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Currency Risk Premia in Global Stock Markets

Shaun K. Roache and Matthew D. Merritt

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Western Hemisphere Department

Currency Risk Premia in Global Stock Markets

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Authorized for distribution by David O. Robinson

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Abstract

Large fundamental imbalances persist in the global economy, with potential exchange rate implications. This paper assesses whether exchange rate risk is priced across G-7 stock markets. Given the multitude of hedging instruments available, theory suggests that stock market investors should not be compensated for currency risk. However, data covering 33 industry portfolios across seven major stock markets suggest that not only is exchange rate risk priced in many markets, but that it is time-varying and sensitive to currency-specific shocks. With stock market investors typically exhibiting "home bias," this suggests that investors are using equity asset proxies to hedge the exchange rate risks to consumption.

JEL Classification Numbers: F31, F37, G12, G15

Keywords: Arbitrage pricing theory; risk prices; asset pricing

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I. Introduction

The U.S. dollar has been a *theme du jour* for global investors since the U.S. dollar bull market began in the mid-1990s. The direction of the U.S. currency should matter a lot for global equity market investors, since it affects each component driving the valuation of stocks: (i) earnings growth; (ii) interest rates; and (iii) the risk premium, particularly for unhedged participants. There is also the much-highlighted risk of global imbalances forcing a currency realignment. This could increase global financial market fragility.[2] These factors, together with the volume of Wall Street research devoted to dissecting trends in the major global currencies, would suggest that equity markets price the risks of currency exposure, and that these risk prices change over time.

A. Contribution of this Paper

This study assesses the extent to which foreign exchange risks are priced in stock markets. The time-varying nature of risk pricing will also be assessed in order to understand whether investors are now requiring more return for the same amount of currency risk in a world of external imbalances. The innovation in this paper is to test whether factor-specific shocks cause investors to change their risk pricing. If it is possible to conclude that exchange-rate-specific shocks have no effect on risk-pricing in equities, then it is likely that it is the interaction between currencies and other asset classes that drive changes in risk premia, rather than simply volatility in the factor itself.

B. The General Approach of this Paper

The standard manner of testing whether exchange rate risks are priced, and whether those risk prices vary through time, has been through the use of Arbitrage Pricing Theory (APT) models. First introduced by Ross (1976), the main appeal of the APT also constitutes its major drawback. It is a very general approach that can accommodate a host of factors that might influence asset pricing; as a result, it is almost impossible to reject empirically. Indeed, Shanken (1992a) showed that almost any variable could serve as an explanatory factor in a well-defined factor model. Also, Campbell (1996) uses a micro-founded derivation of a multi-factor model to highlight that any variable that might help to predict future returns is an acceptable factor, along with those variables that help to forecast future labor income. The number of such factors may be very large.

[2] It may be assumed that volatility would increase as a result of a currency realignment. However, the risks are currently well known by markets, yet implied volatility as measured by foreign exchange options is currently very low from a historical perspective.

This study adopts a parsimonious representation based on three factors:

- the national market, representing the wealth portfolio;
- long-term interest rates, representing a major component of the discount factor and affecting opportunity cost and leveraged assets; and
- trade-weighted exchange rates.

Country sector indices[3] from the G-7 equity markets are used as assets. Risk prices are calculated for each market separately. There is evidence that an international APT model holds, with common global risk premia. However, there remains a significant amount of home bias in global equity markets,[4] and risk tolerances are likely to vary across countries.

The plan of the paper is as follows. Section II provides a brief overview of empirical results from earlier studies. Section III details the specification of the unconditional and conditional models. Section IV describes the key results, while Section V concludes.

II. Previous Literature

Although results are inconclusive, the majority of empirical studies suggest that foreign exchange risk *is* priced into global equity markets. An early study that refutes this claim for the United States is Jorion (1990), who used an unconditional six-factor model, with the currency innovation taken to be the rate of change in the trade-weighted exchange rate. Using maximum-likelihood techniques, exchange rate risk prices were estimated to be small, with an annual risk premium of 0.2 percent, and insignificant in a variety of model specifications. This implies that U.S. investors do not require compensation for currency risk. The interpretation is that this is a risk that, in common with the idiosyncratic stock-specific risk, may be diversified. These early results have been challenged in much of the subsequent literature.

Recent work has tended to rely on conditional models. Dumas and Solnik (1995) use a conditional framework built upon the pricing kernel formulation of Hansen and Jagannathan (1991), in which the average price of an asset, normalized to one, is equal to the product of the

[3] These are effectively market-value-weighted industry portfolios.

[4] One reason is the asset-liability structure of institutional investors. Long-term liabilities are often denoted in domestic currency rather than an international consumption basket and there is hence a strong incentive to retain a large domestic asset allocation weighting. The extent of home bias is revealed by Lane and Milesi-Ferreti (2001). Using stock market valuation adjusted foreign equity holdings at the end of 1998, the overseas weighting in the total equity portfolio of the total U.S. was below 12 percent. For the rest of the G-7, approximate weightings using the same data and Datastream total market capitalizations was 27 percent for the United Kingdom, 28 percent for Germany, 14 percent for France and Italy, 12 percent for Japan, and 29 percent for Canada.

asset's implicit stochastic discount factor and its payoff. Risk prices are assumed to be linear functions of a set of instrumental variables, including lagged dividend yields and bond yields. Country stock market indices assume global market integration; the pricing kernel and risk price functions are the moment conditions in a generalized method of moments (GMM) estimation, which suggest that foreign exchange risk premia are a significant component of stock market rates of return. The model's parsimony prevents a comparison of risk prices versus reward for factor covariance, however.

Most models have tended to assume a reasonably high degree of market segmentation. Choi, Hiraki, and Takezawa (1998) adopt the same approach as Dumas and Solnik (1995), but focus on Japan. They conclude that exchange risk is priced using a conditional model, with a monthly risk premium of 1 percent per unit of risk. This paper also concludes that there are important intertemporal secular trends that influence risk pricing, with the sign of the risk price shifting in tandem with secular trends in the nominal exchange rate. The null that the coefficients on the conditioning variables for the exchange rate risk prices are zero was rejected and, less formally, large changes were revealed by splicing the sample around the date of the Plaza Accord of 1985. Baba (2000) also uses a pricing kernel approach for Japan and, while rejecting the hypothesis that currency risk is not priced, suggests caution in these results, since the implied stochastic discount factor violates the nonnegativity and volatility bound restrictions of Hansen and Jagannathan (1991).

Bartram and Karolyi (2002) assess the impact of the euro's introduction on factor loadings or betas (rather than risk prices) in Europe. The authors argue that using unexpected innovations in exchange rates may understate the influence that exchange rates play in determining firm valuations. Using the launch of the euro as a natural experiment, this study shows that stock market risk exposure for a large sample of nonfinancial firms declined, with the largest declines observed for those firms with the highest proportion of foreign sales. For the United Kingdom, Antoniou, Garrett, and Priestley (1998) estimate an APT with a host of macroeconomic factors. Joint estimation shows that the exchange rate risk is priced. Assets for which returns respond inversely with the trade-weighted exchange rate, i.e., stocks that benefit from a weaker currency, attracted a monthly premium per unit of risk of 1.6 percent.

Claessens, Dasgupta, and Glen (1995) find that currency risk is priced in a large set of emerging market countries. Carrieri, Errunza, and Majerbi (2004) use a GARCH-M specification of the fully-integrated Adler and Dumas (1983) model for the United States and a sample of emerging market countries. Using real exchange rates to measure deviations from purchasing power parity (PPP) due to the inflation volatility in emerging markets, and assuming only partial integration, real returns are assumed to be a function of risk prices and factor loadings, both of which exhibit time-varying behavior. The study concludes that between 20 percent and 30 percent of the risk premium of emerging markets is accounted for by exchange rates.

III. MODEL SPECIFICATION

A. A Classic Unconditional APT-Model with an Exchange Rate Factor

The capital asset pricing model (CAPM) is based on the premise that idiosyncratic risk can be diversified away, and only undiversifiable market exposure should be compensated. A raft of studies has rejected the CAPM and shown that other factors contribute to the pricing of equity assets. This model extends the CAPM to include two additional factors: long-term interest rates and the nominal exchange rate. The inclusion of the exchange rate was proposed by Adler and Dumas (1983), on the basis that deviations from purchasing power parity implied that investors holding a diversified international portfolio of assets faced consumption risk. For example, with capital market frictions implying less-than-optimal consumption sharing, a real depreciation of the investor's local currency would mean a reduction in real wealth and a lower consumption opportunity set.[5]

To begin, a three-factor return generating process is assumed for the *i*th industry market-capitalization weighted portfolio:

$$r_{it} = \beta_{0i} + \tilde{\beta}_{INT,i}\tilde{f}_{INT,t} + \tilde{\beta}_{FX,i}\tilde{f}_{FX,t} + \beta_{M,i} f_{M,t} + \varepsilon_{it} \qquad (1)$$

The coefficients β are standard time-series regression betas for each of the three factors, f. Where a coefficient or factor carries a tilda, this refers to a variable that has been orthogonalized with respect to the market factor. These factors have been orthogonalized, since our goal is to estimate the risk pricing parameters. In order to test whether each factor contributes to the pricing of any asset i using the expected-return-beta formulation of the risk pricing equation, it is necessary to impose a diagonal factor covariance matrix upon the system (Cochrane, 2001). Orthogonalization was performed by using the residuals from separate OLS regressions of the change in the bond yield on the stock market, and then the change in the exchange rate on both the orthogonalized bond yield and the stock market (Choi, Hiraki and Takezawa, 1998). The mean value of the interest rate and exchange rate factors are then zero, conditional on the market.

Subtracting the return-generating equation's expected value from the original equation obtains an expression showing the unexpected return of an asset i is a function of the zero-mean factors, the unexpected return on the market and an idiosyncratic shock:

$$r_{it} - E(r_{it}) = \tilde{\beta}_{INT,i}\tilde{f}_{INT,t} + \tilde{\beta}_{FX,i}\tilde{f}_{FX,t} + \beta_{M,i}\left[f_{M,t} - E\left(f_{M,t}\right)\right] + \varepsilon_{it} \qquad (2)$$

[5] There is also the key insight of Seigel's paradox (Seigel, 1972). This implies that in a world where consumption opportunity sets differ across countries, there must exist some reward for currency risk. If the forward exchange rate for a country's currency in terms of a foreign numeraire currency implies a zero expected excess return on foreign currency assets, then foreign investors expect to make positive excess returns on domestic assets. This is simply a result of Jensen's inequality and the fact that for a random variable exchange rate e, $E(1/e) \neq 1/E(e)$ (see Karolyi and Stulz, 2002, for a fuller discussion).

A three-factor linear equilibrium risk-pricing model is also assumed. Here, the expected excess return over the risk free rate is determined by a linear combination of risk prices λ and risk exposures β. The expected excess return for asset i at time t is then:

$$E(r_{it}) = \lambda_0 + \lambda_{INT}\tilde{\beta}_{INT,i} + \lambda_{FX}\tilde{\beta}_{FX,i} + \lambda_M \beta_{M,i} \quad (3)$$

From here, traditional two-pass regression techniques may be used to estimate both factor loadings and risk-prices. The estimated factor loadings from (1) are used as regressors in (3). While practically straightforward, this method suffers from a standard "errors-in-variables" problem, since estimated factor loadings are used as regressors in the risk-pricing equation.

An alternative estimation method is to estimate factor loadings and risk prices jointly. To derive a system that allows for joint estimation, note that for the market, the expected return is derived solely from the market risk premium, so that the risk pricing equation is:

$$E(f_{M,t}) = \lambda_0 + \lambda_M \quad (4)$$

Substitute (3) and (4) into (2) to obtain:

$$r_{it} = \lambda_0 + \lambda_{INT}\beta_{INT,i} + \lambda_{FX}\beta_{FX,i} + \lambda_M\beta_{M,i} + \beta_{INT,i}\tilde{f}_{INT,t} + \beta_{FX,i}\tilde{f}_{FX,t} + \beta_{M,i}\left[f_{M,t} - (\lambda_0 + \lambda_M)\right] + \varepsilon_{it} \quad (5)$$

This simplifies to:

$$r_{it} = \lambda_0(1 - \beta_{M,i}) + \lambda_{INT}\beta_{INT,i} + \lambda_{FX}\beta_{FX,i} + \beta_{INT,i}\tilde{f}_{INT,t} + \beta_{FX,i}\tilde{f}_{FX,t} + \beta_{M,i}f_{M,t} + \varepsilon_{it} \quad (6)$$

For N assets and T time periods, this implies a system of equations for each country that may be denoted by:

$$\mathbf{r} = \lambda_0(1 - \boldsymbol{\beta}_M) + \lambda_{INT}\boldsymbol{\beta}_{INT} + \lambda_{FX}\boldsymbol{\beta}_{FX} + \boldsymbol{\beta}\cdot\mathbf{f} + \boldsymbol{\varepsilon} \quad (7)$$

where (1-$\boldsymbol{\beta}_M$), $\boldsymbol{\beta}_{INT}$, and $\boldsymbol{\beta}_{FX}$ are (NT x 1) vectors of factor loadings which vary across industry portfolios but are estimated for the entire sample. The scalars λ denote the common country risk prices for each factor, and $\boldsymbol{\beta}$ refers to the (NT x KT) matrix of factor loadings on **f**, the (KT x 1) vector of observed factor returns. The well-known nonlinear restriction that the exact factor pricing form of the APT imposes on the constant of the unconditional system is:

$$\boldsymbol{\beta}_0 = \lambda_0(1 - \boldsymbol{\beta}_M) + \lambda_{INT}\boldsymbol{\beta}_{INT} + \lambda_{FX}\boldsymbol{\beta}_{FX} \quad (8)$$

This restriction will be tested using the small sample adjusted likelihood ratio statistic (Campbell, Lo and McKinlay, 1997) to assess whether the APT is a valid model for industry portfolio returns. This LR test will also be used to test the null that the exchange rate factor is not priced through the entire sample period.

B. A New Conditional APT-Model with an Exchange Rate Factor

Roll's (1976) original critique of the CAPM was that the investor's true wealth portfolio is unobservable. While this ushered in a role for the less restrictive APT; in its unconditional formulation the APT is clearly open to the Hansen and Richard (1987) critique, which notes that the conditioning information used by investors is not observable to the econometrician. In particular, it typically assumes that risk prices and factor loadings remain constant throughout the sample period. The intention of this paper is to assess whether risk prices have changed, as underlying macroeconomic conditions have changed. In particular, do unanticipated shocks to the factors cause risk prices to change, and do those changes persist?

Since the factors in equation (1) have been orthogonalized, it is proposed that only unanticipated *factor-specific* shocks should influence the risk pricing of that particular asset. Cross-asset-class shocks should be picked up by a variable higher in the ordering; in this case, exchange rate risks that feed through into stock or bond market risk will be picked up by that factor's own risk price. The estimation also avoids the use of instruments to condition risk pricing. This is because if any variable in the investor's conditional information set at time t-1 is relevant for a factor, then by the law of iterated expectations it should already have been reflected in that factor. The question is whether shocks to risk pricing persist due to shocks to the underlying factor. It is therefore assumed that risk prices are a function of the investor's factor-specific information set at the start of time t. Then equation (6) may be written as:

$$r_{it} = \lambda_{0t}\left(1-\beta_{M,i}\right)+\lambda_{INT,t}\left(\mathbf{f}_{INT,t-i}\right)\beta_{INT,i}+\lambda_{FX,t}\left(\mathbf{f}_{FX,t-i}\right)\beta_{FX,i}$$

$$+\beta_{INT,i}\tilde{f}_{INT,t}+\beta_{FX,i}\tilde{f}_{FX,t}+\beta_{M,i}f_{M,t}+\varepsilon_{it} \quad (9)$$

where the risk prices are linear in the conditioning factor vector at time t-1:

$$\lambda_{k,t} = a_{k0}+\sum_{l=1}^{L}a_{kl}f_{k,t-l} \quad (10)$$

There are two null hypotheses that will be tested. The first is that exchange rate risk is not conditionally priced in each market. The second is that risk prices are stable and not time-varying.

IV. Estimation

A number of techniques have emerged in the literature to measure risk prices and capture their time-varying nature. The most popular is use of the pricing kernel representation of the asset pricing function, with risk prices estimated using GMM. This assumes that the average asset price is a function of the stochastic discount factor and the asset's gross payoffs. Normalizing the average asset price to one, the pricing kernel can then be written, with m representing the marginal rate of substitution, ρ the risk-free rate, λ the risk prices for the k factors, and H representing the investor's information set at time t:

$$m_t\left(1+\rho_{t+1}\right)=1-\sum_{k=1}^{K}\lambda_k\left(\mathrm{H}_t\right)r_{k,t+1}$$

This information set *H* is often instrumented using a range of macroeconomic and financial market variables. One important feature of previous work has been the use of series with a high degree of persistence, or even questionable stationarity. This could impart a degree of persistence in shocks to risk prices that, when using zero mean factors as conditioning variables, does not emerge (Dumas and Solnik, 1995).

An alternative typically used in an expected return-beta framework is the iterated nonlinear seemingly-unrelated regression estimation adopted for multifactor risk pricing models by Burmeister and McElroy (1988). This procedure accounts for contemporaneous correlation across industry portfolio residuals and allows for joint estimation of both factor loadings and risk prices. As has been shown, iterated nonlinear SUR (NLSUR) is asymptotically equivalent to maximum likelihood (Gallant, 1987). The estimators are both consistent and asymptotically normal, but use of NLSUR does force the researcher to assume that the specification of the model is "correct," particularly in terms of the joint distribution of errors. In this sense, it is less general than the GMM approach, although it is technically more efficient. In this study, the risk-pricing model is described in terms of an expected return-beta relationship. This has been typically estimated with asymptotic maximum likelihood techniques, and this convention will be followed to ease comparisons of results.

A second approach used in this paper, for comparison purposes, is the standard two-pass regression technique. A time-series regression for the entire sample period estimates the factor loadings for each industry portfolio, and then a cross-section regression is used to estimate the risk prices. Both the ordinary least squares (OLS) and generalized least squared (GLS) estimates are provided; typically the robustness of OLS, with appropriate adjustments to standard errors, offsets the potential efficiency gains from the less robust GLS. As is well known, the two-pass procedure benefits from simplicity and robustness, but suffers from an 'error-in-variables' problem, since the factor loading used in the cross-section regression are estimated. This introduces a downward bias in standard error estimates for risk prices, and this will be adjusted for using Shanken (1992b) standard errors:

$$\boldsymbol{\sigma}^2\left(\hat{\boldsymbol{\lambda}}_{OLS}\right)=1/T\left[\left(\hat{\boldsymbol{\beta}}'\hat{\boldsymbol{\beta}}\right)^{-1}\hat{\boldsymbol{\beta}}'\hat{\boldsymbol{\Omega}}\hat{\boldsymbol{\beta}}\left(\hat{\boldsymbol{\beta}}'\hat{\boldsymbol{\beta}}\right)^{-1}\left(1+\hat{\boldsymbol{\lambda}}'\hat{\Sigma}_f^{-1}\hat{\boldsymbol{\lambda}}\right)+\hat{\Sigma}_f\right]$$

$$\boldsymbol{\sigma}^2\left(\hat{\boldsymbol{\lambda}}_{GLS}\right)=1/T\left[\left(\hat{\boldsymbol{\beta}}'\hat{\boldsymbol{\Omega}}\hat{\boldsymbol{\beta}}\right)^{-1}\left(1+\hat{\boldsymbol{\lambda}}'\hat{\Sigma}_f^{-1}\hat{\boldsymbol{\lambda}}\right)+\hat{\Sigma}_f\right]$$

V. DATA AND PRELIMINARY STATISTICS

The sample data are monthly, and run from January 1974 to February 2005. The assets for each market are the Datastream value-weighted Level III industry portfolios. The maximum number of industries is 33, but some countries do not have stocks in certain sectors; for example, the minimum number of industries was 29 in Italy. The excess return is calculated as the local currency change in the log total return index, over the monthly return on local risk free interest rates. The first factor is the excess return over the local three-month rate of the Datastream value-weighted total market return index. The second factor is the log change in the 10-year benchmark government bond yield. The third factor is the log change in the IMF nominal effective exchange rate index, as published in *International Financial Statistics*.

The need to orthogonolize the factors for use in an expected return-beta specification is seen from the factor covariance matrices in Table A1 of Appendix A. In most markets, there is a strong inverse relationship between the equity market and bond yields, a relationship that can be explained by the role that bond yields play as a discount factor and also simple relative valuations. The sign of the relationship between exchange rates and the other two asset classes is more ambiguous, although relatively high correlations (from an asset price perspective) do exist in most markets.[6]

The distribution of asset returns (in log differences) exhibits some typical asset return characteristics, most obviously negative skew and excess kurtosis (fat tails). However, at an industry level, these problems are less severe than often seen in more aggregated market data. On a simple unweighted average basis, the skew is -0.1 and kurtosis is 2.95.[7]

VI. Main Results

A. Test of the APT Specification

Testing the APT specification of equation (6) against the unrestricted return generating equation (1), it was possible to accept the null hypothesis at the 5 percent level for all markets, with the exception of Italy (for which the null could be accepted at the 10 percent level). Table A2 in Appendix B shows these results in detail. This implies that the APT specification is the "correct" model, and allows the imposition of the linear risk pricing restrictions. Acceptance of the APT specification is a common result in the literature.

B. Unconditional Foreign Exchange Risk Pricing

For the entire sample, the unconditional two-pass regression model provides ambiguous results on foreign exchange risk pricing. As usual, there is a trade-off between the robustness of OLS versus the efficiency of GLS and, given the small country sample sizes (i.e., a maximum of 33 industry portfolios) and use of Shanken-adjusted standard errors, the focus here will be on

[6] For example, the correlation between exchange rates and equity markets has often changed significantly; indeed, in some cases there have been major sign switches.

[7] These results omit the Italian Food Producer and Processing industry. Stock-specific issues in 2004, specifically related to Parmalat, resulted in very large outliers.

the results of OLS estimation (Table A3 in the Appendix C provides the results of both OLS and GLS).

Across the G-7 only the United States, United Kingdom, and Germany exhibit foreign exchange risk prices that were statistically significant using adjusted standard errors. For the United States, the result was particularly strong and contradicts the earlier results of Jorion (1990). Industry portfolios with a positive factor loading to the exchange rate (an appreciating U.S. dollar implies higher stock returns and vice versa), receive a risk premium of 0.5 percent per unit of risk. This figure is within the range found in previous literature. The industries to benefit from this risk premia were predominantly domestic, including financials. In other words, investors required some premium for holding assets that did poorly when the U.S. dollar was weak. There was also a positive risk premium on the exchange rate in the German market, while for the United Kingdom, it was negative.

Perhaps surprisingly, the Japanese market did not appear to price exchange rate risk. The sharp difference between OLS and GLS estimates, with the latter suggesting some pricing, should introduce a note of caution with respect to Japan. Certainly, the Japanese market is typically thought of as "currency sensitive" given the significant weighting of exporters in the index. However, risk pricing should reflect the consumption beta to the exchange rate, rather than factor loadings of stocks to the currency.

C. Conditional Foreign Exchange Pricing

Two sets of tests were undertaken. First, the null that foreign exchange risk was not priced at all. In contrast to the ambiguous results of the two-pass regressions, joint estimation of factor loadings and risk prices suggests that foreign exchange risk *is* priced into most markets. Table A4 in Appendix D shows the result of Wald tests on risk-pricing. The null that the foreign exchange risk price is zero is rejected in all markets except Germany and France, while Italy is a borderline case. This may be related to the introduction of the euro, with currency risk for regionally-exporting industries and regional investors now eliminated.

The second test was the null that the risk price was constant; that is, the coefficients on all lagged changes in the underlying factors were equal to zero. In all markets where risk prices were nonzero, it was possible to reject the null at the 5 percent level. Factor-specific shocks tended to change investor's risk pricing in the United States, the United Kingdom, Italy, and Canada. The pattern of the conditional relationship differed across countries. Table 1 shows the estimated coefficients of risk prices on lagged factor changes, up to a lag order three,[8] i.e., each risk price is equal to λ_{FX} where:

$$\lambda_{FX,t} = a_{FX,0} + \sum_{l=1}^{3} a_{FX,l} f_{FX,t-l}$$

[8] In most cases, a lag order of four obtained the highest information criteria.

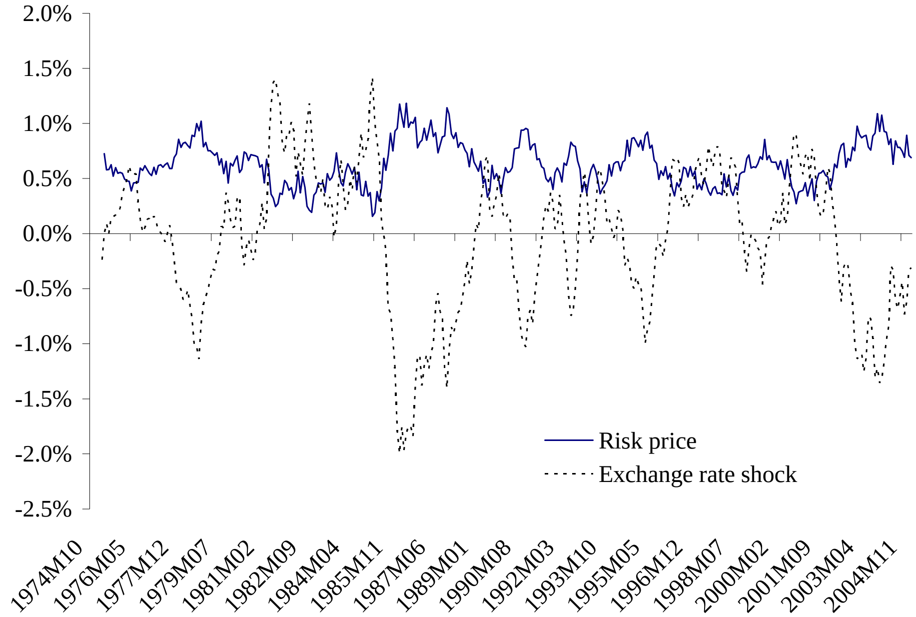
Table 1. Estimated Foreign Exchange Risk Pricing Coefficients

		Constant	$a_{FX,1}$	$a_{FX,2}$	$a_{FX,3}$
U.S.	Coeff	0.0063	-0.5471	0.3618	-0.2049
	Std error	0.0025	0.1360	0.1461	0.1423
	t-stat	2.52	-4.02	2.48	-1.44
U.K.	Coeff	-0.0031	-0.2103	-0.1607	-0.1569
	Std error	0.0019	0.1178	0.1292	0.1242
	t-stat	-1.63	-1.79	-1.24	-1.26
Japan	Coeff	0.0018	0.0968	0.5206	0.0023
	Std error	0.0033	0.1495	0.1574	0.1447
	t-stat	0.55	0.65	3.31	0.02
Canada	Coeff	0.0100	0.0336	-1.4154	0.0125
	Std error	0.0030	0.2307	0.3403	0.2332
	t-stat	3.33	0.15	-4.16	0.05

Source: Authors' calculations.

Perhaps the most interesting result, empirically and given the underlying macroeconomic context, is the time-variation in the U.S. foreign exchange risk price. As in the unconditional model, the market tends to reward positive exposure to the currency. Equivalently, the market requires a risk premium for industries vulnerable to a depreciating U.S. dollar. In fact, if the U.S. dollar experiences unanticipated declines, this risk premium tends to rise. Although the coefficients on lagged factor changes are of a different sign, it is clear from the size of the coefficients and from Figure 1 that the risk premium rises when the currency experiences a negative shock. Recent negative currency-specific shocks have forced the risk price to increase to levels not seen since the aftermath of the Plaza Accord in 1984.

Figure 1. U.S. Equity Market Forex Risk Price and Exchange Rate Shocks (12MAV)

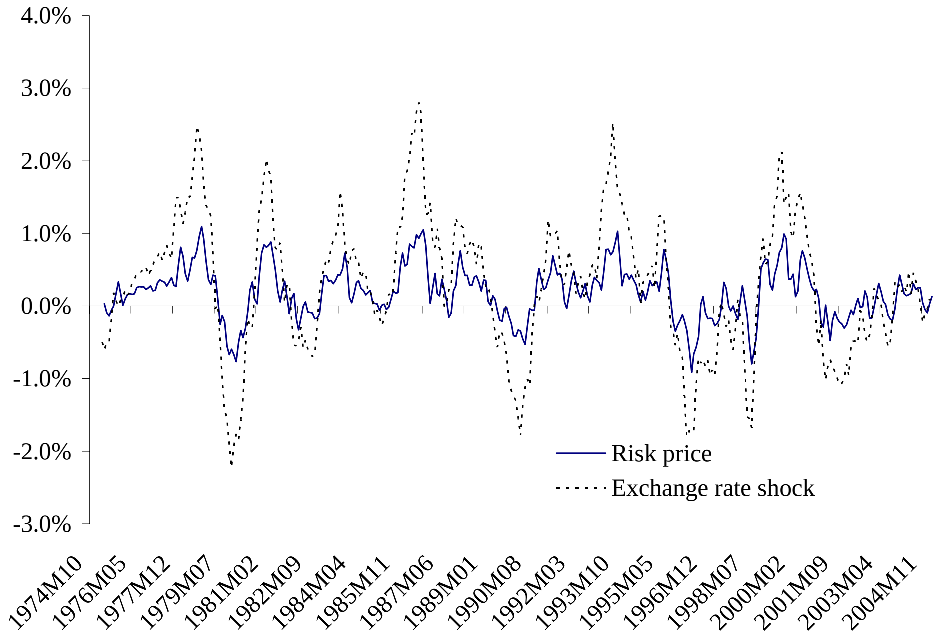


Source: Authors' calculations.

For Japan, the expected conditional risk price is insignificant from zero, confirming the results of the unconditional estimation. In general, risk prices have been marginally positive in Japan, consistent with the hypothesis that stocks with currency exposure play a hedging role for the consumption basket.

However, risk prices are sensitive to factor-specific shocks. The effect is very different from the U.S. since factor shocks can cause the risk price to change sign (a finding partly consistent with the results of Choi et al., 1998). Whenever an unanticipated *appreciation* of the currency occurs, this risk price rises significantly; in a sense, markets require a larger premium from those export-intensive industries that benefit from currency weakness. During periods of sharp yen depreciation, risk prices actually turn negative, implying that the market is willing to take an expected decrease in returns to hold export-intensive industries. Japan is a market heavily weighted by export-sector stocks and the fundamental hedge that these stocks offer during periods of currency weakness appears to be reflected in risk price sensitivity to currency shocks.

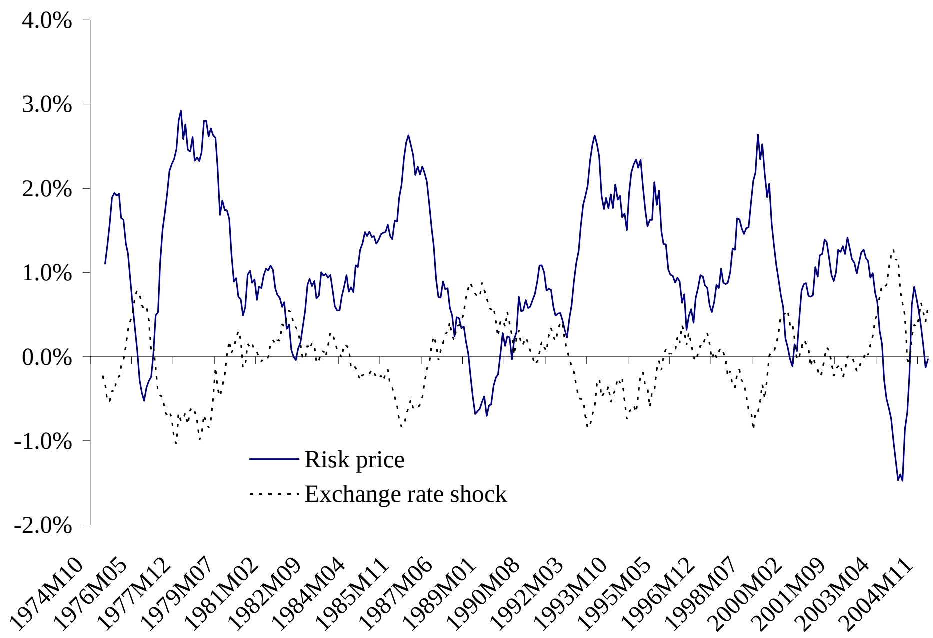
Figure 2. Japan Equity Market Forex Risk Price and Exchange Rate Shocks (12MAV)



Source: Authors' calculations.

Canada exhibits the same pattern as the United States. Risk prices for currency exposure have been positive for many years. These prices react inversely to factor shocks, implying that the risk premium required for holding currency risk through the equity has, in the past, increased when the currency has declined. The dominating factor for Canada, given trade weights, is clearly the Canadian dollar—U.S. dollar exchange rate. Periods of relative U.S. dollar strength pose obvious risks to the Canadian consumption basket, since it tends to increase the cost of importing U.S. goods for Canadian consumers. Such periods have been associated with a higher risk premium to compensate this effect. Periods of U.S. dollar weakness, particularly in recent years, has forced this risk premium lower.

Figure 3. Canada Equity Market Forex Risk Price and Exchange Rate Shocks (12MAV)



Source: Authors' calculations.

VII. Conclusions

A. A Role for Equity Assets as a Currency-Hedging Instrument

Capital markets are subject to many imperfections, for example due to frictional costs of trading, restrictions on the span of tradable securities, particularly for investors with specific benchmarks, and informational asymmetries. This may lead individuals to less than fully hedge all of their risks using first-best strategies.[9] Investors will then seek hedging proxies, that is, securities that provide cover against the risk they wish to hedge. If foreign exchange risk, in the broadest consumption basket sense, is not directly and completely hedged by an investor's wealth portfolio, then it will be optimal for investors to extract a risk premium from assets in that portfolio that underperform when the currency weakens to bridge this hedging gap.[10] For

[9] For example, see Tesar and Werner (1995) on frictional trading costs, while Ahearne, Griever, and Warnock (2004) suggest informational costs may be more important.

[10] Note that we refer to the factor-specific risk. Currency depreciation may also, more broadly, reflect lower economic and consumption growth. In this case, assets that covary relatively more positively with consumption (and potentially the currency) will attract a higher equilibrium return (see Parker and Julliard, 2003). However, in this study, such effects will be picked up by factors higher in the ordering, including the broad market and the long-term bond yield.

most markets in this study, in common with much of the recent literature, it is possible to accept the null that exchange rate risk is priced, implying that certain equity assets fulfill a role as a currency-hedging instrument.

For almost every market where risk is priced, the premium is positive—see Appendix E for a summary of estimates using all methods. This is an interesting result, since it suggests that investors require a premium from those assets that perform poorly when the domestic currency is depreciating.

B. An Empirical Positive Risk Pricing Puzzle?

Global equity markets are characterized by "home bias." The weight of foreign equities in countries' wealth portfolios is typically perceived to be low from the perspective of hedging consumption, but also when considering mean-variance portfolio optimization (e.g., Levy and Sarnat, 1970 and Statman, 1999). However, for developed economies there exist a range of instruments investors may use to hedge currency risk, and with considerably less noise than relying on equity assets. Optimal use of these assets would then imply that the risk price of currency exposure in the stock market is zero; investors only receive the undiversifiable systemic asset class risk premium. So what factors might explain positive currency risk pricing?

One key feature of the global institutional investor landscape is asset-liability matching. Three types of institutional investors face home currency liabilities: (i) defined benefit pension funds; (ii) life insurance funds; and (iii) property and casualty insurance funds. While the ultimate beneficiaries of these investment vehicles are typically individuals who face consumption risk through currency volatility, the institutional investor faces relatively lower currency risk when invested in home equity assets.[11] The beneficiary's optimal response must then be to hedge the outstanding currency risk. The implementation of a full currency overlay strategy is beyond the reach of most ordinary investors. As a result, to partially hedge their exposure, investors should either:

- hold more foreign assets, or
- accept a lower equilibrium rate of return on domestic stocks that perform well when the home currency is weak.

[11] This assumes that the earnings of firms listed on the domestic equity market are indexed to local prices and inflation. With the liabilities of domestic institutional investors likely increasing in domestic prices (e.g., insurance funds), domestic equities provide a partial hedge against currency-related pass-through inflation. However, if the institutional investor's liability is a fixed local currency amount or indexed against nontradeable prices, the investor's incentive to hedge currency risk is either zero or lower than the ultimate beneficiary.

With the preference among retail investors—particularly in the United States—to remain in domestic equities, the second choice becomes optimal. As a result, a positive equilibrium risk price for currency exposure should hold for the equity market.

C. Risk Prices Most Significant in North America

In country terms, one key conclusion is that both the United States and Canadian equity markets exhibit relatively high and positive risk-prices for currency exposure. These risk prices are also sensitive to exchange-rate-specific shocks. This implies that even if other asset classes weather further potential U.S. dollar depreciations, investors will demand a high risk premium for currency exposure. The U.S. dollar, in its own right, matters for Wall Street.

In Europe, there is less evidence of currency risk-pricing. This suggests that investors perceive that they are already fully hedged or, more likely, that they are using different instruments. With the equity culture in much of Europe at a less advanced stage than in the United States, this may be one factor driving this result.

REFERENCES

Adler, M., and B. Dumas, 1983, "International Portfolio Choice and Corporate Finance: A Synthesis," *Journal of Finance*, Vol. 38, pp. 925–84.

Ahearne, A., W. Griever, and F. Warnock, 2004, "Information Costs and Home Bias: An Analysis of U.S. Holdings of Foreign Equities," *Journal of International Economics*, Vol. 62, pp. 313–35.

Antoniou, Antonios, Ian Garrett, and R. Priestly, 1998, "The APT vs. the CAPM as a Description of Security Returns: The United Kingdom Experience," CERF Discussion Paper Series, Department of Economics and Finance, Brunel University.

Baba, Naohiko, 2000, "A Reexamination of Ex Ante Pricing of Currency Risk in the Japanese Stock Market: A Pricing Kernel Approach," IMES Bank of Japan Working Paper (Tokyo, Bank of Japan).

Bartram, Sohnke M., and Andrew G. Karolyi, 2002, "The Impact of the Introduction of the Euro on Foreign Exchange Rate Risk Exposures," Economics Working Paper Archive at WUSTL.

Burmeister, E., and M.B. McElroy, 1988, "Arbitrage Pricing Theory as a Restricted Nonlinear Multivariate Regression," *Journal of Business and Economic Statistics,*Vol. 6, pp. 29−42.

Carrieri, Francesca, Vihang Errunza, and Basma Majerbi, 2004, "Does Emerging Market Exchange Risk Affect Global Equity Prices?," McGill Finance Research Center Working Paper, Montreal.

Campbell, John Y., 1996, "Understanding Risk and Return," *The Journal of Political Economy*, Vol. 104, No. 2, pp. 298–345.

Campbell, J.Y., A.W. Lo, and A.C. McKinlay, 1997, *The Econometrics of Financial Markets*, (Princeton, NJ: Princeton University Press).

Choi, Jongmoo, 1984, "Consumption Basket, Exchange Risk, and Asset Demand," *Journal of Financial and Quantitative Analysis,* Vol. 19, pp. 287–98.

Choi, Jongmoo Jay, Takato Hiraki, and Nobuya Takezawa, 1998, "Is Foreign Exchange Risk Priced in the Japanese Stock Market?" *The Journal of Financial and Quantitative Analysis*, Vol. 33, No. 3, pp. 361–82.

Claessens, S., S. Dasgupta, and J. D. Glen, 1995, "The Cross-Section of Stock Returns: Evidence from Emerging Markets," World Bank Policy Research Working Paper No. 1505 (Washington: World Bank).

Cochrane, J. H., 2001, *Asset Pricing,* (Princeton, NJ: Princeton University Press).

Dumas, Bernard, and Bruno Solnik, 1995, "The World Price of Foreign Exchange Risk," *The Journal of Finance*, Vol. 50, No.2, pp. 445–79.

Gallant, A.R., 1987, *Nonlinear Statistical Models,* (New York: John Wiley and Sons, Inc.).

Hansen, L. P., and R. Jagannathan, 1991, "Restrictions on Intertemporal Marginal Rates of Substitution Implied by Asset Returns," *Journal of Political Economy*, Vol. 99, pp. 225−62.

Hansen, L.P. and Scott F. Richard, 1987, "The Role of Conditioning Information in Deducing Testable," Econometrica, Vol. 55 (3), pp. 587–613.

Jorion, P., 1990, "The Exchange Rate Exposure of U.S. Multinationals," *Journal of Business*, pp. 331–45.

Karolyi, G, and Rene Stulz, 2002, "Are Financial Assets Priced Locally or Globally?" NBER Working Paper 8994, (Cambridge, Massachusetts: National Bureau of Economic Research).

Lane, Philip R., Gian Maria Milesi-Feretti, 2001, "The External Wealth of Nations: Measures of Foreign Assets and Liabilities in Industrial and Developing Countries," *Journal of International Economics*, Vol. 55, No. 2, pp. 263–94.

Levy, H., and M. Sarnat, 1970, "International Diversification of Investment Portfolios," *American Economic Review*, Vol. 60, No. 4, pp. 668–75.

McElroy, M. B., and E. Burmeister, 1988, "Arbitrage Pricing Theory as a Restricted Nonlinear Multivariate Regression Model," *Journal of Business and Economic Statistics*, Vol. 6, pp. 29–42.

Parker, Jonathan A., and Christian Julliard, 2003, "Consumption Risk and Cross-Sectional Returns," NBER Working Paper 9358 (Cambridge, Massachusetts: National Bureau of Economic Research).

Roll, Richard, 1976. "A Critique of the Asset Pricing Theory's Tests," Journal of Financial Economics, Vol. 4, pp. 129–76.

Ross, S., 1976, "The Arbitrage Theory of Capital Asset Pricing," *Journal of Economic Theory*, Vol. 13, pp. 341–60.

Shanken, J., 1992a, "The Current State of Arbitrage Pricing Theory," *Journal of Finance*, Vol. 47, No.4, pp. 1569–574.

Shanken, J., 1992b, "On the Estimation of Beta-Pricing Models," *Review of Financial Studies*, Vol. 5, pp. 1–34.

Statman, M., 1999, "Foreign Stocks in Behavioral Portfolios," *Financial Analysts Journal*, Vol. 55, pp. 12–16.

Tesar, L. and I. Werner, 1995, "Home Bias and High Turnover," *Journal of International Money and Finance*, Vol. 14, pp. 467–92.

Summary Correlation Statistics

Table A1. Correlation Matrices for Factor Log Returns, January 1974–February 2005

	Stock Market	Bond Yield	Exch. rate	Stock Market	Bond Yield	Exch. rate
	U.S.			**U.K.**		
Stock market	1.000			1.000		
Bond yield	-0.159	1.000		-0.287	1.000	
Exchange rate	-0.096	0.257	1.000	0.011	-0.202	1.000
	Japan			**Germany**		
Stock market	1.000			1.000		
Bond yield	0.056	1.000		-0.133	1.000	
Exchange rate	0.101	-0.090	1.000	-0.080	-0.230	1.000
	France			**Italy**		
Stock market	1.000			1.000		
Bond yield	-0.215	1.000		-0.129	1.000	
Exchange rate	-0.008	-0.054	1.000	0.014	-0.288	1.000
	Canada					
Stock market	1.000					
Bond yield	-0.287	1.000				
Exchange rate	0.170	-0.100	1.000			

Source: Authors' calculations.

Likelihood Ratio Tests of the APT Specification

The test for the null that the linear restrictions imposed by the unconditional APT on the portfolio of industry returns is valid was conducted using the small sample adjusted log-likelihood ratio tests, where:

$$J = -\left(T - \frac{N}{2} - K - 1\right)\left(\ln\left|\hat{\boldsymbol{\Sigma}}\right| - \ln\left|\hat{\boldsymbol{\Sigma}}^{*}\right|\right) \sim \chi^{2}(r)$$

Under the null hypothesis, the test statistic is distributed as a chi-square with degrees of freedom equal to the number of restrictions.

Table A2. Test Statistics for the APT Specification using the Unconditional Model [1/]

	Chi Square (*r*)	***p* Value**	**Critical Value**
U.S.	15.5	0.9958	47.4
U.K.	11.2	0.9998	46.2
Germany	26.5	0.6515	43.8
Japan	26.3	0.7514	46.2
France	27.4	0.6519	45.0
Italy	48.5**	0.0132	39.1
Canada	37.0	0.2505	46.2

Source: Authors' calculations.
1/ Significance at the 10, 5, and 1 percent level denoted by *, **, and ***, respectively.

Two-Pass Regression Estimates

Table A3. Estimated Risk-Pricing from the Two-Pass Regressions 1/

		Risk Price Coefficients				Risk Price Coefficients			
		λ_0	λ_{INT}	λ_{FX}	λ_M	λ_0	λ_{INT}	λ_{FX}	λ_M
		OLS				GLS			
U.S.	Coefs	0.52	-0.04	**0.51****	-0.05	0.61	-0.56	**0.44**	-0.23
	Std. errors	0.16	0.36	**0.13**	0.16	0.26	0.42	**0.19**	0.26
	Adj. std. errors	0.17	0.37	**0.25**	0.28	0.27	0.43	**0.28**	0.35
	t-stat	3.06	-0.11	**2.04**	-0.18	2.26	-1.30	**1.57**	-0.66
U.K.	Coefs	0.77	-0.62	**-0.36***	-0.31	1.14	-0.12	**-0.04**	-0.67
	Std. errors	0.12	0.21	**0.10**	0.12	0.22	0.25	**0.17**	0.20
	Adj. std. errors	0.13	0.24	**0.22**	0.33	0.23	0.28	**0.27**	0.37
	t-stat	5.92	-2.58	**-1.64**	-0.94	4.96	-0.43	**-0.15**	-1.81
Germany	Coefs	0.90	2.09	**0.33***	-0.75	0.50	2.27	**-0.35**	-0.45
	Std. errors	0.25	0.67	**0.04**	0.33	0.31	0.63	**0.34**	0.33
	Adj. std. errors	0.59	1.57	**0.20**	0.82	0.73	1.48	**0.82**	0.81
	t-stat	1.53	1.33	**1.65**	-0.91	0.68	1.53	**-0.43**	-0.56
Japan	Coefs	-0.05	-1.25	**-0.25**	0.36	-1.40	-7.83	**0.82**	2.12
	Std. errors	0.30	1.34	**0.53**	0.33	0.32	2.38	**0.29**	0.39
	Adj. std. errors	0.34	1.52	**0.76**	0.46	0.36	2.70	**0.56**	0.52
	t-stat	-0.15	-0.82	**-0.33**	0.78	-3.89	-2.90	**1.46**	4.08
France	Coefs	0.32	-0.74	**0.09**	0.04	0.66	-1.64	**0.58***	-0.70
	Std. errors	0.34	0.55	**0.21**	0.33	0.46	0.47	**0.18**	0.47
	Adj. std. errors	0.57	0.59	**0.27**	0.67	0.42	0.69	**0.31**	0.52
	t-stat	0.56	-1.25	**0.33**	0.06	1.57	-2.38	**1.87**	-1.35
Italy	Coefs	0.47	0.28	**0.21**	-0.47	0.27	2.69	**0.44***	-0.24
	Std. errors	0.27	0.64	**0.10**	0.28	0.37	0.83	**0.16**	0.39
	Adj. std. errors	0.28	0.66	**0.21**	0.47	0.38	0.86	**0.24**	0.54
	t-stat	1.68	0.42	**1.00**	-1.00	0.71	3.13	**1.83**	-0.44
Canada	Coefs	0.80	-0.29	**0.18**	-0.40	0.33	0.10	**-0.39**	0.27
	Std. errors	0.33	0.45	**0.23**	0.33	0.71	1.06	**0.54**	0.78
	Adj. std. errors	0.35	0.47	**0.30**	0.42	0.73	1.10	**0.59**	0.85
	t-stat	2.29	-0.62	**0.60**	-0.95	0.45	0.09	**-0.66**	0.32

Source: Authors' calculations.
1/ Significance at the 10, 5, and 1 percent level denoted by *, **, and ***, respectively.

Likelihood Ratio Tests for Foreign Exchange Risk Pricing and Time Variation

The first test was based on the system of equations in which all risk prices were risk-varying. The results are shown in Table A4. The null hypothesis was that the risk price for the foreign exchange was zero, such that using the notation from equation (10):

$$H_0 : a_{k0} = a_{k1} = \cdots = a_{kl} = 0$$

The second test was based on the system of equations in which all risk prices were risk-varying. Table 1 shows the estimated coefficients from the conditional model. The null hypothesis was that there was zero time-variation in the risk price for the foreign exchange, such that using the notation from equation (10):

$$H_0 : a_{k1} = \cdots = a_{kl} = 0$$

Both tests used the Wald test statistic, which is distributed as a chi-square with degrees of freedom equal to the number of restrictions under the null.

Table A4. Test Statistics for the APT Specification using the Unconditional Model 1/

	Test 1		Test 2	
	Chi-sq (5)	*p*-value	Chi-sq (4)	*p*-value
U.S.	22.4***	0.0004	17.7***	0.0014
U.K.	12.9**	0.0240	10.7**	0.0303
Japan	14.8**	0.0115	14.6***	0.0056
Germany	5.5	0.3563	5.2	0.2628
France	3.4	0.6422	3.4	0.4982
Italy	10.6*	0.0605	10.6**	0.0321
Canada	27.6***	0.0000	24.1***	0.0001

Source: Authors' calculations.
1/ Significance at the 10, 5, and 1 percent denoted by *, **, and ***, respectively.

Summary of Estimated Foreign Exchange Risk Prices

Both the OLS and GLS estimates are derived from the standard two-pass regression models. SUR1 refers to the jointly estimated model, with no time variation in the risk prices. SUR2 refers to the jointly estimated model with time variation driven by shocks to the factor up to lag three. Since this is the mean, the figure does not reflect the effect of factor-specific shocks, whose expected value is zero.

Table A5. Summary of Estimated Foreign Exchange Risk Prices by Estimation Method

	OLS	GLS	SUR1	SUR2
U.S.	0.51	0.44	0.66	0.67
U.K.	-0.36	-0.04	-0.39	-0.31
Japan	0.33	-0.35	0.17	0.20
Germany	-0.25	0.82	0.55	0.73
France	0.09	0.58	0.02	-0.18
Italy	0.21	0.44	0.44	0.35
Canada	0.18	-0.39	0.32	0.28

Source: Authors' calculations.