# International Evidence on Real Estate as a Portfolio Diversifier

Authors

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Abstract

This paper provides an international comparison of the benefits of including real estate assets in mixed-asset portfolios. Real estate returns are desmoothed using a variant of the Geltner (1993) approach, and Bayes-Stein estimators are used to increase the stability of portfolio weight estimations. Both unhedged and hedged analyses are conducted. Real estate is found to be an effective portfolio diversifier, and even more so when both domestic and international real estate assets are considered. The optimal allocation to real estate is 15% to 25%, and remains stable when the level of the standard deviation of real estate is altered. Real estate allocation between domestic and non-domestic assets, however, varies substantially across countries, depending on whether returns are hedged or not.

This article is the winner of the International Real Estate Investment/Portfolio Management Manuscript Prize (sponsored by LaSalle Investment Management) presented at the 2003 American Real Estate Society Annual Meeting.

## Introduction

The optimal allocation of institutional investors' capital in the various asset classes (often referred to as inter-asset or mixed-asset diversification) is of foremost importance. Indeed, it has a crucial impact on portfolio performance, which in turn impacts the amounts that have to be paid into a fund and/or those that will be distributed to beneficiaries. All things being equal, a better portfolio performance could lead to lower amounts having to be paid in and/or larger benefits being paid to beneficiaries in the future. In the context of mixed-asset portfolio diversification, the positive role of real estate has been well documented in the literature (for a recent review, see Hoesli and MacGregor, 2000, Chapter 10). The studies, for instance, generally conclude that real estate returns are lowly (positively or negatively) correlated to those of stocks and bonds, and that 15% to 30% of a mixed-asset portfolio should be allocated to real estate (Ennis and Burik, 1991; and Ziobrowski and Ziobrowski, 1997). Further evidence on the

usefulness of real estate as a portfolio diversifier is provided by Chaudhry, Myer and Webb (1999). Using co-integration techniques, they find that stocks have an inverse long-run relationship with real estate. They also find that the overall impact of stocks on the real estate market is much less than its impact on bonds and T-bills.

The analysis of the impact of including real estate assets in mixed-asset portfolios has not been examined solely in domestic settings, but also internationally. There is evidence that international diversification is also useful for real estate, although the most reliable results to date are for indirect rather than direct real estate investments. For example, Eichholtz (1996) reports that international diversification works better for real estate than for stocks and bonds. Gordon, Canter and Webb (1998) find that the efficient frontier containing international real estate securities dominates the frontier with international stocks and indirect real estate in the United States.[1] For direct real estate, Case, Goetzmann and Wachter (1997) find that international real estate diversification would have been beneficial to a U.S. investor.[2]

Institutional investors allocate a substantially lower weight to real estate than that reported in the literature (Chun and Shilling, 1998; and Geltner and Miller, 2001). Some recent studies have attempted to provide explanations for this discrepancy. It has, for instance, been argued that the weight that should be allocated to real estate is much more in line with the actual institutional weight when an asset-liability framework is used, rather than an asset-only framework (Chun, Ciochetti and Shilling, 2000; and Craft, 2001), or when real estate market imperfections, such as indivisible assets and no short sales, are considered (Kallberg, Liu and Greig, 1996).

An interesting line of research is that of the impact of parameter uncertainty on optimal portfolio selection. It has been shown that the practical application of portfolio analysis is hampered by estimation error, especially in expected returns. Variances and covariances are also unknown, but are more stable over time [Jorion (1985) and Chopra and Ziemba (1993) for common stocks; Stevenson (2001a) for international real estate stocks]. Given these results, it would seem appropriate to increase the reliability of the point estimates for the optimal asset allocations. One possibility for reducing estimation error is to constrain the allocations, thereby forcing greater spread across the assets (Frost and Savarino, 1988). The choice of constraints is arbitrary, however.

Another possibility is to use the Bayes-Stein shrinkage approach (Jorion, 1985). When such an approach is used, the means usually are ‘shrunk’ towards a common value (the common mean, *i.e.*, the mean across all assets considered). Jorion (1986) uses this approach to investigate the benefits of international stock portfolio diversification. He finds that the out-of-sample performance of the optimal portfolio is substantially improved. Also, he argues that the benefits from diversification are more likely to accrue from a reduction in risk, rather than gains in average returns. Stevenson (2001a), using data pertaining to international real

estate securities, finds an increased stability in calculated portfolio allocations in comparison to the classical mean-variance tangency approach, and significant improvements in out-of-sample performance. One intuitive interpretation of using Bayes-Stein estimates is that they should, when used within an asset class, improve estimates of expected long-term returns for the specific asset classes by diminishing the effect of outlying observations.

This study follows the latter line of research, and extends the literature in a number of ways. It analyzes the impact of including direct real estate in portfolios of financial assets in each of seven countries (U.S., U.K., France, the Netherlands, Sweden, Switzerland and Australia) for the 1987–2001 period. The benefits of including real estate in mixed-asset portfolios have been examined previously for a number of countries, but usually for each country separately and for varying time periods. The analysis here focuses on whether the optimal weight that should be allocated to domestic real estate in mixed-asset portfolios is robust across countries.

The implementation of the Bayes-Stein procedure in this study differs from previous studies, in that asset returns are shrunk to the global mean of each asset class. To our knowledge this is the first time that this procedure is used in a mixed-asset portfolio context with real estate. Given the uncertainty concerning the risk of real estate, the Bayes-Stein procedure is performed for various levels of risk for real estate. For countries where appraisal-smoothing appears to be of concern, the direct real estate data are desmoothed using a variant of the model proposed by Geltner (1993). The analyses are performed with the standard deviation computed on the desmoothed index, but also for three other levels of standard deviation. As the levels of standard deviation that are considered cover a wide spectrum, they provide interesting insights into the robustness of the conclusion pertaining to the optimal allocation to real estate. The benefits for institutions of holding not only domestic real estate, but also international real estate assets are analyzed. For this purpose, international real estate indices are constructed by weighting real estate indices from a number of countries. All analyses are performed both with unhedged returns and returns hedged against movements in exchange rates by using an optimal hedging strategy. To test for the robustness of the results, the analyses are also performed after discarding the first year of the period (*i.e.*, on the restricted 1988–2001 period).

The first section of the paper contains a presentation of the method, while the data are presented in the following section. The next two sections discuss the results with unhedged and hedged returns, respectively. Finally, the last section contains some concluding remarks.

## Method

Using real estate data is not straightforward as it is usually acknowledged that appraisal-based real estate indices are smoothed (*i.e.*, that there is significant serial

correlation in returns).[3] Some authors have suggested that this results from appraisers using weighted averages of the contemporaneous information set and historical appraisals (*e.g.*, Geltner, MacGregor and Schwann, 2003). Such behavior has been documented empirically. The results by Diaz and Wolverton (1998), for instance, support the hypothesis of insufficient adjustment from previous value judgments. Also, Clayton, Geltner and Hamilton (2001) find evidence that appraisers valuing the same property in consecutive periods anchor onto their previous appraised values. Transaction-based indices have also been shown to exhibit greater volatility and less lagging than appraisal-based indices (Fisher, Miles and Webb, 1999; and Fisher, Gatzlaff, Geltner and Haurin, 2003). Given the high levels of serial correlation in the appraisal-based series used in the current study, as compared to the serial correlation of the transaction-based index used here for one country (Switzerland), the primary analysis relies on unsmoothed data.

This is not to say that the smoothing assumption has not been challenged in the real estate literature. Lai and Wang (1998) raise the point that much of the smoothing literature starts from an assumption that smoothing exists. They argue that the favorable risk-adjusted returns observed for real estate can be explained much more by the fact that investors need to be compensated for the illiquidity and high information costs, than by the fact that the data are noisy. They analyze each of the smoothing arguments, and conclude that the variance of real estate returns can in fact be less than the variance of appraisal-based returns (empirical evidence of this is found, for example, in Webb, Miles and Guilkey, 1992). If appraisal-based indices indeed suffer from smoothing, this will lead to the volatility of real estate returns being understated, and thus to the weight that should be allocated to real estate in multi-asset portfolios being overstated (Corgel and deRoos, 1999; and Hoesli and MacGregor, 2000). When unsmoothed returns are used, as is the case in the main analysis here, the results show a rather conservative picture of what the optimal allocation to real estate in a mixed-asset portfolio should be. For this reason, analyses were also performed for varying levels of standard deviation for real estate (these levels are discussed below).

Several approaches have been suggested to recover a 'true' index from a smoothed index. There is no clear consensus on what approach should be used, but two methods have been widely used in previous studies. The first method assumes that real estate markets are fully efficient, while the second approach does not make this assumption. This study employs a variant of the second approach to desmooth indices of capital values. Total returns are then reconstructed by adding the actual income return to the desmoothed capital returns. Of the countries considered, only the Swiss real estate index does not exhibit significant serial correlation, and hence the real estate returns need not be desmoothed. This would be expected as the Swiss index is based on transactions data and is constructed by means of an hedonic regression model. The Dutch index is constructed using the repeated-regression method (Geltner and Goetzmann, 2000). This is a variant of the repeat sales method whereby pairs are formed with appraised values and transaction prices (for details on the Dutch index, see Hordijk, de Kroon and Theebe, 2003).

This index still exhibits high levels of serial correlation, hence the Dutch returns have been desmoothed.

True returns are computed using a reverse filter (Geltner, 1993):

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

where $r_t^u$ is the unsmoothed real estate return for period $t$, $r_t^*$ is the observed appraisal-based return for period $t$ and $a$ is a smoothing parameter.

As mentioned above, the appealing property of this model is that it does not assume that the real estate market is efficient, and hence does not eliminate all the serial correlation. It does require, however, that some assumption be made regarding the standard deviation of real estate. The common assumption is to assume that real estate's volatility is one half that of stocks (Geltner, 1993; Corgel and deRoos, 1999; and Stevenson, 2000). This study, however, assumes that real estate returns are desmoothed under the assumption that the volatility of real estate is the average of the volatility of stocks and that of bonds. This is motivated by the fact that in some cases, using half of the standard deviation of stocks as the risk of real estate results in real estate having a lower risk than bonds. This hypothesis leads to higher risk levels for real estate than if the standard hypothesis is made, and so if anything to lower weights being allocated to real estate.

To address the issue of errors in parameters when constructing efficient frontiers, Bayes-Stein estimators (Jorion, 1985, 1986) are used. As most of the errors in parameters concern the expected returns, the intuition is to shrink the sample averages toward a common mean. Jorion finds that using this methodology results in substantially improved out-of-sample optimal portfolio performance. The general form for the estimators is as follows:

$$E(r_i) = w\bar{r}_g + (1 - w)\bar{r}_i, \tag{2}$$

where $E(r_i)$ is the adjusted mean, $\bar{r}_i$ is the original asset mean, $\bar{r}_g$ the global mean and $w$ the shrinkage factor. Following Jorion (1985, 1986), the shrinkage factor can be estimated from a suitable prior:

$$\hat{w} = \frac{\hat{\lambda}}{(T + \hat{\lambda})} \quad \text{and} \tag{3}$$

$$\hat{\lambda} = \frac{(N + 2)(T - 1)}{(\bar{r} - r_0 1)' S^{-1} (\bar{r} - r_g 1)(T - N - 2)}, \tag{4}$$

where $T$ is the sample size and $S$ is the sample covariance matrix. The shrinkage factor is the key element. As it approaches one, the frontier becomes more horizontal. When $w = 1$, the frontier is entirely flat and there is only a risk trade-off to be considered. At $w = 0$, the frontier is the common mean-variance frontier. Here the adjusted means have been estimated as averages within each separate asset class. The intuition is straightforward: assets are viewed mainly in terms of asset classes, *i.e.*, investors consider long-term returns from, for example, bonds, stocks and real estate, not country returns nor global returns on all possible assets. This is both intuitive and obvious from investment markets where portfolio management is split up by asset classes, often across borders, but where the division is seldom by country.

It also seems reasonable to assume that the globalization of markets will lead to a growing integration of markets by asset class, therefore returns have been shrunk by asset class. Obviously, perfect integration does not exist as portfolio preferences and institutional rigidities somewhat impede the flow of capital across countries. This is reflected by the remaining spread of returns across countries. Thus, the optimization process that solves for frontier allocations for each of the considered countries involves using the unchanged covariance matrix and replacing the original expected returns by a vector of within-asset-class shrunk expected returns. The shrinkage factor, and thus the weight assigned to the asset class mean, also differs across asset classes. For cash, the shrinkage factor is 0.041, while for stocks it is 0.72, the highest in the sample. For direct property, the factor is 0.663, for bonds 0.148 and for real estate stocks 0.239.

Most Bayes-Stein studies to date have used data for common stocks or securitized real estate. With such data, it is realistic to assume that most of the errors in parameters concern the expected returns, and hence the focus of these studies is on reducing such errors for expected returns. This study uses direct real estate data that is prone to smoothing in six of the seven countries, thus the risk estimate depends on the assumptions that are made to desmooth returns. Therefore, Bayes-Stein estimations are performed for various levels of standard deviation for direct real estate. Four levels of standard deviation are considered. The base assumption is to use the standard deviation of returns that have been desmoothed using the method described above. In addition, for each of the six countries for which smoothing constitutes an issue, the distance between the standard deviation of real estate computed with raw returns and the standard deviation of desmoothed returns is computed. The three other levels of risk that are considered correspond to a standard deviation equal to 0.25, 0.50 and 0.75, respectively, of that distance. For Switzerland, the Bayes-Stein procedure is only applied to raw returns.

As international assets are considered, the issue of exchange rate changes has to be addressed. Two alternative approaches can be considered. The first is to consider unhedged returns. The rationale for using this approach is to assume that the investor is willing to accept currency risk, for instance, if exchange rates are

hypothesized to be mean reverting. If such a hypothesis were true, then exchange rate changes will offset one another in the long run. Also, hedging costs can be deemed to be too high, and an investor may choose not to hedge against movements in exchange rates. An alternative approach is to consider that the investor will use forward contracts to hedge currency risk. The forward exchange rate between any two currencies at time $t$ ($F_t$) depends on the spot exchange rate ($S_0$) and the risk-free interest rate in each country over the period $p$. Formally:

$$F_t = S_0 \frac{(1 + r_{DOM})}{(1 + r_{FOR})}, \tag{5}$$

where $r_{FOR}$ is the risk-free interest rate in the foreign country for period $p$, and $r_{DOM}$ is the risk-free interest rate in the domestic currency for period $p$.

Hedging returns is accomplished by using the optimal hedge technique (Gardner and Wuilloud, 1995; and Solnik, 1996). If one assumes that the expected value of the currency surprise, *i.e.*, the change in the exchange rate that is not covered by hedging, is equal to zero, the optimal hedge ratio ($h^*$) can be computed as:

$$h^* = \frac{\sigma_u}{\sigma_e} \rho_{ue}, \tag{6}$$

where $\sigma_u$ is the standard deviation of unhedged returns, $\sigma_e$ is the standard deviation of the currency surprise and $\rho_{ue}$ is the correlation coefficient between the unhedged returns and the currency surprise. The hedge ratio is constrained to be less than or equal to 100%, as a higher ratio would imply that one is taking a position in the currency rather than hedging against currency movements.

When global indices are considered, computing hedged returns is problematic as hedging should be undertaken with respect to each currency. This is difficult to achieve from a practical perspective. For all countries except the U.S., returns were hedged with respect to the U.S. dollar. This is a somewhat simplifying assumption as not all assets are denominated in $US. The bulk of assets, however, are U.S. assets, so the impact of this simplification would be expected to be marginal. For the U.S. investor, the MSCI world hedged index for the period 1988–2001 is used, the period for which the series is available. For 1987, the average cost of hedging for the longer time period is used. The hedged returns for real estate stocks and bonds are computed by deducting the difference between unhedged and hedged returns for common stocks from the unhedged returns. This assumes implicitly that the relative market capitalizations of the various asset classes across countries are the same as for stocks. For real estate, the hedged

returns for each of the foreign countries are computed and then weighted using the GDP figures to obtain the 'world' index.

For each of the seven countries, the impact of including direct domestic real estate investments in portfolios containing financial assets and real estate securities is investigated first. This impact is measured by the reduction in risk that results from including domestic real estate in a portfolio. Also, the weight allocated to real estate in the efficient portfolios is analyzed. The financial assets considered are: domestic cash, domestic stocks, domestic bonds, international stocks and international bonds. Both domestic and international real estate securities are included in the base efficient frontier. This can be motivated by the fact that investing in indirect real estate investments is quite simple (no management burden, easier to achieve intra-asset diversification, more liquidity in some instances), and in that respect listed real estate stocks are quite similar to financial assets.

Once the role of direct domestic real estate investments in diversifying portfolios of financial assets and real estate securities has been ascertained, international real estate investments are investigated to see if they offer diversification benefits above those derived from holding direct domestic real estate. For that purpose, a third efficient frontier containing all asset classes considered in the previous frontier is constructed, but the world real estate index excludes the country under analysis. Again, the reduction in the portfolio's risk indicates the usefulness of adding international direct real estate to portfolios of financial assets, real estate securities and direct domestic real estate assets. The analyses are conducted first with unhedged returns, then with hedged returns. To test for the robustness of the results, the analyses are also undertaken on the restricted 1988–2001 period, *i.e.*, when year 1987 is discarded, and the optimal allocations are compared to real estate in the minimum variance portfolio (MVP).

## Data

This study uses annual data pertaining to stocks, bonds, direct real estate, indirect real estate (*i.e.*, real estate securities) and cash for the U.S., U.K., France, Netherlands, Sweden, Switzerland and Australia for the period 1986–2001; however, optimizations pertain to the period 1987–2001 as one observation is lost in the desmoothing process. All returns are total returns (*i.e.*, they include the capital and income return components). The stock and real estate security data are extracted from the *Ecowin* database. Stock indices are the Morgan Stanley Capital International (MSCI) indices and real estate security indices are the Global Property Research (GPR) indices. The cash data pertain to three-month T-bills. Bond data are from the Salomon Smith Barney (SSB) database and represent all maturity government bond indices. Direct real estate indices are from various sources. Exhibit 1 contains for each of the seven countries the source of the real estate index, the type of index, the number of properties considered in the index

**Exhibit 1** | Description of Direct Real Estate Indices Used

| Country | Source | Type | Properties in Index in 2001 | Value of Buildings in 2001 (bn $US) | Property Types |
|---|---|---|---|---|---|
| U.S. | NCREIF | Appraisal-based | 3,956 | 124 | 42% office, 20% retail, 20% industrial, 18% residential |
| U.K. | IPD | Appraisal-based | 11,934 | 143 | 46% retail, 37% office, 14% industrial, 3% other |
| France | IPD Research | Appraisal-based | 3,921 | 47 | 54% office, 27% residential, 10% retail, 9% other |
| Netherlands | ROZ/IPD | Repeated measures regression | 3,866 observations (in 2000) | N.A. | 53% residential, 26% office, 21% retail |
| Sweden | SFI/IPD | Appraisal-based | 2,401 (in 2001) | 23 | 69% office, 14% residential, 9% retail, 4% industrial, 5% other |
| Switzerland | IAZI/CIFI | Hedonic | 2,835 | 17 | Predominantly residential |
| Australia | Property Council | Appraisal-based | 1,600 | 26 | 50% office, 43% retail, 7% industrial |

*Note*: For France, the IPD index is used for the period 1998–2001, while an index computed by IPD Research is used for prior years. The latter index combines residential and office properties only.

and the main property types included in the index. Concerning the latter point, it must be stressed that the indices reflect the investment policy of institutional investors in each country. In the U.K., for instance, institutions mainly invest in offices and retail, whereas Swiss institutional investors predominantly invest in residential buildings. The asset classes that are included in this study thus are representative of the investment universe of institutional investors in each of the countries.

For Sweden, an additional issue to smoothing has to be addressed. Indeed, in 1991, deregulation occurred, which led to a high taxation of properties and price drops of up to 30%, a drop in values that exceeded the fundamental losses on the market. Here the effect of the shock to the market has been estimated through a regression analysis in order to correct for this one-time effect. The corrected change in value for 1991 used in the analysis is −13.7%. This return was used as the new raw return for 1991, and desmoothing procedures were used on this modified return.

The MSCI global stock index, the SSB world bond index and the GPR world index are also employed. For direct real estate, 'world' indices are constructed by weighting the constituent indices by the respective Gross Domestic Products (GDPs), excluding the country under analysis. A version of the 'world' real estate index is constructed for each country considered by excluding that country from the index. The world index for direct real estate that will be used for the analysis from the perspective of a U.S. investor, for instance, will be constructed ex the U.S. direct real estate index.

Exhibit 2 contains summary statistics for the various asset classes in each country. For real estate, statistics for the raw return series, and when applicable, statistics for the desmoothed real estate returns are reported. As anticipated, stocks constitute the highest return and risk asset class, while cash exhibits low return and risk parameters. Also, bonds appear to have a higher return and risk than cash, but a lower return and risk than stocks. The performance of real estate securities varies quite substantially from one country to another. This is largely due to institutional differences across countries. Real estate funds invest in various property types; their degree of leverage varies, and so does their tax status. U.K. property companies are quite highly leveraged for instance, while Swiss real estate mutual funds are not. U.S. REITs are tax transparent, whereas profits are taxed at the corporation level in most other countries.

From a mean-variance perspective, real estate securities do not appear very appealing as compared to financial assets. In Sweden and the Netherlands, real estate stocks exhibit a lower return than cash, while their standard deviation is quite high. In France, the return on real estate stocks is only marginally higher than that on cash. In the U.S. and U.K., the return on real estate securities lies between that of stocks and bonds, but the standard deviation of securitized real estate is higher than that of common stocks. Switzerland is the only country in which mean-variance efficiency is not violated for real estate securities: the

**Exhibit 2** | Summary Statistics

| Country | Mean | Std. Dev. | Max | Min | B-S Mean |
|---|---|---|---|---|---|
| Panel A: Australia | | | | | |
| Cash | 8.5 | 4.2 | 17.7 | 4.9 | 8.4 |
| Domestic Bonds | 11.8 | 8.5 | 25.5 | −6.5 | 11.4 |
| Global Bonds | 10.6 | 14.4 | 32.7 | −15.8 | |
| Domestic Stocks | 11.6 | 14.2 | 38.7 | −14.1 | 14.1 |
| Global Stocks | 12.4 | 16.5 | 41.6 | −14.2 | |
| Domestic RE Stocks | 16.0 | 10.2 | 32.6 | −2.8 | 14.2 |
| Global RE Stocks | 8.2 | 19.0 | 57.9 | −19.9 | |
| Domestic RE | 9.5 | 10.1 | 31.6 | −7.8 | |
| Global RE | 10.0 | 13.0 | 33.7 | −6.8 | |
| Desmoothed Domestic RE | 9.9 | 12.8 | 36.0 | −14.8 | 9.2 |
| Desmoothed Global RE | 7.8 | 10.6 | 20.3 | −18.0 | |
| Panel B: France | | | | | |
| Cash | 6.6 | 2.7 | 10.3 | 3.0 | 6.6 |
| Domestic Bonds | 8.9 | 7.2 | 20.9 | −5.7 | 9.0 |
| Global Bonds | 9.4 | 12.0 | 25.6 | −12.4 | |
| Domestic Stocks | 14.4 | 26.5 | 57.0 | −28.0 | 14.8 |
| Global Stocks | 12.2 | 20.5 | 45.1 | −25.4 | |
| Domestic RE Stocks | 5.2 | 17.0 | 38.9 | −16.9 | 5.9 |
| Global RE Stocks | 8.4 | 25.3 | 65.6 | −29.7 | |
| Domestic RE | 7.8 | 10.7 | 23.8 | −10.5 | |
| Global RE | 9.2 | 13.4 | 30.4 | −9.8 | |
| Desmoothed Domestic RE | 7.9 | 17.9 | 38.9 | −19.1 | 8.5 |
| Desmoothed Global RE | 7.9 | 10.9 | 20.1 | −18.1 | |
| Panel C: The Netherlands | | | | | |
| Cash | 5.2 | 2.7 | 9.4 | 0.0 | 5.3 |
| Domestic Bonds | 7.4 | 6.5 | 18.6 | −4.5 | 7.6 |
| Global Bonds | 9.4 | 12.6 | 26.9 | −15.1 | |
| Domestic Stocks | 16.2 | 20.8 | 45.9 | −17.4 | 15.3 |
| Global Stocks | 12.1 | 20.8 | 45.1 | −25.0 | |
| Domestic RE Stocks | 4.9 | 16.2 | 37.8 | −26.2 | 5.7 |
| Global RE Stocks | 8.3 | 25.3 | 65.4 | −29.3 | |
| Domestic RE | 10.6 | 4.5 | 18.1 | 2.8 | |

**Exhibit 2** | (continued)

Summary Statistics

| Country | Mean | Std. Dev. | Max | Min | B-S Mean |
|---|---|---|---|---|---|
| Panel C: The Netherlands (continued) | | | | | |
| Global RE | 9.0 | 12.8 | 28.8 | −8.1 | |
| Desmoothed Domestic RE | 10.3 | 13.3 | 31.2 | −11.9 | 9.3 |
| Desmoothed Global RE | 7.8 | 10.7 | 20.2 | −18.4 | |
| Panel D: Sweden | | | | | |
| Cash | 7.9 | 3.6 | 13.7 | 3.1 | 7.9 |
| Domestic Bonds | 12.5 | 12.3 | 29.6 | −11.6 | 12.0 |
| Global Bonds | 11.8 | 15.0 | 40.3 | −13.9 | |
| Domestic Stocks | 20.9 | 33.0 | 90.3 | −27.6 | 16.6 |
| Global Stocks | 14.1 | 19.0 | 45.5 | −23.5 | |
| Domestic RE Stocks | 2.3 | 26.2 | 43.3 | −39.7 | 3.7 |
| Global RE Stocks | 10.5 | 26.1 | 82.8 | −27.8 | |
| Domestic RE | 11.5 | 14.8 | 37.1 | −13.2 | |
| Global RE | 11.2 | 12.3 | 26.5 | −5.5 | |
| Desmoothed Domestic RE | 12.6 | 23.0 | 61.0 | −31.6 | 10.1 |
| Desmoothed Global RE | 7.9 | 10.7 | 20.6 | −18.1 | |
| Panel E : Switzerland | | | | | |
| Cash | 4.2 | 2.6 | 8.9 | 1.4 | 4.3 |
| Domestic Bonds | 5.0 | 5.3 | 14.0 | −3.0 | 5.6 |
| Global Bonds | 8.8 | 13.7 | 26.5 | −17.6 | |
| Domestic Stocks | 14.5 | 24.9 | 57.3 | −28.4 | 14.9 |
| Global Stocks | 11.8 | 22.6 | 46.4 | −29.9 | |
| Domestic RE Stocks | 6.6 | 16.3 | 46.2 | −21.4 | 6.9 |
| Global RE Stocks | 7.9 | 26.3 | 57.1 | −33.9 | |
| Domestic RE | 2.6 | 6.0 | 16.2 | −5.6 | 6.7 |
| Global RE | 8.6 | 14.1 | 34.5 | −12.2 | |
| Desmoothed Domestic RE | NA | NA | NA | NA | |
| Desmoothed Global RE | 7.9 | 10.7 | 20.2 | −18.3 | |

**Exhibit 2** | (continued)

Summary Statistics

| Country | Mean | Std. Dev. | Max | Min | B-S Mean |
|---|---|---|---|---|---|
| Panel F: United Kingdom | | | | | |
| Cash | 8.3 | 3.2 | 14.8 | 4.9 | 8.2 |
| Domestic Bonds | 10.6 | 8.1 | 22.0 | −6.9 | 10.4 |
| Global Bonds | 8.7 | 13.9 | 36.3 | −17.6 | |
| Domestic Stocks | 12.4 | 14.6 | 36.6 | −11.8 | 14.3 |
| Global Stocks | 11.1 | 18.7 | 31.3 | −29.0 | |
| Domestic RE Stocks | 11.7 | 28.7 | 91.6 | −18.1 | 10.9 |
| Global RE Stocks | 7.1 | 22.2 | 58.3 | −33.0 | |
| Domestic RE | 10.9 | 10.5 | 29.6 | −8.5 | |
| Global RE | 7.6 | 10.3 | 25.4 | −8.7 | |
| Desmoothed Domestic RE | 11.0 | 11.5 | 30.1 | −12.1 | 9.5 |
| Desmoothed Global RE | 7.6 | 10.9 | 20.3 | −19.3 | |
| Panel G: United States | | | | | |
| Cash | 5.9 | 1.7 | 9.2 | 3.2 | 5.9 |
| Domestic Bonds | 8.0 | 6.3 | 18.3 | −3.4 | 8.2 |
| Global Bonds | 7.9 | 5.4 | 16.9 | −3.3 | |
| Domestic Stocks | 15.0 | 16.9 | 38.2 | −12.5 | 15.0 |
| Global Stocks | 10.4 | 15.5 | 25.3 | −16.5 | |
| Domestic RE Stocks | 10.6 | 20.0 | 41.0 | −34.2 | 10.0 |
| Global RE Stocks | 6.4 | 19.7 | 54.7 | −21.3 | |
| Domestic RE | 6.7 | 6.0 | 15.3 | −5.6 | |
| Global RE | 9.1 | 8.9 | 25.7 | −3.1 | |
| Desmoothed Domestic RE | 7.6 | 11.7 | 20.6 | −21.0 | 8.4 |
| Desmoothed Global RE | 9.0 | 11.8 | 26.6 | −10.5 | |

*Note*: Average return, standard deviation, maximum return, minimum return and Bayes−Stein shrunk return. All returns are annual and in percentages. RE stands for real estate. The time period is 1987–2001.

standard deviation on real estate stocks lies between that of stocks and bonds, but the average return on indirect real estate investments is only marginally higher than that on bonds. In Australia, the return and risk parameters of real estate securities are very favorable: the return is higher than that on common stocks, while the standard deviation lies between that of stocks and bonds.

Direct real estate in all countries but the U.K. and the Netherlands exhibits a lower return than bonds, but a higher return than cash (except in Switzerland). The relatively poor results for real estate are due partly to the time period examined in that it does not cover the entire bullish period of the 1980s, but includes the bearish markets of the 1990s. Assessing the risk of real estate investments as compared to other asset classes is more difficult due to the smoothing of appraisal-based return series. The standard deviation of real estate as computed on raw returns is higher than that of bonds (except in the U.S. and the Netherlands). There is evidence also to suggest that the risk of real estate is lower than that of stocks (see also Francis and Ibbotson, 2001). If there are benefits associated to holding real estate assets in mixed-asset portfolios, then these would not come primarily as a result of favorable return and risk parameters, but rather from low correlations between real estate returns and the returns of financial assets.

When real estate securities are compared to desmoothed direct real estate investments, the levels of risk appear to be quite comparable in five out of seven countries. In the U.S. and the U.K., however, the standard deviation of indirect real estate is substantially higher than that of desmoothed direct real estate investments. As noted above, the standard deviation of real estate stocks in the two countries is even higher than that of common stocks. Far more discrepancies exist as pertains to the comparison between the average return on direct and indirect real estate investments. In Sweden and the Netherlands, the return on indirect investments is substantially lower than that on direct real estate, while the opposite holds in Australia, but also in Switzerland and in the U.S.

Exhibit 2 also contains the mean of domestic assets when returns have been shrunk using the Bayes-Stein procedure. Obviously, an increase in the mean will lead to that asset class having a larger weight in optimal portfolios than if standard mean-variance analysis was undertaken, and vice versa. In most cases, the impact of shrinking the mean towards the mean of the asset class is small. There are some exceptions, however. The most striking one is the increase of the average return on Swiss real estate, and to a lesser extent the increase of the average return of Australian stocks, and the decrease in the return of Swedish common stocks.

## Results with Unhedged Returns

First, the results with unhedged returns are considered (*i.e.*, with all returns calculated in the currency of the country under consideration). As mentioned above, an investor can well decide to adopt such a strategy, for instance if the individual believes that exchange rates are mean reverting. In such a scenario,

exchange rate changes will offset one another over a reasonable period of time. An unhedged strategy could also be adopted by an investor who is willing to bear exchange rate risk if the belief is that hedging costs are too high. Even if an investor wishes to hedge currency risk, it is important to conduct the analysis in two parts: first with unhedged returns and then with hedged returns.

In portfolio allocation models, correlation coefficients between asset classes have a substantial impact on the amount of risk reduction that is achieved through diversification. The closer the correlation between two assets is to $-1$, the greater the diversification benefits. These benefits diminish with increasing correlation coefficients, and disappear when the correlation coefficient is equal to 1. The correlation coefficients between asset classes in each of the seven countries considered are reported in Exhibit 3, Panels A–G.

Domestic real estate returns appear to be negatively correlated to domestic bond returns in all countries except the Netherlands. In fact, the negative relation is quite strong in five out of seven countries. A negative relation is also found between domestic real estate and international bonds, except for the Netherlands and Switzerland where this relationship is positive. In contrast, real estate returns appear to be positively correlated with the return on both domestic and global stocks. The only exception to this is Australia, where the relationship is negative. Hence, whereas the general conclusion is that real estate returns are negatively correlated with bonds returns, the relationship between real estate and stocks is positive in most instances.

Real estate stocks are in most cases not highly correlated with direct real estate investments, providing further evidence that such stocks are poor indicators of market behavior in the underlying markets and/or that financial markets are more efficient in discounting information. Noticeable exceptions are the U.K. and Sweden: in these two countries, the correlation between direct and indirect real estate returns is fairly high during the period of analysis (correlation of 0.66 and 0.60, respectively). Furthermore, real estate stocks appear to be highly correlated with common stocks, except in the U.S. (0.12). In the context of portfolio diversification, these results suggest that both types of real estate investments are not substitutes for one another, and that for investors holding financial assets, real estate investments offer greater diversification benefits than real estate stocks (see also Stevenson, 2001b).

International direct real estate investments generally appear to have higher correlations with financial assets (both domestic and international) than direct domestic investments, suggesting that the latter provide greater diversification benefits. International real estate investments should, however, still prove very useful in diversifying a portfolio containing financial assets, indirect real estate and direct domestic real estate assets, as the correlation between international and domestic real estate is quite low as compared to the correlations between domestic and international stocks and bonds. This suggests that real estate markets are more local than financial markets, and hence that the benefits from international diversification should be greater.

**Exhibit 3** | Correlation Matrices of Unhedged Returns: 1987–2001

| Country | Cash | Domestic Bonds | Global Bonds | Domestic Stocks | Global Stocks | Domestic RE Stocks | Global RE Stocks | Desmoothed Domestic RE | Desmoothed Global RE |
|---|---|---|---|---|---|---|---|---|---|
| Panel A: Australia | | | | | | | | | |
| Cash | 1.00 | | | | | | | | |
| Domestic Bonds | 0.43 | 1.00 | | | | | | | |
| Global Bonds | −0.17 | 0.53 | 1.00 | | | | | | |
| Domestic Stocks | −0.08 | 0.39 | 0.27 | 1.00 | | | | | |
| Global Stocks | −0.13 | 0.32 | 0.48 | 0.60 | 1.00 | | | | |
| Domestic RE Stocks | −0.11 | 0.60 | 0.43 | 0.64 | 0.35 | 1.00 | | | |
| Global RE Stocks | −0.11 | 0.41 | 0.37 | 0.73 | 0.35 | 0.72 | 1.00 | | |
| Desmoothed Domestic RE | 0.04 | −0.42 | −0.53 | −0.25 | −0.14 | −0.02 | −0.03 | 1.00 | |
| Desmoothed Global RE | −0.27 | −0.38 | −0.10 | −0.08 | 0.34 | 0.09 | 0.18 | 0.68 | 1.00 |
| Panel B: France | | | | | | | | | |
| Cash | 1.00 | | | | | | | | |
| Domestic Bonds | 0.33 | 1.00 | | | | | | | |
| Global Bonds | −0.18 | 0.48 | 1.00 | | | | | | |
| Domestic Stocks | −0.23 | 0.25 | 0.68 | 1.00 | | | | | |
| Global Stocks | −0.29 | 0.23 | 0.63 | 0.91 | 1.00 | | | | |
| Domestic RE Stocks | −0.23 | 0.29 | 0.44 | 0.65 | 0.54 | 1.00 | | | |
| Global RE Stocks | −0.05 | 0.48 | 0.67 | 0.58 | 0.64 | 0.54 | 1.00 | | |
| Desmoothed Domestic RE | −0.38 | −0.49 | −0.01 | 0.42 | 0.35 | 0.34 | 0.03 | 1.00 | |
| Desmoothed Global RE | −0.55 | −0.03 | 0.11 | 0.30 | 0.36 | 0.33 | 0.28 | 0.38 | 1.00 |

**Exhibit 3** | (continued)

Correlation Matrices of Unhedged Returns: 1987–2001

| Country | Cash | Domestic Bonds | Global Bonds | Domestic Stocks | Global Stocks | Domestic RE Stocks | Global RE Stocks | Desmoothed Domestic RE | Desmoothed Global RE |
|---|---|---|---|---|---|---|---|---|---|
| Panel C: The Netherlands | | | | | | | | | |
| Cash | 1.00 | | | | | | | | |
| Domestic Bonds | 0.21 | 1.00 | | | | | | | |
| Global Bonds | −0.11 | 0.36 | 1.00 | | | | | | |
| Domestic Stocks | 0.02 | 0.18 | 0.68 | 1.00 | | | | | |
| Global Stocks | −0.18 | 0.06 | 0.64 | 0.87 | 1.00 | | | | |
| Domestic RE Stocks | −0.31 | 0.20 | 0.60 | 0.71 | 0.66 | 1.00 | | | |
| Global RE Stocks | −0.13 | 0.24 | 0.66 | 0.61 | 0.64 | 0.83 | 1.00 | | |
| Desmoothed Domestic RE | −0.13 | 0.27 | 0.38 | 0.40 | 0.37 | 0.27 | 0.31 | 1.00 | |
| Desmoothed Global RE | −0.52 | −0.14 | 0.10 | 0.39 | 0.39 | 0.40 | 0.25 | 0.18 | 1.00 |
| Panel D: Sweden | | | | | | | | | |
| Cash | 1.00 | | | | | | | | |
| Domestic Bonds | 0.21 | 1.00 | | | | | | | |
| Global Bonds | −0.03 | 0.44 | 1.00 | | | | | | |
| Domestic Stocks | −0.23 | 0.11 | 0.23 | 1.00 | | | | | |
| Global Stocks | −0.20 | 0.36 | 0.57 | 0.84 | 1.00 | | | | |
| Domestic RE Stocks | −0.45 | −0.09 | 0.08 | 0.44 | 0.33 | 1.00 | | | |
| Global RE Stocks | −0.08 | 0.42 | 0.62 | 0.52 | 0.62 | 0.61 | 1.00 | | |
| Desmoothed Domestic RE | −0.28 | −0.33 | −0.20 | 0.21 | 0.22 | 0.60 | 0.10 | 1.00 | |
| Desmoothed Global RE | −0.57 | −0.13 | 0.03 | 0.37 | 0.40 | 0.64 | 0.22 | 0.73 | 1.00 |

**Exhibit 3** | (continued)

Correlation Matrices of Unhedged Returns: 1987–2001

| Country | Cash | Domestic Bonds | Global Bonds | Domestic Stocks | Global Stocks | Domestic RE Stocks | Global RE Stocks | Desmoothed Domestic RE | Desmoothed Global RE |
|---|---|---|---|---|---|---|---|---|---|
| Panel E: Switzerland | | | | | | | | | |
| Cash | 1.00 | | | | | | | | |
| Domestic Bonds | 0.03 | 1.00 | | | | | | | |
| Global Bonds | −0.12 | 0.24 | 1.00 | | | | | | |
| Domestic Stocks | −0.09 | 0.45 | 0.73 | 1.00 | | | | | |
| Global Stocks | −0.36 | 0.02 | 0.73 | 0.67 | 1.00 | | | | |
| Domestic RE Stocks | −0.02 | 0.71 | 0.37 | 0.50 | 0.30 | 1.00 | | | |
| Global RE Stocks | −0.22 | 0.19 | 0.72 | 0.48 | 0.69 | 0.52 | 1.00 | | |
| Domestic RE | −0.20 | −0.12 | 0.17 | 0.44 | 0.35 | −0.12 | 0.05 | 1.00 | |
| Desmoothed Global RE | −0.74 | −0.08 | 0.05 | 0.28 | 0.33 | 0.02 | 0.23 | 0.44 | 1.00 |
| Panel F: United Kingdom | | | | | | | | | |
| Cash | 1.00 | | | | | | | | |
| Domestic Bonds | 0.20 | 1.00 | | | | | | | |
| Global Bonds | 0.03 | 0.45 | 1.00 | | | | | | |
| Domestic Stocks | 0.15 | 0.52 | 0.52 | 1.00 | | | | | |
| Global Stocks | −0.07 | 0.27 | 0.58 | 0.83 | 1.00 | | | | |
| Domestic RE Stocks | −0.29 | 0.29 | 0.00 | 0.32 | 0.21 | 1.00 | | | |
| Global RE Stocks | −0.18 | 0.25 | 0.54 | 0.41 | 0.56 | 0.68 | 1.00 | | |
| Desmoothed Domestic RE | −0.30 | −0.02 | −0.17 | 0.24 | 0.38 | 0.66 | 0.47 | 1.00 | |
| Desmoothed Global RE | −0.48 | −0.09 | −0.11 | 0.15 | 0.26 | 0.35 | 0.13 | 0.65 | 1.00 |

**Exhibit 3** | (continued)

Correlation Matrices of Unhedged Returns: 1987–2001

| Country | Cash | Domestic Bonds | Global Bonds | Domestic Stocks | Global Stocks | Domestic RE Stocks | Global RE Stocks | Desmoothed Domestic RE | Desmoothed Global RE |
|---|---|---|---|---|---|---|---|---|---|
| Panel G: United States | | | | | | | | | |
| Cash | 1.00 | | | | | | | | |
| Domestic Bonds | 0.23 | 1.00 | | | | | | | |
| Global Bonds | −0.06 | 0.86 | 1.00 | | | | | | |
| Domestic Stocks | 0.20 | 0.32 | 0.41 | 1.00 | | | | | |
| Global Stocks | 0.10 | 0.02 | 0.20 | 0.79 | 1.00 | | | | |
| Domestic RE Stocks | −0.34 | 0.27 | 0.42 | 0.12 | 0.16 | 1.00 | | | |
| Global RE Stocks | −0.11 | 0.12 | 0.33 | 0.02 | 0.45 | 0.57 | 1.00 | | |
| Desmoothed Domestic RE | −0.12 | −0.20 | −0.16 | 0.11 | 0.30 | 0.02 | 0.20 | 1.00 | |
| Desmoothed Global RE | 0.38 | −0.28 | −0.42 | 0.15 | 0.42 | −0.13 | 0.18 | 0.56 | 1.00 |

Caution should be exercised when considering the correlations between world indices. As such indices mostly comprise U.S. assets, the true correlations are best asserted by looking at the results in $US. The correlation between world real estate returns and world bond returns in $US is −0.42, while the correlation between global real estate and global stocks is 0.15, confirming the country-level results. With the currency movements, correlations between global returns increase substantially. For the French investor in Euros, the correlation between global real estate returns and global bond returns is 0.11, while the correlation between international real estate and global stocks is 0.36. Choosing between international assets thus does not appear to be straightforward based on the correlation coefficients only, and return and risk parameters will also have a substantial impact in determining the composition of optimal portfolios.

Exhibit 4, Panels A–G, contain the asset weights in the efficient portfolios. The first part of each panel reports the results for the frontier containing financial assets and real estate securities only. Then domestic real estate is added to the portfolio, and finally international real estate assets are considered. In each case, the reduction in risk from the base frontier is reported (*i.e.*, the frontier that includes financial assets and real estate securities only). The risk reduction is for portfolios that have the same return as those of the base frontier. Only desmoothed real estate series are considered. For Switzerland, however, the raw returns are used as smoothing does not appear to be an issue.

Most of the discussion of the results contained in Exhibit 4 pertains to the bottom end of the efficient frontiers (*i.e.*, the low-risk portfolios that institutional investors would typically consider). For a given return, the risk reduction derived from including domestic real estate in a mixed-asset portfolio is typically in the 5% to 10% range. The optimal weight that should be allocated to domestic real estate is in the 5% to 15% range, and very robust across countries. When international real estate is considered in addition to domestic real estate, the risk reduction usually is increased (10%–20%), and so is the weight allocated to real estate (15%–20%). This should provide for a more realistic view of the role of real estate as a portfolio diversifier. Indeed, as both domestic and international investments are considered for the other asset classes (except cash), there is no reason not to consider both domestic and international real estate investments.[4] In three countries (France, the U.K. and the U.S.), real estate holdings are quite evenly split between domestic and international assets, while domestic holdings dominate in Australia. In Sweden, Switzerland and the Netherlands, the bulk of the allocation to real estate is in foreign assets. From a practical perspective, this certainly makes sense as the real estate markets of these countries are quite small and investors would seek investment opportunities overseas. The breakdown between domestic and international real estate obviously depends also on how the currencies have feared over the period. In that respect, it should prove enlightening to examine the hedged returns as is done in the next section.

As far as other asset classes are concerned, the efficient portfolios at the bottom end of the frontier mainly contain low-risk investments (*i.e.*, predominantly cash

**Exhibit 4** | Portfolio Compositions: Unhedged Returns

| Country | MVP | 10% | 30% | 50% | 70% | 90% | Max $\sigma$ |
|---|---|---|---|---|---|---|---|
| Panel A: Australia | | | | | | | |
| Financial Assets Only | | | | | | | |
| RETURN | 9.3 | 9.8 | 10.7 | 11.7 | 12.7 | 13.7 | 14.2 |
| RISK | 3.6 | 3.7 | 4.5 | 5.9 | 7.5 | 9.2 | 10.2 |
| Cash | 80.9 | 73.7 | 58.2 | 41.3 | 24.5 | 7.6 | 0.0 |
| Domestic Bonds | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| International Bonds | 5.4 | 3.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 0.0 | 0.0 | 0.0 | 1.7 | 3.4 | 5.1 | 0.0 |
| International Stocks | 2.6 | 3.5 | 4.5 | 3.9 | 3.4 | 2.8 | 0.0 |
| Domestic RE Stocks | 11.1 | 19.9 | 37.2 | 53.0 | 68.8 | 84.6 | 100.0 |
| International RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Financial Assets and Domestic Real Estate | | | | | | | |
| Risk Reduction | −11% | −8% | −3% | −2% | −1% | −1% | 0% |
| Cash | 65.4 | 57.7 | 46.6 | 33.3 | 5.1 | 0.0 | 0.0 |
| Domestic Bonds | 0.0 | 0.0 | 0.0 | 1.1 | 15.8 | 2.8 | 0.0 |
| International Bonds | 13.5 | 10.7 | 4.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 6.2 | 7.2 | 6.3 | 5.4 | 10.1 | 8.9 | 0.0 |
| International Stocks | 0.0 | 0.0 | 1.3 | 3.1 | 0.9 | 1.1 | 0.0 |
| Domestic RE Stocks | 0.0 | 10.5 | 30.1 | 48.1 | 53.7 | 79.4 | 100.0 |
| International RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE | 14.9 | 13.9 | 10.9 | 8.9 | 14.3 | 7.7 | 0.0 |
| Financial Assets, Domestic Real Estate and International Real Estate | | | | | | | |
| Risk Reduction | −16% | −9% | −3% | −2% | −1% | −1% | 0% |
| Cash | 68.6 | 57.7 | 46.6 | 33.2 | 5.1 | 0.0 | 0.0 |
| Domestic Bonds | 0.0 | 0.0 | 0.0 | 1.2 | 15.8 | 2.8 | 0.0 |
| International Bonds | 8.3 | 8.6 | 4.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 4.7 | 6.5 | 6.3 | 5.5 | 10.1 | 8.9 | 0.0 |
| International Stocks | 0.0 | 0.0 | 1.3 | 3.1 | 0.9 | 1.1 | 0.0 |
| Domestic RE Stocks | 1.1 | 12.9 | 30.0 | 48.1 | 53.7 | 79.4 | 100.0 |
| International RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE | 2.4 | 9.8 | 10.9 | 8.9 | 14.3 | 7.7 | 0.0 |
| International RE | 14.9 | 4.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

but also domestic bonds). The total allocation to these asset classes is in the 50% to 80% range. It is not surprising that low-risk portfolios would contain a high percentage of these low-risk investments. Real estate constitutes an ideal diversifier to these assets as it is a relatively low-risk investment, as well as being negatively correlated to both cash and bonds. Domestic stocks usually do not appear in low-risk portfolios, but their weight increases as higher risk portfolios are considered. Global stocks almost never enter into the efficient combinations of assets even at high risk levels. Real estate stocks—domestic or international—never appear in

**Exhibit 4** | (continued)
Portfolio Compositions: Unhedged Returns

| Country | MVP | 10% | 30% | 50% | 70% | 90% | Max $\sigma$ |
|---|---|---|---|---|---|---|---|
| Panel B: France | | | | | | | |
| Financial Assets Only | | | | | | | |
| RETURN | 6.8 | 7.6 | 9.2 | 10.8 | 12.4 | 14.0 | 14.8 |
| RISK | 2.4 | 3.2 | 6.6 | 10.8 | 16.7 | 23.2 | 26.5 |
| Cash | 91.4 | 73.3 | 26.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 0.0 | 17.0 | 58.9 | 68.2 | 40.9 | 13.6 | 0.0 |
| International Bonds | 3.5 | 1.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 0.0 | 3.5 | 14.9 | 31.8 | 59.1 | 86.4 | 100.0 |
| International Stocks | 2.3 | 5.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 2.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| International RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Financial Assets and Domestic Real Estate | | | | | | | |
| Risk Reduction | −10% | −17% | −11% | 0% | 0% | 0% | 0% |
| Cash | 85.5 | 57.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 1.2 | 26.8 | 75.6 | 65.6 | 41.0 | 13.7 | 0.0 |
| International Bonds | 6.3 | 3.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 0.0 | 0.0 | 5.8 | 31.9 | 59.0 | 86.3 | 100.0 |
| International Stocks | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| International RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE | 6.6 | 11.4 | 18.5 | 2.5 | 0.0 | 0.0 | 0.0 |
| Financial Assets, Domestic Real Estate and International Real Estate | | | | | | | |
| Risk Reduction | −25% | −20% | −11% | 0% | 0% | 0% | 0% |
| Cash | 81.1 | 53.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 0.0 | 25.7 | 75.7 | 65.6 | 41.0 | 13.7 | 0.0 |
| International Bonds | 4.5 | 3.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 0.0 | 0.0 | 5.8 | 31.9 | 59.0 | 86.3 | 100.0 |
| International Stocks | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| International RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE | 3.1 | 9.4 | 18.5 | 2.5 | 0.0 | 0.0 | 0.0 |
| International RE | 11.3 | 7.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

the efficient portfolios, except for domestic real estate securities in Australia and to some extent in the U.S. The result for Australia is due to the fact that real estate stocks exhibit a higher return and lower risk than common stocks over the period 1987–2001.

**Exhibit 4** | (continued)
Portfolio Compositions: Unhedged Returns

| Country | MVP | 10% | 30% | 50% | 70% | 90% | Max $\sigma$ |
|---|---|---|---|---|---|---|---|
| Panel C: The Netherlands | | | | | | | |
| Financial Assets Only | | | | | | | |
| RETURN | 5.4 | 6.4 | 8.4 | 10.4 | 12.3 | 14.3 | 15.3 |
| RISK | 2.4 | 2.9 | 5.7 | 9.1 | 13.4 | 18.3 | 20.8 |
| Cash | 91.2 | 71.4 | 33.6 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 2.0 | 20.0 | 46.9 | 64.8 | 38.9 | 13.0 | 0.0 |
| International Bonds | 0.4 | 1.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 0.0 | 1.9 | 19.6 | 35.2 | 61.1 | 87.0 | 100.0 |
| International Stocks | 0.0 | 5.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 6.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| International RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Financial Assets and Domestic Real Estate | | | | | | | |
| Risk Reduction | −2% | −3% | −1% | −1% | 0% | 0% | 0% |
| Cash | 90.4 | 71.3 | 32.8 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 0.3 | 16.6 | 42.4 | 59.1 | 34.7 | 10.4 | 0.0 |
| International Bonds | 0.0 | 1.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 0.0 | 1.0 | 17.7 | 33.5 | 59.9 | 86.3 | 100.0 |
| International Stocks | 0.0 | 4.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 5.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| International RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE | 3.4 | 5.4 | 7.0 | 7.4 | 5.4 | 3.3 | 0.0 |
| Financial Assets, Domestic Real Estate and International Real Estate | | | | | | | |
| Risk Reduction | −19% | −21% | −6% | −1% | 0% | 0% | 0% |
| Cash | 81.0 | 62.0 | 22.5 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 2.6 | 14.5 | 43.2 | 53.4 | 34.7 | 10.5 | 0.0 |
| International Bonds | 1.4 | 4.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 0.0 | 0.0 | 14.8 | 33.8 | 59.9 | 86.2 | 100.0 |
| International Stocks | 0.0 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| International RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE | 1.1 | 3.3 | 4.9 | 6.1 | 5.4 | 3.3 | 0.0 |
| International RE | 12.9 | 15.5 | 14.6 | 6.8 | 0.0 | 0.0 | 0.0 |

## Results with Hedged Returns

When hedged returns are used, the most striking result concerns the substantial increase of the correlation between domestic and international bond returns, and to a lesser extent between cash and international bonds (Appendix A). The correlation coefficient between domestic and hedged international bonds is in the

**Exhibit 4** | (continued)
Portfolio Compositions: Unhedged Returns

| Country | MVP | 10% | 30% | 50% | 70% | 90% | Max $\sigma$ |
|---|---|---|---|---|---|---|---|
| Panel D: Sweden | | | | | | | |
| Financial Assets Only | | | | | | | |
| RETURN | 7.8 | 8.7 | 10.5 | 12.2 | 14.0 | 15.8 | 16.6 |
| RISK | 2.9 | 3.4 | 6.4 | 10.5 | 16.4 | 27.0 | 33.0 |
| Cash | 89.6 | 81.3 | 48.8 | 12.6 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 0.0 | 6.0 | 29.3 | 54.6 | 52.3 | 19.1 | 0.0 |
| International Bonds | 2.3 | 4.6 | 10.9 | 16.4 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 0.0 | 2.6 | 10.0 | 16.4 | 38.7 | 80.9 | 100.0 |
| International Stocks | 1.7 | 3.6 | 0.9 | 0.0 | 9.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 6.3 | 1.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| International RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Financial Assets and Domestic Real Estate | | | | | | | |
| Risk Reduction | −1% | −10% | −11% | −8% | 0% | 0% | 0% |
| Cash | 88.1 | 78.9 | 38.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 0.0 | 5.7 | 31.1 | 56.0 | 52.4 | 19.2 | 0.0 |
| International Bonds | 3.6 | 6.3 | 11.6 | 16.0 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 0.0 | 2.1 | 6.3 | 11.9 | 38.6 | 80.8 | 100.0 |
| International Stocks | 1.0 | 0.0 | 0.0 | 0.0 | 9.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 5.2 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| International RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE | 2.1 | 6.7 | 12.2 | 16.2 | 0.0 | 0.0 | 0.0 |
| Financial Assets, Domestic Real Estate and International Real Estate | | | | | | | |
| Risk Reduction | −19% | −17% | −11% | −8% | 0% | 0% | 0% |
| Cash | 78.0 | 68.8 | 38.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 0.0 | 8.3 | 31.1 | 56.0 | 52.4 | 19.1 | 0.0 |
| International Bonds | 2.6 | 5.4 | 11.6 | 16.0 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 0.0 | 2.1 | 6.3 | 11.9 | 38.6 | 80.9 | 100.0 |
| International Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 9.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| International RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE | 0.0 | 2.7 | 12.2 | 16.2 | 0.0 | 0.0 | 0.0 |
| International RE | 18.8 | 12.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

80% to 90% range. This is a normal consequence of the currency hedging strategy whose cost is linked to interest rates, which obviously also impact on bond returns. Correlation coefficients between international real estate securities and most other assets diminish when hedged returns are considered.[5] The correlations between domestic real estate returns and the returns on other assets are similar when hedged returns are used, except for the correlation between real estate and global bonds in France, and the correlation between real estate and global stocks in the U.K.

**Exhibit 4** | (continued)
Portfolio Compositions: Unhedged Returns

| Country | MVP | 10% | 30% | 50% | 70% | 90% | Max $\sigma$ |
|---|---|---|---|---|---|---|---|
| Panel E: Switzerland | | | | | | | |
| Financial Assets Only | | | | | | | |
| RETURN | 4.8 | 5.8 | 7.8 | 9.8 | 11.9 | 13.9 | 14.9 |
| RISK | 2.1 | 3.5 | 7.9 | 12.6 | 17.4 | 22.3 | 24.9 |
| Cash | 80.8 | 58.5 | 33.4 | 8.3 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 14.9 | 27.7 | 33.6 | 39.5 | 26.8 | 4.8 | 0.0 |
| International Bonds | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 0.0 | 3.9 | 20.1 | 36.3 | 55.9 | 77.2 | 100.0 |
| International Stocks | 4.2 | 9.9 | 12.9 | 15.9 | 17.3 | 18.0 | 0.0 |
| Domestic RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| International RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Financial Assets and Domestic Real Estate | | | | | | | |
| Risk Reduction | −4% | −3% | −1% | 0% | 0% | 0% | 0% |
| Cash | 77.0 | 50.8 | 27.9 | 4.8 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 15.3 | 30.7 | 35.7 | 40.8 | 26.8 | 4.9 | 0.0 |
| International Bonds | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 0.0 | 2.3 | 18.9 | 35.6 | 55.9 | 77.1 | 100.0 |
| International Stocks | 3.1 | 9.3 | 12.4 | 15.6 | 17.3 | 18.0 | 0.0 |
| Domestic RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| International RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE | 4.7 | 6.9 | 5.0 | 3.2 | 0.0 | 0.0 | 0.0 |
| Financial Assets, Domestic Real Estate and International Real Estate | | | | | | | |
| Risk Reduction | −36% | −31% | −14% | −11% | −8% | −2% | 0% |
| Cash | 75.9 | 54.6 | 27.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 8.1 | 14.5 | 12.1 | 9.7 | 0.0 | 0.0 | 0.0 |
| International Bonds | 0.0 | 5.7 | 9.0 | 11.8 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 0.0 | 0.7 | 15.0 | 29.3 | 55.3 | 84.8 | 100.0 |
| International Stocks | 1.2 | 2.6 | 1.1 | 0.0 | 2.3 | 1.1 | 0.0 |
| Domestic RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| International RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| International RE | 14.8 | 21.9 | 35.6 | 49.2 | 42.4 | 14.1 | 0.0 |

which drop dramatically. The correlations between domestic and global direct real estate remain fairly stable when hedged returns are used.

When hedged returns are considered (Appendix B), the positive impact of including domestic real estate investments in mixed-asset portfolios remains approximately the same as when unhedged returns are used. The reduction in risk is usually in the 5% to 10% range, although a bit higher in France. The optimal

**Exhibit 4** | (continued)
Portfolio Compositions: Unhedged Returns

| Country | MVP | 10% | 30% | 50% | 70% | 90% | Max $\sigma$ |
|---|---|---|---|---|---|---|---|
| Panel F: United Kingdom | | | | | | | |
| Financial Assets Only | | | | | | | |
| RETURN | 8.4 | 9.0 | 10.1 | 11.3 | 12.5 | 13.7 | 14.3 |
| RISK | 2.9 | 3.3 | 5.3 | 7.7 | 10.3 | 13.0 | 14.6 |
| Cash | 92.3 | 80.8 | 57.6 | 34.5 | 11.4 | 0.0 | 0.0 |
| Domestic Bonds | 0.0 | 8.4 | 16.1 | 22.3 | 27.8 | 15.1 | 0.0 |
| International Bonds | 2.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 0.0 | 7.8 | 25.6 | 43.2 | 60.8 | 84.9 | 100.0 |
| International Stocks | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 3.8 | 2.9 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| International RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Financial Assets and Domestic Real Estate | | | | | | | |
| Risk Reduction | −9% | −9% | −4% | −2% | −1% | 0% | 0% |
| Cash | 81.5 | 70.1 | 47.8 | 25.5 | 3.2 | 0.0 | 0.0 |
| Domestic Bonds | 1.0 | 11.8 | 17.2 | 22.7 | 28.1 | 13.7 | 0.0 |
| International Bonds | 4.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 0.0 | 5.0 | 22.8 | 40.7 | 58.4 | 85.0 | 100.0 |
| International Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| International RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE | 13.0 | 13.1 | 12.2 | 11.2 | 10.3 | 1.3 | 0.0 |
| Financial Assets, Domestic Real Estate and International Real Estate | | | | | | | |
| Risk Reduction | −20% | −11% | −4% | −2% | −1% | 0% | 0% |
| Cash | 80.0 | 67.1 | 47.8 | 25.5 | 3.2 | 0.0 | 0.0 |
| Domestic Bonds | 0.0 | 12.0 | 17.2 | 22.7 | 28.1 | 13.6 | 0.0 |
| International Bonds | 3.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 0.0 | 6.4 | 22.8 | 40.6 | 58.4 | 85.1 | 100.0 |
| International Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| International RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE | 0.5 | 9.1 | 12.2 | 11.2 | 10.3 | 1.3 | 0.0 |
| International RE | 14.8 | 5.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

allocation to domestic real estate in mixed-asset portfolios remains unchanged in the 5% to 15% range. Interestingly, international real estate securities usually do not appear in the optimal portfolios despite their returns being much less correlated with those of other assets when hedged returns are considered. This is due to the return and risk characteristics of these investments, which did not compare favorably with those of other assets during this period. The allocations to other asset classes change substantially in some cases. The allocation to bonds in France,

**Exhibit 4** | (continued)

Portfolio Compositions: Unhedged Returns

| Country | MVP | 10% | 30% | 50% | 70% | 90% | Max $\sigma$ |
|---|---|---|---|---|---|---|---|
| Panel G: United States | | | | | | | |
| Financial Assets Only | | | | | | | |
| RETURN | 6.1 | 7.0 | 8.8 | 10.6 | 12.3 | 14.1 | 15.0 |
| RISK | 1.6 | 2.4 | 5.1 | 8.0 | 11.1 | 14.7 | 16.9 |
| Cash | 91.4 | 73.0 | 43.5 | 10.8 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 0.0 | 0.0 | 24.4 | 45.7 | 31.8 | 2.9 | 0.0 |
| International Bonds | 5.9 | 16.6 | 4.5 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 0.0 | 7.0 | 22.0 | 36.5 | 58.1 | 83.2 | 100.0 |
| International Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 2.6 | 3.5 | 5.6 | 7.1 | 10.1 | 13.9 | 0.0 |
| International RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Financial Assets and Domestic Real Estate | | | | | | | |
| Risk Reduction | −4% | −9% | −7% | −6% | −2% | 0% | 0% |
| Cash | 87.2 | 66.0 | 30.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 0.0 | 0.0 | 29.6 | 41.6 | 17.0 | 0.0 | 0.0 |
| International Bonds | 6.9 | 18.7 | 3.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 0.0 | 4.7 | 17.3 | 32.5 | 57.7 | 83.6 | 100.0 |
| International Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 2.3 | 2.6 | 4.0 | 5.4 | 9.4 | 11.2 | 0.0 |
| International RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE | 3.6 | 8.0 | 15.6 | 20.4 | 15.8 | 5.2 | 0.0 |
| Financial Assets, Domestic Real Estate and International Real Estate | | | | | | | |
| Risk Reduction | −4% | −10% | −13% | −10% | −4% | −1% | 0% |
| Cash | 87.2 | 61.4 | 10.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 0.0 | 0.0 | 11.4 | 37.0 | 12.2 | 0.0 | 0.0 |
| International Bonds | 6.9 | 23.3 | 41.5 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 0.0 | 3.0 | 10.8 | 30.2 | 55.3 | 83.5 | 100.0 |
| International Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 2.3 | 2.2 | 2.0 | 6.7 | 10.8 | 9.1 | 0.0 |
| International RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE | 3.6 | 5.4 | 4.0 | 5.2 | 0.1 | 0.0 | 0.0 |
| International RE | 0.0 | 4.7 | 20.2 | 20.9 | 21.6 | 7.4 | 0.0 |

*Notes*: For each country, the upper part of the table reports the portfolios' return and risk, and the portfolio weights when financial assets only are considered. The second part of the table contains the results when financial assets and domestic real estate are considered. The third part contains the results when financial assets, domestic real estate, and international real estate are considered. For the letter two parts, risk reduction from including real estate is reported. Frontiers begin with the minimum variance portfolio (MVP), and end with the maximum risk portfolio. Portfolio compositions are also reported for 5 points on the frontier based on the proportional risk from the MVP to the high−risk portfolio (10%, 30%, 50%, 70% and 90%).

for instance, gets tilted from domestic bonds to global bonds when hedged returns are considered. This is also the case in the U.K. and to some extent in Sweden. Also, global stocks vanish from the portfolio of Swiss investors when hedged returns are used, while the share of domestic stocks increases.

When hedged international real estate investments are considered in addition to domestic real estate assets, the risk reduction is again in the 10% to 20% range. There are some noticeable differences from the benefits that are observed with unhedged returns. In Switzerland, the risk reduction diminishes substantially when hedged real estate returns are considered. The reverse holds for the U.K., where the risk reduction increases from approximately 10% to 20%. Thus, the hedging of currency risk can lead to the positive impact of including global real estate in the portfolio being either increased or decreased. The total allocation to real estate remains remarkably stable. As compared to the unhedged results, the breakdown between domestic and international real estate assets changes substantially in three of the seven countries when hedged returns are considered. The most striking change is for the U.K., where holdings are almost exclusively domestic when unhedged returns are considered, while they are primarily international when returns are hedged. With hedged returns, the U.S real estate holdings are now exclusively domestic, while international assets dominate the real estate component of Australian portfolios.

The allocations to other asset classes are remarkably stable, usually with a slightly higher emphasis on international assets as when unhedged returns are considered. Not surprisingly, the typical allocation at the left-hand side of the efficient frontier contains a high proportion of low-risk investments. The allocations to stocks are low, and so are the allocations to real estate stocks, except for domestic real estate stocks for the U.S. investor and international real estate securities for the Australian investor.[6]

## Sensitivity Analysis

Two types of sensitivity analysis are performed. First, the optimal allocation to real estate for the minimum variance portfolio (MVP) is re-calculated in each country using the restricted 1988–2001 period (*i.e.*, by deleting data for 1987). The MVP was chosen as it would provide the best risk level for comparisons across countries. The results of this analysis appear on the last line of both Panels of Exhibit 5. The overall allocation to real estate remains, in all cases, virtually unchanged,[7] providing support to the results despite the somewhat limited common time period for which data is available.

The second type of analysis addresses the issue of the sensitivity of the allocation to real estate to the level of the standard deviation of real estate that is used in determining the efficient sets using the Bayes-Stein procedure. The reported optimal weights to real estate that are reported in Exhibit 4 and Appendix B are for the desmoothed returns (except for Switzerland). Three alternative levels of

**Exhibit 5** | Sensitivity of Allocation to Real Estate

| | Australia | | France | | The Netherlands | | Sweden | | Switzerland | | U.K. | | U.S. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 87-01 | 88-01 | 87-01 | 88-01 | 87-01 | 88-01 | 87-01 | 88-01 | 87-01 | 88-01 | 87-01 | 88-01 | 87-01 | 88-01 |
| Panel A: Unhedged Returns | | | | | | | | | | | | | | |
| Unsmoothing: 0.25 | 26.6 | 25.6 | 23.2 | 23.6 | 26.6 | 26.6 | 30.0 | 30.2 | 23.3 | 23.3 | 23.8 | 23.6 | 5.3 | 5.2 |
| Unsmoothing: 0.50 | 21.9 | 21.1 | 19.2 | 19.7 | 20.9 | 21.0 | 25.7 | 25.9 | 19.4 | 19.4 | 19.7 | 19.5 | 4.6 | 4.5 |
| Unsmoothing: 0.75 | 19.1 | 18.9 | 16.7 | 17.1 | 17.0 | 17.2 | 22.5 | 22.6 | 16.9 | 16.9 | 17.2 | 17.7 | 4.0 | 4.0 |
| Unsmoothed | 17.3 | 17.9 | 14.4 | 14.8 | 14.0 | 14.0 | 18.8 | 18.7 | 14.8 | 14.7 | 15.3 | 16.6 | 3.6 | 3.5 |
| Panel B: Hedged Returns | | | | | | | | | | | | | | |
| Unsmoothing: 0.25 | 26.6 | 26.4 | 23.5 | 25.1 | 30.8 | 31.5 | 32.6 | 32.8 | 27.2 | 27.2 | 33.6 | 33.7 | 6.9 | 6.8 |
| Unsmoothing: 0.50 | 19.9 | 19.3 | 18.8 | 20.0 | 21.8 | 22.3 | 21.5 | 21.5 | 21.1 | 21.1 | 25.1 | 25.0 | 5.7 | 5.6 |
| Unsmoothing: 0.75 | 16.5 | 16.2 | 16.1 | 16.9 | 16.6 | 16.8 | 16.5 | 16.4 | 17.8 | 17.8 | 20.8 | 20.9 | 4.9 | 4.8 |
| Unsmoothed | 13.9 | 14.2 | 13.8 | 14.4 | 12.9 | 13.0 | 12.9 | 12.8 | 15.1 | 15.2 | 17.8 | 18.4 | 4.2 | 4.2 |

*Notes*: The table reports the optimal allocation to real estate in the MVP for two types of sensitivity analyses: (1) when one year of data is discarded from the analysis and (2) when various levels are used for the standard deviation of real estate. Four levels of standard deviation are used: the standard deviation computed on desmoothed returns, as well as a standard deviation equal to 0.25, 0.50 and 0.75, respectively, of the distance between the standard deviation computed on raw returns and the standard deviation with desmoothed returns. Both unhedged and hedged returns are considered.

standard deviation are considered for real estate returns in the various countries. These are set at 0.25, 0.50 and 0.75, respectively, of the distance between the standard deviation as computed with raw returns and the standard deviation when desmoothed returns are used. The three alternative levels used when estimating the optimal allocations are widespread enough, so that the results would be strengthened if similar conclusions were to prevail for the various levels of standard deviation (see Exhibit 5).

The allocation to real estate remains quite stable in most cases, and the general conclusion that 15% to 25% of a portfolio should be allocated to real estate remains valid. In some cases, however, the allocation to real estate varies quite substantially with the level of standard deviation. In the Netherlands, for instance, the range for the allocation to real estate is 13%–32% when hedged returns are used (Exhibit 5, Panel B). For the U.S. investor, the allocation to real estate in the MVP is lower than in other countries, and remains stable in the various specifications. The robustness of the results is an indication that much of the benefits from diversifying a mixed-asset portfolio with real estate are achieved by the low correlation between the returns on that asset class and the returns on financial assets.

It is interesting to compare the results with those of Corgel and deRoos (1999) who have conducted a comprehensive examination for the U.S. of the sensitivity of the allocation to real estate to the desmoothing method. They use four different ways of desmoothing real estate returns, and compare the optimal allocations to real estate obtained with each method. Three of these methods randomize the real estate series to rid current returns of the previous estimates of value. In other words, these methods assume that real estate markets are efficient. Auto-regressive models are used and the resulting desmoothed series exhibit by construction little serial correlation. The latter method is that devised by Geltner (1993) under the assumption that the volatility of real estate is one-half that of stocks. Corgel and deRoos (1999) use quarterly data for the first three methods, and annual data for the latter.

The Geltner (1993) approach is also used to desmooth real estate returns and use annual data. As discussed in the method section, the study posits that the standard deviation of real estate is half-way between that of stocks and bonds. In general, the results are less sensitive than those reported in Corgel and deRoos (1999), although the ranges for the Netherlands and Sweden are broadly consistent with those they report. Greater variance in the results of Corgel and deRoos would be expected as three of the four desmoothing methods they use will eliminate serial correlation in the series. This will lead to the standard deviation of real estate being inflated quite substantially, and therefore the allocation to real estate being diminished significantly as compared to when raw real estate returns are used. When the assumption is not made that markets are efficient, desmoothing will have less impact on the standard deviation, and hence the results should be more robust. In comparing the results here with those of Corgel and deRoos, one should also note that these authors report results for the whole efficient frontier, whereas

this study focused on the bottom end of the frontier. Further, their results are for the U.S. only, whereas this study examines seven countries including the U.S. Finally, their time period is 1979–1996 when they consider annual time increments, while this analysis spans the period 1987–2001.

## Conclusion

This paper provides an analysis of the benefits of including direct real estate—both domestic and international—in mixed-asset portfolios from the perspective of investors in seven countries on three continents. All countries are analyzed over the same time period (1987–2001) to permit cross-country comparisons. As international investments are considered, appropriate consideration has to be given to the issue of currency risk hedging. All analyses were first performed with unhedged returns, then with hedged returns.

Two main issues pertaining to the quality of real estate data are addressed. First, appraisal-based indices are corrected for smoothing using a variant of the method devised by Geltner (1993). In the desmoothing process, this study uses the average of the standard deviation of stocks and bonds, rather than the standard hypothesis of real estate's standard deviation being half that of stocks as has been made in most previous studies. Also, portfolio allocation models have been shown to be quite sensitive to the mean returns of assets. For that purpose, Bayes-Stein estimators are used, which should increase the stability of the portfolio compositions. The Bayes-Stein estimation of returns also has an intuitive appeal, in that the returns are shrunk towards an asset class global mean, implying less dependence on period-specific national returns. Sensitivity tests of the optimal allocation to real estate to the level of desmoothing of real estate returns are also performed.

The analyses with unhedged returns show that the optimal weight that should be allocated to real estate in mixed-asset portfolios is in the 5% to 15% range, and that the inclusion of real estate assets in such portfolios leads to a 5% to 10% reduction in the portfolio's risk level. When international real estate investments also are considered, the risk reduction is increased to 10% to 20%, and so is the weight that should be devoted to real estate in diversified portfolios. In such portfolios, the optimal allocation is remarkably constant across countries at approximately 15%. Not surprisingly, portfolios to the left of the efficient frontier contain a high allocation to low-risk investments. Domestic stocks usually do not appear in low-risk portfolios, but their weight increases as higher risk portfolios are considered. Real estate stocks seldom enter the efficient combinations of assets.

Results using hedged returns are remarkably similar: adding real estate in mixed-asset portfolios makes it possible to reduce a portfolio's risk by 10% to 20%, and the optimal allocation to real estate is in the 15% to 25% range. This conclusion holds true when a year of data is discarded from the period of analysis, and also

when various levels of the standard deviation of real estate are used in the portfolio optimizations. The breakdown of the real estate allocation between domestic and international assets is found to change from country to country and also depends on whether returns are hedged or not. Thus, although the benefits from including real estate in a portfolio are very similar across countries, the way of gaining exposure to real estate varies across countries: in some countries, the allocation is tilted towards either domestic or international assets, while it is balanced in other countries. The positive role of real estate in diversifying a portfolio is demonstrated, but the ways of achieving this vary according to the correlation of assets within each country, and to the strategy that is considered as pertains to the management of currency risk.

**Appendix A** Correlation Matrices of Hedged Returns

| | Cash | Domestic Bonds | Global Bonds | Domestic Stocks | Global Stocks | Domestic RE Stocks | Global RE Stocks | Desmoothed Domestic RE | Desmoothed Global RE |
|---|---|---|---|---|---|---|---|---|---|
| Panel A: Australia | | | | | | | | | |
| Cash | 1.00 | | | | | | | | |
| Domestic Bonds | 0.43 | 1.00 | | | | | | | |
| Global Bonds | 0.47 | 0.92 | 1.00 | | | | | | |
| Domestic Stocks | −0.08 | 0.39 | 0.45 | 1.00 | | | | | |
| Global Stocks | 0.01 | 0.29 | 0.32 | 0.64 | 1.00 | | | | |
| Domestic RE Stocks | −0.11 | 0.60 | 0.60 | 0.64 | 0.32 | 1.00 | | | |
| Global RE Stocks | −0.03 | 0.06 | 0.12 | −0.48 | −0.14 | −0.25 | 1.00 | | |
| Desmoothed Domestic RE | 0.04 | −0.42 | −0.37 | −0.25 | 0.02 | −0.02 | 0.05 | 1.00 | |
| Desmoothed Global RE | −0.06 | −0.25 | −0.24 | −0.13 | 0.34 | 0.10 | −0.04 | 0.72 | 1.00 |
| Panel B: France | | | | | | | | | |
| Cash | 1.00 | | | | | | | | |
| Domestic Bonds | 0.33 | 1.00 | | | | | | | |
| Global Bonds | 0.52 | 0.83 | 1.00 | | | | | | |
| Domestic Stocks | −0.23 | 0.25 | 0.16 | 1.00 | | | | | |
| Global Stocks | −0.10 | 0.25 | 0.32 | 0.75 | 1.00 | | | | |
| Domestic RE Stocks | −0.23 | 0.29 | 0.15 | 0.65 | 0.44 | 1.00 | | | |
| Global RE Stocks | 0.18 | −0.02 | 0.04 | −0.05 | 0.02 | −0.43 | 1.00 | | |
| Desmoothed Domestic RE | −0.38 | −0.49 | −0.65 | 0.42 | 0.22 | 0.34 | −0.08 | 1.00 | |
| Desmoothed Global RE | −0.38 | −0.02 | 0.01 | 0.25 | 0.42 | 0.26 | 0.11 | 0.25 | 1.00 |

**Appendix A** (continued)

Correlation Matrices of Hedged Returns

| | Cash | Domestic Bonds | Global Bonds | Domestic Stocks | Global Stocks | Domestic RE Stocks | Global RE Stocks | Desmoothed Domestic RE | Desmoothed Global RE |
|---|---|---|---|---|---|---|---|---|---|
| Panel C: Netherlands | | | | | | | | | |
| Cash | 1.00 | | | | | | | | |
| Domestic Bonds | 0.21 | 1.00 | | | | | | | |
| Global Bonds | 0.46 | 0.86 | 1.00 | | | | | | |
| Domestic Stocks | 0.02 | 0.18 | 0.37 | 1.00 | | | | | |
| Global Stocks | −0.01 | 0.15 | 0.26 | 0.78 | 1.00 | | | | |
| Domestic RE Stocks | −0.31 | 0.20 | 0.24 | 0.71 | 0.55 | 1.00 | | | |
| Global RE Stocks | 0.23 | 0.26 | 0.07 | −0.16 | 0.00 | −0.36 | 1.00 | | |
| Desmoothed Domestic RE | −0.13 | 0.27 | 0.26 | 0.40 | 0.25 | 0.27 | −0.14 | 1.00 | |
| Desmoothed Global RE | −0.42 | −0.08 | −0.12 | 0.41 | 0.40 | 0.39 | 0.10 | 0.13 | 1.00 |
| Panel D: Sweden | | | | | | | | | |
| Cash | 1.00 | | | | | | | | |
| Domestic Bonds | 0.21 | 1.00 | | | | | | | |
| Global Bonds | 0.53 | 0.79 | 1.00 | | | | | | |
| Domestic Stocks | −0.23 | 0.11 | 0.06 | 1.00 | | | | | |
| Global Stocks | −0.09 | 0.34 | 0.39 | 0.83 | 1.00 | | | | |
| Domestic RE Stocks | −0.45 | −0.09 | −0.13 | 0.44 | 0.30 | 1.00 | | | |
| Global RE Stocks | 0.30 | −0.08 | 0.18 | −0.08 | 0.01 | −0.14 | 1.00 | | |
| Desmoothed Domestic RE | −0.28 | −0.33 | −0.22 | 0.21 | 0.33 | 0.60 | 0.27 | 1.00 | |
| Desmoothed Global RE | −0.39 | −0.10 | −0.06 | 0.40 | 0.47 | 0.62 | 0.10 | 0.74 | 1.00 |

**Appendix A** (continued)

Correlation Matrices of Hedged Returns

| | Cash | Domestic Bonds | Global Bonds | Domestic Stocks | Global Stocks | Domestic RE Stocks | Global RE Stocks | Desmoothed Domestic RE | Desmoothed Global RE |
|---|---|---|---|---|---|---|---|---|---|
| Panel E: Switzerland | | | | | | | | | |
| Cash | 1.00 | | | | | | | | |
| Domestic Bonds | 0.03 | 1.00 | | | | | | | |
| Global Bonds | 0.34 | 0.87 | 1.00 | | | | | | |
| Domestic Stocks | −0.09 | 0.45 | 0.57 | 1.00 | | | | | |
| Global Stocks | −0.28 | 0.22 | 0.29 | 0.58 | 1.00 | | | | |
| Domestic RE Stocks | −0.02 | 0.71 | 0.63 | 0.50 | 0.35 | 1.00 | | | |
| Global RE Stocks | 0.06 | 0.25 | 0.05 | −0.02 | 0.06 | 0.09 | 1.00 | | |
| Domestic RE | −0.20 | −0.12 | −0.04 | 0.44 | 0.33 | −0.12 | 0.18 | 1.00 | |
| Desmoothed Global RE | −0.66 | 0.04 | −0.13 | 0.34 | 0.38 | 0.09 | 0.07 | 0.41 | 1.00 |
| Panel F: United Kingdom | | | | | | | | | |
| Cash | 1.00 | | | | | | | | |
| Domestic Bonds | 0.20 | 1.00 | | | | | | | |
| Global Bonds | 0.33 | 0.84 | 1.00 | | | | | | |
| Domestic Stocks | 0.15 | 0.52 | 0.50 | 1.00 | | | | | |
| Global Stocks | −0.03 | 0.29 | 0.29 | 0.75 | 1.00 | | | | |
| Domestic RE Stocks | −0.29 | 0.29 | 0.24 | 0.32 | 0.34 | 1.00 | | | |
| Global RE Stocks | 0.07 | 0.20 | 0.16 | −0.09 | 0.01 | −0.17 | 1.00 | | |
| Desmoothed Domestic RE | −0.30 | −0.02 | −0.18 | 0.24 | 0.53 | 0.66 | −0.10 | 1.00 | |
| Desmoothed Global RE | −0.42 | −0.04 | −0.31 | 0.19 | 0.33 | 0.42 | 0.05 | 0.70 | 1.00 |

**Appendix A** (continued)

Correlation Matrices of Hedged Returns

| | Cash | Domestic Bonds | Global Bonds | Domestic Stocks | Global Stocks | Domestic RE Stocks | Global RE Stocks | Desmoothed Domestic RE | Desmoothed Global RE |
|---|---|---|---|---|---|---|---|---|---|
| Panel G: United States | | | | | | | | | |
| Cash | 1.00 | | | | | | | | |
| Domestic Bonds | 0.23 | 1.00 | | | | | | | |
| Global Bonds | −0.16 | 0.80 | 1.00 | | | | | | |
| Domestic Stocks | 0.20 | 0.32 | 0.32 | 1.00 | | | | | |
| Global Stocks | 0.06 | 0.02 | 0.18 | 0.78 | 1.00 | | | | |
| Domestic RE Stocks | −0.34 | 0.27 | 0.42 | 0.12 | 0.18 | 1.00 | | | |
| Global RE Stocks | −0.14 | 0.12 | 0.33 | 0.01 | 0.44 | 0.58 | 1.00 | | |
| Desmoothed Domestic RE | −0.12 | −0.20 | −0.27 | 0.11 | 0.26 | 0.02 | 0.16 | 1.00 | |
| Desmoothed Global RE | 0.54 | −0.25 | −0.51 | 0.36 | 0.51 | −0.32 | 0.00 | 0.44 | 1.00 |

**Appendix B** | Portfolio Compositions: Hedged Returns

| | MVP | 10% | 30% | 50% | 70% | 90% | Max $\sigma$ |
|---|---|---|---|---|---|---|---|
| Panel A: Australia | | | | | | | |
| Financial Assets Only | | | | | | | |
| RETURN | 9.2 | 9.7 | 10.7 | 11.7 | 12.7 | 13.7 | 14.2 |
| RISK | 3.4 | 3.5 | 4.4 | 5.8 | 7.4 | 9.2 | 10.2 |
| Cash | 72.8 | 66.1 | 52.7 | 36.7 | 13.3 | 0.0 | 0.0 |
| Domestic Bonds | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Global Bonds | 0.0 | 0.0 | 0.0 | 6.2 | 22.4 | 15.5 | 0.0 |
| Domestic Stocks | 7.3 | 7.1 | 6.6 | 5.0 | 4.5 | 6.2 | 0.0 |
| Global Stocks | 0.0 | 0.0 | 0.1 | 0.6 | 0.2 | 0.0 | 0.0 |
| Domestic RE Stocks | 11.6 | 19.6 | 35.9 | 49.9 | 59.6 | 78.3 | 100.0 |
| Global RE Stocks | 8.3 | 7.1 | 4.7 | 1.6 | 0.0 | 0.0 | 0.0 |
| Financial Assets and Domestic Real Estate | | | | | | | |
| Risk Reduction | −4% | −4% | −3% | −5% | −3% | −1% | 0% |
| Cash | 65.9 | 59.3 | 38.4 | 1.6 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Global Bonds | 0.0 | 0.0 | 12.7 | 47.2 | 28.2 | 7.2 | 0.0 |
| Domestic Stocks | 10.0 | 9.8 | 8.8 | 8.2 | 8.3 | 8.4 | 0.0 |
| Global Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 8.1 | 15.8 | 25.9 | 25.3 | 51.7 | 79.1 | 100.0 |
| Global RE Stocks | 8.2 | 7.0 | 3.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE | 7.8 | 8.0 | 10.8 | 17.8 | 11.8 | 5.3 | 0.0 |
| Financial Assets, Domestic Real Estate and Global Real Estate | | | | | | | |
| Risk Reduction | −9% | −9% | −8% | −8% | −6% | −2% | 0% |
| Cash | 62.6 | 56.5 | 35.8 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Global Bonds | 0.0 | 0.0 | 11.5 | 44.9 | 22.2 | 0.0 | 0.0 |
| Domestic Stocks | 10.1 | 10.1 | 9.0 | 8.0 | 8.7 | 9.5 | 0.0 |
| Global Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 5.4 | 11.6 | 21.3 | 20.4 | 48.5 | 77.5 | 100.0 |
| Global RE Stocks | 8.1 | 7.1 | 3.6 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE | 0.0 | 0.0 | 0.0 | 4.0 | 0.0 | 0.0 | 0.0 |
| Global RE | 13.9 | 14.7 | 18.8 | 22.8 | 20.6 | 12.9 | 0.0 |

**Appendix B** | (continued)

Portfolio Compositions: Hedged Returns

| | MVP | 10% | 30% | 50% | 70% | 90% | Max $\sigma$ |
|---|---|---|---|---|---|---|---|
| Panel B: France | | | | | | | |
| Financial Assets Only | | | | | | | |
| RETURN | 6.6 | 7.4 | 9.1 | 10.7 | 12.4 | 14.0 | 14.8 |
| RISK | 2.5 | 2.9 | 5.4 | 9.5 | 16.0 | 23.0 | 26.5 |
| Cash | 91.3 | 80.5 | 20.6 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 0.0 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Global Bonds | 0.0 | 13.1 | 69.3 | 70.0 | 42.0 | 14.0 | 0.0 |
| Domestic Stocks | 0.3 | 5.6 | 10.1 | 30.0 | 58.0 | 86.0 | 100.0 |
| Global Stocks | 0.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 5.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Global RE Stocks | 1.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Financial Assets and Domestic Real Estate | | | | | | | |
| Risk Reduction | −9% | −21% | −25% | 0% | 0% | 0% | 0% |
| Cash | 78.6 | 64.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 4.5 | 2.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Global Bonds | 7.2 | 22.3 | 78.6 | 69.1 | 42.0 | 14.1 | 0.0 |
| Domestic Stocks | 0.0 | 0.0 | 3.2 | 29.9 | 58.0 | 85.9 | 100.0 |
| Global Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Global RE Stocks | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE | 8.3 | 10.9 | 18.2 | 1.0 | 0.0 | 0.0 | 0.0 |
| Financial Assets, Domestic Real Estate and Global Real Estate | | | | | | | |
| Risk Reduction | −17% | −25% | −25% | 0% | 0% | 0% | 0% |
| Cash | 81.2 | 63.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 4.4 | 4.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Global Bonds | 0.0 | 15.8 | 78.6 | 69.1 | 42.1 | 14.1 | 0.0 |
| Domestic Stocks | 0.0 | 0.0 | 3.2 | 30.0 | 57.9 | 85.9 | 100.0 |
| Global Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Global RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE | 5.3 | 8.7 | 18.1 | 0.9 | 0.0 | 0.0 | 0.0 |
| Global RE | 8.5 | 7.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

**Appendix B** | (continued)

Portfolio Compositions: Hedged Returns

| | MVP | 10% | 30% | 50% | 70% | 90% | Max $\sigma$ |
|---|---|---|---|---|---|---|---|
| Panel C: The Netherlands | | | | | | | |
| Financial Assets Only | | | | | | | |
| RETURN | 5.4 | 6.3 | 8.3 | 10.3 | 12.3 | 14.3 | 15.3 |
| RISK | 2.4 | 3.0 | 5.7 | 9.1 | 13.4 | 18.3 | 20.8 |
| Cash | 90.8 | 75.6 | 34.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 1.6 | 18.4 | 46.5 | 61.6 | 39.0 | 13.0 | 0.0 |
| Global Bonds | 0.0 | 0.0 | 0.0 | 3.5 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 0.0 | 6.0 | 19.4 | 34.9 | 61.0 | 87.0 | 100.0 |
| Global Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 6.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Global RE Stocks | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Financial assets and domestic real estate | | | | | | | |
| Risk Reduction | −2% | −3% | −1% | −1% | 0% | 0% | 0% |
| Cash | 89.3 | 74.9 | 33.3 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 0.0 | 14.7 | 42.0 | 55.5 | 34.8 | 10.4 | 0.0 |
| Global Bonds | 0.0 | 0.0 | 0.1 | 3.7 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 0.0 | 4.5 | 17.6 | 33.3 | 59.8 | 86.3 | 100.0 |
| Global Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 6.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Global RE Stocks | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE | 3.5 | 6.0 | 7.0 | 7.5 | 5.4 | 3.3 | 0.0 |
| Financial Assets, Domestic Real Estate and Global Real Estate | | | | | | | |
| Risk Reduction | −13% | −15% | −3% | −1% | 0% | 0% | 0% |
| Cash | 82.9 | 64.8 | 21.5 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 1.7 | 15.3 | 30.4 | 55.5 | 34.9 | 10.5 | 0.0 |
| Global Bonds | 0.0 | 0.0 | 17.0 | 3.8 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 0.0 | 2.1 | 14.2 | 33.3 | 59.7 | 86.2 | 100.0 |
| Global Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 2.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Global RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE | 2.4 | 5.2 | 6.6 | 7.5 | 5.4 | 3.3 | 0.0 |
| Global RE | 10.5 | 12.6 | 10.3 | 0.0 | 0.0 | 0.0 | 0.0 |

**Appendix B** | (continued)

Portfolio Compositions: Hedged Returns

| | MVP | 10% | 30% | 50% | 70% | 90% | Max $\sigma$ |
|---|---|---|---|---|---|---|---|
| Panel D: Sweden | | | | | | | |
| Financial Assets Only | | | | | | | |
| RETURN | 7.7 | 8.6 | 10.4 | 12.2 | 14.0 | 15.8 | 16.6 |
| RISK | 3.0 | 3.4 | 5.8 | 9.9 | 16.3 | 27.0 | 33.0 |
| Cash | 90.7 | 77.0 | 19.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 0.6 | 4.5 | 0.0 | 38.5 | 57.9 | 19.3 | 0.0 |
| Global Bonds | 0.0 | 11.8 | 71.8 | 42.6 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 0.0 | 4.0 | 8.5 | 18.9 | 42.1 | 80.7 | 100.0 |
| Global Stocks | 2.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 6.6 | 2.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Global RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Financial Assets and Domestic Real Estate | | | | | | | |
| Risk Reduction | 0% | −7% | −6% | −3% | 0% | 0% | 0% |
| Cash | 89.5 | 81.3 | 19.3 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 2.3 | 9.1 | 9.1 | 50.8 | 57.9 | 19.4 | 0.0 |
| Global Bonds | 0.0 | 0.0 | 56.3 | 21.7 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 0.7 | 2.7 | 6.2 | 16.0 | 42.1 | 80.6 | 100.0 |
| Global Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 5.6 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Global RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE | 1.9 | 6.1 | 9.1 | 11.5 | 0.0 | 0.0 | 0.0 |
| Financial Assets, Domestic Real Estate and Global Real Estate | | | | | | | |
| Risk Reduction | −7% | −16% | −8% | −4% | 0% | 0% | 0.0% |
| Cash | 82.4 | 75.3 | 14.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 1.6 | 5.4 | 7.8 | 50.8 | 58.0 | 19.4 | 0.0 |
| Global Bonds | 0.0 | 0.0 | 54.5 | 21.7 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 0.0 | 1.2 | 5.0 | 16.0 | 42.0 | 80.6 | 100.0 |
| Global Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 3.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Global RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE | 0.0 | 0.0 | 3.6 | 11.5 | 0.0 | 0.0 | 0.0 |
| Global RE | 12.9 | 18.1 | 14.8 | 0.0 | 0.0 | 0.0 | 0.0 |

**Appendix B** | (continued)

Portfolio Compositions: Hedged Returns

| | MVP | 10% | 30% | 50% | 70% | 90% | Max $\sigma$ |
|---|---|---|---|---|---|---|---|
| Panel E: Switzerland | | | | | | | |
| Financial Assets Only | | | | | | | |
| RETURN | 4.7 | 5.7 | 7.7 | 9.8 | 11.8 | 13.8 | 14.9 |
| RISK | 2.2 | 3.5 | 8.0 | 12.7 | 17.6 | 22.5 | 24.9 |
| Cash | 81.6 | 66.9 | 45.5 | 22.5 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 13.6 | 20.3 | 25.5 | 29.6 | 29.0 | 7.3 | 0.0 |
| Global Bonds | 0.0 | 0.0 | 0.0 | 0.0 | 4.3 | 4.0 | 0.0 |
| Domestic Stocks | 0.0 | 9.2 | 29.1 | 47.9 | 66.7 | 88.7 | 100.0 |
| Global Stocks | 4.8 | 3.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Global RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Financial Assets and Domestic Real Estate | | | | | | | |
| Risk Reduction | −5% | −4% | −1% | 0% | 0% | 0% | 0% |
| Cash | 76.7 | 59.1 | 40.6 | 21.9 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 14.9 | 24.8 | 29.1 | 32.6 | 24.7 | 7.3 | 0.0 |
| Global Bonds | 0.0 | 0.0 | 0.0 | 0.0 | 5.5 | 4.0 | 0.0 |
| Domestic Stocks | 0.0 | 7.2 | 26.9 | 46.1 | 66.1 | 88.7 | 100.0 |
| Global Stocks | 2.7 | 2.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Global RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE | 5.6 | 8.3 | 7.5 | 6.2 | 3.6 | 0.0 | 0.0 |
| Financial Assets, Domestic Real Estate and Global Real Estate | | | | | | | |
| Risk Reduction | −29% | −9% | −1% | 0% | 0% | 0% | 0% |
| Cash | 77.9 | 59.5 | 37.2 | 15.1 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 6.6 | 17.2 | 25.0 | 32.6 | 24.7 | 7.3 | 0.0 |
| Global Bonds | 0.0 | 0.0 | 0.0 | 0.0 | 5.5 | 4.0 | 0.0 |
| Domestic Stocks | 0.0 | 8.3 | 27.2 | 46.0 | 66.1 | 88.7 | 100.0 |
| Global Stocks | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Global RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE | 0.0 | 3.3 | 4.9 | 6.2 | 3.6 | 0.0 | 0.0 |
| Global RE | 15.1 | 11.6 | 5.7 | 0.0 | 0.0 | 0.0 | 0.0 |

**Appendix B** | (continued)

Portfolio Compositions: Hedged Returns

| | MVP | 10% | 30% | 50% | 70% | 90% | Max $\sigma$ |
|---|---|---|---|---|---|---|---|
| Panel F: United Kingdom | | | | | | | |
| Financial Assets Only | | | | | | | |
| RETURN | 8.3 | 8.9 | 10.1 | 11.3 | 12.5 | 13.7 | 14.3 |
| RISK | 2.9 | 3.1 | 4.5 | 6.4 | 9.0 | 12.6 | 14.6 |
| Cash | 92.3 | 75.1 | 41.5 | 7.7 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Global Bonds | 0.0 | 18.9 | 47.2 | 72.6 | 51.7 | 17.2 | 0.0 |
| Domestic Stocks | 0.0 | 0.0 | 10.2 | 19.6 | 48.3 | 82.8 | 100.0 |
| Global Stocks | 1.6 | 3.6 | 0.9 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 3.9 | 2.5 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| Global RE Stocks | 2.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Financial Assets and Domestic Real Estate | | | | | | | |
| Risk Reduction | −9% | −12% | −9% | −4% | 0% | 0% | 0% |
| Cash | 76.2 | 65.1 | 27.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Global Bonds | 9.5 | 19.6 | 51.1 | 68.5 | 51.8 | 17.3 | 0.0 |
| Domestic Stocks | 0.0 | 0.0 | 5.7 | 18.5 | 48.2 | 82.7 | 100.0 |
| Global Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Global RE Stocks | 1.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE | 12.8 | 13.6 | 15.4 | 13.0 | 0.0 | 0.0 | 0.0 |
| Financial Assets, Domestic Real Estate and Global Rreal Estate | | | | | | | |
| Risk Reduction | −19% | −24% | −22% | −12% | −1% | 0% | 0% |
| Cash | 69.9 | 68.5 | 24.8 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Global Bonds | 11.5 | 13.3 | 50.0 | 58.8 | 39.4 | 17.3 | 0.0 |
| Domestic Stocks | 0.0 | 0.0 | 1.7 | 18.2 | 50.3 | 82.7 | 100.0 |
| Global Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Global RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE | 1.4 | 1.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Global RE | 16.4 | 16.9 | 25.0 | 22.9 | 10.4 | 0.0 | 0.0 |

**Appendix B** | (continued)

Portfolio Compositions: Hedged Returns

| | MVP | 10% | 30% | 50% | 70% | 90% | Max $\sigma$ |
|---|---|---|---|---|---|---|---|
| Panel G: United States | | | | | | | |
| Financial Assets Only | | | | | | | |
| RETURN | 6.1 | 7.0 | 8.8 | 10.5 | 12.3 | 14.1 | 15.0 |
| RISK | 1.5 | 2.4 | 5.1 | 8.0 | 11.1 | 14.7 | 16.9 |
| Cash | 90.3 | 75.8 | 44.7 | 10.9 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 0.0 | 2.0 | 27.4 | 45.6 | 31.9 | 2.9 | 0.0 |
| Global Bonds | 7.3 | 10.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 0.0 | 7.9 | 22.0 | 36.4 | 58.1 | 83.2 | 100.0 |
| Global Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 2.3 | 4.0 | 5.9 | 7.1 | 10.0 | 13.9 | 0.0 |
| Global RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Financial Assets and Domestic Real Estate | | | | | | | |
| Risk Reduction | −5% | −10% | −7% | −6% | −2% | 0% | 0% |
| Cash | 84.6 | 66.4 | 31.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 0.0 | 0.6 | 31.8 | 41.7 | 17.0 | 0.0 | 0.0 |
| Global Bonds | 9.4 | 16.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 0.0 | 5.4 | 17.3 | 32.5 | 57.7 | 83.7 | 100.0 |
| Global Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 1.8 | 2.6 | 4.2 | 5.4 | 9.5 | 11.2 | 0.0 |
| Global RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE | 4.2 | 8.9 | 15.6 | 20.4 | 15.8 | 5.2 | 0.0 |
| Financial Assets, Domestic Real Estate and Global Real Estate | | | | | | | |
| Risk Reduction | −5% | −10% | −7% | −6% | −2% | 0% | 0% |
| Cash | 84.6 | 66.4 | 31.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Bonds | 0.0 | 0.6 | 31.8 | 41.7 | 17.0 | 0.0 | 0.0 |
| Global Bonds | 9.4 | 16.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Stocks | 0.0 | 5.4 | 17.3 | 32.5 | 57.7 | 83.7 | 100.0 |
| Global Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE Stocks | 1.8 | 2.6 | 4.2 | 5.4 | 9.5 | 11.2 | 0.0 |
| Global RE Stocks | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic RE | 4.2 | 8.9 | 15.6 | 20.4 | 15.8 | 5.2 | 0.0 |
| Global RE | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

*Note*: For each country, the upper part of the table reports the portfolios' return and risk, and the portfolio weights when financial assets only are considered. The second part of the table contains the results when financial assets and domestic real estate are considered. The third part contains the results when financial assets, domestic real estate and international real estate are considered. For the letter two parts, risk reduction from including real estate is reported. Frontiers begin with the minimum variance portfolio (MVP), and end with the maximum risk portfolio. Portfolio compositions are also reported for 5 points on the frontier based on the proportional risk from the MVP to the high-risk portfolio (10%, 30%, 50%, 70% and 90%).

## Endnotes

[1] See also Liu and Mei (1998), Stevenson (2000), and Conover, Friday and Sirmans (2002). For a review, see Worzala and Sirmans (2003).

[2] See also Quan and Titman (1997), and Newell and Webb (1996). For a review, see Sirmans and Worzala (2003).

[3] See Brown and Matysiak (2000, Chapter 12), Geltner and Miller (2001, Chapters 23 and 25), and Geltner, MacGregor and Schwann (2003).

[4] It could obviously be argued that real estate markets are local in nature and that market knowledge is a key to successful real estate investments, making it difficult to invest abroad. Real estate markets, however, are becoming increasingly global and international investments should seriously be considered. It has been suggested that for domestic investments, direct real estate should be privileged, while indirect real estate investments should be emphasized for international investments. The results do not provide any support for such a strategy as international real estate stocks almost never enter the efficient combinations.

[5] The drop in correlations when hedged returns are considered is marginal for the U.S. investor as the bulk of ''international'' assets are U.S.-based and the proportion of international investments that requires hedging thus is limited.

[6] As mentioned before, the very bullish securitized real estate market in Australia during that period leads to a substantial proportion of optimal portfolios being allocated to indirect real estate investments.

[7] Obviously, the allocations to real estate are a bit lower than those that have been discussed above as they pertain to the MVP portfolios.

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*This paper was written while Martin Hoesli was the Hans Dalborg visiting professor of financial economics, Stockholm Institute for Financial Research, Stockholm, Sweden. The views expressed in this paper are those of the authors and not necessarily those of Aberdeen Property Investors nor those of Europa Capital Partners. The paper substantially benefited from comments from three anonymous referees, Ko Wang (the editor) and Foort Hamelink.*

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