Assessing Risk for International Real Estate Investments

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Abstract. **Overseas real estate investment has increased considerably in recent years. The assessment of risk for these investments, especially for real estate, has thus become very important. This study assesses the performance of real estate, stocks and bonds in the U.S., Canada, the United Kingdom, Australia, and New Zealand over the period 1985–93. The results indicate that the degree of appraisal-smoothing and intertemporal correlation in each of the five international real estate series is significant, resulting in the need to increase the real estate risk estimates by 34% to 47%. To account for currency risk over this nine-year period, currency-adjusted returns and risk were also estimated for investors from each of these five countries. All risk profiles increased significantly for international investors when adjusting for currency risk. However, additional portfolio diversification was achieved using real estate for international investors.**

Introduction

The growth, integration and deregulation of world financial markets, as well as changes in international politics and economic policies have resulted in increased global investment opportunities. For example, in 1991, of the $5 trillion in worldwide pension fund assets, 7% was invested abroad. For U.S. and United Kingdom pension funds, 4% and 25% respectively were invested abroad (Odier and Solnik, 1993; Sweeney, 1993).

For stocks and bonds, there is considerable historic evidence that investing internationally offers diversification benefits with respect to reduced portfolio risk and enhanced portfolio performance (Grubel, 1968; Ibbotson, Carr and Robinson, 1982; Jorion, 1985; Odier and Solnik, 1993; Solnik, 1974a,b). Even though foreign real estate accounts for 37% of the total world investable wealth (Ibbotson, Siegel and Love, 1985), the potential role and benefits of international real estate in a mixed-asset portfolio has received little attention in recent years, since assessing risk for foreign real estate is difficult especially when only appraisal-based performance indices are available.

Studies concerning the role of international real estate equities in a mixed-asset portfolio (Asabere, Kleiman and McGowan, 1991; Giliberto, 1990; Kleiman and Farragher, 1992) have demonstrated the significant diversification benefits vis-à-vis U.S. REITs and world securities, although higher volatility was also evident for these international real estate equities. For direct real estate investment in the U.S., it has been shown that investing in U.S. real estate by Japanese and United Kingdom investors did not improve foreign investor portfolio performance (Ziobrowski and Boyd, 1991;

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Ziobrowski and Curcio, 1991; Ziobrowski and Ziobrowski, 1993). This resulted from any portfolio diversification benefits being at least offset by increased exchange rate volatility, even after accounting for the impact of home-country currency borrowings and the use of currency options. Further studies concerning European institutional investors have shown that portfolio diversification was the primary factor in investor decisionmaking concerning overseas real estate investments (Worzala, 1994), with Sweeney (1989, 1993) demonstrating the potential portfolio diversification benefits of including European real estate in an international investment portfolio.

For international real estate investment decisions, it is essential that investors have reliable performance information on the risk and return performance of international real estate markets. This study analyzes the U.S., Canadian, United Kingdom, Australian, and New Zealand real estate investment markets and associated stocks and bond markets over the 1985 to 1993 period. Analyses to be presented include a comparative risk and return analysis for all asset classes in these five countries over the period 1985–93 and an assessment of the impact of appraisal-smoothing and intertemporal correlation in each of the respective real estate performance series. Improved real estate risk estimates are presented to adjust for the presence of appraisal-smoothing and intertemporal correlation. By adjusting for exchange rate variations over this nine-year period, the asset allocation implications of currency risk for international investors from each of these five countries will also be assessed.

Status of International Real Estate Investment

While the United Kingdom, Netherlands and Germany have long-established traditions in international real estate investment (Hines, 1988; Worzala, 1994; Ziobrowski and Curcio, 1991), the extent of international real estate investment by Japan in recent years has attracted considerable attention (McMahan, 1990; Miller, Sklarz and Ordway, 1988; Ziobrowski and Curcio, 1991; Ziobrowski and Ziobrowski, 1993). In contrast, the level of U.S. participation in international real estate investment has been minor (Hines, 1988; Odier and Solnik, 1993).

The major factors contributing to this high level of investment in U.S. real estate in recent years by foreign investors (Hines, 1988; Miller et al., 1988; Mooney and Mooney, 1988; Sweeney, 1993; Ziobrowski and Ziobrowski, 1993) include:

- favourable exchange rates,
- lack of local real estate investment opportunities,
- interest-rate differentials,
- greater liquidity of U.S. real estate markets,
- tax incentives,
- fewer ownership restrictions,
- political diversification,
- economic diversification,
- arbitraging comparable market conditions,
- perceived comparative advantage,
- substantial growth in available investment funds,
- changes in foreign investment policy,

- investment stability,
- strong economy,
- improved global communication,
- improved market information,
- access to investment capital, and
- greater array of investment choices.

While the level of foreign investment in U.S. real estate has been estimated at approximately 1% of total U.S. real estate (Ziobrowski and Curcio, 1991), the extent of foreign investment in several other countries is far more extensive. For example, in Australia, foreign investors account for approximately 15% of the commercial real estate investment market (Jones Lang Wootton, 1990), with foreign investors representing up to 60% of total commercial real estate purchases in recent years (Jones Lang Wootton, 1993). These purchases were predominantly in the office (36%), retail (17%) and hotel (46%) sectors (Jones Lang Wootton, 1993), with most activity being by foreign investors from Japan, New Zealand and Southeast Asia.

The extent of international real estate investment will probably continue to be an important component in institutional investment strategies as market participants become more familiar with the available investment opportunities in a range of real estate markets in Europe and Asia and the quality of real estate market performance information improves.

Data Sources

The data used in the analysis are six-month before-tax total returns for a range of stocks, bonds and real estate for the United States, Canada, United Kingdom, Australia, and New Zealand over the period 1985–93. While the original real estate series used in this study differ in frequency of reporting (either quarterly (U.S., Canada and United Kingdom) or six-monthly (Australia and New Zealand)), six-month returns over 1985–93 were chosen to ensure consistency of all series for comparative purposes. These series are:

United States
- Real estate: NCREIF Real Estate indices
- Stocks: Common Stocks: S&P500
- Bonds: Intermediate-term Government Bonds index

Canada
- Real estate: Russell-Canadian Real Estate indices
- Stocks: TSE300 index
- Bonds: Scotia-McLeod Long-term Government Bonds index

United Kingdom
- Real estate: Jones Lang Wootton Real Estate indices
- Stocks: FTA All Share index
- Bonds: Long-dated Gilts series

Australia
- Real estate: BOMA Real Estate indices
- Stocks: All Ordinaries Accumulation index
- Bonds: Greater than 10-year Government Bonds index

New Zealand
- Real estate: Jones Lang Wootton Real Estate indices
- Stocks: NZSE40 Gross index
- Bonds: CS First Boston Government Bonds index.

The commercial real estate return series were obtained from both institutional sources (U.S., Canada and Australia) and industry-based sources (United Kingdom, New Zealand), with each series being the appropriate "benchmark" real estate series over 1985–93 for their respective countries. In each of the above real estate series, the data used to estimate real estate total returns were derived from appraisal-based information, rather than transaction-based information. No taxes, transaction costs, hedging, leverage or short-selling are considered in this study.

Estimating Real Estate Risk

The standard investment analysis formula to calculate annual risk from six-month risk is given by the formula:

$$Annual\ risk = \sqrt{2} \times (six\text{-}month\ risk). \tag{1}$$

The assumption in equation (1) is that each return series is uncorrelated. While this assumption may be reasonable for transaction-based stock returns, it is highly unlikely to be appropriate for appraisal-based real estate returns. This is evidenced by the strong evidence of appraisal-smoothing and intertemporal correlation shown in the significant autocorrelation structure found in many real estate return series (Geltner, 1989; Ross and Zisler, 1991).

The modification to equation (1) necessary to adjust for the presence of appraisal-smoothing can be achieved using the statistical methodology for the variance of the product of k non-independent variables developed by Goodman (1962). For a six-month real estate series, Newell and MacFarlane (1994) have shown that the annual risk can be determined as:

$$Annual\ risk = \sqrt{2} \times (six\text{-}month\ risk) \times [\tfrac{1}{2}(1+\rho^2)\sigma^2 + (1+\mu)^2(1+\rho)]^{\frac{1}{2}}, \tag{2}$$

where:

μ = average six-month return,
σ = six-month risk, and
ρ = inter-period correlation for six-month returns.

A full derivation of this annualized risk formula is given in the Appendix.

Importantly, equation (2) adjusts for the intertemporal correlation structure in the real estate return series, of which appraisal-smoothing is the likely major contributing factor. This results in more appropriate estimates of real estate risk than previously achieved using equation (1).

Analysis of International Real Estate Series

Comparative Risk and Return Analysis

Exhibit 1 presents the six-month return, risk and autocorrelation structure for each of the real estate, stocks and bond series for the U.S., Canada, United Kingdom, Australia, and New Zealand over the period 1985–93. Significant autocorrelations occurred for each of the real estate series in each country, with significant autocorrelations for lags of up to two years occurring in some cases. This was most evident in the Canadian real estate and U.S. warehouse series, with a lesser degree of autocorrelation evident in the United Kingdom real estate series. The largest first-order autocorrelations occurred in the Australian and New Zealand real estate series. This significant autocorrelation structure provides strong evidence of appraisal-smoothing and intertemporal correlation in each of these real estate series.

In each case, these significant autocorrelations across the five countries were in marked contrast to the generally insignificant autocorrelation structure in the corresponding stocks and bond series shown in Exhibit 1. This reflects the difference between the appraisal-based real estate series and the transaction-based financial series.

While the traditional view is that the volatility of real estate should be somewhere between that of bonds and stocks, this is not evident for the U.S., Canada or the United Kingdom. These low risks and low real estate-to-stocks volatility ratios for each real estate series shown in Exhibit 1 provide further support for the presence of appraisal-smoothing. In each case, the volatility ratios were well below the 60%–65% level suggested by Giliberto (1992) and Hartzell and Webb (1988). This was particularly evident in the U.S. real estate series with volatility ratios of 28% to 36% and in the New Zealand industrial series and Australian retail series with volatility ratios of 23%.

Incorporating Appraisal-Smoothing into Risk Estimates

Exhibit 2 presents the conventional annual risk estimates using equation (1) and the exact annual risk estimates using equation (2) for each real estate series in the five countries. In each case, it was necessary to significantly adjust the conventional annual risk estimates upwards by a factor of 1.34 to 1.47 to account for appraisal-smoothing and obtain more appropriate real estate volatility estimates. The extent of this real estate volatility adjustment was less significant in the U.S. (1.34 to 1.38) and the United Kingdom (1.38), with larger adjustments required for New Zealand (1.44 to 1.47), Australia (1.42 to 1.45) and Canada (1.39 to 1.43). While the volatility adjustment required differed across the five countries, in each case the required adjustment was at least 34%, reflecting the previously low risk estimates for real estate investments.

The consequence of using these adjusted annual risk estimates is shown in Exhibit 2 in the increased real estate-to-stocks volatility ratios for each of the real estate series. The volatility ratios for Canada, United Kingdom, Australia, and New Zealand are now

Exhibit 1
Commercial Real Estate Returns, Risks and Autocorrelations: 1985–93 (semiannual data)

Portfolio Component	Return (Semi-Annual) (%)	Risk (Semi-Annual) (%)	Real Estate-to-Stock Volatility Ratio	Autocorrelations			
				ρ_{6m}	ρ_{12m}	ρ_{18m}	ρ_{24m}
United States							
Total Real Estate	1.47	2.96	28%	.64*	.69*	.34	.24
Office	−.54	3.83	36%	.56*	.76*	.31	.39
Retail	3.55	3.22	30%	.69*	.70*	.36	.23
Warehouse	2.61	3.27	31%	.75*	.78*	.64*	.59*
R&D/Office	1.44	3.26	31%	.71*	.64*	.38*	.23
Stocks	8.20	10.68	n.a.	−.48*	.30	−.35	.21
Bonds	5.48	3.46	n.a.	−.11	.08	.13	−.60*
Canada							
Total Real Estate	3.41	4.91	50%	.62*	.84*	.46*	.53*
Office	2.88	5.64	57%	.53*	.82*	.39	.47*
Retail	4.87	3.73	38%	.58*	.60*	.35	.38
Industrial	4.51	4.41	45%	.74*	.73*	.57*	.55*
Stocks	4.92	9.84	n.a.	−.26	.04	−.19	.31
Bonds	6.80	5.13	n.a.	.12	.00	−.29	−.10
United Kingdom							
Total Real Estate	4.95	6.28	46%	.74*	.33	.05	−.23
Stocks	9.13	13.65	n.a.	−.46*	.26	−.34	−.10
Bonds	6.89	6.53	n.a.	−.12	.30	.03	.06
Australia							
Total Real Estate	5.32	6.99	48%	.86*	.75*	.51*	.32
Office	4.16	8.81	61%	.88*	.79*	.58*	.40
Retail	7.82	3.29	23%	.35	.51*	.07	.11
Stocks	9.57	14.51	n.a.	−.01	−.10	.08	.06
Bonds	9.05	6.71	n.a.	−.35	.27	−.12	−.13
New Zealand							
Office	4.99	9.72	45%	.85*	.67*	.46*	.25
Industrial	6.48	5.08	23%	.86*	.62*	.35	.09
Stocks	6.71	21.72	n.a.	.36	−.20	−.26	−.21
Bonds	8.22	2.56	n.a.	.04	−.10	−.03	.24

*Autocorrelation exceeds twice its standard error.

Exhibit 2
Commercial Real Estate Risk Estimates
(standard deviation): 1985–93

Portfolio Component	Conventional Annual Risk (%)	Exact Annual Risk (%)	Volatility Adjustment Factor*	Real Estate-to-Stocks Volatility Ratio (%)	"Annual" Risk** (%)
United States					
Total Real Estate	4.19	5.70	1.36	38	5.20
Office	5.42	7.26	1.34	48	6.50
Retail	4.55	6.23	1.37	41	5.76
Warehouse	4.62	6.38	1.38	42	5.99
R&D/Office	4.61	6.32	1.37	42	5.91
Canada					
Total Real Estate	6.94	9.92	1.43	71	8.69
Office	7.98	11.09	1.39	80	9.54
Retail	5.28	7.39	1.40	53	6.74
Industrial	6.24	8.92	1.43	64	8.24
United Kingdom					
Total Real Estate	8.88	12.27	1.38	64	12.50
Australia					
Total Real Estate	9·89	14.34	1.45	70	13.76
Office	12.46	17.82	1.43	87	17.07
Retail	4.65	6.60	1.42	32	6.08
New Zealand					
Office	13.75	19.81	1.44	64	20.76
Industrial	7.18	10·59	1.47	34	10.97

*Exact annual risk divided by conventional annual risk; ** annual risk obtained by only using end-of-year results

generally more consistent with the levels suggested by Giliberto (1992) and Hartzell and Webb (1988). Only the U.S. volatility ratios of 38% to 42% were each consistently below the suggested level.

To further assess the validity of these adjusted real estate volatility estimates, a comparison of the conventional annual risk and the exact annual risk with "annual" risk obtained by only using the end-of-year figure was carried out as shown in Exhibit 2. For each real estate series in these five countries, the exact annual risk showed a closer correspondence with the "annual" risk than the correspondence between the conventional annual risk and the "annual" risk.

This analysis further confirms the validity of using the exact annual risk estimates and the need to increase the conventional annual risk estimates to more fully reflect the

volatility of real estate investments in these five countries. Volatility increases of 34% to 47% are the necessary adjustments required to account for appraisal-smoothing and intertemporal correlation in these real estate series. These improved real estate risk estimates should be of considerable benefit in international asset allocation decisionmaking, since they overcome the potential problem of the strategic downgrading for real estate as a valid asset class in a mixed-asset portfolio, due to the investment portfolio manager's lack of confidence in the risk estimates for real estate.

International Portfolio Diversification

Exhibit 3 shows the inter-asset correlation matrix for the real estate, stocks and bond series in the U.S., Canada, the United Kingdom, Australia, and New Zealand over the period 1985–93. Each country's asset performance showing limited correlation with the other countries' asset performance reflects the potential international portfolio diversification benefits available. The largest correlations were seen amongst specific asset classes (e.g., stocks) across the five countries, reflecting some degree of similar movement in financial markets over this period. Lesser correlations were seen amongst the international real estate markets.

Adjusting for Currency Risk

The contribution of currency risk to the risk profile of an international mixed-asset portfolio is significant (Odier and Solnik, 1993). To assess the effect of currency risk, all returns were adjusted for exchange rate variations over the period 1985–93 for international investors in the U.S., Canada, the United Kingdom, Australia, and New Zealand. Exhibit 4 presents the corresponding currency-adjusted returns and risk for each asset class in each country over the period 1985–93.

In each case, a high degree of additional risk was introduced by the volatile exchange rates over this period for each asset class, compared to the corresponding risk exposure for local investors. This additional risk was particularly evident for real estate and bonds in each of the five countries, with the impact of currency risk on stocks only being marginal in comparison. As an example, for U.S. real estate, the risk profile for foreign investors increased by an average of 148% over that of local investors, compared to an average risk increase of only 35% for stocks. This pattern was consistent across each of the five countries under review.

While the increased risk due to currency fluctuations impacts the portfolio diversification benefits from international investment, the corresponding currency-adjusted inter-asset correlation matrix needs to be determined for each country in order to estimate the impact of currency translation on portfolio diversification benefits. Exhibit 5 presents the currency-adjusted inter-asset correlation matrix for foreign investors in the various asset classes across the five countries. For each of the five investor countries, the inter-asset correlations involving real estate were lower after being currency-adjusted than the equivalent inter-asset correlations shown in Exhibit 3. This reflects some degree of additional portfolio diversification benefit for real estate after being currency-adjusted for specific countries. The same extent of diversification benefit, via lower correlations, was not evident in the inter-asset correlations involving stocks and bonds for these five countries.

Exhibit 3
International Investment Correlation Matrix: 1985–93

	USRE	USS	USB	CRE	CS	CB	UKRE	UKS	UKB	ARE	AS	AB	NZRE	NZS	NZB
US Real Estate (USRE)	1.00														
US Stocks (USS)	.03	1.00													
US Bonds (USB)	−.12	.19	1.00												
Canadian Real Estate (CRE)	.77	−.03	−.09	1.00											
Canadian Stocks (CS)	.11	.79	.19	−.10	1.00										
Canadian Bonds (CB)	−.27	.36	.81	−.38	.42	1.00									
UK Real Estate (UKRE)	.57	.03	−.26	.42	.27	−.04	1.00								
UK Stocks (UKS)	.01	.86	−.10	−.20	.80	.19	.15	1.00							
UK Bonds (UKB)	−.35	.35	−.02	−.57	.45	.43	.05	.48	1.00						
Aust. Real Estate (ARE)	.77	−.07	−.15	.78	−.06	−.25	.73	−.13	−.36	1.00					
Aust. Stocks (AS)	.15	.66	.19	−.12	.76	.48	.23	.72	.38	−.05	1.00				
Aust. Bonds (AB)	−.42	.14	.27	−.34	.16	.29	−.34	.06	.50	−.41	.07	1.00			
NZ Real Estate (NZRE)	.44	.27	.06	.26	.32	.07	.19	.34	.18	.39	.47	−.04	1.00		
NZ Stocks (NZS)	.06	.32	.32	−.19	.32	.49	.07	.41	.25	−.17	.72	−.07	.31	1.00	
NZ Bonds (NZB)	.28	.37	−.04	.20	.18	.05	.17	.27	.32	.24	.13	.25	.31	−.13	1.00

Exhibit 4
Currency-Adjusted Average Annual Returns and Risk: 1985–93

Asset	US$ Return (%)	US$ Risk (%)	C$ Return (%)	C$ Risk (%)	UK$ Return (%)	UK$ Risk (%)	AUS$ Return (%)	AUS$ Risk (%)	NZ$ Return (%)	NZ$ Risk (%)
US Real Estate	2.97	4.19	3.00	4.84	1.33	16.14	5.83	12.06	1.41	8.47
US Stocks	17.08	15.10	17.12	15.18	15.83	24.89	22.57	24.49	15.38	16.84
US Bonds	11.26	4.89	11.42	7.61	9.56	17.61	16.61	19.49	9.80	11.33
Canadian Real Estate	7.36	10.15	6.94	6.94	5.29	16.70	9.91	11.91	5.67	12.24
Canadian Stocks	11.43	15.19	10.08	13.91	10.04	23.55	14.34	18.34	9.51	14.94
Canadian Bonds	14.98	7.03	14.06	7.26	13.17	18.09	18.25	14.52	13.41	12.13
UK Real Estate	14.43	17.97	14.19	16.66	10.15	8.88	17.07	19.49	11.99	15.56
UK Stocks	22.49	21.47	22.46	21.03	19.09	19.30	25.42	22.36	19.81	17.33
UK Bonds	18.83	19.40	18.81	19.35	14.26	9.23	21.65	21.03	16.12	16.20
Aust. Real Estate	9.30	16.59	8.88	13.41	6.96	19.71	10.93	9.89	7.32	16.41
Aust. Stocks	18.07	23.79	17.82	22.44	16.57	29.59	20.05	20.52	15.91	22.61
Aust. Bonds	16.99	14.96	16.69	12.67	14.61	19.37	18.93	9.49	14.71	13.34
NZ Real Estate	13.29	20.97	13.23	20.43	10.10	18.91	16.14	22.70	10.23	13.76
NZ Stocks	15.82	31.82	16.29	33.19	14.91	36.88	19.33	34.72	13.87	30.73
NZ Bonds	19.82	12.11	19.73	11.09	17.15	15.84	22.71	13.82	17.12	3.62

Summary and Conclusions

Assessing the risk for foreign real estate has taken on more importance with the increased internationalisation of investment activities. This study has shown that the risk estimates for real estate in the U.S., Canada, the United Kingdom, Australia, and New Zealand over 1985 to 1993 need to increase by 34% to 47% to adjust for appraisal-smoothing and intertemporal correlation in these five international real estate series. After accounting for currency risk, real estate risk estimates increased significantly for international investors.

While the quantity and quality of real estate performance information for foreign real estate has improved considerably in recent years, adequate time-series beyond those five countries considered in this study are still largely unavailable. This prevents the extension of these risk analyses to encompass all major countries available to real estate investors, including other parts of Europe and Asia.

Another potential limitation of this study is obviously the period of analysis. Ideally, risk should be estimated for a period of several cycles, if data is available. Obviously, an eight-year period is not long enough, but, it is as much as is currently available. In addition, different countries can have different lengths and timing for their particular real estate cycles. Although this study compares the risk at the same point in time, each country could potentially be at a different point in its particular real estate cycle. The

Exhibit 5
Currency-Adjusted Inter-Asset Correlation Matrix for Foreign Investors: 1985–93*

	U.S. Investor			Canadian Investor			United Kingdom Investor			Australian Investor			New Zealand Investor		
Asset	USRE	USS	USB	CRE	CS	CB	UKRE	UKS	UKB	ARE	AS	AB	NZRE	NZS	NZB
USRE	1.00	.03	−.12	.13	.02	.10	.17	.40	−.13	.07	.05	−.26	−.33	.21	−.42
USS	.03	1.00	.19	−.22	.74	.48	.04	.75	.16	−.12	.45	.00	−.08	.37	.04
USB	−.12	.19	1.00	−.41	.07	.74	−.05	.36	−.06	−.14	.10	−.03	−.40	.31	−.44
CRE	.68	.02	−.21	1.00	−.10	−.38	.33	.31	−.32	.45	−.06	−.23	−.23	−.10	−.14
CS	.20	.76	.07	−.10	1.00	.42	.28	.72	.19	−.05	.59	.10	−.03	.29	−.02
CB	−.04	.44	.63	−.38	.42	1.00	.15	.44	.08	−.13	.25	.12	−.35	.29	−.21
UKRE	.46	−.16	−.03	.36	−.08	.05	1.00	.15	.05	.40	−.07	−.06	.12	−.19	−.06
UKS	.17	.70	.01	−.08	.61	.25	.15	1.00	.48	−.05	.53	.14	.39	.27	.15
UKB	−.01	.03	.13	−.15	.04	.30	.05	.48	1.00	−.09	.02	.33	.10	−.10	.04
ARE	.52	−.06	−.47	.57	−.10	−.43	.56	.30	−.13	1.00	−.05	−.41	−.07	−.12	−.03
AS	.16	.56	−.12	−.13	.65	.28	.29	.70	.28	−.05	1.00	.07	.19	.61	.02
AB	−.19	.08	−.25	−.27	.06	−.04	.04	.41	.28	−.41	.07	1.00	−.41	−.09	−.01
NZRE	.44	.23	−.08	.11	.30	.01	.22	.64	.29	.22	.32	.07	1.00	.31	.31
NZS	.16	.35	.26	−.24	.35	.46	.10	.53	.29	−.18	.68	.01	.31	1.00	−.13
NZB	.35	.16	−.21	−.06	.19	−.07	.15	.56	.26	.01	.08	.22	.31	−.13	1.00

*Inter-asset correlation matrix is not symmetric due to country-to-country exchange rate variations over 1985–93 for specific countries.

effects, if any, of these considerations is not currently known, but are a limitation of this study.

Similarly, further studies need to take into account exchange risk hedging, country-specific taxation and additional country-by-country transaction costs in order to provide a fully comprehensive profile of foreign real estate investment risks and opportunities.

Appendix
Derivation of Exact Annual Risk Formula: Six-Month Series

Letting r_i=return in period i for i=1, . . . k, then it is required to determine:

$$Annual\ risk = \left[\text{Variance} \left[\prod_{i=1}^{k} (1+r_i) - 1 \right] \right]^{\frac{1}{2}}. \tag{1}$$

For six-month returns (k=2):

$$\begin{aligned} \text{Variance} \left[\prod_{i=1}^{2} (1+r_i) - 1 \right] &= \text{Var}\,(r_1 + r_2 + r_1 r_2) \\ &= (1+\rho^2)\sigma_1^2\sigma_2^2 + (1+\mu_1)^2\sigma_2^2 + (1+\mu_2)^2\sigma_1^2 \\ &\quad + 2\rho\,\sigma_1\sigma_2(1+\mu_1)(1+\mu_2)\,, \end{aligned} \tag{2}$$

where:

μ_i = average six-month return for period i(i=1,2),
σ = six-month risk for period i(i=1,2), and
ρ = inter-period correlation for six-month returns.

Letting $\mu_i=\mu$ and $\sigma_i^2=\sigma^2$ for all i (i=1,2), then:

$$\text{Variance} \left[\prod_{i=1}^{2} (1+r_i) - 1 \right] = (1+\rho^2)\sigma^4 + 2(1+\mu)^2(1+\rho)\sigma^2\,. \tag{3}$$

Therefore:

$$Annual\ risk = \sqrt{2} \times \text{six} - month\ risk \times \left[\frac{1}{2}(1+\rho^2)\sigma^2 + (1+\mu)^2(1+\rho) \right]^{\frac{1}{2}}. \tag{4}$$

References

Asabere, P., R. Kleiman and C. McGowan, The Risk-Return Attributes of International Real Estate Equities, *Journal of Real Estate Research*, 1991, 6:2, 143–51.

Geltner, D., Estimating Real Estate's Systematic Risk from Aggregated Level Appraisal-Based Returns, *AREUEA Journal*, 1989, 17, 463–81.

Giliberto, M., The Salomon-Russell Global Equity Property Sector Index, Salomon Brothers Bond Market Research, February 1990.

———, Real Estate Risk and Return: 1991 Survey Results, Real Estate Research Paper, Salomon Brothers, March 1992.

Goodman, L., The Variance of the Product of k Random Variables, *American Statistical Association Journal*, 1962, 57, 54–60.

Grubel, H., Internationally Diversified Portfolios: Welfare Gains and Capital Flows, *American Economic Review*, 1968, 58, 1299–1314.

Hartzell, D. and J. Webb, Real Estate Risk and Return Expectations: Recent Survey Results, *Journal of Real Estate Research*, 1988, 3:3, 31–38.

Hines, M., International Dimensions of Real Estate, *Appraisal Journal*, March 1988, 492–501.

Ibbotson, R., L. Siegel and K. Love, World Wealth: Market Values and Returns, *Journal of Portfolio Management*, Fall 1985, 4–23.

Ibbotson, R., R. Carr and A. Robinson, International Equity and Bond Returns, *Financial Analysts Journal*, Winter 1982, 61–83.

Jones Lang Wootton, *Movement of Funds Into Australian Investment Property*, Sydney: Jones Lang Wootton Research, 1990.

———, *Movement of Funds Into Australian Investment Property: 1989–92*, Sydney: Jones Lang Wootton Research, 1993.

Jorion, P., International Portfolio Diversification with Estimation Risk, *Journal of Business*, 1985, 58, 259–78.

Kleiman, R. and E. Farragher, Investment Characteristics of International Real Estate Equities, *Real Estate Review*, 1992, 22, 33–39.

McMahan, J., Foreign Investment in U.S. Real Estate, *Real Estate Issues*, 1990, 15, 35–37.

Miller, N., M. Sklarz and N. Ordway, Japanese Purchases, Exchange Rates and Speculation in Residential Real Estate Markets. *Journal of Real Estate Research*, 1988, 3:3, 39–49.

Mooney, S. and K. Mooney, Considerations for the Foreign Investor in the U.S. Real Estate Market, *Journal of Valuation*, 7, 1988, 22–34.

Newell, G. and J. MacFarlane, Property: More Volatile Than You Thought, *Journal of Australian Securities Institute*, March 1994, 25–37.

Odier, P. and B. Solnik, Lessons for International Asset Allocation, *Financial Analysts Journal*, March 1993, 63–77.

Ross, S. and R. Zisler, Risk and Return in Real Estate, *Journal of Real Estate Finance and Economics*, 1991, 4, 129–46.

Solnik, B., An Equilibrium Model of the International Capital Market. *Journal of Economic Theory*, 1974a, 4, 173–82.

———, Why Not Diversify Internationally Rather than Domestically, *Financial Analysts Journal*, July 1974b, 48–54.

Sweeney, F., International Real Estate Diversification: A Viable Strategy, *Journal of Property Management*, 1989, 5, 317–26.

———, Mapping a European Property Investment Strategy, *Journal of Property Valuation and Investment*, 1993, 11, 259–67.

Worzala, E., Overseas Property Investments: How Are They Perceived by the Institutional Investor? *Journal of Property Valuation and Investment*, 1994, 12, 31–47.

Ziobrowski, A. and J. Boyd, Leverage and Foreign Investment in U.S. Real Estate, *Journal of Real Estate Research*, 1991, 7:1, 33–57.

Ziobrowski, A. and R. Curcio, Diversification Benefits of U.S. Real Estate to Foreign Investors, *Journal of Real Estate Research*, 1991, 6:2, 119–42.

Ziobrowski, A. and B. Ziobrowski. Hedging Foreign Investments in U.S. Real Estate with Currency Options, *Journal of Real Estate Research*, 1993, 8:1, 27–54.