The Integration of Securitized Real Estate and Financial Assets

Séverine CAUCHIE
HEC - University of Geneva

Martin HOESLI
HEC - University of Geneva, FAME and University of Aberdeen (School of Business)

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Séverine Cauchie* and Martin Hoesli**

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Abstract

Empirical evidence suggests that U.S. REITs are integrated with common stocks, but not with bonds. The design of the real estate security is likely to impact upon results, however, and it would seem important to analyze the topic of integration for another type of real estate security. Swiss real estate funds constitute an ideal candidate for such an examination as their institutional and legal setup differs substantially from that of other countries. We analyze the integration of such funds with both the stock and bond markets using an APT framework. We employ both the Xu (2003) method and an innovative procedure to determine endogenous and exogenous factors, respectively. Integration is assessed by means of two alternative tests. Our results suggest that Swiss real estate funds are more integrated with stocks than with bonds. Further, we show that the degree of integration between real estate and stocks is due to a stock market factor and changes in expected inflation. No integrating factor is found between real estate and bond funds. Finally, it is found that unexpected inflation is a segmenting factor between real estate securities and financial assets.

Keywords: Securitized Real Estate; Statistical APT; Macroeconomic APT; Market Integration; Risk Factors
JEL Classification: G12

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* University of Geneva, HEC, 40 boulevard du Pont-d'Arve, CH-1211 Geneva 4, Tel: +41 22 379 8804, Fax: +41 22 379 8104, email: severine.cauchie@hec.unige.ch
** University of Geneva, HEC and FAME, 40 boulevard du Pont-d'Arve, CH-1211 Geneva 4 and University of Aberdeen, Business School, Edward Wright Building, Dunbar Street, Aberdeen AB24 3QY, U.K., Tel: +41 22 379 8122, Fax: +41 22 379 8104, email: martin.hoesli@hec.unige.ch
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Executive Summary

Securitized real estate markets have grown substantially in recent years. The market capitalization of public real estate has more than trebled in the past seven years, and as of the end of April 2003 it was estimated at approximately $320 billion. The institutional interest for such securities has also increased significantly, in particular as more tax transparent vehicles are being developed. An important issue for portfolio managers is to examine whether such public real estate vehicles provide portfolio diversification benefits. In other words, a key issue is to analyze how similarly or how differently real estate securities behave as compared with the more traditional assets considered by institutional investors, i.e., stocks and bonds.

This paper examines the level of integration of Swiss real estate funds with stock and bond markets for the period 1986-June 2002. A multifactor approach is chosen as it permits to identify the sources of integration or segmentation between asset classes. Both a statistical and a macroeconomic implementation of the APT are used. Stock returns are found to be generated by five common factors, whereas bond and real estate funds are described by four sources of systematic risk. We find that there are common risk factors across asset classes. Innovations in the term structure premium and changes in expected inflation appear in the stock and bond factor structures. Real estate funds exhibit one common variable with each of the other two asset classes, i.e., innovations in the unemployment rate with stocks and unexpected inflation with bonds.

Several results emerge also from the validation of the APT models. First, stock models explain asset returns in a better manner than either bond or real estate models. Second, a large number of risk factors that exhibit significant risk premia for stocks are also priced for real estate funds. Finally, bond funds and securitized real estate only share two priced factors, i.e., the default and the term structure risk premia.

Our results suggest a greater level of integration between real estate funds and stocks than between real estate and bonds. Thus, despite the different design of Swiss real estate mutual funds, we obtain similar results to those that have been reported for U.S. REITs. Some

sources of integration and segmentation between asset classes emerge. The stock market and changes in expected inflation are found to be integrating factors between real estate funds and stocks. There is also some evidence of general economic conditions playing an integrating role between real estate funds and stocks. Unanticipated inflation clearly emerges as a source of segmentation between real estate stocks and common stocks. No clear-cut factor of integration between real estate funds and bonds is found, but unexpected inflation again is a factor of segmentation. Other sources of segmentation between real estate and bond funds are almost all related to general economic conditions.

The Integration of Securitized Real Estate and Financial Assets

1. Introduction

Securitized real estate markets have grown substantially in recent years. The market capitalization of public real estate has more than trebled in the past seven years, and as of the end of April 2003 it was estimated at approximately $320 billion[1]. The institutional interest for such securities has also increased significantly, in particular as more tax transparent vehicles are being developed. An important issue for portfolio managers is to examine whether such public real estate vehicles provide portfolio diversification benefits. In other words, a key issue is to analyze how similarly or how differently real estate securities behave as compared with the more traditional assets considered by institutional investors, i.e., stocks and bonds.

One way of addressing this issue is to study the co-integrating relationship between real estate securities and financial assets. Such an approach is chosen by several authors. Glascock, Lu and So (2000), e.g., examine the integration of U.S. REIT, bond and stock markets. They show that REITs behave more like stocks and less like bonds after the structural change of the early 1990s. REITs are also shown to provide less diversification benefits in mixed-asset portfolios after 1992. Okunev and Wilson (1997) argue that the relationship between real estate and financial asset markets may be nonlinear rather than linear. They show that REITs are nonlinearly related to stocks, but the extent of the mean reversion between the two markets is quite slow and deviations between the two markets can be prolonged. The results by Wilson, Okunev and Webb (1998) do not support co-integration of real estate security and stock markets in the U.S., U.K., and Australia. For the U.S., however, there is evidence of co-integration of real estate stocks with small cap stocks. As useful as these studies may be in identifying long-run relationships between real estate security markets and stock markets, they do not permit the identification of factors that constitute the sources of integration.

[1] Private real estate vehicles have also increased both in number and market capitalization.

A more fruitful approach is to use an asset pricing model that enables both the testing of integration between two markets, but also the identifying of the sources of risk. The Arbitrage Pricing Theory (APT) framework is particularly well suited for that purpose. Risks in integrated markets should be shared completely and priced identically. In other words, (1) all asset returns are driven by the same systematic risk factors and by no factor specific to an asset class only, and (2) all factors have risk premia that are statistically not different from one another. The relevant risk factors can be determined in two ways, either endogenously or exogenously. In the first case, statistical factors are constructed (Roll and Ross, 1980), whereas pre-specified macroeconomic variables are used in the second case (Chen, Roll and Ross, 1986).

APT models have been used to identify the risk factors of real estate securities. In an early study, Titman and Warga (1986) use a statistical APT model to rank REITs. More recently, Chen, Hsieh and Jordan (1997) use both a statistical and a macroeconomic APT and find that the macroeconomic version of the model is usually superior in explaining Equity REIT (EREIT) returns. Using a macroeconomic model on both securitized and direct real estate data, Ling and Naranjo (1997) report that the growth rate in real per capita consumption is a major risk factor for real estate. Chan, Hendershott and Sanders (1990) find that unexpected inflation and changes in the risk and term structures of interest rates drive EREIT returns, whereas Chen, Hsieh, Vines and Chiou (1998) only report that the unexpected change in term structure is significant. However, none of the macroeconomic variables is significant when size and book-to-market variables are included in the model.

The concept of integration has predominantly been used in the financial economics literature to test whether international stock markets are integrated/segmented and to examine whether the degree of integration has changed over time. Among studies that employ a multifactor framework, Gultekin, Gultekin and Penati (1989) show that the price of risk in the U.S. and Japanese stock markets was different before, but not after, the liberalization[2]. The integration of various domestic markets or asset classes has also been examined. Naranjo and Protopapadakis (1997) use various integration tests for the NYSE, AMEX and NASDAQ markets. They start from the assumption that such markets are as integrated as markets are

[2] Other studies in the context of international diversification include Campbell and Hamao (1992), Mittoo (1992), and Heston, Rouwenhorst and Wessels (1995).

likely to be, and argue that such data can be used to provide a benchmark by which to adjust the significance levels used in other market integration tests. Bubnys, Khaksari and Tarimcilar (1993) find that U.S. stock, bond, and mortgage-backed security markets are integrated. Related to this stream of research is also the work by Grissom, Hartzell and Liu (1987) who use an APT framework to test whether regional direct industrial real estate markets in the U.S. are integrated or not. They conclude that such markets are segmented.

In direct relation with this study is the paper by Ling and Naranjo (1999) who analyze the integration of U.S. securitized real estate and stock markets, but also that of direct real estate and stock markets. They find that the securitized market is integrated with the stock market. Also, the degree of integration is found to have significantly increased during the 1990s. Clearly, further evidence on the degree of integration of securitized real estate markets and stock markets is needed. From this perspective, an investigation of the Swiss securitized real estate market should prove useful for at least three reasons.

First, the type of real estate security on which we focus (i.e., real estate mutual funds) usually trades at a premium to Net Asset Value (NAV) due to the institutional and legal setup in Switzerland (Section 2). Moreover, in the few periods when such securities trade below NAV, the magnitude of the discount is quite limited. This is in sharp contrast with what is observed in many other countries. U.K. property companies, for instance, almost always trade at a discount to NAV, with an average discount of 22% over the 1974-1994 period (Barkham and Ward, 1999). Second, the correlation coefficient between real estate stocks and stocks has been found to be less stable for Switzerland and to exhibit no trend (Gordon and Canter, 1999). These authors conclude that Swiss securitized real estate and stock markets are neither integrated nor segmented. Third, Swiss real estate securities have been shown to be more highly correlated with bond returns than with stock returns (Hoesli, Lekander and Wietkiewicz, 2004). For the period 1987-2001, for instance, the correlation between real estate stock returns and bond returns is 0.71, whereas that between real estate securities and stocks is 0.50. This is in contrast with what is found for most other countries. For the same time period, the correlation coefficients for the French market, for instance, are 0.29 and 0.65.

The purpose of this paper is to examine the integration of the Swiss real estate security and stock and bond markets for the period 1986-June 2002. Both a statistical and a macroeconomic approach are used to identify risk factors. The paper makes three contributions to the literature. First, it provides evidence on the degree of integration of the real estate stock market and financial asset markets for a country where the legal setup of real estate securities differs quite substantially from that of most other countries Second, we use an innovative approach that uses cluster analysis to select macroeconomic variables without making an *a priori* selection. Finally, we suggest a modification to the Gibbons, Ross and Shanken (1989) test so that it can be used in integration analyses.

The remainder of the paper is structured as follows. In section 2, we discuss the institutional framework of Swiss real estate securities, and discuss why we focus on Swiss real estate mutual funds. Our data are discussed in section 3, while endogenous and exogenous models are presented in the next section. Section 5 contains a presentation of methods used to estimate risk premia, while section 6 deals with the integration issue. Finally, a conclusion is provided in section 7.

2. Swiss Real Estate Funds: The Institutional Framework

There are two types of securitized real estate vehicles in Switzerland[3]. The first type are the property companies (*Immobilien Aktiengesellschaften* or *Sociétés Anonymes d'Investissement Immobilier*). These are in many respects similar to property companies or REITs as they exist in many countries. The shares of such companies are traded on the stock exchange and the market value of these shares is usually below the NAV. The second type of real estate securities are the real estate mutual funds. As is discussed below, Swiss real estate mutual funds exhibit some specificities from an institutional framework, and they are the focus of the empirical analysis in this paper[4].

[3] Besides these two types of real estate securities, there are also real estate funds (*Immobilienstiftungen* or *Fondations d'Investissement*) whose shares can only be purchased by institutional investors. As is the case with Commingled Real Estate Funds (CREFs) in the U.S., such shares are not traded on a stock exchange and any transaction occurs at the shares' net asset value.

[4] No comparison can be made of our results with those for the other type of Swiss real estate security (i.e., the property companies) as the latter vehicle has only been created quite recently.

The first Swiss real estate mutual fund was created in 1938. A real estate mutual fund is legally constituted by the combination of many individual contracts between each investor and the fund's management and custodian bank. Each of these contracts binds the fund's management to invest the fund's monies in the best interest of the unitholders[5]. Real estate mutual funds invest the bulk of their assets in apartment buildings, and there is a 50% ceiling to the proportion of financing by leverage. As of the end of 2003, there were 21 real estate mutual funds with a market value of CHF 12.9 billion (U.S.$ 10.4 billion). The largest fund (Sima) accounts for slightly more than 30% of the market capitalization of Swiss real estate mutual funds.

As is the case for any Swiss mutual fund, a real estate mutual fund must abide by the provisions of the Federal Law on Mutual Funds of October 19, 1994 and its Ordinances. This law has important implications for the behavior on the stock market of real estate mutual funds. Indeed, the law provides (Article 41.2) that unitholders can ask for redemption of their units at the closing of the annual accounting period, provided this is notified to the fund's management with a 12-month notice. If the accounting period ends on 31 December, for instance, a unitholder will have to wait 12 months for his/her units to be reimbursed if notification was made on December 31, N-1. If such notification only occurred during Year N, however, reimbursement will be made on December 31, N+1[6]. The redemption price will be equal to the NAV at the time of redemption minus some redemption fee. Unitholders thus have an option to sell their units, but with an exercise price that will be set in 12 to 23 months depending on when notification was made to the fund's management. As real estate assets do not trade frequently, the NAV is based on regular appraisals of the properties by independent real estate experts. An on-site inspection is required for first time appraisals, and subsequently at least every three years. Funds can also issue new units that are offered in priority to current unitholders (Article 41.1).

An important implication of unitholders having the possibility to request redemption of their units is that the stock market price of real estate mutual fund units usually lies above the contemporaneous redemption price. In other words, the redemption price constitutes in most

[5] The 'shares' of Swiss real estate mutual funds are called 'units'.

[6] Under unusual circumstances, a fund can be granted a longer period for reimbursement (Article 24.4).

cases a 'floor' to the stock market value of Swiss real estate mutual funds[7]. A discount to NAV, however, can occur if the market anticipates a decline in NAVs. For instance, if the current NAV of a unit is 100, but that the NAV is expected to decline to 95 by the time units will be reimbursed, the market value of units should be below 100. As of its annual closing, Interswiss, one of the largest real estate mutual funds, for instance, traded at a premium to NAV during 20 years out of the last 28 years. When interest rates were soaring at the end of the 1980s, signaling that the real estate market was soon to become bearish, Interswiss units traded at a discount to NAV. Again, this was because the market was anticipating declines in NAVs.

The institutional setup in Switzerland is thus in contrast with that existing in most other countries. Real Estate Investment Trusts (REITs) or property companies are usually closed-end vehicles with no redemption 'option', and the shares will at times trade at a discount to NAV, while a premium will be observed during some other periods. If REITs are viewed primarily as passive investment vehicles, like closed-end mutual funds, then a discount to NAV would be expected (Geltner and Miller, 2001, pp. 646-649). This is because of the additional layer of management inserted between investors and the underlying properties that adds risk, calling for a compensation. Also, there are some agency cost issues. Alternatively, if properties are expected to yield growth opportunities, then a premium to NAV would be anticipated. REITs usually traded at a discount to NAV in the 1970 and 1980s, but at a premium during most of the 1990s. There is also evidence of U.K. property companies trading at a discount during most of the 1974-1994 period (Barkham and Ward, 1999), whereas Singapore property companies do not exhibit any clear pattern as far as trading at a premium or a discount (Liow, 2003).

3. Data

This study considers three asset classes (stocks, bonds and real estate mutual funds) over the period from the first quarter of 1986 to the second quarter of 2002. The choice of this time period is dictated by two facts. First, several macroeconomic variables were not available

[7] The issue price does not constitute a 'ceiling', however, as new issuances only occur on a very infrequent basis, and in any case current unitholders have preferred issuance rights.

prior to 1984. As the Kalman Filter procedures that we use require that two years of data be used to calibrate models, innovation series can only be constructed starting in 1986. Second, a large number of mergers occurred within the real estate fund sector in the second half of 2002. These led to the number of listed funds declining from 21 to 12, making any analysis beyond that period difficult. We have opted to use quarterly returns rather than monthly returns due to the relatively infrequent trading of Swiss real estate mutual fund units. This lack of liquidity leads prices in some cases to be unchanged during several weeks; and these zero returns would bias our results.

Industrial portfolios of the Swiss stock market are used to avoid the noise of individual stock data. The portfolios are the most disaggregated total return indices provided by *Datastream Thomson Financial*. Nineteen industrial portfolios weighted by market capitalization are available for the period 1986Q1-2002Q2. A 20th portfolio that contains all indices with no complete history of returns is constructed. Summary statistics for these portfolios are contained in Appendix 1.

Bond fund returns are employed to proxy for bond returns as their duration is more constant over time than that of individual bonds. Forty-three Swiss bond funds are available in the *Bloomberg* and *Micropal* databases, but only 7 funds have a complete performance history for 1986Q1-2002Q2, while that number is 14 for 1991Q1-2002Q2 (the latter period is the period over which the risk premia are estimated). The descriptive statistics for the bond funds are reported in Appendix 2. Finally, we use data for 21 real estate mutual funds whose total returns are available in the various databases mentioned above. Only 11 and 19 funds, however, have a complete history of returns for 1986Q1-2002Q2 and 1991Q1-2002Q2, respectively. Appendix 3 contains summary statistics for real estate fund returns.

The selection of the potential macroeconomic risk factors is based on the intuition that any economic force that systematically affects future cash-flows and/or discount rates will impact on asset returns (Chen, Roll and Ross, 1986). This leads to four groups of variables being considered. A first group contains a broad set of variables related to general economic conditions. The gross national product (*GNP*), the gross domestic product (*GDP*) and an industrial production index (*IND*) are included in this group as Fama (1981) demonstrates the relationship between the level of activity and stock returns. Since the evolution of the labor market affects stock returns (Thorbecke and Chisholm, 1995) and interest rates (Jankus, 1997), the unemployment rate (*UNP*) and employment (*EMP*) are also included. The potential influence of oil prices on stock prices is established by Pari and Chen (1984). As Switzerland mainly imports oil from African countries, we select an African crude oil price index (*OIL*). Since more than 50% of sales by Swiss quoted companies are foreign sales (Cauchie, Hoesli and Isakov, 2004), exports (*EXP*) constitute an important determinant of the country's economic activity. Following the results of McElroy and Burmeister (1988) for stocks and those of Ling and Naranjo (1997) for securitized real estate, we choose two indicators of the level of consumption: A retail sales index (*RET*) and private consumption per capita (*PCC*). Finally, we consider the amount of loans granted for consumption (*CRD*) and construction (*CST*).

A second group of indicators pertains to the general level of prices and includes three measures of inflation whose impact on stock prices is established by Fama (1981): Money supply (*M3*), unanticipated inflation computed with Kalman Filter procedures, and changes in expected inflation (*CEI*) calculated as the difference between observed and unanticipated inflation rates. A third group of variables, related to general credit conditions, is composed of a default risk premium (*DEF*), i.e., the spread between risky debt and riskless debt, a term structure premium (*STR*), i.e., the spread between long- and short-term government bond yields, and the real 3-month interest rate (RR_f). The first two variables are assumed to proxy for expected economic growth (Harvey, 1991), whereas the latter has been shown to have a large explanatory power in explaining real estate returns (Ling and Naranjo, 1999). Finally, we use the total return on the *Datastream* market index (R_m) to measure the evolution of the Swiss stock market. All macroeconomic variables are expressed in real terms and are seasonally adjusted, except for employment. All data are from the *Datastream Thomson Financial* database. Summary statistics for these variables are reported in Exhibit 1.

4. Endogenous and Exogenous Models

4.1 Number of Factors and Endogenous Models

The identification of the factor structure for each asset class begins with the determination of the number of factors. This is achieved by using both the Mei (1994) and the Connor and Korajczyk (1993) tests: The number of factors describing the returns of each asset class is ascertained by comparing the results of both tests. We first use the Mei (1994) approach as it does not require that factors be specified. This approach relies exclusively on past returns and assumes that the number of lagged returns is equal to the number of factors that generate asset returns. The test compares the generalized sum of squared residuals of an unconstrained specification containing K lags (Q_K) with that of a constrained model including one lag less (Q_{K-1}). Under the null hypothesis that this restriction holds, the statistic ($L_{K,K-1}=Q_{K-1}-Q_K$) follows a Chi-squared distribution, with degrees of freedom equal to the difference between the number of parameters included in the two specifications. If the $L_{K,K-1}$ statistic is large enough to reject the null hypothesis, this indicates that returns are generated by K factors.

The autoregressive procedure, however, assumes that returns are generated by a strict factor structure. Connor and Korajczyk (1993) show that the number of factors can be over-estimated in such a framework and suggest a test that identifies the appropriate number of factors in an approximate factor structure. They assume that returns are generated by a K-factor model and examine if an additional factor belongs to this structure. Their statistic compares the behavior of the mean squared residuals of models including K and $K+1$ factors, respectively. In order for the statistic to follow a nondegenerate distribution, the test requires that the sample be divided into two sub-samples including each $T/2$ observations, one containing even quarters and the other odd quarters. In a first configuration, K-factor models are estimated during even quarters and $K+1$-factor models during odd quarters, while estimations are inverted in a second configuration, i.e., K-factor models are estimated during odd quarters and $K+1$-factor models during even quarters. Hence, two different but dependent statistics are constructed.

Under the null hypothesis that the additional factor is not a persuasive factor, the statistic asymptotically follows an unilateral Student distribution with $T/2$ degrees of freedom, with T being equal to the number of time periods. If the additional factor is not important in describing returns, the difference between the mean of squared residuals will be trivial and the statistic will converge to zero. Since the implementation of this test requires that statistical factors be defined, the test results will depend on the way the factors are constructed.

For each asset class, endogenous factors for the statistical version of the APT are constructed using the Xu (2003) method. The Maximum Explanatory Component (MEC) analysis permits the extracting of factors that take into account heteroscedasticity both over time and across assets. Such analysis is only possible for those assets that have a complete history of data. For a sample where the number of assets, *N*, is less than the number of time periods, *T*, the *i*-th MEC factor, f_i^*, is constructed as:

$$f_i^* = \frac{1}{\sqrt{\lambda_i}} R^{*\prime} a_i = \frac{1}{\sqrt{\lambda_i}} R' V^{-1} a_i \qquad (1)$$

where λ_i and a_i is the *i*-th eigenvalue and the corresponding eigenvector of the correlation matrix of returns Ω, respectively. $R^{*\prime} = R' V^{-1}$ are transformed asset returns where R are asset returns and V is a diagonal matrix of assets' standard deviations.

Since eigenvalues, λ_i, are sorted in a descending order, the *i*-th factor has by construction an explanatory power of residual returns that is maximized with respect to the preceding factors. Indeed, the first proposition in Xu (2003) shows that the average coefficient of determination $\overline{R}_i^2$ of the regression of f_i^* against residual asset returns is defined as $\overline{R}_i^2 = \lambda_i / N$.

Results of the Mei (1994) test present clear-cut conclusions. For stocks, all $L_{K,K-1}$ statistics for $K = 10$ to $K = 6$ accept the restriction, whereas statistics for $K = 5$ to $K = 1$ systematically reject the null hypothesis at the 1% level. These observations indicate that stock returns are correctly described by a 5-factor structure. The statistics for bond and real estate fund returns suggest that the returns on these asset classes are explained by a 4-factor structure.

The Connor and Korajczyk (1993) test is employed to confirm the previous results, but it requires that factors be defined. For each asset class, a set of endogenous factors is constructed using the Xu (2003) method. By construction, it includes a number of factors that is equal to the number of assets presenting a complete history of returns on 1986Q1-2002Q2. Therefore, the *i*-th MEC factor, f_i^*, is denoted 'Stocks-*i*' for stocks with *i* = 1,…,20, 'Bonds-*i*' for bond funds with *i* = 1,…,7, and 'RE-*i*' for real estate funds with *i* = 1,…,11. The sum of eigenvalues divided by the number of assets gives a measure of the explanatory power of these factors. The first five stock factors explain more than 80% of stock returns, whereas the first four real estate factors describe nearly 90% of real estate fund returns. As the factor construction relies on very few assets, the first four bond factors explain a very large fraction of bond returns (more than 98.5%).

For stocks, the Connor and Korajczyk (1993) statistic is not significant for the first configuration and hence the appropriate number of factors cannot be ascertained. For the second configuration, the statistic comparing residuals of models including 4 and 5 factors, respectively, rejects the null hypothesis at the 5% level, and hence the fifth factor is a persuasive factor that belongs to the stock factor structure. Concerning bond funds, both configurations show significant statistics at the 5% level when comparisons consider less than four factors, indicating that a four-factor structure is appropriate. For real estate funds, none of the configurations exhibits a significant statistic at any level, so no conclusion can be drawn. Results obtained with the Connor and Korajczyk test confirm those observed with the autoregressive test both for bonds and stocks. This indicates that the Mei (1994) test is less sensitive to an over-estimation of the number of factors when a long history of returns is considered.

4.2 Exogenous Models

As for the macroeconomic version of the APT, the construction and selection of exogenous factors is undertaken using a large database of financial and economic variables whose unanticipated changes are hypothesized to influence asset prices. As these unexpected variations are unobservable, we need to create series of innovations that isolate these components and that can be used as factors in tests. These unpredictable innovations have to satisfy the conditions specified by Ross (1976), i.e., they should be white-noise processes with zero-mean and no serial correlation. Since observed economic variables generally do not meet these requirements, we employ the Kalman Filter procedures of Priestley (1996) to generate perfect innovation series. For each observed factor that does not follow a white-noise process, we apply a simple unobserved-components model. If the residuals of this model, which constitute the innovation series, are still serially correlated, an autoregressive model with time varying parameters is used to generate expectations, and the residuals of that model are used as the factor's innovations. Contrary to financial variables whose values are available in real time, macroeconomic data are only disclosed with a lag, usually of one period (e.g., the first quarter's inflation rate is announced during the second quarter only). As expectations in Kalman Filter procedures are revised when information becomes publicly available, we lead macroeconomic variables by one period to make them contemporaneous with the returns that they are hypothesized to influence.

As pre-specified variables are too numerous to all be included in the factor structures, we develop an innovative method to select variables that best describe asset returns, without assuming *a priori* what variables should be included. An agglomerative hierarchical cluster analysis is used to build groups of variables in which factors belonging to the same set are considered substitutable variables, whereas factors belonging to separate clusters are substantially dissimilar. This is achieved using the Ward (1963) procedure implemented with the Wishart (1969) algorithm, guarantying the existence of a compact dendogram and minimizing correlations across groups. The dissimilarities used in the cluster analysis are modified Euclidian distances, which account for the fact that negatively and positively correlated variables should belong to the same cluster. At each step, the algorithm groups the two clusters whose combination yields the minimum increase in the total within group error sum of squares[8]. The dendogram permits to identify groups of substitutable variables, the number of which is set equal to the number of factors as identified above (*K*). We thus have a large number of candidate models as each of the variables within each of the *K* clusters is alternatively selected.

The model that is selected should explain well and in as many cases as possible the cross-section of returns. We use a composite index calculated from the coefficient of determination R^2 and its adjusted form R_A^2. A time series of 46 observations for each of the two explanatory power measures is produced by estimating the model by means of the dynamic validation method presented in section 5.1 below. For each of the two definitions of the coefficient of determination, the average explanatory power ($\overline{R}^2$) and its standard deviation ($\hat{\sigma}_{R^2}$) are computed from the time series to form the following index:

$$I_{R^2} = \frac{\overline{R}^2}{\hat{\sigma}_{R^2}} \qquad (2)$$

The model with the highest composite index defined as $I = \frac{1}{2}\left(I_{R^2} + I_{R_A^2}\right)$ is chosen as the macroeconomic model to explain asset class returns.

The determination of the macroeconomic factor structure begins with the construction of innovation series that can be used as factors in exogenous models. Exhibit 1 shows that all variables except the total return on the Swiss market have a non-zero mean and exhibit a persistent first order autocorrelation. Such variables cannot be used as factors and Kalman

[8] The sum of squares of a given cluster is defined as the sum of squared modified Euclidian distances between cluster's objects and its centroid.

Filter procedures are applied to extract unpredictable components. Only three variables (term structure, industrial production and oil prices) are unpredictable when an unobserved-components model is used (the innovation series are referred as *I*-). Other variables require that an autoregressive model with time varying parameters be used to reveal an unpredictable series. As many lags can be considered, the resulting innovation series are denoted by *AR* followed by the number of lags used. Macroeconomic variables are usually generated by a 1 or 2-order autoregressive model, except for employment which follows a 4-order autoregressive model because no seasonally-adjusted series is available. Changes in expected inflation are computed as the difference between the observed inflation rate (*INF*) and the unanticipated inflation rate (*AR2-INF*). Exhibit 2 shows that all innovation series are perfect factors for exogenous APT models as none of the Student and Ljung-Box statistics is significant at the 5% level.

Based on the results of the tests pertaining to the number of factors, we need to select five factors to explain stock returns and four factors to describe bond and real estate fund returns among the 18 innovation series of our database. Exhibit 3 shows the dendogram resulting from the agglomerative cluster analysis. The two horizontal lines in the exhibit indicate the four and five clusters of substitutable factors. For $K = 5$, the first group includes five variables related to general economic conditions and innovations in the default risk. The second cluster contains three economic variables and changes in expected inflation, whereas the third group includes innovation series of the GNP, oil prices and the 3–month real interest rate. The fourth cluster comprises innovations in the term structure, and returns on the market index. The final group contains two measures of unexpected inflation and the innovation series of construction loans granted.

The composition of the clusters appears to be consistent from an economic point of view. Consumption credit, for instance, is closely related to unexpected changes in GDP. Also, both measures of consumption constitute the root of the second cluster. These observations suggest that Kalman Filter procedures extract coherent unobserved innovation series. Note that the composition of the fourth group confirms the strong relationship between the term structure and stock market returns (Dahlquist and Harvey, 2001). For $K = 4$, the third and the fourth groups merge and a new cluster containing five innovation series is created.

As interactions between factors can modify their explanatory power, each substitutable factor within clusters is alternatively tested. This leads to $6\times4\times3\times2\times3=432$ alternative models being estimated for stocks and ranked by means of the composite index *I*. The best model is composed of innovations in the unemployment rate, oil prices, construction loans granted, term structure, and changes in expected inflation. To check the robustness of the model's composition, we examine the components of the first five models. Innovations in oil prices and changes in expected inflation are present in all models, whereas unexpected changes in the unemployment rate and construction loans appear in three out of five models. Although the term structure appears in the first two models, it exhibits the weakest explanatory power of selected factors. These results are quite similar to those observed in previous studies with the term structure being only mildly significant (Chen, Roll and Ross, 1986; Chen and Jordan, 1993), while changes in expected inflation constitute an important determinant of stock returns (Chen and Jordan, 1993). In contrast, the selection of oil prices is not consistent with the literature as the lack of significance of that variable has often been established (Chen, Roll and Ross, 1986; Clare and Thomas, 1994). The choice of the unemployment rate is also noticeable since studies that have considered this variable generally have not selected it (Groenewold and Fraser, 1997). Finally, the construction loans variable can be interpreted as an additional indicator of economic conditions.

For bond and real estate funds, $6\times4\times5\times3=360$ models are evaluated. For bonds, the best model includes innovations in term structure, default risk, inflation, and changes in expected inflation. Robustness checks indicate that unexpected inflation belongs to four out of five models, whereas the other three variables only appear in the selected model. This lack of robustness is counter-balanced by the observation that the explanatory power of the best model is far greater than that of the second best model. Both interest rate variables being included is consistent with prior studies (Ferson and Harvey, 1991; Knez, Litterman and Scheinkman, 1994). The strong robustness of the unanticipated inflation variable is consistent with the findings by Elton, Gruber and Blake (1995), whereas the selection of changes in expected inflation is peculiar to our results. The best model for real estate funds contains unexpected changes in the unemployment rate, retail sales, inflation and the 3-month real interest rate. The retail sales variable is selected in the first five models and exhibits strong explanatory power, providing further evidence of the importance of consumption in explaining real estate returns (Ling and Naranjo, 1999). The unemployment rate and the unexpected inflation rate are also robust since they appear in four out of the five models, while innovations in the 3-month real rate are only selected twice. These results contrast with those obtained by Ling and Naranjo (1999) as they identify the real T-bill rate as an important determinant of real estate returns, but observe no significant explanatory power for unexpected inflation.

We observe interesting similarities between exogenous determinants of the returns of the three asset classes. Among the 18 potential macroeconomic candidate variables, only 9 are selected to be determinants of asset returns. As the initial database is sufficiently large to conduct to completely different factors being selected for each asset class, this result constitutes first evidence that asset classes are partly integrated. The factor structure of industrial portfolios and bond funds have two factors in common, i.e., innovations in the term structure and changes in expected inflation. This would indicate that Swiss stocks and bonds are the most integrated of the asset classes. Real estate funds seem to be integrated to the same extent with stocks and bonds as their factor structure has one common variable with each of the two asset classes (innovations in unemployment rate with that of industrial portfolios and unexpected inflation with that of bonds). Formal integration tests are discussed in section 6.

5. Asset Pricing and Risk Premia Estimation

Each APT model, i.e., the statistical model and the macroeconomic model for each of the three asset classes, so six APT models in total, is tested with two different approaches. The first method, the so-called dynamic method, assumes that sensitivities and risk premia vary at each period, whereas the second model hypothesizes fixed coefficients for the entire period. Both tests assume that asset returns are generated by the following *K*-factor model:

$$\widetilde{R}_{it} = E(\widetilde{R}_{it}) + \sum_{k=1}^{K} \beta_{ikt} \widetilde{F}_{kt} + \widetilde{\varepsilon}_{it} \qquad (3)$$

where $\widetilde{R}_{it}$ symbolizes the return of asset i at time t and $E(\widetilde{R}_{it})$ its expected return, β_{ikt} represents the sensitivity of returns of asset i to factor k, $\widetilde{F}_{kt}$ is the realization of the k^{th} common factor at time t and $\widetilde{\varepsilon}_{it}$ represents the idiosyncratic return of asset i that is assumed to be normally, identically, and independently distributed. Ross (1976) demonstrates that in absence of riskless arbitrage opportunities, expected returns must satisfy the following pricing relationship:

$$E(\widetilde{R}_{it}) = \lambda_{0t}^{*} + \sum_{k=1}^{K} \beta_{ikt} \lambda_{kt} + \widetilde{\eta}_{it} \quad (4)$$

where λ_{0t}^{*} is the risk-free rate, λ_{kt} symbolizes the risk premium of the common factor k and $\widetilde{\eta}_{it}$ is the residual term. To avoid having to use expected returns to test equation (4), we substitute equation (4) into (3) to obtain a relationship which is directly testable with realized asset returns. In order for the estimated intercept to be as close as possible to zero, we use asset excess returns to test the following pricing relationship:

$$\widetilde{R}_{it} - \widetilde{R}_{ft} = \lambda_{0t} + \sum_{k=1}^{K} \beta_{ikt} \left(\lambda_{kt} + \widetilde{F}_{kt} \right) + \widetilde{\xi}_{it} \quad (5)$$

where $\widetilde{R}_{ft}$ is the risk-free rate, λ_{0t} represents the premium of a zero-beta portfolio over the risk-free rate and $\widetilde{\xi}_{it}$ is the error term.

5.1 Dynamic Validation

The dynamic test of the APT is based on the two-pass method initially proposed by Fama and MacBeth (1973) to test the CAPM. Our time period (1986-June 2002) is divided into 46 overlapping periods of five years each. The first period spans 1986Q1-1990Q4; the period is then shifted by one quarter. In the first pass, the sensitivities of the returns on the i^{th} asset to K common factor realizations at time t are estimated with an OLS time series regression using the returns on the i^{th} asset over the 5-year period, i.e., from t-21 to t-1. In the second pass, a cross-sectional GLS regression of modified excess returns[9] of period t on sensitivities estimated in the first pass permits to calculate the intercept and factors' risk premia for time t. This entire procedure is then repeated for the following period (i.e., the period shifted by one quarter), yielding a time series of 46 estimated risk premia for each factor.

We then test if risks are priced by examining if the mean of each series is statistically different from zero with three alternative estimators of its standard deviation: A Generalized Method of Moments (GMM) estimator that is robust to departures from normality, the

[9] Following equation (5), the cross-sectional regression relies on $\widetilde{R}_{it} - \widetilde{R}_{ft} - \sum_{k=1}^{K} \hat{\beta}_{ikt} \widetilde{F}_{kt} = \lambda_{0t} + \sum_{k=1}^{K} \hat{\beta}_{ikt} \lambda_{kt} + \widetilde{\xi}_{it}$, where the left hand side of the equation are the modified excess returns that are used as dependent variables.

Newey-West (1987) estimator which accounts for autocorrelation and heteroscedasticity, and the Shanken (1992) correction for error-in-variables. Indeed, the errors resulting from the use of estimated sensitivities as dependent variables in the second pass constitute a major drawback of this method. An other disadvantage is that the risk premia are estimated in a strict factor structure that does not account for covariances between idiosyncratic returns.

The dynamic estimation of equation (5) on modified excess returns creates time series of 46 risk premia whose mean is statistically compared to zero by means of a *t*-statistic. Exhibit 4 reports the estimates and level of significance of the premia based on the GMM standard deviation estimator[10], with Panel A containing the results for endogenous models and Panel B those for exogenous models.

The comparison of average R^2s indicates that the endogenous model for stocks is the best model to describe all asset class returns (Panel A). The coefficient of determination ranges from 45% to 66% when the stock model is considered. Models implemented on stock returns present significant risk premia for factors Stocks-1, -2 and -4, Bonds-1 and -4, and RE-1. These factors are statistical factors in nature and are therefore difficult to interpret, but an analysis of the coefficients of correlation between these factors and macroeconomic innovation series provides for a better understanding of forces underlying asset returns. Factors Stocks-1 and RE-1 are strongly correlated with the total return on the Swiss market index, whereas Stocks-2 and Bonds-1 are related to innovations in oil prices. Stocks-4 and Bonds-4 exhibit a significant correlation with innovations in the gross domestic product and changes in expected inflation, respectively. Our results thus provide further evidence of the importance of market returns and gross domestic product in describing stock returns (Kryzanowski and Zhang, 1992). Two of these macroeconomic series (i.e., changes in expected inflation and innovations in oil prices) are contained in the set of exogenous stock factors that were selected. Whereas the result pertaining to expected inflation is consistent with evidence that has been reported for other countries, the conclusion concerning oil prices confirms that oil prices are important in explaining stock returns in Switzerland.

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[10] Both other definitions of the standard deviation, i.e., the Newey and West estimator and the Shanken correction for error-in-variables, yield similar results.

None of the endogenous risk premia estimates for bond funds is significant, but an inspection of the proportion of significant individual risk premia at the 5% level shows a high percentage of occurrences for the Stocks-5 factor. As this factor is significantly related to innovations in GNP, this result is consistent with the findings of Elton, Gruber and Blake (1995). Real estate funds show six significant risk premia, four of which can be interpreted. The high significance of the Bonds-1 factor, which is related to innovations in oil prices, can be interpreted as a proxy of general economic conditions: An unexpected rise in oil prices negatively affects economic growth perspectives and decreases agents' confidence. As Swiss real estate funds largely invest in residential property, economic instability does not lead to increases in the demand for housing and thus reduces the expected return of such investments. Factor RE-2 is related to changes in expected inflation. Since this exogenous factor is not selected in the real estate model and generally exhibits no significant risk premium (Chen, Hsieh and Jordan, 1997), the influence of RE-2 on real estate returns can be due to other underlying forces not identified here. Factor RE-1 is correlated with both stocks returns and innovations in the term structure, two factors that have been shown to be determinants of REIT returns (Chan, Hendershott and Sanders, 1990; Chen, Hsieh and Jordan, 1997). Finally, factor RE-4 is related to unexpected changes in construction loans. As lagged changes of loans are likely to be related to returns on direct real estate, this result would suggest a link between direct and indirect real estate markets.

As for endogenous models, the comparison of average cross-sectional R^2s for exogenous models shows that the model designed to explain stock returns is the best macroeconomic model for each asset class (Exhibit 4, Panel B). For this type of model, the R^2s are slightly lower than those for endogenous models. Only two factors exhibit significant risk premia: Innovations in the term structure for stocks in two instances and expected inflation for real estate funds in one case. The negative sign of the term structure variable is not peculiar to our results (see, e.g., Chen, Roll and Ross, 1986). They argue that agents invest in stocks whose price decrease when long-term rates decline, in order to be hedged against a reduction of long-term real rates. The negative risk premium on unexpected inflation for real estate funds is also consistent with results reported for the U.S. (Chen, Hsieh and Jordan, 1997). This observation indicates that investors are willing to pay a premium for real estate funds as they provide a hedge against unanticipated inflation. Despite the fact that only few exogenous factors exhibit significant average risk premia, three macroeconomic variables are significant in a high percentage of quarters (76% of cases for default risk for bond funds, 72% for unemployment rate for real estate funds, and 70% for retail sales for stocks)[11].

5.2 Static Validation

The static method, based on the Iterated Non-Linear Seemingly Unrelated Regressions (ITNLSUR) approach, estimates fixed sensitivities and risk premia for the 1991-June 2002 sub-period. This is achieved by considering a non-diagonal matrix of covariance error terms and estimating simultaneously sensitivities and risk premia. This test relies on an alternative formulation of equation (5) in which β_{ik} and λ_k are not time varying (McElroy, Burmeister and Wall, 1985). Its implementation uses the Gallant (1987) algorithm that does not require a specific model of the distribution of errors and that yields strongly consistent and asymptotically normal estimators.

Exhibit 5 contains the results of the static validation of models (Panel A for endogenous models and Panel B for exogenous models). For stock excess returns, only three of the six statistical risk factors that are significant in the dynamic validation are still significant (Stocks-1, Stocks-4 and Bonds-4). Contrary to what is the case with the two-pass method, the intercept is always significant. This may either constitute an indication that risk factors have been omitted or that such an estimation method is not able to capture changes in risk premia. Whereas the dynamic validation exhibited no significant risk premia for bond funds, 9 out of 13 endogenous factors are significantly priced with ITNLSUR. The factors are most highly correlated with inflation measures (*AR2-INF* and *CEI*), stocks returns (R_m), oil prices (*I-OIL*) and indicators of the general level of activity (*AR2-GDP* and *AR3-GNP*). Concerning real estate funds, RE-1 is the only factor for which a significant risk premium prevails.

The results for exogenous models confirm the importance of the structure term premium in explaining stock returns and also show the impact of unanticipated inflation. The term structure premium, however, exhibits the opposite sign to that found with the time varying estimates. For bond funds, the three measures of interest rates have significant risk premia. In the case of real estate funds, only default and term premia are priced. The results for Swiss real estate funds are in contrast with those by Ling and Naranjo (1999) for U.S. securitized

[11] The importance of retail sales in explaining stock returns is documented by McElroy and Burmeister (1988).

real estate. They report the important role of the real T-bill rate and not that of the variables we find for Switzerland. For bonds and real estate funds, the conclusions pertaining to exogenous models thus appear to be complementary to those obtained from endogenous models as they underline the importance of variables related to credit conditions in explaining asset returns. Such an interpretation is impossible with endogenous factors since none of them is correlated with interest rates variables, except for Stocks-1 which albeit significantly related to term structure innovations is predominantly related to the market index. Following Srivastava and Giles (1987), the goodness-of-fit measure (denoted R^2) is computed as the average of correlations between observed and estimated excess returns. Endogenous models exhibit a higher explanatory power than exogenous ones and a slight superiority of stock models over bond models, which in turn are superior to real estate models.

To sum up validation results, we observe some similarities between the various sets of estimators and conclude that industrial portfolio returns are mainly influenced by the return on the market index, some indicators of the general level of activity (GDP, oil prices, the unemployment rate, and retail sales), two measures of inflation (unexpected inflation and changes in anticipated inflation), and the term structure premium. For bond fund returns, innovations in GNP and the three indicators of credit conditions are significantly priced. Securitized real estate returns are predominantly described by the return on the common stock market, innovations in oil prices and the unemployment rate, the two measures of inflation, and the default and structure risk premia. This analysis shows a larger number of common significant factors between stocks and securitized real estate than between bonds and real estate funds. However, only formal tests of the integration between asset classes can lead to clear-cut conclusions; such tests are the focus of the next section.

6. Integration of Capital Markets

In tests of integration based on asset pricing models, two asset classes (A1 and A2) are said to be integrated if their risk premia for each factor are equal. This definition implies two types of tests. The first type considers the set of *K* common factors and statistically tests if:

$$\lambda^{A1}=\lambda^{A2} \text{ for } K \text{ common factors.} \qquad (6)$$

Among all systematic risk factors, those that exhibit identical individual risk premia induce integration between markets and hence are considered as sources of their integration. In contrast, factors that exhibit statistically different individual risk premia constitute sources of segmentation. Tests of integration based on each *k* factor thus make it possible to identify the source of integration or segmentation between two asset classes. The second type of test specifically compares the intercept risk premia since the intercept of a regression captures all risk factors that are not included in common risk factors and permits to identify whether or not a specific factor exists[12]. However, differences in estimated intercepts can be interpreted in two ways: (1) Either there exists a common source of risk that is priced differently or (2) there are sources of risk that are specific to the various asset classes. In the latter case, integration will also be rejected as integrated markets must share the same risk factors, so no risk specific to an asset class should exist.

6.1 Dynamic Test of Integration

In the dynamic framework, tests of the null hypothesis specified in equation (6) rely on methods that were initially developed to test the CAPM. Instead of comparing the regression intercept to zero, tests put in relation two individual risk premia or sets of risk premia of common factors. A traditional procedure is the Wald test, but Naranjo and Protopapadakis (1997) find that it is too powerful and leads to the null hypothesis being too often rejected. Campbell, Lo and MacKinlay (1997) explain that this is due to a size issue as an asymptotic test is used in a small sample.

To avoid this issue, we propose a finite-sample statistic based on the Gibbons, Ross and Shanken (1989) test (GRS test). As demonstrated in Appendix 4, under the additional hypothesis that the covariance matrices of error terms follow a Wishart distribution based on an identical matrix $\sigma^2 I$, the following finite-sample statistic can be defined:

$$\frac{2t'-L+1}{L} X' A^{-1} X \sim F_{L;2t'-L+1} \qquad (7)$$

where t' indicates the number of quarters used in the risk premia estimation and L is the number of risk premia considered in the integration test. The L-vector X is defined as

[12] In our case, a specific factor is related to an entire asset class , i.e., is specific to this asset class. It is not a specific risk as usually defined in asset pricing theory.

$X=\left[\left(\hat{\beta}_t^{A1}V_{A1}^{-1}\hat{\beta}'^{A1}_t\right)^{-1}+\left(\hat{\beta}_t^{A2}V_{A2}^{-1}\hat{\beta}'^{A2}_t\right)^{-1}\right]^{-1/2}\left(\hat{\lambda}_t^{A1}-\hat{\lambda}_t^{A2}\right)$, where $\hat{\lambda}_t^{Aj}$ is a L-vector of risk premia estimated on asset class A_j including N_{Aj} assets, $\hat{\beta}_t^{Aj}$ is the $N_{Aj}\times K$ matrix of sensitivities and V_{Aj} is the matrix of weights used in the GLS estimation. The $L\times L$ matrix A is defined as $A=C_{L,t'}^{A1}+C_{L,t'}^{A2}$ where $C_{L,t'}^{Aj}$ is a submatrix of dimension $L<N_{Aj}$ of $C_{t'}^{Aj}=\sum_{t=1}^{t'}V_{Aj}^{-1/2}\xi_t^{Aj}\xi'^{Aj}_tV'^{-1/2}_{Aj}$, where ξ_t^{Aj} represents the N_{Aj}-vector of error terms for quarter t.

Since the number of restrictions L must be at least equal to the number of degrees of freedom of covariance matrix estimators, tests on λ_k^{Aj} individual risk premia are possible for each quarter, but tests considering the set of K risk premia must be implemented on sub-periods spanning at least t' quarters. It is important to stress that for tests of integration to be powerful, they must rely on statistically significant risk premia and, in the dynamic context, risk premia should be identical for each period and not only on average to conclude that markets are integrated.

Exhibit 6 reports results of the modified GRS test. The figures indicate the percentage of quarters in which integration is rejected. Note that these figures only concern quarters in which the following two assumptions are verified: (1) Both risk premia are statistically significant and (2) covariance matrices of errors are similar. When all risk factors and the intercept are considered, real estate funds appear to be more integrated with stocks than with bonds (it is more difficult to reject integration with stocks than with bonds in five out of six models). We now turn to the analysis of results on individual risk premia that allow identification of the sources of integration or segmentation. Our results suggest that factors RE-1 and RE-2 are sources of integration between real estate funds and stocks. These two factors are related to market returns and changes in expected inflation, respectively. In exogenous models, the oil price factor is also a source of integration between these two asset classes. In contrast, Bond-2 (linked to unanticipated inflation), and two macroeconomic factors (term structure premium and short-term real interest rate) constitute sources of segmentation. Concerning the relationship between real estate funds and bonds, the sources of integration are factor RE-1 (related to market returns) and the term structure premium. However, Bonds-2, the unemployment rate and unexpected inflation factors are sources of segmentation with a large proportion of rejection of the null hypothesis. Intercept results generally exhibit a larger proportion of rejection of the null hypothesis for stocks and securitized real estate than for bond and real estate funds. This indicates that bonds and indirect real estate share most of the same sources of risk, but that these sources are remunerated differently.

6.2 Static Test of Integration

In the static framework, integration between asset classes is assessed with a test based on the Jobson and Korkie (1982) finite sample likelihood-ratio approach. It is computed as follows and requires the estimation of two models, one that is constrained (C) and one that is not (NC):

$$LRT = \left(T - \frac{N}{2} - L - 1\right)\left(\log\left|\hat{\Sigma}_C\right| - \log\left|\hat{\Sigma}_{NC}\right|\right) \sim \chi^2_L \qquad (8)$$

where T is the number of time periods, N is the number of assets, L is the number of restrictions, and $\left|\hat{\Sigma}_C\right|$ and $\left|\hat{\Sigma}_{NC}\right|$ is the determinant of the maximum-likelihood estimator of the residual covariance matrix of each model. In spite of its asymptotic correction, Campbell, Lo and MacKinlay (1997) show that this test also suffers from a minor size problem. Since this effect is less important when a small number of assets is considered, the test is only implemented for the asset class whose sample contains the fewer assets in each comparison.

Exhibit 7 reports the results of the Jobson and Korkie (1982) LRT test of integration. When all risk factors and the intercept are considered, the statistics in most cases suggest a greater degree of integration between real estate and bond funds than between real estate funds and stocks, although integration is rejected in all cases[13]. The higher degree of integration with bonds that is apparent here contradicts our previous results only in part, however. Statistics for risk premia without the intercept exhibit smaller levels of rejection between stocks and securitized real estate than between bonds and real estate, indicating a greater level of integration between the former two assets than between the latter two. The integration of intercepts confirms the dynamic results in that there are no specific risk sources between bond and real estate funds, whereas some may exist between stocks and real estate. Thus, in the static framework, the intercept has more impact on the integration results than in the dynamic context.

[13] Bonds and stocks are the most integrated asset classes in the dynamic context, but not in the static framework.

Caution has to be exercised when interpreting the individual risk premium results as tests of integration will fail to reject the null hypothesis if risk premia are not significantly different from zero. For this purpose, we highlight two types of statistics: (1) When both risk premia are significant the figures are in bold indicating that results are very reliable, and (2) when only one risk premium is different from zero the numbers are in italic suggesting less reliable results. The results confirm that market returns (Stocks-1) and changes in expected inflation (Bonds-4) are sources of integration between stocks and real estate funds. Moreover, default and term structure premia constitute additional exogenous sources of integration. The result concerning the latter factor is not consistent with the dynamic results where this factor is found to be a source of segmentation. Tests of integration are joint tests of integration and of a selected model. Depending on the validation method being used, the estimated risk premia can differ. The conflicting results concerning integration with respect to the term structure premium could thus stem from the fact that its estimate is positive in one case and negative in the other. As far as real estate and bond funds are concerned, the sources of integration are the Stocks-5 factor (linked to GNP) and the default risk premium.

Concerning sources of segmentation, the role of unanticipated inflation is confirmed in the relationship between stocks and real estate funds. In contrast, there are numerous sources of segmentation between real estate funds and bonds. Consistent with the dynamic results, the Bonds-2 factor (related to unanticipated inflation) is a segmentation-inducing factor, but there are seven other endogenous factors as well. Two exogenous factors emerge: Term structure and the short-term real interest rate[14].

Overall, our results suggest a greater level of integration between real estate funds and stocks than between real estate and bonds. Thus, despite the unique design of Swiss real estate mutual funds, the same conclusion as for U.S. REITs prevails on approximately the same time period (Glascock, Lu and So, 2000). Some sources of integration and segmentation between asset classes also clearly emerge. The stock market and changes in expected inflation are found to be integrating factors between real estate funds and industrial portfolios. The stock factor has been found to be a determinant of securitized real estate returns in previous studies

[14] The conflicting conclusion between the dynamic and the static results as far as the term structure variable can again be explained by the fact that the sign of the estimated risk premia differs.

(Peterson and Hsieh, 1997). Risk premia on expected inflation for both asset classes do not differ from a statistical point of view. Insofar as their sensitivity to this factor is similar, this result would indicate comparable inflation hedging properties[15]. Not surprisingly, there is also some evidence of general economic conditions playing an integrating role between real estate funds and stocks as the oil price factor only leads to integration being rejected in a third of the cases in the time varying risk premia estimates. Unanticipated inflation clearly emerges as a source of segmentation between real estate stocks and common stocks. Also, real estate funds and stocks do not appear to behave similarly as far as short-term interest rate changes. This would be expected as the underlying real estate of real estate funds should be more sensitive to changes in interest rates than common stocks. As the level of integration between real estate funds and bonds is less pronounced, it is not surprising that no clear-cut factor of integration emerges between the two asset classes. Sources of segmentation are plentiful. Again, unexpected inflation is a factor of segmentation. Other sources are almost all related to general economic conditions, suggesting that the two asset classes react differently to changes in such conditions.

7. Conclusion

This paper examines the level of integration of Swiss real estate funds with stock and bond markets for the period 1986-June 2002. A multifactor approach is chosen as it permits to identify the sources of integration or segmentation between asset classes. Both a statistical and a macroeconomic implementation of the APT are used. Stock returns are found to be generated by five common factors, whereas bond and real estate funds are described by four sources of systematic risk. We find that there are common risk factors across asset classes. Innovations in the term structure premium and changes in expected inflation appear in the stock and bond factor structures. Real estate funds exhibit one common variable with each of the other two asset classes, i.e., innovations in the unemployment rate with stocks and unexpected inflation with bonds.

[15] Liu, Hartzell and Hoesli (1997), e.g., find that both Swiss stocks and real estate funds act as perverse hedges against expected inflation.

Several results emerge also from the validation of the APT models. First, stock models explain asset returns in a better manner than either bond or real estate models. Second, a large number of risk factors that exhibit significant risk premia for stocks are also priced for real estate funds. Finally, bond funds and securitized real estate only share two priced factors, i.e., the default and the term structure risk premia.

Our results suggest a greater level of integration between real estate funds and stocks than between real estate and bonds. Thus, despite the different design of Swiss real estate mutual funds, we obtain similar results to those that have been reported for U.S. REITs. Some sources of integration and segmentation between asset classes emerge. The stock market and changes in expected inflation are found to be integrating factors between real estate funds and stocks. There is also some evidence of general economic conditions playing an integrating role between real estate funds and stocks. Unanticipated inflation clearly emerges as a source of segmentation between real estate stocks and common stocks. No clear-cut factor of integration between real estate funds and bonds is found, but unexpected inflation again is a factor of segmentation. Other sources of segmentation between real estate and bond funds are almost all related to general economic conditions.

Exhibit 1: Summary Statistics for the Macroeconomic Variables

The exhibit contains the mean and standard deviation of the 17 macroeconomic variables. The Jarque-Bera statistic tests whether the variable follows a Normal distribution. The Ljung-Box Q(1) statistic detects the presence of first order autocorrelation.

Macro-economic variable	Name	Mean	Standard deviation	Jarque-Bera statistic	Ljung-Box Q(1) statistic
GDP	Real gross domestic product (CHF Million)	64,269.05	3,239.08	1.51	58.66***
GNP	Real gross national product (CHF Million)	67,465.87	4,111.95	0.46	59.54***
IND	Real industrial production (Index)	100.77	10.93	4.27	59.40***
OIL	Oil prices	28.77	8.52	18.31***	27.87***
EMP	Employment (Thousand)	3,897.38	215.43	8.80**	56.67***
UNP	Unemployment rate	2.52	1.69	6.91**	66.70***
PCC	Real private consumption per capita (CHF)	5,497.31	151.36	2.03	57.35***
RET	Real retail sales (Index)	585.85	28.50	6.18**	60.74***
EXP	Real exports (CHF Million)	17,299.51	2,415.21	8.97**	61.94***
CRD	Real consumption loans granted (CHF Million)	172,902.00	15,990.82	0.29	58.01***
CST	Real construction loans granted (CHF Million)	22,767.91	8,975.96	5.59*	66.09***
M3	Real money supply M3 (CHF Million)	300,277.90	22,439.76	2.31	59.84***
INF	Inflation rate	0.49	0.48	7.25**	41.23***
RR_f	Real Swiss Franc 3-month interest rate	0.51	0.36	1.42	20.17***
STR	Term structure	0.07	0.39	5.88*	58.44***
DEF	Default risk	0.11	0.07	0.82	48.56***
R_m	Total return on the Swiss Datastream total market index	2.41	10.93	89.91***	1.91

***/**/* indicates rejection of the null hypothesis at the 1%, 5% or 10% level, respectively.

Exhibit 2: Summary Statistics for the Macroeconomic Factors (Innovation Series)

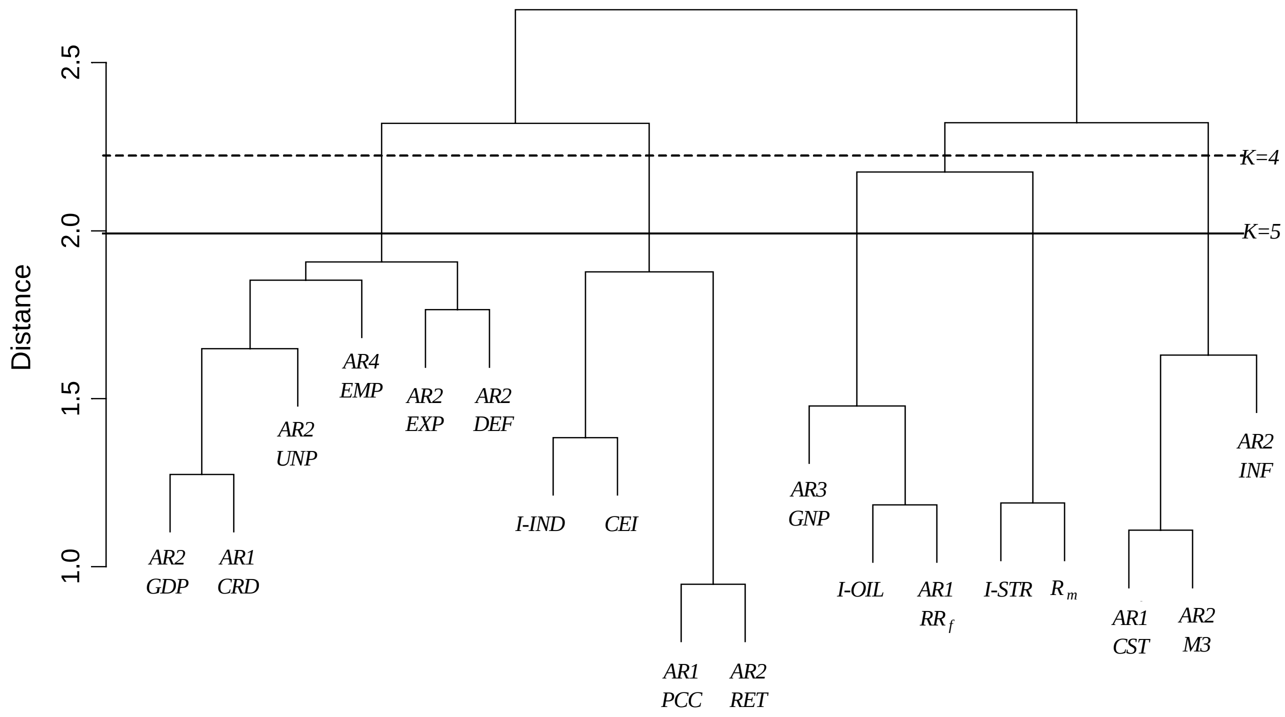
The exhibit shows the mean and standard deviation of 18 innovation series generated from the Kalman Filter procedures. The Student statistic checks if the mean of the series is non different from zero. The Ljung-Box Q(1) statistic detects the presence of first order autocorrelation.

Factor	Mean	Standard deviation	Student statistic (Ho : mean=0)	Ljung-Box Q(1) statistic
AR2-GDP	10.12	418.84	0.19	1.73
AR3-GNP	-134.89	1,261.53	-0.86	3.20*
I-IND	0.46	2.88	1.30	0.01
I-OIL	-0.01	0.24	-0.18	2.53
AR4-EMP	-0.79	47.84	-0.13	0.65
AR2-UNP	-0.02	0.11	-1.29	1.18
AR1-PCC	-2.27	36.73	-0.50	2.08
AR2-RET	0.03	8.16	0.03	0.94
AR2-EXP	56.63	441.51	1.04	0.76
AR1-CRD	43.63	2,292.53	0.15	1.91
AR1-CST	11.86	350.09	0.27	3.66*
AR2-M3	46.11	2,472.51	0.15	0.06
AR2-INF	0.08	0.32	2.03*	0.50
CEI	-0.01	0.17	-0.39	0.40
AR1-RR_f	0.06	0.33	1.48	0.47
I-STR	0.53E-02	0.15	0.29	0.55
AR2-DEF	-0.23E-02	0.03	-0.55	0.22

***/**/* indicates rejection of the null hypothesis at the 1%, 5% or 10% level, respectively.
CRD : real consumption loans granted, *CST* : real construction loans granted, *CEI* : changes in expected inflation, *DEF* : default risk, *EMP* : employment, *EXP* : exports, *GDP* : real gross domestic product, *GNP* : real gross national product, *IND* : real industrial production, *INF* : inflation, *M3* : real money supply, *OIL* : oil prices, *PCC* : real private consumption per capita, *RET* : real retail sales, RR_f: real Swiss Franc 3-month interest rate, R_m : total return on Datastream market index, *STR* : term structure, *UNP* : unemployment rate, *I* -: innovations generated from the unobserved-components model, *AR1/2/3/4-* : innovations generated from an autoregressive model with time varying parameters of degree 1, 2, 3 or 4.

Exhibit 3: Dendogram Resulting from the Cluster Analysis

This exhibit presents the dendogram resulting from the cluster analysis based on the Ward (1963) procedure. The dotted line distinguishes four groups of substitutable variables for bond and real estate models. The solid line identifies five sets of candidate variables for the exogenous model for stocks.



CRD: real consumption loans granted, *CST*: real construction loans granted, *CEI*: changes in expected inflation, *DEF*: default risk, *EMP*: employment, *EXP*: exports, *GDP*: real gross domestic product, *GNP*: real gross national product, *IND*: real industrial production, *INF*: inflation, *M3*: real money supply, *OIL*: oil prices, *PCC*: real private consumption per capita, *RET*: real retail sales, RR_f: real Swiss Franc 3-month interest rate, R_m: total return on Datastream market index, *STR*: term structure, *UNP*: unemployment rate, *I*-: innovations generated from the unobserved-components model, *AR1/2/3/4-*: innovations generated from an autoregressive model with time varying parameters of degree 1, 2, 3 or 4.

Exhibit 4: Results of Dynamic Tests of APT Models (Two-Pass Method)

This exhibit presents average quarterly risk premia estimators computed by means of the dynamic validation based on the following equation $\tilde{R}_{it}-\tilde{R}_{ft}-\sum_{k=1}^{K}\hat{\beta}_{ikt}\tilde{F}_{kt}=\lambda_{0t}+\sum_{k=1}^{K}\hat{\beta}_{ikt}\lambda_{kt}+\tilde{\xi}_{it}$. Results for endogenous models are reported in Panel A, while those of exogenous models are reported in Panel B. The *t*-statistics are based on the GMM standard deviation estimator. R^2 indicates the average cross-sectional coefficient of determination. The percentage of quarters in which individual risk premium is significant at the 5% level is mentioned in parentheses below each factor. F-stat reports the percentage of quarters in which risk premia are jointly significant at the 5% level.

Panel A: Validation of endogenous models on excess returns of asset classes

	Intercept	Stocks-1	Stocks-2	Stocks-3	Stocks-4	Stocks-5	Bonds-1	Bonds-2	Bonds-3	Bonds-4	RE-1	RE-2	RE-3	RE-4	R^2
Industrial portfolios	0.03	-0.31*	-0.14**	0.03	-0.15**	0.08									0.45
F-stat: 100	(78)	(56)	(52)	(48)	(43)	(52)									
	0.02						-0.79***	-0.49	0.22	-0.43*					0.25
F-stat: 98	(61)						(57)	(52)	(61)	(52)					
	0.02										-0.61**	-0.57	-0.10	-0.04	0.32
F-stat: 100	(72)										(61)	(52)	(65)	(70)	
Bond funds	0.01	-0.23	-0.19	-0.25	-0.23	-0.54									0.66
F-stat: 98	(52)	(59)	(59)	(63)	(63)	(72)									
	0.00						-0.59	-0.06	0.24	0.09					0.62
F-stat: 100	(52)						(61)	(43)	(59)	(52)					
	0.00										-0.11	0.22	0.16	0.09	0.47
F-stat: 100	(70)										(61)	(54)	(59)	(59)	
Real estate funds	0.01	0.14	-0.29	-0.35**	-0.21	-0.07									0.48
F-stat: 100	(61)	(46)	(61)	(46)	(54)	(57)									
	0.01						-0.58***	0.13	0.19	-0.06					0.43
F-stat: 98	(63)						(76)	(67)	(57)	(61)					
	0.02*										-0.61**	0.70***	-0.35**	0.21**	0.45
F-stat: 98	(59)										(63)	(59)	(43)	(63)	

Panel B: Validation of exogenous models on excess returns of asset classes

	Intercept	*AR2-UNP*	*CEI*	*I-OIL*	*I-STR*	*AR1-CST*	*AR2-DEF*	*AR2-INF*	*AR2-RET*	*AR1-RR$_f$*	R^2
Industrial portfolios	0.02	0.05	0.08	-0.05	-0.05**	-104.86					0.39
F-stat: 100	(54)	(63)	(63)	(63)	(59)	(57)					
	0.02		0.06		-0.05**		0.01	0.05			0.32
F-stat: 100	(65)		(65)		(59)		(67)	(61)			
	0.02	0.07						0.10	-2.66	-0.04	0.30
F-stat: 100	(70)	(72)						(63)	(70)	(61)	
Bond funds	-0.02	0.99	0.16	-1.35	2.66	650.49					0.63
F-stat: 98	(52)	(57)	(63)	(67)	(52)	(54)					
	0.00		0.02		0.09		-0.01	0.02			0.61
F-stat: 100	(67)		(63)		(48)		(76)	(61)			
	0.01**	-0.04						0.19	-0.13	-0.13	0.51
F-stat: 98	(67)	(63)						(65)	(65)	(61)	
Real estate funds	0.01	0.03	0.11	0.00	-0.02	-8.68					0.44
F-stat: 100	(63)	(63)	(54)	(61)	(52)	(52)					
	0.01		0.12		-0.04		-0.00	-0.06			0.35
F-stat: 98	(65)		(46)		(63)		(59)	(59)			
	0.01	0.03						-0.15*	-2.44	0.03	0.42
F-stat: 100	(74)	(72)						(67)	(65)	(52)	

***/**/* indicates rejection of the null hypothesis at the 1%, 5% or 10% level, respectively.

CST: real construction loans granted, *CEI*: changes in expected inflation, *DEF*: default risk, *INF*: inflation, *OIL*: oil prices, *RET*: real retail sales, *RR$_f$*: real Swiss Franc 3-month interest rate, *STR*: term structure, *UNP*: unemployment rate, *I*-: innovations generated from the unobserved-components model, *AR1/2*-: innovations generated from an autoregressive model with time varying parameters of degree 1 or 2.

Exhibit 5: Results of Static Tests of the APT Models (ITNLSUR)

This exhibit shows fixed quarterly risk premia estimators computed by means of the ITNLSUR applied to equation (5) for the period 1991Q1-2002Q2. Results for endogenous models are reported in Panel A, whereas those of exogenous models are contained in Panel B. The R^2 is defined as the average coefficient of correlation between observed and estimated excess returns.

Panel A: Validation of endogenous models on excess returns of asset classes

	Intercept	Stocks-1	Stocks-2	Stocks-3	Stocks-4	Stocks-5	Bonds-1	Bonds-2	Bonds-3	Bonds-4	RE-1	RE-2	RE-3	RE-4	R^2
Industrial portfolios															
	0.02***	-0.08***	0.09	0.17	0.36**	-0.02									0.88
	0.02**						0.05	-0.21	0.15	-0.49**					0.57
	0.02*										-0.15	-0.17	0.08	-0.58	0.39
Bond funds															
	0.00	0.04	0.29	-0.17	-0.58***	-0.47*									0.57
	0.01***						0.60***	-0.06***	-0.22***	0.09***					0.90
	0.00										0.66**	0.06	-1.07*	0.82*	0.63
Real estate funds															
	-0.00	0.28	0.03	0.34	-0.10	-0.12									0.57
	-0.00						0.26	0.05	-0.17	-0.15					0.50
	-0.00***										0.13***	-0.02	-0.02	-0.00	0.86

Panel B: Validation of exogenous models on excess returns of asset classes

	Intercept	*AR2-UNP*	*CEI*	*I-OIL*	*I-STR*	*AR1-CST*	*AR2-DEF*	*AR2-INF*	*AR2-RET*	*AR1-RR$_f$*	R^2
Industrial portfolios											
	0.04***	-0.02	0.00	0.01	0.07**	143.69					0.43
	0.05***		0.02		0.07***		0.00	0.05			0.37
	0.00	0.08						0.20*	-3.15	0.19	0.21
Bond funds											
	0.01*	-0.08	0.06	0.15	-0.01	-494.37					0.42
	0.00		-0.02		0.04*		-0.03**	0.03			0.43
	-0.00	0.06						0.07	-0.07	-0.37**	0.38
Real estate funds											
	0.00	0.00	-0.03	-0.05	0.05*	-103.13					0.36
	0.01**		-0.00		0.03		0.02**	0.05			0.25
	0.01**	-0.02						-0.05	-2.60	0.09	0.18

***/**/* indicates rejection of the null hypothesis at the 1%, 5% or 10% level, respectively.
CST : real construction loans granted, *CEI* : changes in expected inflation, *DEF* : default risk, *INF* : inflation, *OIL* : oil prices, *RET* : real retail sales, *RR$_f$* : real Swiss Franc 3-month interest rate, *STR* : term structure, *UNP* : unemployment rate, *I* -: innovations generated from the unobserved-components model, *AR1/2-* : innovations generated from an autoregressive model with time varying parameters of degree 1 or 2.

Exhibit 6: Results of Modified GRS Test of Integration (Time-Varying Risk Premia)

This exhibit presents the percentages of quarters in which the null hypothesis of integration is rejected at the 5% level. The results only concern quarters in which both fundamental hypotheses of the modified GRS test are verified: (1) both compared risk premia estimates are statistically significant at the 5% level, and (2) covariance matrices of errors are similar in both asset classes. Tests of integration are based on time varying risk premia estimates.

Panel A: Results of integration on endogenous models

Asset class	All risk premia		Individual risk premia													
	with intercept	without intercept	Intercept	Stocks-1	Stocks-2	Stocks-3	Stocks-4	Stocks-5	Bonds-1	Bonds-2	Bonds-3	Bonds-4	RE-1	RE-2	RE-3	RE-4
Stocks/Bonds	7	13	79	52	64	67	60	67								
Stocks/RE	13	20	71	50	67	67	70	50								
RE/Bonds	20	7	57	67	73	83	70	73								
Stocks/Bonds	27	20	75						72	40	75	50				
Stocks/RE	47	20	100						75	100	90	87				
RE/Bonds	13	13	60						78	100	80	67				
Stocks/Bonds	27	27	78										57	83	100	50
Stocks/RE	33	13	40										17	0	67	50
RE/Bonds	40	13	71										40	75	67	67

Panel B: Results of integration on exogenous models

Asset class	All risk premia		Individual risk premia									
	with intercept	without intercept	Intercept	*AR2-UNP*	*CEI*	*I-OIL*	*I-STR*	*AR1-CST*	*AR2-DEF*	*AR2-INF*	*AR2-RET*	$AR1\text{-}RR_f$
Stocks/Bonds	13	7	100	71	67	57	81	64				
Stocks/RE	0	13	60	46	50	31	83	60				
RE/Bonds	33	33	63	88	63	68	36	69				
Stocks/Bonds	27	27	67		75		83		43	67		
Stocks/RE	33	20	100		75		100		67	67		
RE/Bonds	47	40	73		67		63		67	63		
Stocks/Bonds	40	27	75	60						56	46	57
Stocks/RE	40	27	63	50						67	75	83
RE/Bonds	53	33	63	43						83	43	67

CST : real construction loans granted, *CEI* : changes in expected inflation, *DEF* : default risk, *INF* : inflation, *OIL* : oil prices, *RET* : real retail sales, RR_f : real Swiss Franc 3-month interest rate, *STR* : term structure, *UNP* : unemployment rate, *I* -: innovations generated from the unobserved-components model, *AR1/2-* : innovations generated from an autoregressive model with time varying parameters of degree 1 or 2.

Exhibit 7: Results of Jobson and Korkie LRT Test of Integration (Fixed Risk Premia)

This exhibit presents LRT statistics computed on fixed risk premia. Statistics mentioned in italics refer to the case when one of the two risk premia only is significant at the 5% level. When both risk premia are statistically significant, statistics are mentioned in bold.

Panel A: Results of integration on endogenous models

Asset class	All risk premia with intercept	All risk premia without intercept	Intercept	Stocks-1	Stocks-2	Stocks-3	Stocks-4	Stocks-5	Bonds-1	Bonds-2	Bonds-3	Bonds-4	RE-1	RE-2	RE-3	RE-4
Stocks/Bonds	69.17***	29.53***	_61.17_***	_-1.27_	0.75	-0.11	__31.54__***	_3.85_**								
Stocks/RE	23.63***	9.46*	_22.13_***	_2.50_	0.31	3.79	_12.69_***	0.50								
RE/Bonds	11.53*	12.26**	1.07	7.55***	1.27	0.98	_12.50_***	_2.47_								
Stocks/Bonds	267.63***	273.74***	__0.21__						_224.03_***	_185.24_***	_270.88_***	__253.35__***				
Stocks/RE	31.36***	8.59*	_37.25_***						0.50	5.99**	4.93**	_1.96_				
RE/Bonds	100.29***	103.34***	_0.05_						_186.80_***	_155.32_***	_125.32_***	_191.68_***				
Stocks/Bonds	58.40***	19.57***	_56.96_***										_15.88_***	4.95**	14.41***	29.74***
Stocks/RE	11.07*	8.75*	__19.73__***										_6.04_**	0.82	0.07	3.89**
RE/Bonds	18.70***	10.64**	_14.51_***										__6.57__**	1.04	_12.58_***	_13.86_***

Panel B: Results of integration on exogenous models

Asset class	All risk premia with intercept	All risk premia without intercept	Intercept	_AR2-UNP_	_CEI_	_I-OIL_	_I-STR_	_AR1-CST_	_AR2-DEF_	_AR2-INF_	_AR2-RET_	_AR1-RR $_f$_
Stocks/Bonds	101.37***	32.88***	__104.35__***	1.91	1.83	12.62***	_37.18_***	19.81***				
Stocks/RE	44.61***	13.87**	_50.07_***	0.71	2.80*	4.51**	__1.95__	9.27***				
RE/Bonds	19.45***	21.67***	_-0.24_	3.57*	7.71**	21.44***	_26.94_***	10.03***				
Stocks/Bonds	98.90***	12.67**	_104.98_***		0.97		__18.44__***		_4.49_**	0.60		
Stocks/RE	49.20***	7.33	__50.81__***		1.61		_2.34_		_1.07_	0.05		
RE/Bonds	9.53*	0.43	_10.10_***		0.18		_3.27_*		__0.27__	0.76		
Stocks/Bonds	10.01*	11.15**	1.01	1.75						_3.68_*	3.72*	_20.33_***
Stocks/RE	21.81***	19.53***	_0.04_	6.16**						_16.74_***	0.11	1.87
RE/Bonds	12.25**	7.14	_8.77_***	1.77						0.99	2.11	_14.19_***

***/**/* indicates rejection of the null hypothesis at the 1%, 5% or 10% level, respectively.

CST : real construction loans granted, _CEI_ : changes in expected inflation, _DEF_ : default risk, _INF_ : inflation, _OIL_ : oil prices, _RET_ : real retail sales, RR_f: real Swiss Franc 3-month interest rate, _STR_ : term structure, _UNP_ : unemployment rate, _I_ -: innovations generated from the unobserved-components model, _AR1/2-_ : innovations generated from an autoregressive model with time varying parameters of degree 1 or 2.

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Appendix

Appendix 1: Summary Statistics for the 20 Industrial Portfolios

Industrial portfolio	Mean (%)	Standard deviation (%)	Skewness	Kurtosis
Mineral extractors	3.06	19.91	-0.53	6.25
Building and construction materials	2.11	12.96	-0.99	4.89
Diversified industrials	0.67	14.65	-1.42	6.59
Electrical equipment	2.01	19.94	-1.66	7.06
Engineering contractors	2.44	17.64	-0.66	3.85
Engineering general	1.36	15.16	-1.31	6.18
Food processors	3.41	10.46	0.22	6.08
Pharmaceuticals	4.15	11.31	-1.61	7.54
Retailers multidepartment	-0.46	16.02	-0.48	4.26
Hotels	0.87	12.99	-0.51	4.58
Education, training	0.19	25.18	-0.93	4.18
Airlines and airports	-3.25	21.71	-1.83	8.72
Food and drug retailers	1.95	12.93	-1.11	6.34
Electricity	1.76	9.54	0.26	6.26
Banks	1.72	15.01	-1.95	11.23
Insurance nonlife	1.58	13.98	-0.53	9.06
Reinsurance	3.75	13.47	-0.50	3.45
Other insurance	1.75	16.15	-1.07	5.76
Investment companies	2.19	14.62	-1.93	8.94
Miscellaneous	1.48	14.59	-2.26	9.86

Appendix 2: Summary Statistics for the 43 Bond Funds

Bond fund	Mean (%)	Standard deviation (%)	Skewness	Kurtosis
BSI Multibond CHF	1.07	2.04	0.30	6.53
CS BF Dynamic Sfr	1.26	2.61	0.63	3.95
CS BF Swiss Franc	1.13	1.76	0.08	2.76
Julius Bär Helvetbär	1.34	1.64	0.42	3.83
LODH Obliflex CHF Bond A	0.87	2.23	-0.71	3.99
UBS (CH) Bond Fund - CHF	1.21	1.69	0.29	2.98
UBS (CH) Bond Fund - CHF Domestic	1.15	1.82	0.16	2.98
Swissca Bond SFr.	1.04	2.10	0.45	3.78
AIG Bond Fund CHF	0.89	2.08	-0.05	3.21
Leu Swiss Franc Foreign Bonds	1.25	1.91	0.07	2.80
LODH Obliflex CHF Bond D	1.20	1.71	-0.31	2.54
UBS (Lux) Bond Fund - CHB B	1.26	1.67	0.09	2.88
Lloyds TSB International Portfolio Swiss Franc Bond Fund	1.26	1.82	-0.46	2.50
Scontinvest Bond Fund - Multi Hedged CHF	0.99	1.98	-0.33	3.74
CA Funds Swiss Franc Bond (CHF)	1.06	1.92	-0.32	3.57
CS Bond Fund (Lux) Sfr A	1.24	1.96	0.23	3.64
Julius Bär Swiss Bond Fund B	1.20	1.73	-0.07	3.00
Vontobel Fund SICAV - Swiss Franc Bond B	1.32	1.79	-0.05	2.85
Uni-Global (CHF)	1.11	1.77	-0.42	2.34
RBZ Swiss Franc Bonds	1.15	1.45	-0.09	3.07
Gottardo Bond Fund CHF	1.25	2.13	0.64	4.37
LODH Obliflex CHF Short Term Bond A	0.55	0.28	0.56	2.47
Bank Hofmann Swissrent	0.99	1.67	-0.47	2.46
Swissca Bond Invest CHF -A-	0.93	1.52	-0.32	2.15
Mercury Selected Trust - Swiss Franc Global Bond Fund A	0.75	1.73	0.11	2.27
Pleiade Swiss Franc Reserve	0.45	0.35	0.21	2.05
Raiffeisen - Fonds Swiss Obli B	0.99	1.49	-0.19	2.23
UEB Investment Fund CHF Bond Portfolio	0.61	1.21	-0.23	2.18
CS PF (Lux) Fixed Inc (Sfr) A	0.67	0.87	0.18	2.77
DWS (CH) - Bond Fonds (SFR)	0.93	1.24	0.08	2.62
Pictet - Obligations	1.19	1.82	0.58	3.37
UBS (Lux) Medium Term Bond Fund - CHB A	0.69	0.95	-0.19	2.57
CS BF (Lux) Short-Term Sfr A	0.42	0.85	-0.07	2.11
Parvest Swiss Franc Bond C	0.70	1.25	-0.34	2.33
Von Ernst Global Portfolio Swiss Franc Bonds	0.52	1.33	-0.18	2.31
Von Ernst Global Portfolio Swiss Franc Short Term	0.18	0.46	-0.79	3.13
Synchrony Market Fund Swiss Government Bonds	0.92	1.74	-0.56	2.18
Scontinvest BF Multi-CHF	0.65	1.92	0.40	3.08
Sogelux Fd Bonds CHF	0.79	1.59	-0.63	2.23
Generalux CHF B	0.58	1.26	-0.55	2.47
Robeco Bond Plus (CHF)	0.30	0.49	-0.23	2.82
UBS (Lux) Bd Fd-Global CHF B	0.54	1.83	-0.09	2.40
Robeco Bond Plus CHF	0.30	0.49	-0.21	2.82

Appendix 3: Summary Statistics for the 21 Real Estate Funds

Real estate fund	Mean (%)	Standard deviation (%)	Skewness	Kurtosis
UBS Anfos 1	1.32	5.32	0.62	4.99
UBS Anfos 2	1.74	6.14	0.72	4.72
UBS Foncipars Série Ancienne	2.07	6.04	0.51	5.49
UBS Swissimmobil Neue Serie	1.54	4.68	0.70	7.09
UBS Sima	1.38	5.44	0.43	4.41
UBS Swissreal	1.38	5.59	0.19	4.58
UBS Swissfonds 1	1.98	8.96	0.15	4.57
UBS Swissfonds 2	2.12	7.64	0.14	5.07
Immofonds	1.99	5.39	0.74	6.70
UBS Swissimmobil 61	1.52	4.92	-0.14	5.75
Solvador 61	1.49	3.45	-0.53	6.51
Immovit	1.48	6.25	-0.11	4.86
CS Interswiss	1.41	5.44	0.02	4.08
Swissca Ifca	1.75	6.80	1.51	8.23
CS Siat Alte	1.61	7.07	0.15	4.69
CS Swissimmobil Serie D	1.37	5.45	0.52	5.60
FIR	2.18	7.35	0.04	7.28
FIR 70	2.02	6.82	1.44	6.60
La Foncière	1.44	7.15	0.90	4.31
Clair-Logis	0.67	7.34	0.98	7.03
CS Siat 63	1.45	6.34	1.25	7.93

Appendix 4: Finite-Sample Statistic Derivation

From the GLS cross-sectional regressions of excess returns of N_{Aj} assets belonging to asset class Aj on K common factors at time t, we assume that ξ_t^{Aj} is independently, identically and normally distributed as $N\left(0;\sigma_{Aj}^2 V_{Aj}\right)$, where V_{Aj} is a positive definite symmetric matrix. Transformed errors are defined as $V_{Aj}^{-1/2}\xi_t^{Aj} \sim N\left(0;\sigma_{Aj}^2 I_{NAj}\right)$ where I_{NAj} is the identity matrix of dimension N_{Aj}. By definition and for a time period t, $C_t^{Aj}=V_{Aj}^{-1/2}\xi_t^{Aj}\xi_t'^{Aj}V'^{-1/2}_{Aj}$ follows a Wishart distribution, denoted $W(1;\sigma_{Aj}^2 I_{NAj})$, with 1 degree of freedom and a $\sigma_{Aj}^2 I_{NAj}$ parameter. When t'>1 periods are considered, $t'C_{t'}^{Aj}=\sum_{t=1}^{t'}V_{Aj}^{-1/2}\xi_t^{Aj}\xi_t'^{Aj}V'^{-1/2}_{Aj}$ and is distributed as $W(t';\sigma_{Aj}^2 I_{NAj})$.

Consider two L-vectors containing risk premia, $\hat{\lambda}_t^{A1}$ and $\hat{\lambda}_t^{A2}$, estimated from the same K-factor model on two different asset classes and L=1, K, K+1 according to the number of risk premia considered in the test. Based on the normality assumption above, $\hat{\lambda}_t^{Aj} \sim N\left(\lambda_t^{Aj};\left(\hat{\beta}_t^{Aj}V_{Aj}^{-1}\hat{\beta}_t'^{Aj}\right)^{-1}\sigma_{Aj}^2\right)$, and the difference between estimated risk premia also follows a Normal distribution:

$$\hat{\lambda}_t^{A1}-\hat{\lambda}_t^{A2} \sim N\left(\lambda_t^{A1}-\lambda_t^{A2};\left(\hat{\beta}_t^{A1}V_{A1}^{-1}\hat{\beta}_t'^{A1}\right)^{-1}\sigma_{A1}^2+\left(\hat{\beta}_t^{A2}V_{A2}^{-1}\hat{\beta}_t'^{A2}\right)^{-1}\sigma_{A2}^2\right). \qquad \text{(A.1)}$$

Under the null hypothesis that risk premia are equal, $\lambda_t^{A1}=\lambda_t^{A2}$ so $\lambda_t^{A1}-\lambda_t^{A2}=0$, and the additional hypothesis that $\sigma_{A1}^2=\sigma_{A2}^2=\sigma^2$, (A.1) can be re-written as:

$$\hat{\lambda}_t^{A1}-\hat{\lambda}_t^{A2} \sim N\left(0;\left[\left(\hat{\beta}_t^{A1}V_{A1}^{-1}\hat{\beta}_t'^{A1}\right)^{-1}+\left(\hat{\beta}_t^{A2}V_{A2}^{-1}\hat{\beta}_t'^{A2}\right)^{-1}\right]\sigma^2\right) \qquad \text{(A.2)}$$

and

$$\left[\left(\hat{\beta}_t^{A1}V_{A1}^{-1}\hat{\beta}_t'^{A1}\right)^{-1}+\left(\hat{\beta}_t^{A2}V_{A2}^{-1}\hat{\beta}_t'^{A2}\right)^{-1}\right]^{-1/2}\left(\hat{\lambda}_t^{A1}-\hat{\lambda}_t^{A2}\right) \sim N\left(0;\sigma^2 I_L\right) \qquad \text{(A.3)}$$

Applying theorem 7.3.3 presented on page 163 in Anderson (1958), if $C_t^{Aj} \sim W(1;\sigma_{Aj}^2 I_{NAj})$ then any diagonal submatrix $C_{L,t}^{Aj}$ of dimension $L<N_{Aj}$ follows a Wishart distribution $W(1;\sigma_{Aj}^2 I_L)$. By the reproductive property of the Wishart distribution and under the additional hypothesis that $\sigma_{A1}^2=\sigma_{A2}^2=\sigma^2$, $C_{L,t}^{A1}+C_{L,t}^{A2} \sim W(2;\sigma^2 I_L)$. For t'>1 periods, $C_{L,t'}^{A1}+C_{L,t'}^{A2} \sim W(2t';\sigma^2 I_L)$.

We define the L-vector $X=\left[\left(\hat{\beta}_t^{A1}V_{A1}^{-1}\hat{\beta}'^{A1}_t\right)^{-1}+\left(\hat{\beta}_t^{A2}V_{A2}^{-1}\hat{\beta}'^{A2}_t\right)^{-1}\right]^{-1/2}\left(\hat{\lambda}_t^{A1}-\hat{\lambda}_t^{A2}\right)$ and the (L×L) matrix $A=C_{L,t'}^{A1}+C_{L,t'}^{A2}$. According to Muirhead's (1983) theorem, we obtain the following finite-sample statistic:

$$\frac{2t'-L+1}{L}X'A^{-1}X \sim F_{L;2t'-L+1}.$$

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PO Box, 1211 Geneva 4
Switzerland
Tel (++4122) 312 09 61
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