International Real Estate Security Diversification: Empirical Evidence using Mean-Variance Spanning Tests

Simon Stevenson
University College Dublin

Centre for Real Estate Research, Department of Banking & Finance, Graduate School of Business, University College Dublin, Carysfort Avenue, Blackrock, County Dublin, Republic of Ireland, Tel: +353-1-716-8848, Fax: + 353-1-283-5482, E-Mail: simon.stevenson@ucd.ie

Paper presented at the Pacific-Rim Real Estate Society Annual Conference, Brisbane, Australia, January 19-22, 2003

Abstract

This study re-examines the diversification opportunities that may arise from the extension of a REIT portfolio into international markets. The results show that while diversification opportunities are apparently available to US investors, the improvement in performance that results from the extension of a REIT portfolio into international markets is generally not statistically significant. Both mean-variance spanning and cointegration tests broadly show diversification benefits. However, despite large estimated allocations in non-US markets the improvement in performance does not appear to strongly encourage the extension of REIT portfolios internationally.

International Real Estate Security Diversification: Empirical Evidence using Mean-Variance Spanning Tests

1. Introduction

A number of papers in recent years have examined the potential diversification opportunities that may arise from extending a domestic real estate security portfolio into international markets. The perceived benefits of international diversification have been well documented in the financial economics literature over the last thirty years. In addition, the empirical evidence in the real estate literature has been largely supportive of the benefits. Eichholtz (1996a) demonstrates that international investment in real estate securities provides more diversification benefits than the corresponding benefits from common stocks. Liu & Mei (1998) also find evidence of diversification benefits from extending a real estate security portfolio into international markets. In addition to a mean-variance portfolio approach the paper also utilises a multi-factor latent variable model. The paper's primary focus is concerned with whether real estate securities add additional diversification benefits to an investor who already holds common equity in that market. Liu & Mei find that the predictable component of both real estate securities and common stocks in a particular market tends to be small and move in line with each other, implying that the two sectors tend to be integrated in each market. The authors find that in most cases, and even where an investor already holds common equity in a particular market, the inclusion of real estate securities provides additional diversification benefits. These findings are also true irrespective of the assumptions made with regard to currency exposure and the hedging policy adopted.

Eichholtz et al. (1998) examine whether continental wide factors play a role in real estate security returns. The authors find that in both North America and Europe there is significant evidence of a continental effect, implying that investors in these markets would be required to extend their portfolio into other continents in order to obtain satisfactory levels of diversification gains. In contrast, investors in the Asia-Pacific region can find diversification benefits within their own region due to the absence of a significant continental affect. Further papers to have examined aspects of this issue include Eichholtz (1996b) and Gordon & Canter (1999) who examine the relative stability of the covariances between international real estate security markets and the stability of the correlation coefficients between real estate securities and common equities respectively. Stevenson (2001, 2002) examines a number of issues in relation to out-of-sample performance of international real estate portfolios. Both papers find some evidence of performance reversals in the international portfolios; however, neither paper explicitly examines

the diversification benefits available from extending a portfolio from a specific country into international markets.

This paper re-examines the perceived benefits from extending a real estate security portfolio into international. While previous studies have clearly illustrated that diversification benefits do accrue from extending a domestic real estate security portfolio into foreign markets, few studies have extended this analysis in order to see if the improvement in performance is statistically significant. Stevenson (2000) uses the Gibbons et al. (1989) test to assess the improvement in performance from extending domestic portfolios into international markets. The reported results differ across markets and according to the assumptions made with regard to constraints and foreign exchange exposure. However, in none of the scenarios does a US domiciled investor achieve significant gains from extending a REIT portfolio into international markets. The current paper re-examines the issue from the perspective of a US domiciled investor. Using a period extending from 1980-2002 a number of alternative tests are used. The primary empirical analysis is based on a mean-variance spanning approach as proposed and empirically tested in papers such as Huberman & Kandel (1987), Hansen & Jagannathan (1991) and Bekeart & Urias (1996). In addition, the markets are examined for evidence of cointegration and the Gibbons et al (1989) test is also examined in order to compare the results with those obtained by Stevenson (2000) paper. The remainder of the paper is laid out as follows. The second section details the data used in this study, while section 3 presents the empirical results. The final section provides concluding comments.

2. Data Requirements

The data used in this study consists of monthly real estate security data, on a total return basis, over the period 1980-2002. The US market is proxied by the NAREIT indices. The tests use both the overall NAREIT index and the sub-sectors for the equity, mortgage and hybrid sectors. The overall index is used as a proxy for a diversified REIT portfolio, while an optimal portfolio is also estimated from the three sub-sectors. The foreign markets comprise of 11 international markets, namely: Australia, Belgium, Canada, France, Hong Kong, Italy, Japan, the Netherlands, Norway, Singapore and the UK. All of these markets are proxied by the appropriate Datastream real estate index. The issue of foreign exchange exposure is handled in two ways. The markets are analysed using both local returns and with returns converted at the appropriate spot rate into US Dollars. The first alternative therefore implicitly assumes that the manager has perfect hedging ability and has no currency exposure. The second approach assumes that the manager does not hedge any of

the exposure and is fully exposed to both price movements in the foreign market and the foreign exchange rate.

3. Empirical Findings

Three primary empirical tests are analysed in this paper. Initially we examine mean-variance spanning, while the second test examines cointegration between REITs and international markets. The final test is the *F*-test for portfolio performance improvement proposed by Gibbons et al. (1989) and used in Stevenson (2000).

The principles of mean-variance spanning were developed by Huberman & Kandel (1987) who show that the inclusion of additional assets into a portfolio of base or benchmark assets only shifts the efficient frontier to the left if the new assets are not mean-variance spanned by the original asset set. Alternative mean-variance spanning tests have been proposed in studies such as Huberman & Kandel (1987), Hansen & Jagannathan (1991), Snow (1991), DeSantis (1995) and Bekeart & Urias (1996). The use of the test to examine the benefits of international diversification has been examined in a number of papers including DeSantis (1995) and Bekeart & Urias (1996). Both of these studies examine the benefits of extending an international portfolio into emerging markets, finding that significant gains are obtained from such an extension of the universe of assets.

The version examined in this paper is similar to that empirically tested by Errunza et al. (1999), and is itself based on the Huberman & Kandel (1987) test. Errunza et al. (1999) examined whether international diversification gains can be obtained without the need to trade in overseas markets. The paper constructs portfolios based on assets traded in the US markets, with the aim that the portfolios mimic international markets. Bekeart & Urias (1996) show that the power of mean-variance spanning tests are sensitive to the number of benchmark assets selected. For the purposes of these tests the three NAREIT sector indices are used as the benchmark assets. The test can represented as follows:

$$R_{i,t} = \alpha_i + \beta_1 R_{e,t} + \beta_1 R_{m,t} + \beta_1 R_{h,t} + \varepsilon_{i,t} \quad (3)$$

Where $R_{i,t}$ is the return on the *i*th foreign market, $R_{e,t}$ is the return on the NAREIT Equity index, $R_{m,t}$ is the return on the NAREIT Mortgage index and $R_{h,t}$ is the return on the NAREIT Hybrid index. The foreign market is spanned by the benchmark assets only if the intercept is zero and the sum of the beta coefficients equals unity. This is tested using an OLS estimation of the model[1].

Table 1 reports the *F*-statistics for the mean-variance spanning tests for the 11 different markets and under the two alternative foreign exchange scenarios. The results are interesting in a number of respects. The results reveal in that spanning is rejected in the majority of cases, indicating significant diversification opportunities available to a US based investor. The results also differ from previous empirical evidence on mean-variance spanning in the broader finance literature. When local returns are used spanning is rejected for each country with the exception of Hong Kong and Singapore. When all of the returns are converted into dollars the impact of the foreign exchange rate and the corresponding exposure again plays a role in reducing the diversification benefits available. In addition to Hong Kong and Singapore, spanning can't be rejected for Canada, while the *F*-statistics for a number of other countries also falls, although they remain significant at conventional levels.

While previous studies of mean-variance spanning in the broader finance literature have tended to find substantial evidence of spanning being rejected for emerging markets (e.g. DeSantis, 1994 and Bekeart & Urias, 1996), the majority of studies have not found such evidence with regard to developed capital markets. For example, DeSantis (1994) finds no evidence of spanning being rejected, and therefore diversification benefits, for the developed markets he examines. The primary exception to this is Errunza et al. (1999) who do reject spanning in a number of cases. However, as previously mentioned the focus of that paper differed slightly in that the paper used base assets whose purpose was to mimic international markets. These findings would appear to indicate that real estate securities provide enhanced diversification benefits over common equity, which supports the previous findings reported in papers such as Eichholtz (1996a)

The second test utilised in this paper examines whether US and foreign markets are cointegrated. The rationale behind testing for evidence of cointegration is based on the premise that if two markets are cointegrated then they share common long-term trend components and thus would provide less diversification opportunities than two markets who are deemed to be segmented. In

terms of previous real estate studies to have used cointegration in this context, Wilson & Okunev (1996) find no evidence of cointegrating relationships between the direct and indirect property markets in Australia, UK and US. Garvey et al. (2001) examine the Australian, Hong Kong, Japanese and Singaporean real estate security markets. Both the Engle-Granger and Johansen approaches are used, with no evidence of cointegration found between any of the pairings using the Johansen. For the Engle-Granger limited evidence is found between Hong Kong and Japan and between Australia and Singapore. However, this evidence is not consistent across different sample periods.

This paper uses the Johansen (1988) procedure, which provides estimates of all of the cointegrating vectors. Under the null hypothesis of no cointegration the Johansen method is based on the maximum likelihood estimation of an error correction representation. Throughout the presented analysis a lag length of 4 is assumed. Table 2 presents the trace statistics that tests the null hypothesis of no cointegrating vectors. It can be seen that in the majority of cases no evidence of cointegration is found, findings that are generally consistent across the different REIT sectors. The main exceptions are the Australian and British markets. For the Australian market significant trace statistics are reported in each case with the exception of the Hybrid REIT index when returns are converted at the Australian $- US$ spot exchange rate. Evidence of cointegration is also found with regard to British property companies, and in particular in relation to Equity REITs. Significant trace statistics are also observed in some instances with regard to Belgium, France, Hong Kong and Norway. These findings would indicate that while US investors would appear to gain little from diversifying into some markets, in the majority of cases with no evidence of cointegration reported, diversification opportunities do occur. It is also noticeable that the number of significant statistics is reduced when currency movements are taken into account. In this scenario the foreign market returns are converted directly at the appropriate spot foreign exchange rate against the dollar and thus are as much affected by currency movements as by movements in their domestic markets. This would indicate that diversification opportunities are greater in instances when fund managers do not hedge any of their currency exposure, with the foreign exchange movements actually adding to the benefits obtained. The cointegration results, together with the mean-variance spanning tests, do broadly indicate that international diversification opportunities are available for US REIT managers

The final test for diversification benefits is the Gibbons, Ross & Shanken (1989) *F*-test for performance improvement. This test was used in Stevenson (2000) and in more general studies of

international investment such as Glen & Jorion (1993). The test is based on a comparison of the Sharpe ratios of a base portfolio, in this case comprising solely of REITs, and an extended portfolio with the inclusion of international real estate securities. The test allows an analysis of whether the improvement in performance obtained from extending the universe of assets is statistically significant. This test therefore extends the analysis from merely examining whether diversification opportunities may occur to an analysis of the actual benefits from diversifying. The optimal portfolios are based on the tangency portfolio, which maximises the Sharpe ratio. We use two alternative base portfolios. The first is the overall NAREIT Index, which is assumed to proxy a well-diversified REIT portfolio. The second base portfolio is the optimal tangency REIT portfolio based on the three REIT sub-sector indices representing equity, mortgage and hybrid REITs. The internationally extended portfolio is also estimated in two slightly different ways. The first directly estimates the tangency portfolios using all 11 foreign markets together with either of the REIT portfolios. This is a simultaneous estimation of the international portfolio. The second approach is a sequential approach and implicitly assumes that fund managers separate their domestic and international asset allocation decisions. The optimal international portfolio is initially estimated without the domestic REITs. The overall portfolio is then estimated using this portfolio and the already estimated REIT portfolio. This approach is adopted due to the fact that fund managers commonly adopt such a sequential approach and separate within and between asset class decisions[2].

Table 3 reports the composition of the estimated optimal portfolios under the alternative scenarios. The reported allocations reveal a number of interesting issues. Firstly, there is a noticeable difference in the unconstrained allocations between the two alternative currency scenarios. The adopted of an unhedged strategy results in a substantial decrease in the allocation given to international markets. This is of interest given the fact that the cointegration results indicated that the currency movements often lead to a reduction in the evidence of cointegration. What would appear to be the reason behind this apparent inconsistency is that while currency movements do lead to less integrated behaviour of real estate security returns, the addition of the currency movements into the analysis also leads to an increase in the volatility of these markets and thus in a portfolio setting leads to a reduction in their attractiveness. The use of alternative scenarios with regard to the optimisation procedure does not lead to substantial differences in the allocations estimated. The unconstrained scenarios show that optimally REIT managers should allocate substantial amounts in international markets. These findings confirm the mean-variance

spanning and cointegration results, and the findings of previous studies such as Eichholtz (1996a) and Liu & Mei (1998).

The *F*-statistic proposed by Gibbons et al. (1989) can be displayed as follows:

$$F = \frac{\frac{(T - N_2)}{N}\left(\hat{\theta}_2^2 - \hat{\theta}_1^2\right)}{(1 + \hat{\theta}_1^2)} \tag{2}$$

Where $\hat{\theta}_1$ is the initial maximum Sharpe ratio, $\hat{\theta}_2$ is the maximum Sharpe ratio from the expanded data set, *T* is the number of observations, N_1 is the number of core assets, N_2 is the number of total assets and *N* can be defined as $N_2 - N_1$. The statistic has a *F*-distribution with $(T - N_2, N)$ degrees of freedom. As an assumption of no short selling is made throughout the portfolio tests the *F* distribution is unknown and needs to be approximated using simulations. We adopt the approach utilised in Glen & Jorion (1993) and Stevenson (2000). As stated previously the aim of this test is to explicitly examine whether the inclusion of additional assets not only provides diversification benefits but whether the inclusion of those assets results in a significant improvement in portfolio performance.

Table 4 reports the *F*-statistics for the US against each of the 11 international markets and under the various different scenarios. The results broadly support the findings of Stevenson (2000), with little evidence of the performance of the portfolios being significantly improved through the extension of the universe of assets to include non-US markets. Out of the 24 scenarios, only two significant *F*-statistics are reported, these being with regard to the unconstrained simultaneous approach when local returns are used. The use of local returns implicitly assumes that the fund has perfect hedging ability with regard to their currency exposure. It is clear from the results that if an unhedged strategy is pursued the diversification benefits reduce dramatically with no significant findings reported. In no cases where the sequential approach is used are significant statistics reported and neither are any found when the international allocation is constrained to more realistic levels. Fund managers would not conceivably allocate such high allocations to international markets as found in the unconstrained simultaneous case. When the foreign allocations are constrained to either maximum weights of 40% or 20% the diversification gains, as measured by the improvement in performance, is not statistically significant.

Concluding Comments

The results reported in this study confirm previous findings on the issue of the relative attractiveness of international real estate securities and the potential diversification opportunities that can arise for a US do0miciled investor. However, the results also confirm that despite the apparent diversification benefits, the improvement in portfolio performance that results from including international securities into a REIT portfolio are for the most part not statistically significant at conventional levels.

References:

Bekeart, G. & Urias, M.S. (1996). Diversification, Integration and Emerging Market Closed End Funds, *Journal of Finance*, **51**, 835-869.

Eichholtz, P.M.A. (1996a). Does International Diversification Work Better for Real Estate than For Stocks and Bonds ?, *Financial Analysts Journal*, **January-February,** 56-62.

Eichholtz, P.M.A. (1996b). The Stability of the Covariance's of International Property Share Returns, *Journal of Real Estate Research*, **11**, 149-158.

Eichholtz, P.M.A., Huisman, R., Koedijk, K. & Schuin, L. (1998). Continental Factors in International Real Estate Returns, *Real Estate Economics*, **26**, 493-510.

Engle, R.F. & Granger, C.W.J. (1987). Cointegration and an Error Correction: Representation, Estimation and Testing, *Econometrica*, **55**, 251-276.

Errunza, V., Hogan, K. & Hung, M.W. (1999). Can the Gains from International Diversification be Achieved without Trading Abroad ?, *Journal of Finance*, **54**, 2075-2108.

Ferson, W.E. (1994). Theory and Empirical Testing of Asset Pricing Models, in Jarrow, R.A., Ziemba, W.T. & Maksimovic, V. *The Finance Handbook*, North Holland: Amsterdam.

Ferson, W.E. & Foerster, S. (1994). Finite Sample Properties of the Generalised Method of Moments in Tests of Conditional Asset Pricing Models, *Journal of Financial Economics*, **36**, 29-55.

Ferson, W.E., Foerster, S. & Keim, D.B. (1993). General Tests of Latent Variables and Mean-Variance Spanning, *Journal of Finance*, **48**, 131-156.

Garvey, R., Santry, G. & Stevenson, S. (2001). The Linkages Between Real Estate Securities in Asia & the Pacific-Rim, *Pacific-Rim Property Research Journal*, **7**, 240-257.

Gibbons, M., Ross, S. & Shanken, J. (1989). A Test of the Efficiency of a Given Portfolio, *Econometrica*, **57**, 1121-1152.

Glen, J. & Jorion, P. (1993). Currency Hedging for International Portfolios, *Journal of Finance*, **48**, 1865-1886.

Gordon, J.N. & Canter, T.A. (1999). International Real Estate Securities: A Test of Capital Markets Integration, *Journal of Real Estate Portfolio Management*, **5**, 161-170.

Hall, S.G. (1991). The Effect of Varying Length VAR Models on the Maximum Likelihood Estimators of Cointegrating Vectors, *Scottish Journal of Political Economy*, **38**, 317-323.

Hansen, L.P. & Jagannathan, R. (1991). Implications of Security Market Data for Models of Dynamic Economics, *Journal of Political Economy*, **99**, 225-262.

Huberman, G. & Kandel, S.A. (1987). Mean-Variance Spanning, *Journal of Finance*, **42**, 873-888.

Johansen, S. (1988). Statistical Analysis of Cointegration Vectors, *Journal of Economic Dynamics & Control*, **12**, 231-254.

Kalberg, J.G., Liu, C.H. & Grieg, D.W. (1996) The Role of Real Estate in the Portfolio Allocation Process", *Real Estate Economics*, **24**, 359-377.

Kandel, S. & Stamburg, R. (1989). A Mean-Variance Framework for Tests of Asset Pricing Models, *Review of Financial Studies*, **2**, 125-156.

Lee, S.L. (1998). *The Case for Property in the Long-Run: A Cointegration Test*, Department of Land Management, working paper 06/98.

Li, Y. & Wang, K. (1995). The Predictability of REIT Returns and Market Segmentation, *Journal of Real Estate Research*, **10**, 471-482.

Ling, D. & Naranjo, A. (1999). The Integration of Commercial Real Estate Markets and Stock Markets, *Real Estate Economics*, **27**, 483-515.

Liu, C.H., Hartzell, D.J., Greig, W. & Grissom, T. (1990). The Integration of the Real Estate Market and the Stock Market: Some Preliminary Evidence, *Journal of Real Estate Finance & Economics*, **3**, 261-282.

Liu, C.H. & Mei, J.P. (1998). The Predictability of International Real Estate Markets: Exchange Rate Risks and Diversification Consequences, *Real Estate Economics*, **26**, 3-39.

MacKinlay, C. & Richardson, M. (1991). Using Generalized Method of Moments to Test Mean-Variance Efficiency, *Journal of Finance*, **46**, 511-527.

Snow, K. (1991). Diagnosing Asset Pricing Models using the Distribution of Asset Returns, *Journal of Finance*, **46**, 955-983.

Stevenson, S. (2000). International Real Estate Diversification: Empirical Tests using Hedged Indices, *Journal of Real Estate Research*, **19**, 105-132.

Stevenson, S. (2001). Bayes-Stein Estimators & International Real Estate Asset Allocation, *Journal of Real Estate Research*, **21**, 89-103.

Stevenson, S. (2002). Momentum Effects & Mean Reversion in Real Estate Securities, *Journal of Real Estate Research*, **23**, 47-64.

Wilson, P. & Okunev, J. (1996). Evidence of Segmentation in Domestic and International Property Markets, *Journal of Property Finance*, **7**, 78-97.

Worzala, E. & Bajtelsmit, V.L. (1997). Real Estate Asset Allocation and the Decision Making Framework used by Pension Fund Managers, *Journal of Real Estate Portfolio Management*, **3**, 47-56.

Tables

Table 1: Mean-Variance Spanning Results

	Local Returns	Dollar Returns
Australia	4.0600**	2.8977*
Belgium	20.3606***	18.7443***
Canada	2.8990*	1.0663
France	65.0160***	1.8231*
Hong Kong	0.9153	0.2002
Italy	5.0117***	7.0916***
Japan	6.9358***	8.2226***
Netherlands	83.5675***	55.9948***
Norway	8.9824***	8.7952***
Singapore	0.6038	0.5259
UK	4.4191**	5.4752***

Notes: Table 1 presents the *F*-statistics for the mean-variance spanning tests. The test can represented as: $R_{i,t} = \alpha_i + \beta_1 R_{e,t} + \beta_1 R_{m,t} + \beta_1 R_{h,t} + \varepsilon_{i,t}$ Where $R_{i,t}$ is the return on the *i*th foreign market, $R_{e,t}$ is the return on the NAREIT Equity index, $R_{m,t}$ is the return on the NAREIT Mortgage index and $R_{h,t}$ is the return on the NAREIT Hybrid index. The foreign market is spanned by the benchmark assets if the intercept is zero and the sum of the beta coefficients equals unity. * indicates significance at a 90% level, ** at a 95% level and *** at a 99% level.

Table 2: Johansen Cointegration Results, Local Returns

	REITs	Equity REITs	Mortgage REITs	Hybrid REITs
Panel A: Local Returns				
Australia	21.174***	22.144***	13.334*	14.486**
Belgium	13.715*	13.029*	13.983*	12.948*
Canada	4.928	4.634	7.230	5.380
France	13.087*	13.443*	6.292	7.210
Hong Kong	12.534*	13.387*	11.192	8.643
Italy	7.264	8.104	5.789	6.949
Japan	7.046	7.928	6.511	4.845
Netherlands	7.585	6.866	6.666	6.878
Norway	12.537*	11.628	12.485*	12.113*
Singapore	6.069	6.531	8.202	7.056
UK	16.208**	21.159***	7.128	4.786
Panel B: Spot Returns				
Australia	12.651*	13.887*	12.440*	9.471
Belgium	6.481	6.140	13.657*	8.074
Canada	6.828	7.018	8.944	5.288
France	7.055	7.039	10.097	6.336
Hong Kong	9.569	10.308	11.336	7.722
Italy	5.343	5.849	7.287	5.600
Japan	6.020	6.934	5.787	4.325
Netherlands	5.574	5.796	8.247	4.953
Norway	9.885	9.421	14.815**	11.561
Singapore	5.914	6.048	8.867	8.489
UK	11.216	12.297*	12.794*	7.184

Notes: Table 2 reports the trace statistics from the cointegration tests under the null hypothesis that there are no cointegrating vectors. * indicates significance at a 10% level, ** at a 95% level and *** at a 99% level.

Table 3: Estimated Portfolio Allocations

	Local Returns		Dollar Returns	
	REITs	**International**	**REITs**	**International**
Panel A: Simultaneous Optimisation				
Overall NAREIT Index	27.01%	72.99%	63.66%	36.34%
Optimal REIT Portfolio	31.29%	68.71%	65.92%	34.08%
Overall NAREIT Index, 40% maximum international allocation	60.00%	40.00%	63.66%	36.34%
Optimal REIT Portfolio, 40% maximum international allocation	60.00%	40.00%	65.92%	34.08%
Overall NAREIT Index, 20% maximum international allocation	80.00%	20.00%	80.00%	20.00%
Optimal REIT Portfolio, 20% maximum international allocation	80.00%	20.00%	80.00%	20.00%
Panel B: Sequential Optimisation				
Overall NAREIT Index	25.17%	74.83%	62.89%	37.11%
Optimal REIT Portfolio	29.66%	70.34%	66.32%	33.68%
Overall NAREIT Index, 40% maximum international allocation	60.00%	40.00%	62.89%	37.11%
Optimal REIT Portfolio, 40% maximum international allocation	60.00%	40.00%	66.32%	33.68%
Overall NAREIT Index, 20% maximum international allocation	80.00%	20.00%	80.00%	20.00%
Optimal REIT Portfolio, 20% maximum international allocation	80.00%	20.00%	80.00%	20.00%

Notes: Table 3 reports the allocation in both REITs and in international real estate security markets under the alternative scenarios regarding constraints, currency exposure and simultaneous and sequential optimisation.

Table 4: Gibbons et al. F-Test

	Local Returns	Dollar Returns
Panel A: Simultaneous Optimisation		
Overall NAREIT Index	2.3457*	0.6443
Optimal REIT Portfolio	2.5302*	0.7164
Overall NAREIT Index, 40% maximum international allocation	2.1303	0.6443
Optimal REIT Portfolio, 40% maximum international allocation	2.1334	0.7164
Overall NAREIT Index, 20% maximum international allocation	1.2846	0.6932
Optimal REIT Portfolio, 20% maximum international allocation	1.3068	0.6910
Panel B: Sequential Optimisation		
Overall NAREIT Index	2.0390	0.4270
Optimal REIT Portfolio	1.8956	0.3919
Overall NAREIT Index, 40% maximum international allocation	1.3203	0.4270
Optimal REIT Portfolio, 40% maximum international allocation	1.3223	0.3919
Overall NAREIT Index, 20% maximum international allocation	0.6201	0.3158
Optimal REIT Portfolio, 20% maximum international allocation	0.6363	0.3127

Notes: Table 4 reports the *F*-statistics for the Gibbons et al. (1989) test for performance improvement. The test compares the Sharpe ratios of the base domestic portfolio and the portfolio after the inclusion of international markets. * indicates significance at a 90% level, ** at a 95% level and *** at a 99% level.

Endnotes:

[1] A number of alternative specifications are also available. Ferson (1994) and Bekeart & Urias (1996) both show that the Hansen & Jagannathan (1991) restrictions are equivalent to those proposed by Huberman & Kandel (1987). Bekeart & Urias (1996) propose an alternative form of test, which rather than use an OLS framework uses a General Method of Moments (GMM) approach to estimate a likelihood ratio form of test. This test also corrects for serial correlation.

[2] Worzala & Bajtelsmit (1997) provide survey evidence that the majority of funds separate the within and between asset class allocation decisions, while Kalberg et al. (1996) illustrate the issue of simultaneous and sequential optimization in the context of real estate.