a mean-aversion effect. The term structure is downward sloping or relatively flat over medium investment horizons of up to ten years, depending on the assumption regarding the smoothing parameter. For every smoothing parameter we see a mean-reversion effect, however, such that the annualized twenty-year return volatility is lower than the volatility at medium investment horizons. The twenty-year volatility is 7.5 to 7.8%, very similar to the UK estimates. Hence, one important conclusion from Figure 1 is that in the long run, US direct real estate returns do not appear to be less volatile than UK direct real estate returns, which contrasts sharply with short-term statistics. Again, the choice of the smoothing parameter has little influence on the return volatility at medium and long horizons. Only the return volatility for short investment horizons (not relevant for most investors in the direct real estate market) is strongly affected by the choice of the smoothing parameter. Even more than in the UK, it is important to include the cap rate in the VARs to capture mean reversion in direct real estate returns. Specifically, when the cap rate is excluded from the five-variable VAR, the twenty-year volatility (per period) is between 15.6 and 17.9% (depending on the unsmoothing parameter), more than twice the estimates from the VARs that include the cap rate.

In both countries, the volatility of securitized real estate returns is notably higher than the volatility of direct real estate returns over all investment horizons. One explanation for this is leverage (see, e.g., Barkham and Geltner 1995 and Pagliari et al. 2005). It is well known that leverage increases the volatility of equity returns. Because the indexes used for the direct real estate markets measure the performance of unlevered investments, while the indexes used for the securitized real estate markets measure the performance of levered real estate firms, leverage is a straightforward explanation for the return volatility differences. Due to the short-term mean aversion effects in the direct real estate markets, in contrast to the mean reversion of securitized real estate returns, the ratio of the volatility of direct real estate returns to the volatility of securitized real estate returns is particularly low at the one-year horizon in the UK and at the one- and two-year horizons in the US. This is similar to the finding of Geltner et al. (1995) that unlevered US REIT returns and direct real estate returns have a similar volatility at a five-year horizon, whereas the one-year volatility of unlevered REIT returns is notably higher.

The R^2 statistics for the one-year horizon calculated from (6) match the actual R^2 statistics reported in Tables 3 and 4 quite good for the UK market. This is also true for the R^2 statistic of US REITs. The one-year R^2 statistics calculated from (6) are notably higher than the actual R^2 statistics for US direct real estate. Therefore, we generally rescaled the k-year R^2 statistics obtained from (6) such that the one-year R^2 statistics are equal to the actual R^2 statistics reported in Tables 3 and 4. These rescaled implied R^2 statistics are shown in Figure 2.

In the UK market, the general pattern is quite similar for the three direct real estate estimates and the estimate for property shares. The R^2 statistics increase over short investment horizons, reaching its maximum at the three-year horizon with 45% for property shares and about 55% for direct real estate ($a = 0.625$), respectively. For investment horizons longer than three years, however, the implied R^2 statistics decrease with the investment horizon. The implied R^2 statistic decreases to 20% at the twenty-year horizon for property shares and to 30% for direct real estate. Thus, direct real estate remains to be more predictable than securitized real estate at longer horizons. For comparison, Campbell (1991) reports that the R^2 statistic of US stock returns implied by a VAR estimate for the 1952 to 1988 period rises to about 45% at a horizon of nine years and only slightly decreases over longer horizons. Over the longer 1927 to 1988 period, the implied R^2 statistics are generally lower, the peak is earlier at about four years and the R^2 statistic is decreasing faster with the investment horizon.

The results for the US market are more complex than the UK results. The implied R^2 statistics for direct real estate are quite flat at horizons between one and five years. As in the UK market, the variance of expected returns increases more than in proportion to the investment horizon. However, recall from Table 1 that realized returns are highly positively autocorrelated in the US (in contrast to the UK), so that the variance of realized returns increases more than in proportion to the investment horizon, too. Therefore, we see the flat line in the US and the increasing R^2 statistics in the UK over short horizons. As in the UK, the implied R^2 statistic is strongly increasing for securitized real estate returns over short horizons. The implied R^2 statistic of REITs is almost 60% at the three-year horizon, much more than the 45% estimated for property shares in the UK. The implied R^2 statistics decrease strongly over medium investment horizons for both direct real estate and REIT returns. At the ten-year horizon all estimates are very similar with implied R^2 statistics of about 30 to 35%. Thus, while US direct real estate returns are more predictable than REIT returns when judged from regressions with annual returns, they appear to be equally predictable over an investment horizon, which is typical for investors in direct real estate. With about 32%, the twenty-year R^2 statistic for direct real estate is again higher than the 24% R^2 statistic for REIT returns.

Variance decompositions

Methodology

Building on Campbell and Shiller's (1988) log-linear present-value model with time-varying discount rates, Campbell (1991) shows that for investor's expectations to be internally consistent, high unexpected returns $r_{t+1} - E_t(r_{t+1})$ must be associated with revisions in expectations about future cash-flow growth or future returns (discount rates), or both:[9]

$$r_{t+1} - E_t(r_{t+1}) = (E_{t+1} - E_t)\sum_{j=0}^{\infty} \rho^j \Delta d_{t+1+j} - (E_{t+1} - E_t)\sum_{j=1}^{\infty} \rho^j r_{t+1+j} \,, \tag{7}$$

[9] Rational bubbles need to be ruled out in the derivation.

where r_{t+1+j} is the log real return and Δd_{t+1+j} is the growth in cash-flow in period $t+1+j$. E_t is the conditional expectation operator such that $(E_{t+1}-E_t)$ denotes the revision in expectations due to the arrival of news in period $t+1$. ρ is a parameter of linearization defined as $\rho = 1/[1+\exp(\overline{d-p})]$, where $\overline{d-p}$ is the mean log cash-payout-yield, i.e., the dividend yield of the securitized real estate market and the cap rate of the direct real estate market, respectively.[10] Revisions in expectations have a greater effect on unexpected returns, the more persistent the revisions are, since discounted individual news terms are summed up. Equation (7) can be expressed in more compact form as

$$r_{t+1} - E_t(r_{t+1}) = \eta_{t+1} = \eta_{d,t+1} - \eta_{r,t+1}. \tag{8}$$

We refer to $\eta_{d,t+1}$ as cash-flow news and to $\eta_{r,t+1}$ as discount rate news, for short. In the remainder, we provide formulas for direct real estate, using the vector ***e*1**. The same formulas apply to securitized real estate, if ***e*1** is exchanged by ***e*2**. Campbell shows that discount rate news can be calculated as:

$$\eta_{r,t+1} = \boldsymbol{\lambda}'\boldsymbol{v}_{t+1}, \tag{9}$$

where $\boldsymbol{\lambda}' = \boldsymbol{e1}'\rho\boldsymbol{\Phi}(\mathbf{I} - \rho\boldsymbol{\Phi})^{-1}$. It is easy to calculate $r_{t+1} - E_t(r_{t+1}) = \eta_{t+1} = \mathbf{e1}'\boldsymbol{v}_{t+1}$, so that cash-flow news can be obtained as a residual from equation (8):

$$\eta_{d,t+1} = \eta_{t+1} - \eta_{r,t+1} = (\boldsymbol{e1}' + \boldsymbol{\lambda}')\boldsymbol{v}_{t+1}. \tag{10}$$

The variances and the covariance of the news terms can be calculated as:

$$\begin{aligned} &Var(\eta_{d,t+1}) = \boldsymbol{\lambda}'\boldsymbol{\Sigma}\boldsymbol{\lambda}, \\ &Var(\eta_{r,t+1}) = (\boldsymbol{e1}' + \boldsymbol{\lambda}')\boldsymbol{\Sigma}(\mathbf{e1} + \boldsymbol{\lambda}), \\ &Cov(\eta_{d,t+1}, \eta_{r,t+1}) = \boldsymbol{\lambda}'\boldsymbol{\Sigma}(\boldsymbol{e1} + \boldsymbol{\lambda}). \end{aligned} \tag{11}$$

[10] The mean log dividend yield of US REITs is -3.33 and thus ρ = 0.9654. For the US direct real estate market ρ is 0.9296 (for a = 0.40). For the UK market we obtain ρ = 0.9658 for the property shares market and ρ = 0.9437 for the direct real estate market (a = 0.625). Small changes due to unsmoothing direct real estate returns with different smoothing parameters are ignored.

Campbell defines persistence as the ratio of the standard deviation of the news about discount rates to the standard deviation of the innovation in the one-period ahead expected return:

$$P = \frac{\sigma(\boldsymbol{\lambda}'\boldsymbol{v}_{t+1})}{\sigma(\boldsymbol{e1}'\boldsymbol{\Phi}\boldsymbol{v}_{t+1})}. \tag{12}$$

This measure says that a typical 1% negative innovation in the expected return causes a *P*% capital gain. When expected returns are highly persistent, asset prices are very sensitive to movements in expected returns.

The statistics (11) and (12) are functions $f(vec(\boldsymbol{\Phi}))$ of the coefficients in the VAR matrix **Φ**.[11] Using the Delta-method, we calculate standard errors for any statistic as $\sqrt{\partial f/\partial Vec(\boldsymbol{\Phi})\boldsymbol{\Omega}\,\partial f/\partial Vec(\boldsymbol{\Phi})'}$. Here, $\partial f/\partial Vec(\boldsymbol{\Phi})$ denotes the (1x25) vector of partial derivatives, evaluated at the estimate of the VAR coefficient matrix **Φ**, and $\boldsymbol{\Omega}$ is the (25x25) covariance matrix of the VAR coefficients.

Results

Table 5 shows the variance decomposition results. The terms $Var(\eta_{d,t+1})$, $Var(\eta_{r,t+1})$ and $-2Cov(\eta_{d,t+1},\eta_{r,t+1})$ are reported both in absolute terms and in relative terms, i.e., as a fraction of the variance of unexpected returns, such that the three terms sum to one.

In the UK, about three quarters of the variance of unexpected returns is attributed to discount rate news for both direct real estate and property shares. About 20% is attributed to cash-flow news. In absolute terms, the variances of cash-flow and discount rate news are much higher for property shares than for direct real estate. The covariance terms, and hence the correlations between cash-flow and discount rate news are small. These variance decomposition results (in relative terms) are similar to the results for the US general stock market in the 1952 to 1988 period (Campbell 1991).

Qualitatively, the estimates for the UK and the US have in common that discount rate news are much more important than cash-flow news. The variance of discount rate news accounts for more than 100% of the variance of unexpected returns for both US direct real

[11] They are also a function of the residual covariance matrix **Σ**, but we treat this as fixed (as in Campbell and Shiller 1988).

estate and REIT returns. From an absolute perspective it makes sense that discount rate are relatively more important in the US than in the UK, because the conditional return volatilities are on a lower level, so that the absolute contributions of discount rate news are more similar across the countries. Despite the larger relative amounts in the US, the absolute amounts of the variance of discount rate news are still lower than in the UK, especially in the direct real estate market. This is reflected in the lower estimates of the persistence measure for expected returns in the US, which are about 1.5. Recall that this estimate says that a 1% positive shock to the expected return tends to be associated with a 1.5% capital loss. This compares to persistence measures of 2.5 to 2.8 for UK direct real estate. In the securitized real estate markets, the absolute contributions of the variance of discount rate news to the variance of unexpected returns are relatively similar in the UK and the US, and so are the estimated persistence measures.

The variance of cash-flow news of US direct real estate ($a = 0.40$) accounts for one third of the variance of unexpected returns, compared to 21% for the benchmark case ($a = 0.625$) in the UK. In absolute terms, however, the variance of cash-flow news is lower in the US. Thus, relative to the variance of unexpected returns, the variance of cash-flow news as well as the variance of discount rate news are more important in the US than in the UK direct real estate market. This implies that the covariance term is substantially negative and hence the correlation between cash-flow news and discount rate news is substantially positive in the US. When there is good news about future cash-flows, expected future returns tend to rise. The correlation estimate is 53% when $a = 0.40$ is used. This estimate is almost three standard errors above zero. Closest to the UK results is the estimate for US REITs; the correlation between cash-flow and discount rate news is relatively mildly positive (28%, with a standard error of 29%).

The variance decompositions help to interpret the differences between the volatility term structures shown in Figure 1. In the UK, most of the variability of unexpected returns for both direct and securitized real estate can be explained by discount rate news, and the correlation between cash-flow and discount rate news is about zero. The term structures reflect strong mean reversion (except for direct real estate at very short horizons), because positive discount rate news decrease prices but increase expected future returns. In the US direct real estate market, the correlation between cash-flow and discount rate news is positive, i.e., positive discount rate news tend to be accompanied by positive cash-flow news. Hence, a positive shock to expected returns (the discount rate effect) may not decrease prices. On the other hand, the persistence in expected returns carries over to realized return, generating mean aversion. The positive correlation between cash-flow and discount rate news also explains the low short-term volatility of US direct real estate returns, since cash-flow and discount rate news of the same sign influence prices in opposite directions. The correlation between cash-flow and discount rate news of US REITs is positive, but relatively small, such that the discount rate effect generates mean reversion.[12]

Market efficiency

Time-variation in expected returns can be due to irrational behavior or rational changing risk aversion of investors. There is an ongoing debate which explanation is more relevant for stock return predictability (see, e.g., Fama 1991 and Shiller 2003). Fama and French (1989) show that the dividend yield and the yield spread track business cycle movements, being low in good times and high in bad times. The variables forecasts both stock and bond returns positively, meaning that future returns are expected to be higher (lower) in bad (good) economic conditions. Because the same is likely to be true for investor's risk aversion, time-variation in expected stock and bond returns may be rational rather than reflect market inefficiency. Plazzi et al. (2010) analyze the role of the cap rate as a predictor of direct real estate returns in detail and find that the cap rate captures the dynamics of direct real estate returns in a similar fashion as the dividend yield captures the dynamics of stock returns. Hence, the predictive power of the yield spread, the cap rate and the yield of the securitized real estate market for direct and securitized real estate returns may also reflect rational time-variation in expected returns.

Recall, however, that direct real estate returns also depend positively on the lagged return on securitized real estate investments and they are also positively autocorrelated, particularly strong in the US. The finding that price discovery occurs first in the more liquid securitized real estate market and then in the direct real estate market has been documented in many studies (for a review see Geltner et al. 2003). Barkham and Geltner (1995) argue that the securitized market leading the direct real estate market is hard to reconcile with a rational explanation and conclude that this finding reflects informational inefficiency of the direct real estate market. Positive autocorrelation in real estate returns is seen to be evidence of an inefficient market, too (e.g., Case and Shiller 1989, Fu and Ng 2001). As noted above,

[12] See Campbell et al. (1997, Chapter 7) for a textbook discussion of these effects.

autocorrelation and the positive relationship of direct real estate returns on lagged securitized real estate returns (in combination with the positive correlation of the return residuals) induces mean aversion in direct real estate returns. Since the UK direct real estate market shows less mean aversion than the US market, the UK market appears to be relatively more informational efficient. An explanation for this might be that the UK market is more homogeneous (Barkham and Geltner 1995).

The variance decompositions shed some more light on the issue of market efficiency. In contrast to the aggregate stock market, where the correlation between cash-flow news and discount rate news is estimated to be negative or close to zero (Campbell 1991, Campbell and Vuolteenaho 2004), Vuolteenaho (2002) finds that the correlation with regard to firm-level stock returns is notably positive. The correlation is largest for small firms (often viewed to be most likely subject to behavioral mispricing), whereas the correlation is almost zero for the largest firms. Vuolteenaho points out that the positive correlation could be due to an underreaction to cash-flow news. When good cash-flow news arrives, the price increase does not reflect the good news fully. In turn, expected returns must increase. Campbell et al. (2009) suggest that this explanation may be relevant for the US housing market. The results reported here suggest that the underreaction explanation may also apply to the US direct commercial real estate market.

To address the question of informational efficiency of a market, Fu and Ng (2001) suggest regressing the one-period unexpected return η_{t+1} on a cumulative price adjustment $\varphi_{t+1}(k) = \eta_{t+1} + \rho\eta_{t+2} + ... + \rho^{k-1}\eta_{t+k}$, where $\eta_{t+1+j} = \mathbf{e1}'\mathbf{\Phi}^{j}\boldsymbol{v}_{t+1}$, $j > 0$, are the innovations to future expected returns. (Again, the formula is for direct real estate; if ***e*1** is exchanged by ***e*2** it applies to securitized real estate.) Consider the example of a two-period cumulative price adjustment. A regression coefficient of larger than one means that η_{t+1} and η_{t+2} are negatively correlated, which can be explained by the discount rate effect: When the contemporaneous unexpected return is negative, this is caused by an upward revision of the future expected return. A coefficient of below one is consistent with the underreaction to cash-flow news hypotheses. Suppose that news about cash-flows justifies a positive contemporaneous unexpected return, but due to underreaction the price adjustment is not complete. Therefore, the full adjustment must take place through a future price appreciation, so that η_{t+1} and η_{t+2} are positively correlated. More generally, a positive correlation between η_{t+1} and η_{t+2} can also be due to an underreaction with regard to news about future expected returns.

We follow the approach of Fu and Ng, and report the coefficient β estimated from a regression of the one-period unexpected return on the two-period cumulative price adjustment $\varphi_{t+1}(2) = \eta_{t+1} + \rho\eta_{t+2}$ in the rightmost column of Table 5:

$$\eta_{t+1} = \beta\varphi_{t+1}(2) + \varepsilon_{t+1}. \quad (13)$$

In line with the underreaction to cash-flow news explanation, we see that the annual unexpected return in the US direct real market captures only about 60% of the two-year cumulative price adjustment. In the securitized real estate markets, we see no evidence of underreaction. The coefficients are larger than one, consistent with the discount rate effect. These results are in line with the results reported by Fu and Ng. They find a regression coefficient of 60% for the (direct) Hong Kong office real estate market and coefficients of about 110 to 120% for the stock market. However, Fu and Ng regress quarterly unexpected returns on the five-quarter cumulative price adjustment, whereas the dependent variable in our regression is the annual unexpected return. Hence, the underreaction appears to be more severe in the US compared to Hong Kong, since there is a notable underreaction even at an annual frequency in the US. The regression coefficients for the direct real estate market in the UK are about one. This result suggests that the discount rate effect tends to be compensated by an underreaction to news effect. Since the correlation between discount and cash-flow news of about zero does not support an underreaction to cash-flow news story, the underreaction appears to be related to discount rate news.

The regression results correspond to the term structure of return volatilities shown in Figure 1. In the UK direct real estate market, the term structures are relatively flat between the one- and two-year horizons. This corresponds to the regression coefficients of about one. The increase in the periodic return volatility of the US direct real estate market can be explained by an underreaction to cash-flow news. It takes some time until prices have fully adjusted to new information, and this slow response leads to the pronounced mean aversion effect over short investment horizons. The regression coefficients of above one in the securitized real estate markets reflect a full adjustment of prices to new information, such that the term structure of the return volatility is decreasing due to the discount rate effect.

Conclusion

Using vector autoregressions, we find – in line with conventional wisdom – that US and UK direct real estate returns exhibit short-term mean aversion and long-term mean reversion. But comparing the two markets, we find huge differences with regard to the importance of these effects. The UK direct real estate market is characterized by a strong mean reversion effect. Over short investment horizons, there is a mean aversion effect in both the UK and the US direct real estate market, but the mean aversion effect is much more pronounced in the US. In the long-term, however, the estimated annualized return volatilities of UK and US direct real estate returns are quite similar. The choice of the parameter used to unsmooth appraisal-based returns has a large effect on the short-term, but not on the long-term volatility of direct real estate returns. UK property shares and US REITs exhibit strong mean reversion, very much like the general stock market. UK direct real estate returns remain more predictable than property share returns in the medium and long term, whereas US REIT returns appear to be equally predictable to direct real estate returns in the medium term.

News about discount rates are more important than cash-flow news in the analyzed real estate markets. The low short-term standard deviation and the mean aversion of US direct real estate returns can be explained by the positive correlation between cash-flow and discount rate news, which can be interpreted as underreaction to cash-flow news.

Of course, the results in this paper have implications for portfolio choice. The volatility results would seem to justify larger allocations to securitized real estate and to direct UK real estate for long-term investors. This is not true for direct US real estate. But of course, horizon effects in return volatilities, return correlations, and expected returns of several asset classes have to be considered jointly.

Appendix A: Data

Table A1 provides information on the data used to construct the VAR variables. Information on the direct real estate data can be found in the main text.

Table A1: Data information

Panel A: UK

	Description	Source
Index of securitized real estate	UK DS real estate total return index	Datastream
Yield of securitized real estate	Dividend yield of UK DS real estate index	Datastream
Cash yield	UK three-month treasury bills rate	Datastream
Long-term bond yield	Yield of Barclays gilt index	Barclays Equity Guilt Study 2009
Inflation rate	Change (%) of UK cost of living index	Barclays Equity Guilt Study 2009

Panel B: US

	Description	Source
Index of securitized real estate	US DS REITs index (rebased)	Datastream
Valuation ratio of securitized real estate	Price/Cash-flow ratio of US DS REITs index	Datastream
Cash yield	US three-month treasury bills rate	Datastream
Long-term bond yield	Yield of US treasury constant maturities 10 years	Datastream
Inflation rate	Change (%) of Consumer Price Index - All Urban Consumers	Bureau of Labor Statistics

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Table 1 Sample statistics

	UK ($a = 0.625$)		US ($a = 0.40$)	
	St.dv.	Auto-correlation	St.dv.	Auto-correlation
Log real return on direct real estate	17.22%	15.49%	10.39%	38.82%
Log real return on securitized real estate	31.18%	-2.22%	23.30%	-3.31%
Log of cap rate	0.2636	60.91%	0.1938	81.07%
Log of yield of securitized real estate	0.3176	40.03%	0.3433	69.27%
Log yield spread	1.81%	45.28%	1.40%	40.26%

This table shows statistics for the variables included in the VAR models, which are based on annual data. The sample period is 1972 to 2008 for the UK. The US sample period is 1979 to 2008. Direct real estate return and cap rate statistics are based on the smoothing parameter (a) 0.625 for the UK and 0.40 for the US. St.dv.: Standard deviation. Autocorrelation refers to the first-order autocorrelation.

Table 2 Statistics of US direct real estate returns

	St. dv.	Auto-correlation	Correlation with VL	Correlation with CL
NPI				
a = 0.33	14.04%	37.70%	77.34%	83.38%
a = 0.40	11.70%	40.94%	78.87%	83.05%
a = 0.50	9.64%	46.31%	79.89%	81.45%
TBI				
Variable liquidity (VL)	9.00%	47.62%	100.00%	92.98%
Constant liquidity (CL)	11.19%	37.71%	92.98%	100.00%

This table shows statistics of mean-adjusted log real capital returns, based on annual data from 1985 to 2008. Unsmoothed NPI return statistics are reported for three smoothing parameters *a*. TBI return statistics are reported for the variable liquidity (VL) and the constant liquidity (CL) version. St. dv.: Standard deviation. Autocorrelation refers to the first-order autocorrelation.

Table 3 UK VAR results

Panel A: VAR coefficients

Variable	Coefficients on lagged variables 1	2	3	4	5	R^2 (*p*)
a = 0.625						
1 Log real return on direct real estate	0.199	0.162	0.323	0.016	2.180	42.82%
	[0.858]	[1.177]	**[2.414]**	[0.122]	[1.590]	(0.28%)
2 Log real return on property shares	0.105	0.161	0.344	0.336	2.109	29.24%
	[0.219]	[0.569]	[1.251]	[1.240]	[0.748]	(4.72%)
3 Log of cap rate	-0.087	-0.224	0.600	0.024	-4.594	57.06%
	[-0.295]	[-1.280]	**[3.520]**	[0.140]	**[-2.632]**	(0.00%)
4 Log of dividend yield	-0.065	-0.027	-0.334	0.622	-4.054	26.81%
	[-0.134]	[-0.095]	[-1.204]	**[2.271]**	[-1.426]	(7.04%)
5 Log yield spread	0.012	-0.032	0.004	0.001	0.460	42.66%
	[0.461]	**[-2.182]**	[0.243]	[0.086]	**[3.118]**	(0.29%)
a = 0.50						
1 Log real return on direct real estate	0.133	0.212	0.387	0.024	2.736	43.65%
	[0.564]	[1.196]	**[2.452]**	[0.147]	[1.612]	(0.23%)
a = 0.75						
1 Log real return on direct real estate	0.285	0.132	0.278	0.014	1.835	43.79%
	[1.269]	[1.199]	**[2.419]**	[0.124]	[1.585]	(0.22%)

Panel B: Standard deviations and correlations of VAR residuals

	1	2	3	4	5
a = 0.625					
1 Log real return on direct real estate	13.73%	76.92%	-96.90%	-73.36%	-39.13%
2 Log real return on property shares	76.92%	28.21%	-76.44%	-94.23%	-30.86%
3 Log of cap rate	-96.90%	-76.44%	17.47%	78.46%	36.92%
4 Log of dividend yield	-73.36%	-94.23%	78.46%	28.46%	33.05%
5 Log yield spread	-39.13%	-30.86%	36.92%	33.05%	1.48%
a = 0.50					
1 Log real return on direct real estate	17.14%	76.69%	-97.65%	-73.09%	-39.14%
a = 0.75					
1 Log real return on direct real estate	11.44%	76.91%	-96.04%	-73.37%	-38.88%

The results are based on mean-adjusted annual data from 1972 to 2008. Full VAR results are reported for the smoothing parameter *a* = 0.625, and VAR results concerning only direct real estate are reported for *a* = 0.50 and *a* = 0.75. Panel A shows the VAR coefficients. The *t*-statistics are in square brackets; values corresponding to *p*-values of 10% or below are highlighted. The rightmost column contains the R^2 values and the *p*-value of the *F*-test of joint significance in parentheses. Panel B shows results regarding the covariance matrix of residuals, where standard deviations are on the diagonal and correlations are on the off-diagonals.

Table 4 US VAR results

Panel A: VAR coefficients

Variable	Coefficients on lagged variables 1	2	3	4	5	R^2 (*p*)
a = 0.40						
1 Log real return on direct real estate	0.710	0.186	0.242	0.011	1.013	60.10%
	[3.570]	**[2.791]**	**[2.878]**	[0.238]	[0.972]	(0.03%)
2 Log real return on REITs	0.376	-0.015	0.266	0.309	4.520	34.79%
	[0.667]	[-0.077]	[1.117]	**[2.369]**	[1.530]	(5.35%)
3 Log of cap rate	-0.604	-0.237	0.795	-0.004	-1.182	80.04%
	[-2.304]	**[-2.699]**	**[7.187]**	[-0.074]	[-0.861]	(0.00%)
4 Log of cash-flow yield	-0.127	-0.011	-0.154	0.621	-2.934	50.32%
	[-0.194]	[-0.050]	[-0.556]	**[4.096]**	[-0.853]	(0.30%)
5 Log yield spread	-0.033	0.008	-0.003	0.003	0.356	21.85%
	[-0.957]	[0.663]	[-0.207]	[0.438]	**[1.979]**	(26.56%)
a = 0.33						
1 Log real return on direct real estate	0.652	0.228	0.256	0.014	1.199	58.32%
	[3.146]	**[2.784]**	**[2.757]**	[0.243]	[0.936]	(0.05%)
a = 0.50						
1 Log real return on direct real estate	0.780	0.148	0.222	0.008	0.865	63.34%
	[4.246]	**[2.839]**	**[3.059]**	[0.227]	[1.053]	(0.01%)

Panel B: Standard deviations and correlations of VAR residuals

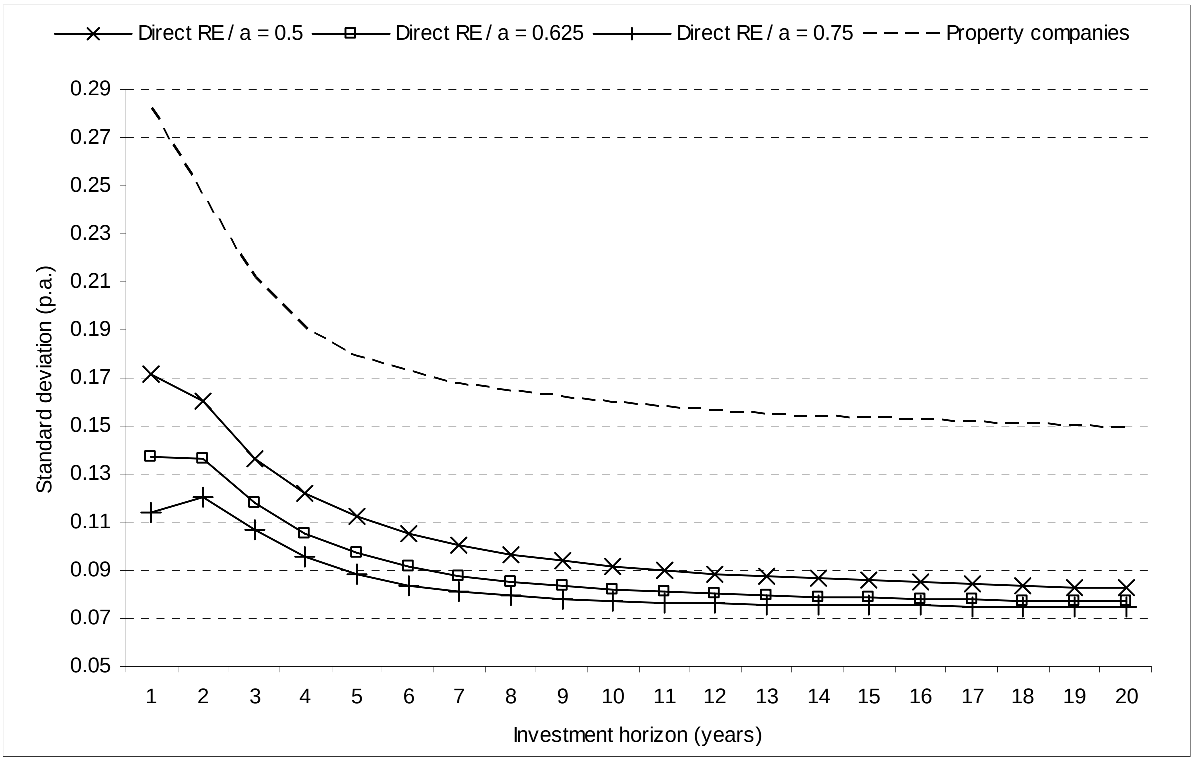
	1	2	3	4	5
a = 0.40					
1 Log real return on direct real estate	7.17%	51.30%	-90.31%	-38.23%	-49.89%
2 Log real return on REITs	51.30%	20.34%	-36.69%	-87.12%	-27.10%
3 Log of cap rate	-90.31%	-36.69%	9.45%	32.15%	44.55%
4 Log of cash-flow yield	-38.23%	-87.12%	32.15%	23.67%	18.36%
5 Log yield spread	-49.89%	-27.10%	44.55%	18.36%	1.24%
a = 0.33					
1 Log real return on direct real estate	8.80%	51.60%	-93.11%	-38.12%	-50.29%
a = 0.50					
1 Log real return on direct real estate	5.65%	51.21%	-86.03%	-38.70%	-49.30%

The results are based on mean-adjusted annual data from 1979 to 2008. Full VAR results are reported for the smoothing parameter $a = 0.40$, and VAR results concerning only direct real estate also reported for $a = 0.33$ and $a = 0.50$. Panel A shows the VAR coefficients. The *t*-statistics are in square brackets; values corresponding to *p*-values of 10% or below are highlighted. The rightmost column contains the R^2 values and the *p*-value of the *F*-test of joint significance in parentheses. Panel B shows results regarding the covariance matrix of residuals, where standard deviations are on the diagonal and correlations are on the off-diagonals.

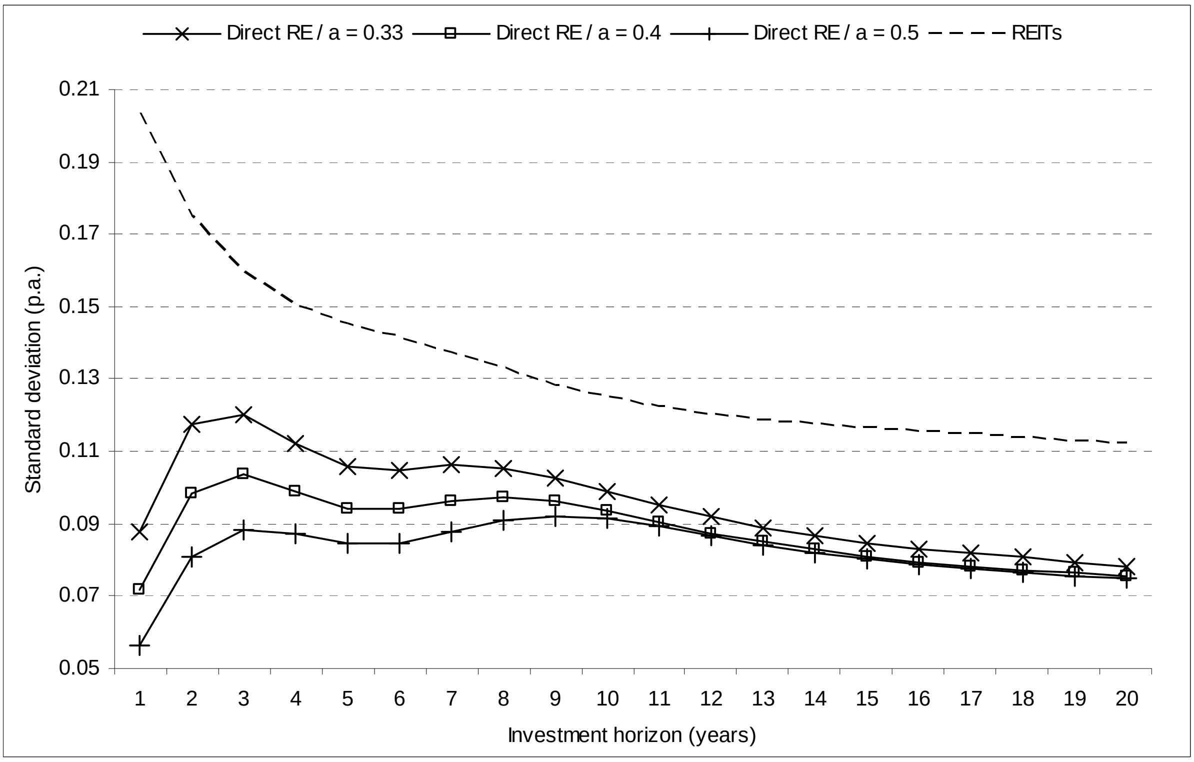
Table 5 Variance decompositions

	$Var(\eta_{d,t+1})$		$Var(\eta_{r,t+1})$		$-2Cov(\eta_{d,t+1},\eta_{r,t+1})$		$Corr(\eta_{d,t+1},\eta_{r,t+1})$	Persistence	β
	Relative	Absolute	Relative	Absolute	Relative	Absolute			
UK									
Direct real estate ($a = 0.50$)	13.83%	0.0041	75.83%	0.0223	10.33%	0.0030	-0.160	2.453	1.081
	(7.04%)	(0.0021)	(13.84%)	(0.0041)	(15.43%)	(0.0045)	(0.271)	(0.936)	(0.063)
Direct real estate ($a = 0.625$)	20.53%	0.0039	73.54%	0.0139	5.93%	0.0011	-0.076	2.824	0.974
	(10.35%)	(0.0020)	(18.26%)	(0.0034)	(21.60%)	(0.0041)	(0.297)	(1.219)	(0.049)
Direct real estate ($a = 0.75$)	29.28%	0.0038	74.28%	0.0097	-3.55%	-0.0005	0.038	2.838	0.881
	(14.82%)	(0.0019)	(23.77%)	(0.0031)	(30.36%)	(0.0040)	(0.314)	(1.282)	(0.039)
Property companies	22.61%	0.0180	69.26%	0.0551	8.14%	0.0065	-0.103	2.131	1.309
	(9.06%)	(0.0072)	(21.77%)	(0.0173)	(24.68%)	(0.0196)	(0.337)	(0.835)	(0.070)
US									
Direct real estate ($a = 0.33$)	20.17%	0.0016	119.68%	0.0093	-39.85%	-0.0031	0.406	1.522	0.614
	(2.85%)	(0.0002)	(25.81%)	(0.0020)	(27.49%)	(0.0021)	(0.219)	(0.412)	(0.035)
Direct real estate ($a = 0.40$)	33.34%	0.0017	139.35%	0.0072	-72.69%	-0.0037	0.533	1.525	0.592
	(6.49%)	(0.0003)	(34.61%)	(0.0018)	(39.47%)	(0.0020)	(0.185)	(0.393)	(0.034)
Direct real estate ($a = 0.50$)	61.32%	0.0020	179.48%	0.0057	-140.80%	-0.0045	0.671	1.571	0.564
	(15.83%)	(0.0005)	(51.33%)	(0.0016)	(64.84%)	(0.0021)	(0.140)	(0.386)	(0.032)
REITs	21.40%	0.0089	105.03%	0.0435	-26.43%	-0.0109	0.279	2.087	1.287
	(6.43%)	(0.0027)	(28.91%)	(0.0120)	(33.83%)	(0.0140)	(0.286)	(0.832)	(0.116)

This table reports how much of the variance of unexpected returns is attributed to the variance of cash-flow news, $Var(\eta_{d,t+1})$, to the variance of discount rates news, $Var(\eta_{r,t+1})$, and minus two times the covariance, $-2Cov(\eta_{d,t+1},\eta_{r,t+1})$. The three terms are reported in absolute terms, and as a fraction of the variance of unexpected returns, such that the three terms sum to one. $Corr(\eta_{d,t+1},\eta_{r,t+1})$ is the correlation between cash-flow and discount rate news. Persistence refers to the persistence measure for expected returns defined in (12). β is the regression coefficient of the one-period unexpected return on the two-period cumulative price adjustment. Standard errors are in parentheses. a is the smoothing parameter.



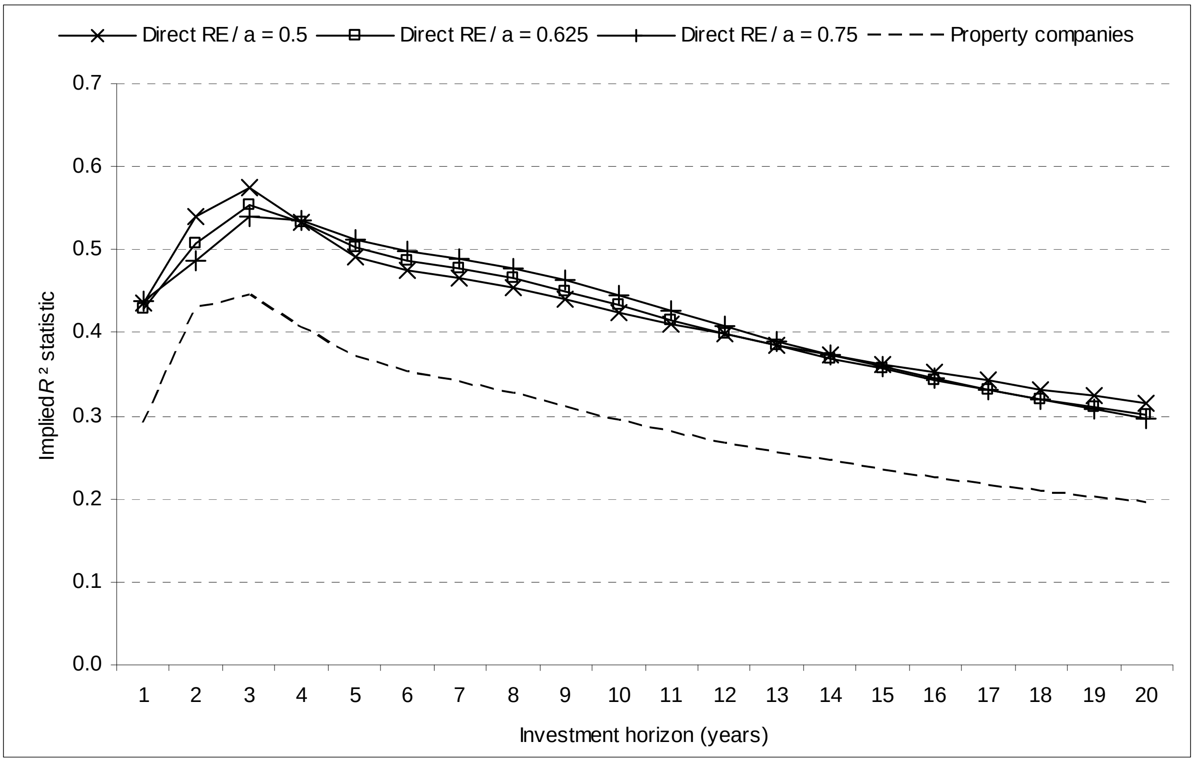
Panel A: UK



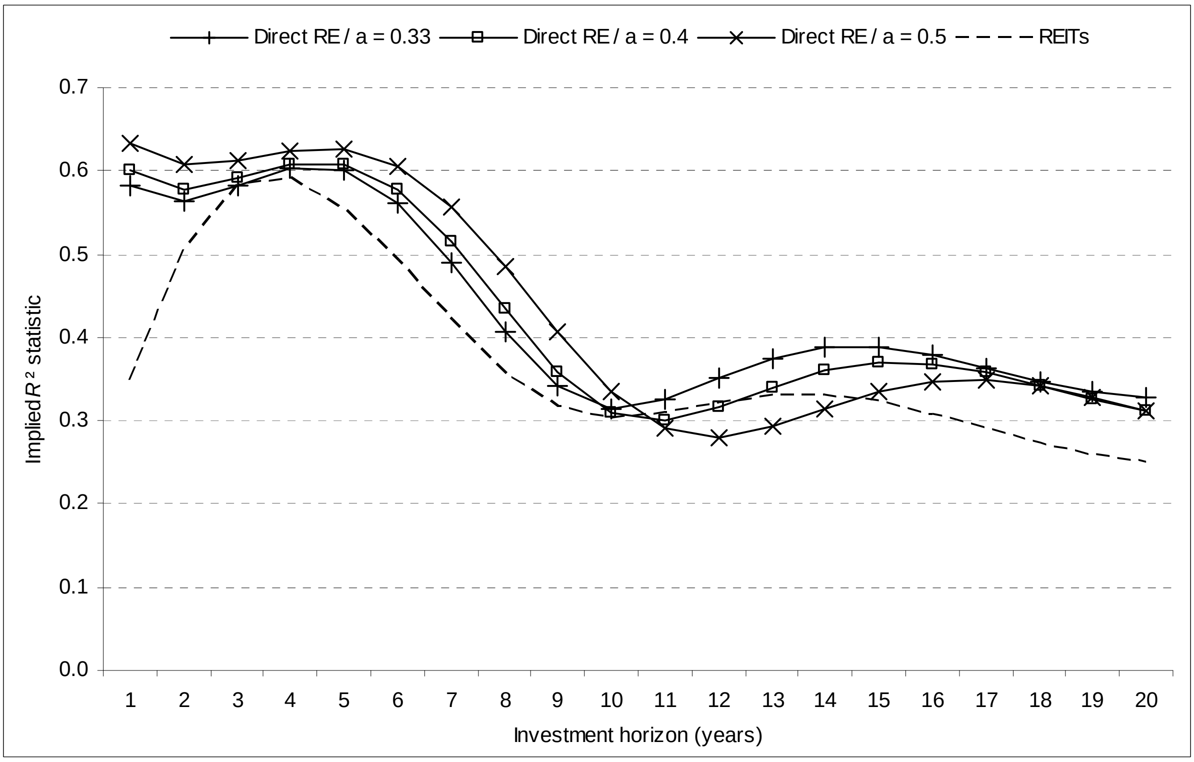
Panel B: US

Figure 1 The term structure of return volatilities

The figure shows conditional annualized standard deviations of real returns depending on the investment horizon. RE: Real estate. *a* is the smoothing parameter.



Panel A: UK



Panel B: US

Figure 2 Implied R^2 statistics

The figure shows R^2 statistics, implied by the VAR estimates, depending on the investment horizon. The k-year R^2 statistics obtained from (6) are rescaled such that the one-year R^2 statistics are equal to the actual R^2 statistics reported in Tables 3 and 4. RE: Real estate. a is the smoothing parameter.