

"EQUITY RISK PREMIA AND THE PRICING  
OF FOREIGN EXCHANGE RISK"

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# EQUITY RISK PREMIA AND THE PRICING OF FOREIGN EXCHANGE RISK

## Abstract

We investigate the relation between the risk premia observed in forward foreign exchange markets and international equity markets. If these markets share common sources of risk then the time variation in forward risk premia should be related to the forward contract's sensitivity to well-diversified equity benchmark portfolios and the time variation in the risk premia of those benchmark portfolios. We find that the forward contracts have a component of their conditional mean returns that is not reflected in their relation to the equity markets.

There is an extensive body of empirical work which indicates that forward prices for foreign exchange are not unbiased predictors of future spot exchange rates, [e.g., Hansen and Hodrick (1980, 1983), Bilson (1981), Korajczyk (1985), Mark (1985), and the extensive review by Hodrick (1987)]. That is, the evidence indicates that  $E_{t-1}[S_t] \neq G_{t-1}$ , where  $G_{t-1}$  is the forward exchange rate set at time  $t-1$  for delivery at time  $t$ ,  $S_t$  is the spot exchange rate at time  $t$ , and  $E_{t-1}[\cdot]$  denotes expectations conditional on information available at time  $t-1$ .

This evidence has been variously interpreted as evidence of (a) inefficiencies in the forward market; (b) forward risk premia which vary through time; and (c) "peso" problems in which the anticipation of rare, but important, events influence the pricing of assets in ways that induce ex post bias in the forward rates when the observation period is short.

There is also a growing body of evidence that the risk premia on common stocks vary through time. This can be seen through the evidence of seasonality in stock returns [e.g., Gultekin and Gultekin (1983)] as well as evidence on the relation between equity risk premia and observable instruments for time varying expected returns [e.g., Keim and Stambaugh (1986) or Fama and French (1988)].

The purpose of this paper is to investigate the relation between the forecastable components of returns in the forward exchange market and international equity markets. In particular we wish to determine whether the observed risk premia in the forward market can be explained by the premia observed in the equity markets.

## I. The Implications of an Intertemporal Asset Pricing Model

We begin by utilizing the first order conditions from a standard

representative agent's discrete-time utility maximization problem, [see Lucas (1982) or Hodrick (1987, Chp.2)] which states that

$$E_{t-1}[Q_{mt}R_{jt}] = 1 \quad (1)$$

where  $R_{jt}$  is the gross nominal (currency m) return on asset j from t-1 to t and  $Q_{mt}$  is the marginal rate of substitution of currency m between t-1 and t. Now let  $R_{ft}$  denote the gross return on a nominally (in currency m) riskless asset. Relation (1) implies that  $R_{ft}E_{t-1}[Q_{mt}] = 1$ . This plus the definition of conditional covariance leads to

$$E_{t-1}(R_{jt}) - R_{ft} = -R_{ft} \text{Cov}_{t-1}[Q_{mt}, R_{jt}] \quad (2)$$

where  $\text{Cov}_{t-1}[\cdot, \cdot]$  denotes the covariance conditional on time t-1 information.

From this we obtain a conditional asset pricing relation in terms of a benchmark portfolio which is on the conditional mean/variance frontier.

Assume that there is a traded asset with returns given by

$$R_{mt} = Q_{mt}/E_{t-1}(Q_{mt})^2. \quad (3)$$

Hansen and Richard (1987) show that the conditional mean/variance frontier can be formed by linear combinations of  $R_{mt}$  and  $R_{ft}$ . That is, if  $R_{bt} = \omega_{t-1}R_{mt} + (1-\omega_{t-1})R_{ft}$  then the benchmark portfolio return,  $R_{bt}$ , is conditionally mean/variance efficient. This allows us to write (2) as

$$E_{t-1}(R_{jt}) - R_{ft} = \beta_{jt-1}[E(R_{bt}) - R_{ft}] \quad (4)$$

where  $\beta_{jt-1} = \text{Cov}_{t-1}[R_{jt}, R_{bt}] / \text{Var}_{t-1}[R_{bt}]$ .

This is true for any asset or portfolio,  $j$ . Consider the following portfolio. Invest  $S_{t-1}$  dollars in  $R_f$ , where  $S_{t-1}$  is the current spot exchange rate for the foreign currency, and enter into a forward contract for one unit of the currency. The excess rate of return on this portfolio is

$$r_{Gt} = (S_t - G_{t-1} + R_{ft}S_{t-1})/S_{t-1} - R_{ft} = (S_t - G_{t-1})/S_{t-1}.$$

Thus, we get an expression for the equilibrium difference between the forward exchange rate and the expected future spot rate

$$E(S_t - G_{t-1})/S_{t-1} = \beta_{Gt-1}[E(R_{bt}) - R_{ft}]. \quad (5)$$

The single-beta relation in (5) has been the point of departure for a number of studies which treat the excess return on the benchmark portfolio as a latent variable [e.g., Hansen and Hodrick (1983), Hodrick and Srivastava (1984), and Giovannini and Jorion (1987)]. The latent variable approach utilizes the fact that movements in asset expected returns should be proportional to movements in the expected return on the benchmark portfolio,, where the constant of proportionality is the conditional beta. That is, if<sup>1</sup>

$$E(r_{bt}) = [E(R_{bt}) - R_{ft}] = \alpha' \underline{z}_{t-1},$$

then  $E(r_{jt}) = \beta_{jt} \alpha' \underline{z}_{t-1} \quad (6)$

for all  $j$ . If we assume that betas are constant through time ( $\beta_{jt} = \beta_j$ ) or

explicitly model the time variation in betas, then (6) implies testable restrictions on a pooled times series/cross-section of asset returns. These types of restrictions are tested in the studies cited above.

## II. The Role of a Factor Model

Our approach is somewhat different from the one outlined above. We assume that asset returns follow a factor structure with the factors spanning the state variables that describe the evolution of the investment opportunity set. This implies that our benchmark portfolio return,  $R_{bt}$ , is a linear combination of the returns on factor mimicking portfolios. This, in turn, implies that the risk premia in the forward exchange market should be determined by the forward contracts' conditional covariances with the factor mimicking portfolios. This allows us to use security return data to estimate the return on our benchmark portfolio.

Our assumed factor structure is given by

$$r_{jt} = \mu_{jt} + b_{j1}\delta_{1t} + \dots + b_{jk}\delta_{kt} + \epsilon_{jt} \quad (7)$$

where  $\mu_{jt}$  is the expected excess return on asset  $j$ ,  $b_{ji}$  is the sensitivity of asset  $j$  to factor  $i$ ,  $\delta_{it}$  is the realization of factor  $i$  in period  $t$ , and  $\epsilon_{jt}$  is the diversifiable component of asset  $j$ 's return. We assume that  $E(\epsilon_{it}) = 0$ ;  $E(\delta_{it}) = 0$ ;  $E(\delta_{it}\epsilon_{jr}) = 0$  for all  $i, j, t$ , and  $r$ ; and, for simplicity,  $E(\delta_{it}\delta_{lr}) = 0$  for all  $i, l, t$  and  $r$ . Let  $V_n$  denote the covariance matrix of  $\underline{\epsilon}_n' = (\epsilon_{1t}, \dots, \epsilon_{nt})$ . The diversifiability of the  $\epsilon$ 's implies that the eigenvalues of  $V_n$  are bounded as  $n$  approaches infinity, [see Chamberlain and Rothschild (1983)].

Constantinides (1989) discusses the relation between the pricing implications of (1)-(4) and the intertemporal arbitrage pricing theory. In general the marginal rate of substitution,  $Q_{mt}$ , is a function of all information available at  $t$ , denoted  $\Phi_t$ . Let  $\underline{s}_t$  denote the  $p$ -vector of state variables which, given information available at  $t-1$ , represent a sufficient statistic for  $Q_{mt}$  [that is  $Q_{mt}(\Phi_t) = \hat{Q}_{mt}(\Phi_{t-1}, \underline{s}_t)$ ]. The expected returns on asset  $j$  will be determined by the factor sensitivities  $b_{ji}$  ( $i = 1, \dots, k$ ) as well as the covariance of  $\epsilon_j$  with the state variables,  $\underline{s}_t$ . If we assume that the factors span the state variable, that is  $\underline{s}_t = \Omega \delta_t$ ,<sup>2</sup> then this covariance is zero since  $E(\epsilon_{jt} \delta_{it}) = 0$ . Thus, under this spanning assumption, the expected returns on assets are determined by their conditional covariances with the factor. If we can construct portfolios which are perfectly correlated with the factors then the asset pricing model implies that our benchmark portfolio is a linear combination of these factor mimicking portfolios. Thus we can price assets, including forward contracts for foreign exchange, relative to these factor mimicking portfolios.

We use the asymptotic principal components technique of Connor and Korajczyk (1986, 1988) to construct factor mimicking portfolios from the returns on common stocks. If exchange rates and common equities are influenced by the same factors or state variables, then we should be able to use the time variation in the factor mimicking portfolios to explain the apparent time variation in the risk premia in the forward market.

### III. Data Description

We examine eight exchange rates in terms of US dollars: the British pound, the Canadian dollar, the Dutch guilder, the French franc, the Italian

lira, the Japan yen, the Swiss franc and the German mark. We use end-of-month exchange rates from August 1973 to December 1986. The starting date was chosen to coincide with the beginning of the current floating exchange rate regime. Spot and forward exchange rates were taken from the Data Resources Incorporated (DRI) data files.

Our sample of equity returns includes stocks from France, Japan, United Kingdom and the United States and spans the period August 1973 to December 1986. Stock exchange data and a summary of our sample data are presented in Table 1. The equity sample includes all assets traded on the New York and American Stock Exchanges, the Tokyo Stock Exchange and the London Stock Exchange. It includes approximately 20% of the Paris Bourse listed stocks. At the end of 1986, these four markets represented nearly 60% of the world stock market capitalization.

Monthly returns in French francs, British pounds and Yen, adjusted for dividends and stock splits, are transformed into US dollar returns using end-of-month exchange rates from the DRI data files. To compute excess returns we use the US Treasury Bill returns from Ibbotson Associates (1988).

To estimate the excess returns on the factor mimicking portfolios we use the asymptotic principal components technique of Connor and Korajczyk (1986, 1988) instead of standard factor analytic techniques. The choice was made on the basis of computational convenience. The asymptotic principal components procedure can accommodate the large number of stocks in our sample (up to 6692) while standard factor analysis packages could not.

The procedure assumes the factor structure in (7) and that an exact multifactor pricing relationship holds, i.e.

$$\mu_i = b_{i1}\gamma_1 + b_{i2}\gamma_2 + \dots + b_{ik}\gamma_k \quad (8)$$

Let  $T$  be the number of time periods;  $n$  the number of securities;  $R^n$  the  $n \times T$  matrix of excess returns;  $F$  the  $k \times T$  matrix of realized factors plus risk premia ( $F_{jt} = \delta_{jt} + \gamma_{jt}$ ) and  $B^n$  the  $n \times k$  matrix of factor loadings. Note that the estimation procedure allows the risk premia,  $\gamma_{jt}$ , to vary through time. Equation (8) implies that:

$$R^n = B^n F + \varepsilon^n \quad (9)$$

with:  $E(F\varepsilon^{n'}) = 0$ ,  $E(\varepsilon^n) = 0$ , and  $E(\varepsilon^n \varepsilon^{n'}) = V^n$ .

Let  $\Omega^n$  be the  $T \times T$  matrix defined by  $\Omega^n = R^n R^n / n$  and  $G^n$  the  $k \times T$  matrix of the first  $k$  eigenvectors of  $\Omega^n$ . Under the assumption that asset returns follow an approximate  $k$ -factor model [in the sense of Chamberlain and Rothschild (1983)] Connor and Korajczyk (1986) show that  $G^n$  converges towards a non-singular transformation of  $F$  as  $n$  goes to infinity. We assume that our equity sample size is large enough to consider  $G^n$  estimated from the sample as a transform of  $F$ . Consequently, the first  $k$  eigenvectors of  $G^n$  are estimates of the excess returns on factor mimicking portfolios. In order to use all available data in our sample we employ an extension of the principal components technique from Connor and Korajczyk (1988) which does not require that asset returns must exhibit continuous time series of returns. As a consequence we avoid any survivorship bias.

A major difficulty in any application of factor analysis is the determination of the appropriate number of factors. We choose to present our results using five factors. We have performed our tests using different

numbers of factors and found that the main results of the paper are robust to changes in the number of factors.

#### IV. Empirical Results

We begin by documenting the fact that returns on forward contracts have forecastable components, hence forward prices cannot be conditionally unbiased predictors of future spot prices. In Table 2 we present results in which we regress  $r_{G_t} - (S_t - G_{t-1})/S_{t-1}$  on a constant and the forward premium observed at time  $t-1$ ,  $(G_{t-1} - S_{t-1})/S_{t-1}$ . If  $G_{t-1}$  is a conditionally unbiased predictor, then the intercepts and the slope coefficients should be equal to zero. We use data on eight exchange rates relative to the US dollar. The time period is August 1973 to December 1986. We reject the hypothesis that the intercepts are jointly zero and the hypothesis that the slope coefficients are jointly zero. Thus, the results in Table 2 confirm the findings of others in that there is reliable evidence that forward exchange rates are not unbiased predictors of future spot rates. We also split the period into two subperiods 8-1973 to 7-1979 and 8-1979 to 12-1986. The results are not reported here, but we reject the unbiasedness hypothesis over each subperiod.

We now wish to determine whether the time variation in expected returns on the forward contracts are explained by the risk premia in the factor mimicking portfolios. We begin by assuming that the conditional factor betas of the forward returns are constant through time. We regress each currency's excess forward return,  $r_{G_t}$ , on a constant, the excess returns on five factor mimicking portfolios, and the observable forward premium at the beginning of the period. If the factor mimicking portfolios represent the benchmark portfolio,  $r_{b_t}$ , and the conditional betas are truly constant, then the

intercept and the slope coefficient on the forward premium should be zero. The results are shown in Table 3. The factors, in general, have significant explanatory power as can be seen from the increase in  $R^2$  from Table 2 to Table 3. We do not report the factor betas because their interpretation is made difficult by the standard rotational indeterminacy problem of factor analytic or principal components based methods. Inclusion of the factor mimicking portfolios does not change the joint significance of the intercepts or of the coefficients on the forward premium. In particular, the coefficients seem to change very little with the inclusion of the factor mimicking return. Thus, while the forward returns have significantly correlated with the factor returns, there remains a time-varying component of the forward returns which is unrelated to the time-varying component of equity returns.

Giovannini and Jorion (1987) find that the performance of the latent variable model described above is significantly improved when they allow for time variation in the conditional betas. We allow the forward contracts to have factor betas which are functions of the beginning-of-period forward premium and a dummy which splits the period into two subperiods 8-1973 to 7-1979 and 8-1979 to 12-1986. While we can reject the hypothesis that the factor betas are constant, we still reject the hypothesis that the intercept and forward premium coefficients are zero.

We have also estimated the above models using standard proxies for the benchmark portfolio. These are the value-weighted and equal-weighted portfolios of stocks from the UK, UK, Japan, and France. We obtain basically the same results.

## V. Conclusion

We investigate the relation between the risk premia observed in forward foreign exchange markets and international equity markets. If these markets share common sources of risk then the time variation in forward risk premia should be related to the forward contract's sensitivity to well-diversified equity benchmark portfolios and the time variation in the risk premia of those benchmark portfolios.

We find that the forward contracts have a component of their conditional mean returns that is not reflected in their relation to the equity markets. Potential explanations of this phenomenon are (a) there are sources of risk peculiar to the forward markets that are not reflected in equity markets; (b) the methods of constructing benchmark portfolios or modelling the time-variation in conditional betas have failed to reflect important influences in the true benchmark returns; (c) the equity and exchange markets are not fully integrated; or (d) pricing related to rare events (the "peso" problem) leads to measured "risk premia" which are related to perceived changes in the probability of these events. We hope to expand on these potential explanations in future work.

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## Endnotes

1. We will use lower case  $r$ 's to denote excess returns, while upper case  $R$ 's denote gross returns.
2. Note that this requires  $p \leq k$ . Here  $\underline{f}_t$  denotes the  $k \times 1$  vector of factor realizations and  $\Omega$  is a  $p \times k$  matrix with rank  $p$ .

Table 1

Stock Exchange and Sample Data

Stock Exchange Data

Market	Market capitalization as per- cent of World Capitalization <sup>a</sup> 31.12.86	Number of listed firms <sup>a</sup> 31.12.86
NYSE & AMEX	27	2371
Tokyo	22	1551
London	6	2685
Paris	<u>2</u>	<u>677</u>
TOTAL	<u>57%</u>	<u>7284</u>

Sample Data

I. Data Source and Frequency of Returns

<u>Country</u>	<u>Data Source</u>	<u>Frequency of Returns</u>
United States	CRSP	Monthly
Japan	Japan Securities Research Institute	Monthly
United Kingdom	London Share Data Base	Monthly
France	Compagnie des Agents de Change	Monthly

II. Number of sample firms

Maximum : 6692

Average : 5716

Minimum : 4167

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<sup>a</sup> Source: International Federation of Stock Exchanges Statistics, 1987

Table 2

Regression of forward returns on forward premia,  
August 1973 - December 1986

$$(S_t - G_{t-1})/S_{t-1} = a_0 + a_1(G_{t-1} - S_{t-1})/S_{t-1} + v_t$$

Country	$a_0 \times 100$	$a_1$	$R^2$
United Kingdom	-0.51 (-1.84)	-2.08 (-3.54)	0.08
Canada	-0.28 (-2.62)	-2.10 (-3.45)	0.06
Netherlands	0.14 (0.54)	-0.90 (-7.77)	0.03
France	-0.15 (-0.55)	-0.70 (-2.48)	0.03
Italy	-0.54 (-1.83)	-1.11 (-4.18)	0.05
Japan	0.31 (1.12)	-0.72 (-1.96)	0.01
Switzerland	0.98 (2.43)	-2.16 (-3.80)	0.07
West Germany	0.20 (0.73)	-1.12 (-3.48)	0.02

T-statistics in parentheses.

Wald tests: (a)  $a_0 = 0$  for all countries  $\chi_8^2 = 31.0$ , p-value  
<.001;

(b)  $a_1 = 0$  for all countries  $\chi_8^2 = 112.8$ , p-value  
<.001.

Table 3

Seemingly unrelated regression of forward returns on factor  
mimicking portfolio returns and forward premia.

August 1973 - December 1986

$$(S_t - G_{t-1})/S_{t-1} = a_0 + b_1 f_{1t} + \dots + b_5 f_{5t} + a_1 (G_{t-1} - S_{t-1})/S_{t-1} + v_t$$

Country	$a_0 \times 100$	$a_1$	$R^2$
United Kingdom	-0.74 (-3.62)	-1.04 (-2.16)	0.54
Canada	-0.35 (-3.26)	-1.98 (-3.26)	0.13
Netherlands	-0.21 (0.90)	-0.89 (-8.03)	0.27
France	-0.49 (-2.11)	-0.65 (-2.36)	0.32
Italy	-0.80 (-2.88)	-1.16 (-4.44)	0.23
Japan	-0.09 (-0.46)	-0.60 (-2.10)	0.52
Switzerland	0.56 (1.46)	-2.05 (-3.71)	0.30
West Germany	-0.13 (-0.50)	-1.13 (-3.72)	0.24

T- statistics in parentheses.

Wald tests: (a)  $a_0 = 0$  for all countries  $\chi_8^2 = 38.5$ , p-value  
<.001;

(b)  $a_1 = 0$  for all countries  $\chi_8^2 = 113.6$ , p-value  
<.001.

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