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Spanning Tests on Asian Real Estate Securities

Ming-Long Lee　Department of Finance, National Yunlin University of Science and Technology
Ming-Te Lee　Department of Finance, Yuan Ze University
Kevin C.H. Chiang　College of Business Administration, Northern Arizona University

Abstract

This study uses mean-variance spanning tests to examine the role of Asian real estate securities in real-estate-only portfolios from a U.S. investor's perspective. The results suggest that the usefulness of including Asian real estate securities in improving investment opportunity sets is sensitive to the specification of benchmark assets. The results show that including Asian real estate securities helps enhance the mean-variance efficient frontier when the benchmark assets include only U.S. real estate investment trusts. In addition, this diversification benefit appears only in the vintage REIT era; it disappears after the Asian financial crisis. Furthermore, Asian real estate securities do not provide significant diversification benefit to investors who already hold U.S. private real estate, European real estate securities, or Australian real estate securities.

Key words: Asian; spanning test; real estate; property; portfolio

1. Introduction

Institutional investors have increasingly accepted real estate as a distinct asset class that deserves a permanent strategic allocation in a multi-asset class portfolio. Nevertheless, only a small subset of U.S. investors has international real estate exposure within their overall allocation (Bigman and Chiu, 2005). In light of the rapid evolution of global real estate market and the ever-increasing globalization of financial markets, Bigman and Chiu (2005) argue that investors should implement a strategic allocation to global real estate to achieve higher risk-adjusted returns. Furthermore, the authors believe that this strategic allocation can be implemented through real estate securities. This belief is shared by many other researchers who favor using international real estate securities to overcome the difficulties of buying direct real estate offshore (Worzala and Sirmans, 2003; Wilson and Zurbruegg, 2003). The results in Gilberto (1990), Asabere, Kleiman, and McGowan (1991), Addae-Dappah and Kion (1996), Eichholtz (1997), Pierzak (2001) and Bigman (2002) supports the notion that holding international real estate securities is a beneficial strategy to achieve risk reduction under the mean-variance framework.

In another strand of the international real estate literature, Eichholtz (1996) Liu and Mei (1996), and Wilson and Okunev (1996) show that international real estate markets are not integrated. Their co-integration test results imply risk-reduction benefits through international diversification. However, these results are not without challenges. The reason for this is that co-integration test results can be sensitive to the existence of structural breaks. Wilson and Zurbruegg's (2002) co-integration analysis shows that once possible structural breaks are taken into account, international real estate markets are interrelated since the early 1990s, particularly with the inclusion of the U.S. market.

The purpose of this study is to seek further evidence regarding whether international real estate diversification improves investment opportunity sets under the mean-variance framework. To do so, we make some improvements on research design. First, the previous studies of this kind stop short of presenting a formal statistical test on whether the inclusion of international real estate securities enhances the efficient frontier of a real estate portfolio. We carry the literature a step further by implementing spanning tests of Huberman and Kandel (1987) and Kan and Zhou (2001). Specifically, we formally test the potential benefits of holding international real estate securities from a U.S. investor's perspective.

Second, this study considers a broader set of domestic benchmark assets, including public and/or private real estate. The correlation analyses in Pierzak (2001) and Bigman (2002) do not include private real estate. We believe that the inclusion of domestic private real estate investments is important because many leading fund sponsors, including California Public Employees' Retirement System and Alaska Permanent Fund, have private real estate in their portfolios. Because the results in Pierzak (2001) and Bigman (2002) indicate that Asian real estate securities appear to provide largest potential diversification benefits to U.S. investors. Therefore, this study focuses on the potential diversification benefits of holding Asian real estate securities.

Third, this study accounts for the potential impacts of financial events on test results. Mei (1999) points out that the 1997-1998 financial crisis in Asia leads U.S. investors to question the wisdom of investing in Asian real estate investments. In addition, U.S. real estate investment trust (REIT) market may experience a structure break during early 1990 because of the Revenue Reconciliation Act of 1993 and the 1993-1994 IPO wave (Glascock, Lu, and So 2000; Lee and Lee, 2003). To account

for the potential impact of these events, our tests are implemented for the whole sample period as well as for various sub-periods.

Our spanning test results show that including Asian real estate securities helps enhance the mean-variance efficient frontier in the vintage REIT era when the benchmark assets include only U.S. REITs. This diversification benefit disappears after the Asian financial crisis. The results are consistent with Wilson and Zurbruegg's (2002) co-integration analysis and support investors' skepticism about the benefit of investing in Asian real estate investment (Mei, 1999). In addition, our results indicate that Asian real estate securities do not provide significant diversification benefit to U.S. real estate investors who already hold private real estate or invest in European or Australian real estate securities.

2. Mean-variance spanning tests

Academicians and practitioners are often interested in finding out whether the addition of new asset classes (test assets) can improve the efficient frontier of the existing set of asset classes (benchmark assets). This question was first formally addressed by Huberman and Kandel (1987). Their null hypothesis is that the efficient frontier of a set of K benchmark assets is the same as the efficient frontier of the K benchmark assets plus a set of N additional test assets, where N has the value of one or more. If the null hypothesis is rejected, the evidence supports the notion that the test assets expand the mean-variance efficient frontier and provide diversification benefits.

A complete survey of mean-variance spanning tests can be found in Kan and Zhou (2001). This section briefly describes these statistical tests. The K-vector returns on the K benchmark assets are denoted as R_{1t}. R_{2t} is an N-vector of the returns on the

N test assets. $R_t \equiv [R'_{1t} \quad R'_{2t}]'$. $E[R_t] \equiv \mu$. $\text{Var}[R_t] \equiv V$. Ordinary least squares are used to estimate the following specification:

$R_{2t} = \alpha + \beta R_{1t} + \varepsilon_t$, $t = 1, 2, \ldots, T$ ($R = XB + E$ in matrix form),

where ε_t is independently and identically distributed as a multivariate normal with mean zero and variance Σ. Define $\delta \equiv 1_N - \beta 1_K$, where 1_N is an N-vector of ones. The null hypothesis is that:

$H_0 : \alpha = 0_N$, $\delta = 0_N$.

The logic of the test is that, if the tangency portfolio and the global minimum-variance portfolio have zero weights in the test assets, the two-fund separation theorem guarantees that every portfolio on the efficient frontier of the $N + K$ assets will have zero weights in the test assets.

Define $\Theta = [\alpha \quad \delta]'$. Denote λ_1 and λ_2 as the two eigenvalues of $\hat{H}\hat{G}^{-1}$:

$$\hat{H} = \hat{\Theta}\hat{\Sigma}^{-1}\hat{\Theta}'$$

$$\hat{G} = T A (X'X)^{-1} A'$$

$$A = \begin{bmatrix} 1 & 0'_K \\ 0 & -1'_K \end{bmatrix}$$

This leads to the first test, the likelihood ratio test:

$$LR = T \sum_{i=1}^{2} \ln(1 + \lambda_i)$$

The second test is a Wald test:

$$W = T (\lambda_1 + \lambda_2)$$

The third test is a Lagrange multiplier test:

$$LM = T \sum_{i=1}^{2} \frac{\lambda_i}{1 + \lambda_i}$$

LR, *W*, and *LM* all have an asymptotic x^2_{2N} distribution. The fourth test is an *F* test:

$$\left(\frac{1}{U} - 1\right)\left(\frac{T-K-1}{2}\right) \sim F_{2,(T-K-1)} \text{ for } N = 1,$$

where $U = |\hat{G}| / |\hat{H} + \hat{G}|$.

When ε_t exhibits conditional heteroskedasticity, the GMM method can be used to account for non-normality (Hansen 1982; Ferson, Foerster, and Keim 1993). The moment condition is:

$$E[g_t] = E[x_t \otimes \varepsilon_t] = 0_{(K+1)N}$$

where $x_t = [1 \quad R_{1t}']'$. The GMM Wald test is:

$$W_a = T\,\text{vec}(\hat{\Theta}')' \left[(A_T \otimes I_N)\, S_T\, (A_T' \otimes I_N)\right]^{-1} \text{vec}(\hat{\Theta}')$$

where S_T is a consistent estimate of $E[g_t\, g_t']$, and

$$A = \begin{bmatrix} 1+\hat{a}_1 & -\hat{\mu}_1 \hat{V}_{11}^{-1} \\ \hat{b}_1 & -1_K' \hat{V}_{11}^{-1} \end{bmatrix}.$$

W_a has an asymptotic x^2_{2N} distribution.

3. Data

This study retrieves the returns on Asian, European, and Australian estate investments from Datastream real estate securities return indices. This study uses the monthly returns of all REITs from the National Association of Real Estate Investment Trusts to gauge the returns on U.S. public real estate. The quarterly Russell-NCREIF property returns are used to measure the returns on U.S. private real estate.[1] Because the returns on private real estate are available only in quarterly frequency, this study compounds all monthly return series into quarterly return series.

[1] Following He (2002) and Tuluca, Myer, and Webb (2000), this study does not unsmooth the Russell-NCREIF returns. Tuluca, Myer, and Webb (2000) give two reasons not to unsmooth the series: (1) investors have access to returns of commingled real estate funds that comprise NCREIF; and (2) the ways to correct the problems inherent in the appraisal-based series are still under refinement.

To test for return uniqueness in Asian real estate returns, this study selects the following set of benchmark assets: (1) U.S. public real estate, (2) U.S. private real estate, (3) European real estate, and (4) Australian real estate. All these return series are measured in US dollars. The test period is from 1978 to 2005 because the Russell-NCREIF property returns starts in 1978.

4. Empirical results

4.1. *Description of variables*

Table 1 reports summary statistics. During the sample period, 1978-2005, Asian real estate securities yield the highest quarterly mean return, 4.15%, and the highest standard deviation, 15.97%. The quarterly mean return and standard deviation of U.S. REITs are 3.25% and 7.41%. The NCREIF Index has lower quarterly mean return and standard deviation: 2.40% and 1.70%, respectively. The quarterly mean returns for European and Australian real estate securities are 3.52% and 4.12%, respectively. The associated standard deviations are 9.03% and 10.58%.

The correlation structures reported in Panel B of Table 1 reveal that U.S. REIT returns are loosely related to international real estate returns. The correlation coefficient between REITs and Asian real estate securities has the lowest value, 20.49%. The correlation coefficients with European and Australian real estate securities are 22.65% and 22.89%, respectively.

Panel C of Table 1 shows that U.S. private real estate returns even less co-move with international real estate securities than does U.S. public real estate. Similar to the REIT results, the size of the correlation coefficient between the NCREIF Index and Asian real estate securities is the smallest of the three, -00.67%. European real estate securities have the largest correlation coefficient of 14.40% with the NCREIF Index. The correlation coefficient between the NAREIF Index and

Australian real estate securities is 10.05%.

On the surface, these correlations are low and the results are consistent with the results in Pierzak (2001) and Bigman (2002): (1) that diversification benefits may exist for investing in international real estate securities, and (2) that Asian real estate securities appear to have the largest capacity to provide potential diversification benefits to U.S. investors.

4.2. *Spanning test results*

Table 2 presents the spanning test results for Asian real estate securities during the 1978:1-2005:4 period. Panel A presents the results when the domestic real estate portfolio consists of only REITs. When the benchmark assets consists of only REITs, the *LR*, *W*, *LM*, *F*, and W_a test statistics have a value of 7.91, 8.20, 7.64, 4.03, and 7.71, respectively. These values are all statistically significant at the 5% level. The result is consistent with Gilberto (1990), Wilson and Okunev (1996), Pierzak (2001), and Bigman (2002) that international real estate securities provide diversification benefits from a U.S. investor's perspective. Nevertheless, when the benchmark assets are expanded by including European and/or Australian real estate securities, the addition of Asian real estate securities does not significantly enhance the efficient frontier. The remaining test statistics in Panel A are all statistically insignificant. The results suggest that diversifying into Asian real estate securities is desirable only for a pure U.S. REIT portfolio.

Panel B of Table 2 reports test results for Asian real estate securities during the 1978:1-2005:4 when the domestic real estate portfolio consists of only the NCREIF Index. In contrast to the REIT results in Panel A, this set of test results reveals no need to diversify into Asian real estate securities at all. All test statistics in Panel B are statistically significant. That is, the NCREIF Index leaves no room for Asian real

estate securities to improve the mean-variance frontier. This extends Chiang and Lee's (2006) result. The authors show that REITs lose their diversification effects when the NCREIF Index is already in mixed asset portfolios.

Panel C of Table 3 reports test results for a more complete set of domestic real estate portfolio that consists of both REITs and the NCREIF Index. The test results are similar to those in Panel B: all test statistics are statistically significant regardless of whether European or Australian real estate securities are included into benchmark assets. Overall, it is quite clear that the inclusion of the NCREIF Index leaves no room for Asian real estate securities to improve the mean-variance frontier.

It is widely known that the growth of REIT markets and increasing participation by institutional investors resulted in a structural change in the early 1990s (Glascock, Lu, and So 2000; Lee and Lee, 2003). Are our results driven by vintage data prior to the new REIT era? To check this, we repeat our analyses for the following two sub-periods: 1978:1-1993:4 and 1994:1-2005:4. The cutoff point of 1994 is chosen because the Revenue Reconciliation Act of 1993 was implemented that year. Table 3 presents the results for the period, 1978:1-1993:4. Similar to the full sample results, when the benchmark assets consists of only REITs, the *LR*, *W*, *LM*, *F*, and W_a test statistics have a value of 7.45, 7.90, 7.03, 3.83, and 7.96, respectively. These values are all statistically significant at the 5% level. Again, when the benchmark assets contain NCREIF, European securities, or Australian securities, spanning tests yield no statistical significance. These results suggest that in the vintage REIT era Asian real estate securities are able to enhance mean-variance efficient frontiers when a U.S. investor holds only REITs in his/her real estate portfolio.

Table 4 reports the test results for the new REIT era, 1994:1-2005:4. When the

benchmark assets consist of only REITs, the *LR*, *W*, *LM*, *F*, and W_a test statistics have a value of 1.73, 1.76, 1.70, 0.84, and 2.38, respectively. These values are not statistical significant at any conventional level. This suggests that REITs behave more like the NCREIF Index in terms of their roles in real-estate-only portfolios in the new REIT era. The result is consistent with Ziering, Winograd, and McIntosh (1997), Clayton and Mackinnon (2003) and Lee, Lee, and Chiang (2006). They claim or show that REITs behave more like unsecuritized real estates starting from early 1990s. In addition, Table 4 shows that when the benchmark assets contain NCREIF, European securities, or Australian securities, spanning tests yield no statistical significant results. Overall, in the new REIT era diversifying into Asian real estate securities does not seem to improve investment opportunity sets.

Before the 1997-1998 Asian financial crisis, Asian real estate securities has been favorites among institutional investors (Mei, 1999). However, the Asian crisis has led U.S. investors to question the usefulness of Asian real estate investment in risk reduction (Mei, 1999). To examine whether this event affects our baseline results, we split our samples into the following sub-periods: 1978:1-1998:1 and 1998:2-2005:4. The selection of this cutoff point follows Sing, Ho, and Mark (2002). Table 5 shows the results for the period before the Asian crisis. When the benchmark assets consist of only REITs, the *LR*, *W*, *LM*, *F*, and W_a test statistics have a value of 7.69, 8.06, 7.33, 3.93, and 8.06, respectively. These values are all statistically significant at the 5% level. The results are consistent with practitioners' perception, as observed by Mei (1999), that Asian real estate securities provide beneficial diversification opportunities. Nevertheless, similar to the results reported earlier, this diversification benefit diminishes when the NCREIF Index or other international real estate securities are included into in portfolios.

Table 6 presents test results for the period after the crisis. The results are similar to those reported in Table 4 for the new REIT era. When benchmark assets consist of only REITs, the *LR*, *W*, *LM*, *F*, and W_a test statistics have a lower value of 0.94, 0.96, 0.93, 0.45, and 1.02, respectively. All these values are not statistically significant at any conventional level. In addition, with other specifications of benchmark assets, spanning tests yield no evidence indicating that Asian real estate securities provide diversification benefits. Together, the results in Tables 5 and 6 seem to confirm U.S. investors' suspicion about the benefit of Asian real estate investment (Mei, 1999).

5. Conclusions

This study examines the role of Asian real estate securities in real-estate-only portfolios. We find that investment in Asian real estate securities does not always help enhance the mean-variance efficient frontier. The role of Asian real estate securities is sensitive to the specification of benchmark assets. Our test results show that including Asian real estate securities helps enhance the mean-variance efficient frontier of a real estate portfolio only when the portfolio consists of REITs. Furthermore this diversification benefit appears only in the vintage REIT era; it disappears in the new REIT era and after the Asian financial crisis.

These results are consistent with Wilson and Zurbruegg's (2002) co-integration analysis. The authors how that U.S. real estate securities become more interrelated with international real estate securities since early 1990s. Our findings also support investors' suspicion about the benefit of Asian real estate investment after the Asian crisis (Mei, 1999).

Our results suggest that Asian real estate securities do not appear to have particularly unique return characters. Diversification into Asian real estate securities does not provide significant benefits to U.S. real estate investors who already hold European or Australian securities. Complementing with Chiang and Lee's (2006) result, our results show that Asian real estate securities lose their diversification effects when private real estate is included into portfolio holdings.

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Table 1. Summary statistics.

Panel A. Means (Standard Deviations)				
Asia	NAREIT	NCREIF	Europe	Australia
0.0415	0.0325	0.0240	0.0352	0.0412
(0.1597)	(0.0741)	(0.0170)	(0.0903)	(0.1058)
Panel B. Correlation Coefficients with NAREIT				
NCREIF	Asia		Europe	Australia
-0.0350	0.2049		0.2265	0.2289
Panel C. Correlation Coefficients with the NCREIF Index				
NAREIT	Asia		Europe	Australia
-0.0350	-0.0067		0.1440	0.1005

Note: The sample period is from 1978 to 2005. The reported numbers are based on quarterly returns of Asian real estate securities (Asia), the NAREIT Index (NAREIT), the NCREIF Index (NCREIF), European real estate securities (Europe), and Australian real estate securities (Australia).

Table 2.
Mean-variance spanning tests of Asian real estate securities, 1978:1-2005:4.

LR	*W*	*LM*	*F*	*Wa*
Panel A. Domestic Real estate portfolio consists of NAREIT				
Benchmark Assets: NAREIT				
7.91	8.20	7.64	4.03	7.71
(0.02)**	(0.02)**	(0.02)**	(0.02)**	(0.02)**
Benchmark Assets: NAREIT + Europe				
0.29	0.29	0.29	0.14	0.29
(0.87)	(0.87)	(0.87)	(0.87)	(0.87)
Benchmark Assets: NAREIT + Australia				
1.04	1.05	1.04	0.51	1.19
(0.59)	(0.59)	(0.60)	(0.60)	(0.55)
Benchmark Assets: NAREIT + Europe + Australia				
0.43	0.43	0.43	0.21	0.44
(0.81)	(0.81)	(0.81)	(0.81)	(0.80)
Panel B. Domestic Real estate portfolio consists of NCREIF				
Benchmark Assets: NCREIF				
2.76	2.80	2.73	1.37	0.46
(0.25)	(0.25)	(0.26)	(0.26)	(0.11)
Benchmark Assets: NCREIF + Europe				
1.55	1.56	1.54	0.76	2.55
(0.46)	(0.46)	(0.46)	(0.47)	(0.28)
Benchmark Assets: NCREIF + Australia				
1.34	1.35	1.33	0.65	1.93
(0.51)	(0.51)	(0.51)	(0.52)	(0.38)
Benchmark Assets: NCREIF + Europe + Australia				
1.16	1.17	1.16	0.56	1.64
(0.56)	(0.56)	(0.56)	(0.57)	(0.44)
Panel C. Domestic Real estate portfolio consists of NAREIT and NCREIF				
Benchmark Assets: NAREIT + NCREIF				
1.20	1.20	1.19	0.59	1.60
(0.55)	(0.55)	(0.55)	(0.56)	(0.45)
Benchmark Assets: NAREIT + NCREIF + Europe				
0.83	0.84	0.83	0.40	1.43
(0.66)	(0.66)	(0.66)	(0.67)	(0.49)
Benchmark Assets: NAREIT + NCREIF + Australia				
0.61	0.61	0.61	0.30	0.84
(0.74)	(0.74)	(0.74)	(0.74)	(0.66)
Benchmark Assets: NAREIT + NCREIF+ Europe + Australia				
0.69	0.69	0.68	0.33	1.03
(0.71)	(0.71)	(0.71)	(0.72)	(0.60)

Note: The test period is from 1978 to 2005. The test assets are Asian real estate securities. The benchmark assets include the NAREIT Index (NAREIT), the NCREIF Index (NCREIF), Europe real estate securities (Europe), and Australia real estate securities (Australia). The *p*-values are in parentheses. ***Significant at the 1% level. **Significant at the 5% level. *Significant at the 10% level

Table 3.
Mean-variance spanning tests of Asian real estate securities, 1978:1-1993:4.

LR	*W*	*LM*	*F*	*Wa*
Panel A. Domestic Real estate portfolio consists of NAREIT				
Benchmark Assets: NAREIT				
7.45	7.90	7.03	3.83	7.96
(0.02)**	(0.02)**	(0.03)**	(0.03)**	(0.02)**
Benchmark Assets: NAREIT + Europe				
1.26	1.27	1.25	0.60	1.19
(0.53)	(0.53)	(0.54)	(0.55)	(0.55)
Benchmark Assets: NAREIT + Australia				
3.10	3.18	3.03	1.51	3.09
(0.21)	(0.20)	(0.22)	(0.23)	(0.21)
Benchmark Assets: NAREIT + Europe + Australia				
1.20	1.21	1.19	0.57	1.06
(0.55)	(0.55)	(0.55)	(0.57)	(0.59)
Panel B. Domestic Real estate portfolio consists of NCREIF				
Benchmark Assets: NCREIF				
3.16	3.24	3.08	1.57	3.81
(0.21)	(0.20)	(0.21)	(0.22)	(0.15)
Benchmark Assets: NCREIF + Europe				
1.59	1.61	1.57	0.77	2.10
(0.45)	(0.45)	(0.46)	(0.47)	(0.35)
Benchmark Assets: NCREIF + Australia				
1.97	2.00	1.94	0.95	2.24
(0.37)	(0.37)	(0.38)	(0.39)	(0.33)
Benchmark Assets: NCREIF + Europe + Australia				
1.35	1.37	1.34	0.64	1.74
(0.51)	(0.50)	(0.51)	(0.53)	(0.42)
Panel C. Domestic Real estate portfolio consists of NAREIT and NCREIF				
Benchmark Assets: NAREIT + NCREIF				
2.22	2.26	2.18	1.08	2.20
(0.33)	(0.32)	(0.34)	(0.35)	(0.33)
Benchmark Assets: NAREIT + NCREIF + Europe				
1.14	1.15	1.13	0.54	1.29
(0.57)	(0.56)	(0.57)	(0.59)	(0.52)
Benchmark Assets: NAREIT + NCREIF + Australia				
1.45	1.47	1.43	0.69	1.37
(0.48)	(0.48)	(0.49)	(0.51)	(0.50)
Benchmark Assets: NAREIT + NCREIF+ Europe + Australia				
1.00	1.01	0.99	0.46	1.12
(0.61)	(0.61)	(0.61)	(0.63)	(0.57)

Note: The test period is from 1978 to 1993. The test assets are Asian real estate securities. The benchmark assets include the NAREIT Index (NAREIT), the NCREIF Index (NCREIF), European real estate securities (Europe), and Australian real estate securities (Australia). The *p*-values are in parentheses. ***Significant at the 1% level. **Significant at the 5% level. *Significant at the 10% level

Table 4.
Mean-variance spanning tests of Asian real estate securities, 1994:1-2005:4.

LR	*W*	*LM*	*F*	*Wa*
Panel A. Domestic Real estate portfolio consists of NAREIT				
Benchmark Assets: NAREIT				
1.73	1.76	1.70	0.84	2.38
(0.42)	(0.41)	(0.43)	(0.44)	(0.30)
Benchmark Assets: NAREIT + Europe				
0.19	0.19	0.19	0.09	0.22
(0.91)	(0.91)	(0.91)	(0.92)	(0.90)
Benchmark Assets: NAREIT + Australia				
1.71	1.74	1.68	0.82	2.25
(0.42)	(0.42)	(0.43)	(0.45)	(0.32)
Benchmark Assets: NAREIT + Europe + Australia				
1.70	1.73	1.67	0.79	2.46
(0.43)	(0.42)	(0.43)	(0.46)	(0.29)
Panel B. Domestic Real estate portfolio consists of NCREIF				
Benchmark Assets: NCREIF				
1.07	1.08	1.06	0.52	1.23
(0.59)	(0.58)	(0.59)	(0.60)	(0.54)
Benchmark Assets: NCREIF + Europe				
1.41	1.43	1.39	0.67	1.21
(0.50)	(0.49)	(0.50)	(0.52)	(0.55)
Benchmark Assets: NCREIF + Australia				
0.84	0.85	0.84	0.40	0.71
(0.66)	(0.65)	(0.66)	(0.67)	(0.70)
Benchmark Assets: NCREIF + Europe + Australia				
0.88	0.89	0.88	0.41	0.70
(0.64)	(0.64)	(0.65)	(0.67)	(0.71)
Panel C. Domestic Real estate portfolio consists of NAREIT and NCREIF				
Benchmark Assets: NAREIT + NCREIF				
0.75	0.75	0.74	0.35	0.73
(0.69)	(0.69)	(0.69)	(0.71)	(0.69)
Benchmark Assets: NAREIT + NCREIF + Europe				
1.20	1.21	1.18	0.56	1.15
(0.55)	(0.55)	(0.55)	(0.58)	(0.56)
Benchmark Assets: NAREIT + NCREIF + Australia				
0.87	0.88	0.86	0.40	0.75
(0.65)	(0.65)	(0.65)	(0.67)	(0.69)
Benchmark Assets: NAREIT + NCREIF+ Europe + Australia				
0.88	0.89	0.87	0.40	0.74
(0.64)	(0.64)	(0.65)	(0.67)	(0.69)

Note: The test period is from 1994:1 to 2005:4. The test assets are Asian real estate securities. The benchmark assets include the NAREIT Index (NAREIT), the NCREIF Index (NCREIF), European real estate securities (Europe), and Australian real estate securities (Australia). The *p*-values are in parentheses. ***Significant at the 1% level. **Significant at the 5% level. *Significant at the 10% level

Table 5.
Mean-variance spanning tests of Asian real estate securities, 1978:1-1998:1.

LR	*W*	*LM*	*F*	*Wa*
Panel A. Domestic Real estate portfolio consists of NAREIT				
Benchmark Assets: NAREIT				
7.69	8.06	7.33	3.93	8.06
(0.02)**	(0.02)**	(0.03)**	(0.02)**	(0.02)**
Benchmark Assets: NAREIT + Europe				
0.38	0.38	0.37	0.18	0.35
(0.83)	(0.83)	(0.83)	(0.83)	(0.84)
Benchmark Assets: NAREIT + Australia				
2.49	2.53	2.45	1.22	2.65
(0.29)	(0.28)	(0.29)	(0.30)	(0.27)
Benchmark Assets: NAREIT + Europe + Australia				
0.36	0.36	0.36	0.17	0.30
(0.84)	(0.84)	(0.84)	(0.84)	(0.86)
Panel B. Domestic Real estate portfolio consists of NCREIF				
Benchmark Assets: NCREIF				
3.12	3.18	3.06	1.55	4.42
(0.21)	(0.20)	(0.22)	(0.22)	(0.11)
Benchmark Assets: NCREIF + Europe				
1.96	1.99	1.94	0.96	2.66
(0.38)	(0.37)	(0.38)	(0.39)	(0.26)
Benchmark Assets: NCREIF + Australia				
1.97	1.99	1.96	0.96	2.72
(0.37)	(0.37)	(0.38)	(0.39)	(0.26)
Benchmark Assets: NCREIF + Europe + Australia				
1.75	1.77	1.73	0.84	2.18
(0.42)	(0.41)	(0.42)	(0.44)	(0.34)
Panel C. Domestic Real estate portfolio consists of NAREIT and NCREIF				
Benchmark Assets: NAREIT + NCREIF				
1.57	1.58	1.55	0.76	1.86
(0.46)	(0.45)	(0.46)	(0.47)	(0.39)
Benchmark Assets: NAREIT + NCREIF + Europe				
1.03	1.03	1.02	0.49	1.39
(0.60)	(0.60)	(0.60)	(0.61)	(0.50)
Benchmark Assets: NAREIT + NCREIF + Australia				
1.08	1.09	1.08	0.52	1.31
(0.58)	(0.58)	(0.58)	(0.60)	(0.52)
Benchmark Assets: NAREIT + NCREIF+ Europe + Australia				
1.00	1.01	1.00	0.47	1.24
(0.61)	(0.60)	(0.61)	(0.63)	(0.54)

Note: The test period is from 1978:1 to 1998:1. The test assets are Asian real estate securities. The benchmark assets include the NAREIT Index (NAREIT), the NCREIF Index (NCREIF), European real estate securities (Europe), and Australian real estate securities (Australia). The *p*-values are in parentheses. ***Significant at the 1% level. **Significant at the 5% level. *Significant at the 10% level

Table 6.
Mean-variance spanning tests of Asian real estate securities, 1998:2-2005:4.

LR	*W*	*LM*	*F*	*Wa*
Panel A. Domestic Real estate portfolio consists of NAREIT				
Benchmark Assets: NAREIT				
0.94	0.96	0.93	0.45	1.02
(0.62)	(0.62)	(0.63)	(0.64)	(0.60)
Benchmark Assets: NAREIT + Europe				
0.01	0.01	0.01	0.01	0.01
(0.99)	(0.99)	(0.99)	(0.99)	(0.99)
Benchmark Assets: NAREIT + Australia				
1.26	1.29	1.24	0.58	1.08
(0.53)	(0.53)	(0.54)	(0.57)	(0.58)
Benchmark Assets: NAREIT + Europe + Australia				
1.22	1.25	1.20	0.54	1.12
(0.54)	(0.54)	(0.55)	(0.59)	(0.57)
Panel B. Domestic Real estate portfolio consists of NCREIF				
Benchmark Assets: NCREIF				
0.05	0.05	0.05	0.02	0.10
(0.98)	(0.98)	(0.98)	(0.98)	(0.95)
Benchmark Assets: NCREIF + Europe				
0.01	0.01	0.01	0.01	0.01
(0.99)	(0.99)	(0.99)	(0.99)	(0.99)
Benchmark Assets: NCREIF + Australia				
0.36	0.37	0.36	0.17	0.46
(0.83)	(0.83)	(0.83)	(0.85)	(0.80)
Benchmark Assets: NCREIF + Europe + Australia				
0.35	0.36	0.35	0.15	0.37
(0.84)	(0.84)	(0.84)	(0.86)	(0.83)
Panel C. Domestic Real estate portfolio consists of NAREIT and NCREIF				
Benchmark Assets: NAREIT + NCREIF				
0.02	0.02	0.02	0.01	0.02
(0.99)	(0.99)	(0.99)	(0.99)	(0.99)
Benchmark Assets: NAREIT + NCREIF + Europe				
0.01	0.01	0.01	0.01	0.01
(0.99)	(0.99)	(0.99)	(0.99)	(0.99)
Benchmark Assets: NAREIT + NCREIF + Australia				
0.43	0.44	0.43	0.19	0.54
(0.81)	(0.81)	(0.81)	(0.83)	(0.77)
Benchmark Assets: NAREIT + NCREIF+ Europe + Australia				
0.45	0.45	0.45	0.19	0.48
(0.80)	(0.80)	(0.80)	(0.83)	(0.79)

Note: The test period is from 1998:2 to 2005:4, the post-Asian financial crisis period. The test assets are Asian real estate securities. The benchmark assets include the NAREIT Index (NAREIT), the NCREIF Index (NCREIF), European real estate securities (Europe), and Australian real estate securities (Australia). The *p*-values are in parentheses. ***Significant at the 1% level. **Significant at the 5% level. *Significant at the 10% level.