Is Foreign Exchange Risk Priced in the Japanese Stock Market?

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Abstract

The exchange rate is an important variable that affects international competitiveness and performance of Japanese firms. We use an unconditional and a conditional multi-factor asset pricing model to examine whether exchange risk is recognized and priced in the Japanese stock market. The results indicate that the exchange risk is generally priced in Japan. More specifically, we provide evidence, in the unconditional model, that the exchange risk is priced in both weak and strong yen periods, when the bilateral yen/U.S. dollar exchange rate measure is used. The results are more mixed when the trade-weighted exchange rate is used. For the conditional model, the exchange risk is priced regardless of the exchange rate measure used. The combined evidence from the two models suggests an interesting observation about the role of the secular exchange rate trend in shaping the perception of exchange risk in the Japanese capital markets.

I. Introduction

A major issue in asset pricing (and the cost of capital) in an international context is whether exchange risk is priced in capital markets. Theoretically, the exchange risk may be priced if there are international differences in consumption baskets of investors or if there is a deviation from purchasing power parity. Solnik (1974), Sercu (1980), and Stulz (1981) developed models of international asset pricing where investors in different countries have different consumption baskets and face different prices of consumer goods. In such a world, asset pricing models include a risk premium term that contains the covariance of the return on an asset with the exchange risk factor. Adler and Dumas (1983) discuss the foreign exchange risk premium when there is a deviation from purchasing power parity for other reasons.[1]

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[1]Considering the specific connection between consumption basket and exchange risk, Choi (1984), however, argues that the foreign exchange risk, once created, is preserved regardless of mar-

Empirically, Jorion (1991) finds—within the framework of an unconditional multi-factor asset pricing model—that the exchange risk is not priced for the U.S. stock market, even though the sample covered the period of the 1970s and 1980s, a time when the U.S. dollar appreciated dramatically. Hamao (1988) examines the exchange risk for Japanese stocks in a similar framework and also finds that it is not priced. In another study on the Japanese market, Brown and Otsuki (1990), using non-linear seemingly unrelated regressions for an unconditional model, also provide evidence that exchange risk is not priced in the Japanese stock market. Dumas and Solnik (1995), however, show that a conditional international asset pricing model with exchange risk outperforms an unconditional model used in prior work, and report that the exchange risk is priced for equity and currency markets of the four largest countries (Germany, U.K., Japan, and the U.S.). However, their study uses national stock price *indexes* (rather than individual stock prices) and is concerned with the integrated world market as a whole (four countries) rather than a single national capital market.[2] Given partially segmented international capital markets, it is interesting to see whether the exchange risk is priced *within* a major national stock market such as Japan based on *individual* stock data. It is important to examine the disaggregate data, especially in Japan where international trade, and the currency impact on it, is traditionally given a high priority. In addition, as we empirically investigate both an unconditional and a conditional model, this allows us the unique opportunity to compare results from different model specifications using the same data set.

This paper investigates whether the exchange risk is priced in Japan within an unconditional and conditional multi-factor asset pricing model. We employ the stochastic discount factor (pricing kernel) approach in estimating our conditional model. On the other hand, our unconditional model is developed within the traditional framework by explicitly specifying and estimating the parameters in the return-generating process. We note that Zhou (1998) shows that traditional methods provide more precise estimates of the model than does the stochastic discount factor methodology in cases where the asset return process is fully specified in the economy—which is the case with our unconditional model but not the conditional model. Hence, the traditional framework is adopted for estimating the unconditional model in this paper to provide a more robust investigation and comparison of foreign exchange risk pricing with the conditional model counterpart.

In contrast to Dumas and Solnik (1995), we do not assume integrated world capital markets and use individual stock return data for Japan. Furthermore, unlike the existing work of Hamao (1988), Brown and Otsuki (1990), and He, Ng, and Wu (1996) on Japan, we use both unconditional and conditional asset pricing models, as well as an updated comprehensive stock return data set to form industry portfolios from January 1974 to December 1995. The results show that the

ket equilibrium conditions such as purchasing power parity. The exchange risk simply transforms to inflation risk under purchasing power parity, which may modify the existing asset risk depending on the specification of real returns in the investor's objective function. See Choi (1986), (1989) for the analysis of the effect of exchange rates on an individual firm.

[2]Similarly, Brown and Otsuki (1993) show that the yen/U.S. dollar is a significant factor affecting stock returns of several Pacific-Basin countries. A paper by He, Ng, and Wu (1996) also reports significant exchange exposure and pricing in Japan. Kaneko and Lee (1995) provide evidence consistent with the above findings when more recent data are used.

exchange risk is generally priced in the Japanese stock market. More specifically, we provide evidence that exchange risk—when defined as the percentage change in the bilateral rate—is priced in the unconditional model. However, the fact that the exchange risk premiums change signs intertemporally suggests a changing behavior of Japanese investors regarding the perception of exchange risk based on the secular yen/U.S. dollar rate trend. The conditional model provides evidence that exchange risk is priced, and that these findings are robust with respect to the choice of exchange rate data, the method of portfolio formation, and model specification. These results have important implications for asset valuation for portfolio managers in Japan as well as the determination of the cost of capital in Japan and for Japanese firms.

II. The Unconditional Model

We assume a three-factor return-generating process where the ith industry portfolio excess return over the risk-free (i.e., call) rate is a linear function of the orthogonalized exchange risk factor, $\widehat{R}_{\mathrm{FX},t}$, orthogonalized interest rate risk factor, $\widehat{R}_{\mathrm{INT},t}$, and the market risk factor, $R_{\mathrm{MKT},t}$,

$$(1) \qquad R_{it} = \beta_{0i} + \widehat{\beta}_{\mathrm{FX},i}\widehat{R}_{\mathrm{FX},t} + \widehat{\beta}_{\mathrm{INT},i}\widehat{R}_{\mathrm{INT},t} + \beta_{\mathrm{MKT},i}R_{\mathrm{MKT},t} + \nu_{it},$$

where the coefficients $\widehat{\beta}_{\mathrm{FX},i}$, $\widehat{\beta}_{\mathrm{INT},i}$, and $\beta_{\mathrm{MKT},i}$ are the orthogonalized foreign exchange risk, orthogonalized interest risk, and the market risk exposure coefficients for industry i, respectively, and ν_{it} is the error term. The hat notation in equation (1) denotes that either the variable is orthogonalized or that the coefficient is for an orthogonalized variable. Orthogonalization is achieved by running a side regression of the actual percentage change in the exchange rate on the market factor. Then the orthogonalized exchange risk factor is defined as the difference between the actual percentage change in the exchange rate and the estimated value (Elton and Gruber (1991)). The orthogonalized interest rate factor is obtained in the same fashion but adjusted with respect to both the market and exchange risk factors. Thus, the mean value of the orthogonalized exchange risk factor and interest risk factor is zero conditional on the market.[3]

Inclusion of the exchange risk factor in a stock return equation was suggested by Adler and Dumas (1983) and empirically examined in work by Jorion (1990), (1991), Bodnar and Gentry (1993), Choi and Prasad (1995), He and Ng (1998), and others. However, a large volume of literature (e.g., Sweeney and Warga (1986)) suggests an alternative two-factor model with interest rate risk and market risk. Oxelheim and Wihlborg (1987), Choi, Elyasiani, and Kopecky (1992), and Prasad and Rajan (1995) apply a multi-factor model to interest rate and foreign exchange risks in addition to market risk.

We assume a three-factor pricing model so that the expected excess return over the risk-free rate for portfolio i, $E(R_{it})$, takes the following form,

$$(2) \qquad E(R_{it}) = \lambda_0 + \widehat{\lambda}_{\mathrm{FX}}\widehat{\beta}_{\mathrm{FX},i} + \widehat{\lambda}_{\mathrm{INT}}\widehat{\beta}_{\mathrm{INT},i} + \lambda_{\mathrm{MKT}}\beta_{\mathrm{MKT},i},$$

[3]We can also interpret the orthogonalized exchange risk factor as a conditional unexpected change in the exchange rate.

where the constant term λ_0 reflects the zero beta portfolio return in excess of the risk-free rate (which ought to be zero), $\widehat{\lambda}_{FX}$ is the premium on the exchange risk, $\widehat{\lambda}_{INT}$ is the premium on the interest rate risk, and λ_{MKT} is the premium on the market risk. Since $E(R_{MKT,t}) = \lambda_0 + \lambda_{MKT}$, then we can rewrite (2) to obtain

$$(3) \qquad E(R_{it}) = \lambda_0 + \widehat{\lambda}_{FX}\widehat{\beta}_{FX,i} + \widehat{\lambda}_{INT}\widehat{\beta}_{INT,i} + [E(R_{MKT,t}) - \lambda_0]\beta_{MKT,i}.$$

Taking expectations of equation (1) and subtracting them from (1) gives

$$(4) \quad R_{it} = E(R_{it}) + \widehat{\beta}_{FX,i}\widehat{R}_{FX,t} + \widehat{\beta}_{INT}\widehat{R}_{INT,t} + \beta_{MKT,i}[R_{MKT,t} - E(R_{MKT,t})] + \nu_{it}.$$

Next substitute (3) into (4) to yield

$$(5) \qquad R_{it} = \lambda_0(1 - \beta_{MKT,i}) + \widehat{\lambda}_{FX}\widehat{\beta}_{FX,i} + \widehat{\lambda}_{INT}\widehat{\beta}_{INT,i} + \widehat{\beta}_{FX,i}\widehat{R}_{FX,t} + \widehat{\beta}_{INT}\widehat{R}_{INT,t} + \beta_{MKT,i}R_{MKT,t} + \nu_{it},$$

which is the unconditional equation we use to obtain estimates of the risk premiums.

III. The Conditional Model

Following Dumas and Solnik (DS hereafter) (1995), we assume that the expected excess return over the risk-free rate on an asset or portfolio i at time t, $E[R_{it}|\Omega_{t-1}]$, is conditional on an information set Ω_{t-1} available at $t-1$. DS employ a model with exchange rate factors and a world market risk factor. We assume the following K-factor conditional asset pricing model for portfolio i,

$$(6) \qquad E(R_{it}|\,\Omega_{t-1}) = \lambda_0(\Omega_{t-1}) + \sum_{k=1}^{K} \gamma_k(\Omega_{t-1})\,\mathrm{cov}(R_{it}, R_{kt}|\,\Omega_{t-1}),$$

where $E(R_{it}|\Omega_{t-1})$ is the expected excess return on portfolio i, $\mathrm{cov}(R_{it}, R_{kt})$ denotes the covariance between the ith portfolio excess return and the kth risk factor, R_k, λ_0 is the zero-beta portfolio return in excess of the risk-free rate conditioned on information set Ω_{t-1}, γ_k is the price of the kth risk factor also conditioned on information set Ω_{t-1}. In the basic model, we employ a three-factor model with market, interest rate, and exchange rate risk factors for k = MKT, INT, FX. Specifically, we include the following measures for the risk factors: R_{MKT} is the excess return on the domestic market index, R_{INT} is the first difference in the yield of long-term Japanese government bonds, and R_{FX} is the percentage change in the exchange rate. Note that equation (6) in this factor setting is the same as equation (2) in the special case where the information set is stationary ($\Omega_{t-1} = \Omega$ for all t).[4] Following DS, we alternatively test the two-factor model with the market and exchange risk as a special case. To examine the effect of partial segmentation of international capital markets, we also consider the augmented four-factor model

[4]Conditions, $\lambda_k = \gamma_k[\mathrm{var}(R_k)]$ for k = MKT, INT, FX, assure that equation (6), the conditional model, is equivalent to equation (2), the conditional model, in the special case $\Omega_{t-1} = \Omega$ for all t.

with the world market return. All four risk factors mentioned here are suggested in theoretical international asset pricing models.[5]

The first order condition for a portfolio choice problem can be written as

$$(7) \qquad E[M_t(1+\rho_{t-1}) | \Omega_{t-1}] = 1,$$

$$(8) \qquad E[M_t R_{it} | \Omega_{t-1}] = 0, \quad \text{for } i = 1, \ldots, n\text{th portfolio},$$

where M_t is the conditional marginal rate of substitution between nominal returns from time $t-1$ to time t or the pricing kernel, and ρ_{t-1} is the conditional risk-free rate at time $t-1$. Any asset pricing model is a particular application of M_t (Ferson (1995)). The basic model's conditional marginal rate of substitution, M_t, is specified as

$$(9) \quad M_t = \frac{[1 - \gamma_{0,t-1} - \gamma_{\text{FX},t-1} R_{\text{FX},t} - \gamma_{\text{MKT},t-1} - R_{\text{MKT},t} - \gamma_{\text{INT},t-1} R_{\text{INT},t}]}{(1+\rho_{t-1})},$$

where $\gamma_{0,t-1}$ represents a time-varying constant.[6]

In order to empirically implement the model above, we must specify the variables contained in the information set Ω_{t-1}. We specify a row vector of L instrumental variables, $\mathbf{Z}$, as a proxy for Ω_{t-1}. Thus, the risk premium γ_k or the price of risk for factor k, as well as γ_0, is conditioned on $\mathbf{Z}_{t-1}$. Furthermore, the risk premiums and γ_0 are assumed to be linearly related to the instruments such that

$$(10) \qquad \gamma_{0,t-1} = -\mathbf{Z}_{t-1}\phi'_0,$$

$$(11) \qquad \gamma_{k,t-1} = \mathbf{Z}_{t-1}\phi'_k,$$

where the ϕ's are row vectors of weights for the instruments for each of the k risk factors. In our basic three-factor model, k = FX, MKT, INT. We employ six instruments in the basic model: a constant; the long-term government bond yield in excess of the call rate, BOND; the lagged excess return on the equally-weighted market index, R_{EWR}; the dividend yield in excess of the call rate, DIV; the call rate, r; and the January dummy, JD. These variables are defined at time $t-1$ (with the exception of JD) and, thus, reflect the most recent available information prior to time t. These instruments are consistent with those used by Ferson and Harvey (1991) for the U.S. market, as well as Harvey (1991), DS (1995), and Solnik (1993) for international markets.[7]

The pricing error for period t, u_t, is given by $u_t = 1 - M_t(1+\rho_{t-1})$ from equation (7). Then it follows that

$$(12) \qquad u_t = -\mathbf{Z}_{t-1}\boldsymbol{\phi}'_0 + \mathbf{Z}_{t-1}\boldsymbol{\phi}'_{\text{FX}} R_{\text{FX},t} + \mathbf{Z}_{t-1}\boldsymbol{\phi}'_{\text{MKT}} R_{\text{MKT},t} + \mathbf{Z}_{t-1}\boldsymbol{\phi}'_{\text{INT}} R_{\text{INT},t},$$

[5]Solnik (1974) and Stulz (1981), (1992), among others, suggest such risk factors. Choi and Rajan (1997) empirically examine the domestic market, world market, and exchange risk factors jointly.

[6]The constant term, $\gamma_{0,t-1}$, does not represent any part of the expected return in the conditional model, i.e., equation (6), but is determined by the current level of the conditional short rate of interest and that of the conditional risk premiums.

[7]Our use of the lagged equally-weighted index is based on Chan, Hamao, and Lakonishok (1991) who suggest that an equally-weighted index performs substantially better in predicting cross-sectional returns than the value-weighted index depending on the size of the portfolio investigated.

assuming that equations (10) and (11) hold. The pricing errors should be zero, on average, conditional on the set of instrumental variables. From equation (8), we can define the innovation h_{it} as

$$(13) \qquad h_{it} = R_{it} - R_{it}u_t, \quad \text{for } i = 1, \ldots, n\text{th portfolio.}$$

The expected value of the innovations in equation (13), conditioned on the information set of instrumental variables, is zero. The assumption $E[\boldsymbol{\delta}_t|\mathbf{Z}_{t-1}] = 0$, where $\delta_t = (u_t, \mathbf{h}_t)$ implies the unconditional condition of $E[\delta_t \mathbf{Z}_{t-1}] = 0$. Hansen's (1982) generalized method of moments (GMM) minimizes the average deviation from the moment condition $\delta_t \mathbf{Z}_{t-1} = 0$. Since we use six instruments in this study and have 14 residual series (13 return series from equation (13) and the one innovation variable from equation (12) in the base case of 13 industry portfolios), there are $84(=14 \times 6)$ moment conditions.

Finally, it must be noted that our use of a combination of risk factors and instruments may also be viewed as an extension of macroeconomic or firm-specific fundamental multi-factor unconditional models in the tradition of Chen, Roll, and Ross (1986) and Fama and French (1992). However, in contrast to their method of including fundamental variables directly in the asset return equation, we include those risk factors specifically suggested in the theoretical asset pricing models while including others as instruments. We believe that our method has an advantage in that risk factors are chosen on the basis of international asset pricing theory rather than an ad hoc reference to the general economy.

IV. The Data

Our data span the flexible exchange rate period of January 1974–December 1995. This period is long enough to cover various macroeconomic events: the oil shocks, the high growth of the Japanese economy in the late 1970s to early 1980s, a time of large government deficits, a growing surplus in the merchandise trade balance, the "bubble period" of the mid to late 1980s, and the economic sluggishness associated with the post-bubble period of the early 1990s. Most important, our sample period roughly coincides with a period of continuous yen appreciation and includes one of the most dramatic incidents of appreciation following the Plaza accord in 1985. Given these changes and dynamics of the Japanese economy, we would expect that the stock market prices reflect risks generated by such underlying macro-factors, in particular, the exchange rate.

We use monthly industry portfolio returns expressed in excess of the risk-free rate (the call rate). The industry portfolio returns are fully adjusted for dividends. This data set contains all stocks listed on the first section of the Tokyo Stock Exchange (TSE). The shares of large firms are usually listed on the first section, while the second section is mostly comprised of stocks of smaller firms. There were 1,253 stocks listed on the first section of the TSE as of December 1995. Individual stocks are grouped into the following 13 value-weighted industry portfolios:

i) fishery, agriculture, forestry, and mining (15 firms); ii) construction and real estate (125 firms); iii) foods (57 firms); iv) textiles and apparel, pulp and paper, and chemicals (199 firms); v) oil and coal products, rubber products, glass and ceramic products, and non-ferrous metals (69 firms); vi) iron and steel and metal products (64 firms); vii) electric appliances and precision instruments (139 firms); viii) machinery, transportation equipment, and other products (183 firms); ix) transportation services (45 firms); x) banking and insurance (146 firms); xi) commerce and warehousing (143 firms); xii) communication and services (33 firms); and xiii) electric power and gas (14 firms).

For computational reasons (i.e., dimensional constraints of matrices), we formed 13 industry portfolios. The industry grouping used in this study is consistent with the classification scheme employed by the Investment Trust Association of Japan.[8] Our industry groups are also similar to those used by Ferson and Harvey (1991). Survivorship biases are not serious in the Japanese industry portfolio return data because delisting due to poor performance, and mergers and acquisitions on the TSE is rare in comparison to the U.S. For example, the average number of firms delisted from the first or the second section of the TSE during the 1980s was less than four per year.

The market risk factor, R_{MKT}, is a value-weighted return of the TSE first section stocks adjusted for cash dividends in excess of the call rate. The interest rate factor, R_{INT}, is the first difference in the *shinpatsu* bond yield. The *shinpatsu* bonds are 10-year Japanese government bonds newly issued in each month and first traded on the TSE. For the exchange risk factor, R_{FX}, we take the percentage change of two different exchange rates: i) the month-end nominal bilateral yen/U.S. dollar exchange rate, and ii) the multilateral trade-weighted value of the yen. A positive change in the bilateral rate indicates a depreciation of the yen against the dollar whereas a positive change in the trade-weighted exchange rate indicates an appreciation of the yen against its trading partners. Both the bilateral and trade-weighted exchange rates are obtained from the International Financial Statistics tapes of the International Monetary Fund.

For the instruments, DIV is the dividend yield in excess of the call rate, BOND is the long-term government bond yield in excess of the call rate, and R_{EWR} is the equally-weighted market return in excess of the call rate. The dividend yield is an arithmetic average of the dividend yields of all dividend paying companies listed on the first section of the TSE at the end of each month. The equally-weighted market return is computed as a percentage change of the arithmetic average of stock prices, not adjusted for dividends, for all stocks listed on the first section of the TSE. The call rate used in this study is an average of daily

[8]The Investment Trust Association of Japan adopted "industry/sector selective index" funds based on eight broad classification categories for open-end investment trust funds in Japan (Monthly Report of Investment Trust, No. 440, May 1997, pp. 59–60 in Statistical Appendix). The "industry/sector selective index" funds are further divided into 10 sub-categories, each of which is a combination of the standard industry classifications used by the TSE. Our 13 industry classification, based on TSE classifications, reflects 10 sub-categories used by the Investment Trust Association and three not used in it. See Cai, Chan, and Yamada (1997), and Brown, Goetzmann, Hiraki, Otsuki, and Shiraishi (1997) for the difference between Japanese open-type investment trusts and U.S. mutual funds.

collateralized overnight rates each month. In addition, as in DS, a January dummy variable, JD, and a constant are also included.

In the augmented model, R_{WORLD} is the value-weighted dividend-adjusted return on the world stock market portfolio (as computed by Morgan Stanley International Perspectives) in excess of the call rate (in yen terms). The world index used here is adjusted to exclude the Japanese market. As an additional instrument we used the Morgan Stanley world dividend yield in yen terms, WDIV, also adjusted to exclude the Japanese market.

Individual stock returns are aggregated in the Japan Securities Research Institute (JSRI) tape according to the standard industry classification of the TSE. In order to reflect changes in industry classification by the TSE in August 1993, the market value-weighted returns for the 13 industry portfolios are computed using the market capitalization information obtained from various issues of Monthly Reports of the Tokyo Stock Exchange. The value-weighted dividend-adjusted market returns are also from the JSRI tape, while the equally-weighted market returns (not adjusted for dividends) are from the Nikkei NEEDS tape (series #33036). The market-wide dividend yield (#33038), long-term government bond yield (#38400), *shinpatsu* government bond yield (#38410), and call rate (#33019) data are taken from the Nikkei NEEDS tape.

Summary statistics for instruments and risk factors used in this paper are presented in Table 1. The mean excess returns on both the value-weighted market and the equally-weighted market portfolio are positive for the 1974–1995 sample period. However, the high standard deviations relative to the mean for these two market returns indicate that it was also a period of high volatility and uncertainty. The bilateral and trade-weighted exchange rate data show that the yen has appreciated during the period. Note that a yen appreciation is indicated by a decrease in the yen/U.S. dollar rate or an increase in the trade-weighted value of yen.[9]

In sum, we have, in the basic model, $K =$ three risk factors, $n = 13$ industry portfolios, $L = 6$ instruments (including a constant), $T = 264$ monthly time-series observations for each variable. The number of numerical points to be estimated is $24 + (84)(85)/2 = 3594$ and the number of data points is $264(13 + 6) = 5016$.

V. Estimation of the Unconditional Multi-Factor Model

In estimating equation (5), we employ the iterated non-linear seemingly unrelated regression (SUR) method used by Gibbons (1982), and McElroy and Burmeister (1988). This method estimates the factor risk exposure coefficients and risk premiums jointly in non-linear iterations. The system is estimated separately for each of the two different exchange rates as well as for different sample periods. The results are presented in Table 2.

A likelihood ratio test is used to determine whether the data are consistent with cross-sectional restrictions imposed by the three-factor model (Choi and Rajan (1997), Campbell, Lo, and MacKinlay (1997)). We cannot reject the null hypothesis that the cross-sectional restrictions hold at the 5% significance level

[9]We did not take the reciprocal of the multilateral trade-weighted exchange rate because it may add to the measurement error due to Jensen's inequality. The trade-weighted multilateral exchange rate is more general than the bilateral rate, although it excludes non-OECD trading partners of Japan.

TABLE 1
Summary Statistics of Risk Factors and Instruments: January 1974–December 1995

	Mean (%)	Standard Deviation (%)	LBP(12)
Risk Factors:			
R_{INT}	−0.0191	0.3437	1397*
R_{MKT}	0.3520	5.1354	6.22
R_{FX} (Bilateral)	−0.3374	3.2968	15.08
R_{FX} (Weighted)	0.4199	2.3949	45.56*
R_{WORLD}	0.2216	4.4057	13.61
Instruments:			
BOND	6.4834	1.5655	26.78*
DIV	1.2208	0.5861	2618*
R_{EWR}	0.0099	4.2255	31.60*
r	0.4989	0.2332	1833*
WDIV	3.0872	0.9575	2655*

R_{INT} is the first difference of the TSE listed *shinpatsu* bond yield. R_{MKT} is the excess return on the value-weighted market index (all first section TSE stocks). R_{FX} (Bilateral) is the percentage change of the bilateral nominal yen/U.S. dollar exchange rate. R_{FX} (Weighted) is the percentage change of the trade-weighted exchange rate of the yen against the currencies of all OECD trading partners. R_{WORLD} is the excess return on the Morgan Stanley world stock price index (in yen, adjusted to exclude the Japanese market and to include the effect of dividends). BOND is the yield of long-term Japanese government bonds in excess of the call rate. DIV is the dividend yield in excess of the call rate. R_{EWR} is the excess return on the equally-weighted market index (all first section TSE stocks). r is the call rate. WDIV is the Morgan Stanley world dividend yield in yen terms, adjusted to exclude the Japanese market. LBP(12) is the Ljung-Box (portmanteau) test statistic for 12 lags and is distributed χ^2_{12} (the null hypothesis is that the series is white noise). * indicates statistical significance at the 1% level.

for both the weighted and bilateral exchange rates over the entire sample period. The only exception is the pre-Plaza period for the weighted exchange rate.

We find that both the exchange and interest rate risk price coefficients are statistically significant over the whole sample when we use the bilateral exchange rate, using both the t and Wald tests. Moreover, the price coefficient for exchange risk, $\hat{\lambda}_{FX}$, is statistically significant for both the pre-Plaza and the post-Plaza periods. This finding for the pre-Plaza period stands in contrast with Hamao (1988) who reported insignificant exchange risk pricing in Japan, although our results are only marginally significant at the 9% level based on a Wald test.[10] The significant pricing result for the entire sample period and each of the two sub-periods is consistent with the invoice currency hypothesis in which the value of the yen relative to the U.S. dollar is important not only for trade with the U.S. but also for trade with its non-U.S. trading partners due to the dollar domination of most Japanese foreign trade.

For the multilateral trade-weighted exchange rate, we find that both the exchange and interest rate risk price coefficients, however, are not statistically different from zero. A partial explanation for these results is a time-varying risk premium where the price coefficient changes in sign dramatically. This is evident in the shift of signs of the exchange risk price coefficient from the pre-Plaza to

[10]The sample size is relatively small and thus statistical significance at the 9% level for the post-Plaza period may represent only weak evidence of the pricing of the (bilateral) exchange rate risk.

TABLE 2

Unconditional Three-Factor Model Using the Multilateral Trade-Weighted Effective and Bilateral Yen/U.S. Dollar Exchange Rates: Non-Linear Seemingly Unrelated Regression, January 1974–December 1995

$$R_{it} = \lambda_0(1 - \beta_{\mathrm{MKT},i}) + \widehat{\lambda}_{\mathrm{FX}}\widehat{\beta}_{\mathrm{FX},i} + \widehat{\lambda}_{\mathrm{INT}}\widehat{\beta}_{\mathrm{INT},i} + \widehat{\beta}_{\mathrm{FX},i}\widehat{R}_{\mathrm{FX},t} + \widehat{\beta}_{\mathrm{INT}}\widehat{R}_{\mathrm{INT},t} + \beta_{\mathrm{MKT},i}R_{\mathrm{MKT},t} + \nu_{it}$$

	λ_0	$\widehat{\lambda}_{FX}$	$\widehat{\lambda}_{INT}$	LRT	Number of FX beta > 0
Multilateral Trade-Weighted Exchange Rate:					
Full Sample	2.9706	−3.8590	−0.3227	15.16	8
Jan. 74–	(1.626)	(1.541)	(1.486)		
Dec. 95	[2.64, 0.10]	[2.37, 0.12]	[2.21, 0.14]		
Pre-Plaza	−3.8632	11.9611	1.1490	18.48**	8
Jan. 74–	(0.536)	(0.589)	(0.567)		
Sept. 85	[0.287, 0.59]	[0.35, 0.55]	[0.321, 0.57]		
Post-Plaza	0.9511	−6.0143	−0.2952	13.62	4
Oct. 85–	(0.340)	(1.357)	(1.194)		
Dec. 95	[0.115, 0.73]	[1.84, 0.17]	[1.42, 0.23]		
Bilateral Yen/U.S. Dollar Exchange Rate:					
Full Sample	1.9507*	2.5403*	−0.2713*	13.38	7
Jan. 75–	(1.818)	(1.938)	(1.937)		
Dec. 92	[3.31, 0.07]	[3.75, 0.05]	[3.75, 0.05]		
Pre-Plaza	−2.4514	−5.4822*	0.2908	16.99*	5
Jan. 75–	(1.401)	(1.691)	(1.407)		
Aug. 85	[1.96, 0.16]	[2.86, 0.09]	[1.98, 0.16]		
Post-Plaza	1.0942	2.3081**	−0.2605**	10.00	9
Sept. 85–	(0.723)	(1.998)	(2.050)		
Dec. 92	[0.52, 0.47]	[3.99, 0.04]	[4.20, 0.04]		

Estimation is based on the orthogonalized exchange risk factor. $R_{\mathrm{MKT},t}$ is the unadjusted market risk factor (value-weighted market return) in excess of the call rate. $\widehat{R}_{\mathrm{FX},t}$ is the orthogonalized exchange risk factor. $\widehat{R}_{\mathrm{INT},t}$ is the orthogonalized interest rate factor. λ_0 is the return on a zero-beta portfolio in excess of the risk-free rate, $\widehat{\lambda}_{\mathrm{FX}}$ is the exchange rate risk premium, $\widehat{\lambda}_{\mathrm{INT}}$ is the interest rate risk premium, $\widehat{\beta}_{\mathrm{FX},i}$ is the orthogonalized exchange risk factor exposure coefficient, $\beta_{\mathrm{MKT},i}$ is the market factor beta, and $\widehat{\beta}_{\mathrm{INT},i}$ is the orthogonalized interest rate factor exposure coefficient. R_{it} is the value-weighted industry portfolio return in excess of the call rate. i denotes industry (13 industry portfolios). t-statistic is in parentheses. p-value for Wald statistic is in square brackets. ** and * indicate statistical significance at the 5% and 10% levels, respectively (two-tail test). LRT is the likelihood ratio test-statistic, which is distributed χ^2 (10 degrees of freedom) and used to test the cross-sectional restrictions imposed by the multi-factor model.

the post-Plaza period and, thus, provides motivation for a conditional asset pricing model.

It should be noted that the sign change of the exchange risk premium does not necessarily portray inconsistent exchange rate impacts. For the bilateral rate, in the pre-Plaza period of a secularly strong dollar, the expected equity return in Japan increases (decreases) if the portfolio's exposure to the deviation from the trend in the yen/U.S. dollar exchange rate is negative (positive). In this case, the negative (positive) exposure is the source of high (low) risk and high (low) expected return. The relationship is reversed in the post-Plaza period. It follows that the sign of the exchange risk premium could depend on prior perceptions established by the secular exchange rate trend. In other words, the shifts in investor valuation could result in changes of the pricing of exchange risk over time, sometimes very drastically. Interestingly, the first half of the post-Plaza period in our sample approximately coincides with the "bubble" period of the TSE. The valuation standard applied to Japanese firms may have changed particularly over this period. At any rate, since the unconditional model does not explicitly take into account changes in the investor valuation effect associated with currency or other macroeconomic regime or structural shifts, an application of a conditional model specification to Japanese data is in order.

He and Ng (1998) find about 25% of the 171 Japanese multinational firms' stock returns are positively and significantly correlated with contemporary (multilateral) exchange-rate changes for the January 1978 to December 1993 period. There are more statistically significant positive coefficients in the second sub-period, which approximately coincides with our post-Plaza sub-period, and the number of statistically significant positive (as well as negative) coefficients doubles over the sub-periods. This indicates relative instability of the risk exposure coefficient estimates over time. Although our industry portfolio-based result in Table 2 is opposite in direction from He and Ng, both studies suggest the instability of exchange risk exposures over a similar sample period. In addition to the changing nature of risk premiums, the instability of exchange risk also suggests the use of the conditional model rather than the unconditional model.

VI. Analysis of Instruments and Risk Factors

The conditional model we use allows for time variability of the price of risk. This specification requires the choice of instrumental variables as a proxy for the information set. Econometric estimation of the model is conducted by the generalized method of moments (GMM). Since the GMM estimation of the conditional model reflects the intertemporal change in information, we have estimated the model for the entire sample period rather than by sub-periods. Prior to estimating the price of the risk factors, we perform preliminary analysis of the data.

First, we calculate the correlations of instruments and risk factors in Table 3. The correlations between the risk factors for the basic model were not large and ranged from −0.27 to 0.35. This approximates the factor orthogonality condition required in the asset pricing model.

Second, in Table 4, we regress each risk factor on the instruments. The overall fit of each regression, as measured by the adjusted R^2, is not too high but comparable to (and slightly higher than) those reported by DS. Each instrument is statistically significant in at least one of the regressions.

TABLE 3

Correlation of Instruments and Risk Factors: January 1974–December 1995

	Instruments					Risk Factors				
	$BOND_{t-1}$	$R_{EWR,t-1}$	DIV_{t-1}	r_{t-1}	$WDIV_{t-1}$	R_{FX} (Bilateral)	R_{FX} (Weighted)	R_{MKT}	R_{INT}	R_{WORLD}
$BOND_{t-1}$	1.0									
$R_{EWR,t-1}$	−0.0859	1.0								
DIV_{t-1}	0.7388	−0.0736	1.0							
r_{t-1}	0.8258	−0.0888	0.6519	1.0						
$WDIV_{t-1}$	0.7379	−0.0813	0.7704	0.4548	1.0					
R_{FX} (Bilateral)	0.0049	0.1161	0.0289	0.0049	0.0388	1.0				
R_{FX} (Weighted)	0.0296	0.0010	−0.0203	0.0156	−0.0272	−0.6302	1.0			
R_{MKT}	−0.0439	0.0321	−0.0257	−0.0851	0.0260	−0.1121	0.0832	1.0		
R_{INT}	−0.0806	0.1909	−0.0126	−0.0275	−0.0100	0.3539	−0.2708	−0.1527	1.0	
$R_{WORLD,t-1}$	−0.0668	0.0205	−0.0100	−0.0743	0.0496	0.4420	−0.2562	0.5216	0.0504	1.0

BOND is the yield of long-term Japanese government bonds in excess of the call rate. WDIV is the Morgan Stanley world dividend yield in yen, adjusted to exclude the Japanese market. DIV is the dividend yield in excess of the call rate. R_{EWR} is the excess return on the equally-weighted market index (all first section TSE stocks). r is the call rate. R_{MKT} is the excess return on the value-weighted market index (all first section TSE stocks). R_{INT} is the first difference of the TSE listed *shinpatsu* bond yield. R_{FX} (Bilateral) is the percentage change of the bilateral nominal yen/U.S. dollar exchange rate. R_{FX} (Weighted) is the percentage change of the trade-weighted exchange rate of the yen against the currencies of all OECD trading partners. R_{WORLD} is the excess return on the Morgan Stanley world stock index (in yen terms), adjusted to exclude the Japanese market and to include the effect of dividends.

TABLE 4

Regression of Risk Factors on Instruments: January 1974–December 1995

$$R_{kt} = \beta_{k0} + \beta_{k,\mathrm{BOND}} + \mathrm{BOND}_{t-1} + \beta_{k,\mathrm{EWR}} R_{\mathrm{EWR},t-1} + \beta_{k,\mathrm{DIV}} \mathrm{DIV}_{t-1} + \beta_{k,r} r_{t-1} + \beta_{k,\mathrm{JD}} \mathrm{JD} + u_t \quad k = \mathrm{INT, MKT, FX}$$

	β_0	β_{BOND}	β_{EWR}	β_{DIV}	β_r	β_{JD}	R^2
R_{INT}	0.1602	−0.0520*	0.0152**	0.0563	−0.3914*	0.0126	0.050
	(1.510)	(1.922)	(3.070)	(1.062)	(1.825)	(0.163)	
R_{MKT}	0.6845	−0.0120	0.0281	1.262*	−2.773	1.913	0.029
	(0.427)	(0.029)	(0.374)	(1.676)	(0.856)	(1.646)	
R_{FX} (Bilateral)	−0.3851	0.0909*	−0.0595	0.3268	−0.3954	0.4616	0.016
	(0.372)	(1.873)	(0.225)	(0.631)	(1.268)	(0.614)	
R_{FX} (Weighted)	−0.1421	0.0016	0.1697	−0.3721	1.5103	−0.0997	0.005
	(0.189)	(0.044)	(0.879)	(0.984)	(0.987)	(0.181)	

R_{INT} is the first difference of the TSE listed *shinpatsu* bond yield. R_{MKT} is the excess return on the value-weighted market index (all first section TSE stocks). R_{FX} (Bilateral) is the percentage change of the bilateral nominal yen/U.S. dollar exchange rate. R_{FX} (Weighted) is the percentage change of the trade-weighted exchange rate of the yen against the currencies of all OECD trading partners. BOND is the yield of long-term Japanese government bonds in excess of the call rate. DIV is the dividend yield in excess of the call rate. R_{EWR} is the excess return on the equally-weighted market index (all first section TSE stocks). r is the call rate. JD is the January dummy variable. Numbers in parentheses are the t-values. ** and * indicate statistical significance at the 5% and 10% levels, respectively.

VII. Estimation of the Conditional Multi-Factor Pricing Models

Applying the GMM method to the set of equations in (12) and (13), we obtain estimates of the coefficients $\phi_{k,j}$, where $k = 0$, FX, MKT, INT and j = constant, EWR, BOND, DIV, JD. The coefficients are obtained in such a way that the average deviation from the moment conditions defined in equations (12) and (13) are minimized. The model is estimated for alternative exchange rate data, model specifications, and portfolio formulations.

A. The Basic Three-Factor Model

The estimation results of the basic three-factor model are presented in Table 5 when the percentage change in the trade-weighted exchange rate is used as the exchange risk factor. As evidenced by the J test for overidentifying restrictions with a p-value of 0.77, the conditional three-factor model is not rejected by the data. The results in Table 5 show the pattern of association between the price of risk and instrumental variables. For instance, an increase in the dividend yield affects the price of market and interest risk positively, and the price of exchange risk negatively. Pricing coefficients of all three risk factors (market, exchange rate, and interest rate) are negatively related to long-term bond yields. None of the risk prices is significantly affected by the equally-weighted market return with the exception of γ_0. The call rate instrument negatively affects the price of exchange risk as well as the interest risk. Differing from DS, we find that the January dummy does not have a statistically significant effect on any of the prices of risk in

Table 5. Thus, with the exception of the January dummy, each of the instruments used in this model has at least one significant effect on the time-varying expected return of industry stock portfolios.

We also used the change in the bilateral yen/U.S. dollar exchange rate as the exchange risk factor in Table 6. The results are qualitatively similar to those for the trade-weighted exchange rate.

In both Tables 5 and 6, we test various restrictions using a Wald test to examine the null hypothesis that all ϕ_{kj} coefficients of instrumental variables are zero with respect to a particular risk factor k. The test statistics in both tables show that the market risk is significant at the 1% level. Similarly, the Wald test rejects the null that all $\phi_{\mathrm{FX},j}$ coefficients for the exchange risk factor are zero at the 1% level. Similar results hold for the interest rate risk factor, and these results are robust whether the trade-weighted exchange rate is used (Table 5) or the bilateral yen/U.S. dollar rate is used (Table 6).

We also perform a time-invariant Wald test by retaining a time-invariant constant and restricting all other ϕ_{kj} coefficients to be zero with respect to a particular factor k. The null hypothesis of time-invariance is rejected for both the bilateral and trade-weighted rates.

In sum, in Tables 5 and 6, we display the results testing the conditional model with a null that the ϕ_k coefficients for all instruments are zero. The result indicates the rejection of the null at the 1% level. This suggests that the five instruments as a group have a significant relation with the prices of the three risk factors within the conditional asset pricing model. These results are consistent with He, Ng, and Wu (1996) and confirms our earliest conjecture from the unconditional model that the perception of exchange risk, i.e., exchange risk pricing, may have changed in the Japanese capital markets as a result of a change in the secular exchange rate trend from the strong dollar (relatively weak yen) period to the weak dollar (relatively strong yen) period.

B. Further Explorations

To gain additional insight about the role of exchange risk, we investigate three alternative model specifications. First, we estimate a two-factor model, similar to the one in DS (1995) and He, Ng and Wu (1996), with the market and exchange risk factors only as a special case (Table 7). The Wald test indicates that both factors are significant individually and as a group. This is true regardless of whether the risk coefficient contains a time-invariant component. Therefore, the positive presence of exchange risk reported by DS, based on price indexes for the integrated world, is transferable to the individual/industry stock data in the Japanese capital market. Overall, the above results indicate that, after the market risk, the exchange risk factor is as important as the interest rate risk factor in the Japanese stock market.

TABLE 5

GMM Estimation of the Three-Factor Model Using the Multilateral Trade-Weighted Exchange Rate and Industry Portfolios: January 1974–December 1995

$$\gamma_k = \phi_{k,\text{constant}} + \phi_{k,\text{BOND}}\text{BOND}_{t-1} + \phi_{k,\text{EWR}}R_{\text{EWR},t-1} + \phi_{k,\text{DIV}}\text{DIV}_{t-1} + \phi_{k,r}r_{t-1} + \phi_{k,\text{JD}}\text{JD} \quad k = 0, \text{FX}, \text{MKT}, \text{INT}$$

	γ_0	γ_{FX} (Weighted)	γ_{MKT}	γ_{INT}
$\phi_{k,\text{constant}}$	−0.0137	0.0119**	0.0023	0.2166
	(0.598)	(18.021)	(0.254)	(0.852)
$\phi_{k,\text{BOND}}$	0.0066	−0.0009**	−0.0035	−0.1368*
	(1.358)	(8.098)	(1.598)	(1.926)
$\phi_{k,\text{EWR}}$	−0.0025*	−0.00005	−0.0002	−0.0008
	(1.943)	(0.325)	(0.535)	(0.060)
$\phi_{k,\text{DIV}}$	−0.0111	−0.0012**	0.0096**	0.3283**
	(1.034)	(5.009)	(2.587)	(2.974)
$\phi_{k,r}$	0.0519	−0.0099**	−0.0164	−0.8341*
	(1.244)	(8.335)	(0.985)	(1.800)
$\phi_{ik,\text{JD}}$	−0.0121	0.0001	−0.0073	−0.0802
	(0.714)	(0.668)	(1.262)	(0.788)
	$k=0$	$k=\text{FX}$	$k=\text{MKT}$	$k=\text{INT}$
Null: $\phi_{k,\text{constant}} = \phi_{k,\text{BOND}} = \phi_{k,\text{EWR}} = \phi_{k,\text{DIV}} = \phi_{k,r} = \phi_{k,\text{JD}} = 0$				
χ^2(all)	5.80	3886.82	27.41	20.46
	[0.44]	[0.00]	[0.00]	[0.00]
Null: $\phi_{k,\text{BOND}} = \phi_{k,\text{EWR}} = \phi_{k,\text{DIV}} = \phi_{k,r} = \phi_{k,\text{JD}} = 0$				
χ^2 (time-invariant)	4.80	256.83	26.32	9.92
	[0.44]	[0.00]	[0.00]	[0.08]
Null: $\phi_{k,\text{constant}} = \phi_{k,\text{BOND}} = \phi_{k,\text{EWR}} = \phi_{k,\text{DIV}} = \phi_{k,r} = \phi_{k,\text{JD}} = 0$ for all k				
χ^2(cond)	6003.95			
	[0.00]			

J-test overidentifying restrictions 51.78 [0.76]

γ_0 is the time-varying constant in the GMM framework. γ_k is the price of risk for factor k(=FX, MKT, INT). BOND is the yield of long-term Japanese government bonds in excess of the call rate. DIV is the dividend yield in excess of the call rate. R_{EWR} is the excess return on the equally-weighted market index (all first section TSE stocks). r is the call rate. JD is the January dummy. R_{MKT} is the excess return on the value-weighted market index (all first section TSE stocks). R_{INT} is the first difference of the TSE listed *shinpatsu* bond yield. R_{FX} (Bilateral) is the percentage change of the bilateral nominal yen/U.S. dollar exchange rate. R_{FX} (Weighted) is the percentage change of the trade-weighted exchange rate of the yen against the currencies of all OECD trading partners. χ^2 (all) is the Wald test statistic for the null that all coefficients in the column equal zero. χ^2 (time invariant) is the Wald test statistic for the null that all coefficients in the column equal zero except $\phi_{k,\text{constant}}$. χ^2 (cond) is the Wald test statistic for null that $\phi_{k,\text{constant}} = \phi_{k,\text{BOND}} = \phi_{k,\text{EWR}} = \phi_{k,\text{DIV}} = \phi_{k,r} = \phi_{k,\text{JD}} = 0$ for all k. *J*-test for overidentifying restrictions is distributed χ^2. *t*-statistics are in parentheses. *p*-value in brackets for the Wald tests. ** and * indicate statistical significance at the 5% and 10% levels, respectively.

TABLE 6

GMM Estimation of the Three-Factor Model Using the Bilateral Exchange Rate and Industry Portfolios: January 1974–December 1995

$$\gamma_k = \phi_{k,\text{constant}} + \phi_{k,\text{BOND}}\text{BOND}_{t-1} + \phi_{k,\text{EWR}}R_{\text{EWR},t-1} + \phi_{k,\text{DIV}}\text{DIV}_{t-1} + \phi_{k,r}r_{t-1} + \phi_{k,\text{JD}}\text{JD} \qquad k = 0, \text{FX, MKT, INT}$$

	γ_0	γ_{FX} (Bilateral)	γ_{MKT}	γ_{INT}
$\phi_{k,\text{constant}}$	−0.0161	0.0118**	0.0020	0.2114
	(0.692)	(17.891)	(0.223)	(0.837)
$\phi_{k,\text{BOND}}$	0.0055	−0.0009**	−0.0034	−0.1346*
	(1.139)	(8.095)	(1.573)	(1.905)
$\phi_{k,\text{EWR}}$	−0.0018	−0.00002	−0.0002	−0.0006
	(1.438)	(0.163)	(0.555)	(0.053)
$\phi_{k,\text{DIV}}$	−0.0079	−0.0012**	0.0097**	0.3238**
	(0.749)	(4.987)	(2.617)	(2.954)
$\phi_{k,r}$	0.0441	−0.0099**	−0.0160	−0.8190*
	(1.030)	(8.314)	(0.964)	(1.778)
$\phi_{ik,\text{JD}}$	−0.0111	0.0001	−0.0070	−0.0794
	(0.649)	(0.696)	(1.231)	(0.785)
	$k=0$	$k=\text{FX}$	$k=\text{MKT}$	$k=\text{INT}$
Null: $\phi_{k,\text{constant}} = \phi_{k,\text{BOND}} = \phi_{k,\text{EWR}} = \phi_{k,\text{DIV}} = \phi_{k,r} = \phi_{k,\text{JD}} = 0$				
χ^2 (all)	3.03	3986.63	27.51	20.20
	[0.805]	[0.00]	[0.00]	[0.00]
Null: $\phi_{k,\text{BOND}} = \phi_{k,\text{EWR}} = \phi_{k,\text{DIV}} = \phi_{k,r} = \phi_{k,\text{JD}} = 0$				
χ^2 (time invariant)	3.01	255.42	26.36	9.78
	[0.69]	[0.00]	[0.00]	[0.08]
Null: $\phi_{k,\text{constant}} = \phi_{k,\text{BOND}} = \phi_{k,\text{EWR}} = \phi_{k,\text{DIV}} = \phi_{k,r} = \phi_{k,\text{JD}} = 0$ for all k				
χ^2 (cond)	6050.85			
	[0.00]			
J-test overidentifying restrictions 51.68 [0.77]				

γ_0 is the time-varying constant in the GMM framework. γ_k is the price of risk for factor k(= FX, MKT, INT). BOND is the yield of long-term Japanese government bonds in excess of the call rate. DIV is the dividend yield in excess of the call rate. R_{EWR} is the excess return on the equally-weighted market index (all first section TSE stocks). r is the call rate. JD is the January dummy. R_{MKT} is the excess return on the value-weighted market index (all first section TSE stocks). R_{INT} is the first difference of the TSE listed *shinpatsu* bond yield. R_{FX} (Bilateral) is the percentage change of the bilateral nominal yen/U.S. dollar exchange rate. χ^2 (all) is the Wald test statistic for the null that all coefficients in the column equal zero. χ^2 (time invariant) is the Wald test statistic for the null that all coefficients in the column equal zero except $\phi_{k,\text{constant}}$. χ^2 (cond) is the Wald test statistic for null that $\phi_{k,\text{constant}} = \phi_{k,\text{BOND}} = \phi_{k,\text{EWR}} = \phi_{k,\text{DIV}} = \phi_{k,r} = \phi_{k,\text{JD}} = 0$ for all k. *J*-test for overidentifying restrictions is distributed χ^2. *t*-statistics are in parentheses. *p*-value in brackets for the Wald tests. ** and * indicate statistical significance at the 5% and 10% levels, respectively.

Second, to investigate the effect of partial segmentation of international capital markets, we estimate a four-factor model by including the world market return as an additional risk factor. Inclusion of the world market factor in addition to the domestic market factor is suggested in the literature on international asset pricing under partially segmented international capital markets (survey by Stulz (1992)). Therefore, we estimate the augmented four-factor model. The return on the Morgan Stanley world market index is included as a fourth factor and the world dividend yield (Morgan Stanley) is added as a sixth instrument. The results are presented in Table 8. The Wald test indicates that the world market factor is not statistically significant. More importantly, we again find that the exchange risk is priced in the Japanese stock market regardless of whether we apply the trade-weighted or bilateral exchange rate.[11]

Finally, as these pricing results may not be robust to an alternative formation of portfolios, we estimate the basic three-factor model using the 10 asset category-based portfolios from Nikko J-MIX instead of the 13 industry based portfolios.[12] The results (not shown but available upon request) indicate that exchange risk is significantly priced whether we employ the trade-weighted or bilateral exchange rate. This provides additional evidence on the robustness of our basic finding that exchange risk is priced in the Japanese stock market for the conditional model.

An overriding conclusion from the conditional models is that the result of exchange risk pricing is economically consistent, statistically significant, and robust with respect to alternative data, model specifications, and portfolio formulations. This contrasts with the results from the unconditional model, in which the pricing significance of the exchange risk is more tentative depending on the measure of exchange rate data used as well as the period of investigation. The unconditional model does not capture the time-varying risk and risk premium when the sample covers periods of dramatic structural changes and extraordinary pricing and volatility shifts that the Japanese economy and capital markets seem to have experienced over the past three decades or so. For example, investors' exchange risk perception and pricing behavior most likely reversed through a dramatic currency regime shift from the pre-Plaza to the post-Plaza period, which partially includes the bubble formation period on the TSE. The success of the conditional model specification documented in this section is due to the fact that the time-varying risk prices during the period of significant environmental changes are explained by the instruments that we have used in our empirical investigation. Given the significant relationship between the price of exchange risk and the instrumental variables, the constancy of risk premiums assumed in the uncon-

[11]Inclusion of one additional risk factor and one additional instrument means that there are 3570 elements to be estimated but only 4427 data points. The estimated variances of the parameter estimates must be adjusted upward by a factor of approximately 5.3 for the augmented four-factor model (Ferson and Foerster (1994)).

[12]Nikko J-MIX, obtained from the Institute of Investment Technology, Nikko Securities, Co., is a broad market index consisting of major asset categories held by all investors domiciled in Japan. All equity indices are adjusted for dividends and cross shareholdings. The 10 domestic J-MIX asset classes used in this paper for portfolios are i) money market instruments; ii) domestic short-term bonds; iii) intermediate-term bonds; iv) long-term bonds; v) domestic convertible bonds; vi) small firm stocks; vi) raw materials/whole sale; viii) manufacturing; ix) social infrastructure/services; and x) financial sector stocks. These indices are mainly used for asset allocation benchmarks by Japanese investors.

TABLE 7

GMM Estimation of the Two-Factor Model with Market and Exchange Risks for Industry Portfolios: January 1974–December 1995

$$\gamma_k = \phi_{k,\text{constant}} + \phi_{k,\text{BOND}}\text{BOND}_{t-1} + \phi_{k,\text{EWR}}R_{\text{EWR},t-1} + \phi_{k,\text{DIV}}\text{DIV}_{t-1} + \phi_{k,r}r_{t-1} + \phi_{k,\text{JD}}\text{JD} \quad k = 0, \text{FX}, \text{MKT}$$

	Bilateral Yen/ U.S. Dollar Exchange Rate			Trade-Weighted Exchange Rate		
	γ_0	γ_{FX}	γ_{MKT}	γ_0	γ_{FX}	γ_{MKT}
$\phi_{k,\text{constant}}$	−0.0047	0.0121**	0.0009	−0.0044	0.0121**	0.0011
	(0.417)	(29.983)	(0.148)	(0.487)	(29.888)	(0.171)
$\phi_{k,\text{BOND}}$	0.0008	−0.0874**	−0.0021	0.0024	−0.0008**	−0.0021
	(0.308)	(13.219)	(1.320)	(1.039)	(13.094)	(1.327)
$\phi_{k,\text{EWR}}$	0.0005	−0.0001**	−0.0002	−0.0001	−0.0008	−0.0002
	(1.108)	(2.226)	(0.784)	(0.342)	(13.094)	(0.765)
$\phi_{k,\text{DIV}}$	0.0026	−0.0013**	0.0043	−0.0022	−0.0001**	0.0042
	(0.570)	(11.313)	(2.147)	(0.541)	(2.469)	(2.105)
$\phi_{k,r}$	−0.0008	−0.0100**	−0.0054	0.0135	−0.0099**	−0.0055
	(0.037)	(13.764)	(0.451)	(0.726)	(13.657)	(0.462)
$\phi_{ik,\text{JD}}$	0.0026	0.0001	0.0003	0.0027	0.0001	0.0002
	(0.233)	(1.283)	(0.063)	(0.276)	(1.299)	(0.049)
	k =0	k =FX	k =MKT	k =0	k =FX	k =MKT
Null: $\phi_{k,\text{constant}} = \phi_{k,\text{BOND}} = \phi_{k,\text{EWR}} = \phi_{k,\text{DIV}} = \phi_{k,r} = \phi_{k,\text{JD}} = 0$						
χ^2 (all)	4.396	1500.542	36.242	3.232	1428.502	35.600
	[0.62]	[0.00]	[0.00]	[0.78]	[0.00]	[0.00]
Null: $\phi_{k,\text{BOND}} = \phi_{k,\text{EWR}} = \phi_{k,\text{DIV}} = \phi_{k,\text{JD}} = 0$						
χ^2 (time invariant)	2.137	1009.750	30.719	1.681	959.821	29.933
	[0.83]	[0.00]	[0.00]	[0.89]	[0.00]	[0.00]
Null: $\phi_{k,\text{constant}} = \phi_{k,\text{BOND}} = \phi_{k,\text{EWR}} = \phi_{k,\text{DIV}} = \phi_{k,r} = \phi_{k,\text{JD}} = 0$ for all k						
χ^2 (cond)		1823.827			1874.397	
		[0.00]			[0.00]	

J-test overidentifying restrictions 64.08 [0.54]
J-test overidentifying restrictions 64.55 [0.53]

γ_0 is the time-varying constant in the GMM framework. γ_k is the price of risk for factor k(= FX, MKT). BOND is the yield of long-term Japanese government bonds in excess of the call rate. DIV is the dividend yield in excess of the call rate. R_{EWR} is the excess return on the equally-weighted market index (all first section TSE stocks). r is the call rate. JD is the January dummy. R_{MKT} is the excess return on the value-weighted market index (all first section TSE stocks). R_{FX} (Bilateral) is the percentage change of the bilateral nominal yen/U.S. dollar exchange rate. R_{FX} (Weighted) is the percentage change of the trade-weighted exchange rate of the yen against the currencies of all OECD trading partners. χ^2 (all) is the Wald test statistic for the null that all coefficients in the column equal zero. χ^2 (time invariant) is the Wald test statistic for the null that all coefficients in the column equal zero except $\phi_{k,\text{constant}}$. χ^2 (cond) is the Wald test statistic for the null that $\phi_{k,\text{constant}} = \phi_{k,\text{BOND}} = \phi_{k,\text{EWR}} = \phi_{k,\text{DIV}} = \phi_{k,r} = \phi_{k,\text{JD}} = 0$ for all k. *J*-test for overidentifying restrictions is distributed χ^2. *t*-statistics are in parentheses. *p*-value in brackets for the Wald tests. ** and * indicate statistical significance at the 5% and 10% levels, respectively.

TABLE 8

GMM Estimation of the Augmented Four-Factor Model: January 1974–December 1995

$$\gamma_{k,t} = \phi_{k,\text{constant}} + \phi_{k,\text{BOND}}\text{BOND}_{t-1} + \phi_{k,\text{EWR}}R_{\text{EWR},t-1} + \phi_{k,\text{DIV}}\text{DIV}_{t-1} + \phi_{k,r}r_{t-1} + \phi_{k,\text{JD}}\text{JD} + \phi_{k,\text{WDIV}}\text{WDIV}_{t-1} \qquad k = 0, \text{FX, MKT, INT, WORLD}$$

	Multilateral Trade-Weighted Exchange Rate					Bilateral Yen/U.S. Dollar Exchange Rate				
	γ_0	γ_{FX}	γ_{MKT}	γ_{INT}	γ_{WORLD}	γ_0	γ_{FX}	γ_{MKT}	γ_{INT}	γ_{WORLD}
$\phi_{k,\text{constant}}$	−0.0003	0.0126**	0.0088	−0.1969	−0.0097	−0.0027	0.0126**	0.0088	−0.0103	−0.1895
	(0.009)	(15.361)	(0.513)	(0.583)	(0.305)	0.067	(15.061)	(0.510)	(0.325)	(0.561)
$\phi_{k,\text{BOND}}$	0.0047	−0.0009**	−0.0132	0.0275	−0.0007	0.0031	−0.0009**	−0.0129	−0.0007	0.0279
	(0.425)	(5.537)	(1.879)	(0.219)	(0.106)	0.270	(5.442)	(1.841)	(0.104)	(0.221)
$\phi_{k,\text{EWR}}$	−0.0031	−0.0003	−0.0004	0.0078	−0.0002	−0.0023	−0.00003	−0.0004	0.0002	0.0076
	(1.767)	(1.522)	(0.568)	(0.476)	(0.238)	1.255	(1.346)	0.568	(0.241)	(0.462)
$\phi_{k,\text{DIV}}$	−0.0231	−0.0013**	−0.0074	0.6166	0.0089	−0.0176	−0.0012**	−0.0069	0.0082	0.6191
	(1.138)	(3.879)	(0.473)	(1.459)	(0.432)	0.846	(3.801)	0.440	(0.403)	(1.430)
$\phi_{k,r}$	0.0227	−0.0110**	−0.0967	1.161	−0.0046	0.0129	−0.0111**	−0.0942	−0.0048	1.1650
	(0.225)	(6.103)	(1.689)	(0.849)	(0.069)	0.125	(5.982)	1.634	(0.071)	(0.841)
$\phi_{ik,\text{JD}}$	0.0003	0.0001	0.0099	−0.0498	−0.0228	0.0039	0.0001	0.0099	−0.0221	−0.0446
	(1.365)	(0.498)	(0.945)	(0.394)	(1.685)	0.134	(0.541)	0.926	(1.314)	(0.311)
$\phi_{k,\text{WDIV}}$	0.0013	−0.0002	0.0154	−0.2791	0.0050	0.0012	0.0003	0.0149	0.0054	−0.2825
	(0.104)	(0.103)	(1.167)	(1.124)	(0.407)	0.096	(0.107)	1.126	(0.438)	(1.101)
Null: $\phi_{k,\text{constant}} = \phi_{k,\text{BOND}} = \phi_{k,\text{EWR}} = \phi_{k,\text{DIV}} = \phi_{k,r} = \phi_{k,\text{JD}} = \phi_{k,\text{WDIV}} = 0$										
	$k = 0$	$k = \text{FX}$	$k = \text{MKT}$	$k = \text{INT}$	$k = \text{WORLD}$	$k = 0$	$k = \text{FX}$	$k = \text{MKT}$	$k = \text{INT}$	$k = \text{WORLD}$
χ^2	6.77	2219.18	12.00	11.99	11.21	3.61	2238.33	11.75	10.39	10.94
	[0.45]	[0.00]	[0.10]	[0.10]	[0.13]	[0.82]	[0.00]	[0.11]	[0.16]	[0.14]
	J-test	28.95				*J*-test	28.76			
		[0.99]					[0.99]			

γ_0 is the time-varying constant in the GMM framework. γ_k is the price of risk for factor k(=FX, MKT, INT, WORLD). BOND is the yield of long-term Japanese government bonds in excess of the call rate. WDIV is the Morgan Stanley world dividend yield in yen terms adjusted to exclude the Japanese market. DIV is the dividend yield in excess of the call rate. R_{EWR} is the excess return on the equally-weighted market index (all first section TSE stocks). r is the call rate. JD is the January dummy. R_{MKT} is the excess return on the value-weighted market index (all first section TSE stocks). R_{INT} is the first difference of the TSE listed ***shinpatsu*** bond yield. R_{FX} (Bilateral) is the percentage change of the bilateral nominal yen/U.S. dollar exchange rate. R_{FX} (Weighted) is the percentage change of the trade-weighted exchange rate of the yen against the currencies of all OECD trading partners. R_{WORLD} is the excess return on the Morgan Stanley world stock index in yen terms adjusted to exclude the Japanese market. χ^2 (all) is the Wald test statistic for the null that all coefficients in the column equal zero. *J*-test for overidentifying restrictions is distributed χ^2. *t*-statistics are in parentheses. *p*-value in brackets for the Wald tests. ** and * indicate statistical significance at the 5% and 10% levels, respectively.

ditional tests could mislead portfolio selection decisions over time. The change in sign of the (time-invariant) exchange risk premium found in the unconditional tests over the two different sub-periods is not economically inconsistent, especially, for the Japanese data covering periods with significant currency regime and market valuation shifts.

The different pricing results for sub-periods from the unconditional model motivates the use of a conditional model because the latter can incorporate the effects of intertemporal changes in market environments or changes in currency regimes as experienced in the Japanese economy. Moreover, the conditional results are free from biases caused by the smaller sample size, the orthogonalization process and the ex post division of the total sample period into sub-periods inherent in the unconditional model. Thus, the results of the conditional model support the conjecture derived from the unconditional model.

VIII. Conclusion

Existing published work on an unconditional multi-factor asset pricing model generally reports that the exchange risk is not priced in the Japanese (or in the U.S.) stock market. Dumas and Solnik (1995) employ a conditional international asset pricing model and report that the exchange risk is priced in major world stock and currency markets. They employ aggregate national stock market indexes and are concerned with the integrated world market as a whole rather than an individual national market. We do not necessarily assume that the world capital markets are integrated. Rather, we apply both a conditional and an unconditional multi-factor model with the market, the interest rate, and the exchange risk factors to industry level data for one major national capital market, Japan, where international trade—and the potential currency impact on it—has been given high priority. A disaggregate study is important because exchange risk is fundamentally a property of a firm or industry conditions as well as specific market environments. Our work is also differentiated from Hamao (1988), Brown and Otsuki (1993), and He, Ng, and Wu (1996) because it considers both unconditional and conditional asset pricing models.

We find, using an unconditional model, that exchange risk is priced in the pre-Plaza as well as the post-Plaza period when the bilateral yen/U.S. dollar exchange rate measures are used. The exchange risk pricing results from the unconditional model are sensitive to the choice of sub-periods, suggesting a time-varying nature to the price of the exchange risk. On the other hand, the results for the conditional model for the period from January 1974–December 1995 show that the exchange risk is priced in the Japanese market regardless of whether the bilateral yen/U.S. dollar rate or the multilateral trade-weighted exchange rate is used. The battery of Wald tests for various restrictions on the conditional model suggests that the exchange risk is priced and is an important component in forming time-varying expected returns on assets in Japan. We also experimented with the shortened two-factor model and the augmented four-factor model, which includes the world market as an additional factor, and with an alternative portfolio formation beyond equity categories. Under these alternative model and portfolio specifications, we find that exchange risk remains to be priced, and the results are very robust.

The success of the conditional model documented in this study suggests that the price of exchange risk in Japan is time-varying and the exchange risk premium is captured by the instruments that we have used in our empirical investigation. The constancy of exchange risk premium assumed in the unconditional tests could mislead the portfolio as well as the financial manager's decisions over time in a changing economic environment. However, the sub-period estimation of the unconditional model is interesting in that the exchange risk is priced differently depending on the secular yen/U.S. dollar exchange rate trend. We interpret this as evidence on the role of the secular trend in defining the perception of exchange risk in the Japanese capital markets.

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