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ABSTRACT

The Forward Premium Puzzle: Different Tales from Developed and Emerging Economies*

In this paper we document new results regarding the forward premium puzzle. The often found negative correlation between the expected currency depreciation and interest rate differential is, contrary to popular belief, not a pervasive phenomenon. It is confined to developed economies and here only to states where the US interest rate exceeds foreign interest rates. Furthermore, we find that differences across economies are systematically related to per capita GNP, average inflation rates and inflation volatility. Our empirical work suggests that it is hard to justify the cross-sectional differences in the risk premia as compensation for systematic risk. Instead, country-specific attributes seem to be important in characterizing the cross-sectional dispersion in the risk premia.

JEL Classification: F31, G12
Keywords: forward rates, forward premium, systematic risk

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NON-TECHNICAL SUMMARY

An implication of many economic models is that the domestic currency is expected to depreciate when domestic nominal interest rates exceed foreign interest rates. Empirical evidence, however, suggests the opposite: future exchange rate changes and current interest rate differentials are negatively correlated. That is, relatively high domestic nominal interest rates predict an appreciation of the domestic currency. This empirical finding and its implications for returns on international currency deposits, as presented in Fama (1984), is referred to as the 'forward premium puzzle'.

There are two motivations for writing this article concerning the forward premium puzzle. First, much of the empirical wisdom regarding this puzzle is based on the evidence obtained from developed economies, such as the G-7. In contrast to the G-7, emerging economies have lower per capita income, on average higher inflation and inflation uncertainty, and higher nominal interest rates. It seems quite likely that these economic differences have a direct bearing on the correlation between exchange rate change and interest rate differential. If so, additional evidence from emerging economies may provide valuable lessons in understanding the economic sources of the forward premium puzzle. Second, it is well known that the negative correlation between exchange rate changes and interest differentials also has direct implications for the expected excess return from holding foreign deposits. Given the aforementioned economic differences, the risk return trade-off offered by currency deposits in emerging economies is bound to be different from currency deposits in the G-7. These cross-sectional differences across developed and emerging economies should pose special challenges to asset pricing models where compensation for bearing risk is only related to world-wide systematic risk.

Using pooled time-series information from 28 emerging and developed economies, we present new evidence which suggests that the forward premium puzzle is not a pervasive phenomenon, at best, it seems to be confined to high GNP per capita economies (developed economies). The evidence from emerging and lower-income developed economies is consistent with economic intuition: a positive domestic interest rate differential predicts a depreciation of the domestic currency. Additionally, we find a state-dependence in the relation between the expected depreciations and interest rate differentials in developed economies. The forward premium puzzle is present only when US interest rates exceed foreign interest rates. When foreign interest rates exceed US interest rates, the expected depreciation and interest rate differentials are positively related. There seems to be little evidence in favour of this state-dependence in emerging economies. Our investigation shows that the relation between the expected change in exchange rates and interest rate differentials is systematically related to macroeconomic fundamentals. Interest rate differentials are an increasingly biased predictor of currency depreciation as per capita GNP rises and as average inflation and inflation volatility drop: features mostly found in the developed economies. In all, there seem to be significant differences in the relation between the expected depreciation and interest differentials across developed and emerging economies.

As stated earlier, the forward premium puzzle has direct implications for expected returns from international currency deposits. For a given positive interest differential, higher negative correlations between exchange rate change and interest rate differential implies a higher expected excess return. Hansen and Hodrick (1983) develop a latent factor asset pricing model to inquire if the risk premia from investing in foreign currency deposits can be rationalized by a model of friction-less markets. We use the latent factor model to ask if the conditional risk premia across currencies can be accounted for in the time-series. Furthermore, we also use the cross-sectional method to ask if the cross-sectional heterogeneity in the risk premia across currencies can be explained as compensation for systematic risk. Our evidence from both the time-series and the cross-section suggests that a variety of models of systematic risk cannot explain the cross-section of risk premia. In particular, we find that a portfolio of low income developed economies (such as Spain, Italy and Portugal) offer an abnormal risk premium. The risk premia on newly emerging economies are also difficult to justify. In the cross-section of all countries we find that the relative contributions of systematic risk in explaining the risk premia are small: country specific attributes such as per capita GNP, sovereign ratings and interest rate differentials seem to be more important in characterizing the cross-section of risk premia. This evidence thus suggests a rejection of the latent factor model, which differ from earlier results.

Our results have important implications for models that attempt to explain the forward premium puzzle. The negative relation between the expected depreciation and the interest rate differential implies that the risk premium and expected depreciation are negatively related and that the risk premium is more volatile than the expected depreciation. As has been pointed out, the negative correlation between the risk premium and expected depreciation can be qualitatively rationalized by simple asset pricing models. Accounting for the higher relative volatility of the risk premium is, however, more difficult. For example, versions of monetary models of Lucas (1982) and models that incorporate trading frictions in goods markets fail to account for the forward premium puzzle. Eichenbaum and Evans (1995) and Yaron (1996) argue that general equilibrium models which incorporate participation constraints and nominal price rigidities may potentially account for the forward premium puzzle. Our evidence discussed above suggests that there are additional important dimensions in the relation between expected depreciation rates and forward premia which need to be explained. In particular, a credible explanation also needs to address the differences between emerging and developed economies, and the apparent differences across high and low interest rate differentials states in developed economies.

1 Introduction

An implication of many economic models is that the domestic currency is expected to depreciate when domestic nominal interest rates exceed foreign interest rates.[1] Empirical evidence, however, suggests the opposite—future exchange rate changes and current interest rate differentials are negatively correlated. That is, relatively high domestic nominal interest rates predict an appreciation of the domestic currency. This empirical finding and its implications for returns on international currency deposits, as presented in Fama (1984), is referred to as the "forward premium puzzle."

There are two motivations for writing this article concerning the forward premium puzzle. First, much of the empirical wisdom regarding this puzzle is based on the evidence obtained from developed economies, such as the G-7.[2] In contrast to the G-7, emerging economies have lower per capita income, on average higher inflation and inflation uncertainty, and higher nominal interest rates. It seems quite likely that these economic differences have a direct bearing on the exchange rate change—interest rate differential correlation. If so, additional evidence from emerging economies may provide valuable lessons in understanding the economic sources of the forward premium puzzle. Second, it is well known that the negative correlation between exchange rates changes and interest differentials also has direct implications for the expected excess return from holding foreign deposits. Given the aforementioned economic differences, the risk return trade-off offered by currency deposits in emerging economies are bound to be different from currency deposits in the G-7. These cross-sectional differences across developed and emerging economies should pose special challenges to asset pricing models where compensation for bearing risk is only related to world-wide systematic risk.

Using pooled time-series information from 28 emerging and developed economies, we present new evidence which suggests that the forward premium puzzle is not a pervasive phenomenon—at best, it seems to be confined to high GNP per capita economies (developed economies). The evidence from emerging and the lower-income developed economies is consistent with economic intuition—a positive domestic interest rate differential predicts a de-

[1] See, for instance, the quantitative implications of Lucas (1982) in Bansal, Gallant, Hussey, and Tauchen (1995), and Bekaert (1996).

[2] This issue has been studied by Hansen and Hodrick (1983), Hsieh (1984), Fama (1984), Hodrick (1987), and more recently by Backus, Foresi, and Telmer (1996), and Bansal (1997).

preciation of the domestic currency. Additionally, we find a state-dependence in the relation between the expected depreciations and interest rate differentials in developed economies. The forward premium puzzle is present only when U.S. interest rates exceed foreign interest rates. When foreign interest rates exceed U.S. interest rates, the expected depreciation and interest rate differentials are positively related. There seems to be little evidence in favor of this state-dependence in emerging economies. Our investigation shows that the relation between the expected change in exchange rates and interest rate differentials is systematically related to macroeconomic fundamentals. Interest rate differentials are an increasingly biased predictor of currency depreciation as per capita GNP rises, and as average inflation and inflation volatility drop—features mostly found in the developed economies. In all, there seems to be significant differences in the relation between the expected depreciation and interest differentials across developed and emerging economies.

As stated earlier, the forward premium puzzle has direct implications for expected returns from international currency deposits. For a given positive interest differential, higher negative correlations between exchange rate change and interest rate differential implies a higher expected excess return. Hansen and Hodrick (1983) develop a latent factor asset pricing model to inquire if the risk premia from investing in foreign currency deposits can be rationalized by a model of friction-less markets. We use the latent factor model to ask if the conditional risk premia across currencies can be accounted for in the time-series. Furthermore, we also use the cross-sectional method used in Fama and MacBeth (1973) and Jagannathan and Wang (1996) to ask if the cross-sectional heterogeneity in the risk premia across currencies can be explained as compensation for systematic risk. Our evidence from both the time-series and the cross-section suggests that a variety of models of systematic risk cannot explain the cross-section of risk premia. In particular, we find that a portfolio of low income developed economies (such as Spain, Italy, and Portugal) offer an abnormal risk premium. The risk premia on newly emerging economies are also difficult to justify. In the cross-section of all countries we find that the relative contributions of systematic risk in explaining the risk premia are small—country specific attributes such as per capita GNP, sovereign ratings and interest rate differentials seem to be more important in characterizing the cross-section of risk premia. This evidence thus suggests a rejection of the latent factor model, which differ from the results in Campbell and Clarida (1987), Giovannini and Jorion

(1987), and Huang (1989).

Our results have important implications for models that attempt to explain the forward premium puzzle. Fama (1984) showed that the negative relation between the expected depreciation and the interest rate differential implies that the risk premium and expected depreciation are negatively related, and that the risk premium is more volatile than the expected depreciation. As pointed out by Hodrick and Srivastava (1986), and Backus, Foresi, and Telmer (1996), the negative correlation between the risk premium and expected depreciation can be qualitatively rationalized by simple asset pricing models. Accounting for the higher relative volatility of the risk premium is, however, more difficult. For example, versions of monetary models of Lucas (1982), and models that incorporate trading frictions in goods markets (see Holliefield and Uppal (1997)) fail to account for the forward premium puzzle. Eichenbaum and Evans (1995), and Yaron (1996) argue that general equilibrium models which incorporate participation constraints and nominal price rigidities may potentially account for the forward premium puzzle. Our evidence discussed above suggests that there are additional important dimensions in the relation between expected depreciation rates and forward premia which need to be explained. In particular, a credible explanation also needs to address the differences between emerging and developed economies, and the apparent differences across high and low interest rate differentials states in developed economies.

The rest of the paper is organized in three sections. Section 2 presents our empirical evidence regarding the behavior of the forward risk premium in developed and emerging economies. In this section we also provide an economic interpretation of our findings. Section 3 evaluates the ability of the latent factor asset pricing model in explaining the differences in the forward risk premium across these economies. We also undertake a cross-sectional approach to address this issue. Finally, concluding comments are offered in Section 4.

2 Expected Depreciations and Forward Premia

2.1 Data Description

We collect weekly data on spot exchange rates, forward rates, and interest rates for 28 economies from *Datastream*. According to the *International Finance Corporation* (*IFC*) of the *World Bank*, 16 of the economies are classified as developed and 12 as emerging economies. The sample period covered is from January 1976 to May 1998. It is, however, well known that many emerging economies only were accessible for international investors beginning in the early 1990's. This is reflected in our data base, and the inclusion date for each economy is shown in Table 1. As can also be seen in the table, we have a complete data set from 1976 to 1998 for 14 economies (all developed except for Portugal). Data for emerging economies are included as and when they become available, which typically is after the date which *IFC* regards as the financial market liberalization date.

The main empirical work is undertaken on one-month forward rates, but three-month forward contracts were also used for the developed economies. As our key results are not very different from using one or three-month forward rates, we report only the evidence for one-month forwards. For most of the emerging economies we use one-month interest rates to assess the forward premium puzzle. To keep the comparability with the forward rates for the developed economies, we use interbank rates for the emerging economies. In some cases such interest rates are not available (Argentina, India, Malaysia, Philippines, and Venezuela), and we use bank deposit rates instead. For the emerging economies, we construct interest rate differentials (i.e., forward premia) by subtracting each countries interest rate from the U.S. Eurodollar rate. In the first part of the paper interest rate differentials are only used as predetermined information variables to predict future exchange rate changes. In this case, it is less of an issue whether these international securities (i.e., emerging market deposit rates) are easily accessible to international investors. In the second part of the paper where the focus is on the cross-section of risk premia this could be an issue. In this analysis we evaluate asset pricing models assuming that these securities are available to international investors. However, even in this case, our main results are robust to the inclusion, or exclusion, of investments in emerging markets.[3]

In Table 1 we report summary statistics on monthly spot exchange changes (denominated in U.S. dollar per unit of foreign currency), and the interest rate differential defined as the U.S. interest rate minus the foreign interest rate (i.e., the normalized forward premium). It is evident from the table that over the sample period the U.S. dollar has appreciated against

[3] For many of the emerging economies we were also able to get information on traded forwards from late 1996. We cross-checked our implicit forward premia based on the interest rate differential for the period where both are available, and the differences between the two were minor.

most of the economies, and the exchange rate changes are more volatile for many emerging economies. It also seems to be greater dispersion in the exchange rate volatility of emerging economies.

Table 2 presents information regarding macro-economic attributes of different countries. This information is used to construct portfolios and is also used in our cross-sectional analysis. The countries are ranked by their relative GNP per capita for 1995 (PPP adjusted and in U.S. dollar terms). The average inflation, and inflation volatility as measured by the average and standard deviation of inflation from 1976 (or inclusion date) to 1995 are also reported. The openness attribute is the sum of exports and imports divided by GDP in 1995. These attributes are constructed from data provided by the *World Bank*. It is evident from the table that many of the emerging economies are also economies with relatively low GNP per capita. Further, average inflation and inflation volatility for these economies seem to be higher than for the developed economies. The final variable, ICRG, broadly reflects the country's credit risk rating in December 1995, and is reported by the *International Country Risk Guide* (see Erb, Harvey, and Viskanta (1996) for a more detailed description of the credit risk attribute). From the table it is also clear that the emerging economies have larger country risk.

Our sample begins in 1976 for developed economies, and in the early 1990's for emerging economies. Consequently, only brief data histories are available—particularly for emerging economies. This makes it difficult to solely rely on time-series methods for measurement and statistical inference. To deal with this issue we extensively use pooled cross-sectional methods to estimate various quantities of interest. We report results from both using time-series and pooled methods. The single country time-series evidence for emerging economies should be interpreted with caution as, in some cases, the data may not reflect the their full history of exchange rates and interest rates. However, by pooling the data we combine the information by using the cross-section of economies. This should potentially mitigate the biases induced from short time-series histories for many emerging economies.

We consider two samples of countries. Sample I consists of the 14 countries for which we have a complete data set beginning from 1976 and ending in 1998. Sample II is more comprehensive and includes all countries as they become available. To conduct cross-sectional analysis we categorize countries into income based groups to capture the differences between developed and emerging economies. This is consistent with the *World Bank* and *IFC* classifications of economies. This categorization is also motivated by additional economic considerations—the income based classification by and large also coincides with an inflation based categorization which allows the results to be interpreted in terms of the economic fundamentals. In Sample I, the countries are classified as High (H), Middle (M), or Low (L) income countries (based on their GNP attribute). In Sample II, the countries are divided into Developed (D) and Emerging (E) economies. Information regarding this classification is presented in Table 2. As can be seen from the table, the developed versus emerging classification also coincides with a classification based on low and high average inflation. Essentially the same holds true for the income based classification for developed economies—the low income group which includes Spain, Portugal, and Italy, has higher average inflation than the high and middle income economies. Results based on the income categorization should also carry over to an inflation based categorization. As stated above, our results are robust to the use of all countries, Sample II, or only using the set of developed economies (plus Portugal) in Sample I.

2.2 The Forward Premium Puzzle

In this section we present the puzzles associated with the drift in the exchange rate. We also document new evidence regarding this puzzle, and then discuss the implications for the forward risk premium. We first present the various time-series and pooled regressions and then interpret the evidence. The focus will be on pooled time-series cross-sectional evidence, since this approach provides a more robust estimate of the various parameters and is less subject to small sample biases which may vitiate the empirical evidence.

Let S_{it} be the exchange rate in dollars per unit of the foreign currency i at time t. The percentage change in the spot exchange rate is denoted by $(S_{it+1} - S_{it})/S_{it}$. Associated with each spot price is the forward price F_{it} for delivery in the next period. Let the normalized forward premium, $(F_{it} - S_{it})/S_{it}$, be denoted by x_{it}. Since the normalized forward premium is approximately equal to the interest rate differential, we will use them interchangeably. In the empirical part of the paper, we will mainly consider changes in spot rates and interest rate differentials defined over four weeks, but sampled at a weekly frequency (as in Hansen and Hodrick (1980)). To keep the notation simple, however, a four-week change in a variable is stated as a change from t to $t+1$.

The expected depreciation of the currency, the risk premium on the forward contract, and the forward premium are closely related. Adding and subtracting S_{it+1}/S_{it} from the forward premium and taking conditional expectations implies that

$$\frac{F_{it} - S_{it}}{S_{it}} = \mathrm{E}\left[\frac{S_{it+1} - S_{it}}{S_{it}} | \mathcal{F}_t\right] + \mathrm{E}\left[\frac{F_{it} - S_{it+1}}{S_{it}} | \mathcal{F}_t\right], \tag{1}$$

where $\mathcal{F}_t$ denotes all the information available to agents such as the interest rate differentials of all currencies. The forward premium, x_{it}, is equal to the expected currency depreciation, d_{it}, plus the forward risk premium, p_{it}. This relation ensures that given the forward premium, knowledge regarding the expected depreciation (forward risk premia) is sufficient to restrict the forward risk premia (expected depreciation). Also note that the relation in (1) applies for any horizon of a forward contract. The expected depreciation is commonly measured by regressing the change in spot prices on the forward premium, that is,

$$\frac{S_{it+1} - S_{it}}{S_{it}} = \alpha_{i0} + \alpha_{i1} x_{it} + \epsilon_{it+1}, \tag{2}$$

where ϵ_{it+1} is a projection error. This regression is extensively used to document the forward premium puzzle, and violations of uncovered interest rate parity.

A well known empirical regularity based on (2) is that α_{i1} is significantly less than one, and in fact often negative (see Fama (1984), and Hodrick and Srivastava (1986)). Uncovered interest rate parity holds when the slope-coefficient is one. Departures from this benchmark hypothesis may be explained as an outcome of time-variation in the risk premium. Fama (1984) shows that the finding of a negative slope coefficient, referred to as the forward premium puzzle, has particularly counter-intuitive implications which are discussed below. It is worth noting that given relation (1), the projection in (2) also characterizes the risk premium of an uncovered position from selling the dollar forward. This link between expected depreciation and the risk premium is later used to explore the implications of various asset pricing models for the relation between the expected depreciation and the risk premium.

In a pooled regression we can imposes the additional restriction that α_{i0} and α_{i1} are the same across all i. Moreover, to show how different economic fundamentals affect the evidence regarding the puzzle we allow the α_{i1} to depend on the economic fundamentals in the cross-sectional regression. More specifically, we make the slope-coefficient a linear function of an attribute, that is,

$$\alpha_{i1} = \alpha_{10} + \alpha_{11} A_{ij}, \tag{3}$$

where A_{ij} is the economic attribute j for country i, and α_{10} and α_{11} are the coefficients estimated in the cross-sectional and time-series regression. The attributes we rely on are variables that are amenable to economic interpretation—we use GNP per capita, inflation, inflation volatility, and country credit rating as the attributes. In Appendix A, we describe in more detail the estimation of the pooled models.

To further characterize when the forward premium puzzle is present, we also consider a state-dependent regression as in Bansal (1997). Consider the linear projection

$$\frac{S_{it+1} - S_{it}}{S_{it}} = \alpha_{i0} + \alpha_{i1}^{+} x_{it}^{+} + \alpha_{i1}^{-} x_{it}^{-} + \epsilon_{it+1}, \tag{4}$$

where ϵ_{it+1} again is a projection error, and x_{it}^{+} and x_{it}^{-} are defined according to

$$x_{it}^{+} = \begin{cases} x_{it} & \text{if } x_{it} > 0 \\ 0 & \text{if } x_{it} \leq 0 \end{cases}, \tag{5}$$

$$x_{it}^{-} = \begin{cases} x_{it} & \text{if } x_{it} \leq 0 \\ 0 & \text{if } x_{it} > 0 \end{cases}. \tag{6}$$

The variables x_{it}^{+} and x_{it}^{-} separate the forward premium into regimes (or states) where the forward premium is positive or negative. As the regimes are defined relatively to an arbitrary choice of a zero forward premium, it makes sense to also consider a regression robust to this choice. We therefore use a cubic drift to elicit any state-dependence in the puzzle, that is,

$$\frac{S_{it+1} - S_{it}}{S_{it}} = \alpha_{i0} + \alpha_{i1} x_{it} + \alpha_{i2} x_{it}^{2} + \alpha_{i3} x_{it}^{3} + \epsilon_{it+1}. \tag{7}$$

As it turns out, the results from using (7) are almost identical to those from the state-dependent regression of (4), and adding additional polynomials does not alter the main results. In the pooled regressions we impose the cross-sectional restrictions that the projection coefficients in the various regressions are the same across all economies or groups of economies.

2.3 Economic Implications and Empirical Evidence

2.3.1 Economic Implications

The assumption of rational expectations, along with $x_{it} = d_{it} + p_{it}$ implies that the slope-coefficient in (2), the α_{i1}, is equal to $\text{Cov}(d_{it}, d_{it} + p_{it})/\text{Var}(d_{it} + p_{it})$. Table 3 shows the economic implications for different values of α_{i1}. The forward premium puzzle is the finding of a negative slope coefficient which implies that the risk premium is more volatile than the expected depreciation. A slope coefficient bigger than one implies the opposite. An interesting special case is when the slope coefficient is not different from 0.5, and the variance of d_{it} is equal to that of p_{it} independent of the covariance between d_{it} and p_{it}.

The forward premium puzzle has considerable economic significance. A negative slope-coefficient implies that there is rather large time-variation in the risk premium. In fact, the risk premium varies to such an extent that it leads relatively high domestic nominal interest rates to predict an appreciation of the domestic currency. Many economic models can justify a positive slope-coefficient which is less one (see, for example, Hodrick and Srivastava (1986), Bansal, Gallant, Hussey, and Tauchen (1995), Bekaert (1996), and Yaron (1996)). However, the implication that $\text{Var}(p_{it}) > \text{Var}(d_{it})$ is difficult to satisfy in models with frictionless asset markets as shown in Backus, Foresi, and Telmer (1996), and Bansal (1997). Satisfying this condition requires that the aggregate market price of risk (the volatility of the intertemporal marginal rate of substitution) conditional on knowing the interest rate must be decreasing in the level of the interest rate at a sufficiently high rate. Put differently, the aggregate risk in the economy must be lower when the level of interest rates in high—a feature that most parametric models find difficult to capture. The implications of a slope-coefficient above one for the covariance between d_{it} and p_{it}, and their relative variances thus seem economically more reasonable.

2.3.2 Evidence from the Time-Series

Table 4 presents time-series evidence from regression (2) for each country. In all regressions we use the generalized method of moment of Hansen (1982) to estimate a covariance matrix which takes into account possible heteroskedasticity as in White (1980), and serial correlation as in Newey and West (1987). To focus on the differences across economies, we present all results with the countries being sorted from high income to low income. Our evidence clearly shows that the slope-coefficient is significantly negative and less than one for high income economies. For lower income economies the time-series regression is unable to say much since the standard errors are quite large due to their brief data histories. However, taken at face value, the coefficients are not significantly different from one. Table 4 also presents results from the discrete-state dummy regression (4). The slopes across the two regimes are opposite in sign and significantly different for most developed countries. The Wald[a] statistic for the equality of the slope coefficients across the two states is sharply rejected and confirms the evidence provided by Bansal (1997). This evidence suggests that most of the rejections of uncovered interest rate parity occur when $x_{it} > 0$. When $x_{it} \leq 0$, the evidence is broadly consistent with the uncovered interest rate parity hypothesis. Finally, we report the results from the cubic specification in (7). The evidence is essentially the same as for the discrete-state regression. Countries for which the non-linear terms are not zero (see the Wald[b] statistic) coincide with the rejection of equality of the slope-coefficients in the discrete-state projection discussed above. For many of the emerging markets there is no evidence of non-linearities—this phenomenon seems to be confined to higher income economies. Also note that incorporating the state-dependence improves the adjusted R-squares considerably. Latter in the paper we also provide evidence regarding cross-exchange rates which allows to evaluate the robustness of the various results.

Recent results provided by Baillie and Bollerslev (1997) show that great caution should be exercised in interpreting the univariate results as documented in Table 4. They argue that as the interest rate differential is very persistent, the standard asymptotic distribution for the slope coefficient is a very poor approximation of its small sample small counterpart. For this, and additional reasons discussed below, our main focus will be on results derived using pooled time-series and cross-sectional evidence. Pooling the data in different ways mitigates the important inference problems that Baillie and Bollerslev (1997) document.

2.3.3 Evidence From the Cross-Section

Parameters estimated in the time-series for many of the economies, especially emerging markets, are estimated with imprecision. This makes it difficult to interpret the point estimates in a reliable manner. To provide more robust estimates of the relation between the expected depreciation and interest rate differentials, we also consider pooled time-series cross-sectional evidence. We divide the countries into two samples. Sample I includes the 14 countries for which we have complete data from 1976 to 1998. Moreover, we sort the countries in Sample I into three income groups; high, medium, and low, where each group has about 5 countries. Sample II is more comprehensive than Sample I and includes all time series observations for 28 countries. This sample is further divided into developed and emerging economies. The reason for considering these two samples is to highlight the fact that much of what is true for the lower income developed economies, for whom we a relatively large time-series data, is also true for the newly emerging economies who have data histories beginning in the early 90's. Moreover, for all Sample I economies we have a continuous record for about 22 years, for many of the economies in Sample II we have a much smaller histories which begin at different dates.

The above implications provide a basis for an economic interpretation of the results in Table 5. In Sample I, the point estimate of the slope-coefficient is about 0.26 (with a standard error of 0.14) for all countries. When fixed effects are included in the regression (that is, a country-specific intercept is added to the regression), the slope-coefficient is about zero with a standard error of 0.20. This suggests that, on average, the forward premium is a biased predictor of the expected currency depreciation, though the evidence in favor of the forward premium puzzle (i.e., negative slope-coefficients) is not overwhelming. However, for emerging economies the slope-coefficient is positive and about 0.19 (standard error of 0.19). While uncovered interest rate parity is rejected in all cases, there is little evidence in favor of the forward premium puzzle. Unlike the case of high and middle income economies, the hypothesis that the slope is 0.5 cannot be rejected for emerging economies.

Assuming that the slope-coefficients are the same across all economies may be a too strong assumption, and we relax this assumption by letting the slope to be different across different income categories but allow for country-specific intercepts. Across income categories, the slope-coefficient is on average significantly negative for the high and middle income countries, -1.14 (standard error of 0.41) and -0.60 (standard error of 0.38), respectively. As is the case with emerging economies, we also find that in lower income developed economies the slope is positive at 0.38 (standard error of 0.18). In lower income developed economies and emerging economies (which by and large also have low per capita income), the evidence does not suggest the presence of the forward premium puzzle, which is confined to high income economies. This evidence also suggests that there is only weak evidence in favor of a time-varying risk premium in emerging economies and lower income developed economies. Based on these magnitudes it further appears that high income economies have a risk premium volatility that exceeds that of the expected depreciation (Case II, Table 3), and lower income developed and emerging economies potentially satisfy the opposite (that is, Case IV in Table 3).

There are other important differences across these economies when the relation between the expected depreciation and interest rate differential is measured conditional on the sign of the interest rate differential. Economies in Sample I, and Developed economies in Sample II, show considerable evidence of state-dependence. When U.S. rates are considerably high, the slope is significantly negative, implying that the variance of p_{it} exceeds the variance of d_{it} (see Case II, Table 3). On the other hand, when the interest rate differential is negative the regression coefficient is not significantly different from one, and uncovered interest rate parity is not rejected in this state (see Case I, Table 3). In this case, the implication for the relative variance of d_{it} and p_{it} is opposite to those in the state where the interest rate differential is positive. Note that the Wald[a] statistic of equality of the two slope-coefficients sharply rejects the equality hypothesis (p-values close to zero). A test for non-linearity based on the cubic regression confirms this further (see the Wald[b] statistic). The above results for different income categories are very similar whether we include or exclude country-specific fixed effects. In the case of emerging economies, the hypothesis that the slope-coefficient is the same across the positive and negative interest rate differentials cannot be rejected, suggesting that these economies show little state-dependence (see Emerging in Sample II, Table 5). This result for emerging economies is consistent with the evidence found in the time-series reported in Table 4 where there is little evidence in favor of non-linearities.[4]

The results can also be seen in Figures 1.a-b. In Figure 1.a the depreciation rates for all currencies are depicted versus the associated forward premia (interest rate differentials), whereas Figure 1.b shows the estimated relation in the cubic regression. It is evident that for developed economies, there is a non-linear relation—when the U.S. interest rate exceeds

[4] Two additional observations are worth noting. First, we have also done the above empirical analysis for Sample I using three-month – in addition to one-month – forward contracts and exchange rate changes, and our results are very similar and hence not reported. Second, all results discussed in this section are essentially the same whether we use logged variables or arithmetic ones.

the foreign interest rate the relation is negative, whereas it is positive for the state when the interest rate differential is negative (from -35% per year). For emerging economies, the fitted regression is flatter than the 45-degree line, and shows little evidence of non-linearities after taken into account of sampling error.

As discussed earlier, one might suspect that many of the differences across the economies may be an outcome of differences in their macro-economic environment. Indeed, as documented in Table 6 for Sample I, we find that countries with lower per-capita income, higher inflation uncertainty, and lower country ratings have larger slope-coefficients. High income, high rating, and low inflation uncertainty economies are more likely to have a negative slope-coefficient. Moreover, these different attributes are highly correlated with per capita GNP which provides justification for our income-based classification. The cross-sectional evidence for the GNP and inflation attributes (both relative the U.S.) is also depicted in Figures 2.a-b. The figures show 90% confidence bands for the estimated slope-coefficients as a function of the two attributes. To the extend that inflation and inflation volatility are an outcome of monetary and fiscal policy, our evidence suggests that the cross-sectional differences across economies may, at least in part, be due to differences in the conduct of these policies. When emerging economies are included in the sample, the sign on all the coefficients, and their economic interpretation is the same as for Sample I. The t-ratios are, however, lower. We suspect that for emerging economies, given the small sample size, it is hard to reliably measure variables such as expected inflation in a manner that is representative of the expectations of economic agents.[5]

To further explore the relation between expected exchange rates changes and interest rate differentials, we also consider cross exchange rates. In particular, we run the above regressions with either the DEM or the JPY as the base currency instead of the USD. Table 7 documents the evidence regarding the cross-exchange rates. We find that the results of using the JPY are very similar to the ones reported using the USD as the numeraire. The evidence for the DEM in the pooled estimations suggests that the slope-coefficient in the standard forward premium regression is generally higher. For instance, for all economies the point estimate is about 0.38 which should be compared to -0.02 in the USD case. Hence,

[5] Stated differently, the 5-7 years of annual data that we use to construct the average inflation and inflation volatility may not be close to the expected inflation on average in these economies. For the 14 economies from Sample I we are using 22 years of data to measure these quantities.

when currencies are considered against the DEM, there is even less evidence in support of the forward premium puzzle. This result is also consistent with Flood and Rose (1996) who find a higher slope-coefficient for economies within the European Monetary System (EMS) versus the DEM than for economies versus the USD. We suspect that this may be due to the fact that many European economies, especially within the EMS, try to coordinate their monetary policies with Germany. Despite some differences, the main message from using cross exchange rates is essentially the same as we report for the USD. Moreover, Figures 1.c-d indicate that the evidence of non-linearities is less significant for the DEM compared to the JPY. This is confirmed by the Wald statistics in Table 7.

The above results suggest two puzzles regarding the relation between the expected currency depreciation and the interest rate differential. First, why is this relation different across emerging and developed economies, and second, why is the base currency expected to appreciate when the interest rate differential is large and not otherwise.

Eichenbaum and Evans (1995), and Yaron (1996) suggest that models than incorporate limited participation and/or nominal price rigidities (see Dornbusch (1976), Lucas (1990), Grilli and Roubini (1992), and Grilli and Roubini (1993)) may help in explaining the average negative slope coefficient puzzle. Our cross-sectional evidence is consistent with the intuition contained in models which incorporate non-Fisherian effects (see Lucas (1990)). A feature of these models is that with a rise in inflation uncertainly or expected inflation, the model behaves almost like standard Fisherian models (see Fuerst (1994)). However, non-Fisherian fundamentals have important effects if expected inflation is low. Emerging economies and low income developed economies typically have large expected inflation, hence the Fisherian relation between expected depreciation and interest rate differential (i.e., the absence of the forward premium puzzle) seems to find more support in these economies. For low inflation economies non-Fisherian effects can be important and lead the forward premium puzzle. Indeed Yaron (1996) attempts to explain the forward premium puzzle from the perspective of models which incorporate these effects. Using a reduced form model, Bansal (1997) argues that asymmetries across economies and stochastic volatility may help justify the forward premium puzzle and the documented non-linearities. An explicit general equilibrium model to quantitatively explain the cross-sectional differences is beyond the scope of this paper. In the next section, however, we explore whether the observed risk-premia can be viewed as an outcome of compensation for systematic risk.

3 The Risk Premium

The slope coefficient in (2), α_{i1}, has direct implications for the forward risk premium—the expected excess return from holding the foreign currency deposit (see Fama (1984), and Hodrick (1987)). For a given level of x_{it}, the more negative α_{i1} is, the larger is the risk premium in absolute value. Similarly, for a given $\alpha_{i1} < 1$, an increase in x_{it} raises the absolute value of the risk premium. The fact that α_{i1} is significantly different from one further suggests that there is time-variation in the risk premium. This has motivated several researches to ask if the time-varying risk premium can be explained as compensation for bearing systematic risk. Hansen and Hodrick (1983) develop a latent factor model to explore this issue. Further, exercises undertaken on a few developed economies in a similar spirit find it hard to reject the restrictions imposed by the latent factor models on the risk premia (see Campbell and Clarida (1987), Giovannini and Jorion (1987), Huang (1989), Lewis (1990), Bekaert and Hodrick (1992), among others). In this study, we try to explore this economic issue using a large cross-section of economies, and find that our results differ in many respects from these papers. We first document the differences in risk premia across economies, and then test the implications of various asset pricing models.

Table 8 presents average excess returns and standard deviation from buying foreign currency deposits. The ratio of the average return to the standard deviation measures the Sharpe Ratio. For most of the countries this ratio is statistically not different from zero, implying that on average investing in the foreign currency deposit does not offer an excess return different from zero. Now consider the return on a dynamic trade implied by the regressions discussed earlier.[6] The dynamic trade is to borrow from the low interest rate country and invest in the high interest rate country. For most developed economies (all countries in the table till Spain), the Sharpe Ratio is positive and significantly different from zero. For emerging economies, this trade is profitable for economies such as Portugal, but for many others this Sharpe Ratio is not very different from zero (after taking account of sampling error). This is consistent with our earlier evidence that the uncovered interest rate

[6] This way of exploiting the results in the forward premium regressions is also done by Fung, Hsieh, and Leitner (1993).

parity hypothesis is barely rejected for many of these economies. The evidence in Table 9 regarding the same trades for developed and emerging economies (see Sample II) further confirms this interpretation. The Sharpe Ratios for the income portfolios are significantly positive and large for all income categories. This evidence suggests that there is considerable differences in the cross-section across these economies, which must in principle reflect different exposures to systematic risk. *A priori* it seems that the exposure to systematic risk for emerging economies must be smaller, reflecting its relatively small risk premium.

3.1 Latent Factor Models

3.1.1 Estimation Setup

It is well recognized that in the absence of market frictions, and the absence of arbitrage opportunities, there is a pricing kernel (or, a stochastic discount factor) which must price the traded returns. Let m_{t+1} denote this pricing kernel. The pricing condition that is satisfied is then

$$\mathrm{E}\left[m_{t+1} z_{it+1} | \mathcal{F}_t\right] = 0, \tag{8}$$

where z_{it+1} is the excess return from holding the deposit of currency i. Using the definition of a covariance this implies that

$$\mathrm{E}\left[z_{it+1} | \mathcal{F}_t\right] = -\frac{\mathrm{Cov}(m_{t+1}, z_{it+1} | \mathcal{F}_t)}{\mathrm{Var}(m_{t+1} | \mathcal{F}_t)} \frac{\mathrm{Var}(m_{t+1} | \mathcal{F}_t)}{\mathrm{E}\left[m_{t+1} | \mathcal{F}_t\right]}, \tag{9}$$

where $\mathrm{Var}(m_{t+1}|\mathcal{F}_t)/\mathrm{E}[m_{t+1}|\mathcal{F}_t]$ is the aggregate market price of risk. Relation (9) says that the expected excess return is proportional to the aggregate market price of risk multiplied by its conditional beta, $\beta_{it} = \mathrm{Cov}(m_{t+1}, z_{it+1}|\mathcal{F}_t)/\mathrm{Var}(m_{t+1}|\mathcal{F}_t)$.[7]

Hansen and Hodrick (1983) use equation (9) to write down a latent factor model. This model replaces the aggregate market price of risk with the risk premium on a benchmark asset, z^*_{t+1}, which also satisfies equation (9). In essence, the latent factor model asks the question: Are all risk premia proportional to each other? This is a direct implication of

[7] For a more detailed exposition, see Hansen and Richard (1987), and Bansal, Hsieh, and Viswanathan (1993).

relation (8). The latent factor model then satisfies the asset pricing condition

$$\mathrm{E}[z_{it+1}|\mathcal{F}_t] = \beta_{it}\lambda_t \tag{10}$$

$$\lambda_t \equiv \mathrm{E}[z^*_{t+1}|\mathcal{F}_t], \tag{11}$$

where λ_t is the risk premium on the benchmark. Note that the β_{it} in equation (10) refers to the beta of asset i normalized by the beta of the z^*_{t+1} portfolio.

For our empirical exercise we further assume that β_{it} is at most a function of x_{it}, that is, β_{it} depends only on information specific to exchange rate i. By computing the mean of λ_t conditional on x_{it}, one can further characterize the risk premium of currency i entirely in terms of its interest rate differential. Using the law of iterated expectations, it follows that

$$\mathrm{E}[\lambda_t|x_{it}] \equiv \mathrm{E}[(z^*_{t+1}|\mathcal{F}_t)|x_{it}] = \mathrm{E}[z^*_{t+1}|x_{it}]. \tag{12}$$

Equations (10) to (12) permit a very convenient decomposition of the risk premium into orthogonal components which allows us to characterize the sources of the risk premium for each currency and which provides valuable economic insights (this is discussed in greater detail below). To this end, first note that

$$\lambda_t \equiv \mathrm{E}[z^*_{t+1}|\mathcal{F}_t] = \mathrm{E}[z^*_{t+1}|x_{it}] + \eta^*_{it}, \tag{13}$$

where η^*_{it} is the difference between λ_t and the mean of λ_t conditional on x_{it} (see equation (12)). As $\mathrm{E}[\lambda_t|x_{it}] = \mathrm{E}[z^*_{t+1}|x_{it}]$, it also follows that $\mathrm{E}[\eta^*_{it}|x_{it}] = 0$. Consequently, $\mathrm{E}[\eta^*_{it}] = 0$ and η^*_{it} is also orthogonal to all measurable functions of x_{it}.[8]

To characterize the different sources of the risk premium on currency i, rewrite equation (10) as

$$\mathrm{E}[z_{it+1}|\mathcal{F}_t] = \beta_{it}\mathrm{E}[z^*_{t+1}|x_{it}] + \beta_{it}(\mathrm{E}[z^*_{t+1}|\mathcal{F}_t] - \mathrm{E}[z^*_{t+1}|x_{it}]), \tag{14}$$

or,

$$\mathrm{E}[(z^*_{t+1}|\mathcal{F}_t)|x_{it}] - \mathrm{E}[z^*_{t+1}|x_{it}] = \mathrm{E}[\eta^*_{it}|x_{it}] = 0. \tag{15}$$

The risk premium of currency i conditional on x_{it} must then satisfy,

$$\mathrm{E}[(z_{it+1}|\mathcal{F}_t)|x_{it}] = \mathrm{E}[z_{it+1}|x_{it}] = \beta_{it}\mathrm{E}[z^*_{t+1}|x_{it}]. \tag{16}$$

[8] In particular note that $\mathrm{E}[\eta^*_{it}x_{it}] = \mathrm{E}[\eta^*_{it}\mathrm{E}\big[z^*_{t+1}|x_{it}\big]] = 0$. That is, η^*_{it} is orthogonal to x_{it}, $\mathrm{E}\big[z^*_{t+1}|x_{it}\big]$, and is, in fact, orthogonal to all measurable functions of x_{it}.

While equation (15) characterizes the risk premium conditional on the aggregate information set $\mathcal{F}_t$, equation (16) represents it conditional only on x_{it}. The volatility of the risk premium based on $\mathcal{F}_t$ will at least be as large as that based on x_{it}—a consequence of the fact that $\mathcal{F}_t$ contains more information in addition to x_{it}.

The asset pricing restrictions embodied in equation (16) are important for other reasons as well. Typically, violations of uncovered interest rate parity are empirically documented in terms of the information contained only in x_{it} (see, for instance, Hodrick (1987), Hsieh (1984), and Section 2 of this paper). Given this common procedure it seems natural to ask if the asset pricing model, conditional on knowing only x_{it}, can deliver the same risk premium dynamics as observed in the data.

3.1.2 The Estimated Model

The simplest model assumes a constant beta for each country (that is, $\beta_{it} = \beta_i$). Let $X_t = [1, x_{1t}, \ldots, x_{Nt}]'$ vector of a constant and interest rate differentials associated with N currencies. It is further assumed that

$$\mathrm{E}[z^*_{t+1}|\mathcal{F}_t] \equiv \lambda_t = \delta' X_t, \tag{17}$$

and that

$$\mathrm{E}[z^*_{t+1}|x_{it}] = \kappa_{i0} + \kappa_{i1} x_{it}, \tag{18}$$

where δ is the vector of coefficients obtained by projecting z^*_{t+1} on X_t. Equation (18) represents the risk premium on a zero-cost portfolio of currencies. The above assumptions imply that the analog for equations (15) and (16), in the constant beta model satisfy,

$$\mathrm{E}[z_{it+1}|\mathcal{F}_t] = \beta_i[\kappa_{i0} + \kappa_{i1} x_{it}] + \beta_i[(\delta' X_t) - (\kappa_{i0} + \kappa_{i1} x_{it})], \tag{19}$$

and

$$\mathrm{E}[z_{it+1}|x_{it}] = \beta_i[\kappa_{i0} + \kappa_{i1} x_{it}]. \tag{20}$$

Let the projection errors for equations (17) to (19) be denoted by e^*_{t+1}, e^1_{it+1}, and e^2_{it+1}. Note that the martingale difference errors e^1_{it+1}, and e^2_{it+1} are specific to currency i, whereas the error e^*_{t+1} is not specific to a given currency. The models can be estimated by using the generalized method of moments of Hansen (1982). The orthogonality conditions that we use for the constant beta model are

$$\mathrm{E}[e^{*}_{t+1} X_t] = 0, \tag{21}$$

$$\mathrm{E}[e^{1}_{it+1}] = 0, \tag{22}$$

$$\mathrm{E}[e^{1}_{it+1} x_{it}] = 0, \tag{23}$$

$$\mathrm{E}[e^{2}_{it+1} X_t] = 0. \tag{24}$$

With N currencies this implies that, in all, there are $1 + 4N + N^2$ orthogonality conditions. In addition to the $N + 1$ parameters in δ, there are N parameters of β_i, κ_{i0}, and κ_{i1} to be estimated. Hence, the parameter vector $\theta = [\delta, \beta_i, \kappa_{i0}, \kappa_{i1}]'$ contains $1+4N$ parameters. This implies that there are N^2 overidentifying restrictions to test the model.

We also consider a model in which the beta can vary over time (as in, for instance, Giovannini and Jorion (1987)). We assume that

$$\beta_{it} = \beta_{i0} + \beta_{i1} \left(x_{it} - \mathrm{E}\left[x_{it} \right] \right), \tag{25}$$

and impose this as an additional moment condition. Since there are one more parameter per currency, this system is still overidentified with N^2 restrictions.

We have time-series data for 14 (mostly developed economies) countries with 23 years of weekly observations and another 14 (mostly emerging markets) with shorter histories. Even if one where to use only the 14 economies with the larger history, both the number or orthogonality conditions and the number of parameters is quite large. Hence, we estimate the model for portfolios of currencies (sorted on the GNP attribute).

3.1.3 Evidence from the Model

To keep the number of estimated parameters small X_t comprises of a constant, and the equally-weighted interest rate differential for the countries in each of the income categories. As reasonable time-series estimation is not feasible with a very large cross-section of asset returns, we test the latent factor model only for the income portfolios for the larger sample that begins in 1976. To incorporate more disaggregated information we also report results from an alternative cross-sectional approach in the next sub-section.

Table 10 presents the results regarding the latent factor model. It is evident that the betas are increasing with income. Low income economies seem to have lower exposure to the systematic source of risk—the average beta for the high income countries is about 1.5 and only about 0.5 for the low income economies. In terms of the ability of the model to evaluate the proportionality of the risk premium, it is clear that the model is sharply rejected with p-values close to zero. The time-varying beta model is also sharply rejected. Hence, it seems that these risk premia are not conditionally proportional to each other, as would be required by a model of systematic risk. Table 11 further shows, based on (16), that the model is capable of reproducing the average negative relation between conditional risk premia and the interest rate differentials discussed earlier. Given this, it seems that it is indeed the proportionality of the risk premium that is violated. We also evaluated the average pricing error (the average abnormal excess return) for each of the portfolios. While the average abnormal return for the high and middle income countries was not statistically different from zero, it was significantly positive for the low income portfolio—about 3.39% per year (with a t-ratio of 2.19).

Figures 3.a-b show the distribution of returns for the different income categories. Table 9 shows that the average excess return on the low income portfolio is 2.81, more surprisingly the standard deviation for this portfolio is also the smallest (9.00% per year). The high income portfolio on the other hand only offers about 0.85% per year, and is more volatile. As the systematic exposure of low income economies is smaller, and for individual countries the overall volatility of the excess return larger than that of developed economies, this evidence suggests that portfolio creation across low income economies offers better diversification. This evidence in conjunction with the fact that the low income country portfolio offer positive abnormal returns makes it difficult to interpret the abnormal return as compensation for event risk (such as default). While this may be important for an individual country, it is harder to argue that such an event can occur simultaneously across all or many of the countries in the portfolio. For example, to explain the abnormal annual return of about 3% for the low income portfolio, it is required that all countries (five in all) in this portfolio fully default on their currency deposits about 3% of the time. At least to us, this seems to be implausible on economic grounds, even if one ignores the distribution of returns (see Figure

3.a) based on which one would put almost zero probability on this event.[9]

We have also conducted the latent factor model tests on income portfolios for Sample II during the period from 1991 to 1998, which includes the newly emerging economies. The model is also rejected for this sample. Given the relatively few non-overlapping time-series observations (about 80) and the relatively large number of parameters to be estimated, we view the time-series evidence for this sample with considerable doubt, and hence have not reported it. However, to incorporate the risk premium information from these economies we pursue an alternative cross-sectional approach as used in Fama and MacBeth (1973).

3.2 Asset Pricing Tests in the Cross-Section

As discussed, to keep the estimation in the time-series reasonable, we do not exploit the disaggregated data on the individual countries to test the various asset pricing models. Instead, we use a cross-sectional approach to incorporate the information. From equation (9), we know that the expected excess return is proportional to the risk premium on the systematic source of risk. Let λ_t denote the risk premium for the systematic risk. The cross-sectional tests exploit the following restrictions for each currency i

$$\mathrm{E}[z_{it+1}|\mathcal{F}_t] = \lambda_{0t} + \beta_{it}\lambda_t. \tag{26}$$

If the asset pricing model is correct, then the risk premium for each excess return should be proportional to λ_t, and λ_{0t} should equal zero. This idea can be used to test certain alternative models where J additional cross-sectional attributes A_{ijt} are added to the tests, that is,

$$\mathrm{E}[z_{it+1}|\mathcal{F}_t] = \lambda_{0t} + \sum_{j=1}^{J} A_{ijt}\lambda_{A_j t} + \beta_{it}\lambda_t. \tag{27}$$

In this case λ_{0t}, and $\lambda_{A_j t}$ should all be zero. As in Fama and MacBeth (1973), we test if the time series average of these quantities are significantly different from zero, or not. The average of λ_t represents the average risk premium for bearing systematic risk associated with the β_{it}. Further as shown in Fama (1976), the averages of the λ_{0t} and $\lambda_{A_j t}$ represent the average risk premium on zero-cost portfolios which have no systematic risk. Hence under the

[9] For a more detailed discussion of this issue in general, see Evans and Lewis (1995).

null of the model, all these risk premia should be zero. To run the cross-sectional regression (27) requires prior estimate of β_{it}. We obtain the betas by a time-series regression of the ex-post return on the systematic risk factor with the same specification for betas as in (25).

Table 12 shows the evidence from these cross-sectional tests, where all countries are used in the cross-sectional analysis as they become available. We consider four different specifications of the factor. The first one is a latent factor.[10] The second factor is the excess return on an equally-weighted portfolio of currency returns. The third factor is an equity factor, namely the excess return on the aggregated U.S. market. This factor thus captures a CAPM type of specification. Finally, the fourth factor we consider is a portfolio of currencies that is sorted on their forward premia.[11] Tests based on the various models of systematic risk do poorly. The average R-square is very low and in the case of the CAPM close to zero. Only the latent factor model with an R-square of about 8% has some power in explaining the cross-section of differences in the risk premia.[12]

Using individual country attributes along with the latent factor model leads to the most significant improvement in explaining the cross-section of asset returns. We consider the country interest rate differential, GNP per capita, and the measure of country risk, as the cross-sectional attributes. The inclusion of the interest rate differential as an attribute along with the latent factor model leads to a cross-sectional R-square of 39%, and seems to explain the cross-sectional differences in the risk premium reasonably well. Moreover, the average risk premium on the interest rate differential portfolio is statistically large and seems quite important. Recall that, under the null hypothesis, this risk premium should be zero. Further, inclusion of the GNP or ICRG attributes also increases the explanatory power of the model. The t-ratios on the risk premia for the GNP and ICRG attributes are also significant. These attributes seem to non-trivially affect the cross-section of the risk premia. Figures 4.a-b show the average risk premium and the one implied by two of these models. It is clear that incorporating the spread attribute helps in characterizing the cross-section of premia. It is also evident from these figures that some of the newly emerging economies such as Turkey,

[10] The latent factor is the projection of an equally-weighted currency portfolio of the 14 currencies in Sample I on their forward premia.

[11] The currencies are for each t sorted on their forward premia. Then we form a high minus low portfolio, where high consists of the third of currencies that have the highest forward premia, and low the third of lowest premia. Within the high and low portfolio, the currencies are equally-weighted. The portfolios are rebalanced every t.

[12] The R-squares are the squared correlations between the average return over the sample, and the fitted expected return.

seem like outliers. To make sure, we conducted our cross-sectional tests without Turkey, Poland and the Czech Republic. Excluding these economies did not alter our results in any significant way. Overall, this evidence suggests that these financial markets may not be well integrated as country specific variables seem to be the most important in justifying the different magnitudes of the risk-premia.

To further see how important the newly emerging economies are for the cross-sectional results, we also conducted our analysis without any of the newly emerging economies. Table 12 shows that qualitatively the results are very similar. This evidence suggests the results are not sensitive to relying on the accessibility of the emerging markets for the international investor. Two things worth noting are that the R-square when one uses only the sample without the newly emerging economies is somewhat higher (about 70%), and that the absolute value of the risk premium on the zero cost portfolio associated with the forward premium is also higher (10.45 in Sample I, and 7.59 in Sample II). The Sharpe Ratios (measured here as the ratio of the average to the standard error) is, however, higher in Sample II. Hence, it seems that the inclusion of emerging markets in the portfolio provides useful diversification.

4 Conclusions

The forward premium puzzle—the negative correlation between expected exchange rates and interest rate differentials—has implications which seem anomalous from the perspective of economic models. Using information from 28 developed and emerging economies we document that this puzzle is not a pervasive phenomenon. It is confined to high income economies, and in particular only to states when the U.S. interest rate exceeds the foreign rates. Moreover, the puzzle does not seem to be present in emerging economies. There seems to be a close relation between GNP per capita, average inflation, inflation volatility, country ratings, and the presence of the forward premium puzzle. We find that the cross-section of the risk premia across economies is hard to justify as compensation for systematic risk—country specific attributes such as per capita GNP, average inflation, and credit risk seem to be more important in characterizing the cross-sectional dispersion in the risk premium. This could be interpreted as evidence regarding segmented markets, or a mis-specification of the model of systematic risk used to explain the cross-section of expected returns.

This evidence should help in developing general equilibrium models that attempt at explaining this puzzle as an outcome of time-varying risk premia. In particular, our evidence points out that focusing on the average negative correlation between the expected depreciation and interest rate differentials may not be adequate. These models must also confront the relatively large cross-sectional heterogeneity in the risk premium across countries and that in developed economies (i.e., high income and relatively low inflation economies) the puzzle seems to be present only when U.S. interest rates exceed foreign rates.

A Appendix

This appendix shows the estimation of the pooled systems in more detail. We consider the standard forward premium regression, but the approach extends to the other cases as well. First we derive the exact moment conditions and the expressions for the estimators for a balanced data set. Then we describe how missing data are handled.

A.1 Moment Conditions and Estimators

Let y_{it+1} denote the depreciation of currency i (i.e., $y_{it+1} = \left(S_{it+1} - S_{it}\right)/S_{it}$). Let x_{it} still denote the forward premium for currency i versus the US dollar contracted at time t with a horizon of one period. There are N currencies. The basic regression that we run for each currency is

$$y_{it+1} = \alpha_{i0} + \alpha_{i1} x_{it} + \varepsilon_{it+1}, \quad i = 1, 2, \ldots, N, \tag{28}$$

where ε_{it+1} is assumed to be conditionally mean independent of x_{it}, that is, $\mathrm{E}[\varepsilon_{it+1} \mid x_{it}] = 0$. Suppose now that we want to restrict the slope-coefficients to be equal for all currencies while remaining currency-specific intercepts. We can then formulate moment conditions according to

$$\mathrm{E}\left[\varepsilon_{it+1}\right] = 0, \quad i = 1, 2, \ldots, N, \tag{29}$$

$$\mathrm{E}\left[\varepsilon_{it+1} x_{it}\right] = 0, \quad i = 1, 2, \ldots, N, \tag{30}$$

where

$$\varepsilon_{it+1} = y_{it+1} - \alpha_{i0} - \alpha_1 x_{it}, \quad i = 1, 2, \ldots, N. \tag{31}$$

That is, in a general case we have $2N$ moment conditions, but only $N + 1$ parameters to estimate, so the system is overidentified. Let θ_0 denote the true parameter vector, that is,

$$\theta_0 = \left[\begin{array}{cccc} \alpha_{10} & \cdots & \alpha_{N0} & \alpha_1 \end{array} \right]'. \tag{32}$$

By stacking the sample counterparts of the moment conditions in (29) and (30), we have

$$g_T\left(\theta\right) = \frac{1}{T} \sum_{t=1}^{T} \left[\begin{array}{cccccc} \varepsilon_{1t+1} & \cdots & \varepsilon_{Nt+1} & \varepsilon_{1t+1} x_{1t} & \cdots & \varepsilon_{Nt+1} x_{Nt} \end{array} \right]' \tag{33}$$

Based on Hansen (1982) we know that

$$\sqrt{T} g_T(\theta_0) \xrightarrow{d} N(0, S_0), \tag{34}$$

where S_0 is the variance-covariance matrix of the moment conditions. The sample counterpart S_T is estimated using the procedure in Newey and West (1987).

We estimate the parameters by setting $N+1$ linear combinations of g_T equal to zero. That is, the moment conditions can be written as

$$A g_T = 0, \tag{35}$$

where A is a $N+1 \times 2N$ matrix of constants. In particular, our choice of A is designed to ensure that the point estimates are the ones given by least squares (allowing for fixed effects). The following A matrix results in least square point estimates

$$A = \begin{bmatrix} I_N & 0_{N\times N} \\ 0_{1\times N} & 1_{1\times N} \end{bmatrix}, \tag{36}$$

where I_N is the identity matrix with dimension N, and $0_{N\times N}$ and $1_{1\times N}$ denote matrices of zeros and ones, respectively. This choice of A ensures that

$$A g_T(\theta_T) = \frac{1}{T} \sum_{t=1}^{T} \begin{bmatrix} \varepsilon_{1t+1} & \cdots & \varepsilon_{Nt+1} & \sum_{i=1}^{N} \varepsilon_{it+1} x_{it} \end{bmatrix}' = 0, \tag{37}$$

and the point estimator, θ_T, is then given by

$$\hat{\alpha}_1 = \left(\sum_{t=1}^{T} \sum_{i=1}^{K} (x_{it} - \bar{x}_{it})^2 \right)^{-1} \left(\sum_{t=1}^{T} \sum_{i=1}^{K} (x_{it} - \bar{x}_{it})(y_{it} - \bar{y}_{it}) \right), \tag{38}$$

$$\hat{\alpha}_{i0} = \bar{y}_{it} - \hat{\alpha}_1 \bar{x}_{it}, \quad i = 1, 2, \ldots, N, \tag{39}$$

where $\bar{y}_{it}$ and $\bar{x}_{it}$ are the sample averages of y_{it} and x_{it}, respectively.

As shown in Theorem 3.1 in Hansen (1982), when A linear combinations of g_T is set equal to zero as in (35), the asymptotic distribution of θ_T is given by

$$\sqrt{T}(\theta_T - \theta_0) \xrightarrow{d} N\left(0, (AD_0)^{-1} (AS_0A') (AD_0)^{-1\prime}\right), \tag{40}$$

where D_0 is the gradient of the moment conditions in (33), and which can be estimated by its sample counterpart D_T. Note that the standard errors based on (40) are robust to heteroskedasticity and serial correlation in ε_{it+1}.

A.2 Missing Data

This section reviews the results derived in Bansal and Dahlquist (1999), which are used to estimate the pooled models with missing data. Consider first indicator variables of the data availability according to

$$I_{it+1} = \begin{cases} 1 \text{ if data is observed at } t+1 \text{ for variable } i \\ 0 \text{ if data is } \textit{not} \text{ observed at } t+1 \text{ for variable } i \end{cases}. \tag{41}$$

The critical assumption that we make is that the indicator variable I_{it+1} is independent of ε_{it+1}, which implies that data are missing randomly. We will use the indicator variable to make our unbalanced panel a balanced panel. To achieve this we construct moment conditions based on the product of the previous errors, ε_{it+1} and $\varepsilon_{it+1}x_{it}$, and the indicator variable. For currency i, we then have

$$\mathrm{E}\left[I_{it+1}\varepsilon_{it+1}\right] \tag{42}$$

$$\mathrm{E}\left[I_{it+1}\varepsilon_{it+1}x_{it}\right] \tag{43}$$

to evaluate. Firstly, note that (42) can be written as

$$\mathrm{E}\left[I_{it+1}\varepsilon_{it+1}\right] = \mathrm{E}\left[I_{it+1}\right]\mathrm{E}\left[\varepsilon_{it+1}\right] = 0, \tag{44}$$

by the assumption of independence between ε_{it+1} and I_{it+1}. Secondly, the condition in (43) equals

$$\begin{aligned} \mathrm{E}\left[I_{it+1}\varepsilon_{it+1}x_{it}\right] &= \mathrm{E}\left[\mathrm{E}\left[I_{it+1}\varepsilon_{it+1} \mid x_{it}\right]x_{it}\right] && (45) \\ &= \mathrm{E}\left[\mathrm{E}\left[I_{it+1} \mid x_{it}\right]\mathrm{E}\left[\varepsilon_{it+1} \mid x_{it}\right]x_{it}\right] && (46) \\ &= 0, && (47) \end{aligned}$$

where the first equality (45) follows from the law of iterated expectations, the second equality (46) from the independence of ε_{it+1} and I_{it+1}, and the last equality (47) follows from $\mathrm{E}[\varepsilon_{it+1} \mid x_{it}] = 0$ which we exploit in (29) and (30). This means that the sample counterpart of the following moment conditions

$$\mathrm{E}\left[I_{it+1}\varepsilon_{it+1}\right] = 0, \quad i = 1, 2, \ldots, N, \tag{48}$$

$$\mathrm{E}\left[I_{it+1}\varepsilon_{it+1}x_{it}\right] = 0, \quad i = 1, 2, \ldots, N, \tag{49}$$

can be used within GMM, as outlined in Appendix A.1. In essence, this procedure treats missing observations as zeros, which is similar to the approach in Maddala (1977).

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Table 1: Summary Statistics of Exchange Rate Changes and Forward Premia

	Inclusion Date	FX Changes		Forward Premia	
		Mean	Standard Deviation	Mean	Standard Deviation
Switzerland	76–02	3.07	12.18	3.60	1.13
Hong Kong	86–01	0.03	1.39	0.41	0.39
Singapore	86–05	2.39	4.86	2.18	0.44
Japan	76–02	4.00	11.13	3.15	0.93
Belgium	76–02	0.87	10.71	–1.35	1.09
Austria	76–02	2.18	10.73	1.20	0.98
Denmark	76–02	0.15	10.38	–3.07	1.33
Canada	76–02	–1.41	4.20	–1.32	0.56
France	76–02	–0.63	10.39	–2.09	1.12
Germany	76–02	2.14	10.73	1.97	0.97
Netherlands	76–02	1.76	10.62	1.22	0.97
Italy	76–02	–3.09	10.25	–6.19	1.52
UK	76–02	–0.30	10.59	–2.49	0.91
Australia	95–02	–4.82	7.21	–0.84	0.31
Sweden	76–02	–1.84	9.65	–3.09	1.21
Spain	76–02	–3.21	10.72	–7.13	2.00
Portugal	76–02	–7.22	10.57	–10.82	3.35
Poland	93–07	–12.23	6.77	–20.30	1.21
Greece	94–05	–4.66	8.66	–10.92	3.20
Czech Republic	92–05	–1.43	8.74	–6.92	1.04
Malaysia	82–08	–2.42	8.35	0.60	0.86
Argentina	91–05	–0.29	1.29	–7.30	1.91
Venezuela	92–07	–28.28	24.88	–22.92	4.15
Thailand	92–02	–5.07	15.10	–7.43	1.17
Mexico	94–11	–20.12	23.87	–24.72	4.26
Turkey	97–01	–55.15	4.08	–67.94	1.97
Philippines	93–07	–6.57	11.16	–7.24	0.75
India	91–02	–9.34	8.94	–4.54	0.70

The table presents summary statistics of the weekly observations of exchange rate changes and forward premia on a monthly horizon. Means and standard deviations are annualized by multiplying the variables by 12×100 and $\sqrt{12} \times 100$, respectively. The inclusion date (year–month) is the first month we have observations on both exchange rate changes and forward premia.

Table 2: Country Attributes

	Attributes					Sample	
	GNP	Inflation	Inflation Volatility	ICRG	Openness	I	II
Switzerland	25,860	3.2	1.9	88.5	67.6	H	D
Hong Kong	22,950	8.6	3.6	80.5	296.5	—	D
Singapore	22,770	3.5	3.0	86.0	324.2	—	D
Japan	22,110	2.6	2.2	86.0	17.4	H	D
Belgium	21,660	4.4	1.7	85.5	143.1	H	D
Austria	21,250	4.1	1.4	82.5	77.1	H	D
Denmark	21,230	5.6	3.2	87.5	64.3	M	D
Canada	21,130	5.0	3.3	83.0	71.4	M	D
France	21,030	6.3	3.9	78.5	43.3	M	D
Germany	20,070	3.1	1.7	85.5	45.7	M	D
Netherlands	19,950	3.1	2.4	86.0	99.3	M	D
Italy	19,870	10.9	5.7	76.5	49.5	L	D
UK	19,260	7.8	4.8	80.5	57.0	L	D
Australia	18,940	6.4	3.7	82.0	40.1	—	D
Sweden	18,540	7.3	3.0	79.0	77.0	L	D
Spain	14,520	10.6	5.6	76.0	47.1	L	D
Portugal	12,670	16.3	6.7	82.0	65.9	L	E
Poland	12,670	80.7	120.6	78.0	54.2	—	E
Greece	11,710	16.7	4.1	74.5	56.6	—	E
Czech Republic	9,770	10.4	13.9	83.0	107.8	—	E
Malaysia	9,020	4.2	4.4	80.5	194.4	—	E
Argentina	8,310	435.5	753.9	71.5	16.9	—	E
Venezuela	7,900	25.1	22.4	65.5	48.8	—	E
Thailand	7,540	5.6	2.8	77.0	89.9	—	E
Mexico	9,020	43.2	35.2	68.5	47.7	—	E
Turkey	5,580	54.9	23.7	60.0	45.3	—	E
Philippines	2,850	12.6	10.3	67.5	80.3	—	E
India	1,400	8.8	3.0	68.5	27.2	—	E

The table presents summary statistics of various attributes. The GNP attribute is the GNP per capita for 1995 (PPP adjusted and in U.S. dollar terms). The attributes Inflation and Inflation Volatility refer to the average inflation and standard deviation of inflation (from 1976, or when available, to 1995). The ICRG attribute is the composite country rating in December 1995, provided by the *International Country Risk Guide*. The Openness attribute refers to the ratio of imports plus exports to GDP in 1995. The table also shows the categorization of the countries into High (H), Middle (M), and Low (L) income categories (according to their GNP per capita) in Sample I, which covers data for the period from 1976 to 1998. The economies are categorized into Developed (D) and Emerging (E) in Sample II, which covers all currencies from the inclusion date to 1998.

Table 3: Implications of the Forward Premium Regression

Case		$\alpha_1 = \frac{\text{Cov}(d,d+p)}{\text{Var}(d+p)}$	Var(p) and Var(d)	Cov(d,p)
I	UIP holds	$= 1$	$\text{Var}(d) > \text{Var}(p) = 0$	$\text{Cov}\,(d,p) = 0$
II	Forward premium puzzle	< 0	$\text{Var}(p) > \lvert\text{Cov}\,(d,p)\rvert > \text{Var}(d)$	$\text{Cov}\,(d,p) < 0$
III		> 1	$\text{Var}(d) > \lvert\text{Cov}\,(d,p)\rvert > \text{Var}(p)$	$\text{Cov}\,(d,p) < 0$
IV		$= 0.5$	$\text{Var}(p) = \text{Var}(d)$	Undetermined

The table shows four different cases for the slope-coefficient in the regression of the change in the exchange rate on the forward premium. In Case I, the uncovered interest rate parity (UIP) holds. In Cases II to IV, there is a time-varying risk premium. Case II is referred to as the forward premium puzzle.

Table 4: Forward Premium Regressions for Individual Currencies

	Standard Regressions				State-Dependent Regressions							
					Minus–Plus						Cubic	
	α_1	SE(α_1)	R^2_{adj}	T	α_1^-	α_1^+	SE(α_1^-)	SE(α_1^+)	Wald[a]	T^+	Wald[b]	R^2_{adj}
Switzerland	–1.05	(0.60)	0.87	1163	3.17	–2.01	(2.61)	(0.78)	[0.09]	950	[0.44]	1.23
Hong Kong	–0.01	(0.16)	–0.15	643	0.39	–0.12	(0.31)	(0.19)	[0.19]	426	[0.21]	–0.19
Singapore	–1.26	(1.50)	1.16	630	–4.76	–0.10	(3.68)	(0.89)	[0.19]	606	[0.00]	4.01
Japan	–2.21	(0.53)	3.33	1163	3.89	–3.05	(2.45)	(0.68)	[0.01]	947	[0.00]	4.82
Belgium	–0.77	(0.40)	0.54	1163	0.46	–5.55	(0.48)	(1.29)	[0.00]	464	[0.01]	1.69
Austria	–0.76	(0.57)	0.39	1163	1.27	–2.47	(1.09)	(1.11)	[0.05]	816	[0.46]	0.71
Denmark	–0.56	(0.34)	0.43	1163	0.32	–7.05	(0.38)	(1.71)	[0.00]	303	[0.00]	2.94
Canada	–1.04	(0.33)	1.85	1163	–1.11	–0.85	(0.48)	(0.86)	[0.82]	269	[0.18]	1.82
France	0.00	(0.61)	–0.09	1163	1.38	–5.24	(0.74)	(1.63)	[0.00]	319	[0.01]	3.12
Germany	–0.56	(0.63)	0.17	1163	2.56	–2.53	(1.36)	(1.00)	[0.01]	925	[0.10]	1.47
Netherlands	–1.38	(0.55)	1.51	1163	1.75	–4.17	(1.04)	(0.98)	[0.00]	853	[0.04]	2.61
Italy	0.08	(0.32)	–0.07	1163	0.17	–5.97	(0.32)	(6.17)	[0.32]	22	[0.55]	0.06
UK	–1.55	(0.61)	1.68	1163	–0.69	–4.67	(0.73)	(1.57)	[0.04]	196	[0.08]	2.57
Australia	–8.40	(3.11)	12.32	172	–8.88	–7.05	(4.40)	(14.36)	[0.92]	48	[0.99]	11.32
Sweden	0.56	(0.57)	0.40	1163	1.03	–3.67	(0.63)	(2.13)	[0.05]	213	[0.01]	2.84
Spain	0.67	(0.42)	1.48	1163	0.79	–8.48	(0.43)	(2.59)	[0.00]	71	[0.00]	4.78
Portugal	0.46	(0.20)	2.06	1163	0.53	–3.06	(0.21)	(1.44)	[0.02]	76	[0.09]	3.16
Poland	0.46	(0.50)	0.28	255	—	—	—	—	—	—	[0.02]	4.72
Greece	–0.38	(0.18)	1.47	211	—	—	—	—	—	—	[0.39]	2.57
Czech Rep.	1.35	(0.63)	2.26	314	—	—	—	—	—	—	[0.26]	2.41
Malaysia	0.35	(0.58)	0.01	824	0.97	–0.06	(1.25)	(0.56)	[0.47]	470	[0.42]	0.23
Argentina	0.08	(0.07)	1.28	369	—	—	—	—	—	—	[0.09]	3.35
Venezuela	0.71	(0.31)	1.07	305	—	—	—	—	—	—	[0.15]	2.78
Thailand	0.53	(2.97)	–0.14	329	—	—	—	—	—	—	[0.00]	30.91
Mexico	–1.40	(0.86)	5.68	185	—	—	—	—	—	—	[0.00]	15.80
Turkey	0.28	(0.20)	0.38	69	—	—	—	—	—	—	[0.41]	–1.07
Philippines	0.81	(1.99)	–0.10	252	—	—	—	—	—	—	[0.27]	2.12
India	–0.98	(1.17)	0.33	381	—	—	—	—	—	—	[0.37]	0.66

The table shows the results from the forward premium regressions. The standard regression is the regression of percentage change in the exchange rate on the associated forward premium. The corresponding standard error is given within parenthesis. T refers to the number of observations in the regression. The minus-plus regression refers to the case when observations of the forward premia are categorized into negative and positive observations. The α_1^+ and α_1^- coefficients refer to negative and positive observations, respectively. The corresponding standard errors are given within parentheses. The Wald[a] statistic refers to the test of the hypothesis that the α_1^+ and α_1^- coefficients are equal, and p-values are reported within square brackets. T^+ refers to the number of observations of the forward premium that are positive. The cubic regression refers to the case when squared and cubic terms of the forward premium are added. The Wald[b] statistic refers to the test of the hypothesis that the added terms are zero, and p-values are reported within square brackets. R^2_{adj} refers to the adjusted coefficient of determination (in %) in the regressions. Constant terms in the regressions are not reported. Covariance matrices are robust to heteroskedasticity and serial correlation.

Table 5: Forward Premium Regressions for All Currencies Pooled

	Standard Regression		State–Dependent Regressions					
			Minus–Plus					Cubic
	α_1	SE(α_1)	α_1^-	α_1^+	SE(α_1^-)	SE(α_1^+)	Wald[a]	Wald[b]
Sample I								
All (No Fixed Effects)	0.26	(0.14)	0.74	–1.57	(0.15)	(0.49)	[0.00]	[0.00]
All	–0.02	(0.21)	0.53	–2.78	(0.19)	(0.68)	[0.00]	[0.00]
High	–1.14	(0.41)	0.65	–2.35	(0.60)	(0.60)	[0.00]	[0.04]
Middle	–0.60	(0.38)	0.65	–3.35	(0.44)	(0.92)	[0.00]	[0.00]
Low	0.38	(0.18)	0.54	–4.44	(0.18)	(1.24)	[0.00]	[0.01]
Sample II								
Developed	–0.32	(0.29)	0.51	–2.69	(0.28)	(0.66)	[0.00]	[0.00]
Emerging	0.19	(0.19)	0.21	–0.32	(0.19)	(0.65)	[0.43]	[0.44]

The table shows the results from the forward premium regressions when data is pooled. Results are presented for two samples. Sample I covers 14 currencies from 1976 to 1998, and sample II covers all currencies from inclusion date to 1998. In Sample I, High, Middle, and Low refer to high, middle, and low income classifications. All refers to all currencies. In Sample II, economies are categorized as developed or emerging. The standard regression is the regression of percentage change in the exchange rate on the associated forward premium. The corresponding standard error is given within parenthesis. The minus-plus regression refers to the case when observations of the forward premia are categorized into negative and positive observations. The α_1^+ and α_1^- coefficients refer to negative and positive observations, respectively. The corresponding standard errors are given within parentheses. The Wald[a] statistic refers to the test of the hypothesis that the α_1^+ and α_1^- coefficients are equal, and p–values are reported within square brackets. The cubic regression refers to the case when squared and cubic terms of the forward premium are added. The Wald[b] statistic refers to the test of the hypothesis that the added terms are zero, and p–values are reported within square brackets. All regressions allow for country-specific intercepts, except All (labeled No Fixed Effects) in Sample I. The country-specific intercepts are not reported. Covariance matrices are robust to heteroskedasticity and serial correlation.

Table 6: Forward Premium Regressions Using Attributes

	α_{11} to Attribute				
α_{10}	GNP	Inflation	Inflation Volatility	ICRG	Openness
Sample I					
2.35	–3.78				
(0.62)	(1.12)				
–0.64		1.03			
(0.34)		(0.29)			
–0.61			1.08		
(0.35)			(0.36)		
10.31				–10.51	
(2.75)				(2.84)	
0.25					–0.10
(0.29)					(0.09)
Sample II					
0.72	–1.42				
(0.52)	(0.96)				
–0.35		0.36			
(0.31)		(0.27)			
–0.23			0.22		
(0.30)			(0.25)		
2.09				–2.25	
(1.81)				(1.93)	
0.01					–0.02
(0.25)					(0.08)

The table reports on the results of pooled regressions of the change in the exchange rates on the forward premia when the slope-coefficient is conditioned on an attribute ($\alpha_{i1} = \alpha_{10} + \alpha_{11} A_{ij}$, where A_{ij} is attribute j for country i). The attributes are all measured relative the U.S. The Inflation and Inflation Volatility attributes are expressed in logs. Argentina is not included in the regressions with the Inflation and Inflation Volatility attributes. Sample I covers 14 currencies from 1976 to 1998, and sample II covers all currencies from inclusion date to 1998. There are about 16,000 observations in Sample I, and about 21,000 observations in Sample II. Country-specific intercepts are not reported.

Table 7: Forward Premium Regressions for Cross-Currencies

	DEM			JPY		
	α_1	SE(α_1)	Wald	α_1	SE(α_1)	Wald
Sample I						
All (No Fixed)	0.50	(0.10)	[0.02]	0.31	(0.13)	[0.00]
All	0.38	(0.13)	[0.00]	0.08	(0.20)	[0.00]
High	–0.43	(0.26)	[0.04]	–1.47	(0.33)	[0.09]
Middle	0.24	(0.18)	[0.15]	–0.93	(0.34)	[0.00]
Low	0.52	(0.15)	[0.04]	0.60	(0.20)	[0.04]
Sample II						
Developed	0.26	(0.18)	[0.14]	–0.47	(0.27)	[0.00]
Emerging	0.29	(0.20)	[0.11]	0.37	(0.21)	[0.06]

The table shows the results from the forward premium regressions for cross-currencies (DEM and JPY) when data is pooled. Results are presented for two samples. Sample I covers 14 currencies from 1976 to 1998, and sample II covers all currencies from inclusion date to 1998. In Sample I, High, Middle, and Low refer to high, middle, and low income classifications. All refers to all currencies. In Sample II, economies are categorized as developed or emerging. The standard regression is the regression of percentage change in the exchange rate on the associated forward premium. The corresponding standard error is given within parenthesis. The Wald statistic refers to the test of the hypothesis that the added terms in the cubic regression are zero, and p–values are reported within square brackets. All regressions allow for country-specific intercepts, but they are not reported. Covariance matrices are robust to heteroskedasticity and serial correlation.

Table 8: Currency Trading Strategies

	FX Returns				Returns from Dynamic Strategies			
	Mean	Standard Deviation	Sharpe Ratio	Wald	Mean	Standard Deviation	Sharpe Ratio	Wald
Switzerland	–0.53	12.33	–0.04	[0.79]	1.93	12.32	0.16	[0.36]
Hong Kong	–0.38	1.44	–0.26	[0.12]	0.79	1.43	0.56	[0.00]
Singapore	0.21	4.92	0.04	[0.84]	0.07	4.92	0.01	[0.93]
Japan	0.85	11.34	0.08	[0.66]	2.82	11.31	0.25	[0.16]
Belgium	2.21	10.85	0.20	[0.24]	7.58	10.63	0.71	[0.00]
Austria	0.98	10.84	0.09	[0.59]	2.99	10.80	0.28	[0.10]
Denmark	3.22	10.55	0.30	[0.08]	8.72	10.29	0.85	[0.00]
Canada	–0.09	4.31	–0.02	[0.88]	1.96	4.27	0.46	[0.01]
France	1.46	10.44	0.14	[0.41]	6.38	10.29	0.62	[0.00]
Germany	0.18	10.82	0.02	[0.91]	1.64	10.81	0.15	[0.37]
Netherlands	0.54	10.79	0.05	[0.76]	2.83	10.72	0.26	[0.12]
Italy	3.10	10.34	0.30	[0.09]	3.42	10.33	0.33	[0.06]
UK	2.19	10.74	0.20	[0.23]	6.92	10.53	0.66	[0.00]
Australia	–3.99	7.30	–0.55	[0.21]	5.74	7.20	0.80	[0.07]
Sweden	1.26	9.64	0.13	[0.45]	4.62	9.55	0.48	[0.01]
Spain	3.92	10.65	0.37	[0.04]	5.43	10.59	0.51	[0.00]
Portugal	3.60	10.61	0.34	[0.06]	5.36	10.54	0.51	[0.00]
Poland	8.07	6.77	1.19	[0.00]	8.07	6.77	1.19	[0.00]
Greece	6.27	9.62	0.65	[0.11]	6.27	9.62	0.65	[0.11]
Czech Republic	5.50	8.62	0.64	[0.03]	5.50	8.62	0.64	[0.03]
Malaysia	–3.02	8.36	0.36	[0.08]	1.17	8.40	0.14	[0.48]
Argentina	7.01	2.16	3.24	[0.00]	7.01	2.16	3.24	[0.00]
Venezuela	–5.36	24.70	–0.22	[0.44]	–5.36	24.70	–0.22	[0.44]
Thailand	2.36	15.07	0.16	[0.62]	2.36	15.07	0.16	[0.62]
Mexico	4.60	25.20	0.18	[0.68]	4.60	25.20	0.18	[0.68]
Turkey	12.79	4.25	3.01	[0.00]	12.79	4.25	3.01	[0.00]
Philippines	0.67	11.12	0.06	[0.86]	0.67	11.12	0.06	[0.86]
India	–4.80	9.01	–0.53	[0.02]	–4.88	9.01	–0.54	[0.02]

The table presents summary statistics of returns from trading strategies. The FX Returns are the (uncovered) excess returns for a U.S. investor borrowing in the U.S. and lending in foreign instruments with a one-month horizon. The Returns from Dynamic Strategies are the (uncovered) returns for a U.S. investor borrowing in the low interest currency and lending in the high interest currency for a one-month horizon. Means and standard deviations are annualized by multiplying the variables by 12×100 and $\sqrt{12} \times 100$, respectively. The Sharpe Ratio is the annualized mean divided by the annualized standard deviation of the excess returns. The Wald statistics refer to tests of the hypothesis of zero Sharpe Ratio, where p-values are given within parentheses. The period covered is from the inclusion date of each currency to 1998.

Table 9: Currency Trading Strategies for Portfolios

	FX Returns				Returns from Dynamic Strategies			
	Mean	Standard Deviation	Sharpe Ratio	Wald	Mean	Standard Deviation	Sharpe Ratio	Wald
Sample I								
All	1.63	8.89	0.18	[0.29]	4.47	4.98	0.90	[0.00]
High	0.85	10.27	0.08	[0.63]	3.62	7.99	0.45	[0.00]
Middle	1.05	8.91	0.12	[0.49]	5.35	6.87	0.78	[0.00]
Low	2.81	9.00	0.31	[0.07]	4.62	7.01	0.66	[0.00]
Sample II								
Developed	1.24	8.31	0.15	[0.38]	4.16	4.51	0.92	[0.00]
Emerging	0.73	7.78	0.09	[0.58]	3.53	7.35	0.48	[0.02]

The table presents summary statistics of returns from trading strategies for income portfolios. High, Middle, and Low refer to portfolio returns sorted on high, middle, and low income classifications. All refer to the portfolio return of all currencies. The FX Returns are the (uncovered) excess returns for a U.S. investor borrowing in the U.S. and lending in foreign instruments with a one-month horizon. The Returns from Dynamic Strategies are the (uncovered) returns for a U.S. investor borrowing in the low interest currency and lending in the high interest currency for a one-month horizon. Means and standard deviations are annualized by multiplying the variables by 12×100 and $\sqrt{12} \times 100$, respectively. The Sharpe Ratio is the annualized mean divided by the annualized standard deviation of the excess returns. The Wald statistics refer to tests of the hypothesis of zero Sharpe Ratio, where p-values are given within parentheses. Results are presented for two sample periods. Sample I covers 14 currencies from 1976 to 1998, and Sample II covers all currencies from their inclusion date to 1998.

Table 10: Latent Factor Estimation for Sample I

Projection, δ				Latent Factor						
				Constants, β_{i0}			Slopes, β_{i1}			
Constant	Low	Middle	High	Low	Middle	High	Low	Middle	High	J-Statistic
–3.78	–0.68	–0.17	–0.96	0.40	1.06	1.55				39.79
(2.04)	(0.30)	(0.61)	(0.55)	(0.19)	(0.06)	(0.16)				[0.00]
–0.01	–0.20	0.85	–0.90	0.43	0.44	2.42	–0.32	0.36	–0.05	37.30
(0.54)	(0.18)	(0.75)	(0.78)	(0.58)	(0.56)	(1.24)	(0.29)	(0.34)	(0.18)	[0.00]

The table shows estimates from the latent one-factor model for three portfolios: Low, Middle, and High. The Low, Middle, and High portfolios are sorted on the GNP attribute. The models presented are with and with-out time-variation in βs. The δ-parameters refer to the projection of an equally-weighted currency portfolio on the low, middle, and high income forward premia. The β-parameters refer to the exposure versus the latent factor given from the above projection. The systems are both overidentified with 9 degrees of freedom (see the text for the exact moment conditions utilized). The J-statistic refers to the test for overidentified restrictions, and p-values are shown within square brackets.

Table 11: Re-Projection in the Latent Factor Model for Sample I

Constants, κ_{i0}			Slopes, κ_{i1}			Variance Ratios		
Low	Middle	High	Low	Middle	High	Low	Middle	High
–7.12	–2.50	0.66	–0.97	–1.55	–1.36	0.83	0.78	0.74
(2.26)	(1.03)	(0.78)	(0.30)	(0.43)	(0.40)			

The table shows the reprojection in the latent factor model with constant betas. The Variance Ratios refer to the amount of variance in the risk premium which is explained by the individual forward premium.

Table 12: Estimates of Factor and Attribute Premia

λ_{0t}	Factor Premia, λ_t: Latent Factor	Factor Premia, λ_t: Currency Portfolio	Factor Premia, λ_t: Equity Portfolio	Factor Premia, λ_t: Forward Portfolio	Attribute Premia, $\lambda_{A_j t}$: Forward Premium	Attribute Premia, $\lambda_{A_j t}$: GNP	Attribute Premia, $\lambda_{A_j t}$: ICRG	R^2
Sample II								
–0.09	2.03							8.14
(0.82)	(1.33)							
–1.09		2.36						0.96
(0.71)		(1.53)						
1.47			–24.31					0.00
(1.33)			(6.22)					
3.03				–2.69				3.97
(1.18)				(1.04)				
–1.24	2.47				–5.96			38.89
(0.78)	(1.35)				(0.79)			
–9.08	2.46				–7.59	10.39		42.71
(2.04)	(1.36)				(0.89)	(2.49)		
–19.43	1.86				–6.81		18.71	44.65
(5.92)	(1.35)				(0.86)		(6.20)	
Sample I								
–10.14	2.00				–10.45	12.24		77.51
(2.59)	(1.67)				(1.83)	(2.91)		
–22.01	0.73				–9.77		22.21	71.12
(5.69)	(1.65)				(1.29)		(5.76)	

The table shows averages of factor and attribute premia from the cross-sectional analysis for Sample I and Sample II. Sample I covers 14 currencies from 1976 to 1998. Sample II covers all currencies from inclusion date to 1998. The latent factor is the projection of an equally-weighted portfolio of currency returns on predetermined forward premia. The currency portfolio refers to an equally-weighted portfolio of currency returns. The equity portfolio is the return on U.S. equity in excess of a U.S. 30-day T-bill. The forward premium portfolio is the excess return on a currency portfolio sorted by individual forward premia. The R^2 is the squared correlation coefficient between the time-series average of the returns, and the fitted expected return. The forward premium, GNP, and ICRG refer to country-specific attributes.

Figure 1a. Depreciation Rates and Forward Premia
All Observations (USD)

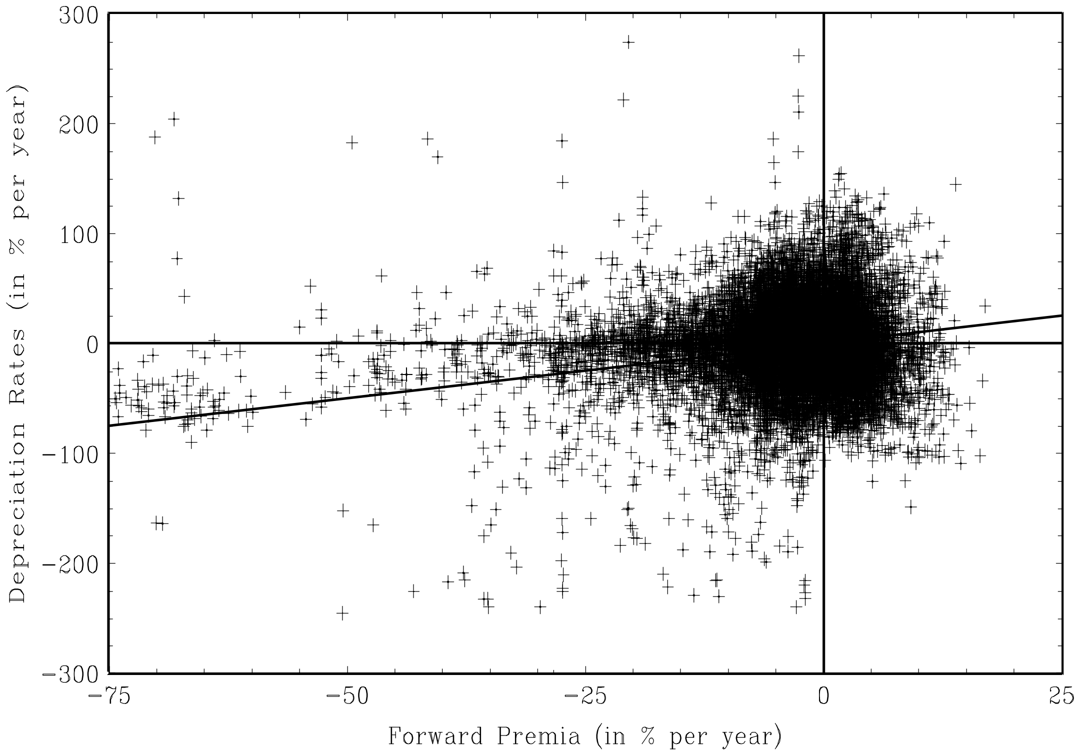

Figure 1b. Depreciation Rates and Forward Premia
Emerging and Developed Economies Pooled (USD)

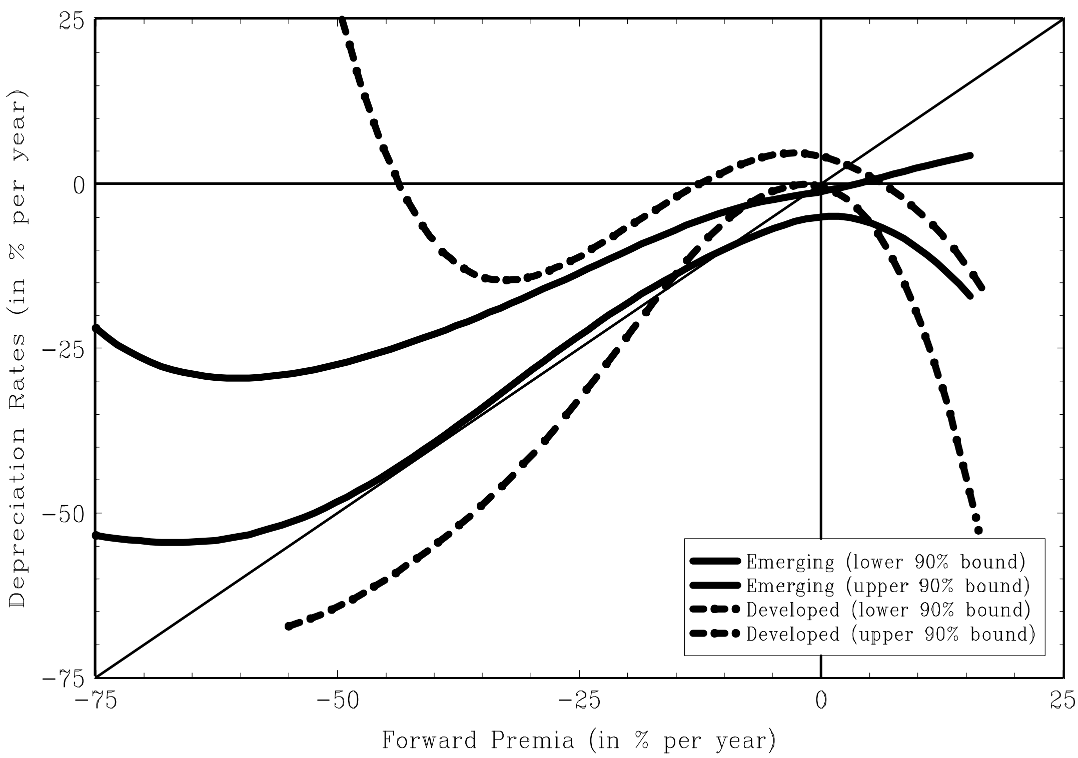

Figure 1c. Depreciation Rates and Forward Premia
Emerging and Developed Economies Pooled (DEM)

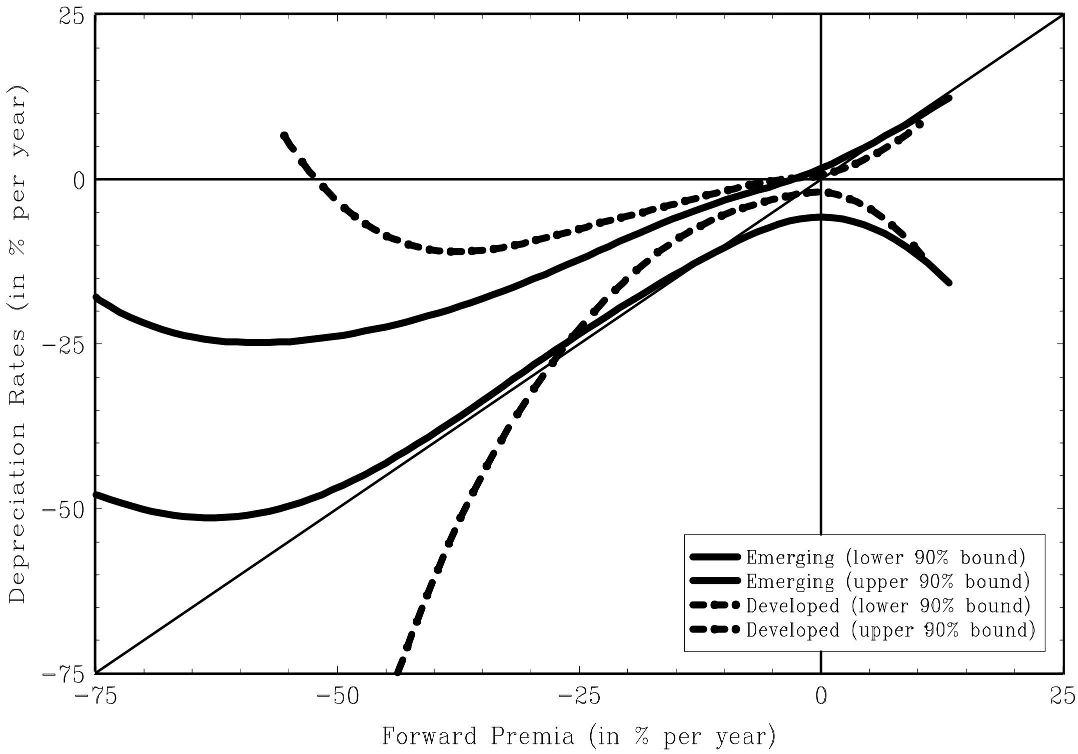

Figure 1d. Depreciation Rates and Forward Premia
Emerging and Developed Economies Pooled (JPY)

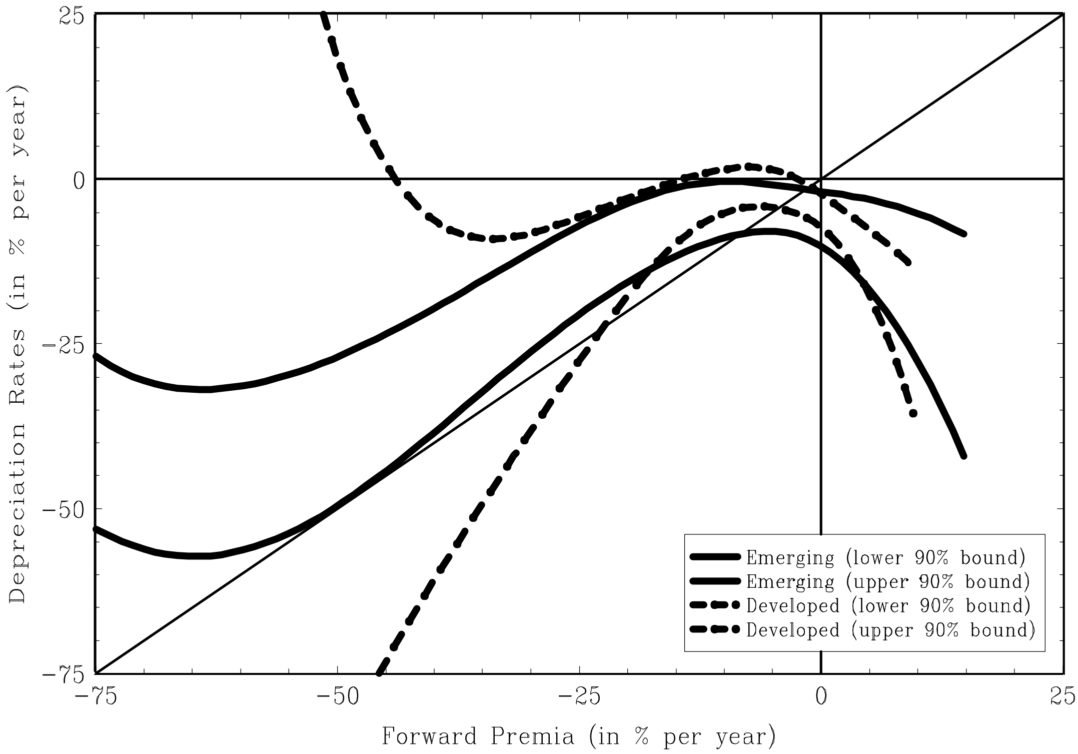

Figure 2a. Fitted Slope-Coefficient
GNP Attribute

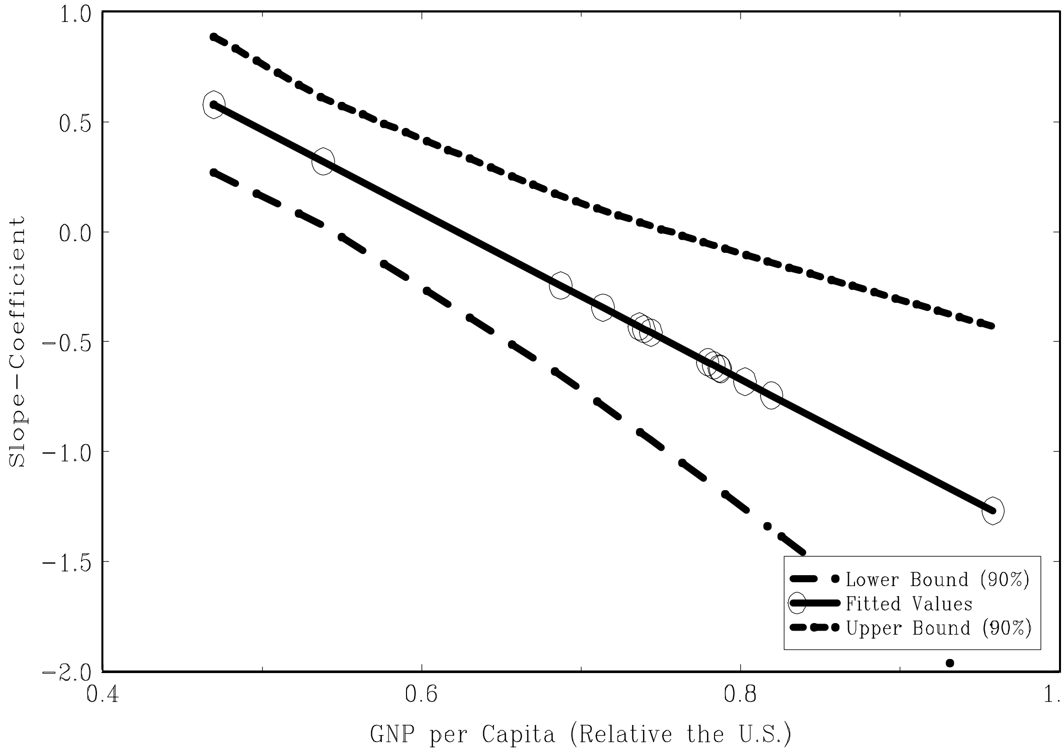

Figure 2b. Fitted Slope-Coefficient
Inflation Attribute

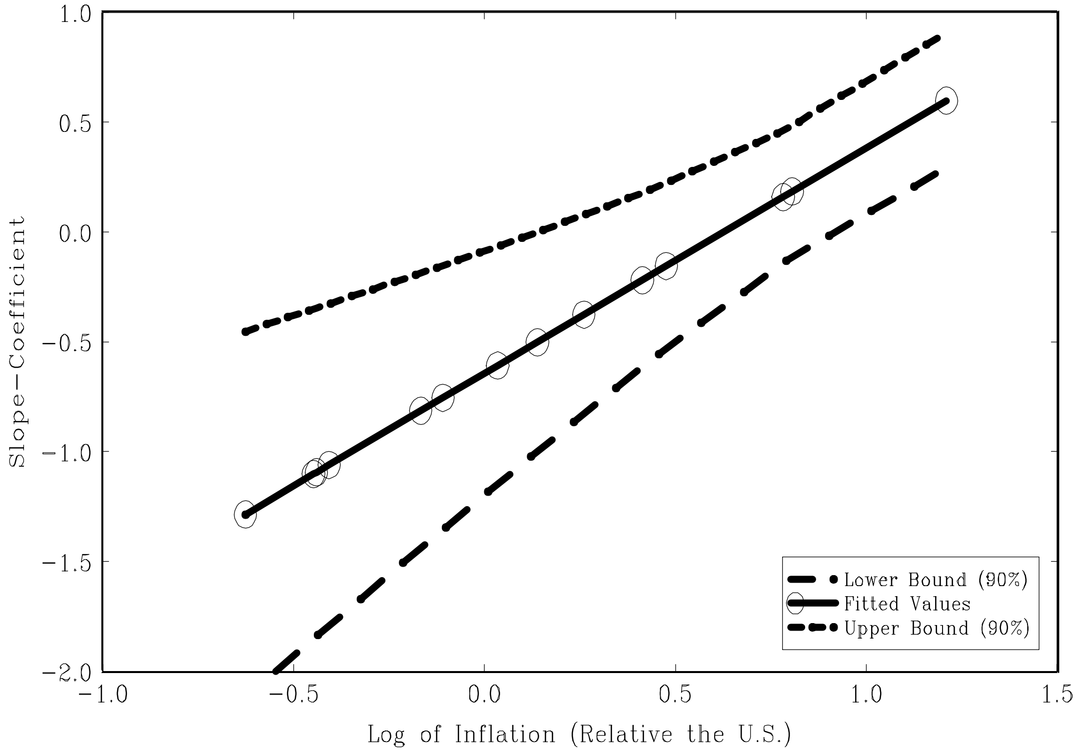

Figure 3a. Distribution of Returns for Portfolios
Low, Middle, and High Income

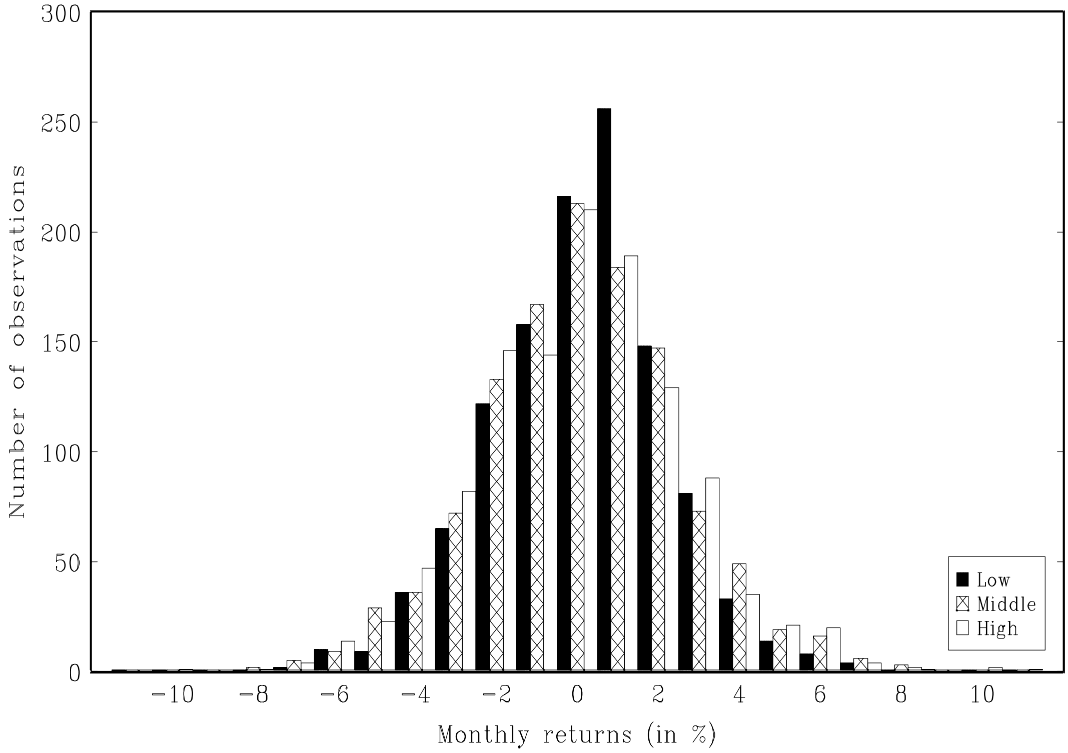

Figure 3b. Distribution of Returns for Portfolios
Emerging and Developed Economies

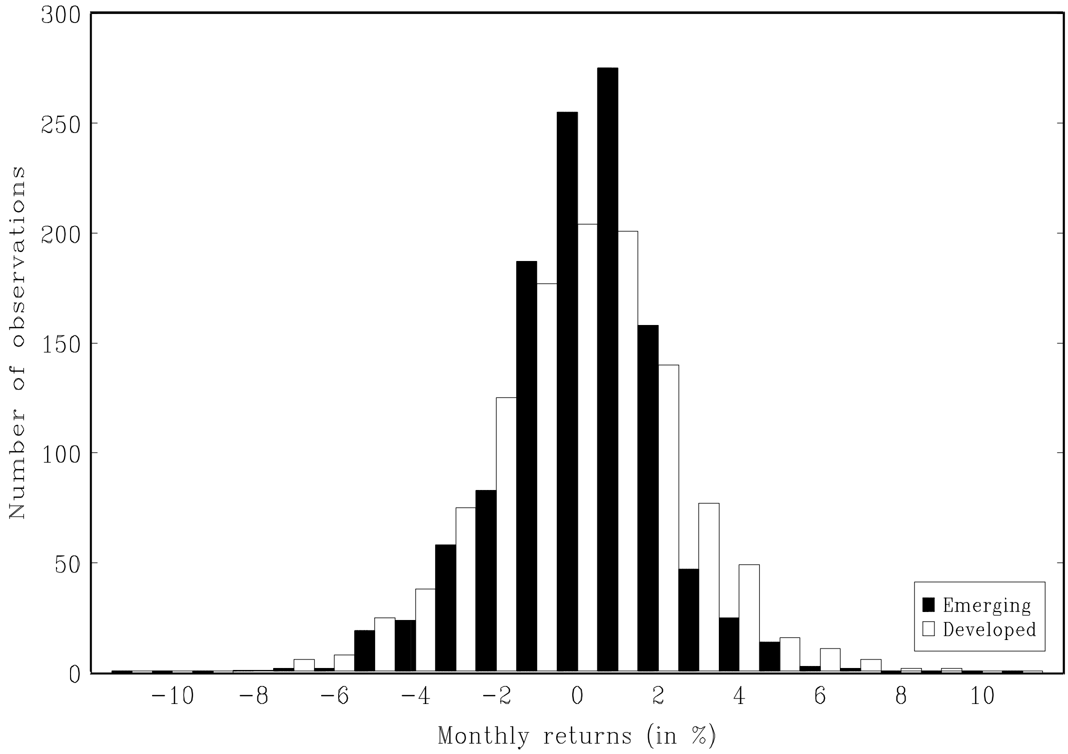

Figure 4a. Fitted Expected Returns versus Average Returns
Latent Factor (No Attributes)

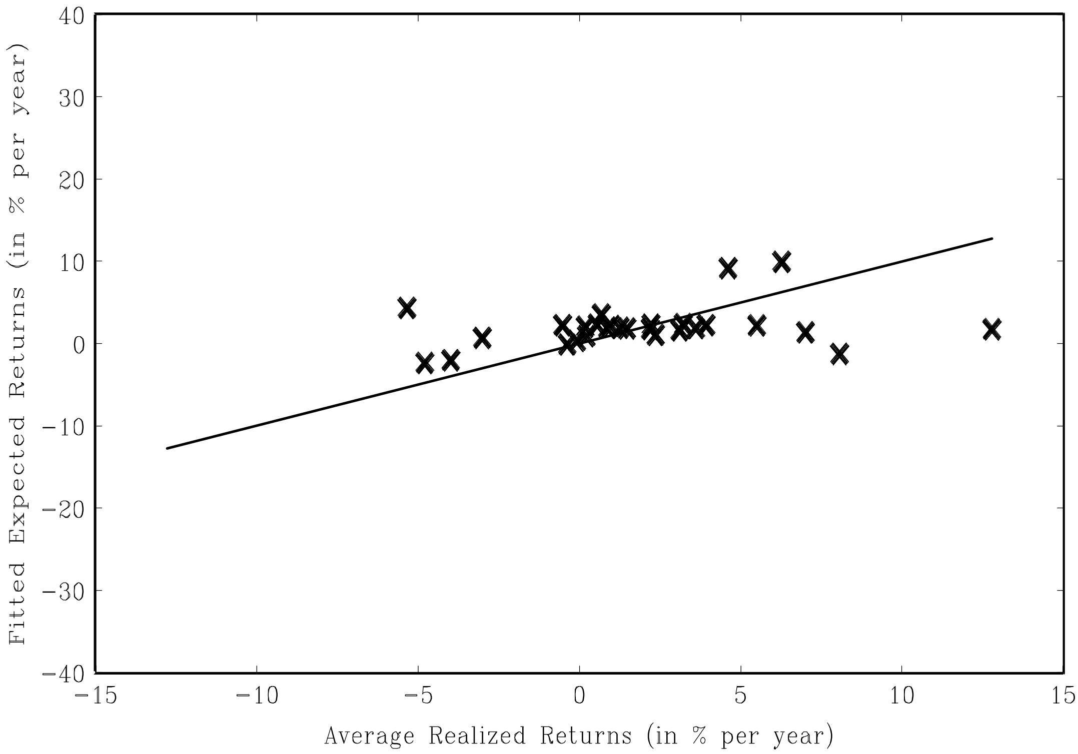

Figure 4b. Fitted Expected Returns versus Average Returns
Latent Factor, and Forward Premium and ICRG Attributes