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Risk Assessments and Risk Premiums in the Eurodollar Market

GERSHON FEDER and KNUD ROSS*

ABSTRACT

Increasing awareness of the potential risks involved in lending to heavily indebted governments focuses attention on credit pricing in the Eurodollar market. This paper utilizes a recent survey of country-by-country risk assessments as perceived by lenders to show that a systematic relationship exists between these assessments and interest rates in the Euromarket. The relationship is derived from an underlying model described in the paper. The estimated parameters verify a number of hypotheses, providing insights on the loss rates lenders expect to incur in case of default.

THE OIL CRISIS OF 1973 and the consequent balance of payments shifts induced a substantial expansion in international lending by commercial banks. In particular, loans to governments (or to government sponsored entities) of developing nations have increased significantly. Most of this international lending activity takes place within the so-called Eurocredit Market, which is a general term used to describe lending by banks in currencies other than that of the country of domicile. While banking within the national economy is heavily regulated, international lending operations have not been subjected to the same degree of government control. Furthermore, many banks in the Euromarket have no obvious lender of last resort (Frydl [10]).

Lending to sovereign borrowers is not free of risk (recall the recent debt servicing problems of Zaire, Turkey, Peru, Nicaragua, and Jamaica). This fact, combined with the ambiguity of the "lender of last resort" issue, engendered considerable interest in the quality and role of risk assessment by Eurodollar banks. One subject which has been debated in the last few years is whether risk assessments are reflected (as they theoretically should) in the pricing of Euroloans: several observers have argued that credit prices in the Euromarket do not reflect a logical and consistent pattern, due to extremely competitive pressures in recent years, and that risk considerations are ignored in the process of credit pricing (*Euromoney* (March 1977), p. 7; Dizard [7]; *Institutional Investor* (September 1979), p. 64).

Such assertions would normally be subjected to a formal empirical test. One serious problem, however, prevented such a test: in order to relate observed market prices (i.e., terms of credit) to bankers' risk assessments, one needs data

* World Bank and Bergen Bank, respectively. The views expressed in this paper are those of the authors, and do not necessarily represent the World Bank or its affiliated institutions. The authors benefited from useful discussions with T. N. Srinivasan and M. Hartley, as well as from the comments of R. Dornbusch. M. Parthasarathy assisted with the computations, and V. Lake provided valuable editorial assistance.

on default probabilities as perceived by bankers. Such information did not exist until recently. Nevertheless, indirect tests were conducted on the basis of the hypothesis that perceived probabilities can be reasonably approximated by various economic variables characterizing the borrowing nations. The rationale is that such economic variables serve as inputs in the analysis leading to lenders' perceived probabilities.

Based on the above hypothesis, studies by Feder and Just [8, 9] and Sargen [22] found a statistically significant relationship between various economic indicators and risk premiums in the Euromarket. However, the findings may be viewed as indirect (and thus insufficient) evidence only; moreover, they do not cover the period after 1977 to which most critics of Euromarket lending procedures refer.

The present paper provides a direct test of the relation between risk assessments and credit pricing employing 1979 data. Section I provides background information on Euroloan pricing and the data involved in the development of a reliable test for the aforementioned hypothesis. Section II presents a model of risk premium determination in a competitive market, identifying certain parameters of importance. In addition to providing insights regarding the impact of variables such as maturity, grace, and cost of capital, the model generates a fully specified estimable equation. The estimates which are then performed constitute a proper test of the relation between risk assessments and credit terms in the Euromarket. Section III discusses the estimation of the model. Finally, some concluding remarks are presented in Section IV.

I. Background

Recently, the *Institutional Investor* (June 1979) conducted a survey among 90 banks involved in international lending. Bankers were asked to assign scores, on a scale from zero to ten,¹ to different countries according to their perceptions of the country's chances of default. The scores were averaged across banks using a weighting procedure which gave representation to larger banks. The present study starts with the conviction that these weighted scores are a reasonable measure of the market's perceived default probabilities.² If the majority of lenders make lending decisions which are consistent with their perceived probabilities, then the price of credit should reflect these assessments. This is obviously a crude hypothesis since the price of credit in general reflects other factors besides risk, such as supply and demand forces. Nonetheless, since accounting for these other factors can be accomplished quite easily in the particular period covered by this study, a reasonably reliable test of the hypothesis that Euromarket lending decisions are consistent with lenders' risk assessments can be performed.

Interest rates in the Euromarket are composed of two parts: (1) a fluctuating component which is usually equal to the three-month or six-month London Inter-Bank Offer rate (referred to as LIBO), and (2) a component which is referred to

¹ In subsequent surveys the range has been refined to (0, 100). The zero refers to a certain default while a 100 refers to a risk-free borrower.

² This view should not be interpreted as an endorsement of the rankings reports by lenders.

as “spread” (or “margin”) and is fixed. If there is a relation between credit terms and risk assessments, it must be reflected in the spread, because the LIBO rate is identical for all borrowers, while the spread differs between transactions. Since it is conceivable that the spread is affected not only by risk but also by the lengths of the maturity and grace periods (i.e., the initial period in which interest, but not amortization, is paid), these variables need to be taken into account.

The data for the test should obviously cover a period corresponding to the time when subjective assessment was elicited in the *Institutional Investor's* survey (i.e., June–July 1979). The period covered should also be short enough so that factors such as changes in market liquidity and changes in expectations regarding cost of capital will not distort the results. Two further constraints are that all loans be denominated in the same currency so that foreign exchange risks will not affect the results, and that they all be government (or government guaranteed) loans. The data on U.S. dollar-denominated loans in the third quarter of 1979 seem to satisfy these requirements. Altogether, 78 observations on loan transactions of 34 countries were obtained from a World Bank publication. The data include the interest spread (r), the maturity (T), and the length of the grace period (G).³

The simple correlation coefficient between the spread charged in the 78 loan transactions and the *Institutional Investor* scores is $-.71$. While this correlation seems to provide preliminary support for the hypothesis that Eurocredit prices are consistent with lenders' underlying risk perceptions, it is clear that a more credible test is required.

II. The Model

Consider a loan of size L and maturity T . Typically, a Eurocredit carries a grace period of G years in which only interest is paid. Thereafter, both interest and principal payments are made until the loan is fully repaid after T years. Denote the rate of interest by i and suppose that after the grace period ends, the principal is repaid in equal installments (a common procedure in the Euromarket). The cash flow profile of the loan is then:

<u>Year (t)</u>	<u>Cash flow</u>
0	$-L$
$t = 1, 2, \dots, G$	$i \cdot L$
$t = G + 1, G + 2, \dots, T$	$L \cdot [1 + i \cdot (T + 1 - t)] / (T - G)$

Now define the bank's discount rate ρ . The proper discount rate in a situation of abundant liquidity is the cost of funds to the bank plus a minimal markup to cover operational costs per dollar lent.⁴ The risk premium, denoted by r , is the difference between the rate of interest charged on the loan (i) and the cost of capital (ρ), i.e.,

$$i = \rho + r \quad (1)$$

³ “Borrowing in International Capital Markets,” World Bank publication EC/181/793, January 1980.

⁴ These are quite small (between one-tenth and two-tenths of one percent) in Euroloan operations. See Richolt [21, p. 106].

Assuming that all contractual payments are received on schedule, the discounted present value of the loan transaction (which is denoted by V_0) is given by⁵

$$\begin{aligned} V_0 &= -L + L \cdot \sum_{t=1}^G (r + \rho)(1 + \rho)^{-t} \\ &\quad + \left\{ L \cdot \sum_{t=G+1}^T (1 + \rho)^{-t} [1 + (r + \rho)(T + 1 - t)] / (T - G) \right\} \\ &= L \cdot \{-1 + (r + \rho) \sum_{t=1}^G (1 + \rho)^{-t} + (1 + \rho)^{-G} \\ &\quad \sum_{t=1}^{T-G} [1 + (r + \rho)(T - G + 1 - t)](1 + \rho)^{-t} / (T - G)\} \end{aligned} \quad (2)$$

It is shown in the Appendix that, for any given integer X ,

$$\sum_{t=1}^X (X + 1 - t)(1 + \rho)^{-t} = X \cdot \left[1 - \frac{1}{X} \sum_{t=1}^X (1 + \rho)^{-t} \right] \cup \rho$$

Using this result and the expression for the sum of a geometric progression Equation (2) can be written as

$$V_0 = r \cdot \psi \cdot L$$

where

$$\psi(\rho, G, T) \equiv \left\{ 1 - \frac{[(1 + \rho)^{-G} - (1 + \rho)^{-T}]}{\rho \cdot (T - G)} \right\} \cup \rho \quad (3)$$

From Equation (3), it is apparent that the term $r \cdot \psi$ is the rate of profit to be derived from the transaction if the loan is repaid on schedule. It can be shown (see Appendix) that higher values of either T or G increase the rate of profit (i.e., $\partial\psi/\partial T > 0$, $\partial\psi/\partial G > 0$). The explanation for these results is intuitive: a longer grace period implies a longer period during which the premium r is charged on the whole principal of the loan, and thus discounted profits are higher. A longer maturity extends the period throughout which the premium r is charged. It is also clear that a higher discount rate will reduce ψ (and hence profits) since the present value of all future receipts is reduced.

These results assume no default (or any other change in original loan terms). The lenders must consider, however, the possibility that a default (or a rescheduling) will take place, in which case the originally stipulated cash inflow will not materialize. In the event of a default, the lender expects to recover, on average, only a portion, say h ($0 \leq h < 1$), of the original gross cash inflow. Furthermore, a distinction may be drawn between the occurrence of default within the grace period and afterwards. An argument may be advanced that lenders expect to recover less from a loan which turns bad while the whole of the principal is still outstanding, than from a loan where a portion of the principal had already been repaid (Nagy [19, p. 143]). This is an hypothesis which will be tested later, but for the purpose of the present analysis, denote by h_1 and h_2 the respective recovery

⁵ A somewhat more accurate formulation (in the Euromarket context) would also take into account front-end fees paid to lenders. However, as demonstrated in *Euromoney* (May 1978, pp. 13–14), these fees are of negligible significance to the profitability of the loan for most participants in syndicated loans; only for the lead manager, and to a lesser degree for the comanagers, are these fees significant.

rates expected by lenders in the case of default within the grace period and in the period of repayment.

Equation (3) implies that the discounted cash inflow (i.e., excluding the initial outflow) of the loan is $(1 + r \cdot \psi) \cdot L$; therefore, it follows that the discounted net value of the transaction, if a default takes place within the first G years (to be denoted by V_1), is

$$V_1 = L \cdot [-1 + h_1 \cdot (1 + r \cdot \psi)] = [-(1 - h_1) + h_1 \cdot r \cdot \psi] \cdot L \quad (4)$$

Similarly, if a default occurs in the last $T - G$ years, the net value (denoted by V_2) is

$$V_2 = L \cdot [-(1 - h_2) + h_2 \cdot r \cdot \psi] \quad (5)$$

It was implicitly assumed that only one default can affect a given loan throughout its maturity. The assumption is valid because, once rescheduled and renegotiated, the new arrangement with its revised terms may be considered as a new loan.

Given that only one default, at most, can affect the loan, the discussion of perceived default probabilities is greatly simplified. Suppose that, on the basis of creditworthiness evaluation, the lender estimates the default probability within the next N years to be q^* . This N -year period may be termed the "reference period" and does not depend on the time parameters of the loan (i.e., G and T); rather, N is dictated by the quality of past data and projections of economic and political variables available to lenders in general, and, in particular, to the lender contemplating that loan. Given q^* , the probabilities corresponding to the periods $(1, \dots, G)$, $(G + 1, \dots, T)$, and $(1, \dots, T)$ can be calculated by the following extrapolation procedure: the probability of no-default within the reference period N (i.e., $(1 - q^*)$) can be viewed as being derived from constant annual conditional probabilities, say q_0 , where q_0 is the probability that default will occur at any year t , provided that no default took place in the years $(1, 2, \dots, t - 1)$. Using the basic formula of conditional probabilities $\{Pr(B/A) = Pr(A \cap B)/Pr(A)\}$, it can be shown that $(1 - q^*) = (1 - q_0)^N$, or

$$(1 - q_0) = (1 - q^*)^{1/N} \quad (6)$$

Using this procedure, one can easily calculate the probability of default within the first G years of the loan (say, P_1):

$$P_1 = 1 - (1 - q_0)^G = 1 - (1 - q^*)^{G/N} \quad (7)$$

The probability of default within the years $\{G + 1, G + 2, \dots, T\}$ (say P_2) is

$$P_2 = (1 - q_0)^G - (1 - q_0)^T = (1 - q^*)^{G/N} - (1 - q^*)^{T/N} \quad (8)$$

The probability of no-default throughout the loan's duration (say P_{ND}) is

$$P_{ND} = 1 - P_1 - P_2 = (1 - q_0)^T = (1 - q^*)^{T/N} \quad (9)$$

Clearly, given q^* , the probability of default within the loan duration increases with loan maturity.⁶ Similarly, the probability of default within the grace period increases with the length of the grace period G .

⁶ This is the common view among bankers. See Bench [4, p. 50].

Combining Equations (3)–(5) and (7)–(9), the expected discounted profit from the transaction (denoted by Π) is:

$$\begin{aligned}\Pi \equiv & (1 - P_1 - P_2) \cdot V_0 + P_1 V_1 + P_2 V_2 = \{(1 - q^*)^{T/N} \cdot (r \cdot \psi) \\ & + [1 - (1 - q^*)^{G/N}] \cdot [-(1 - h_1) + h_1 \cdot r \cdot \psi] \\ & + [(1 - q^*)^{G/N} - (1 - q^*)^{T/N}] \cdot [-(1 - h_2) + h_2 \cdot r \cdot \psi]\} \cdot L\end{aligned}\quad (10)$$

If the market is highly liquid, and if risk neutrality is a good approximation for lenders' behavior, then competition will drive Π to zero so that more-than-normal profits will be eliminated.

Observers of the Euromarket have confirmed that until very recently the market has been highly competitive. The reasons for this situation are that demand in the home economies of Eurobanks was weak and substantial liquidity was available from various depositors such as OPEC surplus countries. Indications of the intense competition that developed abound in various periodicals covering the international banking industry.⁷

The risk-neutrality approximation is justifiable for two reasons. First, banks seem to conduct their sovereign lending such that *expected profits* are maximized subject to self-imposed country borrowing limits, where these country limits are decided periodically taking into account availability of funds and portfolio considerations.⁸ With abundant liquidity, borrowing limits are mostly nonbinding, and the equilibrium risk premium will then be closely approximated by a risk-neutral model. Second, as shown by Feder and Just [9] within the context of a risk-aversion model, given the small size of each Euromarket transaction relative to the assets of the individual banks involved, the risk-aversion premium is negligible relative to the variation in the spread r .

The analysis is thus carried out with the constraint that expected profit above the opportunity cost of capital equals zero. Accordingly, setting Equation (10) equal to zero yields the following equilibrium relation for the risk premium r :

$$r = \frac{1}{\psi} \cdot \frac{\{(1 - h_1) \cdot [1 - (1 - q^*)^{G/N}] + (1 - h_2)[(1 - q^*)^{G/N} - (1 - q^*)^{T/N}]\}}{\{h_1 + (1 - h_2) \cdot (1 - q^*)^{T/N} + (h_2 - h_1) \cdot (1 - q^*)^{G/N}\}}\quad (11a)$$

which can be simplified further by properly rearranging to

$$r = \frac{1}{\psi} \cdot \{[h_1 + (h_2 - h_1) \cdot (1 - q^*)^{G/N} + (1 - h_2)(1 - q^*)^{T/N}]^{-1} - 1\}\quad (11b)$$

Differentiation of the risk premium r with respect to loan maturity T demonstrates that the impact can go both ways: on one hand, a longer maturity increases loan profitability (recall $\partial\psi/\partial T > 0$), thus affording a lower risk premium. But a longer maturity also implies a higher default risk, which tends to reduce the expected value of the transaction and necessitates a higher risk premium. It is not obvious which effect dominates.⁹

⁷ See, for example, the *Economist* (18 March 1978, p. 113); *Euromoney* (May 1978, p. 10); *Euromoney* (July 1979, p. 86); and van den Adel [1].

⁸ Cleveland and Brittain [5].

⁹ This result as well as other comparative static results for the risk premium r are rigorously developed in the appendix.

A lengthening of the grace period also has two effects with opposing signs, if $h_2 > h_1$ (i.e., if recovery rates are lower for a default occurring within the grace period). It can be observed from (11b) that in the case $h_2 = h_1$, the length of the grace period G enters only in the component ψ . By an argument of continuity, it follows that if the difference $(h_2 - h_1)$ is relatively small, the dominant effect of G is through its impact on ψ , which would imply $\partial r / \partial G < 0$ (since $\partial \psi / \partial G > 0$).

Differentiation of (11b) with respect to h_1 or h_2 verifies that the risk premium will be smaller if recovery rates are higher. Similarly, a higher reference-period default probability (q^*) (i.e., a more risky borrower) implies a higher risk premium. As pointed out earlier, this has been a point of substantial controversy among a number of commentators discussing the Euromarket, and our preliminary empirical result has already tended to support the view that the risk premium is positively related to borrowers' risk.

A higher discount rate will require a higher risk premium (i.e., $\partial r / \partial \rho > 0$) since, otherwise, the expected present value of profits will be negative.

III. Estimation of the Model

Before we turn to estimate the model presented above, some hypotheses may be suggested. It was already argued that the recovery rate in the case of the default within the grace period (h_1) is expected to be smaller than the rate relevant for defaults occurring after year G (h_2). It can be argued further that both recovery rates are likely to be high (or alternatively, that the loss rates which bankers expect to incur in the case of default are low). This hypothesis is based on the observation that in most cases where debt service difficulties were experienced by a sovereign borrower, the loans were renegotiated and rescheduled. The losses incurred were essentially the transaction costs of renegotiation and the opportunity cost of having to wait for payments until a rescheduling agreement was reached. (Cleveland and Brittain [5, p. 374]; Nagy [19, pp. 137, 146]; Bee [2, p. 33]; Johnston [16, pp. 40, 41; Labou  rie [17, p. 94]).

The reference period N , for which the bank's country-risk assessment is defined, is not likely to extend beyond the medium-run. This is a result of the limited manpower resources which most banks can allocate for the purpose of country-by-country detailed analysis.¹⁰ Reliable long-run economic projections require econometric country models which are not feasible for most commercial banks.

The central hypothesis being tested is, of course, whether risk assessments and perceived default probabilities significantly affect the risk premiums charged in the Euromarket.

The set of data on spreads, lenders' perceived probabilities, maturities, and grace periods provide most of the required inputs in estimating the parameters of Equation (11). In particular, q^* is the most logical probability concept which bankers would use to assign scores to countries according to their default probabilities. We thus maintain that the credit assessment scores published in the *Institutional Investor* survey are a proper approximation of the variables $(1 - q^*)$ as defined in the model of the preceding section.

¹⁰ See, for instance, Haeusgen [13, p. 14].

The discount rate ρ is not directly observable, as it depends on banker's perceptions of the opportunity cost of capital. It is, however, closely related to the Euromarket interbank deposit rates, and can thus be confined within a fairly narrow range. Furthermore, as will be shown, estimation results are quite robust for all values of ρ within the relevant range. Noting, therefore, that the average three-month deposit in the period July 1978–July 1979 is .104 while the average six-month deposit rate is .107, alternative estimates with values of ρ within the range .09–.14 were obtained.¹¹

The equilibrium condition $\Pi = 0$ can be approximated by two alternative stochastic specifications, yielding two variants of the estimated equation: first, suppose that the observed Euromarket interest margin is composed of the “true” risk premium plus a random effect ϵ_1 with a zero mean and finite variance. Then Equation (11b) can be estimated as it stands, with the addition of an error term ϵ_1 on its right-hand side. This specification will be referred to as Case A. The alternative specification replaces the equilibrium condition $\Pi = 0$ by $\Pi = \bar{\epsilon}_2$, where $\bar{\epsilon}_2$ is a random variable. Setting expression (10) equal to $\bar{\epsilon}_2$ and rearranging yields the following estimable relationship (Case B):

$$\ln(1 + r \cdot \psi) = -\ln[h_1 + (h_2 - h_1)(1 - q^*)^{G/N} + (1 - h_2) \cdot (1 - q^*)^{T/N}] + \epsilon_2 \quad (12)$$

where the error term is $\epsilon_2 \equiv \ln(1 + \bar{\epsilon}_2)$, and it is assumed that ϵ_2 has a zero mean and finite variance.

Using a nonlinear least-squares estimation procedure, the parameters $S_1 (\equiv 1 - h_1)$, $S_2 (\equiv 1 - h_2)$, and N (i.e., the expected loss rate within the grace period, the expected loss rate after the grace period, and the lender's reference horizon, respectively) can be estimated. A relevant issue is the extent to which the variables T and G are being determined simultaneously with the risk premium r . Discussions by Beim [3], Curran [6], Wellons [23, p. 88], and a description of loan negotiations in *Euromoney*, (September 1978, pp. 90–92) imply that the amortization structure (maturity and grace) are determined prior to the risk premium, mainly due to considerations of liquidity profile. Thus, the simultaneous equations system which determines the endogenous variables T , G , and r is recursive, and the structural equation with r on the left-hand side (Equation (11b) or (12)) has only exogenous variables (q^*) or predetermined endogenous variables (T and G) on the right-hand side. Provided that the random error of the latter equation is independent of the other random errors in the system, the structural parameters S_1 , S_2 , and N can be estimated without a simultaneity bias. The estimates are consistent and asymptotically normally distributed (Jennrich [15]). Obviously, if the system were not recursive, the estimated parameters could be seriously biased.

Table I represents the estimation results for Equations (11b) and (12), under alternative values of the discount factor ρ within the relevant range.

A number of immediate conclusions can be derived from these results: first, within each of the two specifications the estimates are robust with respect to changes in the underlying discount factor ρ . The values of the estimated coeffi-

¹¹ A direct estimate of ρ from the model yields a point estimate of .21, but values in the range (.09, .21) cannot be rejected on the basis of a significance test.

Table I
Estimated Model Parameters^a

Parameter	Equation													
	$r = \frac{1}{\psi} \cdot \{[1 - S_1] + (S_1 - S_2) \cdot (1 - q^{*})^{G/N} + S_2 \cdot (1 - q^{*})^{T/N} - 1\} + \epsilon_1$							$\ln(1 + r \cdot \psi) = -\ln[(1 - S_1) + (S_1 - S_2) \cdot (1 - q^{*})^{G/N} + S_2 \cdot (1 - q^{*})^{T/N}] + \epsilon_2$						
	$\rho = .09$	$\rho = .10$	$\rho = .11$	$\rho = .12$	$\rho = .13$	$\rho = .14$	$\rho = .09$	$\rho = .10$	$\rho = .11$	$\rho = .12$	$\rho = .13$	$\rho = .14$		
$S_1(\equiv 1 - h_1)$	.0754 (8.867)	.0723 (9.034)	.0694 (9.141)	.0668 (9.180)	.0644 (9.214)	.0622 (9.212)	.0605 (12.01)	.0582 (12.12)	.0561 (12.16)	.0541 (12.17)	.0522 (12.15)	.0504 (12.13)		
$S_2(\equiv 1 - h_2)$	.0434 (5.352)	.0427 (5.447)	.0420 (5.534)	.0416 (5.635)	.0412 (5.730)	.0408 (5.829)	.0426 (4.934)	.0420 (5.057)	.0415 (5.187)	.0410 (5.314)	.0406 (5.435)	.0401 (5.550)		
N (years)	4.427 (5.272)	4.420 (5.357)	4.410 (5.416)	4.433 (5.467)	4.453 (5.514)	4.489 (5.556)	3.102 (5.331)	3.124 (5.414)	3.157 (5.489)	3.192 (5.558)	3.227 (5.622)	3.261 (5.681)		
R^2	.407	.411	.416	.419	.422	.424	.522	.520	.518	.515	.513	.510		

^a Figures in parentheses indicate asymptotic 't' values.

cients with $\rho = .14$ are within a 95 percent confidence interval of the estimates for the $\rho = .09$ case. This implies that lack of direct information on lenders' expected cost of funds does not significantly affect the quality of the estimates.

Second, it is observed that for each given value of ρ , the corresponding parameter estimates in the two alternative specifications are fairly close. In fact, each parameter in model B is within the 95 percent confidence interval around the corresponding parameter in Model A. This indicates that the estimates are robust to changes in model specification, and lends credibility to the results.

Thirdly, each of the estimated coefficients is significantly different from zero (on the basis of a '*t*' ratio test). This tends to confirm the relevance of the underlying model. In particular, it is verified that lenders do expect to incur losses in the case of default or rescheduling, and that the expected magnitude of such losses combined with perceived default probabilities affect the risk premiums in the Euromarket.

As hypothesized earlier, the expected loss rates (S_1 and S_2) are relatively low, in accordance with international banks' past experience with sovereign borrowers. Furthermore, in all estimated equations the loss rate to be incurred should a default take place within the grace period (S_1) is consistently higher than the loss rate which is expected with defaults occurring later (S_2). Testing the hypothesis $S_1 = S_2$ against the alternative hypothesis $S_1 > S_2$, the former hypothesis is indeed rejected at the 95 percent confidence level for all Case A estimates and for the $\rho = .09, .10$ estimates of Case B, while requiring a 90 percent confidence level to be rejected in the rest of Case B estimates.

The estimated length of the reference period (N) is within the range hypothesized (i.e., not exceeding a medium-run horizon of five years). This confirms that most lenders do not have the capacity to derive direct probability assessments covering long periods; rather, they tend to assess probabilities pertaining to a medium-term horizon, using these as a basis for extrapolations covering longer periods.

A direct test of the whole equation is not possible, but given the reasonable and robust results for estimated model parameters, the preliminary indications of a systematic relation between perceived default probabilities and credit terms are supported by the results of this section.

IV. Concluding Remarks

This paper has established the existence of a systematic relation between bankers' subjective probabilities and credit terms in the Euromarket. The discussion demonstrates the role of average recovery rates or average conditional loss rates which bankers anticipate if a sovereign borrower defaults. The results show that bankers expect low conditional loss rates on loans to LDC governments. This is compatible with the postwar record of commercial loans to sovereign borrowers; it may be argued, however (Greayer [12], Quirk [20]), that such low loss rates were experienced by commercial lenders only because the main burden of accommodating the requirements of rescheduling sovereign debts was borne by official (mostly OECD governments) creditors. If this attitude changes, average recovery rates for commercial lenders may be revised, which, in turn, will be translated into higher interest rates.

The trade-off between recovery rates and default probabilities may be a factor explaining the relatively low risk premium paid in the past by some countries with low debt servicing capacity. These countries had a substantial outstanding debt to OECD governments and benefited from a strong aid commitment (because of political or other considerations) on the part of these governments. This situation may have been assumed by lenders to imply high recovery rates in the case of debt servicing difficulties, thus allowing relatively low risk premiums.

The analysis in the preceding sections clarified the determination of credit terms in the Euromarket during the recent period characterized by fierce competition. As the results indicate that credit pricing in the market is generally consistent with lenders' risk perceptions, judgment regarding the appropriateness of credit pricing will need to focus on the quality of country-risk analyses performed by lenders.

APPENDIX

I. To show that for any integer X

$$\sum_{t=1}^X (X+1-t) \cdot (1+\rho)^{-t} = X \cdot \left[1 - \frac{1}{X} \cdot \sum_{t=1}^X (1+\rho)^{-t} \right] / \rho \quad (\text{A.1})$$

write the left-hand side of (A.1) in detail as

$$\begin{aligned} \sum_{t=1}^X (X+1-t) \cdot (1+\rho)^{-t} &= X/(1+\rho) + (X-1)/(1+\rho)^2 \\ &\quad + (X-2)/(1+\rho)^3 + \dots + 1/(1+\rho)^X \end{aligned} \quad (\text{A.2})$$

When X is increased to $X+1$, the increment to the term in (A.2) is

$$\begin{aligned} (1+\rho)^{-(X+1)} + (1+\rho)^{-X} + \dots + (1+\rho)^{-1} &= \sum_{t=1}^{X+1} (1+\rho)^{-t} \\ &= [1 - (1+\rho)^{-X-1}] / \rho \end{aligned} \quad (\text{A.3})$$

The right-hand side of (A.1) can be written in detail as

$$\begin{aligned} X \cdot \left[1 - \frac{1}{X} \sum_{t=1}^X (1+\rho)^{-t} \right] / \rho &= (X/\rho) - [(1+\rho)^{-1} \\ &\quad + (1+\rho)^{-2} + \dots + (1+\rho)^{-X}] / \rho \end{aligned} \quad (\text{A.4})$$

When X is increased to $X+1$, the increment to the term in (A.4) is

$$(1/\rho) - [(1+\rho)^{-X-1}/\rho] = [1 - (1+\rho)^{-X-1}]/\rho \quad (\text{A.5})$$

Since (A.5) is the same as (A.3) for any X , all that is needed is to show that for $X=1$, Equality (A.1) holds. But this can be trivially verified, thus concluding the proof.

II. The effect of maturity (T) and grace (G) on the discount factor ψ : Using the definition of ψ , derive:

$$\frac{\partial \psi}{\partial T} = \frac{(1+\rho)^{-T}}{\rho^2 \cdot (T-G)^2} \cdot \{ (1+\rho)^{(T-G)} - [1 + (T-G) \ln(1+\rho)] \} \quad (\text{A.6})$$

Using the fact $\ln(1 + \rho) \leq \rho$ and writing $(1 + \rho)^{T-G}$ in detail, one obtains

$$\frac{d\psi}{dT} \geq \frac{(1 + \rho)^{-T}}{\rho^2 \cdot (T - G)^2} \cdot \{1 + \rho \cdot (T - G) + \rho^{(T-G)} + \dots - [1 + \rho \cdot (T - G)]\} > 0 \quad (\text{A.7})$$

Similarly for the impact of G ,

$$\frac{\partial\psi}{\partial G} = \frac{(1 + \rho)^{-T}}{\rho^2 \cdot (T - G)^2} \cdot \{(1 + \rho)^{T-G} \cdot [(T - G) \cdot \ln(1 + \rho) - 1] + 1\} \quad (\text{A.8})$$

Note that $T - G = 0$ implies that the term in the curly brackets is zero, while $\partial\{(1 + \rho)^{T-G}[(T - G)\ln(1 + \rho) - 1]\}/\partial(T - G) = (1 + \rho)^{-T} \cdot (T - G) \cdot [\ln(1 + \rho)]^2 > 0$ for $T - G > 0$. Thus, the conclusion is $\partial\psi/\partial G > 0$ for $T > G$.

III. Comparative static results for r :

Denote

$$Y \equiv h_1 + (h_2 - h_1) \cdot (1 - q^*)^{G/N} + (1 - h_2) \cdot (1 - q^*)^{T/N} > 0 \quad (\text{A.9})$$

Then, using (11b), it follows

$$\ln r = -\ln \psi + \ln(Y^{-1} - 1) \quad (\text{A.10})$$

Differentiating with respect to T yields

$$\frac{1}{r} \cdot \frac{\partial r}{\partial T} = -\frac{1}{\psi} \cdot \frac{\partial \psi}{\partial T} + \left[\frac{-Y^{-2} \cdot (1 - q^*)^{T/N} \cdot (1 - h_2) \cdot \ln(1 - q^*)}{Y^{-1} - 1} \right] \quad (\text{A.11})$$

We have already established that $-\partial\psi/\partial T < 0$, while the second term on the *RHS* of (A.11) is clearly positive; thus, the sign cannot be determined a priori. The derivation of $\partial r/\partial G$ is performed in the same manner.

Differentiation of (A.10) with respect to h_1 and h_2 , yields, respectively,

$$\frac{1}{r} \cdot \frac{\partial r}{\partial h_1} = \frac{-Y^{-2} \cdot [1 - (1 - q^*)^{G/N}]}{Y^{-1} - 1} < 0 \quad (\text{A.12})$$

$$\frac{1}{r} \cdot \frac{\partial r}{\partial h_2} = \frac{-Y^{-2}(1 - q^*)^{G/N} - (1 - q^*)^{T/N}}{Y^{-1} - 1} < 0 \quad (\text{A.13})$$

Thus, higher loss rates (i.e., lower recovery rates) imply higher risk premiums.

Differentiation with respect to the probability of default q^* yields

$$\frac{1}{r} \cdot \frac{\partial r}{\partial q^*} = \frac{Y^{-2} \cdot [(h_2 - h_1) \cdot G \cdot (1 - q^*)^{G/N} + (1 - h_2) \cdot T \cdot (1 - q^*)^{T/N}]}{(1 - q^*)(Y^{-1} - 1) \cdot N} > 0 \quad (\text{A.14})$$

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