Risk Premiums in the Foreign Exchange Markets

— A Latent Variable Model Approach —

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Ⅰ. Introduction

Since the era of flexible exchange rate, there has been considerable political, commercial and academic interest in the efficiency of the forward foreign exchange markets. Policy makers are concerned that excess speculation in the forward exchange market results in unwarranted volatility in the spot exchange market, and the predictability of forward exchange rates in forecasting the future spot exchange rates is used in arguments against intervention by central banks.

Early studies by Frenkel(1977) and Levich(1979) supported the proposition that the forward rate was an unbiased predictor of the future spot rate which was taken as an indication of the efficiency of the market. There is growing literature showing that forward exchange rates are systematically biased predictors of future spot exchange rates when expectations are posited to be rational. The unbiasedness hypothesis is rejected in mamy empirical studies(Cumby and Obstfeld(1981), Bilson (1981), Fama(1984)). Theoretically, numerous international asset pricing models

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demonstrate that the bias is their risk premium, possibly time varying, risk-averse investors receive as compensation for the risk inherent in forward exchange rate speculation. Unfortunately, despite the general agreement over the significance of the risk premiums, few of these theoretical specifications are empirically tractable and the rejection of unbiasedness hypothesis has not been considered as an acceptance of a particular risk premium model. In an important contribution to the literature, Fama (1984) showed that the nature of the risk premium can be further understood without the need to utilize a particular model. Specifically, Fama decomposed the forward premium into two unobservable components; the expected spot exchange rate and the risk premium. He not only found the risk premium to be time-varying but that its variations rather movements in expected spot exchange rates account for most of the volatility in one-month forward premiums. The results are further supported by Hodrick and Srivastava(1986) employing different methodologies. However, these studies examined just one-month maturity forward contract.

In a previous study, Lim(1989) utilized Generalized Method of Moments (GMM) to show if the nature of time variation in risk premiums is invariant with respect to the maturity of the forward contracts. Lim(1989) documents a rejection of the hypothesis that forward exchange rates are unbiased predictors of future spot rates. The rejection of unbiasedness hypothesis is consistent with various maturities and exchange rates. Joint tests across currency and across maturity also confirm not only the existence of time-varying risk premiums in the forward exchange market but that the variations in the forward premiums rather than movements in expected spot exchange rate changes account for most of the volatility in forward excnange rates.

The purpose of this paper is to extend the existence of the time-varying risk premiums in the forward excnange market into the framework of the single latent variable model to test whether the risk premiums in the forward excnange markets move in proportion to a single latent variable.

Ⅱ. Model Specification and Data

1. Model Specification

In the finance literature the risk-return trade-off has been characterized with a single beta model. The riskiness of any asset is measured by the covariation of the excess return on the asset with the excess return from some benchmark portfolio.

(1) $E_t(R_{t+k,k} - R^z_{t+k,k}) = \beta_t \; E_t(R^b_{t+k,k} - R^z_{t+k,k})$,

where $E_t(\;)$ is an expectation operator conditioned on an information set I_t.

$R_{t+k,k}$ is the k-period return on an asset purchased at time t.

$R^z_{t+k,k}$ is the k-period return on a zero-beta portfolio.

$R^b_{t+k,k}$ is the k-period return on a benchmark portfolio, and

$$\beta_t = \frac{\mathrm{cov}(R_{t+k,k}, R^b_{t+k,k})}{\mathrm{Var}(R^b_{t+k,k})}$$

The same asset pricing relationship can be derived from a more general framework of the Intertemporal Capital Asset Pricing Model(ICAPM).[1)]

The ICAPM of Merton(1973) and Lucas(1978) impose some testable restrictions on asset pricing. In discrete time framework with a representative investor with time separable utility functiion defined over consumption c, the behavior of the excess return must satisfy the following first-order condition.

(2) $E_t[Q_{t,\,t+k}\,(1+h_t(i))] = 1$,

where $1+h_t(i)$ is the dollar price of the consumption good i at time t, and

$$Q6_{t,\,t+k} = \frac{\delta\, U'(c_{t+k})\; P_t}{U'(c_t)\; P_{t+n}}$$

1) There are conceptual advantage in using ICAPM. As pointed out by Roll(1977), the econometric content of static CAPM is valid only if the benchmark return $R^b_{t+k,k}$ lies on the conditional mean-variance frontier. However, ICAPM does not have the implication that the return on the aggregate wealth portfolio be mean-variance efficient and it is not required that observations on a benchmark return for a single beta model be available a priority.

is the marginal rate of substitution of dollar between t and t+k and δ is a discount factor.

Then using risk premium (1) can be rewritten as

(3) $E_t[r_t(i)] = \beta_{it} E_t[r_t(b)]$, where

$$\beta_{it} = \frac{cov_t[r_t(i), r_t(b)]}{var_t[r_t(b)]}$$

Thus, the expected dollar excess return on asset i is proportional to the expected excess return on a benckmark portfolio whose payoff is conditionally correlated with the intertemporal marginal rate of substitution of dollar. As With most empirical CAPM, we assume that conditional betas are constant.[2)]

For the empirical representation of (3), we define risk premium of exchange rate i as

(4) $y_{t+k}(i) = \log(F_{t,k}(i) - S_{t+k}(i)$,

where $F_{t,k}(i)$ is the k-period forward rate for currency i observed at time t and S_{t+k} (i) is the spot exchange rate for currency i observed at time t+k. All exchange rates are measured by the dollar prices of foreign currencies. Since the expected excess return on the benchmark portfolio is unobservable, the expected excess return on the benchmark portfolio is treated as a latent variable and the information variables observed at time t are substituted. In this study, Euro-interest differentials are used as information variables.

Then the 7-equation system of latent variable model is

(5) $y_{1t} = \alpha_0 + \alpha_1 x_{1t} + \alpha_2 x_{2t} + \cdots + \alpha_7 x_{7t} + e_{1t}$,

$y_{it} = \beta_i \alpha_0 + \beta_i \alpha_1 x_{1t} + \beta_i \alpha_2 x_{2t} + \cdots + \beta_i \alpha_7 x_{7t} + e_{it}$, $i=2,\cdots 7$.

In a compact form,

(6) $Y_t = \Gamma X_t + E_t$, where

Y_t is a 7-dimensional vector of risk premiums,

X_t is a vector of information available including a constant,

E_t is a 7-dimensional vector of forecast errors which are orthogonal to X_t, and Γ is a 7X8 matrix of regression coefficients.

2) It should be noted that, as pointed out by Hansen and Hodrick(1993), such tests are not tests of a fully specified general equilibrium model, but are tests of a proportional co-movement of expected excess returns which are motivated by the ICAPM

The model (4) imposes non-linear restrictions of a single latent variable structure, $\gamma_{ij}=\beta_i\alpha_j$, on (5). β_1 is normalized to unity so the first row of Γ estimates the α coefficients, the first column estimates the other β coefficients, and the lower right-hand block diagonal matrix is restricted. Thus, there are 42 restrictions which force risk premiums to move together in proportion with one another.

The equation system (5) is estimated by the GMM. The GMM estimation is based on 56 (7 equations by 8 information variables) orthogonality conditions. More precisely, the first conditions of the GMM sets 14 (number of coefficients) linear combinations of the 56 orthogonality restrictions equal to zero. Thus there are 42 linearly independent combinations that are not necessarily equal to zero but which should be close to zero under the specified restrictions.

Estimation without restrictions, which is identical to the usual GMM estimation, is equivalent to setting 56 sample orthogonality conditions equal to zero. A test of specified non-linear restrictions is conducted by examining the minimized value of the objective function. A theoretical value of objective function is zero without restrictions.

Hence, the value of the minimized objective function, which is the difference between the value of the objective functions with and without restrictions, serves as a test statistic.

Each α coefficients measures the impact of each information variables on the asset's risk premium and each β coefficient represents the riskiness of each asset relative to the asset whose β is normalized to one.

2. Data

Weekly data for the 9 spot and forward exchange rates come from the Weekly Review of the Harris Trust and Savings Banks. Friday close exchange rates of U.S. dollar per foreign currencies are used. The sample period begins August 31, 1973, which coincides with Fama's(1984) study and ends May 9, 1986. Four maturities for forward contracts are available. For the non-overlapping sample, one-, three-, six-,

and twelve - month forward rates are sampled at 4, 13, 26, and 52 weeks interval, respectively. Data availability for the twelve - month contracts limits its starting date to September 6, 1974.

Ⅲ. Empirical Results

Among seven risk premiums (the British pound, the Canadian dollar, the Deutsche mark, the French franc, the Dutch guilder, the Swiss franc, and the Japanese yen), the Deutsche mark (DM) is chosen as a benchmark risk premium whose β is set to one.[3)]

Table 1 reports the cross - currency latent variable estimation for three different maturities. For one - month maturity, the restrictions of the latent variable model is not rejected. Even though almost all individual coefficients are significant for three - and six - month maturities, risk characteristics of foreign exchange rates are not persistent across maturities. In other words, the cross - currency estimation fails to reveal any systematic currency - specific risk characteristics.

Table 2 reports the cross - maturity joint estimation of a single latent variable model for each exchange rate. As with the previous cross - maturity estimations, the longest lags of six - month forward rate(moving average of 26 lags) is used in the GMM implementation. All seven equation systems are not rejected. Individual betas of four exchange rates (the Canadian dollar, the Deutsche mark, the Dutch guilder, and the Japanese yen) are significant and they show that betas of longer maturity is larger than those of short maturity. Cross - maturity test results are consistent with our intuition and reveal maturity - specific risk characteristics of foreign exchange rates.

3) In an original Harris data, 9 exchange rates for 4 different maturities (one -, three -, six -, and twelve - month)forward exchange rates and Euro - interest rates are available. Due to frequent missing observations in the Belgian franc and the Italian lira, only seven exchange rates are included in this study. Also, frequent missing values in twelve - month Euro - interest rates forces us to drop twelve - month maturity in our study.

Ⅳ. Conclusions

The existence of time-varying risk premiums in the forward foreign exchange market is extended into the framework of the single latent variable model to test whether the risk premiums in the forward exchange markets move in proportion to a single latent variable. The single latent variable can be interpreted as a constant beta on a single, unobservable benchmark portfolio in the Intertemporal Capital Asset Pricing Model(ICAPM).

The non-linear restrictions imposed by the single latent variable model are not rejected only for three- and six-month maturity cross-maturity estimation. We cannot identify any systematic currency-specific risk characteristics. However, for the cross-maturity estimation, the single latent variable model is not rejected for all seven currencies. Furthermore, all significant betas of longer maturity risk premiums (three- and six-month) are larger than those of short maturity risk premiums (one-month).

Table 1 Latent Variable Estimates
(Cross-Currency Estimation)

Panel A : Maturity = 1 month
Number of observations = 547
$X^2(42)$ = 86.45 P=0.00

	Coeff.	SE	P		Coeff.	SE	P
				α0	-0.0006	0.0009	(0.23)
β1	1.0000			α1	-2.6496	0.7059	(0.00)
β2	3.0875	0.8105	(0.00)	α2	-0.1984	0.1881	(0.15)
β3	0.9883	0.1770	(0.00)	α3	-0.0339	0.0352	(0.17)
β4	-0.1031	0.1300	(0.21)	α4	-0.0337	0.1820	(0.43)
β5	2.8080	0.4493	(0.00)	α5	2.6481	0.6762	(0.00)
β6	1.2048	0.2259	(0.00)	α6	0.3874	0.1870	(0.02)
β7	0.9104	0.2109	(0.00)	α7	0.2100	0.1356	(0.06)

Panel B : Maturity = 3 month
Number of observations = 538
$X^2(42)$ = 41.18 P=0.51

	Coeff.	SE	P		Coeff.	SE	P
				α0	-0.0042	0.0024	(0.04)
β1	1.0000			α1	-2.1747	0.3912	(0.00)
β2	0.6335	0.1554	(0.00)	α2	-0.3889	0.0881	(0.00)
β3	0.6322	0.0556	(0.00)	α3	-0.1212	0.0495	(0.01)
β4	0.4304	0.0855	(0.00)	α4	0.4123	0.1991	(0.02)
β5	- 0.0391	0.1091	(0.36)	α5	0.2806	0.0521	(0.00)
β6	1.4867	0.1037	(0.07)	α6	1.9687	0.2734	(0.00)
β7	-1.5896	0.4218	(0.00)	α7	-0.1986	0.1136	(0.04)

Panel C : Maturity = 6 month

Number of observations = 525

$X^2(42)$ = 20.70 P=0.99

	Coeff.	SE	P		Coeff.	SE	P
				$\alpha0$	-0.0021	0.0009	(0.01)
$\beta1$	1.0000			$\alpha1$	-0.2570	0.1800	(0.01)
$\beta2$	5.1984	0.7387	(0.00)	$\alpha2$	0.5337	0.0898	(0.00)
$\beta3$	2.0700	0.2027	(0.00)	$\alpha3$	0.0727	0.0219	(0.00)
$\beta4$	-0.8932	0.1363	(0.00)	$\alpha4$	-0.5575	0.0940	(0.00)
$\beta5$	1.8536	0.1481	(0.00)	$\alpha5$	0.1251	0.0432	(0.00)
$\beta6$	0.1598	0.1626	(0.16)	$\alpha6$	-0.0548	0.0388	(0.08)
$\beta7$	5.4786	0.7884	(0.00)	$\alpha7$	0.0606	0.0269	(0.01)

Notes : Coeff. = Estimates of coefficients

SE = Standard errors of estimates

P = Marginal significance levels

$\beta1$ = β of Deutsche mark

$\beta2$ = β of British pound

$\beta3$ = β of French franc

$\beta4$ = β of Canadian dollar

$\beta5$ = β of Dutch guilder

$\beta6$ = β of Swiss franc

$\beta7$ = β of Japanese Yen

$\alpha1$ = Euro interest rate differential (US-DM)

$\alpha2$ = Euro interest rate differential (US-BP)

$\alpha3$ = Euro interest rate differential (US-FF)

$\alpha4$ = Euro interest rate differential (US-CD)

$\alpha5$ = Euro interest rate differential (US-DG)

$\alpha6$ = Euro interest rate differential (US-SF)

$\alpha7$ = Euro interest rate differential (US-JY)

Table 2 Latent Variable Estimates
(Cross-Maturity Estimation)

Canadian dollar

$X^2(6) = 10.05$ P=0.12

	Coeff.	SE	P		Coeff.	SE	P
				$\alpha 0$	0.0021	0.0008	(0.01)
$\beta 1$	1.0000			$\alpha 1$	1.8142	1.1526	(0.06)
$\beta 2$	1.8091	0.4390	(0.00)	$\alpha 2$	-0.2028	0.6770	(0.38)
$\beta 3$	2.3661	0.9352	(0.00)	$\alpha 3$	0.1760	0.2792	(0.26)

British pound

$X^2(6) = 9.26$ P=0.16

	Coeff.	SE	P		Coeff.	SE	P
				$\alpha 0$	0.0036	0.0002	(0.07)
$\beta 1$	1.0000			$\alpha 1$	2.5157	2.3404	(0.14)
$\beta 2$	1.3416	0.6496	(0.02)	$\alpha 2$	2.5424	1.6981	(0.07)
$\beta 3$	0.0807	1.9910	(0.48)	$\alpha 3$	-0.7175	0.9691	(0.04)

French franc

$X^2(6) = 2.18$ P=0.90

	Coeff.	SE	P		Coeff.	SE	P
				$\alpha 0$	0.0002	0.0006	(0.37)
$\beta 1$	1.0000			$\alpha 1$	0.0205	0.0945	(0.41)
$\beta 2$	-10.9235	37.58	(0.39)	$\alpha 2$	0.0682	0.2053	(0.37)
$\beta 3$	-23.0495	74.67	(0.38)	$\alpha 3$	-0.0244	0.0753	(0.37)

Deutsche mark

$X^2(6) = 6.66$ P=0.35

	Coeff.	SE	P		Coeff.	SE	P
				$\alpha 0$	-0.0124	0.0050	(0.01)
$\beta 1$	1.0000			$\alpha 1$	-0.3439	2.3368	(0.44)
$\beta 2$	3.3777	0.7351	(0.00)	$\alpha 2$	-2.9813	1.9258	(0.06)
$\beta 3$	5.7475	1.7423	(0.00)	$\alpha 3$	2.0875	0.9137	(0.01)

Dutch guilder

$X^2(6) = 6.63$ P=0.36

	Coeff.	SE	P		Coeff.	SE	P
				α0	-0.0103	0.0033	(0.00)
β1	1.0000			α1	0.0568	1.1240	(0.48)
β2	2.9691	0.2834	(0.00)	α2	-0.0153	0.0116	(0.10)
β3	4.9218	0.6821	(0.00)	α3	0.8456	0.2744	(0.00)

Swiss franc

$X^2(6) = 8.81$ P=0.18

	Coeff.	SE	P		Coeff.	SE	P
				α0	-0.0067	0.0036	(0.03)
β1	1.0000			α1	14.5014	4.3985	(0.00)
β2	-0.0459	0.5376	(0.47)	α2	-6.4454	2.1329	(0.00)
β3	-0.3081	0.8770	(0.36)	α3	1.0048	0.6614	(0.06)

Japanese yen

$X^2(6) = 6.03$ P=0.42

	Coeff.	SE	P		Coeff.	SE	P
				α0	-0.0129	0.0037	(0.00)
β1	1.0000			α1	-0.2985	1.9659	(0.44)
β2	3.2397	0.3084	(0.00)	α2	-0.1931	0.9352	(0.42)
β3	6.5373	0.9852	(0.00)	α3	0.7583	0.3854	(0.02)

Notes : Coeff. = Estimates of coefficients
SE = Standard errors of estimates
P = Marginal significance levels
β1 = β of 1−month risk premium
β2 = β of 3−month risk premium
β3 = β of 6−minth risk premium
α1 = 1−month forward premium
α2 = 3−month forward premium
α3 = 6−month forward premium
Number of observation = 525.

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국 문 요 약

외환시장에서의 위험 프리미엄(Latent Variable) 모형

先物換(forward exchange rate)에는 미래에 실현될 현물환율의 不偏期待値와 선도거래에 따라 발생하는 위험에 대한 보상인 危險補償이 포함되어 있다는 가설에 대한 많은 실증분석 결과 위험 프리미엄의 존재는 물론 이러한 위험보상이 시간에 따라 달라진다는 사실이 밝혀졌다. 이 논문에서는 선물환에 포함된 위험보상이 하나의 관찰할 수 없는 변수에 따라 변하는 가를 검증한다. 이러한 가설에 대한 배경은 임의의 자산에 대한 期待收益率은 기준이 되는 포트폴리오(benchmark portfoilo)와의 공분산에 따라 위험보상이 주어진다는 資本資産價格決定模型(CAPM)이다.

실증분석을 위한 모형은 일반적인 국제자본자산가격결정모형(ICAPM)에서 유도되었으며, 자료는 Harris Trust and Savings Bank가 제공하는 주별 외환시세를 이용하였다. 사용된 외환은 미국의 달러를 중심으로 7개(영국의 파운드, 캐나다 달러, 독일의 마르크, 네덜란드의 길더, 스위스 프랑, 일본의 엔)이며, 모형의 검증에는 GMM이 활용되었다.

검증 결과, latent variable 모형에 의한 非線型의 制約條件들이 3개월과 6개월 만기의 선물환에서 기각되었으며, 통화에 따른 어떠한 특이한 현상도 발견할 수 없었다. 하지만 각 만기간의 관계에서는 7개의 모든 통화에 있어서 모형을 기각할 수 없었다. 만기간의 검증에서는 모든 베타가 통계적으로 유의하였으며, 만기가 긴 선물환의 베타가 만기가 짧은 선물환에 대한 베타보다 크다는 사실을 알 수 있었다.