# THE PRICING OF EXCHANGE RATE RISK IN UP AND DOWN WORLD STOCK MARKET PERIODS

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## ABSTRACT

*This paper examines the pricing of exchange rate risk in up and down world stock market periods using multifactor arbitrage pricing models during the period of January 1973 through June 2007. The risk premium of exchange rate exposure in up market periods appears to be small and insignificant. However, it appears to be priced and significant under down market periods. The results in this study help understand why investors decide to hedge exchange rate exposure. The above asymmetry in pricing exchange rate risk seems to justify the use of hedging strategies when investors face low international stock market returns due to depressed world stock market conditions.*

**JEL**: G12, G15

## INTRODUCTION

Accepted methods for testing whether the exchange rate risk is priced in the world stock market do not address the possibility that such risk should be differently priced under up and down world stock market periods. We discuss this oversight in the literature review section of the paper. Currency exposure could lead to different risk premia depending on previous up and down market conditions. This scenario may arise from various sources. Investor optimism or pessimism, for instance, may result in asymmetric responses under such market conditions. This could generate differences in an investor's return expectations about the potential international impact of changes in foreign stock markets (Erb et al., 1994). For instance, a small negative movement in the U.S. stock market could lead to larger declines in other stock markets due to widespread earnings disappointment among investors rather than as a result of the particular magnitude of U.S. stock market decline. Conversely, a small positive movement in the U.S. stock market could have no larger effects in other stock markets (Skinner and Sloan, 1999).

Thus, when investors price currency exposure in down rather than in up world stock market periods, investors' pessimism or their widespread earnings disappointment in such market conditions may lead them to use financial hedging strategies with the objective of protecting their returns against exchange rate risk and, thus, prevent financial portfolio difficulties or going bust.

Although different exchange rate risk premia for up and down world stock market periods could be due to various sources, our main objectives in this paper are 1) to examine whether currency risk is a priced factor under up and down world stock market periods and 2) to estimate the compensation that investors expect to receive in order to bear the exchange rate risk if it is finally priced under such world stock market conditions. Thus, we aim at contributing to the literature by closely examining the relationship between exchange rate risk and stock market returns under conditions of both up and down world stock market periods. The paper is organized into five sections. Section 2 discusses the main contributions in the relevant literature, more specifically the multifactor arbitrage pricing model. Section 3 presents the methodology of empirical research including data and main measures. Section 4 summarizes the empirical results. The last section offers a summary of the research and the conclusions.

## LITERATURE REVIEW

Two key assumptions are considered when addressing the relationship between stock market pricing and exchange rate risk pricing. First, if the effects of exchange rate risk do not disappear in a well-diversified portfolio, then investors should price such pervasive risk. Second, if Purchasing Power Parity (PPP) theory holds among countries and if stock markets behave perfectly, then the single-market factor Capital Asset Pricing Model (CAPM) should hold internationally. As a consequence of the latter, the exchange rate risk should not be a pervasive risk factor priced by investors.

Diverse studies have considered the effects of exchange rate risk on asset returns when examining international asset pricing models, which include both the exchange rate risk factor and the market risk factor (Solnik, 1974; Sercu, 1980; Stulz; 1981; Adler and Dumas, 1983; Solnik, 1997). However, the empirical evidence shows mixed results. On one hand, results from testing unconditional asset pricing models are not conclusive. Seminal studies (e.g., Hamao, 1988; Jorion, 1991) do not find evidence in favor of pricing exchange risk on the Japanese or the U.S. stock markets. More recent studies (e.g., Carrieri and Majerbi, 2006), however, show significant unconditional exchange risk premium when emerging stock markets are analyzed. On the other hand, results from testing time varying conditional asset pricing models generally conclude that foreign exchange risk is priced in the stock markets of major developed countries (Dumas and Solnik, 1995; De Santis and Gerard, 1998; Choi, et al., 1998; Doukas, et al., 1999; Carrieri, 2001). Moreover, Vassalou (2000) shows that exchange rate risk, along with foreign inflation risk, can explain an important portion of the cross-sectional variation in stock market returns of 10 developed countries.

Previous studies, however, do not evaluate the issue that exchange risk premia may differ under up and down stock market periods. Traditional approaches based on either conditional or unconditional models do not consider previous possibility, even after controlling for the effects of stock market and/or foreign inflation risk factors. A pioneering study (Pettengill, et al., 1995) recognized that a conditional relationship between market beta risk and return may take place in up and down stock market periods and that a systematic relationship must exist between market beta risk and return for the former to be a useful measure of risk. Theoretically, the CAPM shows a systematic and positive tradeoff between market beta and expected return. Yet, in line with rational expectations and Pettengill, et al. (1995), there should be a positive relationship between realized returns and market beta during positive market-excess return periods and a negative relationship during negative market-excess return periods.

However, the above prediction applies only to the case of one systematic risk factor, the market beta risk factor. The question is what would happen if more risk factors that are also systematic affect the stock market's return generating process. To answer this question, we extend Pettengill, et al's model in order to incorporate the effect of orthogonal innovations that arise from macroeconomic risk factors under a conditional framework. The extension is based on Ross' Arbitrage Pricing Theory (APT) model (Ross, 1976). We conduct an analysis using a three-factor model conditional to up and down world stock market periods in an international context where both inflation and exchange rate innovations are pervasive systematic risk factors in addition to the world stock market factor.

Vassalou (2000), for instance, supports a three-factor solution. It is well known that countries with relatively high unexpected inflation rates transfer this uncertainty to their stock markets by making their stocks less attractive. Investors would require higher compensation risk and thus higher rates of returns if they would invest in such stocks. A similar situation is observed when net importing/exporting countries deal with unexpected depreciation/appreciation in their currencies. However, it is not known whether risk premia that are associated to previous macroeconomic risk factors are positive or negative in up or down world stock market periods, respectively, and whether such relationships are symmetric or asymmetric. Our empirical research addresses those questions next.

## METHODOLOGY

### Data

The data consist of monthly returns for 18 country stock market indexes as well as the Morgan Stanley Composite World Index (MSCI World Index[SM]) as proxy for the world stock market. The indexes are available in www.mscibarra.com. MSCI Barra is a leading provider of investment decision tools to investment institutions worldwide and its products include indices and portfolio risk and performance analytics for use in managing equity, fixed income and multi-asset class portfolios. On the one hand, to construct a particular country market index, every listed security in the market is identified for inclusion. Eligible securities are free float adjusted, classified in accordance with the Global Industry Classification Standard (GICS®), and screened by size, liquidity and minimum free float. On the other hand, the MSCI World Index is constructed as a free float-adjusted market capitalization index designed to measure global developed market equity performance. The stock market indexes included are Australia, Austria, Belgium, Canada, Denmark, France, Germany, Hong Kong, Italy, Japan, The Netherlands, Norway, Singapore, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

The sample period extends from January 1973 through June 2007. This period is initially characterized by the Bretton Woods (1973) and the Jamaica Agreements (1976), which established a set of rules for the international monetary system, where flexible exchange rates were declared acceptable to the IMF members, and central banks were allowed to intervene in the exchange markets in order to control unwarranted volatilities. Despite the regulations, however, $\widetilde{R}_{st}$, the proxy for foreign exchange rate variations used in this study, showed significant volatility over the sample period, with an annualized standard deviation of 7.85% versus 0.86% for the U.S. Treasury Bill rate. It is important to note that $\widetilde{R}_{st}$ is estimated as the rate of change for a world stock market capitalization-weighted exchange rate index, measured as the dollar price of foreign currency. Given that the MSCI World Index is a linear combination of various stock market indexes with their respective market capitalization weights, we perform the restricted multiple regression approach suggested by Sharpe (1992) in order to obtain explicit weights for such exchange rate index. The regression sets the MSCI World Index returns as dependent variables and the stock market indexes returns as independent variables. Consequently, the estimated coefficients are restricted to be non-negative and their sum equal to one. Thus, in the construction of $\widetilde{R}_{st}$, these coefficients can be interpreted as those "naive" weights used in an internationally diversified portfolio of foreign currencies, which are essentially the same weights used in the MSCI World Index construction once extracted the U.S. market capitalization weight due to the fact that this stock market uses the USD as numeraire currency.

### Analytical Procedures

Our analysis starts by applying factor analysis to the database of excess return on stock market indexes in the sample. We have 18 time series containing such excess returns with 414 months associated to each time series, totaling 7,452 data entries. With the application of factor analysis, we pursue identification of the underlying factor structure with its respective number of factors through data summarization. Thus, we at least may identify the number of factors behind the dataset, which is an important step for later APT pricing model specification. Then, we continue by splitting the total sample period into up and down world stock market periods. Following a modified Jorion's approach, which is based on Ross's APT, and the results from the factor analysis, a three-factor arbitrage-pricing model is analyzed in up and down world stock market periods. The tests of model rest on the assumption that the included factors are well specified. The model includes the world stock market returns as the first factor, and the orthogonal component (of the world stock market factor) of innovations in a world stock market capitalization-weighted inflation rate factor as a second factor. The weights used to build this factor are the same as those used as market capitalization weights in the MSCI World Index.

The third and last factor is the orthogonal component (of the two previous orthogonal factors) of innovations in a world stock market capitalization-weighted exchange rate factor. The proposed three-factor model is well founded. On the one hand, the world stock market returns are used by several empirical studies as a reliable source of important systematic risk factors that help explain stock market returns [See for example; Gupta and Finnerty (1992); Dumas and Solnick (1995)]. On the other hand, inflation rate and foreign exchange rate are pervasive macroeconomic factors that involve risk and affect security returns. A three-factor model allows a direct test of the CAPM where inflation and exchange rate innovations are assumed pervasive orthogonal factors.

The orthogonalization process is useful in order to avoid spurious pricing correlation among inflation rates, foreign exchange rates and world stock market returns. The parameters of the model are estimated using generalized least squares seemingly unrelated regressions (SUR), which are said to be a more powerful technique than the traditional Fama-MacBeth (1973) approach. Yet, differing from Jorion's approach, we jointly estimate the parameters of the unrestricted and restricted three factor model in up and down world stock market periods, respectively. This process allows us to test for statistically significant differences in the price for exchange rate exposure under such conditions in the world stock market, which is a major contribution of the study.

Three-Factor Model

The dollar rate of return in excess of the risk-free rate, $\widetilde{R}_{jtUS\$}$ , that an investor can make from an investment in the $jth$ stock market is given by

$$\widetilde{R}_{jt} = \widetilde{R}^*_{jt} - \widetilde{R}_{ft} \tag{1}$$

where $\widetilde{R}^*_{jt}$ is the $j_{th}$ stock market return, $\widetilde{R}_{ft}$ is the U.S. risk-free rate, both are measured in U.S. dollars, and the symbol "~" indicates a random variable. A Ross's (1976) APT three-factor linear model can be written as

$$E(\widetilde{R}_j) = \delta_0 + \delta_m \beta^m_j + \delta_i \beta^i_j + \delta_s \beta^s_j \tag{2}$$

where $E(\widetilde{R}_j)$ is the $j_{th}$ stock market expected return, $\beta^m_j$ is the sensitivity to the world stock market returns, $\beta^i_j$ and $\beta^s_j$ are the sensitivities to inflation and exchange rate variations, respectively. The sensitivities are restricted to be orthogonal to the world stock market returns, which is consistent with Ross's (1976) APT assumptions. This framework is correct if loadings on non-included risk factors are near zero. Given that the world stock market itself must have neither inflation nor exchange rate systematic risks ( $\beta^i_m$ and $\beta^s_m = 0$ ) and must follow equation (2) at the same time, this equation can also be expressed as:

$$E(\widetilde{R}_j) = \delta_0 + [E(\widetilde{R}_m) - \delta_0]\beta^m_j + \delta_i \beta^i_j + \delta_s \beta^s_j \tag{3}$$

The empirical test of equation (3) is developed next. Assuming stationarity, the time series of $j_{th}$ stock market returns can be written as:

$$\tilde{R}_{jt} = E(\tilde{R}_{jt}) + \beta_j^m [\tilde{R}_{mt} - E(\tilde{R}_{mt})] + \beta_j^i \tilde{F}_{it} + \beta_j^s \tilde{F}_{st} + \tilde{\varepsilon}_{jt} \quad (4)$$

where

$$\tilde{F}_{st} = \tilde{R}_{st} - (\hat{\gamma}_0 + \hat{\gamma}_1 R_{mt}^* + \hat{\gamma}_2 \tilde{F}_{it}) \quad (5)$$

is the residual after running an OLS regression with exchange rate variations $\tilde{R}_{st}$ as dependent variable and world stock market returns $\tilde{R}_{mt}^*$ and inflation rate innovations $\tilde{F}_{it}$ (orthogonal to world stock market returns) as independent variables. Thus, $\tilde{F}_{st}$ has, by construction, zero mean and zero correlation (orthogonal) to world stock market returns and inflation rate innovations. The orthogonalization avoids spurious pricing correlation between exchange rate and world stock market returns. Under rational expectations, equation (3) can be substituted in equation (4) to get the testable three factor model:

$$\tilde{R}_{jt} = [\delta_0 (1 - \beta_j^m) + \delta_i \beta_j^i + \delta_s \beta_j^s] + \beta_j^m \tilde{R}_{mt} + \beta_j^i \tilde{F}_{it} + \beta_j^s \tilde{F}_{st} + \tilde{\varepsilon}_{jt} \quad (6)$$

Now, we introduce a dummy variable into equation (6) in order to split the sample into up and down world stock market periods so that we can test whether there are statistically significant differences in pricing exchange rate exposure in such market conditions.

The econometric specification that captures the above conditions can be written as:

$$\begin{aligned}\tilde{R}_{jt} = \{&[\delta_0^u D + \delta_0^d (1-D)][1 - (\beta_j^{um} D + \beta_j^{dm}(1-D))] + \delta_i^u \beta_j^{ui} D + \delta_i^d \beta_j^{di}(1-D) + \\ &\delta_s^u \beta_j^{us} D + \delta_s^d \beta_j^{ds}(1-D)\} + \beta_j^{um} \tilde{R}_{mt} D + \beta_j^{dm} \tilde{R}_{mt}(1-D) + \\ &\beta_j^{ui} \tilde{F}_{it} D + \beta_j^{di} \tilde{F}_{it}(1-D) + \beta_j^{us} \tilde{F}_{st} D + \beta_j^{ds} \tilde{F}_{st}(1-D) + \tilde{\varepsilon}_{jt} \quad (7)\end{aligned}$$

where

$D$ = Dummy variable with $D = 1$ *if* $(\tilde{R}_{mt*} - \tilde{R}_{ft}) >= 0$
(up world stock market periods) and zero otherwise (down world stock market periods)

$\beta_j^{um}$ = World stock market systematic risk of jth stock market in up world stock market periods

$\beta_j^{dm}$ = World stock market systematic risk of jth stock market in down world stock market periods

$\beta_j^{ui}$ = Inflation rate systematic risk of jth stock market in up world stock market periods

$\beta_j^{di}$ = Inflation rate systematic risk of jth stock market in down world stock market periods

$\beta_j^{us}$ = Exchange rate systematic risk of jth stock market in up world stock market periods

$\beta_j^{ds}$ = Exchange rate systematic risk of jth stock market in down world stock market periods

$\delta_i^u$ = Risk premium of inflation rate exposure in up world stock market periods

$\delta_i^d$ = Risk premium of inflation rate exposure in down world stock market periods

$\delta_s^u$ = Risk premium of exchange rate exposure in up world stock market periods

$\delta_s^d$ = Risk premium of exchange rate exposure in down world stock market periods

Measurement

$\tilde{R}_{st}$, the exchange rate variation in equation (5), corresponds to the rate of change in a world stock market capitalization-weighted exchange rate index. In previous data section of this paper, we discuss and explain its construction and estimation. Both the market excess return and exchange rate variations series are tested for stationary. Using the Augmented Dickey-Fuller test, we reject the unit root hypothesis for both series at the 1% level of significance. Therefore, a positive value in $\tilde{R}_{st}$ shows a depreciation of the U.S. dollar. The use of this proxy is adequate when foreign exchange rate variations are unanticipated. An alternative proxy would be to use the forward premium on the exchange rate. However, several empirical studies show that the forward rate is a biased estimator of future spot exchange rate and does not even outperform the current spot exchange rate (e.g., Levich, 1982).

Next, we focus on building the innovations in a world stock market capitalization-weighted inflation rate factor. To do this, we start by considering the 18 inflation rate time series associated with the countries under study. Countries' inflation rates were obtained from International Financial Statistic (IFS) available as an electronic database in the International Monetary Fund's web site. Then these series are weighted using the same weights that arise from the MSCI world index. Thus, we obtain a composite factor that represents a world stock market capitalization-weighted inflation rate factor. However, in our framework, investors should price only orthogonal innovations associated with this factor. We generate such innovations by first taking the residuals that arise after running an autoregressive world inflationary model (AR Model). The AR model has the following specification: the composite world index inflation rate is used as a dependent variable. The independent variables are lags 1, 3, 5, 11, 12, 13, and 24, of the dependent variable and are all significantly different from zero at the 5% level. The model has a R-Squared of 0.67 and was the best fitted model compared to alternative AR specifications according to Schwarz' criterion. Using the Augmented Dickey-Fuller test, we reject the unit root hypothesis at the 1% level of significance for the innovations (residuals) that arise from previous AR model. Then, in order to get orthogonality, we run a new OLS regression where previous residuals enter as dependent variables and the world stock market returns as independent variables. Thus, the new residuals generated from previous regression represent the orthogonal series of inflation rate innovations, which is used further as $\tilde{F}_{it}$ in this research.

Variations in the value of $\tilde{R}^{*}_{jt}$ are estimated by the MSCI rate of return of *j*th stock market index included in the sample. Excess Returns, $\tilde{R}_{jt}$, are computed by subtracting the series of monthly return on a 3-month U.S. Treasury Bill available in the Federal Reserve electronic database. It should be noted that the world stock market return was higher than the contemporaneous U.S. risk-free return (up market periods) in 230 instances during the sample period of January 1973 through June 2007. It was lower in 184 instances (down market periods). This yields a statistic of approximately 56% and 44% for up and down world stock market periods, respectively. This observation is useful for further pricing analysis of foreign exchange rate exposure in such world stock market conditions.

Empirical Results

We start by reporting factor analysis results. The overall significance of the excess stock market returns' correlation matrix is jointly analyzed through the Barlett and MSA tests. The first test shows that the correlations, when taken overall, are significant at the 1% level. The Barlet test of sphericity yields a value of 4,286 with a p-value of 0.00 for 153 relevant correlations among the 18 stock markets under study. However, this test is able to test the presence of nonzero correlations but not the pattern of these correlations. The second test, which is able to manage this issue, is the measure of sampling adequacy

(MSA test), which in this case falls in the acceptable range (over 0.50) with a value of 0.944. Therefore, the set of variables meet the requirements for factor analysis. The next step is to select the number of factors to be extracted. We use the principal component as method of extracting factors. Table 1 shows information regarding the 18 possible factors and their relative explanatory power as expressed by their eigenvalues. In addition to assessing the relative importance of each factor, the eigenvalues can be used to select the number of factors. Thus, according to the latent root criterion, three factors can be retained.

The rationale for the latent root criterion is that any individual factor should account for the variance of at least a single variable if it is to be retained for analysis. Each variable contributes a value of 1 to the total eigenvalue. Thus, only factors having latent roots or eigenvalues greater than 1 are considered significant. These three factors account for 62% of the variance of the 18 excess market returns' database. Therefore, the results after applying factor analysis suggest the presence of three significant risk factors. This is an important finding that is incorporated in the specification of the three factor model whose results are further reported in this section.

Table 1: Total Variance Explained

| Factor | Eigenvalues | | |
|---|---|---|---|
| | Total | % of Variance | Cumulative % |
| 1 | 8.724 | 48.090 | 48.090 |
| 2 | 1.470 | 8.103 | 56.193 |
| 3 | 1.050 | 5.788 | 61.981 |
| 4 | 0.873 | 4.812 | 66.793 |
| 5 | 0.700 | 3.859 | 70.652 |
| 6 | 0.636 | 3.506 | 74.158 |
| 7 | 0.603 | 3.324 | 77.482 |
| 8 | 0.557 | 3.070 | 80.552 |
| 9 | 0.515 | 2.839 | 83.391 |
| 10 | 0.477 | 2.629 | 86.021 |
| 11 | 0.465 | 2.563 | 88.584 |
| 12 | 0.422 | 2.326 | 90.910 |
| 13 | 0.374 | 2.062 | 92.972 |
| 14 | 0.335 | 1.847 | 94.818 |
| 15 | 0.281 | 1.549 | 96.367 |
| 16 | 0.266 | 1.466 | 97.834 |
| 17 | 0.217 | 1.196 | 99.030 |
| 18 | 0.176 | 0.970 | 100.000 |

*First column in Table 1 shows the factors extracted after applying factor analysis. Second column shows eigenvalues associated to each factor. Third column shows the % of total data variance explained by each correspondent factor and the last column shows the cumulative % of variance when additional factor are added.*

Table 2 shows the world stock market systematic risk and exchange rate exposure of the 18 stock markets for the unrestricted linear three-factor model. The exchange rate exposure coefficients are presented after accounting for the effects of both the world stock market factor and the orthogonal world stock market capitalization-weighted inflation rate factor. Thus, Table 2 reports results that are estimated under unrestricted conditions using the SUR method of estimation. Conversely, Table 3 reports results obtained under restricted parameters for the model, in line with the SUR estimation in equation (7). The results are reported separately for up and down world stock market periods.

Across models and stock markets, the results show that the exchange rate exposure coefficients appear to be very different for either up or down world stock market periods. A negative sign for a single stock market's exposure coefficient indicates that this stock market tends to decrease investors' benefits when U.S. dollar depreciates. That is the case of the U.S. stock market. Given that on average the U.S. stock market index is characterized by import net-oriented industries, their stock prices tend to decrease when the dollar falls. Conversely, a positive sign shows that a stock market tends to increase investors' benefits when the U.S. dollar depreciates. Austria, Belgium, Denmark, France, Germany, Japan, and Switzerland, where export-oriented industries compete in worldwide-diversified operations, illustrate this condition.

Japan, for instance, has experienced a strong yen in recent years making Japanese exports more expensive.

The stock markets of previously cited countries show significant positive exposure coefficients either in up or down world stock market periods. To empirically test whether the exchange rate exposure coefficients are equal across stock markets, Wald-test statistics are presented at the bottom of Table 2. These statistics significantly reject the null hypothesis of equal exchange rate exposure coefficients. Therefore, we find significant cross-sectional variations in exchange rate exposure coefficients across stock markets in up and down world stock market periods, respectively.

Table 2: Exchange Rate Exposure of Stock Markets (Monthly Data, January 1973-June 2007).
Unrestricted Three-Factor Model

$$\tilde{R}_{jt} = \alpha_j^u D + \alpha_j^d (1-D) + \beta_j^{um} \tilde{R}_{mt} D + \beta_j^{dm} \tilde{R}_{mt} (1-D) + \beta_j^{ui} \tilde{F}_{it} D + \beta_j^{di} \tilde{F}_{it} (1-D) + \beta_j^{us} \tilde{F}_{st} D + \beta_j^{ds} \tilde{F}_{st} (1-D) + \tilde{\varepsilon}_{jt}$$

| | Stock Market | Up World Stock Market Periods: Exchange Rate Beta (after accounting for the effects of world stock market and inflationary factor) | Up World Stock Market Periods: Exchange Rate Beta Standard Error | Down World Stock Market Periods: Exchange Rate Beta (after accounting for the effects of world stock market and inflationary factor) | Down World Stock Market Periods: Exchange Rate Beta Standard Error |
|---|---|---|---|---|---|
| | | $\beta_j^{us}$ | $S(\beta_j^{us})$ | $\beta_j^{ds}$ | $S(\beta_j^{ds})$ |
| 1 | Australia | 0.026648 | 0.167087 | -0.010085 | 0.169244 |
| 2 | Austria | 0.823911* | 0.165091 | 0.731473* | 0.167221 |
| 3 | Belgium | 0.628596* | 0.126170 | 0.619198* | 0.127798 |
| 4 | Canada | -0.315294* | 0.113885 | -0.211302 | 0.115354 |
| 5 | Denmark | 0.361516* | 0.128547 | 0.741544* | 0.130206 |
| 6 | France | 0.479450* | 0.141136 | 0.373308* | 0.142957 |
| 7 | Germany | 0.318767* | 0.140290 | 0.501158* | 0.142100 |
| 8 | Hong Kong | 0.956450* | 0.279157 | -0.407100 | 0.282760 |
| 9 | Italy | 0.271876 | 0.197414 | 0.399659* | 0.199961 |
| 10 | Japan | 0.897598* | 0.134311 | 0.772014* | 0.136044 |
| 11 | Netherlands | 0.186044 | 0.099776 | 0.329696* | 0.101063 |
| 1 | Norway | 0.155107 | 0.188605 | 0.140738 | 0.191039 |
| 13 | Singapore | -0.218628 | 0.205343 | -0.052545 | 0.207973 |
| 14 | Spain | 0.458764* | 0.161563 | 0.217807 | 0.163648 |
| 15 | Sweden | 0.074771 | 0.161507 | 0.039323 | 0.163591 |
| 16 | Switzerland | 0.590408* | 0.111115 | 0.561191* | 0.112549 |
| 17 | U.Kingdom | 0.353373* | 0.140096 | 0.160892 | 0.141903 |
| 18 | U.S.A | -0.530197* | 0.060361 | -0.524964* | 0.061140 |
| Test of Equal Exchange Rate Betas | | | | | |
| Wald Test | | 169.2167* | | 151.5465* | |
| [p-value] | | [0.0000] | | [0.0000] | |

*The header of Table 2 shows the specification of the unrestricted three-factor model where Rmt is the MSCI value-weighted world stock market return. $F_{it}$ is the orthogonal component of innovations in a composite inflationary factor. D is a dummy variable which takes D =1 if $R^*_{mt} >= R_{ft}$ (up world stock market periods) and D = 0 otherwise (down world stock market periods). Fst is the orthogonal component of the exchange rate variation. Second column in Table 2 shows the stock markets under study. Third and fourth columns show the exchange rate betas and their correspondent standard error in up world stock market periods, respectively. Fourth and fifth columns show the exchange rate betas and their correspondent standard error in down world stock market periods, respectively.* Significant at the 5-percent level.*

Next, the Wald test and p-value columns reported in Table 3 show the value of the test and its statistical significance under the null hypothesis of equal exchange rate exposure coefficients in up and down world stock market periods for each stock market under study. The null hypothesis is rejected only for Denmark and Hong Kong stock markets, which indicates statistically different exchange rate exposure coefficients at the 5% level. Therefore, investors in these stock markets seem to react differently to the exchange rate risk factor in up and down world stock market periods, respectively. However, for the remaining 16 stock markets, investors seem to react similarly under previous world stock market conditions. Given the presence of asymmetries in the exchange rate exposure for some stock markets and significant differences in this exposure across all stock markets for up and down world stock market periods, these findings allow us to continue with the pricing analysis of exchange rate risk.

Table 3: Exchange Rate Exposure of Stock Markets (Monthly Data, January 1973-June 2007). Restricted Three-Factor Model

$$\tilde{R}_{jt} = \{[\delta_0^u D + \delta_0^d (1-D)][1-(\beta_j^{um} D + \beta_j^{dm}(1-D))] + \delta_i^u \beta_j^{ui} D + \delta_i^d \beta_j^{di}(1-D) + \delta_s^u \beta_j^{us} D + \delta_s^d \beta_j^{ds}(1-D)\} + \beta_j^{um} \tilde{R}_{mt} D + \beta_j^{dm} \tilde{R}_{mt}(1-D) + \beta_j^{ui} \tilde{F}_{it} D + \beta_j^{di} \tilde{F}_{it}(1-D) + \beta_j^{us} \tilde{F}_{st} D + \beta_j^{ds} \tilde{F}_{st}(1-D) + \tilde{\varepsilon}_{jt}$$

| | Stock Market | Up World Stock Market Periods<br>**Exchange Rate Beta**<br>(after accounting for the effects of world stock market & inflationary factor)<br>$\beta_j^{us}$ | Down World Stock Market Periods<br>**Exchange Rate Beta**<br>(after accounting for the effects of world stock market & inflationary factor)<br>$\beta_j^{ds}$ | Wald Test | |
|---|---|---|---|---|---|
| 1 | Australia | 0.043053 | 0.003450 | 0.027709 | 0.8678 |
| 2 | Austria | 0.831356* | 0.726547* | 0.197118 | 0.6571 |
| 3 | Belgium | 0.630252* | 0.627745* | 0.000195 | 0.9888 |
| 4 | Canada | -0.307060* | -0.208793 | 0.368009 | 0.5441 |
| 5 | Denmark | 0.358965* | 0.746307* | 4.491892* | 0.0341 |
| 6 | France | 0.483747* | 0.379040* | 0.271078 | 0.6026 |
| 7 | Germany | 0.305996* | 0.518897* | 1.136482 | 0.2864 |
| 8 | Hong Kong | 0.939063* | -0.371498 | 10.90457* | 0.0010 |
| 9 | Italy | 0.267074 | 0.402000* | 0.231389 | 0.6305 |
| 10 | Japan | 0.891550* | 0.757924* | 0.480542 | 0.4882 |
| 11 | Netherlands | 0.176053 | 0.137960* | 1.407557 | 0.2365 |
| 12 | Norway | 0.166111 | -0.006655 | 0.011016 | 0.9164 |
| 13 | Singapore | -0.209620 | -0.006655 | 0.483655 | 0.4868 |
| 14 | Spain | 0.464311* | 0.212214 | 1.203602 | 0.2726 |
| 15 | Sweden | 0.051105 | 0.052201 | 0.000022 | 0.9962 |
| 16 | Switzerland | 0.585710* | 0.575107* | 0.004508 | 0.9465 |
| 17 | U.Kingdom | 0.365556* | 0.171175 | 0.946967 | 0.3305 |
| 18 | U.S.A | -0.527334* | -0.519507* | 0.007630 | 0.9304 |

*Notes: The header of Table 3 shows the specification of the restricted three-factor model where $R_{mt}$ is the MSCI value-weighted world stock market return. $F_{it}$ is the orthogonal component of innovations in a composite inflationary factor. D is a dummy variable which takes D =1 if $R^*_{mt}$ >= $R_{ft}$ (up world stock market periods) and D = 0 otherwise (down world stock market periods). $F_{st}$ is the orthogonal component of the exchange rate variations. Second column in Table 3 shows the stock markets under study. Third and fourth columns show the exchange rate betas in up and down world stock market periods, respectively. Fourth column shows the Wald test while fifth column its correspondent p-value. Wald test tests whether there is significant difference between up and down exchange rate betas.* Significant at the 5-percent level.*

It is important to note that parameters reported in Tables 2, 3 and 4 are estimated using generalized least squares seemingly unrelated regressions (SUR), which has been documented to be a more powerful technique than the traditional Fama-MacBeth (1973) approach. The SUR technique offers two advantages. First, the constraints imposed by the models to the parameters can be tested by a likelihood ratio test. This test is defined as $L(k) = T \ln \frac{|\Sigma R|}{|\Sigma U|}$ and is distributed as a $\chi^2$ with $k$ degrees of freedom equal to the difference between the number of parameters estimated under unrestricted and restricted three factor model, respectively. The values of $|\Sigma R|$ and $|\Sigma U|$ represent the determinants of the residual covariance matrices of the restricted and unrestricted model, respectively. T is the number of observations. This test also allows us to evaluate the extent to which the models fit the data. Second, following the SUR technique no data is lost. In the Fama-McBeth approach, the initial data period (typically 5 years) is lost when the $\beta$ parameters are estimated by OLS regression.

Table 4 shows the exchange rate risk premia ($\delta$ coefficients) and their respective standard errors for up and down world stock market periods after running the restricted three-factor model. We also perform tests for foreign exchange rate exposure without including up and down world stock market periods (equation (6)). The tests for such model (not reported here) confirm that the exchange rate exposure coefficient is not significantly different from cero. Thus, the foreign exchange rate exposure is not priced under such conditions. This result is in line with Jorion's method where such risk is not price in the U.S. stock market.

The last column shows the chi-squares statistics for the cross-sectional restrictions imposed on the model. With no variations for up world stock market periods, the pricing of exchange rate exposure results are small and insignificant in any time periods. Conversely, for down world stock market periods the price of exchange rate risk is positive and significant with one exception in the period from July 1984 through December 1995. Yet, for the entire period of January 1973 to December 2007, it is positive and significant. Previous results indicate that investors who invest in those stock markets with positive exposure (e.g., 0.233 an average estimate number for exchange rate coefficients in the restricted three-factor model, see Table 3) require 4.1% more USD annual return than those who invest in the stock markets with no exposure.

Table 4: Pricing of Exchange Rate Risk (Monthly Data January 1973-June 2007). Restricted Three-Factor Model

$$\widetilde{R}_{jt} = \{[\delta_0^u D + \delta_0^d (1-D)][1 - (\beta_j^{um} D + \beta_j^{dm}(1-D))] + \delta_i^u \beta_j^{ui} D + \delta_i^d \beta_j^{di}(1-D) + \delta_s^u \beta_j^{us} D + \delta_s^d \beta_j^{ds}(1-D)\} + \beta_j^{um}\widetilde{R}_{mt} D + \beta_j^{dm}\widetilde{R}_{mt}(1-D) + \beta_j^{ui}\widetilde{F}_{it} D + \beta_j^{di}\widetilde{F}_{it}(1-D) + \beta_j^{us}\widetilde{F}_{st} D + \beta_j^{ds}\widetilde{F}_{st}(1-D) + \widetilde{\varepsilon}_{jt}$$

| Period | Up World Stock Market Periods Exchange Rate Risk Premium $\delta_s^u$ (Coefficient Standard Error) | Down World Stock Market periods Exchange Rate Risk Premium $\delta_s^d$ (Coefficient Standard Error) | Test of Fit (p-values) $\chi^2_{30}$ |
|---|---|---|---|
| 1973:01-2007:06 | -0.002274 | **0.014712*** | 41.61 |
| | (0.002622) | (0.005969) | (0.077) |
| 1973:01-1984:06 | -0.031168 | **0.010940*** | 37.83 |
| | (0.055372) | (0.002478) | (0.154) |
| 1984:07-1995:12 | 0.012026 | -0.100937 | 27.95 |
| | (0.009456) | (0.340192) | (0.573) |
| 1996:01-2007:06 | -0.089370 | **0.014207*** | 34.48 |
| | (0.111720) | (0.007080) | (0.262) |

*The header of Table 4 shows the specification of the restricted three-factor model where $R_{mt}$ is the MSCI value-weighted world stock market return. Fit is the orthogonal component of innovations in a composite inflationary factor. D is a dummy variable which takes D =1 if $R^*_{mt} >= R_{ft}$ (up world stock market periods) and D = 0 otherwise (down world stock market periods). $F_{st}$ is the orthogonal component of the exchange rate variations.Second column in Table 4 shows the exchange rate risk premium and its correspondent standard error through four up world stock market subperiods. Third column shows the exchange rate risk premium and its correspondent standard error through four down world stock market subperiods. The last column shows The chi-square statistic $\chi^2_{30}$, which tests the cross-sectional restrictions required by the three-factor model, with a 5% critical value of 43.77.*
**Significant at the 5% level*

## SUMMARY AND CONCLUSIONS

An increasing number of empirical studies based on Ross's Arbitrage Pricing Theory (APT) have studied the effect of exchange rate risk on stock market returns and adopted either unconditional time-unvarying ways to test the models or alternative conditional time-varying approaches. Nonetheless, following the conditional approach to up and down stock market periods developed by Pettengill et al. (1995), there is no empirical evidence on whether foreign exchange exposure commands different and significant conditional risk premia in such market conditions.

We replicate Pettengill et al.'s empirical observation by inspecting the world stock market return and the risk-free rate series. The results indicate that, for the entire sample period of January 1973 through June 2007, 56% of the time the world stock market return was higher than the contemporaneous U.S. risk-free rate (up market periods) and was lower 44% of the time (down market periods). From this observation, we conclude that the examination of the pricing of foreign exchange exposure is a relevant issue under such world stock market conditions. Consequently, the purpose of this paper is to examine the pricing of exchange rate risk when the world stock market returns are split into up and down world stock market periods within a framework of three-factor APT model. Our findings, after applying factor analysis, suggest the presence of three significant risk factors.

The results also suggest that exchange rate risk appears to be a diversifiable risk in up world stock market periods. For down market periods (pessimistic stock market periods), the risk appears to be not diversifiable. In fact, under down world stock market periods, the empirical results show that investors who invest in those stock markets with positive exposure (i.e., 0.233, an average estimate number for restricted three-factor model, see Table 4) demand 4.1% more USD annual return than those who invest in those stock markets with no exposure.

Therefore, financial hedging strategies seem to be justified when investors face low international stock market returns due to depressed world stock market conditions. In such conditions, the investors try to protect their returns against exchange rate exposure and, thus, hedge their returns. It is important to note that the results on this study are conditional to the currency used as numeraire. We use the USD as numeraire. Future research can also analyze different currencies depending on what kind of currency the investors are interested on hedging. Thus, we may have euros, British pounds, yens as potential currencies for future study.

Finally, the results provide guidance to government policy-makers and financial managers worldwide. Since there is a high probability that up and down world stock market periods will be observed in the future, policymakers should offer an international regulatory financial framework that ensures adequate conditions for the development of competitive financial derivatives markets. Similarly, financial managers should be prepared to use economically the instruments designed for managing foreign exchange rate exposure, especially when they have to face depressed conditions in the world stock market.

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