ELSEVIER Journal of Banking & Finance 23 (1999) 1–20

Journal of BANKING & FINANCE

The pricing of currency risk in Japan

John Doukas [a,*], Patricia H. Hall [b], Larry H.P. Lang [c,d]

[a] *Finance Department, Graduate School of Business, CBPA, Old Dominion University, Norfolk, VA 23508, USA*

[b] *Finance Department, Central Connecticut State University, New Britain, CT 06050, USA*

[c] *Graduate School of Business, University of Chicago, Chicago, IL 60637, USA*

[d] *Finance Department, Chinese University of Hong Kong, Hong Kong, People's Republic of China*

Received 20 April 1998; accepted 21 July 1998

Abstract

Previous work on the pricing of exchange-rate risk has primarily focused on US firms and, surprisingly, found stock returns were not significantly affected by exchange-rate fluctuations. In this paper we conduct an in-depth investigation that examines whether exchange-rate risk is priced in the equity market of Japan using an intertemporal asset pricing testing procedure that allows risk premia to change through time in response to changes in macroeconomic conditions. Our multiperiod asset pricing tests show that the foreign exchange-rate risk premium is a significant component of Japanese stock returns. Specifically, the results suggest that currency-risk exposure commands a significant risk premium for multinationals and high-exporting Japanese firms. The currency-risk factor is found to be less influential in explaining the behavior of average returns for low-exporting and domestic firms. However, it is shown to exhibit large return volatility that is likely to be perceived by investors, who wish to control portfolio risk, as an important underlying source of risk. Furthermore, Japanese stock returns are found to be related to the relative distress and size factors above and beyond the covariation explained by the currency-risk factor. © 1999 Elsevier Science B.V. All rights reserved.

JEL classification: G12; G15

[*] Corresponding author. Tel.: 1 755 683 5521; fax: 1 755 683 5639; e-mail: jdoukas@odu.edu

PII: S0378-4266(98)00112-5

Keywords: Exchange-rate exposure of Japanese firms; Multifactor asset pricing model; Pricing of currency risk in Japan; Currency pricing tests

1. Introduction

Since the introduction of the floating exchange-rate regime in 1973, exchange-rate volatility has increased markedly, and with it, the levels of foreign exchange risk. In fact, foreign exchange risk has become of increasing concern to firms as it is generally believed that exchange-rate uncertainty impacts on the return and the riskiness of a firm's cash flows. For example, Kyocera, a Japanese ceramics maker, reported unconsolidated pretax profit for the year ended 31 March 1996 of 163.77 billion yen ($1.53 billion), more than double the year-earlier 87.18 billion yen. But consolidated, or parent-company, results fell short of expectations, which Kyocera executives attributed to the strong yen. [1] The financial press provides ongoing anecdotal evidence on the effects of exchange-rate movements. [2] In response to increased exchange-rate volatility financial managers have turned to active currency-risk management strategies in the foreign exchange market. The growing emphasis on exchange risk management and the extensive use of foreign currency derivatives and other hedging instruments by corporations to protect firms' foreign currency denominated cash flows from unexpected exchange-rate movements, suggests that firm's market value is sensitive to exchange-rate uncertainty.

Previous work on the pricing of currency-risk in the US appears to be in sharp contrast with the view that exchange-rate risk is priced in the stock market. Jorion (1991), using the multifactor model of Chen et al. (1986), reports that exchange-rate risk is not priced in the stock market. His empirical tests, however, rest on the maintained assumption that the price of exchange risk is constant through time. In other words, they rely on the assumption of a nonzero unconditional risk premium. The reliance of currency tests on the assumption that currency-risk is constant through time is in contrast with the increasing evidence that the foreign exchange market is characterized by

[1] The Wall Street Journal, 20 May 1996.

[2] For instance, on 3 May, 1991, the Wall Street Journal writes: "Caterpillar sees gains in efficiency imperiled by the strength of dollar: Japanese rival (Komatsu) wins an edge". From August 1985 to May 1994, the yen's surge against the US dollar made Japanese exports more expensive for foreign buyers and raised Japanese exporters' concerns about losing key foreign markets (Economist, 4 June 1994). For the 40% depreciation of the yen against the US dollar over the June 1995–November 1996 period Business Week (11 November 1996) writes: "Detroit is getting sideswiped by the yen: the big three have taken their case to Washington. Will it fall on deaf ears?".

nonzero conditional risk premia. [3] Recent empirical evidence on the pricing of currency-risk is also inconsistent with the US based results of Jorion. Dumas and Solnik (1995), and De Santis and Gerard (1998) show that time-varying exchange risk receives a statistically significant price in international capital markets, consistent with the International Capital Asset Pricing Model (ICAPM) of Solnik (1974), Sercu (1980), Stulz (1981), and Adler and Dumas (1983). These results imply that investors are sensitive to currency-risk exposure and therefore are expected to be compensated from bearing currency-risk. [4,5] It should be noted, however, that these asset pricing tests were conducted at the aggregate national stock market level for Germany, Japan, the UK and the US.

In light of this conflicting evidence, there is a compelling need to examine three related issues. First, whether currency-risk is priced at the firm level in Japan. Second, if currency-risk is priced, it becomes important to determine if investors' compensation for currency-risk varies across firms with different international trade characteristics. Third, whether the currency-risk factor accounts for systematic return commovements. Apparently, the results of this investigation have direct implications for currency hedging strategies, because if currency-risk is not compensated in terms of expected returns, must be hedged. The choice of country is dictated as a partial safeguard against data-snooping, the weak evidence of previous studies on the pricing of currency-risk in US, the growing importance of the Japanese economy in terms of international trade, and that many Japanese firms are internationally involved that are likely to be more sensitive to unanticipated exchange rate movements. Therefore, the nature of our sample is expected to reduce the noise into the analysis because Japanese firms are more likely to be susceptible to unexpected exchange-rate movements. [6] Finally, given Japan's reliance on foreign markets and dependence on foreign inputs of production, the analysis of the pricing of the exchange-rate risk in the Japanese stock market is overdue.

Consistent with Dumas and Solnik (1995), and De Santis and Gerard (1998), our tests rely on the assumption that the foreign exchange market is characterized by nonzero time-varying risk premia which avoid the limitations

[3] See Fama (1984), Korajczyk (1983) and Giovannini and Jorion (1989) for evidence in support of the view that the foreign exchange market is characterized by nonzero conditional risk premia.

[4] The security risk is measured by the covariance of each security with exchange rates.

[5] Hamao (1988), however, shows that exchange-rate risk is not recognized by investors in the stock market of Japan over the 1975–1984 period.

[6] Bartov and Bodnar (1994) argue that failure of previous studies to control for firms' linkages to international conditions may have been the reason why they could not document a significant relationship between exchange rate changes and stock returns.

of previous studies that fail to account for investors' changing currency-risk perceptions and information that is available at any given point in time. [7] The use of an intertemporal asset pricing model which allows risk premia to change through time in response to predetermined information should permit us to use the appropriate measure of currency exposure and re-examine accurately the relation between exchange-rate changes and equity value. To the best of our knowledge, currency-risk pricing tests, are the first to be carried out on a firm-specific, as opposed to aggregate, dataset of 1079 Japanese firms. Furthermore, our approach builds on Fama and French's (Fama and French, 1996) work in the sense that it accounts for the sensitivity of returns to the difference between the return on a portfolio of small stocks and the return on a portfolio of large stocks (small minus large factor), the difference between the return on a portfolio of high-book-to-market stocks and the return on a portfolio of low-book-to-market stocks (high minus low factor), including a residual market factor orthogonal to other factors. [8]

Using monthly returns on portfolios of domestic, low-exporting, high-exporting and multinational firms for the period January 1975 to December 1995, we find that exchange-rate risk is priced in the Japanese stock market. The pricing of the exchange-rate risk, however, appears to be stronger for firms with broad foreign trade linkages and operations. The pricing of the contemporaneous exchange-rate risk supported by our asset pricing tests suggests that currency-risk is of hedging concern to investors in Japan.

The remainder of the paper is organized as follows: Section 2 describes the data. Section 3 presents the intertemporal asset pricing model and the econometric methods used in our analysis. Section 4 presents the empirical results on the pricing of the currency-risk and the other factor-mimicking portfolios in Japan. Section 5 concludes.

2. Data description

Monthly time-series of stock returns (inclusive of dividends) for 1079 Japanese firms traded on the Tokyo Stock Exchange for the period from January 1975 to December 1995 are used in this study. Returns data were obtained from Worldscope, 1996, Datastream, and the Pacific Basin Capital Markets

[7] Recent international finance literature, summarized by Giovannini and Jorion (1989), suggests that unconditional expected returns from forward market speculation are generally rather small.

[8] This method is suggested by McElroy and Burmeister (1988). They argue that this procedure gives 1 degree of freedom in specifying the factors. Further it permits the CAPM to be a simple parametric restriction of the Arbitrage Pricing Theory (APT). Considering the residual market factor as a latent variable in the analysis, this model is consistent with the multibeta framework of Shanken (1987).

(PACAP) Database. [9] Worldscope is additionally used to identify the firm's primary SIC code, market value, and percent of foreign to total sales. The Directory of Multinationals (Stopford, 1992) is used to determine firms' multinational status. Firms are classified as multinationals (MNCs) when they meet the following criteria set by the Directory: (a) firms have a minimum of 25% of the voting equity of manufacturing or mining companies in at least three foreign countries; (b) firms have a minimum of 5% of consolidated sales or assets attributable to foreign investments; and (c) firms have a minimum of 7.8 billion yen in sales generated by foreign production operations. Sixty-two (62) firms from our sample were classified as MNCs based on these criteria with complete stock return and dividend information. We have formed three additional samples of firms according to their foreign to total sales ratios. The second sample consists of 260 firms with reported foreign sales to total sales in excess of 20% (i.e., high-exporting firms). The third sample is composed of 281 firms with reported foreign to total sales in excess of 0%, but less than 20% (i.e., low-exporting firms). The last sample consists of 476 firms with no reported foreign sales to total sales (i.e., pure domestic firms). A close investigation of the business activities of these firms confirmed that they did not have any direct foreign operations. The use of this type of firm in the analysis permits us to examine whether domestic firms are indirectly (i.e., through changes on aggregate demand, or on the cost of imported inputs or competition by importing firms) exposed to unexpected exchange-rate volatility. Furthermore, the inclusion of firms with no direct linkages to international conditions (i.e., nonexporting firms or firms with no foreign activities) is motivated by the argument that the failure of previous studies to identify significant exchange-rate exposures is due to their poor sample selection procedures used. The nonexporting type of firm, then, allows us to test this hypothesis. Unlike previous studies our sample includes not only MNCs and large exporting firms, but small exporting firms as well as firms with no linkages to the international environment. [10] This selection procedure, undoubtedly, yields a sample of firms that (a) contains firms that are not uniformly involved in the international environment, and (b) are unlikely to hedge their foreign currency exposures uniformly.

The 1079 sample firms are from 25 different two-digit standard-industrial classification (SIC) industries, hence a broad cross-section of industries is represented in the sample. The monthly return spread between a portfolio of

[9] Worldscope is a database distributed by Compaq Disclosure and is updated annually. Datastream is an on-line database distributed by Datastream International and is updated daily. The PACAP Database is distributed by the University of Rhode Island.

[10] Jorion (1991) and Amihud (1993) consider only US multinational firms with reported foreign operations and large US exporting firms, respectively.

Japanese value stocks (i.e., high book-to-market) and a portfolio of Japanese growth stocks (i.e., low book-to-market), and the monthly return spread between a portfolio of Japanese small-capitalization stocks and a portfolio of Japanese large-capitalization stocks were obtained from Boston International Advisors (BIA). BIA creates value and growth indexes market-by-market. It ranks stocks by their book-to-market ratio. BIA selects the highest book-to-price stocks one-by-one from the top of the list of stocks tracked in each country including Japan until half of the capitalization of each market has been accumulated. These stocks, then, become the constituents of the value index and the remaining stocks become the growth index. This implies that when the performance of value and growth index series is compared, the two investment strategies have equal liquidity characteristics and therefore are equally viable for large institutional investors. The division is performed every January, based on data available at year-end. Each index is estimated based on the companies that are in the Morgan Stanley comprehensive database, as of the rebalance date. The monthly return for each index (value or growth) is computed by taking a weighted average of total returns (price change plus dividends) on the underlying stocks, using outstanding total market capitalization (price per share times number of shares) as weights. Large-capitalization and small-capitalization return series are created in a similar fashion. However, stocks are ranked by their capitalization and the market is split 70/30. The large-capitalization index encompasses 70% of the total market capitalization while the small-capitalization index covers the bottom 30%. These index series are market-capitalization weighted. The procedure used by BIA in creation of these indexes are similar to those used by Lakonishok et al. (1994), and Fama and French (1996).

Descriptive statistics for the entire sample of Japanese firms and for each category of firms are displayed in Table 1. The sample includes 1079 firms representing 25 industries and they are classified into MNCs, high-exporting, low-exporting, and domestic firms. As expected, the sample of MNCs consists of very large firms compared to high- and low-exporting firms with a mean (median) value of market capitalization of 12.15 (18.12) billion yen. MNCs' foreign sales to total sales is also exceeding that of the other two types of exporting firms in the sample because of their greater involvement in foreign operations and trade. MNCs, however, seem to have a somewhat smaller leverage than the high-exporting firms. The debt to asset ratio data evidence that domestic firms are more levered than any of the other firms in the sample. This finding may reflect the large number, 83, of depository institutions included in this sample. Finally, MNCs' profitability, estimated by the return on equity and the return on asset measures, exceeds that of the rest of the Japanese firms.

The end-of-month exchange rate for the Japanese yen against the US dollar (bilateral exchange rate – BXR) and a real, moving, trade-weighted exchange rate (multilateral exchange rate – TWXR) published by the Bank of England

Table 1
Descriptive statistics

Type of firm	Foreign sales/Total sales	Market capitalization[a] (yen 000s)	Debt/Asset ratio	Return on equity (ROE)	Return on assets (ROA)
All firms					
$N = 1079$					
Mean	0.2223	346,189	0.3617	−0.0431	0.0141
Median	0.1800	501,412	0.3412	0.0109	0.0163
Standard deviation	0.1987	646,050	0.1975	0.1069	0.0302
Minimum	0.0100	89,213	0.0100	−0.1768	−0.2006
Maximum	1.000	76,420,556	0.8895	0.2945	0.1602
MNCs					
$N = 62$					
Mean	0.4163	12,155,853	0.3404	0.0127	0.0203
Median	0.4400	18,128,396	0.3506	0.0186	0.0223
Standard deviation	0.1226	13,022,241	0.1191	0.0567	0.0175
Minimum	0.2200	709,825	0.0664	−0.1768	−0.0581
Maximum	0.7400	76,420,556	0.5786	0.1797	0.0638
High exporters					
$N = 260$					
Mean	0.4037	3,055,326	0.3954	−0.0902	0.0127
Median	0.3800	5,468,617	0.3762	−0.0216	0.0146
Standard deviation	0.1991	4,970,051	0.2213	0.0333	0.0381
Minimum	0.2000	189,461	0.0100	−0.1333	−0.2006
Maximum	1.000	36,728,726	0.8795	0.0572	0.0881
Low exporters					
$N = 281$					
Mean	0.1266	1,780,756	0.3383	−0.0153	0.0138
Median	0.1100	2,317,880	0.3426	0.0010	0.0164
Standard deviation	0.0419	2,351,635	0.1870	0.0201	0.0246
Minimum	0.0100	118,051	0.1100	−0.0628	−0.0911
Maximum	0.1900	14,660,415	0.8895	0.0510	0.1314
Domestic firms					
$N = 476$					
Mean	NA[b]	533,612	0.3968	−0.0388	0.0183
Median		413,214	0.4237	0.0093	0.0191
Standard deviation		612,920	0.1432	0.0152	0.0212
Minimum		89,213	0.0100	−0.0538	−0.1063
Maximum		13,263,021	0.7966	0.2945	0.1602

The sample includes 1079 Japanese firms representing 25 industries in the period 1975–1995.
[a] Year-end market value of common stock times number of outstanding shares.
[b] This sample consists of firms with zero reported foreign sales to total sales.

are retrieved from Datastream. This exchange-rate index is measured in yen per unit of foreign currencies (17) in period t. The method of estimation and relative weights used are similar to those the IMF uses to estimate its Multilateral

Exchange Rate Model (MERM) exchange-rate index. In this form, an increase in the index represents a depreciation of the Japanese yen. The data for the macroeconomic variables are obtained from the International Financial Statistics (IFS). The choice of fundamental factors that explain equity risk premia relies on the work of Chen et al. (1986) and Hamao (1988) who find some evidence that the factors identified for the US have some validity in Japan. These factors are: (a) IP, the Industrial Production growth series, constructed as the logarithm of price relatives of the seasonally adjusted index of industrial production reported by the IMF; (b) UI, the Unexpected Inflation series, estimated by subtracting the expected inflation at month $t-1$ from the realized inflation (CPI) rate during month t; (c) UTS, the Term Structure series, is constructed from the difference between Japanese long-term government bond series and short-term bonds; (d) MS, the Money Supply series, is the monthly change in the Japanese money supply; (e) UJS, the US–Japan Interest Rate Spread, is the monthly return difference between US and Japanese short-term bill rates; and (f) XM, the Trade Balance series, is the monthly logarithmic difference between exports and imports. The market rate of return, R_{mt}, is the value-weighted index of all firms included in the Nikkei 225 index.

3. The pricing of exchange-rate risk

Previous empirical tests by Jorion (1991) on the pricing of currency-risk in the US stock market were conducted based on the assumption that the currency-risk premium is constant over time. Using a variation of the asset pricing methodology originally proposed by Chen et al. (1986), he finds that the price of currency-risk is not different from zero and, therefore, investors are not sensitive to firm's currency exposure. Dumas and Solnik (1995) and De Santis and Gerard (1998), however, using conditional versions of the ICAPM proposed by Harvey (1991), find that the price of currency-risk is significantly different from zero. Hence, the findings of these two studies strongly support a model of international asset pricing which includes both market and foreign exchange risk. While these results are very interesting in the sense that they document exchange-rate risk as a priced factor at the aggregate level in international capital markets, they are in sharp contrast with the existing empirical evidence at the firm level. We attribute the different pricing of currency-risk results between aggregate and disaggregate studies to the unconditional testing methodology used in the latter tests (Jorion, 1991). The more recent aggregate-based currency pricing tests, however, have several limitations. First, they are conditional versions of ICAPM designed to investigate whether market risk, or currency-risk, or both are priced factors without accounting for other factors such as size and financial distress that have been documented in the asset pricing literature (see, Fama and French, 1996; Arshanapalli et al., 1998). Second, tests such as the Dumas and Solnik (1995) do not specify the dynamics of the conditional second moments and, therefore, they cannot measure the magnitude of exchange-rate risk relative to the market premium. Third, without second moments, estimates of interest to investors such as correlations, betas and hedge ratios cannot be measured. Fourth, these tests should be interpreted as tests of some of the unconditional implications of the conditional CAPM rather than a direct test of the conditional model. Fifth, the empirical findings of these tests are limited to the use of the aggregate data and, therefore, there is no knowledge whether currency-risk is priced at the firm level. Finally, if currency-risk is priced, it is not known if the magnitude of the currency-risk premia vary across different type of firms.

In this paper we use a multifactor asset pricing framework to test whether exchange-rate risk is priced in the context of an intertemporal asset pricing model which allows risk premia to change through time in response to macroeconomic factors. Specifically, we test the hypothesis that exchange-rate risk is not priced (i.e., obtains a zero value) against the alternative that it is priced in the stock market of Japan. That is, we are interested to examine whether currency-risk reflects other effects. To the extent that currency-risk is not just a manifestation of other effects, Japanese stock returns should load significantly on the currency-risk factor when considered together with other underlying factors. The approach used in this paper prespecifies a small set of macroeconomic factors including a residual market factor ($f_{\mathrm{m}t}$), orthogonal to the currency-risk ($f_{\mathrm{s}t}$) and other factors (f_i). Following Fama and French (1996), the other two risk factors comprise the difference between the return on a portfolio of Japanese value (high-book-to-market) stocks and the return on a portfolio of Japanese growth (low-book-to-market) stocks (f_{vg}), the difference between the return on a Japanese portfolio of small capitalization stocks and the return on a Japanese portfolio of large capitalization stocks (f_{sl}). The intertemporal version of this asset pricing model implies that the risk factors will themselves depend on a set of instrumental variables (see, for example, Brown and Otsuki, 1993). Since asset pricing models do not specify the choice of instrumental variables, in any empirical work of this kind the choice of which variables to include is bound to be somewhat arbitrary. Our choice of instrumental variables was guided by the variables used in previous studies. The first step, then, of this procedure requires the estimation of the following set of regressions to form the four residual risk factors, ($f_{i\,t}$):

$$r_{\mathrm{s}t} = \phi_{0\mathrm{s}} \sum_{j=1}^{7} \phi_{j\mathrm{s}} \mathrm{IV}_{jt-1} + \sum_{i=1}^{3} \beta_{i\mathrm{s}} R_{it-1} + f_{\mathrm{s}t}, \tag{1a}$$

$$r_{\mathrm{vg}t} = \phi_{0\mathrm{vg}} + \sum_{j=1}^{7} \phi_{j\mathrm{vg}} \mathrm{IV}_{jt-1} + \sum_{i=1}^{3} \beta_{i\mathrm{vg}} R_{it-1} + f_{\mathrm{vg}t}, \tag{1b}$$

$$r_{slt} = \phi_{0sl} + \sum_{j=1}^{7} \phi_{jsl} \mathrm{IV}_{jt-1} + \sum_{i=1}^{3} \beta_{isl} R_{it-1} + f_{slt}, \tag{1c}$$

$$r_{mt} = \phi_{0m} + \sum_{j=1}^{7} \phi_{js} \mathrm{IV}_{jt-1} + \sum_{i=1}^{3} \beta_{im} R_{it-1} + f_{mt}, \tag{2}$$

where the left-hand side variables represent: the foreign exchange risk premium (r_{st}) defined as the one-month Eurodollar interest rate compounded by the yen variation relative to the US dollar minus the one-month Japanese risk free rate of return [11] (r_{st}), the Fama and French (1996) type value minus growth (r_{vgt}) and small minus large (r_{slt}) return spreads, and the market rate of return (r_{mt}). $R_{i\,t-1}$ represents lagged values of these macrovariables, and $\mathrm{IV}_{j\,t-1}$ represents the instrumental variables, described earlier. The dependence of expected risk premiums on the information set available to investors at the beginning of each period, represented by the lagged information variables (1) and (2), permits equity risk premiums to vary through time. The residuals from regressions (1a)–(1c) define the unanticipated components of a set of risk factors (f_{it} which, along with a residual market factor (f_{mt}) obtained by estimating the market regression (2), are used to estimate equity risk premia from the following regression:

$$r_{pt} = \rho_{0p} + \sum_{j=1}^{7} \rho_{jp} \mathrm{IV}_{jt} + \sum_{i=1}^{4} \beta_{ip} \hat{f}_{it} + u_{pt}, \tag{3}$$

where r_{pt} represents the equity return on a Japanese portfolio in excess of the short-term bill rate, IV_{jt}'s are the predetermined macroeconomic variables which explain equity risk premia and f_i represents the set of four risk factors obtained from Eqs. (1a)–(1c) and (2). In this asset pricing model, the observed risk premium contains the elements of expected risk premium and a set of risk factors. The asset pricing Eq. (3) describes how excess equity returns relate to instrumental variables and the four risk factors. The rho coefficients in (3) capture the information about expected returns in the premium for state variables (IV) (i.e., they determine the way expected returns vary systematically through time [12]) that is not captured by the market premium, the premiums

[11] The foreign exchange risk premium variable used in our analysis is the currency adjusted return on a foreign currency deposit in excess of the domestic risk free rate as in Dumas and Solnik (1995)

[12] This system of equations is similar to one provided by Ferson (1990). A difference is that Ferson prefers a reduced form of Eq. (6) and defined in terms of k reference assets, where k defines the number of factors. Our Eq. (6), however, is simpler to estimate using standard numerical maximum likelihood or GMM procedures.

associated with currency-risk and the FF factors. The beta coefficients measure how returns depend on the currency-risk factor and the other three factors defined in Eqs. (1a)–(1c) and (2); that is, the sensitivity coefficients to these macroeconomic risks determine investors' expected risk premium for bearing a company's exposure to these sources of underlying risk. Therefore, if currency-risk, size and book-to-market represent a set of state variables of hedging concern (priced), state variables such as the market portfolio should have no additional information about expected returns. Therefore, the intercepts and the rho coefficients in (3) must be zero. Hence, our approach of identifying whether currency-risk is priced along with the two FF factors centers mostly on the intercepts and rho coefficients in (3), not on the expected excess returns on the explanatory portfolios. However, examining the behavior of the explanatory (mimicking) portfolios' returns helps to determine whether the underlying factors represent the sources of systematic return comovement. If a factor is found to exhibit large return volatility, it would imply that such a factor contributes substantially to return movements that investors perceive as important in managing portfolio risk. If a factor is found (i) to explain well the behavior of stock returns and (ii) account for substantial return comovement this would identify a source of risk that is more likely to be important for the expected stock returns. Hence, a factor that has high (low) explanatory power for the comovement in stock returns it is likely that it would require a high (low) premium.

The main innovation of our approach, is that it checks whether the currency-risk factor (i) generates a nonzero risk premium by looking at the *t*-statistic for the hypothesis that the time-series mean of β_s equals zero and (ii) whether it is important for explaining return covariation (i.e., the volatility of the currency factor is large). Furthermore, the residuals that proxy for the risk factors are time-varying and the risk premia are themselves functions of vectors of instruments, known as of the beginning of each month. [13,14] Unlike previous studies, the risk premiums in our analysis capture the impact of changing business conditions and investors' changing risk perceptions over time. Hence, this approach takes into account information from security returns that may be useful in estimating these innovation processes.

[13] Mei (1992) considers another extension of this model where there is more than one latent market factor as well.

[14] For a comprehensive discussion of the relationship of the approach used here with the APT and CAPM models, see McElroy and Burmeister (1991).

4. Intertemporal asset pricing tests of exchange-rate risk

Following McElroy and Burmeister (1988), the asset pricing model is estimated using the Iterated Nonlinear Seemingly Unrelated Regression Equation (INSURE) procedure. This estimation procedure uses all available information to estimate both factor sensitivities and risk premia. Furthermore, this approach permits residuals to be cross-sectionally correlated. [15] Table 2 presents results of the pricing tests from estimating Eq. (3). The results in Panel A show regression coefficients of the risk-factor Eqs. (1a)–(2). The results reported in the last column of Panel A represent likelihood ratio statistics associated with the hypothesis that the slope coefficients of the right-hand side variables allowing time variation in risk premiums are jointly equal to zero. These statistics are distributed as a chi-square with n degrees of freedom. The chi-square values indicate that these variables are significantly associated with all four macro-risk factors. Hence, there is evidence of significant time-varying risk premiums for exchange-rate risk, market risk, and the FF risk factors. This result is in sharp contrast with the evidence of previous currency pricing tests which relied on the assumption of unconditional (i.e., time-invariant) premium for currency-risk.

The main results are reported in Panel B. An alternative testing of whether risk premiums are time-varying requires that we constrain the impact of the lagged information variables, which proxy for equity risk premiums, to be the same across all excess return series. As in the earlier Panel A, the chi-square tests strongly suggest that there is evidence of significant time-varying premiums for all risk factors. The last column of Panel B shows that the rho coefficients are jointly equal to zero, implying that the risk premium factors explain a large fraction of the variation of Japanese excess stock returns in our sample of 1079 firms.

The results listed in Panels B1 and B2 show that the coefficient of the currency-risk factor, β_s, is positive and significant, at the 5% level, for both periods implying that investors, on average, require a higher rate of return for bearing currency-risk. MNCs and high-exporting firms' currency exposure, however, commands a higher risk premium in the Japanese stock market than low-exporting and domestic firms. The risk premium coefficient representing the pricing of exchange-rate exposure for low-exporting and especially domestic firms is small and not significant at conventional levels. Overall, our results are consistent with those of Dumas and Solnik (1995), and De Santis and Gerard

[15] The system-estimation approach yields efficient estimates (see McElroy and Burmeister, 1988) which eliminates several of the problems associated with measurement errors in the cross-sectional analysis (see Ferson and Harvey, 1993), factor analysis techniques and/or the conventional two-step estimation method based on Fama and MacBeth (1973).

Table 2
Currency pricing effects on Japanese stock returns

Macro-risk factor	ϕ_0	ϕ_{IP-1}	ϕ_{UI-1}	ϕ_{UTS-1}	ϕ_{MS-1}	ϕ_{UJS-1}	ϕ_{XM-1}	ϕ_{i-1}	β_{vg-1}	β_{sl-1}	β_{s-1}	β_{mt-1}	$R^2(\chi^2)$
Panel A1: Macro-risk factors – bilateral (BXR) exchange rate (1975 – 1995)													
r_{st}	−0.3076	−0.4255	0.6932	0.3688	−0.1537	−0.0580	0.0089	−0.4717	1.253	0.3896		1.274	0.1128
	(−1.09)	(−1.15)	(1.85)*	(1.91)*	(−0.184)	(−2.78)**	(1.67)*	(−0.294)	(1.38)	(0.213)		(2.06)**	(26.8)***
r_{vgt}	0.0108	−0.1079	0.0005	−0.0016	0.0172	−0.0001	−0.0001	0.0550		0.1275	0.4767	0.8362	0.1297
	(0.933)	(−0.704)	(0.307)	(−0.526)	(0.498)	(−0.019)	(−1.05)	(0.815)		(1.07)	(0.253)	(1.28)	(16.4)*
r_{slt}	−0.0144	0.2539	−0.0016	0.0021	−0.0411	0.0001	0.0001	0.0924	0.7593		0.6299	0.9463	0.1402
	(−1.28)	(1.68)*	(−1.06)	(0.819)	(−1.22)	(0.157)	(1.17)	(1.37)	(0.669)		(0.390)	(1.31)	(21.6)**
r_{mt}	0.0142	0.4210	0.0003	−0.0032	−0.0774	0.0126	0.0004	−0.0367	0.0002	0.0954	−0.1156		0.1846
	(0.559)	(1.51)	(0.096)	(−0.534)	(−1.13)	(0.807)	(0.066)	(−0.498)	(0.003)	(1.08)	(−0.884)		(18.1)*
Panel A2: Macro-risk factors – multilateral (TWXR) exchange rate (1978 – 1995)													
r_{st}	−0.0029	−0.3305	0.7721	0.4420	0.0125	−0.1129	0.0001	0.0201	1.382	0.409		1.275	0.1096
	(0.034)	(−0.943)	(1.93)*	(1.63)*	(0.315)	(−2.17)**	(1.80)*	(0.263)	(1.44)	(0.398)		(2.06)**	(24.8)***
r_{vgt}	0.0136	0.0119	0.0021	−0.0055	0.0031	0.0010	−0.0001	−0.0084		0.1285	0.3317	0.9931	0.1159
	(1.12)	(0.071)	(1.17)	(−1.51)	(0.090)	(0.766)	(−0.884)	(−0.114)		(1.18)	(0.102)	(1.31)	(17.2)*
r_{slt}	−0.0161	−0.0118	−0.0025	0.0057	−0.0032	−0.0009	0.0001	0.0339	0.8838		−0.4421	1.082	0.1342
	(−1.30)	(−0.070)	(−1.41)	(1.57)	(−0.090)	(−0.673)	(0.846)	(0.463)	(0.707)		(−0.320)	(1.43)	(19.4)**
r_{mt}	0.0224	0.2865	0.0033	−0.0082	−0.0512	0.0043	0.0001	0.0165	0.0041	0.1123	−0.1301		0.1722
	(0.752)	(1.02)	(0.512)	(−1.01)	(−0.883)	(1.18)	(0.180)	(0.199)	(0.031)	(0.832)	(−1.11)		(16.9)*

Type of firm	ρ_0	ρ_{IP}	ρ_{UI}	ρ_{UTS}	ρ_{MS}	ρ_{UJS}	ρ_{XM}	β_{vg}	β_{sl}	β_s	β_m	$R^2(\chi^2)$
Panel B1: Pre-Plaza Accord equity risk premia and risk factors – bilateral (BXR) exchange rate (January 1975 – September 1985)												
All firms	0.761	2.47	0.102	−0.199	−0.637	−0.016	0.006	1.18	1.51	0.844	0.817	0.5321
$N = 1079$	(0.368)	(1.79)*	(1.34)	(−0.479)	(−0.320)	(−0.914)	(0.686)	(1.55)*	(1.90)*	(1.82)*	(2.12)**	(11.86)*
I: MNCs	0.953	1.29	0.381	−0.272	−0.220	0.055	0.003	1.50	1.23	0.377	0.927	0.4306
$N = 62$	(1.35)	(1.73)*	(1.66)*	(−1.49)	(−0.768)	(1.36)	(0.324)	(1.81)*	(1.66)*	(1.72)*	(2.63)**	(13.14)*
II: High	0.166	0.217	0.964	−0.259	−0.479	0.179	0.005	1.01	1.21	0.626	0.974	0.4112

Table 2 (Continued)

Type of firm	ρ_0	ρ_{IP}	ρ_{UI}	ρ_{UTS}	ρ_{MS}	ρ_{UJS}	ρ_{XM}	β_{vg}	β_{sl}	β_s	β_m	$R^2(\chi^2)$
$N=260$	(0.140)	(0.131)	(2.21)**	(−1.91)*	(−0.406)	(1.95)*	(0.047)	(1.73)*	(1.81)*	(1.66)*	(2.11)**	(12.88)*
III: Low	0.458	0.257	0.177	−0.236	0.043	0.104	0.068	0.716	0.990	0.473	0.828	0.4763
$N=281$	(1.70)*	(1.86)*	(1.55)*	(−0.924)	(1.27)	(1.02)	(0.461)	(1.84)*	(1.69)**	(0.024)	(2.31)**	(10.98)*
IV:Dom	0.204	0.021	0.369	−0.258	0.108	0.558	0.051	1.11	1.06	−0.223	0.916	0.4292
$N=476$	(0.811)	(0.004)	(1.49)	(−1.43)	(0.773)	(1.91)*	(0.305)	(1.74)*	(1.41)	(−0.880)	(2.61)**	(11.02)*
Panel B2: Post-Plaza Accord equity risk premia and risk factors – bilateral (BXR) exchange rate (October 1985 – December 1995)												
All firms	1.17	0.216	0.962	−0.127	−0.196	0.362	−0.005	1.08	1.13	0.640	0.925	0.5049
$N=1079$	(1.61)*	(1.14)	(1.91)*	(−1.97)*	(−0.586)	(1.63)*	(−0.574)	(1.65)*	(2.15)**	(2.05)**	(1.81)*	(14.02)**
I: MNCs	1.55	0.242	0.012	−0.036	−0.016	0.070	0.004	1.29	1.24	0.245	0.715	0.5163
$N=62$	(1.27)	(0.158)	(1.76)*	(−2.54)**	(−0.223)	(1.55)	(0.276)	(2.12)**	(1.94)*	(2.20)**	(2.36)**	(15.69)**
II: High	1.22	0.161	0.492	−0.764	0.034	0.560	0.014	1.04	0.964	0.502	0.917	0.4938
$N=260$	(1.41)	(1.39)	(2.17)**	(−1.64)*	(0.406)	(0.764)	(0.036)	(1.86)*	(2.02)**	(2.18)**	(2.34)**	(14.77)**
III: Low	0.963	0.139	0.432	−0.720	0.007	0.863	0.033	0.708	0.963	0.324	1.03	0.4194
$N=281$	(1.34)	(0.684)	(1.86)*	(−0.472)	(0.127)	(1.76)*	(0.266)	(1.21)	(1.73)*	(0.984)	(1.86)*	(12.02)*
IV: Dom	1.05	0.863	0.334	−0.811	−0.293	1.02	0.091	1.22	0.763	0.461	1.05	0.4383
$N=476$	(1.83)*	(0.713)	(1.34)	(−1.71)*	(−0.116)	(2.01)**	(0.393)	(1.90)*	(1.32)	(1.23)	(2.31)**	(13.84)**
Panel C1: Pre-Plaza Accord equity risk premia and risk factors – multilateral (TWXR) exchange rate (January 1975–September 1985)												
All firms	0.398	1.88	0.139	0.003	−0.339	0.223	0.008	0.965	1.25	0.665	0.909	0.4985
$N=1079$	(0.229)	(1.63)*	(1.42)	(0.102)	(−0.003)	(0.033)	(0.887)	(1.61)*	(2.02)**	(1.98)*	(2.48)**	(12.03)*
I: MNCs	1.18	1.34	0.288	−0.404	−0.119	0.077	0.005	1.33	0.966	0.337	1.04	0.5586
$N=62$	(1.43)	(1.84)*	(1.74)*	(−1.33)	(0.558)	(1.48)	(0.587)	(1.76)*	(1.84)*	(2.02)*	(2.42)**	(14.33)**
II: High	−0.033	0.356	0.645	−0.448	−0.554	0.208	0.003	0.886	1.03	0.746	1.21	0.4377
$N=260$	(−0.118)	(0.299)	(1.88)*	(−2.21)**	(−0.663)	(1.77)*	(0.017)	(1.85)*	(1.94)*	(1.69)*	(2.45)**	(15.29)**
III: Low	0.336	0.377	0.203	−0.001	0.060	0.223	0.088	0.884	0.783	0.330	1.05	0.4662
$N=281$	(1.45)	(1.92)*	(1.66)*	(−0.228)	(1.43)	(1.24)	(0.664)	(1.95)*	(1.71)*	(0.163)	(2.13)*	(12.13)*
IV: Dom	0.552	−0.223	0.447	−0.338	0.227	0.774	−0.153	0.884	0.896	0.118	1.04	0.4199
$N=476$	(0.946)	−(0.177)	(1.58)*	(−01.39)	(0.837)	(2.04)**	(−0.498)	(1.46)	(1.60)*	(0.663)	(2.11)**	(10.86)*

Table 2 (Continued)

Type of firm	ρ_0	ρ_{IP}	ρ_{UI}	ρ_{UTS}	ρ_{MS}	ρ_{UJS}	ρ_{XM}	β_{vg}	β_{sl}	β_s	β_m	$R^2(\chi^2)$
Panel C2: Post-Plaza Accord equity risk premia and risk factors – multilateral (TWXR) exchange rate (October 1985 – December 1995)												
All firms	0.886	0.332	1.02	−0.332	−0.228	0.538	−0.007	0.973	1.04	0.576	1.07	0.5188
$N=1079$	(1.32)	(1.28)	(1.94)*	(−2.12)**	(−0.769)	(1.74)*	(−0.664)	(1.71)*	(1.99)*	(1.84)*	(1.91)*	(13.89)**
I: MNCs	1.32	−0.099	0.034	−0.129	−0.033	0.112	0.020	1.11	1.13	0.423	0.986	0.5299
$N=62$	(1.03)	(−0.143)	(1.96)*	(−2.35)**	(−0.452)	(1.91)*	(0.487)	(2.03)**	(1.86)*	(2.13)**	(2.28)**	(16.03)**
II: High	0.886	0.088	0.607	−0.653	0.120	0.767	−0.027	0.944	1.17	0.616	1.06	0.5060
$N=260$	(1.29)	(1.09)	(2.32)**	(−1.77)*	(515)	(0.870)	(−0.119)	(1.93)*	(2.11)**	(2.22)**	(2.16)**	(15.12)**
III: Low	1.11	0.288	0.516	−0.883	−0.013	1.22	0.044	0.886	1.11	0.447	1.23	0.5231
$N=281$	(1.41)	(0.771)	(1.92)*	(−0.667)	(−0.223)	(1.87)*	(0.387)	(1.43)	(1.84)*	(1.23)	(2.12)**	(11.32)*
IV: Dom	0.886	0.943	0.424	−1.02	−0.330	1.32	0.103	1.04	0.654	0.515	1.18	0.4853
$N=476$	(1.67)*	(0.886)	(1.40)	(−1.92)*	(−0.234)	(2.12)**	(0.449)	(1.93)*	(1.45)	(1.32)	(2.02)*	(12.04)*

Time period	Bilateral (BXR) exchange rate					Multilateral (TWXR) exchange rate				
	β_{vg}	β_{sl}	β_s	β_m	R^2	β_{vg}	β_{sl}	β_s	β_m	R^2
Panel D: Equity risk factors for all firms ($N=1079$) over different periods										
Pre-Plaza Accord Period										
Jan75 – Sep 85	1.18	1.51	0.844	1.17	0.5321	0.965	1.25	0.665	0.909	0.4985
	(1.55)*	(1.90)*	(1.82)*	(2.12)**		(1.61)*	(2.02)**	(1.98)*	(2.48)**	
Post-Plaza Accord period										
Oct 85 – Dec 90	0.964	1.34	0.543	0.863	0.5241	1.06	1.29	0.432	0.803	0.5067
	(1.63)*	(1.87)*	(1.23)	(1.93)*		(1.75)*	(1.76)*	(1.46)	(1.74)*	
Oct 85 – Dec 91	0.987	1.24	0.496	0.702	0.4976	0.864	1.20	0.502	0.931	0.5140
	(1.69)*	(1.83)*	(1.53)	(1.84)*		(1.64)*	(1.74)*	(1.61)*	(1.82)*	
Oct 85 – Dec 92	1.12	1.37	0.586	0.918	0.5332	1.15	1.03	0.561	1.04	0.5469
	(1.82)*	(1.90)*	(1.71)*	(1.94)*		(1.71)*	(1.61)*	(1.64)*	(1.90)*	
Oct 85 – Dec 93	1.03	1.18	0.687	1.08	0.5149	1.08	1.14	0.594	1.11	0.5233
	(1.79)*	(1.97)*	(1.86)*	(1.74)*		(1.83)*	(1.86)*	(1.70)*	(1.98)*	

Table 2 (Continued)

Time period	Bilateral (BXR) exchange rate					Multilateral (TWXR) exchange rate				
	β_{vg}	β_{sl}	β_{s}	β_{m}	R^2	β_{vg}	β_{sl}	β_{s}	β_{m}	R^2
Oct 85–Dec 94	1.06	0.960	0.763	1.14	0.5263	0.942	1.11	0.686	0.980	0.5163
	(1.74)	(1.82)*	(1.77)*	(1.73)*		(1.63)*	(1.91)*	(1.65)*	(0.871)*	
Oct 85–Dec 95	1.08	1.13	0.640	1.05	0.5049	0.973	1.04	0.576	1.07	0.5188
	(1.65)*	(2.05)**	(2.05)*	(1.81)*		(1.71)*	(1.99)*	(1.84)*	(1.91)*	

This table reports the coefficients of Eq. (3). Sample I is composed of firms identified as MNCS in *The World Directory of Multinational Enterprises*; Sample II is composed of firms with reported foreign sales to total sales in excess of 20%; Sample III is composed of firms with reported foreign sales to total sales in excess of 0%, but less than 20%; and Sample IV is composed of firms with no reported foreign sales to total sales. *N* is the number of firms in each sample. * denotes significance at the 10% level, ** denotes significance at the 5% level, and *** denotes significance at the 1% level. The *t*–statistics are reported in parentheses.

Note to Panel A2: Chi-square tests of the hypothesis that the slope coefficients allowing time-varying risk premiums are jointly equal to 0.

Note to Panel B2: Chi-square tests of the hypothesis that the rho coefficients are jointly equal to zero. Critical values of χ^2_6 :10% = 10.64;5% = 12.59; 1% = 16.81.

Note: Chi-square tests of the hypothesis that the rho coefficients are joinlty equal to zero. Critical values of χ^2_6 :10% = 10.64;5% = 12.59;1% = 16.81.

(1998) who find that exchange risk is priced in the international financial market using a conditional asset pricing model. Our findings, however, are in sharp contrast with the evidence on the pricing of currency-risk in the US market reported by Jorion (1991). Based on a sample of 20 US industry-portfolios over the 1971–1987 period, Jorion (1991) finds that the exposure of US common stocks to exchange-rate risk is not systematically related to expected returns. That is, US investors do not appear to require compensation for bearing foreign currency-risk.

The use of the trade-weighted exchange rate in place of the yen/US dollar rate in Panels C1 and C2 yields very similar results. [16] Hence, the results are not sensitive to the choice of currency-risk measure. It is interesting to note that most regressions produce slopes on the market portfolio close to one. This implies that the sensitivity to the market factor does not explain much of the variation in average returns across firms. Essentially, these results suggest that the market factor explains why average stock returns exceed the risk free rate. In light of these results, the relative distress, size and exchange risk variables appear to represent underlying risk factors of special hedging concern to investors. This evidence complements and extends that of Fama and French (1996), Arshanapalli et al. (1998) time-series evidence, in which they identify three factors (i.e., relative distress (VG), size (SL) and the market portfolio) that help explain the common variation in stock returns in the US and internationally, respectively. By introducing the currency-risk factor in our intertemporal asset pricing tests we are able to show that the residual currency-risk is systematically related to expected returns. The exchange-rate exposure of Japanese firms, especially MNCs and firms with higher involvement in foreign operations or trade, appears to be of special hedging concern to Japanese investors. Therefore, lack of shareholders' indifference to the firms' currency-risk exposure coupled with managers' risk aversion, especially if they hold a relatively large stake in the firm's stock, can explain why firms may elect to actively manage foreign exchange risk.

The results from the pricing tests of exchange-rate risk across different time-intervals, as shown in Panel D, indicate that the currency-risk exposure commands a significant risk premium that varies predictably through time. These results also show that the Japanese equity returns have a reliable and stable covariation with the other three risk factors across subperiods which confirm the results obtained for the pre and post-Plaza Accord periods.

Finally, summary statistics for the time series of each factor return from Eq. (3) for the entire sample period, reinforce the view that the currency factor,

[16] Jorion (1991) and Ferson and Harvey (1993) report results using a similar measure of exchange-rate risk.

found to be associated with large return differential, is also important for explaining return covariation. For instance, the t-statistic for the mean premium on the currency factor is 1.97 and the volatility of its mimicking portfolio return is the second highest (0.022) among the four considered in this study, imlpying that it is important for investors interested to control portfolio risk. The FF factors also contribute a substantial common component to return comovements with high t-statistics and and volatilities. The volatility of the size mimicking portfolio is the highest(0.046), while the volatility of the distress mimicking portfolio is ranked third (0.020). The market portfolio, however, has the lowest volatility (0.018) with a t-statistic of 1.42 for its mean premium, indicating that the bulk of return covariation is explained by the currency-risk factor and the FF factors.

5. Conclusion

This paper tests whether foreign currency exposure is priced in the capital market of Japan using an intertemporal multifactor asset pricing model that relies on the assumption that the currency-risk premium changes through time in response to changes in business conditions and investors' perception of risk. Our results show that Japanese stock returns are associated with significant risk premia. Specifically, we find currency-risk exposure to command a significant risk premium for MNCs and high-exporting Japanese firms. Although the currency-risk factor is found to be less influential in explaining the behavior of average returns for low-exporting and domestic firms, it is shown to exhibit large return volatility that is likely to be perceived by investors, who wish to contol portfolio risk, as an important underlying source of risk. Overall, our results are consistent with those of Dumas and Solnik (1995), De Santis and Gerard (1998) who find foreign exchange-risk premia to be a significant element of securities rates of return in international financial markets using a conditional asset pricing testing procedures. Our analysis also shows that there is a covariation in Japanese returns related to the relative distress (value minus growth return spread) and size (small minus large return spread) factors. These results complement and extend those of Fama and French (1996), and Arshanapalli et al. (1998) in the sense that they confirm the validity of a multifactor asset pricing model for Japanese equity returns and that currency-risk is identified as one of the factors being of special hedging concern to investors in Japan. In brief, our results favor the existence of an equilibrium pricing model that is consistent with a four-factor version of Merton's (Merton, 1973) intertemporal CAPM or Ross' (Ross, 1976) APT. Whether these results carry to the pricing of exchange-rate risk along with the other three factors in other stock markets remains an open question, which is left for future research.

Acknowledgements

We are also grateful to Yakov Amihud, Bertrand Jacquillat, Roger Huang, Richard Levich, Eli Ofek, Bruno Solnik, Rene Stulz, participants at the 1996 FMA, 1996 PACAP, and 1997 EFMA conferences for their suggestions that have considerably improved the paper. This article was completed after the untimely and sudden death of Patricia H. Hall. She will be sorely missed as a colleague and a scholar.

References

Adler, M., Dumas, B., 1983. International portfolio choice and corporation finance: A synthesis. Journal of Finance 38, 925–984.
Amihud, Y., 1993. Evidence on exchange rates and the valuation of equity shares. In: Amihud, Y., Levich, R. (Eds.), Exchange Rates and Corporate Performance. Businessone, Irwin, IL.
Arshanapalli, B., Coggin, D., Doukas, J., 1998. Multifactor asset pricing analysis of international value investment strategies. Journal of Portfolio Management 24 (4), 10–33.
Bartov, E., Bodnar, G.M., 1994. Firm valuation, earnings expectations, and the exchange-rate exposure effect. Journal of Finance 49, 1755–1785.
Brown, S.J., Otsuki, T., 1993. Risk premia in Pacific-Basin capital markets. Pacific-Basin Finance Journal 1, 235–261.
Chen, N.-F., Roll, R., Ross, S., 1986. Economic forces and the stock market. Journal of Business 59, 383–403.
De Santis, G., Gerard, B., 1998. How big is the premium for currency risk? Journal of Financial Economics 49 (3), 375–412.
Dumas, B., Solnik, B., 1995. The world price of foreign exchange risk. Journal of Finance 50, 445–479.
Fama, E.F., 1984. Forward and spot exchange-rates. Journal of Monetary Economics 14, 319–338.
Fama, E.F., French, K.R., 1996. Multifactor explanations of asset pricing anomalies. Journal of Finance 51, 55–84.
Fama, E.F., MacBeth, J., 1973. Risk, return and equilibrium: Empirical test. Journal of Political Economy 81, 607–636.
Ferson, W., 1990. Are the latent variables in time-varying expected returns compensation for consumption risk?. Journal of Finance 45, 397–430.
Ferson, W.E., Harvey, C.R., 1993. The risk and predictability of international equity returns. Review of Financial Studies 6, 527–566.
Giovannini, A., Jorion, P., 1989. The time-variation of risk and return in the foreign exchange and in the stock markets. Journal of Finance 44, 307–325.
Hamao, Y., 1988. An empirical examination of arbitrage pricing theory: Using Japanese data. Japan and the World Economy 1, 45–61.
Harvey, C.R., 1991. The world price of covariance risk. Journal of Finance 46, 111–157.
Jorion, P., 1991. The pricing of exchange rate risk in the stock market. Journal of Financial and Quantitative Analysis 26, 363–376.
Korajczyck, R., 1983. The pricing of forward contracts for foreign exchange. Journal of Political Economy 93, 346–368.
Lakonishok, J., Shleifer, A., Vishny, R.W., 1994. Contrarian investment, extrapolation, and risk. Journal of Finance 49, 1541–1578.

McElroy, M.B., Burmeister, E., 1988. Arbitrage pricing theory as a restricted nonlinear regression model. Journal of Business and Economic Statistics 6, 29.

McElroy, M.B., Burmeister, E., 1991. The residual market factor, the APT, and mean variance efficiency. Review of Quantitative Finance and Accounting 1, 27–49.

Mei, J., 1992. Estimation of time-varying factor premiums for the APT model with observed and unobserved factors. Working paper, New York University, New York.

Merton, R.C., 1973. An intertemporal asset pricing model. Econometrica 41, 867–880.

Ross, S.A., 1976. The arbitrage theory of capital asset pricing. Journal of Economic Theory 13, 341–360.

Sercu, P., 1980. A generalization of the international asset pricing model. Finance 91–135.

Shanken, J., 1987. Multivariate proxies and asset pricing relations: living with the roll critique. Journal of Financial Economics 18, 91–110.

Solnik, B., 1974. An equilibrium model of the international capital market. Journal of Economic Theory 8, 500–524.

Stopford, J., 1992. Directory of Multinationals. MacMillan, New York.

Stulz, R., 1981. A model of international asset pricing. Journal of Financial Economics 9, 383–406.