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AN ANALYSIS OF CREDIT TERMS IN THE EURODOLLAR MARKET

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by

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Abstract

A model is presented incorporating various elements involved in the determination of the interest rate in a capital market that is not purely competitive. It yields an equilibrium relation between the interest rate and the probability of default such that higher probability implies higher interest. Other factors affecting the rate of interest are the elasticity of demand, the perceived rate of loss related to default, and an extra premium due to risk aversion. The equilibrium relation is used as an econometric model which, under appropriate specifications, generates estimates of the weights attached to subjective risk indicators. The data cover transactions in the Eurocurrency market and deal only with publicly guaranteed loans to developing countries. Several economic indicators are identified as significantly affecting the subjective probability. These can be used to generate estimates of the subjective probabilities themselves.

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An Analysis of Credit Terms in the Eurodollar Market

There is no doubt that the probability of default in international borrowing is linked to the economic determinants of debt-servicing capacity (DSC) and that lenders are greatly concerned with the nature of this link. A logical implication of this fact is that the terms of credit extended to various borrowers (as far as terms are a decision variable on the part of the lender) are related to DSC as reflected through the probability of default. Even in cases where the terms of credit cannot be differentiated (e.g., noncommercial international organizations), it may be that the volume of credit is influenced by the probability of default. Thus, a knowledge of the relationship of determinants of DSC and the probability of default is of interest not only to lenders but also to borrowers, at least if they expect to be in need of foreign resources in the foreseeable future. This is especially true since the relative portion of noncommercial concessionary credit is on the decline. Between 1967 and 1974, the share of private creditors in the total outstanding debt of the developing countries rose from 27.5 percent to 32.3 percent, and their share in the incremental indebtedness between 1973 and 1974 was 41 percent. The Eurocurrency market, which is a major center of international banking, is becoming an important source of finance for developing countries. While in 1974 less-developed countries (LDC) accounted for a third of publicized Eurocurrency credits, 58 percent of publicized transactions in the first half of 1975 involved developing countries.

The purpose of this paper is to investigate the relationship of DSC, the probability of default, and the terms of credit obtained by developing countries in the Eurodollar market. First, a theoretical model is constructed which describes lenders' determination of credit terms in a framework of monopolistic competition. The theoretical model yields an equilibrium condition which demonstrates the relationship of default probability and the terms of credit. Elasticity of loan demand, the perceived rate of loss in the event of default, and risk aversion are other factors which apparently enter the relationship. Representing the probability of default as a function of DSC indicators in the logit form [Theil (1970)], it becomes possible to econometrically estimate the resulting equilibrium relationship. The model is thus applied to the Eurodollar market to investigate the empirical importance of various DSC determinants and perceived default probability in determining interest rates.

1. A model of lenders' decision making in the Eurocurrency market[1]

Lending practices in the Eurocurrency market differ from traditional banking procedures in several respects.[2] The rate of interest in Eurocurrency transactions is composed of two elements: (1) the interbank rate of interest and (2) the interest margin. The interbank rate of interest--usually referred to as the "London Interbank Offer" (LIBO) rate--is the three-month or (six-month) deposit rate. Almost all transactions allow the LIBO rate to float as a measure of protection to the lender, and the LIBO rate is in general the same for all borrowers.[3]

The interest "margin"--also referred to as the "spread"--is a fixed rate of interest charged in addition to the LIBO rate. It differs from transaction to transaction and reflects both the credit worthiness of the borrower and the loan duration. The margin is obviously associated with the profit margin of the bank since the LIBO rate is closely related to the cost of capital to the bank.

Typically, a Euroloan is granted in the form of revolving credit, i.e., as a short-term advance which has to be renewed every six months for the duration of the commitment period (which may sometimes be as long as 15 years). This procedure often leads to a "balloon" form of repayment (i.e., repayment in one installment at the end of the commitment period).

Most of the lending in Eurocurrency is done by syndicates of banks or by consortia banks affording a much greater distribution or risks. Usually one bank serves as a manager (lead bank) and conducts the negotiations with the prospective borrower. "A comprehensive evaluation of risk is normally made by the lead bank with participant banks relying almost exclusively on the information provided by the lead bank."[4] But there are a number of factors which produce differentiation between banks both within the market and with respect to other financial institutions. For example, banks differ in their attitudes toward risk because of different sizes or different preferences. Also, information on credit terms is limited (at least during the negotiation process) since negotiations are kept secret; and, banks may offer different options with respect to the currency to be used at the time of repayment.

Thus, the Eurocurrency market appears to be a case of monopolistic competition [Cohen and Cyert (1965, pp. 207-228)]. Accordingly, when dealing with a potential borrower, the bank (or the leading bank) faces a downward sloping residual demand curve. The residual demand is determined by the overall demand of the borrower for external resources as well as by alternative sources of supply. These alternative sources include other financial markets, bonds, other banks in the Euromarket, the country's own resources (in the case of a government), etc.

When negotiating with a potential borrower on a possible loan, the bank is aware of the possibility that the loan and interest will not be fully paid if the borrower does not (or cannot) meet obligations. National defaults (in the sense of unwillingness or inability on the part of governments to honor contractual obligations to foreign creditors) have occurred in a number of developing countries since World War II. Unlike the prewar era, it has been common for the creditors and the debtor to work a rescheduling or refunding that provides for delays in debt service, reduced interest rate, a spreading of maturities, and/or elimination of part of the loan.[5] Such arrangements are advantageous for creditors because they commit the borrower to at least a partial repayment and also for debtors because the need for formally announcing default is eliminated. However, the debtor's advantage may be more psychological and political than economic since, as Myrdal (1970, pp. 291 and 292) comments, such arrangements are nothing but "a more considerate way of managing a bankruptcy."

In most of these cases, the creditors incur some loss either because payments are delayed and their value is reduced due to inflation or because there is pressure to soften the terms of credit or to write off part of the debt. In addition, transaction costs are incurred in the process of renegotiation. A risk evaluation is thus made specifically for the purpose of assessing the probability of default and the loss that may be suffered in the event of default. Such an evaluation obviously focuses on the economic characteristics of the country as a whole (in the case of public or publicly guaranteed loans) since these are the determinants of DSC.[6] It thus seems reasonable that the process of risk evaluation provides the bank with some (subjective) notion of the probability of default, $P(X)$, where X is a vector of economic indicators related to that probability. Furthermore, if banks are concerned with the rate of loss that is incurred following a default, then a subjective probability--say, $\Psi(h)$--is likely formed for loss rate h, given that the full terms of the agreement are not met (i.e., given that default occurs). For notational purposes, let the random variable h be contained in the range $[\underline{h}, 1]$, where $h = 1$ implies a complete loss and $\underline{h}$ is the minimal expected rate of loss; hence,

$$\int_{\underline{h}}^{1} \Psi(h)\,dh = 1. \tag{1}$$

It is reasonable to assume that $0 < \underline{h}$ since countries will avoid default (or rescheduling) if the deficit is relatively small.

When default does not occur (which has probability $[1 - P(X)]$), the bank receives a net revenue of $r \cdot L(r)$ each year throughout the duration of the loan where r is the interest margin and L is the size of the loan.[7] The size of loan demanded obviously depends on what the borrower expects regarding the behavior of the LIBO rate during the period of repayment, but this is given exogenously for the bank. Hence, residual demand for loans is represented only as a function of the margin rate,

$$L \equiv L(r); \qquad \frac{\partial L}{\partial r} \equiv L_r < 0. \tag{2}$$

Suppose the stream of net revenues is discounted because of the cost of capital to the bank. The cost of capital (which is related to the LIBO rate) is not known a priori for the entire duration of the loan, but it is reasonable to assume that the bank has some perceived notion of the cost of capital (say, r*) that may prevail until the loan matures based on experience and expectation. Using this perceived rate to discount the net revenues, one obtains:

$$\sum_{i=1}^{N} \frac{rL}{(1 + r^*)^i} = rL \sum_{i=1}^{N} (1 + r^*)^{-i} = rL \cdot \frac{[1 - (1 + r^*)^{-N}]}{r^*} \equiv rL\theta \tag{3}$$

where

$$\theta \equiv \theta(r^*, N) \equiv \frac{[1 - (1 + r^*)^{-N}]}{r^*} \tag{3a}$$

and N is the commitment period or loan duration. In the case of a syndicated loan, one may consider a fraction of the loan (αL) without changing the model as long as α is predetermined. For the purposes of this paper, it is assumed that the borrower seeks credit for a given duration; hence, N is determined exogenously for the lender.

Suppose that the bank has a utility function defined on net discounted revenue (Π), say,[8]

$$U = U(\Pi), \qquad U' > 0, \qquad U'' \leq 0, \tag{4}$$

thus implying risk aversion or risk neutrality. Given the situation of uncertainty, it is assumed that the lender's objective is to maximize expected utility by optimally choosing the interest margin r, i.e.,[9]

$$\underset{r}{\text{Max}}\ \tilde{U} = [1 - P(X)] \cdot U\{r\theta L\} + P(X) \int_{\underline{h}}^{1} U\{-hL\}\Psi(h)dh. \tag{5}$$

The first-order condition for maximization of (5) requires:[10]

$$(1 - P) \cdot \theta \cdot (rL_r + L) \cdot U'(r\theta L) - PL_r \int_{\underline{h}}^{1} h\Psi(h)U'\{-hL\}dh = 0. \tag{6}$$

From this condition, an econometric relationship may be developed as follows. Rearranging equation (6), one obtains

$$r = \frac{\eta}{\eta - 1} \cdot \frac{P}{[1 - P]\theta} \cdot \int_{\underline{h}}^{1} \frac{U'\{-hL\} \cdot h \cdot \Psi(h)dh}{U'\{r\theta L\}}, \tag{7}$$

where η is the elasticity of demand for loans,

$$\eta = \left| \frac{rL_r}{L} \right|. \tag{8}$$

Since r should be nonnegative and $U' > 0$, it follows that $\eta > 1$ at the point of optimality.

In order to summarize the factors affecting interest margin, it is useful to consider equation (7) assuming, for simplicity, that h takes only one value, $\bar{h}$,

$$r = \frac{\eta}{\eta - 1} \cdot \frac{1}{\theta} \cdot \frac{P(X)}{1 - P(X)} \cdot \bar{h} \cdot \frac{U'(-\bar{h}L)}{U'(r\theta L)}. \tag{9}$$

Here the term, $\eta/(\eta - 1)$, reflects the borrower's bargaining position which depends on alternative sources of supply and the overall demand of the borrower. The factor θ^{-1} is a profitability parameter related to both the discount rate and the duration of the loan. The risk aspect of loan maturity is included in the term, $P(X)/[1 - P(X)]$, where N (loan duration) is an element in the X vector. Other economic indicators are also reflected in this term which is thus the link between DSC (as perceived by the lender) and the terms of credit. The last term, $U'(-hL)/U'(r\theta L)$, represents the extra risk premium that is charged due to risk aversion on the part of the lender. (With risk neutrality, this term is identically equal to 1 while under risk aversion, $U'' < 0$, it is always larger than 1.) This premium, however, may be negligible if the volume of the transaction (i.e., the volume of L or of the portion of L that is undertaken by the bank) is small relative to the initial wealth of the bank.

Another property of the model which is useful in interpreting econometric results with the model relates to risk neutrality. Namely, in the case of risk neutrality (where the risk aversion premium is unity), the model in (7) reduces to

$$r = \frac{\eta}{\eta - 1} \frac{\bar{h}}{\theta} \frac{P}{1 - P} \tag{10}$$

where

$$\bar{h} = \int_{\underline{h}}^{1} h\Psi(h)\,dh = E(h)$$

whether or not loss rate has a singular distribution as in (9). Hence, to the extent that Euromarket lenders are risk neutral or individual transactions are small relative to total wealth, econometric interpretations can be greatly simplified.[11] Furthermore, these conditions indeed seem plausible in the Eurodollar market because of the size of financial institutions involved and the extent to which loans may be syndicated or distributed among banks.

2. An econometric formulation

The analysis of the previous section has postulated that the risk of default is one of the factors determining interest margin in Euromarket transactions. Risk is represented by two components: (1) the probability of default $P(X)$ and (2) the rate of loss h or its distribution $\Psi(h)$. The function $P(X)$ may be regarded as the lender's subjective probability of default based on available economic data for determinants of DSC. That is, the vector X is composed, in addition to loan duration, of economic variables which are considered by lenders as reflecting DSC. Hence, while observations on subjective probabilities are not available, data on economic indicators can be used to estimate the relationship in (9). To do this, however, it is necessary to specify a functional form for the function $P(X)$. Such a functional form should be bounded between zero and one for all values of X and should be sufficiently flexible so that P can increase with positive risk indicators and decrease with credit-worthiness indicators. One of the most widely used specifications for probability functions which satisfies these conditions is the logistic form [Cox (1970)]

$$P(X) = \left\{1 + \exp\left(\beta_0 + \sum_{i=1}^{k} \beta_i x_i\right)\right\}^{-1} \exp\left(\beta_0 + \sum_{i=1}^{k} \beta_i x_i\right)$$

where k is the dimension of X. Using this specification, however, one finds that the logarithm of odds is linear in the parameters

$$\ln \frac{P}{1 - P} = \beta_0 + \sum_{i=1}^{k} \beta_i x_i$$

and, hence, the structural equation in (9) may be written in logarithmic form as

$$\ln r = \beta_0 + \sum_{i=1}^{k} \beta_i x_i - \ln\theta + \ln\left(\frac{\eta}{\eta - 1}\right) + \ln\left[\frac{\int_{\underline{h}}^{1} \Psi(h)U'(-hL)h\,dh}{U'(r\theta L)}\right]. \quad (11)$$

Turning to the other terms in the model, recall that θ depends on N (loan duration) which is observable and r* (the perceived average cost of capital) which is not observable. Here one may postulate that r* depends on historical LIBO rates since expectations are usually based on past experience. In this context one might introduce a distributed lag relationship for r* or simply postulate that r* is an average of past rates. For simplicity it is assumed in the empirical part of this paper that the expected r* is the average of LIBO rates in the 12-month period preceding the transaction.[12] Hence, ln θ becomes observable and must simply be constrained to have a coefficient of -1.

The elasticity of demand for loans cannot be observed; thus, the term $\eta/(\eta - 1)$ is not known. Since the elasticity is country specific, the introduction of a country dummy variable may suffice. But the elasticity may also be influenced by time effects. For instance, when supply conditions in the Euromarket or other major financial markets are changing, the residual demands facing a single Euromarket lender will all be changing in the same direction. Moveover, even for observations relating to a given country at a given point in time, there may be differences in η if observations represent government-guaranteed loans taken by different private or semiprivate institutions within a country. Thus, it seems more appropriate to view $\ln \eta/(\eta - 1)$ as a random variable incorporating both time and country specific effects as well as an effect related to the particular transaction considered. For empirical purposes, this paper considers

$$\ln\left[\frac{\eta_{itj}}{\eta_{itj} - 1}\right] = \mu + u_i + v_t + w_{itj} \tag{12}$$

where μ is a constant, i is a country index, t is a time index, j is an index of the transaction, and u_i, v_t, and w_{itj} are random variables with zero expectations. The assumption of random time and country effects thus corresponds to the variance-components approach which has been used econometrically in the context of combining cross-section and time series data.[13]

The last term of equation (11) is not observable but, as indicated above, it may be considered minor in the case where the loan is but a small fraction of the bank's wealth. In this case, one obtains

$$\ln\left[\frac{\int_{\underline{h}}^{1} \Psi(h)U'(-hL)h\,dh}{U'(r\theta L)}\right] \approx \ln\bar{h}$$

where $\bar{h} \equiv E(h)$. If there is some small variation about $\ln \bar{h}$, it may be considered as part of the error term with possibly several components depending on time or transaction similar to (12).

Following the above discussion the model in (11) can be rewritten as

$$\ln r = \beta_0^* + \sum_{h=1}^{k} \beta_h x_h - \ln\theta + u_i + v_t + w_{itj}, \quad E(u_i) = E(v_t) = E(w_{itj}) = 0 \tag{13}$$

where $\beta_0^* \equiv \beta_0 + \mu + \ln \bar{h}$. The model now appears in the familiar error components form [Wallace and Hussain (1969)]. Assuming that

$$E(u_i v_t) = E(v_t w_{itj}) = E(u_i w_{itj}) = 0$$

and that $E(u_i^2) = \sigma_u$, $E(v_t^2) = \sigma_v$, and $E(w_{itj}^2) = \sigma_w$ for all i, j, and t, it is thus possible to estimate β_0^*, β_1, ..., β_k consistently and asymptotically efficiently [see Nerlove (1971) and Maddala and Mount (1973) for an evaluation of various alternative estimators]. Furthermore, it is possible to estimate σ_u, σ_v, and σ_w consistently so that some information on the importance of variation in demand elasticity and risk preferences can be obtained.

3. Determinants of DSC

To estimate the model in (13), it is necessary to determine the x_i factors which possibly affect lenders' subjective evaluation of default probability. As indicated earlier, requested loan duration is one variable which should be considered in the X vector. But obviously many other factors also affect the probability of default (or DSC). Many such economic factors have been discussed by Alter (1961), Finch (1951), Mikesell (1962), Gulhati (1967), Bittermann (1973), and Avramovic et al. (1964). Furthermore, an objective and quantitative study of default probabilities by Frank and Cline (1971) has also indicated the statistical importance of a number of these variables. Thus, the results of this study serve to reveal the extent to which lenders actually consider all of the factors affecting DSC in practice.

Nine economic indicators are used in the analysis of which seven are the same as those used by Frank and Cline (1971). The variables are defined as much as possible like the ones used by Frank and Cline to facilitate comparability of results; hence, only a brief description of most of the indicators of DSC is required here. The measure of noncompressible imports used in the previous study, however, is not included because the data for calculating it were not comparable among countries for all of the years used and because theoretical arguments have been developed which qualify this indicator. The usual argument is that imports of various consumption goods, which are not vital necessities, can be curtailed temporarily so as to increase availability of foreign exchange for debt servicing purposes. The assessment of this factor thus requires detailed data on import composition patterns. Moreover, there may be raw materials and intermediate goods that are imported for production of domestic nonessential goods which can be reduced, but separation of these from other intermediate goods is usually impossible. Furthermore, possibilities for reducing imports may depend heavily on a government's internal political status rather than on the economic importance of import items. Thus, it seems that the notion of compressible imports may be of little empirical use until a reasonable approach for including political status is developed.[14]

In the short run, debt servicing difficulties manifest themselves as a balance-of-payments crisis. Thus, short-run DSC may be studied by analyzing the various elements of the balance of payments [Avramovic et al. (1964, p. 13)]. The most common indicator is the debt-service ratio, i.e., the ratio of debt service to exports [Frank and Cline (1971)]. Supposedly, a high ratio (indicating a heavy burden on the country's resources) is related to a higher risk of default. Irvine et al. (1970) have also suggested, however, that capital inflows should be taken into account in the short run. Although this variable was not considered empirically in the Frank and Cline study (1971), capital flows in the form of loans, grants, direct investments, and transfer payments are an important source of foreign exchange receipts which can be used for debt service. Hence, higher capital inflows may be associated with lower default probabilities.[15] To include capital inflows, one may define a ratio analogous to the debt-service ratio--i.e., the ratio of debt-service payments to capital inflows[16]--or combine the two in a "modified debt-service ratio" where the denominator is the total of foreign exchange earnings. The latter is the approach used here.[17]

As a balance against fluctuations which are caused by factors beyond the control of the economy, one may consider flexible elements in the balance of payments that are controlled by the government within some limits. Foreign exchange reserves, for instance, serve as a buffer against exchange earnings fluctuations. In order to have comparable measures among countries, it is common to consider a reserve-imports ratio (or an imports-reserve ratio). With a larger ratio of imports to reserves, one expects lower DSC.

Another variable suggested by Frank and Cline (1971) is the average maturity of debt (measured as the ratio of outstanding debt to current amortization).[18] Their argument is that a predominantly long-term debt implies that debt service burden cannot be alleviated in the short run by reducing the amount of borrowing.

Given the difficulty of calculating a reasonable measure of compressible imports and the need to have some measure of dependency on imports, another possible variable is the ratio of imports to GNP. In many developing countries (especially those which have undergone an extensive process of import substitution like many Latin American countries), a substantial part of imports is in the form of capital and intermediate goods. Thus, the share of imports in GNP reflects a degree of rigidity since a substantial cut in imports implies a considerable level of unemployment. Even if mostly nonessential industries are affected, unemployment is still a cost not easily accepted. Therefore, it seems that a higher import-GNP ratio would lead to a higher probability of default in the short run.[19]

Turning to a somewhat longer time horizon, the growth of the export sector has been suggested to be an important element in DSC since, if the economy is not stagnating, its import expenditures (and, very likely, its debt service obligations) are bound to increase. A growth of exports is thus necessary for countering these developments [Mikesell (1962, p. 385)]. Presumably, a country with a high rate of export growth is less likely to default or ask for rescheduling than otherwise.

A related variable that can also affect the risk of default is export fluctuations. Higher export fluctuations should generally be associated with higher probabilities of a balance-of-payments crisis and, hence, higher default probabilities. For example, a country exporting primarily agricultural commodities subject to periodical crop failures may be regarded as having a lower DSC, *ceteris paribus*. Alter (1961) has suggested that export fluctuations should be calculated around a rising trend since export growth is a desirable indicator. This is the approach taken here [see, also, Frank and Cline (1971)].

In the long run, it has been argued that one of the most important factors affecting DSC is the growth of per capita domestic product.[20] This is a factor, however, not considered by Frank and Cline (1971). The underlying assumption is that the limiting factor in the long run is the savings gap. Increased per capita output provides additional resources for both debt service and increased consumption. It is usually assumed that the process of growth is such that export capacity is increased both through expansion of the traditional exports sector and by developing new industries producing for export or producing marketable goods which can be redirected into export channels. Hence, one would expect an improving debt servicing capacity and a declining probability of default.

Another indicator which has been suggested by Hanson (1974) is the debt-capital ratio. The underlying explanation is that the total burden over a long period of time is compared to the overall productive capacity represented by the stock of capital. It is thus a rather static measure since growth of capital and debt is assumed equal.[21] For practical purposes, however, it would seem that GNP should be used rather than capital since international comparison of capital stocks may not always be meaningful, i.e., the productivity and quality are not always comparable. A higher value of the debt-GNP ratio is expected to indicate a higher probability of default.

An additional factor which may affect either short-run or long-run DSC is the level of per capita income. The argument here is that a higher level of income implies higher levels of nonessential consumption (both private and public). This allows the government more flexibility in terms of releasing resources for debt service payments and hence a lower probability of default.

4. Empirical results

The World Bank publishes quarterly data on publicized Eurocurrency transactions. To estimate the model, 102 observations on public and publicly guaranteed loans involving 27 countries are used for the eight quarters during 1973 and 1974. These observations include interest margin and loan duration. Data for calculation of θ are published by the Morgan Guaranty Trust. Data for the determinants of DSC are available in publications of the World Bank, International Monetary Fund, and the United Nations and are discussed in detail by Feder (1976). The underlying assumption is that bankers use these indicators to evaluate the probability of default in the short run, and a duration factor is used to generate long-run probability under the assumption of approximately constant short-run probability. Alternatively, one may hypothesize that the lender attempts to estimate directly the overall probability using both long-run and short-run indicators and incorporating the duration N to account for lower reliability of long-run projection.

By way of summary, the nine economic indicators used in the present study are (1) the modified debt-service ratio (which includes both exports and capital inflows), (2) the debt-GNP ratio, which is an approximation to Hanson's (1974) debt-capital ratio, (3) an exports fluctuations index, (4) projected exports growth rate, (5) the amortization-debt ratio,[22] (6) GNP per capita, (7) the import-GNP ratio, (8) the import-reserves ratio, and (9) projected GDP growth rate. In addition, loan duration was considered as an explanatory variable. Its coefficient should thus reflect the pure risk effect of loan maturity.

Using the above definitions for the x_i variables, the equation in (13) was estimated with the following error components approach. First, estimates of β_0^*, β_1, ..., β_k were obtained by ordinary least squares using dummy variables to represent the time (v_t) and country (u_i) effects; hence, estimates of the v_t and u_i were also obtained as coefficients for the dummy variables. Then estimates of σ_u and σ_v were obtained by computing the sample variance of estimated u_i and v_t. The estimate for σ_w was based on the residual sum of squares. Using estimates for σ_u, σ_v, and σ_w, and error covariance matrix was then estimated and used in computing generalized least-squares estimates. This is the method which was found to be superior for error components estimation by Nerlove (1971) when lagged endogenous variables are present. Although there are no lagged endogenous variables included explicitly in this study, some of the exogenous variables may be influenced by perceived DSC in preceding years. In addition, Maddala and Mount (1973) have also found that this two-stage method and a number of other alternative two-stage estimates are about equally superior for error components estimation without lagged endogenous variables. Furthermore, as indicated by Nerlove (1971), the method used here is the easiest way to assure all positive variance component estimates in the unbalanced block case.[23]

The resulting estimates (and corresponding standard errors) for the unobservable parameters of the model in (13) are presented in table 1.[24] In cas 1 all estimates have the expected sign, but the amortization-debt ratio appears to have been very unimportant. Both cases 1 and 2 indicate the the debt-GNP ratio estimate is not highly significant. Deleting both of these variables, the resulting estimates in case 3 are all significant (in an asymptotic sense) at about a 7.5 percent level.[25] It can also be noted from the asymptotic F test that the hypothesis that both the amortization-debt and debt-GNP ratio coefficients are simultaneously zero cannot be rejected. But because of the asymptotic nature of these tests, one is reluctant to use solely the results of one case or another. In this context, one of the more pleasing aspects of the results is that coefficient estimates for the statistically important variables change very little when the insignificant variables are excluded.[26]

On the basis of these results, it may be concluded that at least six economic indicators seem to be related to DSC: (1) the modified debt-service

TABLE 1

Regression Results for the Euromarket Model, 1973 and 1974[a]

Variable	Case 1	Case 2	Case 3	Mean value in sample
Constant	- 3.5702	- 3.5730	- 3.5463	
Loan duration	.0559 (9.9972)	.0559 (9.7576)	.0563 (9.8192)	9.353 (5.934)
Modified debt-service ratio	1.2771 (1.1155)	1.2743 (1.8700)	1.3115 (2.0240)	.096 (.002)
Debt-GNP ratio	.1057 (.6504)	.1076 (.7789)	b	.277 (.039)
Exports fluctuations index	.1842 (2.0086)	.1858 (2.0488)	.1842 (2.0865)	.623 (.041)
Amortization-debt ratio	- .0184 (.0127)			.075 (.001)
GNP per capita	- .0001 (.8416)	- .0001 (.8591)	- .0001 (1.4138)	628.0 (173,314.)
Imports-GNP ratio	.5735 (2.2128)	.5718 (2.4073)	.6718 (3.4950)	.218 (.020)
Imports-reserves ratio	.0252 (2.6692)	.0252 (2.6838)	.0237 (2.6084)	3.155 (5.536)
Projected GDP growth	- 1.2722 (1.9637)	- 1.2751 (1.9707)	- 1.3656 (2.2350)	.064 (.003)

[a]Figures in parentheses are (asymptotic) "t" values except in the right-hand column where variances of data are given in parentheses.

[b]Blanks indicate variables omitted.

ratio, (2) export fluctuations, (3) the imports-reserves ratio, (4) the import-GNP ratio, (5) GNP per capita, and (6) projected GDP growth. While the first four of these variables may be considered as short-run indicators, the last two relate to the longer run. This is consistent with the fact that most of the transactions included in this study are within the range of 7-10 years, which may be considered long enough for lenders to try to project overall development in the economy rather than simply the growth of the export sector. Exports, however, are considered important for short-run risk evaluation as reflected in the debt-service ratio and the export fluctuations index. As for the lenders' underlying behavior, the results may support the suggestion that bankers try to estimate the overall probability (for the full duration of the loan) rather than a short-run probability which is then assumed constant for each year. The outcomes also confirm the hypothesis that loan duration has a pure (positive) risk effect on the probability of default as perceived by the lenders.

5. Perceived DSC in the Eurodollar market

Perceived (or subjective) probabilities can now be estimated except that β_0 is not identified (only $\beta_0^* = \beta_0 + \mu + \ln \bar{h}$ is estimated). However, if one considers various hypothetical constants, some insights are possible since the ordering of probabilities is not affected by arbitrarily changing the constant. Table 2 presents estimates of the subjective probabilities for the 102 observations with several hypothetical values of β_0.

It seems reasonable to expect that the subjective probabilities will not assume very high values since in that case the interest rate is probably so high as to deter the potential borrower. In this case a constant

TABLE 2

Subjective Probabilities in the Eurocurrency Market, 1973 and 1974

Country and observation number	Probability					
	$\beta_0 = -2.00$	$\beta_0 = -2.25$	$\beta_0 = -2.50$	$\beta_0 = -2.75$	$\beta_0 = -3.00$	$\beta_0 = -3.25$
<u>Algeria</u>						
1	.256803	.212043	.173266	.140318	.112780	.090080
2	.314713	.263433	.217861	.178260	.144528	.116276
3	.279494	.232014	.190468	.154861	.124884	.100023
4	.257405	.212570	.173718	.140698	.113096	.090339
5	.310613	.259753	.214628	.175483	.142186	.114330
<u>Argentina</u>						
6	.218710	.178991	.145145	.116789	.093367	.074248
7	.253949	.209546	.171127	.138517	.111287	.088858
8	.204405	.166729	.134821	.108226	.086354	.068562
9	.232678	.191043	.155349	.125291	.100358	.079933
10	.220825	.180811	.146682	.118067	.094416	.075100
11	.230658	.189295	.153865	.124053	.099338	.079103
<u>Bolivia</u>						
12	.252192	.208011	.169813	.137412	.110371	.088108
13	.214761	.175598	.142282	.114410	.091416	.072664
<u>Brazil</u>						
14	.245622	.202281	.164916	.133299	.106967	.085325
15	.197274	.160647	.129721	.104012	.082912	.065778
16	.196203	.159735	.128958	.103382	.082398	.065363
17	.195538	.159170	.128485	.102991	.082080	.065106
18	.213848	.174814	.141621	.113862	.090967	.072300
19	.213171	.174233	.141132	.113456	.090634	.072030
20	.242849	.199868	.162857	.131573	.105541	.084160
21	.215755	.176451	.143001	.115007	.091906	.073062
22	.215787	.176478	.143025	.115027	.091922	.073074
23	.197353	.160715	.129778	.104058	.082950	.065809
24	.215707	.176410	.142967	.114979	.091882	.073042
25	.197278	.160651	.129725	.104014	.082914	.065780
26	.180073	.146059	.117548	.093991	.074754	.059197
27	.156481	.126237	.101137	.080568	.063885	.050467
<u>China</u>						
28	.219012	.179251	.145364	.116971	.093517	.074369
29	.239251	.196740	.160193	.129341	.103698	.082656
<u>Colombia</u>						
30	.247554	.203964	.166352	.134505	.107965	.086140
31	.247854	.204226	.166576	.134692	.108120	.086267
32	.303906	.253740	.209364	.170970	.138385	.111178
<u>Costa Rica</u>						
33	.248472	.204765	.167036	.135079	.108440	.086528
<u>Dominican Republic</u>						
34	.249595	.205744	.167873	.135782	.109021	.087004
35	.223062	.182737	.148311	.119422	.095530	.076005
<u>Egypt</u>						
36	.203505	.165961	.134176	.107693	.085918	.068209
37	.269156	.222924	.182618	.148210	.119339	.095461
38	.270143	.223759	.183338	.148819	.119845	.095877

(Continued on next page.)

TABLE 2--continued.

Country and observation number	Probability					
	β_0 = -2.00	β_0 = -2.25	β_0 = -2.50	β_0 = -2.75	β_0 = -3.00	β_0 = -3.25
El Salvador						
39	.240883	.198159	.161401	.130353	.104533	.083337
Gabon						
40	.327850	.275294	.228302	.187258	.152138	.122612
41	.311719	.260746	.215498	.176231	.142816	.114853
42	.307938	.257352	.212524	.173678	.140665	.113068
Greece						
43	.230227	.188922	.153549	.123788	.099121	.078926
44	.230029	.188751	.153404	.123668	.099021	.078845
45	.234129	.192299	.156416	.126182	.101093	.080532
46	.228391	.176488	.149558	.120810	.098260	.077298
Guyana						
47	.313354	.262216	.216788	.177338	.143750	.115629
Indonesia						
48	.325913	.273541	.226754	.185922	.151006	.121668
Iran						
49	.219474	.179648	.145700	.117250	.093746	.074555
50	.258176	.213245	.174297	.141186	.113500	.090671
51	.237216	.194975	.158691	.128084	.102661	.081810
52	.239009	.196531	.160014	.129192	.103575	.082555
53	.211015	.172385	.139576	.112164	.089576	.071172
Ivory Coast						
54	.258981	.213951	.174903	.141696	.113924	.091017
55	.253095	.208800	.170488	.137980	.110842	.088493
56	.285644	.237464	.195190	.158873	.128237	.102787
Jamaica						
57	.262735	.217244	.177730	.144081	.115904	.092641
58	.287861	.239432	.196898	.160327	.129454	.103790
59	.280696	.233078	.191389	.155643	.125537	.100560
Korea						
60	.251943	.207794	.169626	.137255	.110241	.088002
61	.229831	.188580	.153259	.123546	.098921	.078763
62	.269871	.223519	.183131	.148644	.119699	.095757
63	.248811	.205060	.167289	.135291	.108615	.086672
Malaysia						
64	.270705	.224253	.183764	.149180	.120146	.096124
Mexico						
65	.259769	.214641	.175495	.142196	.114338	.091357
66	.238721	.196281	.159802	.129014	.103428	.082436
67	.220484	.180517	.146434	.117860	.094246	.074962
68	.272589	.225915	.185197	.150392	.121156	.096955
69	.269149	.222883	.182583	.148180	.119314	.095440
70	.247596	.204001	.166384	.134531	.107987	.086158
71	.225713	.185023	.150245	.121034	.096854	.077081
72	.245984	.202596	.165185	.133525	.107154	.085477
73	.215984	.176648	.143168	.115145	.092019	.073153
74	.228020	.187015	.151932	.122440	.098011	.078022
75	.199676	.162694	.131436	.105428	.084067	.066712

(Continued on next page.)

TABLE 2--continued.

Country and observation number	Probability					
	β_0 = -2.00	β_0 = -2.25	β_0 = -2.50	β_0 = -2.75	β_0 = -3.00	β_0 = -3.25
Nicaragua						
76	.258736	.213737	.174719	.141541	.113795	.090912
77	.223043	.182721	.148297	.119411	.095520	.075997
Peru						
78	.233616	.191855	.156038	.125867	.100833	.080320
79	.223694	.183282	.148771	.119806	.095845	.076261
80	.254327	.209877	.171410	.138755	.111485	.089019
81	.254031	.209618	.171188	.138569	.111330	.088893
82	.246510	.203055	.165576	.133853	.107425	.085699
83	.245983	.202595	.165183	.133524	.107153	.085477
84	.244706	.201483	.164235	.132728	.106495	.084939
85	.215085	.175876	.142517	.114605	.091576	.072794
Senegal						
86	.272206	.225576	.184905	.150145	.120950	.096786
87	.301032	.251168	.207117	.169048	.136769	.109838
88	.277896	.230601	.189245	.153824	.124018	.099309
Spain						
89	.193289	.157257	.126886	.101672	.081004	.064237
90	.184564	.149856	.120709	.096587	.076864	.060897
91	.184564	.149856	.120709	.096587	.076864	.060897
92	.193182	.157166	.126810	.101610	.080953	.064196
93	.202103	.164764	.133172	.106862	.085239	.067660
94	.211590	.172877	.139990	.112508	.089858	.071400
Sudan						
95	.248951	.205182	.167393	.135378	.108687	.086731
96	.248809	.205058	.167287	.135290	.108614	.086671
97	.213294	.174339	.141221	.113529	.090694	.072079
Zaire						
98	.241728	.198893	.162026	.130877	.104966	.083690
99	.245488	.202164	.164816	.133215	.106898	.085268
100	.254528	.210052	.171560	.138882	.111589	.089105
Zambia						
101	.304792	.254533	.210057	.171564	.138885	.111592
102	.338124	.284619	.236554	.194401	.158202	.127676

term between -3.25 and -2 indicates an average probability of default from less than .1 to over .2. Although the estimated subjective probabilities do not include any extreme values, there is still considerable variation. One can show that the model presented in the first part of this paper implies high sensitivity of the interest margin to small variations in the probabilities, especially when the probabilities are relatively low. Consider, for instance, the case of risk neutrality and suppose that, for a borrower with probability of default equal to 10 percent, the interest margin rate is .80 of 1 percent. Suppose now that the probability increases to 15 percent while all the other elements remain constant. Then, using equation (10), the new interest margin becomes 1.27 percent. This is an increase of more than 58 percent in the interest margin. In general, the elasticity of interest margin with respect to probability changes is always more than unity (for the case of risk neutrality) since differentiating the logarithm of equation (10) obtains

$$\frac{dr}{dP} \cdot \frac{P}{r} = \frac{1}{1 - P} > 1.$$

Recalling the definition of β_0^*, it is evident that assumptions about β_0 have implications for demand elasticity and loss rates. These implications can be examined most easily under the assumption of risk neutrality which has been argued to hold as an approximation. In this case, $\beta_0^* = \beta_0 + \ln \bar{h} + \mu$ where μ is the expectation of $\ln[\eta/(\eta - 1)]$ in the sample. If average loss rate $\bar{h}$ is about .10, then the case 3 estimate of β_0^* implies that

$$\mu = -3.5463 - \beta_0 - \ln (0.10) = -1.2337 - \beta_0.$$

Hence, in the case of risk neutrality, it is not reasonable to consider $\beta_0 > -1.23$ since that corresponds to $\mu < 0$ and thus implies a positively sloped demand curve. On the other hand, β_0 only slightly less than -1.23 corresponds to large η (i.e., very elastic residual demand). Finally, as β_0 gets large in absolute value, the implied demand elasticity continues to decline toward $\eta = 1$ ($\eta = 1.1536$ at $\beta_0 = -3.25$).

Based on the variance components estimates, several conditional conclusions are possible. The variance components estimates for case 3 in table 1 (which are approximately the same in cases 1 and 2 also) are

$$\hat{\sigma}_u = .17208 \qquad \hat{\sigma}_v = .02407 \qquad \hat{\sigma}_w = .01520.$$

It is thus evident that at least the country effects are quite important relative to the unexplained disturbances. But in the context of the model of this paper, any differences in countries are due to differing demand elasticities, differing loss rate expectations, or differing risk attitudes of lenders. If lenders are approximately risk neutral (which may be reasonable as argued earlier) and perceived loss rate possibilities are approximately the same for all countries (which may well be the case because of limited default experience), then the magnitude of $\hat{\sigma}_u$ suggests variation in demand elasticities or $\ln[\eta/(\eta - 1)]$ among countries. This case would necessarily preclude the possibility of highly elastic residual demand (or a highly competitive market structure) for all countries since $\ln[\eta/(\eta - 1)] \approx 0$ in that case. Because of the relative unimportance of $\hat{\sigma}_v$, the same conditions would also suggest that demand conditions within a country and alternative sources of supply are not changing rapidly for borrowing countries in the Eurodollar market. Technically, however, these same observations would also be possible if residual demand were highly elastic but perceived loss rates were quite different for different countries. Differing risk attitudes (alone), on the other hand, cannot lead to these results unless risk attitudes (of the negotiating bank) vary systematically with the country, i.e., a country tends to obtain all of its loans from the same bank.

6. Comparison with objective studies of default probability

It is interesting to compare the estimates of lenders' subjective default probabilities with the results of objective studies which have attempted to estimate true default probabilities. Objective studies of default probabilities have been made by Frank and Cline (1971) and by Feder and Just (1977). Comparing with the results of Frank and Cline, it appears that many more indicators are incorporated in the subjective probability than actually have a significant effect on default probability; their results indicated the objective importance of only the debt-service ratio, the amortization-debt ratio, and possibly the import-reserves ratio. However, their statistical significance tests were applied incorrectly in concluding the insignificance of other variables; and several potentially important variables were not considered. Using at least asymptotically applicable statistical tests, the Feder and Just study indicates the significant importance of at least six indicators in the objective estimation of default probabilities. These include the debt-service ratio, the imports-reserves ratio, GNP per capita, the capital inflows-debt service ratio (which is combined with the debt-service ratio to form the modified debt-service ratio in the present study), and (although less significant) GDP growth.[27] All these variables appear important in the subjective results as well (table 1).

Because of the method of analysis (discriminant analysis) used by Frank and Cline (1971), no estimates for default probabilities are possible;

but the Feder and Just study uses logit analysis and hence allows the objective estimation of default probabilities for the same set of data used in the present subjective study. These results cannot be reported here because of their lengthiness, but the differences are striking. Using the objective model, estimated default probabilities range from less than 10^{-6} to more than 0.99. Except for four countries, the estimates are all less than 0.01. In the estimates of lenders' subjective probabilities, however, if β_0 is adjusted so that some subjective probabilities are in the neighborhood of 0.01, then all subjective probability estimates fall under 0.1. These results seem to be consistent with the criticism by Howard (1972) and von Clemm (1971), referring to the quality of risk analysis in the Euromarket.

7. Summary and conclusions

The indirect approach used in this study is based on the notion that the probability of default is one of the factors entering lenders' decisions regarding the terms of credit to be charged. The model describes the various elements involved in the determination of the rate of interest with special reference to procedures of the Euromarket. It yields an equilibrium relation between the interest margin and the probability of default which implies higher interest for higher risks. Other factors which affect the interest margin are the elasticity of residual demand for loans, the perceived rate of loss related to default, and an extra premium due to risk aversion on the part of the lender.

Assuming a logit specification for the relation between the probability of default and various economic indicators, the equilibrium relation between the interest margin and the probability of default was then transformed into an econometric model. The parameters of the model were estimated using Euromarket data on publicly guaranteed loans. Results suggest that six economic indicators significantly affect lenders' subjective probability: (1) the modified debt-service ratio, (2) income per capita, (3) the projected rate of growth of GDP, (4) the imports-reserves ratio, (5) the share of imports in GNP, and (6) export fluctuations. In addition, it was confirmed that the maturity term of the loan has a positive effect on the subjective probability of default. Using the estimated coefficients, lenders' subjective probabilities were also estimated for each specific transaction observed. Comparing with objective measurements of default probabilities, it appears that some improvements in lenders' subjective probabilities are possible.

Finally, the results of this study suggest some interesting possibilities for policy formulation in borrowing countries. Increasingly, developing countries are entering commercial capital markets for funds; and, of course, the availability of these funds depends on how lenders perceive their DSC. The controlled regulation of important DSC indicators can thus become an important part of government policy in reaching many national objectives (Irvine et al., 1970; Hanson, 1974). A study of these policy-related issues has already begun and is currently being expanded by the authors. But the forthcoming results will be treated in another paper.

Footnotes

*Giannini Foundation Paper No. 449. We are indebted to G. Ohlin for helpful comments.

[1]A complete and much more lengthly treatment of this model is given in Feder and Just (1976).

[2]For a detailed description of Eurocurrency banking practices, see Mohammed and Saccomanni (1973).

[3]However, there have been short periods in which the LIBO rate has been slightly different between banks depending on their financial strength. Consequently, borrowers who have engaged in loans from these institutions may have been charged a different LIBO rate. But the differences were quite small and endured for only a short period.

[4]Mohammed and Saccomanni (1973, p. 622). Other peculiar features of Eurocurrency banking are described in Carli et al. (1972), Furth (1973), Timmermans (1975), Hewson and Sakakibara (1974), Savona (1974), and Levin (1974) but do not have direct bearing on the model developed here; hence, the related discussion is omitted.

[5]For a description of such arrangements, see Bitterman (1973).

[6]Of course, such an evaluation would also depend on political factors which cannot be quantified. For example, the decision to adjust a balance-of-payments disequilibrium by defaulting on liabilities instead of by other methods (depreciation of the exchange rate, exchange controls, export subsidies, repression of domestic demand via fiscal or monetary policy, etc.) is a political decision. However, the cost (political and economic) of using alternative methods depends on economic conditions and, hence, the

probability of selecting default likely depends on economic indicators. The event of default is <u>probabilistic</u>, however, because default may or may not be selected in a given economic situation depending on random political factors.

[7]It is assumed, for simplicity, that all the loans are of the balloon type.

[8]This, of course, does not exclude the case where utility depends on the present value of terminal wealth. To see this, suppose that V is a utility function defined on terminal wealth [$V = V(W_o + \Pi)$, $V' > 0$, $V'' \leq 0$], where W_o is initial wealth. Then $U(\Pi) \equiv V(W_o + \Pi)$, $U' = V'$; $U' = V''$.

[9]In certain lending problems, it is also reasonable to consider loan duration as a decision variable. Generally, the borrower will seek to manage currency outflows that are related to debt service so as to avoid a cash squeeze. In the case of balloon payments, in particular, the borrower would like to choose a maturity which will fit in his overall projected scheme of inflows and outflows. The borrower's freedom of choice about maturity may thus be quite limited. It should be noted, however, that a two-equation (usually nonlinear) system is generally obtained as first-order conditions when N and r are both decision variables. Hence, an econometric application such as the one in this study would require nonlinear simultaneous equations estimation. Even when N is controllable within a certain specified interval, however, it has been shown by Feder (1976) that the borrower in this framework will generally choose a boundary point; hence, the duration would be exogenous and could be treated as a single equation system for econometric purposes.

[10] Although second-order conditions will not be developed here, it can be shown that they are satisfied when

$$2L_r - L \cdot \frac{L_{rr}}{L_r} < 0.$$

In the case, for example, of a constant elasticity demand function, second-order conditions are thus clearly satisfied when the elasticity of demand η is greater than 1. That $\eta > 1$ is indeed plausible will become evident as the paper progresses. Throughout the analysis, however, it will be assumed that second-order conditions are satisfied.

[11] If the utility function is written more explicity as depending on terminal wealth, $U(\Pi) \equiv V(W_o + \Pi)$ where W_o represents initial wealth, then it is clear that

$$U'(-hL) \equiv V'(W_o - hL) \approx V'(W_o + r\theta L) \equiv U'(r\theta L)$$

where U or V is a sufficiently smooth function and L is sufficiently small relative to W_o.

[12] As it turns out, however, the results are not very sensitive to different assumptions regarding r*.

[13] See, for instance, Wallace and Hussain (1969), Maddala (1971), and Nerlove (1971).

[14] It may also be noted that this variable was not found significant by Frank and Cline (1971).

[15] On the other hand, if these inflows are volatile and subject to domestic mismanagement, then they could possibly be positively related to default probability.

[16]In fact, however, the inverse relation should be used since capital flows may be positive, negative, or zero.

[17]With the data used in this study, the correlation between the capital inflow-debt ratio and the debt-service ratio was 0.95. Hence, the two ratios were combined to avoid problems of multicollinearity.

[18]Actually, they have used the inverse ratio. Although there is no particular reason for their choice, it was also adopted in this study for comparability.

[19]This, of course, is correct only in a ceteris-paribus sense, since a high import/GNP ratio combined with a high export/GNP ratio may represent an open economy which is capable of servicing significant levels of foreign capital.

[20]For instance, Avramovic et al. (1964, p. 69) conclude: "The only important factor from the long run point of view is the rate of growth of production." Alter (1961, p. 146) also states: "A minimum condition for developing even a small sustainable margin for debt service over the long term would appear to be some increase in per capital income." For related comments, see Kindleberger (1958, pp. 265 and 266) and Faarland (1967, pp. 263 and 264).

[21]Hanson's model is indeed a steady state model.

[22]While this is not necessarily a causal variable, it may be used by lenders because it was recommended by Frank and Cline (1971) if not for other reasons.

[23]With the data used here, there is an unequal number of observations across time periods and countries because more than one loan was often made to an individual country in a single quarter.

[24]Export growth, although considered in the empirical work, is not included in any of the results reported in table 1 because its inclusion always indicated an implausible (although insignificant) coefficient (sign). It was thus concluded that the model was misspecified when export growth was included.

[25]One-sided tests are used rather than two-sided tests since the alternative hypothesis specifies the sign of the coefficient according to theoretical considerations.

[26]This behavior of coefficient estimates implies that multicollinearity among the independent variables is not responsible for insignificance of some variables in cases 1 and 2. In fact, it was found that the highest correlation between any pair of independent variables investigated in the study was only .43.

[27]The objective study, however, also indicated the importance of export growth and greater importance of the amortization-debt ratio than in the present subjective study.

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