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What factors determine international real estate security returns?

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Abstract

In this paper, we use constrained cross-section regressions to disentangle the effects of various factors on real estate security returns in 21 countries. A better knowledge of the risk factors driving real estate returns is crucial, whether a pure real estate portfolio is constructed, or whether real estate is considered as an alternative asset class within the traditional stock portfolio. Besides a common factor, "pure" country, size, and value/growth factors are considered. The value/growth measure that is used in this paper is a unique indicator developed by Salomon Smith Barney (SSB). It provides for each stock the relative importance of the value and growth components, rather than using a binary classification. The value/growth factor is found to have a substantial and increasing effect on returns over the analyzed period February 1990-April 2002. Country factors are important determinants of real estate security returns also. Statistical analysis of the residuals indicates that additional "hidden" factors most likely exist. These statistical factors are shown to explain about one third of specific returns on international real estate securities. Nevertheless, as is the case for traditional stock portfolios, stock picking keeps all its importance for real estate stocks as well.

Keywords: securitized real estate, international diversification, multi-factor model, value/growth

JEL classification: C21, G11 and G15

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What factors determine international real estate security returns?

1. Introduction

For stock portfolio managers executing a top-down approach it is crucial to decide whether the strategy will be based primarily on countries, sectors, industries, or some other factor such as size or value/growth. Diversification by sectors is growing in importance, but geographical allocation remains important despite the globalization of international financial markets. In this context, real estate securities are considered as one industry, but are too often discarded from the strategic portfolio allocation. This is surprising given that real estate securities have been shown to be effective diversifiers of common stock portfolios (Liang *et al*., 1996; Gordon *et al*., 1998). Moreover, the correlation of U.S. REITs with common stocks has been declining (Khoo *et al*., 1993; Ghosh *et al*., 1996). Also, the market value of publicly traded real estate companies has grown substantially in recent years (approximately US$ 400 billion as of the end of 1999, as reported by Ling and Naranjo, 2002).

Extensive research has been conducted since the 1970s on the benefits of international diversification for stock portfolios. There is also more recent evidence on the benefits of international diversification both for portfolios of direct and indirect real estate investments. The cross-country correlations are usually lower for real estate investments than for common stocks. There is evidence, however, of an international real estate factor (Ling and Naranjo, 2002), and also of continental factors (Eichholtz *et al*., 1998). Country-specific factors remain important, however, which explains the diversification benefits.

When constructing a portfolio of publicly traded real estate stocks, much emphasis is placed on the analysis of the correlation coefficients across countries (or across continents). We argue that while these correlations are useful, it would be important to disentangle the effects of various factors on real estate company returns and hence on cross-country correlation coefficients. The aim of this paper is to calculate the "pure" effects of various factors on international real estate security returns. For this purpose we use real estate security returns for 21 countries for the period from February 1990 to April 2002, and extract such "pure" effects using a cross-sectional factor estimation technique. The factors that we consider are the following: a common factor affecting all securities, the well known size effect first analyzed by Banz (1981), the value/growth factor of Fama and French (1992), and the country of origin of the security. Cluster analysis and principal component analysis (PCA) are used on the residuals of this analysis to ascertain whether an additional factor can be extracted, once the effect of the common and "pure" factors has been eliminated. The relative importance of the common factor and that of each "pure" factor is highlighted. Such an analysis is of great importance as changes in cross-country correlation coefficients may be due to changes in any of the other factors. By extracting the influence of other factors on cross-country correlations, it is possible to ascertain the true potential of international real estate portfolio diversification.

The paper is organized as follows. In section 2, we discuss related work on international real estate diversification. In section 3, we present our data and also evidence on the usefulness of real estate in diversifying a stock portfolio. The method that we use to assess the risk of real estate portfolios is discussed in section 4. Section 5 contains our results, and section 6 some concluding remarks.

2. International Real Estate Diversification

The issue of international diversification of stock portfolios has received substantial attention in the financial economics literature since the seminal work by Solnik (1974). The general conclusion is that widening the investment spectrum to non-domestic stocks permits an increase in risk-adjusted returns. Moreover, geographical diversification has been shown to be more effective than diversification by industry (Heston and Rouwenhorst, 1994 and 1995). Recent work has shown that the world economy is becoming increasingly global, with international stock markets becoming more and more correlated with each other (Solnik and Roulet, 1999). In such a context, industrial factors have gained in importance (Cavaglia *et al.*, 2000; Hamelink *et al.*, 2001).

Far less attention has been given to this issue in the real estate literature due to the relative lack of quality international data on the performance of real estate. Case *et al.* (1997) find that returns to commercial real estate tend to move together (although not perfectly) across property types within each country, and that international diversification within three segments of the real estate market (industrial, office and retail) would have been beneficial over the period 1986-1994. Quan and Titman (1997) report that U.S. real estate returns are less highly correlated with real estate returns in other countries, than is the case of U.S. stocks with international stocks, suggesting significant benefits from international real estate diversification (see also Newell and Webb, 1996). Goetzmann and Wachter (1999) also find that cross-border real estate diversification is useful. They show that cross-border correlations are due in part to common exposure to fluctuations in the global economy, but that country-specific GDP changes help explain more of the variation in real estate returns than the global factor. This would indicate a stronger impact of local factors than has been reported for common stocks (Beckers *et al*., 1996). Goetzmann and Wachter (1999) report that international real estate diversification is more beneficial than international stock diversification for industrial real estate, but not for other property types. Several studies have also looked at whether international real estate portfolios should be hedged against currency fluctuations (see e.g. Ziobrowski *et al*., 1997). The results concerning the usefulness of hedging are mixed. When it is decided to hedge, then currency swaps have been shown to be best suited given the long term nature of real estate investments.

Securitized real estate has been shown to be quite highly correlated with common stocks on an international basis (Eichholtz, 1997), although there is evidence for U.S. REITs that this correlation has been declining (Khoo *et al*., 1993; Ghosh *et al*., 1996). Also, and as is the case for direct real estate (Goetzmann and Wachter, 1999), there is evidence of a world-wide factor in international indirect real estate returns (Ling and Naranjo, 2002). The latter authors also find that a country-specific factor is highly significant, which would suggest that international diversification is useful when constructing portfolios of real estate securities. Eichholtz *et al*. (1998) find clear evidence of a continental factor in Europe and in North America, but not in the Asia-Pacific region. Their results also suggest growing integration within Europe. This result would seem to indicate that a parsimonious international real estate security diversification strategy is most beneficial when conducted across continents rather than within continents.

Correlations of real estate securities across countries are lower than cross-border correlations between common stocks (Eichholtz, 1996a; Gordon *et al*., 1998). Eichholtz (1996a) additionally finds that international real estate security diversification is more effective than international stock diversification. Wilson and Okunev (1996) use cointegration tests and show that international real estate markets are segmented. Benefits are to be gained from diversification, although potential gains are dependent on the exchange rate risk. Stevenson (2000) also reports evidence on the benefits of international diversification for real estate security portfolios (although he finds that these benefits are greater for common stocks), and on the positive impact of including international real estate stocks in global equity portfolios (see also Liu and Mei, 1998).

3. Data and Analysis of the Role of Real Estate Stocks in Diversifying Stock Portfolios

In this section, we present the data that we use (3.1), and also make the case for the usefulness of real estate securities in diversifying common stock portfolios (3.2).

3.1 Data

We use all real estate stocks included in the Salomon Smith Barney (SSB) Developed World Equity database for the period February 1990-April 2002. Countries that have at least one real estate security in the SSB database as of the end of April 2002 are retained, leading to a total of 21 countries. Total returns calculated on monthly time increments are available from the database. To conduct various comparative analyses, we also use stock market index data for the same countries. The source of the data is also SSB. All returns are in US$. We use unhedged returns as we consider that this is the most realistic assumption: in most cases the benchmark against which the portfolio manager is evaluated is unhedged. This generally makes sense, as for a well diversified international benchmark the currency risk tends to be diversified away. Therefore, managers who decide to include real estate stocks in their portfolio will hardly decide to hedge these positions. As unhedged returns are used, the currency effects will be included in the "pure" country effects. In this framework, an exposure to a given country entails an exposure to the country's currency.

This database entails two major advantages as compared to other databases. First, it contains every company whose available equity capitalization or float is greater than US$ 100 million. So all shares that can be realistically purchased by institutional investors are considered. Another major advantage of this database is that for each stock a growth and a value weight is provided; the total of weights for each stock being equal to one. Any given stock is therefore not either a growth stock or a value stock as is the case when other style classifications are used, but is some combination of both attributes. We discuss the method used by SSB to compute the growth and value weights later in this section. There are also two drawbacks from using this database: (1) no indication is given on the type of real estate company (investment, trading, or development), and (2) the company's main investment focus (residential, office, retail, etc.) is not reported. These variables can therefore not be considered in the analysis. It is hypothesized that some of the impact of these missing characteristics is captured by the country, growth, and size variables, with the remaining effects appearing in the specific return component. Statistical techniques are used in this paper to examine whether additional factors can be extracted from the specific component.

Summary statistics for real estate securities are presented in *Table 1*. The continental returns are computed as the weighted average of returns in the constituent countries. As of the end of April 2002, the total number of real estate securities included in the database amounts to 337, and the market capitalization to approximately US$ 280 billion. The five largest countries in terms of market capitalization account for 86.8% of total market capitalization as of the end of April 2002. This table also shows that the market capitalization of real estate stocks as a percentage of the market capitalization of common stocks included in the SSB database varies quite substantially from one country to another, with Hong Kong and to a lesser extent Australia, Singapore, and Austria exhibiting high ratios. *Figure 1* shows the evolution of the number of real estate stocks included in the SSB database, and also of securitized real estate market capitalization. Market capitalization has increased substantially over the period (see also Eichholtz and Koedijk, 1996). The number of companies in the SSB database has increased from 146 in 1990 to 396 in August 1997, but has diminished in recent years.

< INSERT TABLE 1 HERE >

< INSERT FIGURE 1 HERE >

Table 1 also reports the average growth probability weight of real estate stocks in each country, continent, and globally. The growth and value probability weights of each company are reported on a 0 to 1 scale by Salomon Smith Barney. For each company, the total of the growth and value weights is 1. The procedure that is used by SSB is as follows (Salomon Smith Barney, 2000). First, a set of 10 variables related to growth, and a set of five variables related to value are identified. As these variables have different measurement units, they have to be standardized. Standardization also leads to all variables having approximately the same influence upon the measurement of the style characteristics. Ideally, standardization should be undertaken on a world-wide basis, but this is impossible as different accounting principles prevail across countries. Thus, standardization is undertaken by country when the number of companies is sufficiently large, else it is achieved by groupings of countries that are geographically and culturally similar and that have similar accounting standards (an example of one such grouping is Denmark, Finland, Norway, and Sweden). Cluster analysis is then applied to both sets of variables, and three growth and four value variables are retained. The growth variables are:

- 5-year earnings per share growth rate;
- 5-year sales per share growth rate;
- 5-year internal growth rate = ROE $\times$ (1 – payout ratio);

and the value variables:

- book value to price;
- cash flow to price;
- sales to price;
- dividends to price (yield).

Growth and value scores are computed for each stock as the equally weighted average of the value of these variables. A stock that is clearly either a growth or a value stock, will be considered as a pure growth or value stock, and assigned a probability weight of 1 for that characteristic. If a stock is not clearly a growth or a value stock, the weight is split according to distances from pure growth and value stocks. The final step is to ensure that (1) each SSB country style index represents exactly 50% of the total float-adjusted market capitalization of the corresponding country[1], and (2) for each stock, the sum of probability weights is equal to 1. The above procedure is applied each year in June.

Figure 2 depicts the average weight of the growth factor (on a scale from 0 to 1) for real estate companies in the various continents and on a world-wide basis for the period from February 1990 to April 2002. Real estate companies have become less and less growth companies (as defined by SSB) over the 1990s, with relatively large swings during the beginning of the current decade for Asian and Oceania real estate stocks. Real estate companies appear to be clearly less growth companies at the end of the period as compared to what was the case at the beginning of the period.

[1] Ideally, the measurement of growth and value weights should not be country-specific, but global. As stated above, this is hardly possible due to different accounting practices across countries, and SSB have decided to measure the probability weights within countries. It is acknowledged here that biases may occur if the relative importance of growth and value dimensions varies dramatically from one country to another.

< INSERT FIGURE 2 HERE >

3.2 The Case for Real Estate Securities in the Portfolio

Several facts have been reported in previous research. First, real estate securities have been shown to be effective diversifiers for portfolios of stocks and bonds (Gordon *et al*., 1998). Second, the beta of real estate securities on the general stock index has been declining, indicating that real estate securities are less and less tied to the general stock market (Khoo *et al*., 1993; Ghosh *et al*., 1996), which would suggest that diversification opportunities have increased. Third, the benefits of international diversification appear to be greater than what is the case for common stocks (Eichholtz, 1996a). Finally, international real estate securities have been shown to act as portfolio diversifiers, even in portfolios containing international stocks (Gordon *et al*., 1998).

In this section, we investigate the ability of real estate stocks to diversify a stock portfolio using our database of international real estate securities. We thus provide up-to-date evidence on the usefulness of real estate stocks in diversifying stock portfolios, which supports the in-depth analysis of international real estate diversification that is conducted in the subsequent two sections. We first compute rolling betas of the real estate security indices on the general stock indices for the five largest countries in terms of current market capitalization (the U.S., Hong Kong, the U.K., Australia, and Japan). We use a 36-month moving window that is shifted by one month for each regression. The rolling betas show whether the degree of association between real estate stocks and common stocks is time-varying. We also compute cross-country correlation coefficients, both for real estate securities and common stocks. The ten countries that have the largest market capitalization in real estate securities are considered (i.e. in addition to the above five countries, the Netherlands, Canada, France, Singapore, and Sweden). Rolling average correlation coefficients across the 10 countries are also analyzed, both for real estate stocks and common stocks. This analysis sheds light on the integration of international real estate security and stock markets, respectively. Finally, we investigate the increase in tracking error for a portfolio manager when real estate securities are included in a stock portfolio. Such an analysis is important for portfolio managers who include real estate in their portfolio but who have nevertheless a pure stock index as benchmark. Increasing the exposure to real estate may add some additional return to the total portfolio and lower the standard deviation of the portfolio, but will also increase the tracking error when performance is measured against such a benchmark.

Figure 3 shows the 36-month rolling beta for the five countries with the largest securitized real estate market capitalization. There is a clear downward trend in the beta for the U.S., the U.K. and Japan, and at the end of the period under review the beta is only in the 0.2-0.5 range. These lower betas confirm the results of previous studies for the U.S. market. The beta for Hong Kong real estate securities is high and remains high over the period. This is not surprising as real estate securities represent a large fraction of the Hong Kong stock market (32.6% on average over the analyzed period). For Australia, the end of period beta is approximately at the same level as that at the beginning of the period (0.4-0.5 range), with a steady increase followed by a steady decrease in years 1997-2001. Overall, the betas for real estate securities are low and have a tendency to decline over the period.

< INSERT FIGURE 3 HERE >

The cross-country correlation coefficients are reported in *Table 2* (*Panel A* for real estate stocks, *Panel B* for stocks). As reported by Eichholtz (1996a), the correlations are smaller for real estate stocks than for common stocks, suggesting greater benefits from international diversification for real estate stocks than for stocks. It is interesting to examine whether such correlations are time-varying. For that purpose, the 36-month rolling average correlation coefficients are depicted in *Figure 4*. The average correlation for stocks is increasing, while the average correlation for real estate stocks is quite stable[2]. In all cases, the average correlation for real estate securities is lower than that for stocks. Hence the international stock markets are becoming increasingly integrated which is not the case of real estate security markets. When cross-continent relationships are considered[3], it is found that the correlation coefficients between real estate stocks across continents are lower also than the average correlation between common stocks across continents. The results also show a growing integration of the stock market, but contrary to the cross-country analysis, the correlation coefficients between real estate stocks across continents are rising over the period, albeit at a much lower rate than that of common stocks. Although we do not investigate the

[2] Eichholtz (1996b) tests the stability of correlation coefficients over time for nine countries and also concludes that correlation coefficients are quite stable. A reverse conclusion is found for variances and covariances.
[3] The figures are not reported in this paper, but are available from the authors.

diversification benefits of international diversification in a formal way, these results constitute tentative evidence on greater benefits from international diversification on the securitized real estate market than on the common stock market.

< INSERT TABLE 2 HERE >

< INSERT FIGURE 4 HERE >

Finally, *Figure 5* shows the increase in the tracking error for a portfolio manager when he or she includes real estate stocks in his/her portfolio. For an allocation of 15% in real estate securities, the tracking error is in the 2-3% range. This should be a more than acceptable level of relative risk if the portfolio manager has strong convictions about any of the sources of the return generating process for real estate stocks. These sources may include a general world-wide real estate factor, country factors, size and value/growth factors, but also specific views on real estate stocks. In particular, in a bearish market for common stocks, a portfolio manager may have a higher expected return for real estate stocks, as a world-wide asset class, than for stocks. The low betas between real estate stocks and common stocks shown in *Figure 3* suggest that during such times diversification through real estate securities is especially beneficial, and *Figure 5* suggests that even within reasonable levels of tracking error the allocation to real estate may be substantial.

< INSERT FIGURE 5 HERE >

4. Assessing the Risk of Real Estate Portfolios

4.1 The Model

Modern Portfolio Theory (MPT) provides us with the theoretic tools to estimate an asset's, and hence a portfolio's, risk. On the one hand, we have systematic sources of risk (i.e. sources of risk that influence a large number of assets), and on the other we have the stock's specific risk. As these two sorts of risk are independent, the total risk of a stock or that of a portfolio is simply the sum of the two types of risk. Systematic risk originates from the behavior of the common factor(s) influencing the returns. In the case of the Capital Asset Pricing Model (CAPM), the common factor is the market return in excess of the risk free rate, while in multi-factor models a larger number of common factors determine the total level of systematic risk.

Determining the common factors in a multi-factor model may be done using a variety of techniques, depending on the initial assumptions. All models have in common that there are common factor returns and factor loadings, i.e. the exposure of each stock to each factor. We may either observe factor returns and estimate the factor loadings (such as in the CAPM, where the betas are the loadings), observe the loadings and estimate the returns (loadings are usually country or sector dummy variables), or estimate both the loadings and the factor returns (as in the Arbitrage Pricing Theory, APT, class of models). In some cases it is possible to give a specific meaning to the factors, for instance, the price of one unit of risk (in which case it is argued that the factor is "priced").

Extending the model developed by Heston and Rouwenhorst (1994)[4], the model we propose in this paper is based on observed exposures, and the factor returns are estimated. No assumption is made as to whether these estimated factors are "priced". The idea is that the considered factors are "pure" in the sense that they are not influenced by any of the other factors. For instance, the "pure" U.S. factor represents what is really due to the fact that a stock is U.S. based. If there are more growth or value stocks, or more large or small caps in the U.S. than world-wide, then that growth or size effect will be captured by the corresponding "pure" factors, and hence the country factors will not be influenced by these dimensions. There is also a "common factor", which is the factor to which all stocks are exposed. Formally, the model is written as follows:

$$R_{i,t} = F_t + \sum_{k=1}^{K} D_i^k \times F_t^k + p_{it}^G \times F_t^G + p_{it}^V \times F_t^V + S_{i,t} \times F_t^S + \varepsilon_{i,t}, \qquad (1)$$

where $R_{i,t}$ is the return on stock i at time t. K is the number of countries. D_i^k is a dummy variable, set to one if stock i belongs to country k, with $k = 1, \dots, K$. p_{it}^G and p_{it}^V are the Salomon Smith Barney's (SSB) Growth and Value probability weights of stock i at time t. $S_{i,t}$ is the size exposure of stock i at time t. In the above equation, the unknowns are F_t (the

[4] Heston and Rouwenhorst (1994) assess the relative importance of diversification by country and by industry for international common stock portfolios. Country and industry dummy variables are used. A similar methodology is used to investigate the benefits of sector and regional diversification for U.S. private real estate portfolios by Fisher and Liang (2000), and for U.K. private real estate portfolios by Lee (2001).

return on the common factor, which is equivalent to the weighted average of all real estate stock returns), F_t^k (the returns on the "pure" country factors), F_t^G and F_t^V (the returns on the "pure" growth and value factors), and F_t^S (the return on the "pure" size factor). Finally, $\varepsilon_{i,t}$ is the stock-specific return, which means the return on stock i at time t once its country, value/growth and size attributions are taken into account.

The above model is estimated under the constraint that for the benchmark portfolio (the portfolio containing all real estate stocks in the SSB universe weighted by the relative market caps), the value-weighted sums of exposures to the country factors, to the value/growth factors and to the size factor are all equal to zero. In other words, the benchmark portfolio does not have any global country exposure, nor any exposure to value/growth, nor size. This translates into the constraints:

$$\sum_{i=1}^{N}\sum_{k=1}^{K} w_{i,t} D_i^k F_t^k = 0 \text{ for the country exposures,}$$

$$\sum_{i=1}^{N} w_{i,t}\left(p_{it}^G F_t^G + p_{it}^V F_t^G\right) = 0 \text{ for the value and growth exposures, and}$$

$$\sum_{i=1}^{N} w_{i,t} S_{i,t} = 0 \text{ for the size exposure.} \qquad (2)$$

Recognizing that, by definition, $p_{it}^G = 1 - p_{it}^V$, we may simplify equation (1) and the constraints (2). Furthermore, each stock's exposure to size is a transformation of its relative market weight $w_{i,t}$, such that the exposure to size of the largest real estate stock in the universe is equal to one.[5]

In order to estimate equation (1), we have to make sure there are enough representative observations for each country. For instance, if there is a single real estate stock in a given country, then estimating a "pure" country effect would not be relevant (in fact, the country factor would also pick up the specific return). We therefore require that there be at least five stocks belonging to any country for any given month. If there are less than five, then the country is dropped and the corresponding real estate stocks have no country exposure (in

[5] It can be shown that for the size variable we have to set a scaling arbitrarily. Indeed, we may have very small stock exposures and a large return on the size factor, or large stock exposures and a small return on the size factor. The constraint that the largest stock has an exposure of one yields a better economic interpretation of the returns on the size factor.

which case part of the country effect, if there is any, will be found in the real estate stock's specific return $\varepsilon_{i,t}$). Finally, equation (1) is estimated using a value-weighted OLS regression scheme, such that $\sum_{i=1}^{N} w_{i,t}\, \varepsilon_{i,t} = 0$. The latter ensures that a large cap real estate stock has a larger effect than a small cap one. The equation is estimated in a cross-sectional way, that is, each month, the regression is performed and the factor returns at that time estimated, independently from observations for other time periods.

4.2 Additional Factors

The cross-section regression in equation (1) decomposes the return on an asset *i* at time *t* into returns on the various factors, and an error term denoted $\varepsilon_{i,t}$. This term represents the return that cannot be explained by the common factor and "pure" factors, and is therefore also referred to as the stock's specific return. The specific returns may, of course, be influenced by other "common factors" that are not included in the model. For instance, as model (1) does not account for the various property types in which real estate companies invest, it could be that the specific returns on all real estate stocks of a given property type move together during a given month. As was mentioned, information about property types is not available from this database, but there may also be other common characteristics among real estate stocks. It is therefore of interest to extract these "hidden" factors from the specific returns. This is also the basic technique underlying APT models.

We argue that although it may be difficult to find an economic interpretation for such statistical factors, they are of foremost importance to the portfolio manager. If some stocks behave differently because they have an exposure to some statistical factor, and if the return on that factor is statistically and economically important, then a portfolio manager should actively manage the portfolio's exposure to that factor. If he/she does not have a specific view on the expected return on the factor, he/she should make sure that the portfolio has the same exposure to that factor as the benchmark. If he/she does have a view, on the other hand, then he/she may bet on the performance of the factor by over-weighting (relative to the benchmark) the exposure of the portfolio to that factor. Not doing so will inevitably result in higher tracking error for the portfolio, without a higher expected return. This is an important issue in active management, and whether a factor is merely a statistical one (without economic interpretation) or not, is of little relevance here.

The most straightforward way to extract statistical factors is Principal Component Analysis (PCA). The matrix of variances-covariances or correlations is computed from the data, and through decomposition of eigen-values / eigen-vectors, orthogonal factors are obtained that fully explain the data structure. It is a powerful technique, but it uses the variance as the measure of risk, and therefore assumes normality of the data. This may be a strong assumption indeed, and therefore we develop also an alternative technique, based on cluster analysis, that makes no distributional assumption.

Cluster analysis allows to form groups of observations, the degree of similarity of which is similar within each group, but dissimilar across groups. Once the membership of each stock to a cluster is determined, we calculate the average return of all observations within each cluster. These are the factor returns, and each stock has an attribute (one or zero) for each cluster. In the case of the PCA, the factor returns are the orthogonal PCA factors, and a stock has any exposure, either positive or negative, to each of the factors.

Applying cluster or PCA techniques to a set of data will always reveal some kind of *ex post* structure in the data. What is important, however, is the *out-of-sample* usefulness of the techniques. We apply therefore the following estimation procedure: we use the first 36 months of returns on all assets for which we have returns for all months, apply either the cluster algorithm or PCA, and measure the equally-weighted average return within each group over the subsequent 12 months. We then move the estimation window forward by 12 months, and re-estimate the groups. If the Clustering or the PCA approach had no predictive power (in other words, if the membership of each stock to a particular cluster, or the loading of each stock to a PCA factor were highly unstable over time), then there would be no reason to expect any *out-of-sample* difference in estimated factor returns.

The next section contains a discussion of our results.

5. Results

5.1 Common Factor and "Pure" Factors

Table 3 contains summary statistics for returns on the common factor, returns on the "pure" country factors for the 10 countries with the largest securitized real estate market capitalization, returns on the "pure" growth factor, and returns on the "pure" size factor. By construction, the average return on the common factor is the mean return on the market weighted world index of real estate securities (the small difference is due to rounding errors). The countries that experience a high (low) average return during the period generally also have a high (low) average return on the "pure" country factor, i.e. there is a wide discrepancy in returns across countries even after controlling for the common factor and the "pure" growth and size factors. There is a strong positive "pure" country effect in Hong Kong, while the country effect is not surprisingly very negative for Japan. The number of observations is not equal to 147 for all countries, as a country is only considered if there is a minimum of five companies in any given month. Caution must be exercised when interpreting the results of countries for which there is not a minimum of five real estate securities in any given month during the entire period (i.e. the Netherlands, Canada, and Sweden).

< INSERT TABLE 3 HERE >

The return on the "pure" growth factor is negative on average, indicating that real estate securities that have a large growth weight are negatively affected over the period. The average return on the size factor is positive: all things held constant, large capitalization real estate stocks perform better than smaller capitalization real estate securities. Hence, much of the effect of size that has been reported in the literature may not be related to size, but to country and/or style effects.

Table 4 contains the correlation coefficients between the common factor and "pure" country, growth and size factors. The correlation coefficients between "pure" country factors, and growth and size factors are close to zero. This indicates that if an active portfolio manager makes a bet according to any of the three factors (country, growth, or size), this does not imply that he or she is making simultaneously a bet according to any other dimension. For instance, if one believes that a country will perform well in the future and a decision is made to overweight this country, this does not imply that this decision will have an impact in terms of the exposure to growth or size. This discussion is of course based on “pure” factors. In reality, it is not possible to gain exposure to the “pure” factors, but rather when a decision is made for instance to overweight one country, then this will not have in most cases a neutral effect on the growth and size exposures. To overcome this difficulty, constrained optimization techniques may be used to construct a model portfolio that takes active bets on specific “pure” factors, while keeping the exposures to other factors neutral (relative to the benchmark).

< INSERT TABLE 4 HERE >

Correlation coefficients between “pure” country factors are generally low. This is particularly true between the returns on the “pure” Hong Kong factor and the returns on the “pure” factor for several other countries. In fact, many of these correlations are negative. On the other hand, the returns on the “pure” country factors are highly correlated in two instances (Hong Kong and Singapore, and France and the Netherlands). This may indicate that diversification opportunities exist primarily across continents, and to a lesser extent only within continents (see also Eichholtz *et al*., 1998).

The “pure” factor approach that we use has important implications for portfolio management. The active portfolio manager will have to decide according to which factor he or she wants to make a bet. If countries with positive expected returns and low cross-country correlation coefficients are selected for instance (in most cases, this will imply selecting stocks of companies in different continents), he or she has to make sure that this strategy is neutral with respect to the growth and size dimensions. Alternatively, it could be decided that an investment in high growth or large size real estate companies should be emphasized. If the “pure” factor approach is not used, such strategies will almost certainly involve making implicit country bets simultaneously. With the “pure” approach, the effects of such strategies on the exposure to “pure” country factors as compared to that of the benchmark can be minimized.

Figure 6 depicts the rolling average of cross-country correlation coefficients for the 10 countries with the largest securitized real estate market, both for raw and “pure” country returns. The average cross-country correlation coefficients on the “pure” country factor returns are much lower than the average correlations on raw returns, and are very close to zero. The lower correlations would be expected as the common factor, which obviously has a positive effect on the correlation, has been extracted when returns on "pure" factors are used. Both sets of rolling average correlation coefficients are stable during the period. The low cross-country correlations on raw returns suggest substantial benefits can be obtained from diversifying a portfolio of real estate stocks internationally.

< INSERT FIGURE 6 HERE >

It is now interesting to focus on the cumulative returns for the various factors. *Figure 7* depicts the cumulative logarithmic returns for the common factor, the "pure" growth and value factors, and for the size factor[6], while *Figure 8* shows the cumulative logarithmic returns for the "pure" country factors. There is a strong upward trend in cumulated returns for the common factor, with two slumps. The cumulative returns for the size factor are also rising. The returns on the size factor appear to be important, and large stocks are more exposed to this factor than smaller ones. As explained in section 4, the maximum exposure to size is for the largest real estate stock in the sample at any given month (size exposure = 1). For smaller stocks, the exposure is less, and even negative for many stocks as by construction the weighted average of the exposure to size is zero. As would have been expected, the cumulative returns for the growth factor pick up in the second half of the 1990s, but all of this increase vanishes in the beginning of the current decade. The cumulative logarithmic returns for the "pure" country factors shows that the Hong Kong securitized real estate market performed very well over the period, while the Japanese real estate stock market declined substantially as did the overall stock market (*Figure 8*).

< INSERT FIGURE 7 HERE >
< INSERT FIGURE 8 HERE >

Of particular interest is to analyze the importance of the market cap weighted average absolute returns on the common factor, the "pure" country, size, growth and value factors, and the specific component as a percentage of the total of these absolute returns. The relative importance of each factor and that of the specific return component is depicted in *Figure 9*.

[6] The return on the value factor is not exactly the opposite of the return on the growth factor because the model is estimated using a sub-set (the real estate stocks) of the full SSB universe (PMI World) used to estimate the value and growth probability weights.

Of the traceable factors, the (weighted) average "pure" country factor appears to be the most important, but its importance has diminished slightly during the period. A large fraction also stems from the common factor. Growth and value did not have a large influence on real estate security returns at the beginning of the 1990s, but the importance of this factor has grown during the period. As of the end of the period, the growth and value factors appear to be more important than the size factor. There is thus clearly a growth/value factor in real estate securities, and that factor should be taken into consideration when building real estate stock portfolios. The importance of size has diminished slightly over the period, and remains rather marginal. The specific component represents a large fraction of total absolute returns, and its share varies somewhat during the period. This indicates that stock picking remains a very important issue when constructing real estate security portfolios.

< INSERT FIGURE 9 HERE >

The SSB database makes it possible to extract a common factor and "pure" country, growth and size factors, and to ascertain the relative importance of these factors. Several other characteristics that are not included in this analysis should have an impact on real estate security returns. Examples of such characteristics are tax status, type of company (investment, trading, or development), investment focus (residential, offices, retail, etc.), and leverage. The impact of these characteristics will not necessarily be included in the specific return. Indeed, characteristics of real estate companies that are specific to a country will have been included into the "pure" country factor. This will be the case for instance of the tax status, which will apply to all real estate companies in a given country. Some type of company and investment focus effects will also be captured by the country factors if there is a predominant type of company and/or focus in any given country. Similarly, if some omitted characteristic of real estate securities is related to the growth or the size characteristics, then it will have been captured by these factors. Leverage for instance should be captured by the growth factor as one of the variables that is used by SSB to measure the growth characteristic is the internal growth rate calculated from the Return on Equity (ROE). Leverage should have an effect on ROE, and hence increase the growth exposure of the company. Type of property and investment focus should also partly be captured by the growth and size characteristics. Developers should have a stronger growth component for instance. The specific factor will thus capture any remaining effects, as well as the true specific component. In the next section, we analyze whether it is possible to extract an additional factor from the specific component that remains after taking into consideration the common factor and "pure" country, growth and size factors. For this purpose, we use cluster analysis techniques and principal component analysis.

5.2 Additional "Hidden" Factors

The clustering algorithm used in this study can be summarized as follows: *k*-means clustering is applied iteratively on the N–by–(T=36) dataset of logarithmic asset returns until the largest group contains approximately 50% of the observations. This first cluster is referred to as "Cluster 1". The two next retained clusters are the ones that contain the second and third largest number of observations, respectively. Finally, the final cluster (Cluster 4) contains all other observations. From one estimation period to the other (which is moved forward by 12 months each time), we make sure that Clusters 2 and 3 correspond to the same clusters as in the previous estimation period by measuring the correlation over the 24 overlapping months of the estimated factor returns. If necessary, we adjust the memberships. With this procedure we make sure that the created clusters have some desired characteristics:

- the first cluster contains approximately 50% of the observations and should correspond to what is observed most of the time for specific real estate stock returns;
- Clusters 2 and 3 contain a reasonable number of stocks that behave in a very specific way;
- Cluster 4 contains all other stocks. This is probably the least homogenous group.

The results are represented in *Figure 10*, which shows the cumulative logarithmic returns on all four cluster factors. Not surprisingly, Cluster 1 shows little variability over time, although the trend over the almost 10-year *out-of-sample* period is positive. It is probably also the least interesting cluster to analyze, as by construction it contains most of the observations. Cluster 2 is clearly more variable, and its returns are economically important: drop of approximately 15% during year 2000, positive return in excess of 15% in 2001. Cluster 3 is highly volatile in 1997 and 1998, while little effect can be seen during the rest of the period. Finally, Cluster 4 shows mostly negative returns, especially during the second half of the sample period.

< INSERT FIGURE 10 HERE >

Clearly, the constructed clusters behave differently, not only *in-sample*, but also *out-of-sample*. From a portfolio management point of view, it is important to measure the risk of being over- or under-exposed to these factors, relative to the benchmark. A portfolio manager who picks stocks that belong, by chance and without the manager being aware of it, to Cluster 4 would significantly lower his/her portfolio return. This is important, even if it is difficult to attribute any economic “label” (such as a property type, for instance) to a cluster factor.

Figure 11 shows the percentage of real estate stocks that change cluster every year. The figures are quite high, but this is due in part to the fact that a cluster membership can only be given to stocks that have been in the database for at least 36 months, at any point in time. A new stock will increase the percentage of stocks changing clusters. A real estate stock that merges with another company or changes its SEDOL code for some other reason will also increase that percentage.

< *INSERT FIGURE 11 HERE* >

The second approach is PCA. We arbitrarily set the number of PCA factors to three (results for other numbers of PCA factors are available from the authors), and apply the same *out-of-sample* approach as with the cluster analysis: the first 36 months are used to compute correlations from the available specific real estate stock returns (in logarithms). These correlations are used to estimate the three PCA factors along with the factor loadings. The *out-of-sample* performance on the three factors over the subsequent 12 months is reported. The estimation window is then rolled forward by 12 months. Correlations over the overlapping 24 months are again calculated to rotate and/or permute factors to ensure continuity. The results are reported in *Figure 12*. The first PCA factor has a surprisingly strong uptrend over the full period. The magnitude of the factor returns is large. The second PCA factor has a zero return over the 10-year period, but during that period the cumulated return (in logarithms) ranges between –120% and +50%. The magnitude of the returns is large again. The last PCA factor has also a large variability.

< *INSERT FIGURE 12 HERE* >

The correlation coefficients between the PCA factors and the Cluster factors are given in *Table 5*. The correlations for the PCA factors are not zero because these are the factors measured *out-of-sample* (there is no reason to expect exact orthogonality *out-of-sample*). The low correlations, together with the large factor returns (especially for the PCA factors), make us believe that there are strong and persistent hidden factors in the specific returns. These factors may be linked to company specific characteristics, such as the property types the companies invest in, the level of leverage, other activities of the firm, but also geographical presence of the holdings (remember that this will not be picked up by the country factors, as these refer only to the country of origin of the company). There may also be a link between the statistical factors and macro-economic variables, such as GDP growth or interest rate changes.

< INSERT TABLE 5 HERE >

Finally, in order to assess the economic importance of the above methodology, we show in *Figure 13* the relative importance of the absolute return on the three PCA factors, as well as the absolute unexplained residual, as a percentage of the total. Between 30% and 40% of the total is explained by the returns on the three PCA factors. Without being a formal test, it sheds some light on what a portfolio manager, who is measured against a benchmark, might expect from applying a three-PCA factor decomposition of the specific returns: one third of the portfolio specific risk is explained by the common PCA factors, which is a risk that can be hedged simply by ensuring that the portfolio has the same exposure to these common PCA factors as the benchmark portfolio.

< INSERT FIGURE 13 HERE >

6. Concluding Remarks

The benefits of international real estate diversification have been documented in the literature, albeit to a lesser extent than for common stocks. We argue that while it is important to recognize the advantages of cross-country diversification, it would be at least equally important to isolate the effect of various factors on international real estate security returns. A low cross-country correlation coefficient between real estate securities in two countries, for instance, could be due to the fact that real estate stocks in both countries differ with respect to size, to their exposure to growth or value, or to any remaining effects such as their tax status or their investment focus. We use constrained cross-section regressions to disentangle a common factor, and "pure" country, size, and value/growth effects. It is found that the value/growth factor is an important determinant of real estate security returns, and that the importance of this factor is growing. Country factors are also important, while the effect of size remains marginal. Statistical analysis of the residuals indicates that additional "hidden" factors most likely exist.

An important practical implication of the method used in this paper is that an investor can decide according to what factors he or she wants to make bets. For instance, a bet can be made to overweight countries with high expected returns and low cross-country correlation coefficients (this will in most cases involve selecting real estate stocks from countries in different continents), without simultaneously making a growth/value bet nor a size bet. For that purpose, an optimizer can be used to gain exposure to the selected countries, while minimizing at the same time the difference between the exposure of the portfolio to other factors and the exposure of the benchmark to these factors.

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Table 1 **Summary statistics for real estate companies included in the Salomon Smith Barney (SSB) database, February 1990-April 2002**

For each of the 21 countries included in the SSB database, for continental groupings, and on a world-wide basis, the following statistics are reported: annualized mean return, standard deviation, number of monthly observations, average number of stocks in the index, average growth exposure, average market capitalization, average market capitalization as a percentage of stock market capitalization, current market capitalization (i.e. as of April 2002), current market capitalization as a percentage of stock market capitalization, and current market capitalization as a % of total market capitalization of real estate stocks.

	Annualized Mean	Standard Deviation	Monthly Observations	Average Number of Stocks in Index	Average Growth Exposure	Average Market Cap	(as percentage of MCAP stocks)	Current Market Cap	(as percentage of MCAP stocks)	Current Market Cap (Percentage of total)
United States	9.9%	13.0%	147	99.0	26%	61,584.5	1.2%	150,290.5	1.7%	50.8%
Hong Kong	12.7%	38.8%	147	31.8	42%	36,460.3	32.5%	34,642.9	28.5%	11.7%
United Kingdom	5.5%	19.5%	147	32.3	23%	20,315.0	1.9%	29,871.7	1.9%	10.1%
Australia	7.7%	15.3%	147	19.4	24%	10,759.0	8.1%	25,263.8	11.3%	8.5%
Japan	-9.0%	33.6%	147	24.3	57%	20,455.3	1.5%	17,344.4	1.5%	5.9%
Netherlands	0.5%	13.0%	147	6.7	3%	5,240.3	2.4%	9,254.6	2.7%	3.1%
Canada	-7.6%	21.8%	147	7.1	41%	2,885.4	1.4%	6,822.3	2.0%	2.3%
France	4.1%	14.6%	147	16.4	19%	5,865.4	1.9%	6,469.6	1.2%	2.2%
Singapore	1.2%	43.5%	147	10.8	41%	5,250.4	16.3%	4,457.9	7.4%	1.5%
Sweden	1.6%	35.8%	147	4.8	45%	1,266.2	1.3%	2,768.5	2.2%	0.9%
Spain	1.5%	28.7%	147	3.4	23%	1,559.1	1.6%	1,999.1	1.1%	0.7%
Switzerland	8.5%	17.1%	147	2.2	41%	627.1	0.2%	1,411.4	0.3%	0.5%
Germany	8.5%	22.8%	118	2.9	24%	1,465.5	0.5%	1,380.0	0.3%	0.5%
Austria	0.3%	16.9%	63	2.3	46%	493.7	5.1%	981.1	11.5%	0.3%
Belgium/Lux	-1.3%	18.5%	147	2.1	48%	525.3	1.2%	958.9	1.2%	0.3%
Ireland	-25.5%	52.5%	106	1.3	37%	371.5	1.6%	595.9	1.5%	0.2%
Italy	-26.5%	37.6%	123	2.3	23%	560.0	0.4%	555.4	0.2%	0.2%
New Zealand	-39.1%	41.8%	75	1.0	36%	141.2	1.6%	203.0	3.2%	0.1%
Denmark	-3.4%	30.0%	142	1.3	31%	252.7	0.8%	136.7	0.3%	0.0%
Finland	-3.9%	21.0%	46	1.0	26%	113.5	0.2%	126.9	0.1%	0.0%
Norway	0.0%	23.4%	70	1.6	82%	179.6	1.1%	77.0	0.3%	0.0%
WORLD	4.3%	16.5%	147	283.9	35%	178,480.9	1.8%	295,611.7	2.0%	
AMERICA	8.5%	12.9%	147	106.1	27%	64,469.9	1.2%	157,112.8	1.7%	53.1%
EUROPE	4.0%	14.6%	147	76.8	22%	37,942.6	1.4%	56,586.7	1.4%	19.1%
ASIA	0.2%	31.2%	147	81.1	48%	65,237.5	4.3%	56,445.3	3.9%	19.1%
OCEANIA	6.7%	15.5%	147	19.9	25%	10,831.0	7.7%	25,466.8	11.1%	8.6%

Table 2 **Cross-country correlation coefficients for real estate securities and common stocks, February 1990-April 2002**

Cross-country correlations of monthly returns for both real estate securities and common stocks. The 10 countries with the largest securitized real estate market capitalization are considered (U.S., Hong Kong, U.K., Australia, Japan, Netherlands, Canada, France, Singapore, and Sweden).

***Panel A*: Real estate securities**

	United States	Hong Kong	United Kingdom	Australia	Japan	Netherlands	Canada	France	Singapore	Sweden
United States	1.00									
Hong Kong	0.28	1.00								
United Kingdom	0.40	0.25	1.00							
Australia	0.29	0.41	0.30	1.00						
Japan	0.10	0.12	0.27	0.25	1.00					
Netherlands	0.26	0.22	0.38	0.41	0.20	1.00				
Canada	0.43	0.27	0.36	0.31	0.23	0.31	1.00			
France	0.19	0.16	0.45	0.32	0.25	0.56	0.19	1.00		
Singapore	0.36	0.78	0.27	0.39	0.26	0.26	0.33	0.18	1.00	
Sweden	0.20	0.19	0.39	0.35	0.21	0.34	0.38	0.27	0.20	1.00

***Panel B*: Common stocks**

	United States	Hong Kong	United Kingdom	Australia	Japan	Netherlands	Canada	France	Singapore	Sweden
United States	1.00									
Hong Kong	0.55	1.00								
United Kingdom	0.65	0.48	1.00							
Australia	0.53	0.53	0.55	1.00						
Japan	0.37	0.32	0.48	0.44	1.00					
Netherlands	0.64	0.51	0.75	0.55	0.44	1.00				
Canada	0.76	0.62	0.50	0.61	0.37	0.56	1.00			
France	0.59	0.46	0.68	0.47	0.41	0.77	0.52	1.00		
Singapore	0.57	0.75	0.49	0.57	0.39	0.53	0.56	0.46	1.00	
Sweden	0.59	0.49	0.54	0.55	0.48	0.62	0.59	0.67	0.49	1.00

Table 3 Summary statistics for the common factor and the "pure" factors, February 1990-April 2002

Annualized mean return, standard deviation, and number of observations for the common factor, the "pure" country factors in the 10 countries with the largest securitized real estate market capitalization, the "pure" growth factor, and the "pure" size factor.

	Annualized Mean	Standard Deviation	Number Obs.	Sum
Common Factor	4.3%	16.6%	147	52.9%
United States	5.0%	15.1%	147	60.7%
Hong Kong	9.5%	28.3%	147	116.8%
United Kingdom	-0.3%	15.8%	147	-3.3%
Australia	2.9%	15.5%	147	35.5%
Japan	-15.6%	29.9%	147	-190.8%
Netherlands	-1.4%	13.5%	94	-11.2%
Canada	3.5%	16.5%	68	19.8%
France	-1.2%	16.9%	147	-14.6%
Singapore	-1.0%	33.5%	147	-12.4%
Sweden	15.0%	19.7%	58	72.5%
Growth	-0.3%	5.8%	147	-3.5%
Size	2.9%	13.4%	147	35.3%

Table 4 Correlation coefficients between the returns on the common factor and on "pure" factors, February 1990-April 2002

"Pure" factors are: country factors for the 10 countries with the largest securitized real estate market capitalization as of March 2002, a growth factor and a size factor.

	MONTHLYOBS	Common Factor	United States	Hong Kong	United Kingdom	Australia	Japan	Netherlands	Canada	France	Singapore	Sweden	Growth	Size
Common Factor	147	1.00												
United States	147	-0.64	1.00											
Hong Kong	147	0.39	-0.42	1.00										
United Kingdom	147	-0.29	0.25	-0.46	1.00									
Australia	147	-0.52	0.41	-0.22	0.11	1.00								
Japan	147	-0.03	-0.16	-0.39	-0.04	-0.03	1.00							
Netherlands	94	-0.54	0.25	-0.49	0.29	0.26	0.08	1.00						
Canada	68	-0.11	0.39	-0.37	0.16	0.24	0.00	0.12	1.00					
France	147	-0.60	0.39	-0.40	0.37	0.43	0.07	0.64	0.09	1.00				
Singapore	147	0.38	-0.27	0.62	-0.37	-0.16	-0.13	-0.49	-0.15	-0.34	1.00			
Sweden	58	-0.29	0.18	-0.52	0.49	0.39	-0.09	0.36	0.19	0.49	-0.57	1.00		
Growth	147	0.02	-0.02	0.06	0.12	0.00	-0.16	0.11	-0.05	-0.04	0.16	0.30	1.00	
Size	147	0.12	0.04	-0.03	-0.10	0.16	-0.03	-0.26	0.04	0.02	0.04	0.14	-0.09	1.00

Table 5 **Correlation coefficients between cluster returns and PCA returns**

The table shows the correlations over time of the "out-of-sample" Cluster and PCA factors. These factors are out-of-sample because the first 36 months (2/1990-1/1993) of data is used to estimate the first year of out-of-sample factor returns (2/1993-1/1994). The estimation procedure is then moved forward by 12 months.

	PCA 1	PCA 2	PCA 3	CLUSTER 1	CLUSTER 2	CLUSTER 3	CLUSTER 4
PCA 1	1.00						
PCA 2	-0.07	1.00					
PCA 3	-0.08	0.14	1.00				
CLUSTER 1	-0.16	0.25	-0.03	1.00			
CLUSTER 2	0.25	-0.31	0.29	-0.09	1.00		
CLUSTER 3	0.12	0.53	0.24	0.05	-0.07	1.00	
CLUSTER 4	0.12	-0.08	-0.19	-0.12	0.08	0.19	1.00

Figure 1 **Number of real estate stocks and market capitalization of real estate stocks included in the SSB database, February 1990-April 2002**

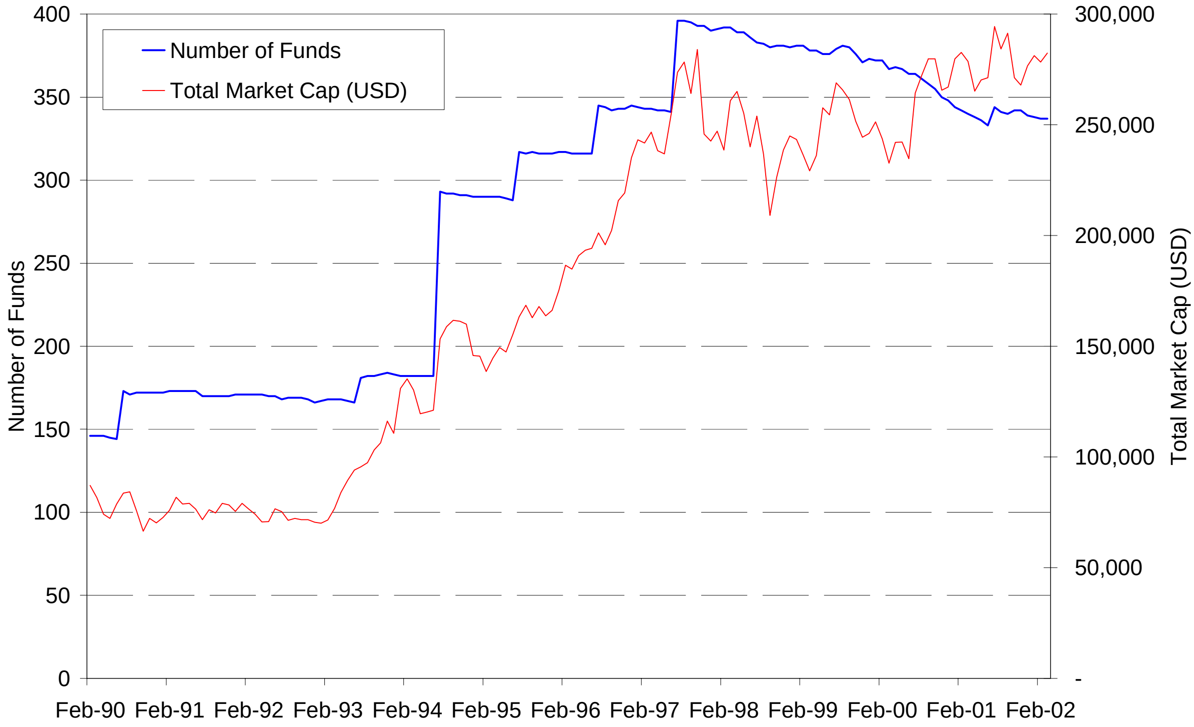

Figure 2 **Average growth exposure for real estate stocks in Europe, Asia, North America, Oceania, and the World, February 1990-April 2002**

Growth exposure (on a scale from 0 to 1) as defined by Salomon Smith Barney (SSB). Five-year earnings per share growth rate, five-year sales per share growth rate and five-year internal growth rate are taken into account. Measure is relative to other stocks in the country or region and the sum of growth rate and value weight for each stock is 1.

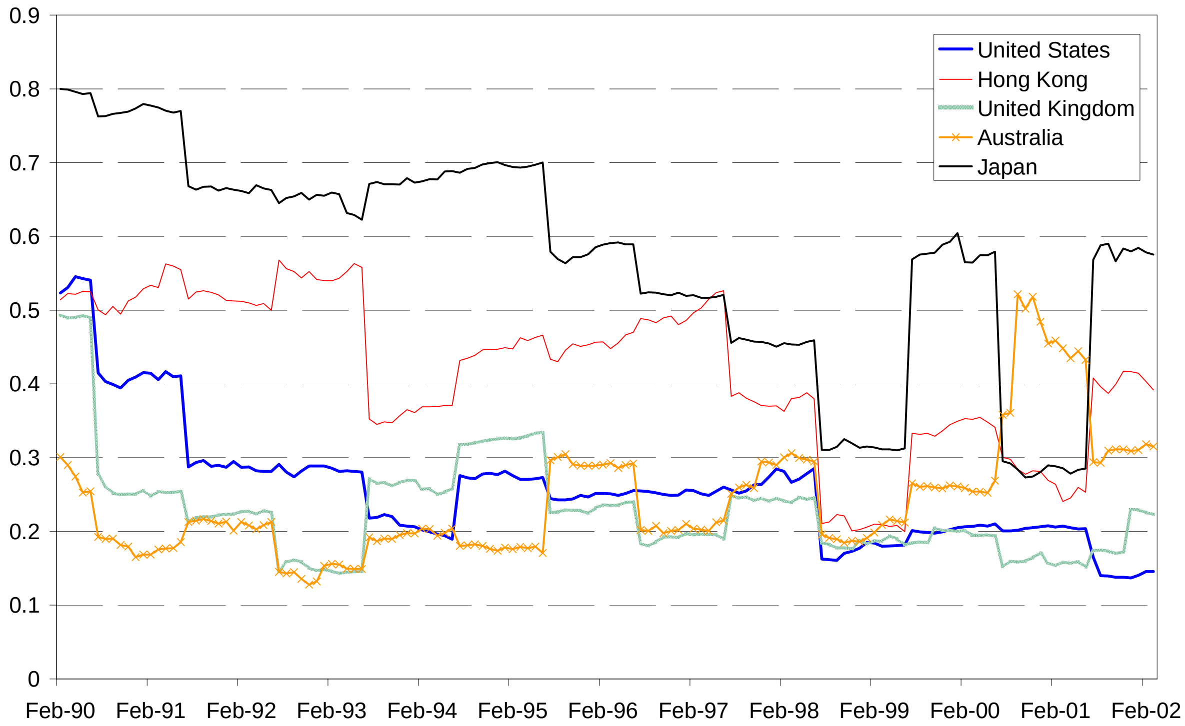

***Figure 3* Rolling betas of real estate stocks on common stocks for the U.S., Hong Kong, the U.K., Australia, and Japan, February 1990-April 2002**

Rolling betas calculated from regressions of real estate stock returns on common stock returns using 36-month windows. The window is shifted by one month for every regression. The first regression covers the period 2/1/1990-1/31/1993, the second regression the period 3/1/1990-2/28/1993, and so on until the last regression for the period 5/1/1999-4/31/2002.

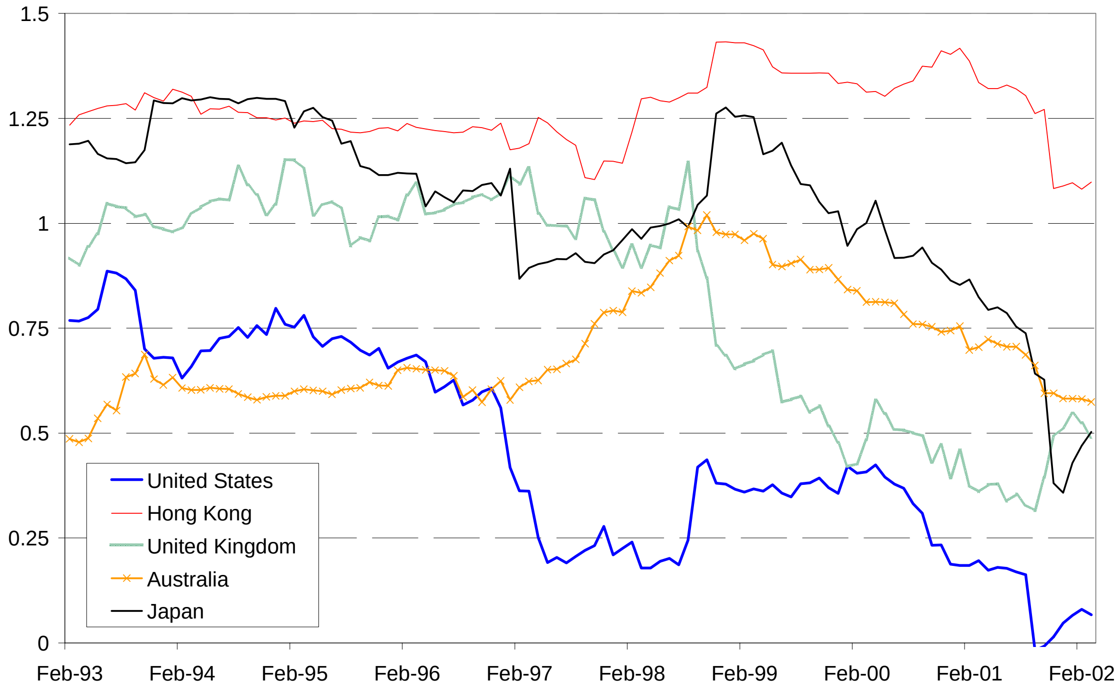

***Figure 4* Rolling average cross-country correlation coefficient for real estate securities and stocks, February 1990-April 2002**

Rolling average correlation coefficients calculated on 36-month windows. The window is shifted by one month for every computation. The countries considered in the average are the 10 countries with the largest securitized real estate market capitalization (U.S., Hong Kong, U.K., Australia, Japan, Netherlands, Canada, France, Singapore, and Sweden).

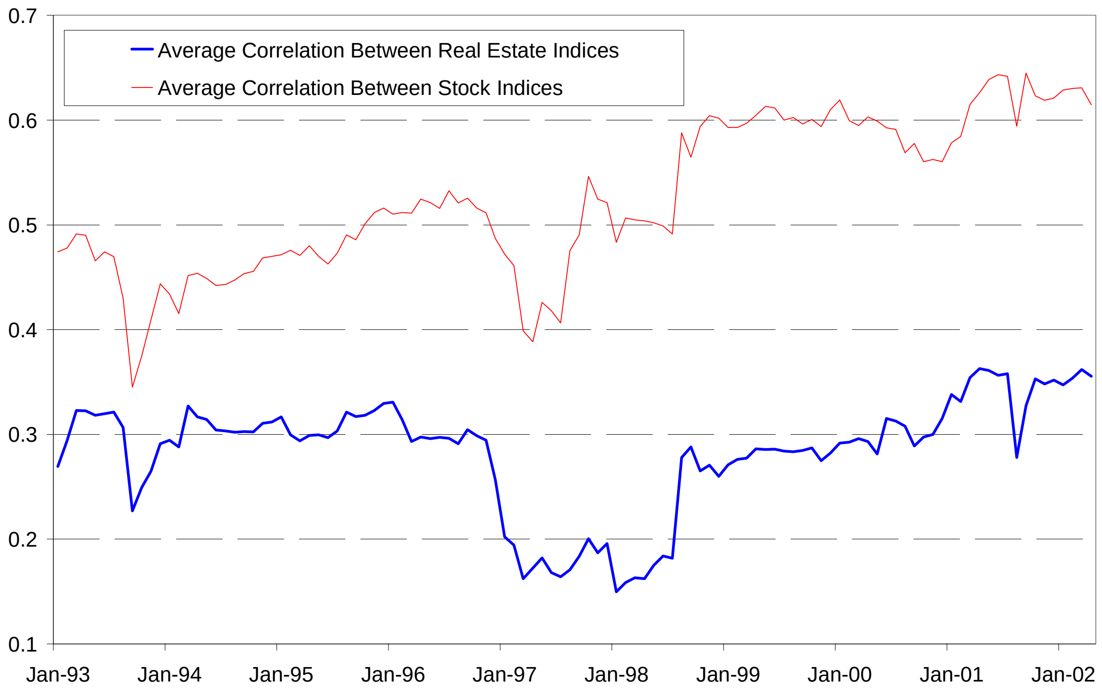

Figure 5 **Stock portfolio tracking error as a function of the percentage of real estate securities included in the portfolio (for the U.S., Hong Kong, U.K., Australia, and Japan)**

The following example best explains the graph: if we add 15% of U.S. real estate to a U.S. stock portfolio, measured against a U.S. stock benchmark, then the tracking error of that portfolio is 2.3%. For all countries, the impact on the tracking error of adding real estate to a pure stock portfolio is very reasonable.

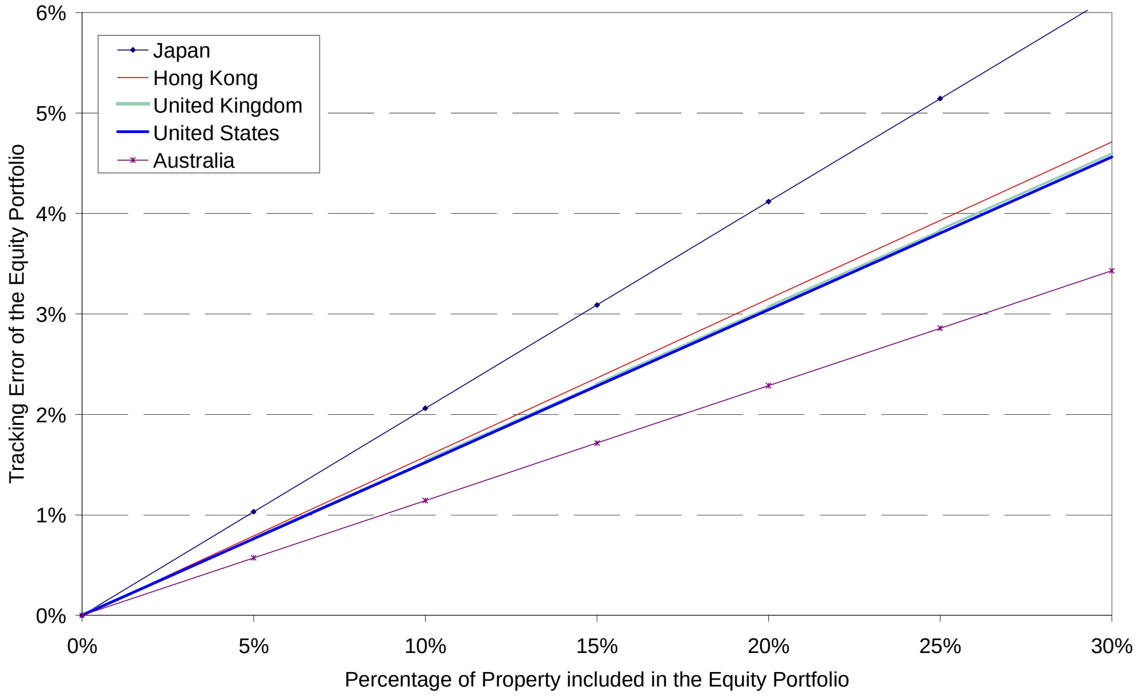

Figure 6 **Rolling average correlation coefficient for raw returns and returns on "pure" country factors, February 1990-April 2002**

Average of cross-country correlation coefficients for the 10 countries with the largest securitized real estate market capitalization. 36-month rolling windows are used.

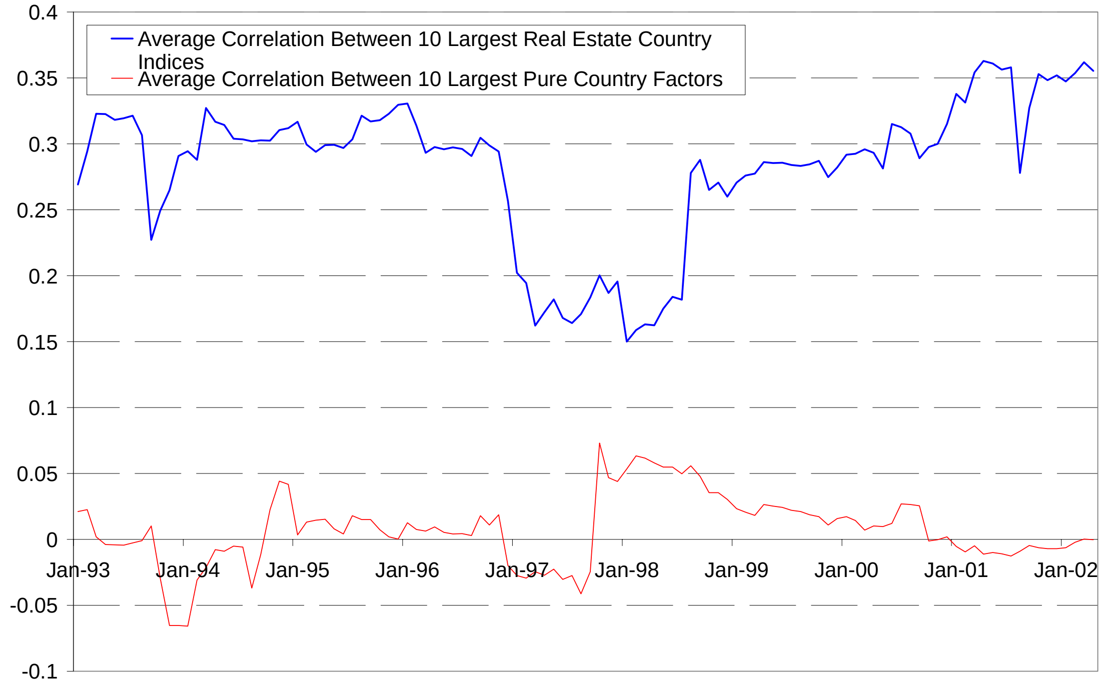

Figure 7 **Cumulative logarithmic returns on the common factor, the "pure" growth and value factors, and the "pure" size factor, February 1990-April 2002**

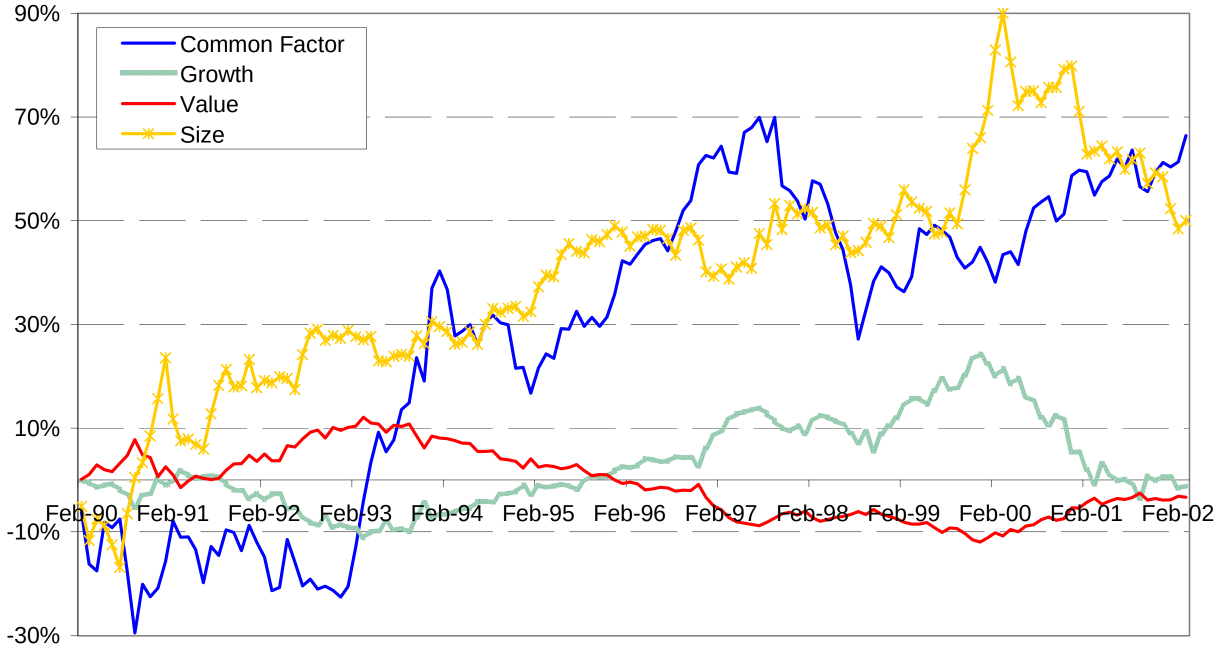

Figure 8 **Cumulative logarithmic returns on the "pure" country factors for the U.S., Hong Kong, U.K., Australia, and Japan, February 1990-April 2002**

Cumulative returns on the "pure" country returns are reported for the five countries with the largest securitized real estate market capitalization (U.S., Hong Kong, U.K., Australia, and Japan).

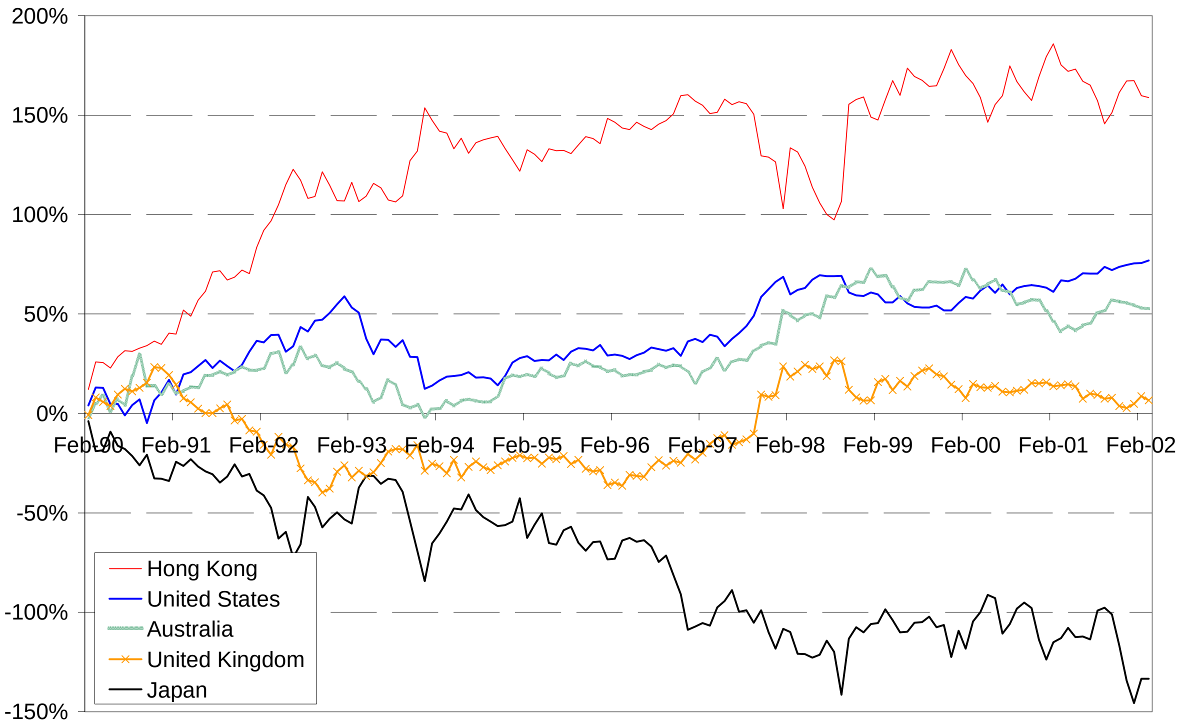

Figure 9 **Average absolute returns on each factor as a percentage of total absolute returns, February 1990-April 2002 (12-month moving averages)**

Importance of the average absolute returns on the common factor, the "pure" country, size, growth and value factors, and the specific component as a percentage of the total absolute returns from these various sources.

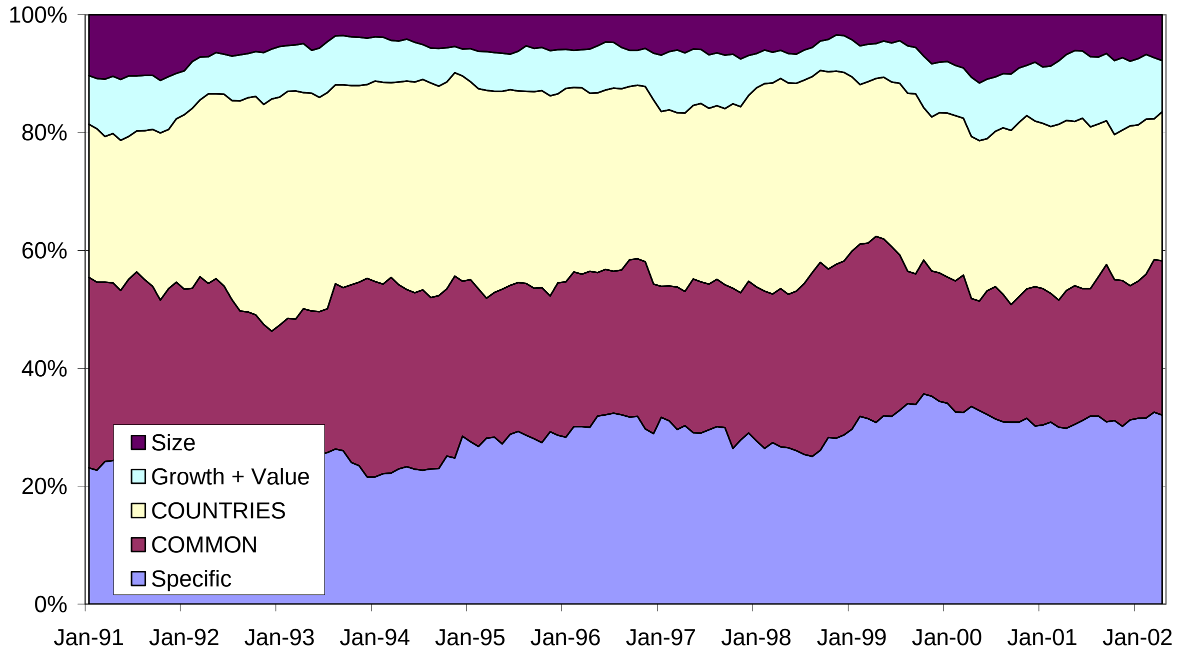

Figure 10 **Out-of-sample cumulative logarithmic returns on the four cluster factors, February 1993-April 2002**

The first year of out-of-sample returns (02/1993 to 01/1994) are obtained through cluster analysis of the real estate returns from 02/1990 to 01/1993. The 36-month rolling window is then moved forward by 12 months to obtain the cluster factor returns over the full period.

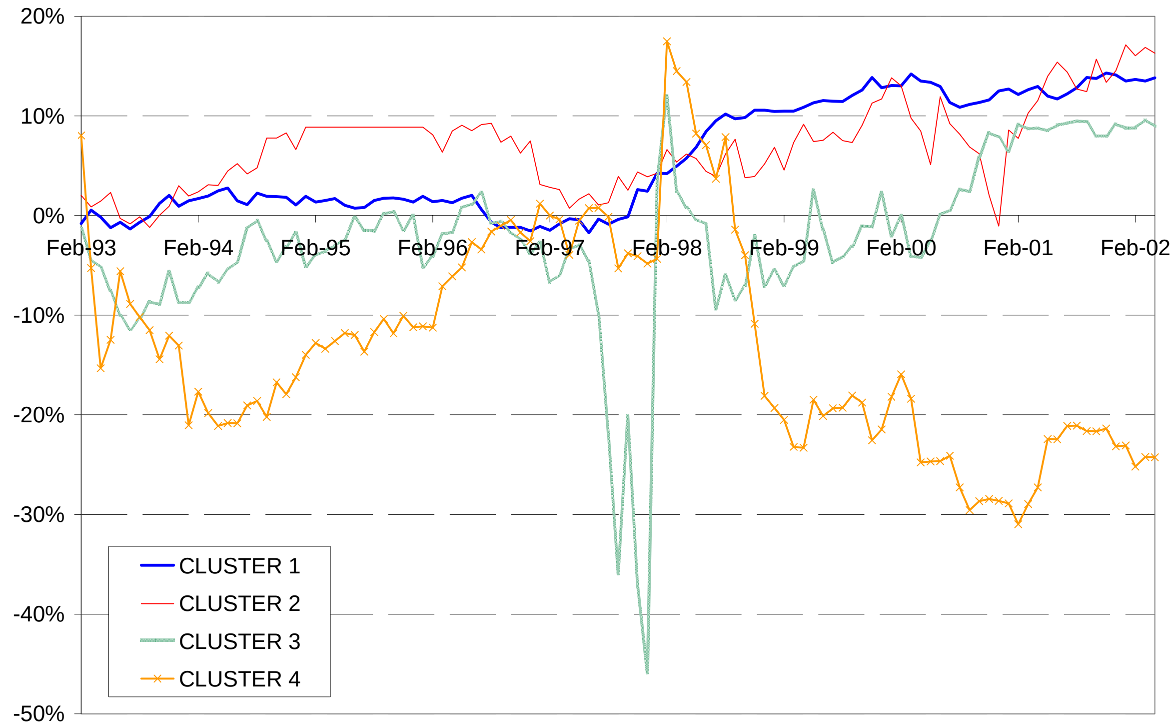

Figure 11 **Percentage of real estate companies having changed clusters from one year to another, 1994-2002**

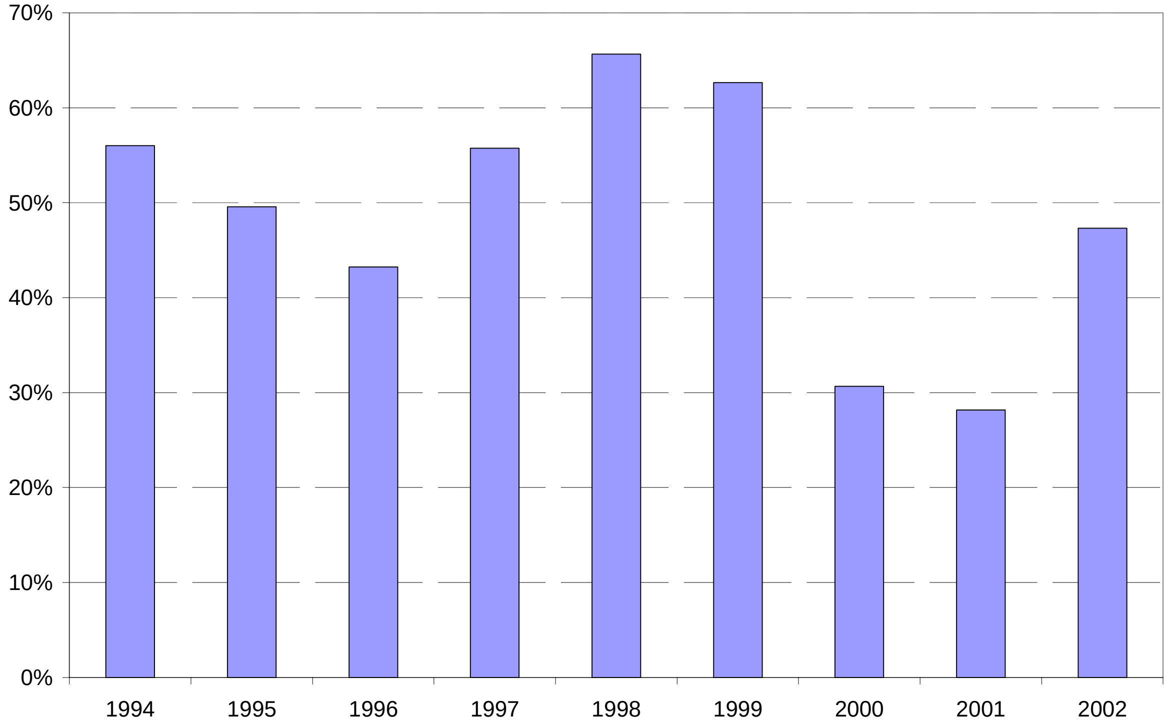

Figure 12 **Out-of-sample cumulative logarithmic returns on the three components from the principal component analysis, February 1993-April 2002**

The first year of out-of-sample returns (02/1993 to 01/1994) are obtained through PCA analysis of real estate returns from 02/1990 to 01/1993. The 36-month rolling window is then moved forward by 12 months to obtain the PCA factor returns over the full period.

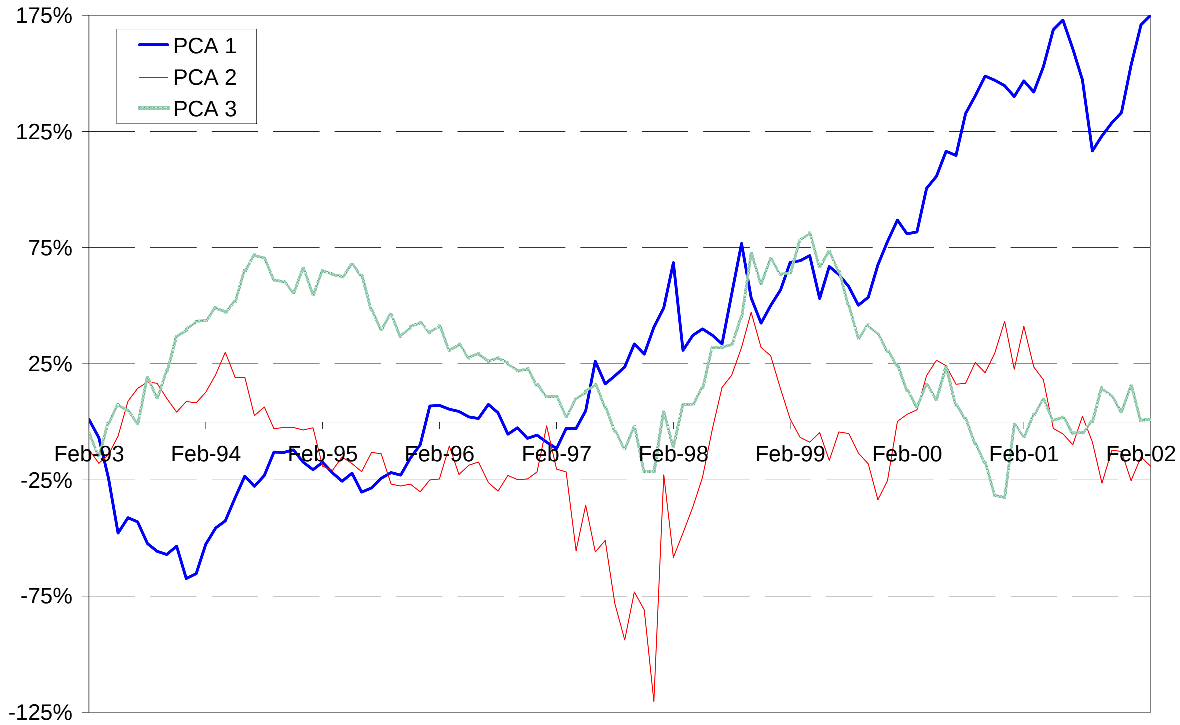

Figure 13 **Average absolute returns on each of the PCA factors and on the residual, as a percentage of total absolute returns, February 1993-April 2002 (12-month moving averages)**

Each stock's residual return is defined as its specific return, from which the returns on the estimated PCA factors (times each stock's sensitivity to each of these factors) is subtracted. A substantial percentage of the stock's specific returns can be explained by the three PCA factors (which are truly out-of-sample).