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Term Premia on Euro Rates

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THERE ARE AT LEAST two statistically firm results regarding international money and capital markets. The first is the theory of interest rate parity is empirically valid for Euro interest rates [8]. The second is forward exchange rates are poor, very likely biased, predictors of future spot exchange rates [1, 3, 10, 12, 13]. The former is a comforting finding in that it assures there are no unexploited arbitrage profits. The latter is troubling (to some) because it might be a symptom of an inefficient market.

That interest rate parity holds suggests international exchange and money market arbitrageurs are fully exploiting all profit opportunities. They are behaving rationally. That forward exchange rates fail to predict future spot rates at least unbiasedly suggests the existence of some unknown mechanism which robs predictive ability. In a naive rational expectations view of the world, the failure of forward rates to be unbiased predictors of future spot rates implies either that there is some difference between interest rate pairs other than inflationary expectations, or that forward rates do not capture expected inflation differences in any simple way. (See [9]).

This paper addresses the first issue. If there are differences in interest rate pairs which do not solely reflect expected inflation divergences, this must show up as a difference in real interest rates. Such could be the result of actual instantaneous real rates of identical risk being unequal in magnitude, or what is more likely, differences in term premia between interest rate pairs when periods greater than, say, one day are used in interest rate parity and forward rate prediction tests.

If there are differential term premia in interest rate pairs of, say, one month or longer then forward exchange rates will mispredict the future spot exchange rate by that margin.[1]

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[1] Consider a simple case:

$$F_t/S_t - 1 \cong (i_1 + P_1) - (i_2 + P_2)$$

Where F = forward exchange rate; S = spot exchange rate; i_1, i_2 = instantaneous real rate of interest plus inflation expectations in countries 1 and 2, respectively, and P_i, P_2 are term premiums. Let's further suppose that there is zero expected inflation in both countries over the relevant time horizon, So $S_t = E(S_{t+1})$. $F_t = E(S_{t+1})$ iff $P_1 = P_2$. If $P_1 \neq P_2$, $[F_t - E(S_{t+1})]/S_t = P_1 - P_2 \neq 0$. That is, the forward rate would be a biased predictor.

In this paper, we examine Eurocurrency interest rate data to determine first whether there are term premia or what seem to be term premia, and second to see how closely those for one currency correlate with those from others. We find there are term premia, or at least a two factor characterization of the term structure of interest rates is necessary. Further, for each currency the second factor, possibly the term premium, does not seem closely related to that of any other.

Prior Work

Fama [5] and Roberts [19] showed there are term premia in U.S. Treasury security interest rates. Fama attributed these to uncertainty induced by inflation. Santomero [22], in a study largely using 1960's data, found evidence of term premia in Eurodollar interest rates.

In contrast, a very recent study by Cosset [4] found no support for the term premium hypothesis. Examining tri-monthly interest rate data for seven different Eurocurrencies for the period December 1973 through December 1980, he finds prediction errors—the difference between implied forward interest rates and subsequent future spot interest rates—are not systematically influenced by his measures of interest rate uncertainty. He writes, "however, on the basis of this evidence, we cannot completely rule out the existence of a systematic risk premium because we can never exclude the possibility that there exists an omitted variable that explains the risk premium," [4, p. 80]. Nor, we might add, can the possibility be ignored that the author's measures of uncertainty were not as meaningful as they might have been.

Data

Throughout the paper, the data base consists of interest rate observations on Eurocurrency CD's. The data were taken from Morgan Guaranty's *World Financial Markets* (various issues; the data used are available from the authors). Eurocurrency deposit rates for six currencies, the Dollar, the Deutsche Mark, the Swiss Franc, the Pound Sterling, the French Franc, and the Japanese Yen, were obtained for one, three, six and twelve month deposits. These are prime London banks' and in the case of Sterling non British banks' bid rates, set in competitive markets for large deposits.

The sample period runs from January 1977 through February 1982. Of course, it would have been desirable to obtain data through the entire 1970's, but our search uncovered no federal agency or banking institution which gathered such data on a regular basis prior to 1977. Table I shows summary statistics for the data.

One of the attractive features of CD rates is they represent annualized rates of return as well as annualized yields. These instruments are customarily held to and interest paid at maturity so the interest rate is a rate of return: there is no organized resale market and no reinvestment risk.

In the tests which we report, first differences in interest rates are used. This tends to purge the data of trends. Results from using interest rate levels are not unlike first difference results, however.

Table 1

Interest Rate Summary Data
January 1977–February 1982*

	1 Month	3 Months	6 Months	12 Months
Euro dollars				
Mean	11.39	11.67	11.80	11.53
Standard Deviation	4.32	4.22	4.01	3.59
Euro Deutschemark				
Mean	6.94	7.05	7.11	7.09
Standard Deviation	3.55	3.34	3.23	3.05
Euro Swiss Franc				
Mean	3.92	4.17	4.45	4.44
Standard Deviation	3.25	3.31	3.16	2.79
Euro Sterling				
Mean	12.71	12.87	12.85	12.66
Standard Deviation	3.49	3.34	3.00	2.62
Euro French Franc				
Mean	12.44	12.66	12.91	13.01
Standard Deviation	4.88	4.09	3.66	3.06
Euro Yen				
Mean	5.86	6.35	6.61	6.61
Standard Deviation	3.68	3.38	2.88	2.44

* $N = 62$ observations.

Method

One of the difficulties associated with detection of term premia is they are quite likely to be variable over time. This means that any straight-forward regression approach may fail to uncover what is actually happening.

For instance, Cosset's [4] conclusion was based on a regression of the form:

$$_{t+3}F_{3,t} - R_{3,t+3} = \alpha + \beta U_{nt} + \epsilon_t$$

where

$_{t+3}F_{3,t}$ = the forward rate applicable to period $t + 3$ implied by the yield curve of a security at time t.

$R_{3,t+3}$ = the 3 month interest rate at $t + 3$, and

U_{nt} = measure of uncertainty concerning the change in interest rates between the periods t and $t + 3$.

If there is a term premium embedded in $_{t+3}F_{3,t}$, it would have to be a comparatively stable function of U_{nt}. If it was unstable, the coefficient, β, may very well not reveal it. Intuition, on the other hand, suggests that at very high levels of uncertainty the premium may be way out of proportion to what it would be (possibly zero) at very low levels of uncertainty. While this sort of phenomenon might show up if an U_{nt}^2 term was used in the regression analysis (it was not), the identification of term premia could still elude the analyst. Moreover, a measure of historical variability might not contain much information about uncertainty regarding the future. We note in passing our early tests in which we regressed actual spot rates against implied forward rates generally produced coefficients of sufficient magnitude to suggest term premia.

In this paper, we employ principal components analysis to investigate whether a term premium exists. This approach has the advantage of allowing the data to speak for themselves, and does not force a stable relationship upon the data. A related technique, factor analysis, has been used by Oldfield and Rogalski [18], Roll and Ross [20], and Bower, Bower, and Logue [2] to investigate the applicability of Arbitrage Pricing Theory (see Ross [21] to common stock returns, and by Logue, Salant, and Sweeney [14] to study international capital market integration.

We chose principal components analysis instead of factor analysis because factor analysis allows an error term. Complete explanation is important for our purposes since we ultimately want to create time series of the principal components. Creation of time series of factors derived from factor analysis is possible, but there is too much room for error, the inexact recreation of the original data series. Moreover, as a very practical matter we found virtually no difference in the basic results using either technique, hence made our decision to forge on using principal components analysis because of the ease and unambiguity with which time series of components could be estimated.

In brief, principal components analysis takes the variance/covariance matrix of the interest rate series and extracts orthogonal variables from those data which sequentially maximize the explanatory power of those variables.[2] For each Eurocurrency, there are four interest rate series. Thus we estimated the four principal components for each currency.[3]

Principal components results for interest rate levels and first differences in interest rates are reported in Table 2. We report only the percentage of variance explained by the first two principal components for convenience sake only. For interest rate levels, the first two principal components explain over 99 percent of the variance of the time series of the four interest rates. For first differences, the first two principal components explain 95 percent or more of the variation in each Eurocurrency's interest rates.

II

Term Premia

The striking feature of Table 2 is the significance of the second principal component. In each case, it explains a meaningful portion of the relevant matrix's

[2] See Morrison [18] for a detailed explanation and Nellis [19] for a comparison with factor analysis. See Fase [6] for an application to interest rate data.

[3] Hansen and Hodrick [10] detail the problems of dealing with overlapping observations, as we have done here. We know of no way to cope satisfactorily with this problem using multivariate techniques, nor are we sure of the small sample properties of the estimates proposed by Hansen and Hodrick. Thus we proceeded without regard to the problem.

Table 2
Principal Components Analysis

	Interest Rate Levels		First Differences	
Euro Currency	Percentage of Variation Explained by First Principal Component	Percentage of Variation Explained by Second Principal Component	Percentage of Variation Explained by First Principal Component	Percentage of Variation Explained by Second Principal Component
Euro Dollars	99.22	0.68	94.06	4.94
Euro Deutschemark	99.56	0.40	93.50	5.61
Euro Swiss Franc	99.12	0.63	87.52	8.94
Euro Sterling	97.88	1.97	86.32	12.43
Euro French Franc	97.66	2.15	94.65	4.58
Euro Yen	98.90	0.78	90.38	6.76

variation. We conjecture that the second principal component is the forcing term for the term premia; without term premia, the first component would explain all systematic movements in interest rates, leaving no residual systematic movement to estimate. Of course, this is a matter of interpretation. What we certainly have is a two factor characterization of the term structure, and the results which we later report provide a reasonable basis for this interpretation.

If there are term premia in interest rates, it should be revealed through the following regression:

$$\Delta SR_t^n = \alpha_0 + \alpha_1 DPC_{1t} + \alpha_2 DPC_{2t} + \epsilon t \tag{1}$$

where

ΔSR_t^n = First difference in spot interest rate for maturity n in period t.

DPC_{1t} and DPC_{2t} = the time series recreation of the first and second principal components, respectively.

Results from estimating the above relationship for each maturity and for each currency appear in Table 3.

It is not surprising that all α_1 coefficients are statistically significant and positive. We interpret the first principal component as broadly influential general market factor. The pattern of α coefficients shows a decline from shortest to longest maturity.

What is most noteworthy is the pattern of the α_2 coefficients, all but two of which (out of twenty-four) are statistically significant. For five of the six Eurocurrencies α_2 ascends from one to twelve months. Only for the Euro Swiss Franc is there a deviation, and it is modest; α_2 for the last 12 month interest rate is marginally less than α_2 for the 6 month interest rate.

The explanatory strength of the second principal component, especially its magnitude, sign, and significance for the shortest (negative) and longest (positive) maturities, strongly suggests the conclusion that there are term premia in Eurocurrency rates, particularly in view of the reverse pattern of the coefficients on the first factor.

The principal component analysis, it should be emphasized, merely suggests the existence of term premia. Many analysts would argue that term premia and

Table 3

Principal Components Analysis
First Differences

$$\Delta SR_t^n = \alpha_0 + \alpha_1\, DPC_{1t} + \alpha_2\, DPC_{2t} + \epsilon_t$$

	Euro Dollar				Euro French Franc				Euro Deutschemark			
Coefficients	α_0	α_1	α_2	$\bar{R}^2$	α_0	α_1	α_2	$\bar{R}^2$	α_0	α_1	α_2	$\bar{R}^2$
1 month	0.004	0.522	−0.786	.997	0.005	0.750	−0.584	.999	0.001	0.566	−0.714	.997
	(0.38)*	(143.68)	(−49.54)		(0.37)	(239.71)	(−41.06)		(0.14)	(141.28)	(−43.61)	
3 months	0.004	0.532	0.048	.983	0.010	0.500	0.220	.985	−0.002	0.535	−0.028	.991
	(−0.17)	(58.73)	(1.20)		(−0.30)	(62.54)	(6.05)		(0.18)	(79.63)	(−1.03)	
6 months	−0.008	0.516	0.310	.991	−0.043	0.360	0.519	.990	0.000	0.467	0.364	.988
	(−0.48)	(83.51)	(11.51)		(−0.22)	(74.47)	(23.61)		(0.03)	(69.65)	(13.30)	
12 months	0.011	0.422	0.533	.986	0.012	0.240	0.584	.968	0.001	0.417	0.598	.983
	(0.60)	(60.66)	(17.55)		(0.46)	(36.72)	(19.61)		(0.06)	(55.47)	(19.48)	
Principal component mean	0.306		0.006		0.117		0.057		0.171		0.013	
Standard Deviation	2.762		0.310		4.098		0.902		1.553		0.380	
1 month	0.000	0.522	−0.701	.995	0.000	0.639	−0768	.999	−0.000	0.643	−0.713	.996
	(0.03)	(95.54)	(−48.63)		(0.24)	(762.74)	(−293.18)		(0.04)	(111.46)	(−33.82)	
3 months	−0.001	0.539	−0.138	.986	−0.005	0.483	0.374	.937	0.002	0.534	0.167	.949
	(−0.05)	(64.67)	(−6.29)		(−0.18)	(28.47)	(7.04)		(0.06)	(32.80)	(2.80)	
6 months	−0.001	0.501	0.371	.984	−0.001	0.473	0.388	.972	−0.003	0.434	0.462	.980
	(0.04)	(57.76)	(16.20)		(−0.04)	(43.09)	(11.30)		(0.16)	(51.06)	(14.89)	
12 months	−0.000	0.430	0.593	.982	0.007	0.366	0.345	.898	0.001	0.338	0.500	.929
	(0.02)	(49.56)	(25.96)		(0.25)	(21.64)	(6.52)		(0.05)	(25.51)	(10.33)	
Principal component mean	0.038		0.023		0.195		0.039		.014		−0.008	
Standard deviation	2.408		0.913		1.737		0.555		2.305		0.63	

*t-statistic.

the base level of interest rates are correlated. Principal components analysis, however, faces orthogonality between each component. Nonetheless, the use of first differences in our analysis should to some extent minimize the difficulties associated with faced orthgonality. Further, we do not contend that the second principal component is the term premium, rather only that it is likely only a good indication that one exists and may serve as a convenient proxy for a term premium.

Correlation Between Interest Rates

The following regression equation was estimated to see how closely term premia (or proxies) in any Eurocurrency corespond to the Eurodollar term premia proxy.

$$DPC^k_{Ft} = \alpha + B_{kf}DPCED^k_t + \epsilon \tag{2}$$

where

DPC^k_{Ft}= Principal Component k for the F Eurocurrency in period t, based on first differences.

$DPCED^k_t$ = Principal Component k for the Euro Dollar in period t, based on first differences.

The results reported in Table 4 are less than remarkable. There seems to be some relationship between each Eurocurrency's first principal component with that of the Eurodollar. Given the estimates of principal components were obtained

Table 4

Regression Results of Principal Components Across Countries

	$DPC_{KF_t} = a + B_{Kf}DPCED^k_t + e_t$ (First Differences)			
Dependent	Constant	$B_{1f}\, DPCED^1$	$B_{2f}\, DPCED^2$	$\bar{R}^2$
PC_K				
French Franc 1	0.034	0.272		.034
	(0.06)	(1.43)		
French Franc 2	0.054		0.526	.136
	(0.50)		(3.051)	
Deutschemark 1	0.123	0.155		.076
	(0.64)	(2.20)		
Deutschmark 2	0.013		0.014	.001
	(0.272)		(0.18)	
Pound 1	−0.015	0.162		.035
	(−0.04)	(1.45)		
Pound 2	0.022		0.122	.007
	(0.19)		(0.65)	
Swiss Franc 1	0.133	0.202		.103
	(0.62)	(2.61)		
Swiss Franc 2	0.039		0.005	.000
	(0.54)		(0.05)	
Yen 1	−.0.058	0.233		.078
	(−0.20)	(2.238)		
Yen 2	−0.009		0.079	.006
	(−0.11)		(0.61)	

Table 5

Principal Component Analysis for First Differences in Interest Rates Across Six Countries by Maturity

Maturity	Percent of Variance Explained by K^{th} Principal Component Principal Component 1	2	3	4	5	6
One month	52.577%	14.517%	12.438%	11.247%	6.430%	2.791%
Three months	42.012%	20.787%	16.089%	10.355%	7.720%	3.037%
Six months	43.453%	20.658%	16.385%	8.849%	7.778%	2.878%
Twelve months	46.541%	18.848%	15.034%	8.667%	7.436%	3.475%

using first differences, the lack of uniform strength in these relationships is not surprising. However, the complete absence of any relationship between second principal components is also somewhat surprising. If second principal components do reflect term premia or serve as proxies for them, these do not seem to be highly correlated among countries. And if they are not, this could explain the failure of forward exchange rates to predict future spot exchange rates.

Table 5 reports the findings from a principal components analysis on the collection of Eurocurrencies by maturities. The first differences in one month rates for all Eurocurrencies were analyzed, the first differences in three month rates, and so on.

The first principal component in each instance explains a very substantial percentage of the variation of interest rate first differences. This is what we would expect in a highly integrated international capital market. However, the fact that the remaining five principal components also explain meaningful portions of the cross currency variations was not expected. This result suggests a substantial amount of idiosyncratic movement in each currency's interest rates, and it is not unreasonable to surmise that some portion of that idiosyncratic movement is a consequence of differing term premia or more succinctly, differing real rates of interest.

Conclusions

Using principal components analysis, we have uncovered what seem to be term premia, or at least proxies for term premia, in Eurocurrency interest rates. These may arise for several difference reasons (see [5], [15], [19]). If our results adequately characterize the term structure, then we may be a step closer to explaining why forward exchange rates are unreliable predictors of future spot exchange rates. In fact, some very preliminary work shows that interest rate term structure data can explain a very substantial portion of the difference between forward exchange rates and actual future spot rates. While this work still requires much refinement, the results are sufficiently good to tempt us to continue work on this project.

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DISCUSSION

RICHARD J. HERRING*: Forward exchange rates predict subsequent spot exchange rates very badly. Forecast errors are often of roughly the same magnitude as actual changes in exchange rates. Moreover, recent evidence indicates that forward rates are also biased predictors. Why forward rates predict so badly is of considerable academic interest. Whether and how the forecast errors can be reduced is of obvious practical importance. Logue and Sweeney (L&S) propose a new approach to these problems.

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