Exchange Rate Regimes and the Price of Exchange Rate Risk

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Abstract

We investigate the price of exchange rate risk in the US stock market across exchange rate regimes. We find that exchange rate risk is a priced factor and that the sign of the price of risk is affected by the exchange rate regime. The results have important implications for risk management policies.

Key words:
Exchange rate regimes, Exchange rate price of risk
JEL Classification: F31, G12, G15

Introduction

Due to the globalization of product and financial markets an increasing number of firms are involved in trade where future cash flows are denominated in foreign currencies. Deviations from Purchasing Power Parity make the future value of these cash flows uncertain. Consequently this has led to an increase in the number of firms that engage in hedging the exchange rate risk that such trade entails (see, for example, Allayannis and Weston (2001) and Allayannis and Ofek (2001)). In the light of this, it is important to know whether the exchange rate is a priced risk factor because, if it is, hedging may be rewarded with a lower cost of capital. On the other hand, if exchange rate risk is not a priced factor then there is no reason for firms to hedge this type of risk, as least

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from the point of view of lowering the firms cost of capital. As many firms do expend considerable resources on hedging using both financial and operating policies, it is of considerable interest to establish whether these actions actually benefit investors. [2]

In this paper we examine the pricing of exchange rate risk whilst simultaneously considering how long swings in the dollar (which we refer to as regimes) might affect the price of exchange rate risk. Our motivation for considering regimes stems from the theoretical literature's suggestion that firm behaviour may well be different in periods of depreciation and appreciation, which should have an impact on how exchange rates affect cash flows and hence the expected returns that investors demand.

Krugman (1987) shows that firm behaviour can change across different regimes if import prices are held constant when the dollar appreciates because there are costs for foreign firms to expand sales rapidly. Baldwin and Krugman (1989) and Dixit (1989) argue that both import and export pass–through could be affected when there are nonrecoverable fixed costs of entry. Knetter (1994) argues that if firms care about protecting market share, there are quotas on exports, or firms have a limited distribution capacity, their behaviour may be different in periods of appreciation and depreciation.

Baldwin (1988) argues that the existence of sunk entry costs may lead to hysteresis when there are large swings in the dollar. If the swing in the dollar is of sufficient size this would induce foreign firms to enter the market place. However, because entry costs are sunk not all foreign firms leave the market when the exchange rate returns to its previous level. Baldwin (1988) considers the overvaluation of the dollar in the early 1980s and argues that it was so large and persistent that US firms abandoned some markets altogether, and foreign firms entered markets that before the rise in the value of the dollar were dominated by US firms. The subsequent weakness in the dollar may not have reversed these effects. Consequently, firms behaviour in different exchange rate regimes will reflect these changes in market structure and have an impact on firm's cash flows.

[2] It is surprising that more attention has not been given to the question of whether exchange rate risk can explain within-country cross-sectional differences in expected returns. Jorion (1991) finds no evidence that a cross section of 20 US industry stock returns receive a reward for bearing exchange rate risk as proxied by a currency basket. Antoniou et al. (1998) find that the price of British pounds exchange rate risk is statistically significant for a small cross-section of UK stock returns over a short period of time involving the UK's membership of the European Exchange Rate Mechanism. Vassalou (2000) presents evidence of exchange rates being priced in US stock returns. In most tests of multifactor asset pricing models using domestic assets the exchange rate is not considered as a potential risk factor even though there are sound theoretical reasons for doing so.

In sum, it is possible that investors may demand a different risk premium in periods of appreciation and depreciation because of the different implications the regimes have on firm behaviour and hence their cash flows. We test this hypothesis and find strong support for it.

1 Data

The analysis focuses on a sample of monthly value weighted excess returns for 48 US industries sorted according to level four SIC codes. [3] Excess returns are calculated by subtracting the three month US treasury bill rate from the actual return.

Most studies use a currency basket to measure exchange rate risk. This has the effect of imposing the same sign and size of the price of currency risk irrespective of the currency. We find this to be an unnatural choice. If a firm exports in one currency and imports in another the sign and size of the price of risk may depend on the extent of imports and exports and on the particular currency's movements. We therefore work with individual currencies and choose the dollar Yen (JPY) and dollar ECU rates because of their large weights in US imports and exports. We follow earlier work in this area and use the percentage change in bilateral rates as exchange rate risk factors.

The starting date for the analysis is May 1979, the inception of the ECU. There have been specific, distinct periods, which we call regimes, of US dollar (USD) movements. From 1979 up until February 1985 the dollar appreciated substantially. The USD peaked in February 1985 and subsequently undertook a steep depreciation until the end of 1990. The period from the end of 1990 to the end of the sample is characterized by a more stable period of USD rates.

When we estimate the prices of risk associated with exchange rates we also include other factors to capture the sources of systematic risk in the economy. These are the excess return on the aggregate US stock market portfolio and four macroeconomic factors: the change in industrial production, the change in inflation, the term spread and the default spread. The excess return on the market portfolio is the total return on the aggregate, value weighted CRSP stock market index minus the three month treasury bill rate. The choice of macroeconomic risk factors and their definitions follows the work of Chen et al. (1986). The change in industrial production is the change in the log of the total industrial production for the US economy. The change in inflation is the change in the log of the consumer price index. The term spread is the difference between the yield on twenty year US government bonds and the yield

[3] The appendix gives some more detail of the equity data.

on three months US treasury bills. The default spread is difference between the yield on AAA rated US corporate bonds and the yield on twenty year US government bonds. All data on the macroeconomic factors are obtained from the Federal Reserve.

The inclusion of these additional risk factors is important since it is possible that stock returns might appear to be related to exchange rates because they are affected by the economy in general which also affects the exchange rate. Including separate macroeconomic factors that control for such general effects is important in order to rule out spurious findings that exchange rates are priced.

2 Methodology

We assume a k factor model for expected returns, where the k factors are the stock market factor, the four macroeconomic factors and the two bilateral exchange rates, and specify the following relationship:

$$\mathbf{R}_t = E(\mathbf{R}) + \beta_k \mathbf{F}_{kt} + \mathbf{u}_t \tag{1}$$

$$E(\mathbf{R}) = \lambda_0 \iota_N + \beta_k \lambda_m \tag{2}$$

where $\mathbf{R}_t$ is an N vector of security returns, $\mathbf{F}_{kt}$ is a k vector of observations on the k risk factors, β_k is an $N \times k$ matrix of betas (sensitivities of returns to the factors), $\mathbf{u}_t$ is an N vector of residual error terms, $E(\mathbf{R})$ is an N vector of expected returns, λ_0 is the return on the risk free asset, ι_N is an N vector of ones and λ_k is a k vector of prices of risk.

We use an nonlinear seemingly unrelated regression (NLSUR) framework to jointly estimate the parameters of the asset pricing model (McElroy and Burmeister, 1988). The nonlinear estimation proceeds by substituting equation (2) into (1) and stacking the equations for the N securities to give:

$$\mathbf{R} - \lambda_0 = \{\mathbf{I}_N \otimes [(\lambda' \otimes \iota_{\mathbf{T}}) + \mathbf{F}]\}\, \beta + \mathbf{u} \tag{3}$$

where $\mathbf{R}$ is an $NT \times 1$ vector of returns, λ is a $k \times 1$ vector of prices of risk, $\mathbf{F}$ is a $T \times k$ matrix of observations of the factors, β is an $Nk \times 1$ vector of sensitivities, $\mathbf{I}_N$ is a $N \times N$ identity matrix and $\otimes$ is the Kronecker product operator. The NLSUR estimators solve the following minimization problem:

$$\min_{\lambda, \mathbf{B}} \mathbf{u}' \left(\hat{\mathbf{\Sigma}}_{\mathbf{u}}^{-1} \otimes \mathbf{I}_T \right) \mathbf{u} \tag{4}$$

where $\mathbf{u}$ is derived from (1), and $\hat{\mathbf{\Sigma}}_{\mathbf{u}}^{-1}$ is the estimated residual covariance matrix from estimating (3).

3 Results

In terms of interpreting the prices of risk on the Yen and ECU it is important to consider that over the sample period the US was a large net importer from Japan. Exports to Japan were limited due to, amongst other things, trade restrictions and the pricing behaviour of Japanese firms. On the other hand, whilst the US had a negative total trade balance over the whole period relative to the EU, in about half the years it was positive and moreover, the negative balance was around ten times smaller than the balance with respect to the Yen. We may therefore expect investors to demand different risk premia for the Yen and ECU given that the US exported more to the EU and imported more from Japan.

Table 1
Estimates of the Price of Risk

λ_m	λ_{ecu}	λ_{yen}	λ_{ip}	λ_i	λ_{ts}	λ_{dr}	LR
			1978:8-1985:02				
0.003 (2.55)	0.031 (4.70)	−0.038 (4.11)	−0.009 (3.46)	−0.008 (9.63)	−0.002 (0.49)	−0.006 (12.85)	< 0.01
			1985:3-1989:12				
0.007 (2.67)	−0.009 (1.67)	0.022 (2.55)	−0.003 (2.70)	−0.006 (9.32)	−0.020 (9.63)	−0.003 (2.02)	< 0.01
			1990:1-1998:12				
0.002 (3.84)	0.028 (2.83)	−0.033 (2.84)	-0.001 (0.66)	−0.003 (8.44)	0.023 (7.51)	0.005 (13.11)	< 0.01

The table provides estimated prices of risk, where λ_m refers to the stock market, λ_{ecu} to the ECU, λ_{jpy} to the JPY, λ_{ip} to changes in industrial production, λ_i to changes in inflation, λ_{ts} to the term spread and λ_{dr} to the default spread. LR provides the probability level of a LR test for the exchange rate prices of risk (λ_{ecu} and λ_{jpy}) both being zero.

Table 1 reports estimates of prices of risk in the three subperiods. In the first regime of dollar appreciation the ECU price of risk is positive and the Yen price of risk negative. If on average firms are exporters to the EU then the appreciation is bad news for exporters and hence investors should demand a premium to hold stocks of companies that are exporters to the EU. Conversely, under an appreciating dollar, the large trade deficit with Japan indicates that firms that are importing experience a decrease in their imported costs. Consequently, investors are willing to pay a premium to hold these stocks, and hence we observe a negative Yen price of risk.

The second regime is characterized by a strong dollar depreciation. This will have the reverse effect on the firms than that described above in the first regime. Consistent with this we observe that the prices of risk switch sign: now that exports to the EU become more competitive investors are willing to pay a premium to hold these stocks; imported costs from Japan become more expensive and hence investors demand a risk premium for holding these

stocks.

The final regime is one of relatively stable exchange rates. There is a small appreciation relative to the ECU and we observe that the ECU price of risk switches sign to be consistent with the first regime of dollar appreciation. The sign on the Yen price of risk becomes negative. However, in this regime there is a small continual depreciation of the dollar relative to the Yen. A potential explanation for this is that the dollar has depreciated so much relative to the Yen by this time, coupled with the opening up of Japanese markets, that more and more firms have found it profitable to begin exporting to Japan and hence they are benefiting from this.

In addition to the possibility of increasing numbers of exports from US companies to Japan, a further explanation of the change in the sign relative to the Yen is that importers of Japanese products are increasing their use of hedging tools and are being rewarded by a reduction in their cost of capital. That is, investors in stocks that have large Yen imports do not require an additional return in the final regime because firms have hedged their positions. [4]

The final column of table 1 reports the results of a test of the restriction that the exchange rate prices of risk are jointly zero. In all three regimes we can easily reject this hypothesis. The remaining prices of risk in the table indicate that they are important in capturing macroeconomic state variables, hence it is unlikely that the exchange rate risk factors are picking up spurious correlations between stock returns and the macroeconomy that are unrelated to exchange rate exposure.

The market price of risk is positive and statistically significant in all three regimes. The prices of risk associated with both the inflation and industrial production risk factors are relatively constant over the three regimes and do not change sign. The term structure and default risk factors have negative signs in the first two periods but both become positive in the final regime. One possible explanation of this is that the final regime coincides with a change in the macroeconomic conditions between the 1980s and 1990s which are reflected in the default risk and term structure of interest rates.

We have shown that exchange rates are priced risk factors, that the price of risk is different for different currencies and different across regimes. We reason that this reflects the different trade balance between the EU and Japan. Discovering that the price of risk is statistically significant is important for hedging reasons: firms will obtain a lower cost of capital if they hedge to eliminate exchange rate risk. However, this is conditional on the exchange rate regime and the currency.

[4] We thank the referee for suggesting this possibility.

4 Conclusion

This paper has investigated whether investors price exchange rate risk in different exchange rate regimes. We find that the Yen and ECU are both priced and that prices of risk change across regimes. We contend that this dynamic behaviour in exchange rate prices of risk is due to the extent of imports and exports to the EU and Japan. These results have important implications for risk management policies of both firms and investment managers, as well as the general issue of determining which factors explain the cross section of expected returns.

Appendix

A Industry stock returns

The paper uses data for 48 different industries. The dataset is calculated and provided by Kenneth French. The indices has been compiled by sorting US companies based on their four digit SIC level. The data is available for downloading and described at the web address
`http://mba.tuck.darthmouth.edu/pages/faculty/ken.french/data_library.html`.
We are grateful to Ken French for providing the data. A listing of industries and some descriptive statistics for the data is provided in table A.1.

Table A.1
Descriptive Statistics of industry stock returns

	Industry	Mean	Standard Deviation
1	Agriculture	1.02	(6.88)
2	Food Products	1.05	(4.70)
3	Candy and Soda	1.37	(5.44)
4	Beer and Liquor	1.11	(5.20)
5	Tobacco Products	1.48	(6.16)
6	Recreation	1.29	(7.67)
7	Entertainment	1.05	(6.72)
8	Printing and Publishing	1.01	(5.46)
9	Consumer Goods	1.01	(4.77)
10	Apparel	0.57	(6.18)
11	Healthcare	1.03	(7.28)
12	Medical Equipment	1.06	(5.67)
13	Pharmaceutical Products	1.24	(5.09)
14	Chemicals	0.79	(5.29)
15	Rubber and Plastic Products	0.72	(5.79)
16	Textiles	0.69	(5.93)
17	Construction Materials	0.79	(5.68)
18	Construction	0.40	(7.17)
19	Steel	0.30	(6.22)
20	Fabricated Products	0.43	(6.22)
21	Machinery	0.40	(5.95)
22	Electrical Equipment	0.68	(6.01)
23	Automobiles and Trucks	0.80	(5.83)
24	Aircraft	0.90	(6.38)
25	Shipbuilding, Railroad Equipment	0.93	(6.96)
26	Defense	0.90	(6.49)
27	Precious Metals	0.35	(11.26)
28	Non-Metallic and Indus. Metal Mining	0.30	(7.09)
29	Coal	0.03	(6.53)
30	Petroleum and Natural Gas	0.73	(5.51)
31	Utilities	0.64	(3.55)
32	Communication	1.08	(4.70)
33	Personal Services	0.69	(5.89)
34	Business Services	1.24	(6.35)
35	Computers	0.61	(6.17)
36	Electronic Equipment	0.97	(6.67)
37	Measuring and Control Equipment	0.88	(7.82)
38	Business Supplies	0.70	(5.69)
39	Shipping Containers	0.61	(4.97)
40	Transportation	0.73	(5.88)
41	Wholesale	0.84	(5.55)
42	Retail	1.18	(5.74)
43	Restaurants, Hotels, Motels	0.77	(5.62)
44	Banking	1.04	(5.96)
45	Insurance	0.93	(4.88)
46	Real Estate	0.71	(5.71)
47	Trading	1.01	(4.74)
48	Others	0.58	(6.44)

We describe the 48 different industry indices by providing the means and standard deviations of percentage monthly excess returns. The sample period is 1979:4 through to 1998:12. The numbers are in percent per month.

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