

Hajivassiliou, Vassilis Argyrou

**Working Paper**

## Analyzing the Determinants of the External Debt Repayment Problems of LDC's: Econometric Modelling Using a Panel Set of Data

Center Discussion Paper, No. 495

**Provided in Cooperation with:**

Yale University, Economic Growth Center (EGC)

*Suggested Citation:* Hajivassiliou, Vassilis Argyrou (1985) : Analyzing the Determinants of the External Debt Repayment Problems of LDC's: Econometric Modelling Using a Panel Set of Data, Center Discussion Paper, No. 495, Yale University, Economic Growth Center, New Haven, CT

This Version is available at:

<https://hdl.handle.net/10419/160418>

**Standard-Nutzungsbedingungen:**

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

**Terms of use:**

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*

ECONOMIC GROWTH CENTER

YALE UNIVERSITY

P.O. Box 1987, Yale Station  
27 Hillhouse Avenue  
New Haven, Connecticut 06520

CENTER DISCUSSION PAPER NO. 495

ANALYZING THE DETERMINANTS  
OF THE EXTERNAL DEBT REPAYMENTS PROBLEMS OF LDC'S:  
ECONOMETRIC MODELLING USING A PANEL SET OF DATA

Vassilis Argyrou Hajivassiliou

Yale University

December 1985

Notes: Center Discussion Papers are preliminary materials circulated to stimulate discussion and critical comment. References in publications to Discussion Papers should be cleared with the author to protect the tentative character of these papers.

## ABSTRACT

This paper offers an econometric analysis of the problems of repayment of external debt of developing countries along credit rationing lines, using a panel set of data of 79 nations observed through 1970 to 1982. The main model presented employs hitherto unexploited sources of information about the incidence and extent of credit constraints. The estimation techniques pay particular attention to the panel nature of the data, by allowing for random effects to model unobserved country heterogeneity. The problem of initial conditions in non-linear dynamic models in panels is examined. Several hypotheses in the international finance literature are formulated and tested using the main model of this paper, including the role the "petrodollars" played following the 1973 oil-shock, and the "liquidity versus solvency" question. A major empirical finding is that time dependence seems to arise both through persistent country specific unobservable characteristics, and through information theoretic conditions that make important the history of debt repayments problems of a country.

Vassilis Argyrou Hajivassiliou, "Analyzing the Determinants of the External Debt Repayments Problems of LDC's: Econometric Modelling Using a Panel Set of Data"

Analysing the Determinants  
of the External Debt Repayments Problems of LDC's:  
Estimations Using a Panel Set of Data\*

V.A. Hajivassiliou

August 1985

Part I

Introduction

This paper, using as a starting point our recent work with others ([23], [15]), attempts to analyze and model the determinants of repayment problems of the developing countries. For a general review of the literature see [23]. The basic thread in our analysis here is the claim that the specific cost charged to a country by the international bankers (in the form of a "spread" over the London interbank offer rate (LIBOR)) does not perform the key role of clearing the market for international loans. Instead the allocation of scarce credit among third world countries is fundamentally carried out through quantity offers and requests. The interest rate cannot function as a pure price in this context for at least two reasons: First, as is well known from the credit rationing literature ([27]), moral hazard and other information theoretic issues become very important in the absence of complete information about the creditworthiness of the borrowers, prospective or otherwise. Second, the probability of default of a borrower is affected by changes in the interest rate charged. Hence it might be rational for the agents to decide to let bargaining over levels of lending perform the main allocative role in this market, at a more or less exogenous price that is primarily determined by the LIBOR plus some "token" spread over that. Recent empirical evidence ([8])

\*I would like to thank Stanley Fischer, Jerry Hausman and Daniel McFadden for very helpful comments. Financial support by the A.P. Sloan Foundation in the form of Doctoral Dissertation Fellowship #DD-20 is gratefully acknowledged. The author retains full responsibility for any errors and shortcomings.

confirms the notion that the spreads perform only a minor role in the allocation of international credit, since they do not seem to respond very significantly to usual creditworthiness indicators. Given that all our modelling will fundamentally be based on the premise that the spread does not endogenously perform any significant allocative function, it becomes imperative that we formally test this exogeneity assumption. [13] derives appropriate asymptotic tests in the context of disequilibrium econometric models.

We leave theoretical justification of this claimed exogeneity of the spread to future research; here we only note that recent game theoretic work on the bargaining problem with a "shrinking pie" as time goes by (see [3] and [26] for results and references) yields the implication that the eventual division will tend to favour the short side of the market, potentially very strongly so. We view this as providing a basic motivation for our modelling of lending transactions as the realizations of various versions of the "short-side" rule of the standard disequilibrium literature.<sup>1</sup>

Section I of Part II sets up the basic framework of modelling and discusses further the motivation for such an approach. Three classes of models are estimated and compared: The first formulation (Model A), which is analogous to the analysis in [6] and [7], proceeds with the standard minimum side rule of the disequilibrium literature, without any prejudgement as to whether in a particular period of observation a country in question could or could not satisfy its demand for international credit that her optimization planning model would ideally dictate. The second formulation (Model B), attempts to exploit potentially valuable information (neglected in [6] and [7]) about the

binding nature of credit constraints that is contained in the incidence of repayments problems, as manifested by requests (explicit or otherwise) of reschedulings of debt obligations, the existence of arrears in these obligations, and of requests for International Monetary Fund (IMF) assistance and/or involvement. The third modelling approach (the first versions of which appear in [23] and [15]) further considers the extra information that can be gleaned from the level of arrears on the outstanding debt service obligations of the country in question. We present and estimate a model along these lines. The latter two approaches offer potentially significant advantages over past treatments of the subject, that neglected these extra sources of information.

Section II of Part II discusses another important innovation of our paper which is the specific recognition of the panel nature of the set of data used in the empirical implementation of the models. To the best of our knowledge all previous analyses of disequilibrium models using panel data (including [7]) have neglected the strong possibility of country heterogeneity. A priori, countries appear to be heterogeneous along many dimensions that are never modelled explicitly. For example, LDC's differ significantly in terms of colonial history, and political and financial institutions. As a result the assumption of i.i.d. errors, necessary for the validity of econometric inferences drawn from such studies, becomes untenable.<sup>2</sup> In this paper, in contrast to past econometric practice, we introduce explicitly an error-components structure in the unobservables, with country-specific unobserved effects that persist over time. In the Appendix, we

describe the incorporation of unobservable country-specific random effects as well as general year-specific fixed effects into the three-regime level-of-arrears model mentioned above.<sup>3</sup>

The actual specification of the models to be estimated and the hypotheses to be tested in this paper are discussed in Part III. Part IV presents and analyzes the empirical implementation of these models. We first examine whether factors suggested in the literature as determining country-creditworthiness indeed appear important. We then use our models to examine an ongoing controversy in the context of international lending termed the "liquidity versus solvency" debate. According to the first view, the international capital markets are not frictionless, hence a debt crisis might be induced by a lack of liquidity to a financially sound borrower. The "solvency" view maintains that the markets will never refuse access to a solvent borrower, hence credit crises are manifestations of insolvency. Another hypothesis tested concerns the role the "petrodollars" played in the debt problems of the LDC's after the oil-shock of 1973. The view to be investigated is that the current debt problems in international capital markets have been caused to a large extent by "too easy" availability of credit following the influx of "petrodollars" in search of a borrower, that took place after the 1973 events. We further examine the role of the past debt history of a country in affecting its creditworthiness-standing, as well as the importance of country-specific unobservable effects. Part V presents within-sample "predictions" from the 3-regime model C for a subsample of six Latin American countries. We close with a summary of the empirical findings and suggestions for future research.

## Part II

We start from the basic quantity rationing formulation of the repayments models and discuss the motivation for such modelling and for the extensions attempted in this paper.

### Section I: Theoretical Issues

One of the problems that one encounters directly in modelling international debt behavior is that credit transactions are non-uniform across countries and lenders. This has a number of implications. First, these specific characteristics of credit markets suggest a prevalence of quantity rather than price rationing in the equilibration process, since the price performs many roles on top of its usual market-clearing one: a. it affects the distribution of income between the lending and the borrowing country, b. it performs a signalling function, and c. it affects the probability of defaulting on a loan. Hence the "spread" may not be relied upon to perform the primary market-clearing function, quantity-rationing being used instead. This is the basic motivation for the disequilibrium approach we took in [23] and [15] and which we extend below.

It is interesting to note that a number of other studies, (notably [6], [7]), have basically proceeded along disequilibrium lines. The EG papers apply the standard switching regime apparatus, allowing for the separate identification of supply and demand parameters. We initially adopt this approach on a greatly expanded sample of 79 countries observed through the 1970-1982 period, whereas EG only had 45 countries observed for the two years of 1970 and 1974.

While providing important theoretical justification for an approach that emphasizes non-price rationing, the EG technique does not



refine the empirical modeling of repayments problems. For example, it neglects the fact that the observation of a rescheduling provides information on the classification of countries as supply constrained or demand constrained. As is well known in the disequilibrium literature, the value of observations on regime classification can be quite high, in terms of the performance of the estimation techniques used (see [9]). Therefore we proceed with models that use the actual incidence of repayments problems to classify regimes into constrained and unconstrained periods.<sup>4</sup>

A further extra source of information hitherto neglected is data on arrears which can be valuable in assessing the severity of a lending constraint. Hence we employ such extra information and refine the regime-classification into a three-regime one. The first regime is characterized by a total absence of credit rationing, as the "notional" demand for new loans by a country falls short of the maximal supply of loans by bankers, in which case the actual new loans just meet this demand. The intermediate regime is defined by a "moderate" level of excess demand for new loans on the part of the country, a situation in which the country will have to make do with the maximal new loans the bankers are willing to supply and try to fill the gap by drawing up "involuntary" loans in the form of allowing its debt obligations to go into arrears. However a rescheduling or other IMF conditionality-related programs are not yet necessary, as the required arrears are deemed "acceptable" by the bankers in the sense of not exceeding a specific limit. Finally the third regime is defined by an IMF support program and/or a rescheduling, as the arrears limit becomes binding. This 3-regime model may be obtained as a special case of a formal model

of optimization in the face of credit constraints, analyzed in [15], which we now sketch. (The econometric implementation is described in an Appendix): Consider a situation where a country faces the possibility of credit constraints in the International Capital market. The planners of this country solve the dynamic program of maximizing an intertemporally separable welfare function, subject to the possibility of facing borrowing constraints in the future. At the beginning of the period the planners do not yet know whether they will be facing a binding constraint or not in the period in question. As a general notation, denote by CA, R and A the current account deficit, stock of reserves and of arrears respectively. Flow variables are flows during the period, while stocks are at the end-of-period. The full solution to this dynamic program would yield targets  $\tilde{CA}$ ,  $\tilde{R}$  and  $\tilde{A}$  as functions of the credit constraint  $\bar{\Delta S}$ , which is treated exogenous to the borrower:

$$\begin{aligned} \tilde{CA} &= \tilde{CA}(\dots; \bar{\Delta S}) \\ \text{(II.1)} \quad \tilde{R} &= \tilde{R}(\dots; \bar{\Delta S}) \\ \tilde{A} &= \tilde{A}(\dots; \bar{\Delta S}) \end{aligned}$$

We assume that this full solution can be well approximated by the following sequential procedure that actually elucidates the workings of such a market:

Denote by CA\*, R\* and A\* the levels of Current Account deficit, international Reserves and Arrears that solve the optimization problem with the possibility of binding constraints in the future recognized, but under the assumption of no credit constraints in the current period, i.e.  $CA^* = \tilde{CA}(\dots; \Delta S = \infty)$ . (The formal characterization of this problem is given in [25]). Negotiations are then entered with bankers concerning the amount of new lending to be eventually agreed

upon. The Current Account identity

$$(II.2) \quad \Delta D^* = CA^* + (R^* - R_{-1}) - (A^* - A_{-1})$$

implies a demand for new borrowing  $\Delta D^*$ . In general  $A^*$  will be 0 as arrears are more costly than direct borrowing. The bankers then offer a maximal level of new lending they are willing to supply denoted by  $\bar{\Delta S}$ . We assume that the bargaining process will result in the short side getting its way (see [3] and [26]). In cases when the current credit constraint is binding for the country ( $\Delta D^* > \bar{\Delta S}$ ), the administrators are left with a set of irreconcilable targets  $CA^*$ ,  $R^*$  and  $A^*$ . (It is irrelevant for our purposes how the bankers would reallocate their portfolio in case the country takes only part of the offered credit. The lenders are, perhaps unsatisfactorily so, reduced to merely choosing  $\bar{\Delta S}$  rationally). We therefore postulate a quadratic loss function in the deviations of the levels  $CA^*$ ,  $R^*$  and  $A^*$  from their chosen values  $\bar{CA}$ ,  $\bar{R}$  and  $\bar{A}$ , to be minimized by the borrower subject to the identity-constraint:

$$(II.3) \quad \Delta D^* - \bar{\Delta S} = (CA^* - \bar{CA}) + (R^* - \bar{R}) + (\bar{A} - A^*) \geq \Delta D^* - \bar{\Delta S}$$

Formally the problem is:

$$(II.4) \quad \min_{\bar{CA}, \bar{R}, \bar{A}} \quad z' W z$$

subject to

$$(II.5) \quad i' z \geq \Delta D^* - \bar{\Delta S}$$

where

$$(II.6) \quad z' = \{(CA^* - \bar{CA}), (R^* - \bar{R}), (\bar{A} - A^*)\},$$

$$i' = (1, 1, 1)$$

and  $W$  is a positive definite matrix. Note that the constraint can be

simplified to

$$(II.3') \quad \overline{CA} + (\overline{R} - R_{-1}) + (\overline{A} - A_{-1}) < \Delta \overline{S}$$

Note further that the administrators know exactly their targets  $R^*$ ,  $A^*$  and  $CA^*$  obtained under the assumption of no constraints being currently binding. Hence the solution to this constrained loss-minimization problem will be linear in  $CA^*$ ,  $R^*$  and  $A^*$ , and will take the form:

$$(II.7) \quad (\overline{CA}, \overline{R}, \overline{A})' = M \cdot (CA^*, R^*, A^*, \Delta \overline{S})'$$

where  $M$  is a  $3 \times 4$  matrix.<sup>5</sup>

In a more general setup one can imagine that constraints on  $\overline{CA}$ ,  $\overline{R}$  and  $\overline{A}$  exist as well: for example bankers may forbid the stock of arrears ever from rising above some limit  $\overline{A}$  while political feasibility issues might impose similar limits on  $\overline{R}$  and  $\overline{CA}$ . These further constraints would be added along constraint (II.5) in the specification of the two-step problem. In case no  $\overline{CA}$ ,  $\overline{R}$  and  $\overline{A}$  could be found to satisfy all four constraints, a real repayments problem situation would arise that would dictate drastic steps like requesting a rescheduling, defaulting on the debt obligations and/or asking for an IMF agreement with or without conditionality imposed.

We leave implementation of the full model with simultaneous determination of all 3 targets  $CA$ ,  $R$  and  $A$  to future research. Here we examine the assumptions required to obtain the 3-regime specification of the main model we estimate below: with  $A^*=0$ , Regime 1 is defined by non-binding credit constraints in period  $t$ , as  $\Delta D^* < \Delta \overline{S}$ . Alternatively suppose that the credit constraint is binding ( $\Delta D^* > \Delta \overline{S}$ ). Now assume that the weights in the loss function  $W$  are such that always  $CA^* = \overline{CA}$  and  $R^* = \overline{R}$ , i.e., it is deemed extremely costly (for political purposes or

otherwise) to deviate ever so slightly from these two targets. Since  $\overline{\Delta D} = \overline{\Delta S}$  in such case, from constraint (II.3) we obtain

$$\overline{\Delta D^*} - \overline{\Delta D} = \overline{\Delta D^*} - \overline{\Delta S} = \overline{A} - 0 = \overline{A},$$

provided  $\overline{A}$  is considered an acceptable level of arrears by bankers; this defines the second regime of moderate excess demand. Lastly when  $\overline{A}$  is unacceptable to bankers, a real repayments problem faces the country, a situation that defines the third regime. It is important to note that in this "crisis" case the only information we use is that arrears desired by a country in order to fill up its excess demand gap exceed the level acceptable to bankers (see the Appendix). Nothing is said about actual transactions in such a case (e.g. new loans agreed upon and level of arrears maintained). We view negotiations on such issues, which will involve third-parties like the IMF, as falling outside the scope of analysis of this paper.

As can also be seen from the Appendix, our 3-regime model is a highly non-linear econometric model, containing characteristics from all of the usual four classes of limited dependent variables in econometrics: the model simultaneously exhibits a. a probit structure, since an indicator variable identifies the first regime of no debt repayments problems from the repayments problems regimes 2 and 3; b. a tobit structure, in that the observed level of arrears can be either 0 or positive; c. a switching regressions aspect, as the new flow of lending to a country ( $\overline{\Delta D}$ ) can be either equal to  $\overline{\Delta D^*}$  in regime 1 or to  $\overline{\Delta S}$  in regime 2; and finally d. an endogenously missing data structure since, when regime 3 is observed we do not attempt to identify the level of arrears and the new funds flowing to this economy.

## Section II: Country Heterogeneity

The idiosyncracies involved with credit determination in international markets discussed above have another important implication that provides a basic motivation for this paper. An issue neglected in all previous work on LDC debt performance has been the temporal structure of unobservable variables, the implicit assumption being that country-year shocks are all independently and identically distributed. This can be a source of serious misspecification, given the panel nature of most of these studies. (An exception is [23] which allows for country-specific unobserved effects with a generalized probit estimation technique). Temporal dependence can arise in at least two ways in panel data. First, individual (country) specific unobservable characteristics can give rise to serial correlation. Such heterogeneity would seem to be an inevitable result of modelling debt performance as a function of a small number of macroeconomic variables. More importantly, as already mentioned in the introduction, unobservable persistent country heterogeneity appears a priori important, since countries clearly differ in terms of colonial history, and political, religious and financial institutions. All of these factors may affect a country's attitude towards borrowing in general and defaulting on debt obligations, as well as the bankers' attitudes towards the borrowing country in question. Secondly, serial correlation may be induced by state dependence that arises from learning processes of the type stressed in the theoretical literature on credit markets, by the fact that history may be a good predictor of future debt repayments problems; by the role asset accumulation plays

in the problem; or by our failure to address questions about the duration (actual or anticipated) of debt crises.

A simple form of heterogeneity can be incorporated in our models by allowing the disturbance terms to have an error-components structure:

$$(II.8) \quad \varepsilon_{it} = \eta_i + v_{it},$$

where  $v_{it}$  is an i.i.d. normal random variable and  $\eta_i$  is a country-specific normal random variable, uncorrelated with  $v_{it}$ . Using maximum likelihood techniques, the relative importance of the country effect  $\eta$  can be assessed by comparing the estimated variance of  $\eta$  with the estimated variance of  $v$ . Such "one-factor" probit reduced form models were estimated in [23] where the dummy dependent variable was indicating the incidence of repayments problems, with the inclusion of a lagged dependent variable (capturing the incidence of past such problems). Likelihood ratio tests suggested the presence of strong state dependence, with a relatively weaker, but statistically quite significant, effect of heterogeneity. In our estimations below, we introduce for the first time in disequilibrium models country-specific unobservables. The Appendix derives the correct likelihood expressions under such error-components structures, for the three modelling approaches. Note that the estimation of the heterogeneity-model in [23] did not make specific allowance for the presence of the lagged dependent variable among the explanatory variables. As explained in the Appendix below, this amounts to treating the initial values of the dependent variable as exogenous, a procedure that causes inconsistency in the parameter estimates.

### Part III

#### Specification of Demand and Supply

The following issues motivate our empirical implementation of the models we adopt: First, we start from factors already identified in the literature as determining the creditworthiness of a country and, as a result, the supply of lending. We therefore examine the ratio of debt outstanding to exports as providing a measure of the extent to which exports, the main source of foreign exchange, can cover the external indebtedness of the country. This ratio has been singled out as an important indicator of lack of creditworthiness in previous work. Ideally, one would prefer to introduce also a measure of "non-compressible" imports, where the term defines imports that a country would find very difficult to reduce in a debt crisis situation, because of special importance in production and consumption (e.g. oil, basic foodstuffs, primary inputs etc.) Lack of satisfactorily consistent data precluded the construction of such measures.

The ratio of debt service due over exports is considered a further creditworthiness indicator since it describes the ability of an economy to finance its yearly interest and principal obligations that are a pressing concern for the short run. Attempts to break up interest from principal repayments are undertaken in order to shed some light on the on-going controversy over the "liquidity vs. solvency" question. If markets function well in the sense of never refusing access to a basically solvent borrower, the lenders should attach higher significance to receiving promptly interest payments from a country.

The ratio of reserves to imports should be a measure of how long an economy would be able to finance its imports by using its stock of



reserves without seeking refuge in higher levels of external borrowing. This ratio may both indicate high creditworthiness and low demand for new loans, *ceteris paribus*, since existing stocks of reserves can be used to do such financing.

Real GNP per capita captures aid motivations in the supply of new lending, as well as the degree of financial well-being of a country that might signify high creditworthiness. The same applies to the growth rate of real income. Note that one could potentially try direct measures of flows of aid-funds to particular economies, in case such measures were available. A high exports/GDP ratio may be a characteristic viewed as undesirable by international bankers, because an open economy is more vulnerable to price shocks in the commodities-markets and to falling demand for its exported goods following a recession in the industrialized world. On the other hand, the planners of a country with a highly open economy are more likely to be disciplined in their international financial dealings and less likely to repudiate, recognizing that their country stands to lose greatly from a drying-up of sources of international credit.

Past repayments problems reflected in the form of IMF arrangements, reschedulings and/or significant arrears outstanding could be strong indications of a lack of creditworthiness if learning processes are important on the part of the bankers. Various alternatives were tried that counted all past problems from the starting year of observation. The results indicate that the bankers have "short memories" - most of the negative impact is captured by any repayments problem(s) occurring in the immediately preceding period.

To go on to factors that should mainly affect the demand for new

loans, we first mention the debt service obligations that are due, including any accumulated arrears. The next factor is the level of imports that induces a demand for foreign exchange to finance them. The real income generated in an economy and the rate with which it is growing should clearly appear in the optimization problem the planners are solving, as should the terms of trade the country faces. We do not try the latter since they did not appear important enough in [23]. High debt obligations could be expected to raise demand for new loans in order to help meet these obligations. The existing reserves of foreign exchange are an alternative source of financing current account deficits, hence they should affect negatively the demand for new foreign loans. A quickly expanding economy might impose high requirements on external borrowing in order to finance such a fast pace of expansion. On the other hand high levels of real per capita income might characterize a well managed, affluent economy less likely to be in need of amassing huge external debts. With these considerations in mind, the most general formulations we try for the (notional) Demand and Supply functions, and for the Limit on arrears for Model C, are:<sup>6</sup>

$$\begin{aligned} \text{(III.1) DEMAND} &= d1 + d2 * (\text{Debt service due} / \text{Exports}) \\ &+ d3 * (\text{Reserves} / \text{Imports}) + d4 * (\text{Real GNP per capita}) \\ &+ d5 * (\text{Growth rate of real GNP}) \\ &+ d6 * (\text{Imports} / \text{GDP}) + d7 * \text{POST73} \\ \text{(III.2) SUPPLY} &= s1 + s2 * (\text{Total debt outstanding} / \text{Exports}) \\ &+ s3 * (\text{Interest due} / \text{Exports}) + s4 * (\text{Principal due} / \text{Exports}) \\ &+ s5 * (\text{Reserves} / \text{Imports}) + s6 * (\text{Real GNP per capita}) \\ &+ s7 * (\text{Growth rate of real GNP}) \\ &+ s8 * (\text{Exports} / \text{GDP}) + s9 * \text{QRSSIMFL} + s10 * \text{QARRL} + s11 * \text{POST73} \end{aligned}$$

$$\begin{aligned} \text{(III.3) ARREARS\_LIMIT} &= a_1 + a_2 * (\text{Total debt outstanding/Exports}) \\ &+ a_3 * (\text{Debt service due/Exports}) \\ &+ a_4 * (\text{Real GNP per capita}) \\ &+ a_5 * (\text{Growth rate of real GNP}) \\ &+ a_6 * (\text{Exports/GDP}) + a_7 * \text{QRSSIMFL} + a_8 * \text{POST73} \end{aligned}$$

where

QRSSIMFL = Dummy taking the value 1 whenever rescheduling requested  
and/or IMF agreement in effect in the preceding period

QARRL = Dummy taking the value 1 whenever QRSSIMFL equals 1 and non-  
zero arrears on principal and/or on interest existed in  
preceding period

POST73 = Dummy taking the value 1 after 1973

Part IV

Empirical Findings

We begin with Table 1 that presents estimates of the three-regime model obtained under i.i.d. assumptions. We find the demand for debt to increase strongly in the debt service to exports ratio, possibly signifying a desire for new debt to keep financing accumulated obligations. Demand is also found to rise with the imports to GDP ratio, presumably because this ratio implies a high need for foreign exchange financing. The significantly negative coefficient of per capita income seems to imply that relatively affluent countries have a lower need for external debt. This finding agrees with results in [23] where it was found that the behaviour of lower to middle income countries was markedly different from the one of well-off nations. Proceeding to supply factors, we find that history of repayments problems has a strongly depressing effect on the availability of new loans, especially so if the previous period was one with non-zero significant arrears. The stock of debt to exports ratio appears with a significantly positive coefficient (though of a very small magnitude) suggesting that bankers keep supplying funds to countries with which they have a history of commitment. Though statistically not significant, a high reserves to import ratio that is supposed to indicate a creditworthy economy comes out positive. The debt service components (interest due over exports and principal due over exports) turn out positive but insignificant. The positive signs once again suggest that bankers may be influenced by past commitment considerations. However the fact that the principal due coefficient is found to be significantly smaller than one suggests that liquidity

problems are likely since the bankers seem to refuse to roll over principal obligations one for one.

Moving to the determinants of the arrears limit, debt service once again is found to have a significantly positive effect. This suggests that bankers may monitor arrears as a percentage of debt obligations (the stock of debt is also found to have a positive while insignificant effect). As expected, past repayments problems tighten the arrears limit significantly. Exports to GDP come in with a negative (but statistically insignificant) sign both on the supply side and on the arrears limit, which may mean that bankers view a high exports ratio as a "bad" thing - high degree of openness implying that the economy in question is too vulnerable to the vagaries of commodities-markets shocks and to the policies of the industrialized world. We find a significantly positive correlation (0.28) between demand and supply unobservables, with most of the shocks coming from the demand side ( $\sigma_D = 1.28$  versus  $\sigma_S = 0.47$ ).

To examine the robustness of the specification of the 3-regime Model C, we now consider related "limited information" models, that only investigate the incidence of crises. Qualitatively, one may think of the set-up as one with three relevant "choices":

1: no debt-repayments problem, 2: significant arrears, but no real "crisis", and 3: debt crisis.

A natural way of modelling this is through a simple trinomial logit model (see [21]). In the absence of lagged dependent variables the conditional MLE approach of [1] and [5] would have been applicable. Here we will proceed with preliminary estimations that pool together the data, neglecting their panel nature (a possibly

misleading procedure given the random-effects results of [14]). Such trinomial logit estimates are presented in Table 2. The suffix (2 or 3) signifies the alternative-specific dummy variable with which the independent variable in question was interacted to achieve identification. Model  $MNL_{II}$  differs from  $MNL_I$  in allowing for lagged choice variables (denoted by  $REGiLAGj$ ). Two variables,  $IMFHIST_i$  and  $RSSHIST_i$ , count the cumulated number of previous years in which a debt-repayments problem occurred: years in which IMF conditionality-related programs were in effect and years of requesting/signing reschedulings of debt-obligations respectively. In using these variables we attempt to examine, within the limitations of the MNL approach, how "long" memories for past debt problems the bankers have. We generally find that the incidence of most recent problems ( $REGiLAGj$ ) is more important than the cumulated number of problems in the more distant past. The lagged "choice" of regime again exhibits extremely high explanatory power. Given its "limited information" nature, the trinomial logit model does not afford separate identification of D and S parameters.

We next proceed with a nested trinomial logit model (see [22]) of the following structure:

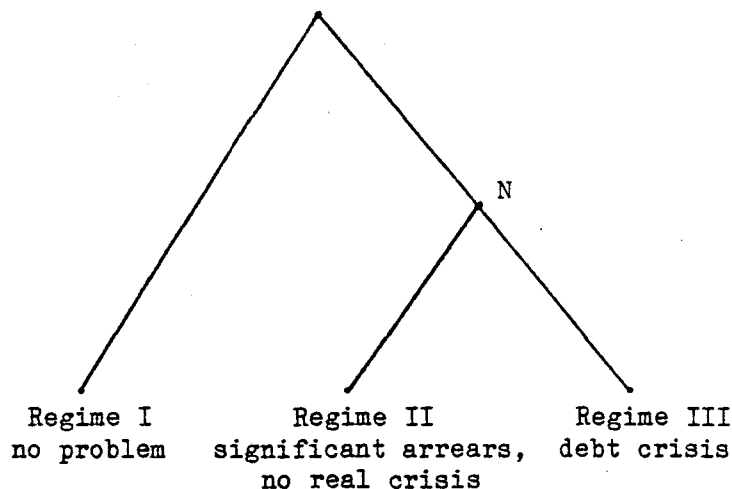


FIGURE 1

This model is tried because "choices" 2 and 3 are both debt-repayments problem cases (albeit of different severity). Hence one might expect higher substitutability between these two, a possibility the standard MNL cannot allow for. The estimates for the nested model appear in Table 3. "THETA" is the dissimilarity parameter associated with node N (see [22]). Application of classical tests presented in [17], indicate that the plain MNL model is not rejected against the Nested model.<sup>7</sup>

We now summarize our findings with the basic two-regime (excess demand, excess supply) models, with- (Model B) and without- (Model A) classifications on regimes. (The detailed estimates can be obtained from the author upon request.) Model B employed the classification of regimes whereby constrained periods were taken to be ones that involved requests for reschedulings, IMF agreements and involvement, and/or significant arrears on either interest or principal obligations. ("Significant" is defined as higher than 1 percent of total debt for principal and 0.1 percent for interest). This classification essentially lumped together the "moderate excess demand" and "crisis" regimes into a single supply-constrained regime. We found no dramatic changes in the signs of the significant coefficients.

An interesting finding was that now the principal due to exports ratio on the supply side became strongly significant (asymptotic t-statistic higher than 7), still with magnitude less than 1. The smaller than 1 coefficient again suggested that liquidity pressures may build up on countries with high external indebtedness, since the bankers seem unwilling to roll-over principal obligations fully.

Model A employed the method that does not use classifications on regimes, but simultaneously tries to estimate the regime classification most consistent with the data. These results were not very close to the ones that employed the classification rule above, suggesting that this classification might be inaccurate. This statement can be formally examined through the use of Hausman tests as explained in [13].

Another interesting finding was that in both two-regime models the shocks seemed to be coming more from the supply rather than the demand side ( $\sigma_s=0.39$ ,  $\sigma_d=0.28$ ). This may suggest that the 3-regime modelling is a sensible way of refining the supply side into supply of new loans and monitoring of arrears.

We also tested the "petrodollars" hypothesis using the 3-regime model. The POST73 dummy was found statistically insignificant on all three sides.<sup>8</sup> The signs of the coefficients, however, were interesting: both the supply of new loans and the arrears limit were found to have risen from 1974 onwards relative to their pre-1974 values, a finding that broadly agrees with the claim that the oil-shock created a glut of petrodollars in the international capital markets. (Of course, this should be weighed against the implied shortage of OECD funds that resulted from the oil shock). The effect on the demand was (insignificantly) negative which is against the usual view that the developing countries attempted to maintain their declining standards of living after the oil-shock by obtaining higher external debts.



We finally present results in Table 4 employing the main econometric innovation of this paper, namely introducing (random) country heterogeneity into the three regime model.<sup>9</sup> The country specific unobservables appear important, with the demand side country effect having a standard deviation  $\sigma_{\eta}$  equal to 0.369 with asymptotic  $t=7.53$ , and the supply side effect  $\theta$  with  $\sigma_{\theta}=0.107$  ( $t=6.43$ ). In general, changes in the t-statistics due to the random effects estimation are of the order of 10-25 percent. There is some evidence of stronger demand-side heterogeneity -  $\sigma_D$  falls from 1.28 to 0.94 and its t-statistic from 8.90 to 2.38 after the introduction of the random effects. The past repayments problems dummies remain significant, though they lose some of their explanatory power. This suggests that the reason we were finding past history to be an important factor under i.i.d. assumptions was not because of neglecting country heterogeneity.

Part V

Ex Post Predictions of Debt Repayments Crises Using the 3-Regime Model

We now present within-sample "predictions" from our 3-regime model with two aims in mind: First, such "predictions" can act as an illuminating check on the specification of the model. Second, an idea can be obtained as to how important the neglect of unobservable heterogeneity can be for our problem.

The following graphs show probabilities of debt repayments "crises" (Regime 3) for a selected subsample of countries (Latin American ones with fairly widely known debt histories). P3 uses the point coefficient estimates of Table 1 that neglect country heterogeneity. In Figure (a) of each graph, P3Z, P3DP, and P3SP all employ the Random Effects estimates of Table 4 and are probabilities conditional on particular values of the random effects. P3Z assumes that both demand and supply effects are at their (unconditional) means of zero. P3DP follows the scenario unfavourable to a country in which its unobserved demand effect is equal to one (estimated) standard deviation above its zero mean, while the supply effect is below the mean by one standard deviation. P3SP pictures the converse situation of demand being uncharacteristically low by one standard deviation of its random effect, while supply being up by one standard deviation.

In Figures (b), P3 is plotted alongside upper (UB) and lower (LB) asymptotic confidence bounds of one estimated (asymptotic) standard deviation  $\tilde{\sigma}_{P3}$ , calculated through the usual Taylor-series asymptotic expansion:

$$\text{Avar}(P3(\tilde{\beta})) = \frac{\partial P3}{\partial \beta}(\tilde{\beta}) \cdot V(\tilde{\beta}) \cdot \frac{\partial P3}{\partial \beta}(\tilde{\beta})', \text{ where } V(\tilde{\beta}) \text{ is } \text{Avar}(\tilde{\beta}).$$

The first general conclusion we draw is that the problem of implausibly high crises probabilities uniformly predicted by various "reduced-form" models in [23] seems to be overcome by the 3-regime model of this paper.

Secondly, we point out that heterogeneity-effects appear important to the extent that fairly probable values of such effects are seen in some cases to double or halve the crisis-probabilities. Moreover, the range from P3DP to P3SP is of the same order of magnitude and generally wider than the range between the asymptotic confidence bounds presented in Figure (b) of each graph.

Thirdly, the probabilities presented below appear to track fairly well events in country-histories that one would expect to affect significantly the external-indebtedness situation of a country.

It is interesting that the debt problems of Brazil appear wholly oil-shock related: the probabilities underwent a distinct jump after 1974 and never receded to their pre-oil shock levels. See Figure (2).

The tracking of actual events exhibited by the figures for Chile is quite impressive. The political and economic upheavals of the 1971-1975 years are captured by steeply rising crisis probabilities, calming down after the decent performance of the economy in the following 3 years. A drastic and apparently ill-timed liberalization policy, as well as a major collapse in the price of copper in 1978-1979, the single most important export good of Chile, appears to have renewed the pressures on the economy.

The predictions for Costa Rica (Figure (4)) agree very well with the events of 1979-1981, which culminated with a major rescheduling signed in 1982. An interesting point is that the Costa Rican

authorities were trying without success for 2 years beginning 1980 to convince their international lenders that the economy was in a crisis and in need of a rescheduling. It is reassuring that the model starts predicting rising crisis probabilities from 1979.

The Jamaican experience has been one of almost continual and recently mounting external debt problems (see Figure (5)). Relative calm followed the IMF arrangements signed for 1973 and 1974. 1977 marks the beginning of a dramatic upward trend in crisis probabilities, reflecting well the subsequent signing of all types of IMF conditionality-related agreements, culminating in a major rescheduling of the debt obligations signed in 1981.

In 1977, the Mexican authorities took a very explicit policy decision of pursuing vigorous economic growth. Our model seems to tell us that the policy was beyond the means of the economy, especially in view of the slackening of the oil-market in the subsequent years, thus leading to the ensuing debt repayments problems.

Finally, Venezuela (Figure (7)) is seen to have been extremely creditworthy (by the standards of the other 5 economies considered) throughout the period under study, which may partially reflect the fact that this country is a major oil exporter.

## Part VI

### Conclusions

This paper presented and estimated models of lending in international capital markets with the allocation of credit being primarily carried out along quantity-rationing lines at basically (statistically) exogenous interest rate cost. New sources of information about the possibility and extent of credit constraints were explored. The main findings confirm the previously documented importance of creditworthiness indicators on the supply of funds and on limits on "acceptable" levels of arrears. We also find that a history of debt repayments problems has a strongly dampening effect on the availability of new funds and a tightening of limits on arrears. Moreover the evidence suggests that high levels of debt obligations force bankers to maintain a flow of funds to such customers.

Demand factors identified here include: the use of existing foreign exchange reserves as an alternative to external debt, high imports levels inducing high demand for foreign debts to finance them, and a lower demand by relatively affluent borrowers, other things being equal. The stochastic shocks were seen to arise primarily from the demand side. This finding is reversed in the two-regime models which do not distinguish supply of pure loans from allowing arrears to rise. High debt obligations are accompanied by high demand for new funds, possibly to keep meeting these existing obligations.

Substantial differences in results were observed in the two-regime models, when classifying as credit constrained an economy that asks to reschedule its debt obligations, requests/accepts an IMF involvement or has its obligations go into arrears. This might suggest that such a

classifying rule is misleading, or that neglecting classifying information can lead to very inaccurate estimates. We find some evidence for the claimed glut of "petrodollars" after the 1973 oil shock leading to higher levels of international lending. Supporting evidence for liquidity problems inducing external debt crises even for overall solvent borrowers is found. The claimed exogeneity of the interest rate costs needs to be analyzed further.

Explicit allowance for the possibility of country heterogeneity establishes a strong role for country-specific persistent unobservable effects, without eliminating the importance of a history of past repayments problems.

Within-sample "predictions" of probabilities of debt crises implied by our estimated models were used for testing the specification of the models. Analogous predictions under alternative scenarios on the LDC's external debt situation can serve to examine the effects of such alternative scenarios. It should further be noted that a more powerful test of our specification would have been a set of out-of-sample predictions. We plan to attempt this further test of the model, as more data gradually becomes available.

The use of classification information in disequilibrium models merits further examination. The question whether it might ever be desirable in finite samples to employ even imperfect such information should be addressed. The issues of duration of debt repayments crises also seem to warrant future study, as does the role of economic conditions in the developed countries in affecting probabilities of debt problems in the developing nations.

Appendix

The Likelihood Function for the 3-Regime Model

with D and S Country-Specific Random Effects

We modify the 3-regime model in [23] and [15] to incorporate heterogeneity, and the likelihood function is derived under "random effects" assumptions on the demand and supply of new loans.<sup>10</sup> Note that fixed year effects can be handled as an extra set of 2T parameters, estimated along with the structural parameters of the model. (The i.i.d. case is presented in Appendix B of [23]).

Stochastic elements enter our model at three points. Both the notional demand  $N^D$  curve and the maximal supply  $N^S$  are linear functions of predetermined variables with additive random shocks for each country and period.

$$(A.1) \quad N_{it}^D = D_{it} + \eta_i + e_{it}^d$$

$$(A.2) \quad N_{it}^S = S_{it} + \theta_i + e_{it}^s$$

Joint normality assumptions are made, with the vector  $(e_{it}^d, e_{it}^s)$  being mutually independently distributed from the vector  $(\eta_i, \theta_i)$ , for all  $i$  and  $t$ . We will use the natural notation for the variances of the four errors.<sup>11</sup> Also let  $\rho = \text{corr}(e^d, e^s)$  and  $\rho_{\eta\theta} = \text{corr}(\eta, \theta)$ .

We next characterize the stochastic nature of the arrears limit  $L^*$  by an exponential random variable with cdf:

$$(A.3) \quad \text{Prob}(L^* < l) = 1 - \exp(-Bl-C),$$

where B and C are linear functions of predetermined variables. The nonnegativity property of the exponential provides a natural characterization of a lower limit on a financial stock like arrears.<sup>12</sup>

Given that  $L^*$  is imposed by suppliers, B and C contain basically the same country characteristics that enter the overall credit limit.

Define the latent variables  $A^*$  ( $= N^D - N^S$ ) and  $L^*$ . Further define the observables to be the realized level of new lending (N), the realized level of arrears (A), and a discrete variable indicating the event of a rescheduling ( $\delta$ ). The three possible regimes can now be formally characterized:

(A.4.1) Regime 1: excess supply

$$A^* < 0 \Leftrightarrow N=N^D, A=0, \delta=0.$$

(A.4.2) Regime 2: moderate excess demand

$$0 < A^* < L^* \Leftrightarrow N=N^S, A=A^*, \delta=0.$$

(A.4.3) Regime 3: large excess demand

$$A^* > L^* \Leftrightarrow \delta=1.$$

The likelihood function for this problem is obtained as follows:

Consider a country  $i$  and evaluate probabilities conditional on the specific random effects of this country. Manipulating the joint normal distributions yields the conditional distributions:

$$(A.5.1) \quad (A^* | N^D, \eta, \theta) \sim N\left(\left(D-S+\eta - \theta \frac{\sigma_D^2 - \rho \sigma_D \sigma_S}{\sigma_D^2} (N^D - (D+\eta))\right), \sigma_S^2 (1-\rho^2)\right)$$



$$(A.5.2) \quad (N^S | A^*, \eta, \theta) \sim N\left(\left(S + \theta + \frac{\rho\sigma_D\sigma_S - \sigma_S^2}{\sigma^2} (A^* + S - D + \theta - \eta)\right), \frac{\sigma_S^2\sigma_D^2}{\sigma^2} (1 - \rho^2)\right)$$

$$(A.5.3) \quad (N^D, N^S | \eta, \theta) \sim N\left((D + \eta, S + \theta), \begin{bmatrix} \sigma_D^2 & \rho\sigma_D\sigma_S \\ \rho\sigma_D\sigma_S & \sigma_S^2 \end{bmatrix}\right)$$

$$(A.5.4) \quad (A^* | \eta, \theta) \sim N((D + \eta - S - \theta), \sigma^2)$$

We are now in a position to calculate the likelihood for each regime.

Regime 1 ( $A=0, \delta=0, N=N^D$ )

$$(A.6.1) \quad h_1 = P(A=0, \delta=0, N=N^D | \eta, \theta) =$$

$$P(A^* < 0 | N^D=N, \eta, \theta) P(N^D=N | \eta, \theta) =$$

$$\Phi\left(\frac{\theta - \eta + S - D - (N - D - \eta)\left(1 - \rho \frac{\sigma_S}{\sigma_D}\right)}{\sigma_S \sqrt{1 - \rho^2}}\right) \frac{1}{\sigma_D} \phi\left(\frac{N - D - \eta}{\sigma_D}\right)$$

Regime 2 ( $A > 0, \delta=0, N=N^S$ )

$$(A.6.2) \quad h_2 = P(A > 0, \delta=0, N=N^S | \eta, \theta) =$$

$$P(N^S=N | A, \eta, \theta) P(L^* > A | A, \eta, \theta) P(A | \eta, \theta) =$$

$$= \frac{\sigma}{\sigma_D \sigma_S \sqrt{1 - \rho^2}} \phi\left(\frac{N - S - \theta - \frac{\rho\sigma_D\sigma_S - \sigma_S^2}{\sigma^2} (A + S - D + (\theta - \eta))}{\sigma_S \sigma_D \sqrt{1 - \rho^2} / \sigma}\right) e^{-BA - C} \frac{1}{\sigma} \phi\left(\frac{A - D + S - \eta + \theta}{\sigma}\right)$$

Regime 3 ( $\delta=1$ )

$$(A.6.3) \quad h_3 = P(\delta=1) = P(L^* < A^*) = \int_0^\infty P(L^* < A^* | A^*, \eta, \theta) P(A^* | \eta, \theta) dA^*$$

$$= \Phi\left(\frac{D-S+\eta-\theta}{\sigma}\right) - \Phi\left(\frac{D-S+\eta-\theta}{\sigma} - B\sigma\right) \cdot \exp(-B(D-S+\eta-\theta) - C + 0.5B^2\sigma^2)$$

The joint likelihood of the  $T_i$  observations on country  $i$ , conditional on the specific effects  $\eta_i$  and  $\theta_i$  is:

$$(A.7) \quad H(\eta_i, \theta_i) = \prod_1 h_1(\eta_i, \theta_i) \prod_2 h_2(\eta_i, \theta_i) \prod_3 h_3(\eta_i, \theta_i)$$

and therefore the  $T_i$  observations on country  $i$  have likelihood<sup>13</sup>

$$(A.8) \quad \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} H(\eta_i, \theta_i) f(\eta_i, \theta_i) d\eta_i d\theta_i = L_i \quad .$$

MLE is then obtained by maximizing  $\sum_{i=1}^I \ln L_i$ .

It is interesting to note that the structure of our specification incorporates characteristics from all of the four usual classes of limited dependent variables in Econometrics. First, we have a probit-like structure through the dummy classification variable  $\delta$ ; second, observed arrears  $A$  have clear tobit-like characteristics; third, transacted new flows of funds  $N$  have a switching regimes structure; fourth,  $N$  and  $A$  both incorporate the feature of endogenously missing data, in that when regime 3 is observed, we do not attempt to identify the levels of  $N$  and  $A$ .

An important issue to be addressed is how we handle the fact that the regressors appearing in Part III include realizations of lagged dependent variables. This creates the initial conditions problem discussed at length in [19] and [14]. To briefly state the problem: let  $y_t^*$  be a latent variable and  $y_t$  its observed counterpart. Since  $y_t^*$  is stochastically dependent upon the random effect  $\theta_1$ , so is  $y_t$ . Therefore inconsistency will in general result if this dependence is neglected by attempting to simply condition on  $y_0$ . In a nutshell,

the true likelihood contribution for country  $i$  takes the form:

$$(A.9) \quad \int_{-\infty}^{\infty} f(y_T, \dots, y_1 | y_0, \theta) f(y_0 | \theta) f(\theta) d\theta$$

and conditioning on  $y_0$  as an exogenous variable neglects the term  $f(y_0 | \theta)$  and results in inconsistency. The approach adopted here amounts to using the same functional form (given by A.6.1-A.6.3) for  $f(y_0 | \theta)$  as for  $f(y_t | y_{t-1}, \theta)$ ,  $t > 1$ , while letting the coefficients of the regressors be different for the  $f(y_0 | \theta)$  term.<sup>14</sup> See [2] for analogues of this approach in the simpler case of the linear regression model. An issue that warrants further investigation is the precise form of the  $f(y_0 | \theta)$  term, which is a non-trivial problem given the non-linearities of our models. The approach suggested by [19] and adopted here, that assumes the same functional form for the reduced form of a dependent variable as the structural equation of this variable is only an approximate solution. We tentatively adopt this approximate technique in this paper, while planning extensive analysis of the issue.

TABLE 1

## MODEL C

Dependent variables are DVDEL, DNEW & ARR\*  
(Asymptotic t-statistics in parentheses)

Variable (lagged one year)	New Loan Demand	New Loan Supply	Limit on Arrears
Constant	-0.3470 [ 3.223]	0.4376 [6.988]	0.2195 [ 0.571]
Debt Service Due/Exports	6.5243 [25.267]	-	1.8449 [ 2.394]
Real GNP/Capita	-0.3911 [ 5.261]	0.0203 [0.493]	-0.0814 [ 0.383]
Growth rate of Real GNP	0.0963 [ 0.120]	0.0597 [0.167]	0.0785 [ 0.041]
Imports/GDP	0.9489 [ 4.885]	-	-
Reserves/Imports	-	0.0771 [ 0.890]	-
Exports/GDP	-	-0.0413 [ 0.369]	-0.3060 [ 0.332]
Debt/Exports	-	0.0875 [ 2.640]	0.1563 [ 1.169]
Indicator for IMF support or rescheduling	-	-0.1451 [ 1.932]	-1.3303 [ 6.082]
Indicator for arrears	-	-0.3058 [ 6.480]	-
Interest due/Exports	-	0.4552 [ 0.505]	-
Principal due/Exports	-	0.2146 [ 1.126]	-
Standard Deviation	1.2759 [ 8.897]	0.4679 [20.284]	
Correlation	0.2788 [ 4.785]		
Likelihood Value	-1668.386		

\*

DVDEL=1 if either a rescheduling is requested  
and/or an IMF agreement is in effect.

DNEW =total new debt obtained within the period  
(scaled by the flow of exports).

ARR =total significant Principal and Interest  
outstanding arrears on debt obligations.

Table 2

Trinomial Logit Estimates of Model C

MNL I

MNL II

VARIABLE	ESTIMATE	STD-ERR	T-STAT	ESTIMATE	STD-ERR	T-STAT
DEBTX3	0.6473	0.187	3.471	0.4193	0.202	2.080
DEBTX2	0.4418	0.158	2.793	0.2615	0.183	1.432
DRGNP3	-5.2060	2.507	-2.077	-2.5357	2.750	-0.922
DRGNP2	0.3020	1.407	0.215	3.0199	1.793	1.685
DSDEXP3	3.1801	0.983	3.235	2.7538	1.067	2.582
DSDEXP2	2.1089	0.853	2.472	0.9059	1.019	0.889
EXPGDP3	1.3786	1.943	0.709	-0.0489	2.125	-0.023
EXPGDP2	0.5095	0.949	0.537	-0.0981	1.243	-0.079
IMFHIST3	0.2889	0.081	3.572	0.0598	0.099	0.606
IMFHIST2	-0.5246	0.097	-5.398	-0.4722	0.125	-3.786
IMPGDP3	-1.4993	1.641	-0.914	-0.3283	1.782	-0.184
IMPGDP2	-0.0118	0.815	-0.015	0.2433	1.067	0.228
RESIMP3	-5.9428	1.022	-5.814	-5.6083	1.057	-5.304
RESIMP2	-1.3097	0.362	-3.615	-1.2879	0.462	-2.786
RGNPPC3	-0.5086	0.252	-2.020	-0.4259	0.261	-1.629
RGNPPC2	-0.6525	0.146	-4.454	-0.4497	0.184	-2.442
RSSHIST3	-0.1982	0.184	-1.078	-0.1400	0.207	-0.677
RSSHIST2	-0.1148	0.188	-0.611	-0.0002	0.225	-0.001
REG2LAG3	-	-	-	1.6021	0.356	4.496
REG2LAG2	-	-	-	3.4115	0.237	14.400
REG3LAG3	-	-	-	2.4728	0.376	6.585
REG3LAG2	-	-	-	1.9957	0.389	5.125
DUMMY3	-0.7589	0.460	-1.649	-1.3529	0.514	-2.630
DUMMY2	0.1269	0.250	0.508	-1.3326	0.332	-4.016
LOGLIKELIHOOD			-683.4544			-516.7693
LOGLIKELIHOOD AT ZERO			-903.0593			-903.0593

Table 3

## Nested Trinomial Logit Estimates of Model C

VARIABLE	<u>NMLN I</u>			<u>NMLN II</u>		
	ESTIMATE	STD-ERR	T-STAT	ESTIMATE	STD-ERR	T-STAT
DEBTX3	0.6804	0.211	3.218	0.3691	0.194	1.907
DEBTX2	0.4312	0.162	2.658	0.2733	0.177	1.546
DRGNP3	-5.9075	3.192	-1.851	-1.4367	2.707	-0.531
DRGNP2	0.4853	1.483	0.327	2.6196	1.817	1.442
DSDEXP3	3.3363	1.099	3.035	2.3619	1.107	2.134
DSDEXP2	2.1022	0.870	2.416	1.0515	0.992	1.060
EXPGDP3	1.5530	2.230	0.696	-0.0805	1.673	-0.048
EXPGDP2	0.5024	0.958	0.524	-0.1142	1.207	-0.095
IMFHIST3	0.3538	0.169	2.098	-0.0128	0.130	-0.098
IMFHIST2	-0.5743	0.149	-3.862	-0.3896	0.156	-2.494
IMPGBP3	-1.7586	1.947	-0.903	-0.1570	1.432	-0.110
IMPGBP2	-0.0207	0.823	-0.025	0.3084	1.044	0.295
RESIMP3	-6.7274	2.140	-3.144	-4.2955	1.768	-2.429
RESIMP2	-1.2297	0.408	-3.012	-1.4664	0.500	-2.933
RGNPPC3	-0.5024	0.282	-1.783	-0.4472	0.216	-2.066
RGNPPC2	-0.6538	0.149	-4.374	-0.4455	0.175	-2.547
RSSHIST3	-0.2107	0.195	-1.078	-0.1120	0.196	-0.571
RSSHIST2	-0.1214	0.198	-0.614	-0.0052	0.204	-0.025
REG2LAG3	-	-	-	2.0782	0.663	3.136
REG2LAG2	-	-	-	3.3250	0.254	13.114
REG3LAG3	-	-	-	2.3908	0.351	6.807
REG3LAG2	-	-	-	2.1726	0.400	5.438
DUMMY3	-0.9326	0.649	-1.437	-1.1482	0.464	-2.473
DUMMY2	0.0887	0.269	0.330	-1.2167	0.349	-3.490
THETA	1.1852	0.430	2.754	0.6467	0.409	1.580
LOGLIKELIHOOD			-683.3529			-516.4444
LOGLIKELIHOOD AT ZERO			-903.0593			

TABLE 4

## PANEL ESTIMATES OF MODEL C

Dependent variables are DVDEL, DNEW\*  
(Asymptotic t-statistics in parentheses)

Variable (lagged one year)	New Loan Demand	New Loan Supply	Limit on Arrears
Constant	-0.342 [ 2.051]	0.460 [ 8.841]	0.0356 [ 0.067]
Debt Service Due/Exports	5.650 [20.072]	-	1.983 [ 2.680]
Real GNP/Capita	-0.439 [ 5.405]	-	-
Imports/GDP	1.149 [ 6.205]	-	-
Reserves/Imports	-	0.116 [ 1.274]	-
Debt/Exports	-	0.0625 [ 1.915]	0.146 [ 1.225]
Indicator for IMF support or rescheduling	-	-0.175 [ 2.358]	-1.375 [ 6.435]
Indicator for arrears	-	-0.261 [ 4.963]	-
Interest due/Exports	-	0.436 [ 0.485]	-
Principal due/Exports	-	0.0624 [ 0.310]	-
Standard Deviation	0.944 [ 2.375]	0.453 [20.975]	
Correlation	0.182 [ 3.828]		
Random Effects :			
Standard deviation	0.367 [ 7.529]		0.111 [ 6.425]

Likelihood Value -1607.892

\*

DVDEL=1 if either a rescheduling is requested  
and/or an IMF agreement is in effect.

DNEW =total new debt obtained within the period  
(scaled by the flow of exports).

Figure 2a  
BRAZIL

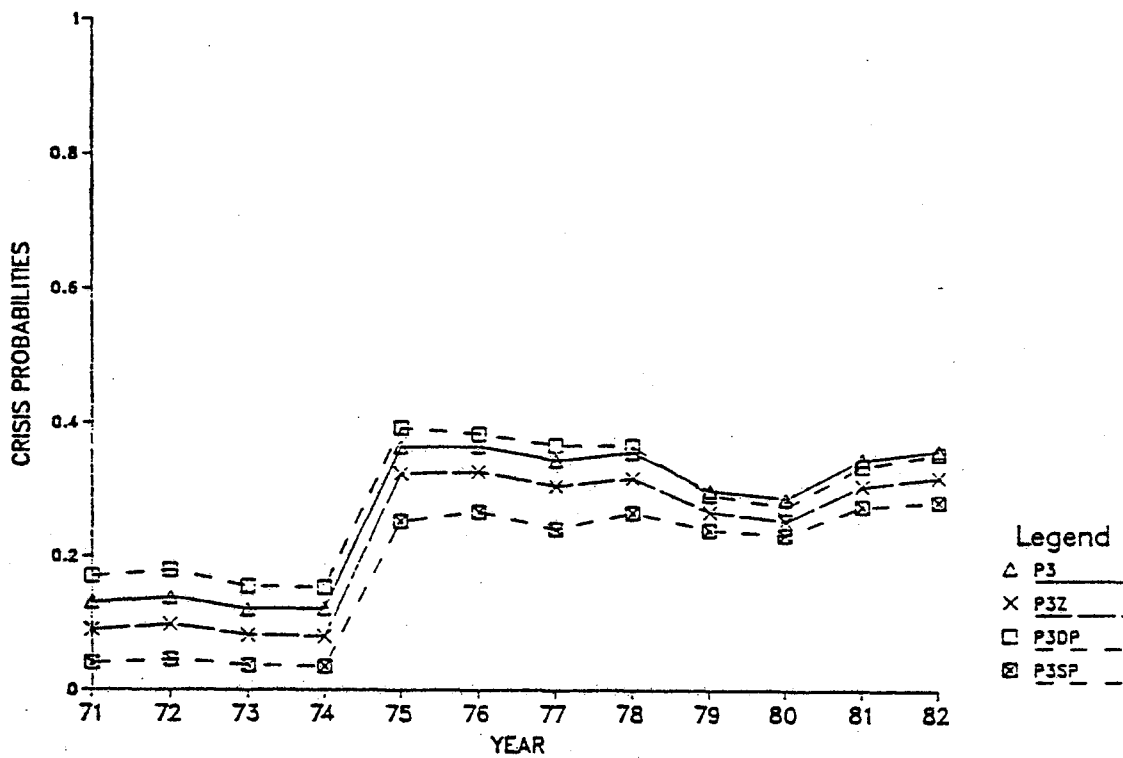


Figure 2b  
BRAZIL

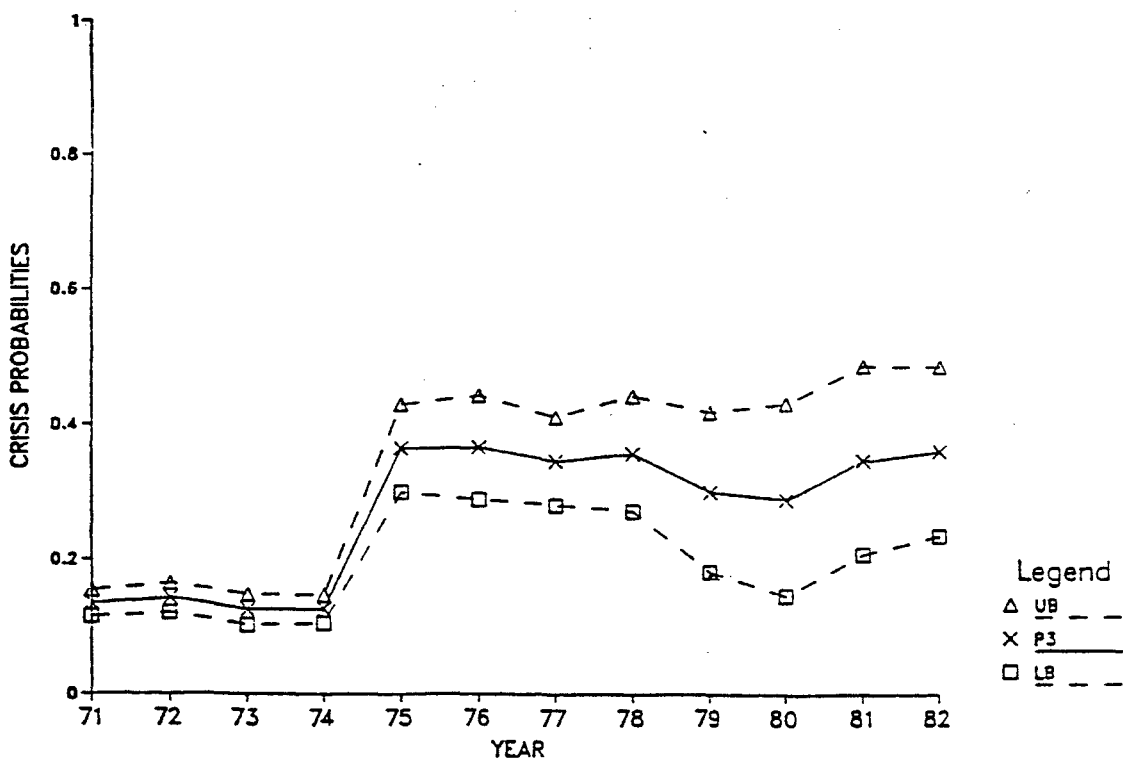




Figure 3a  
CHILE

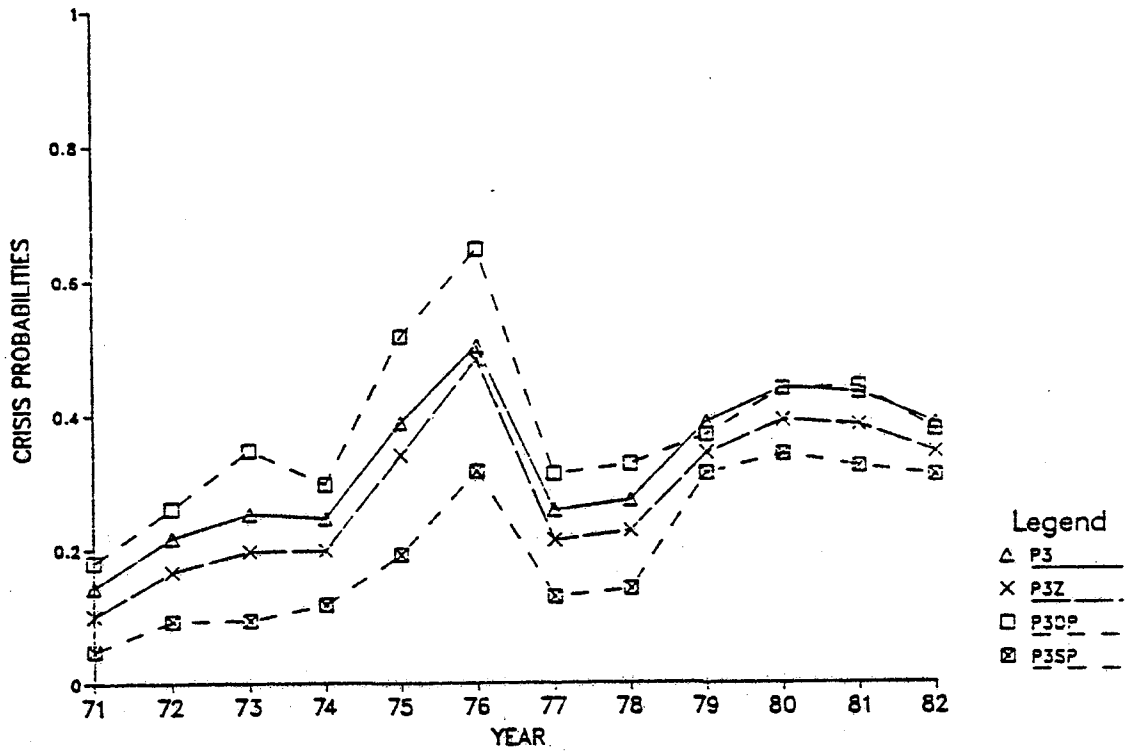


Figure 3b  
CHILE

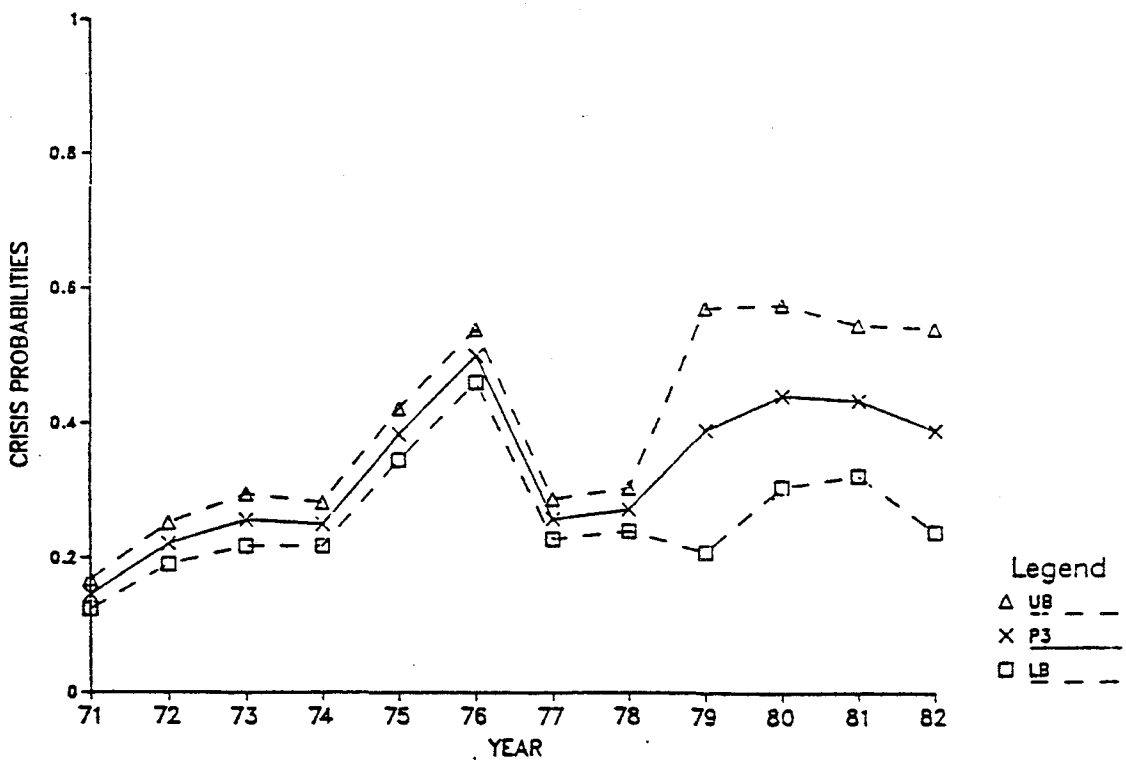


Figure 4a  
COSTA RICA

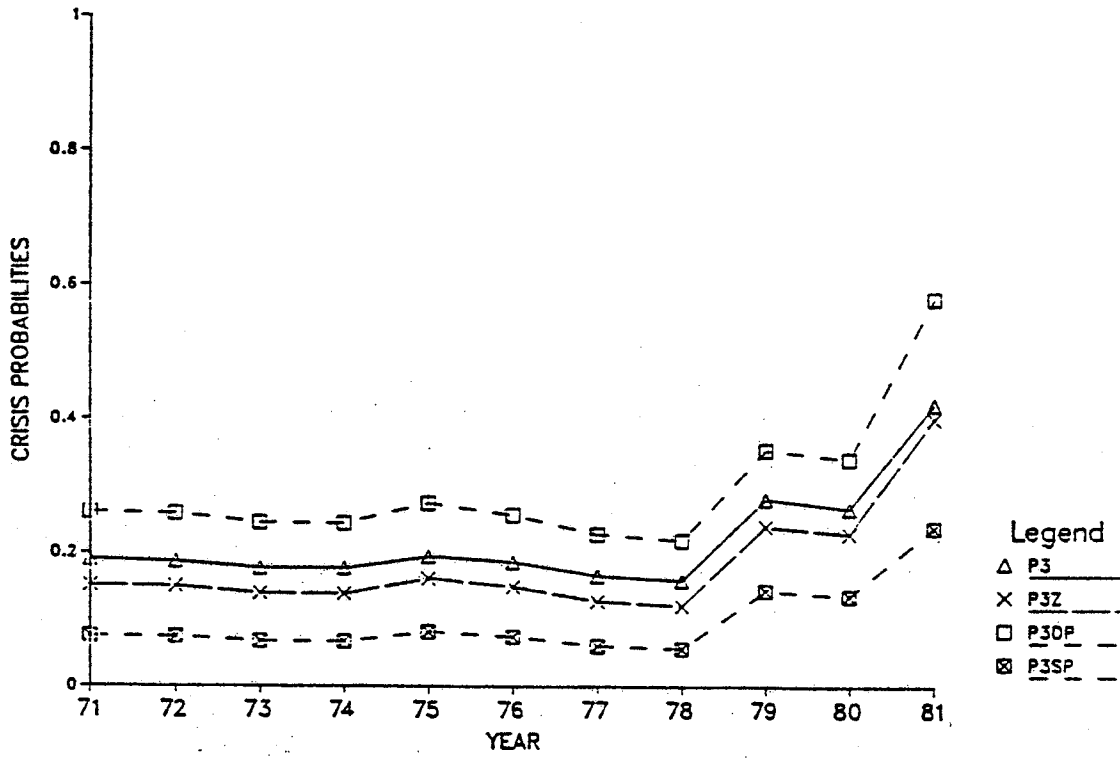


Figure 4b  
COSTA RICA

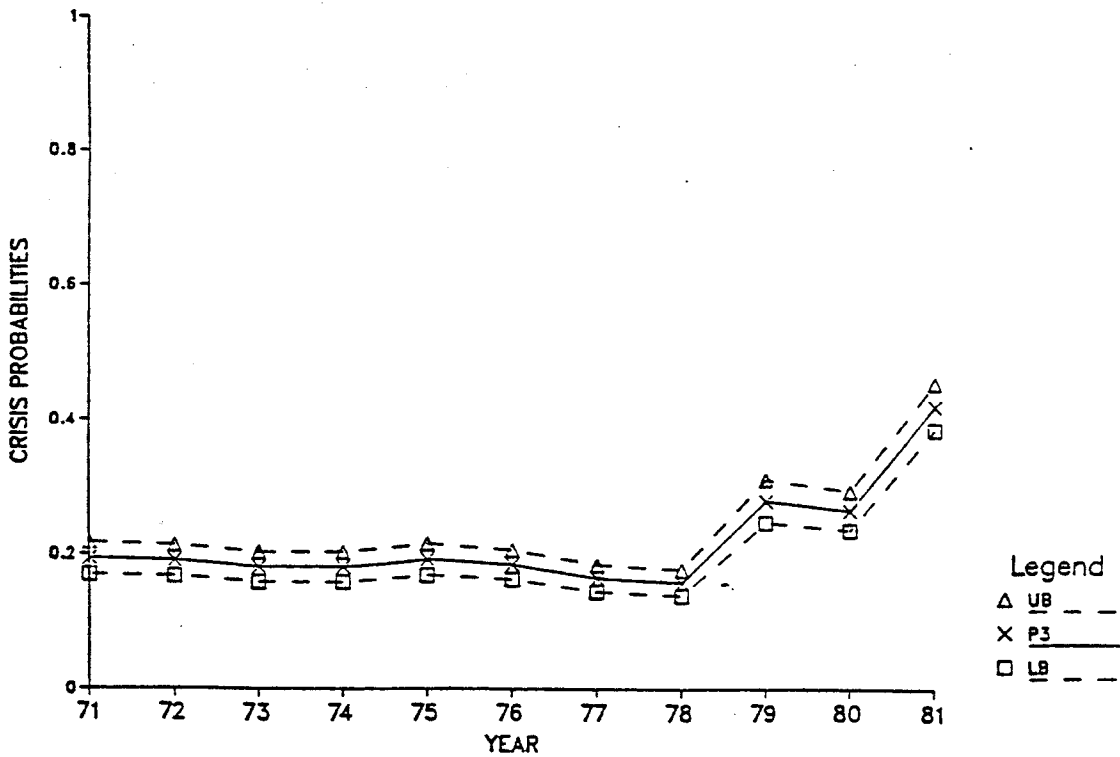


Figure 5a  
JAMAICA

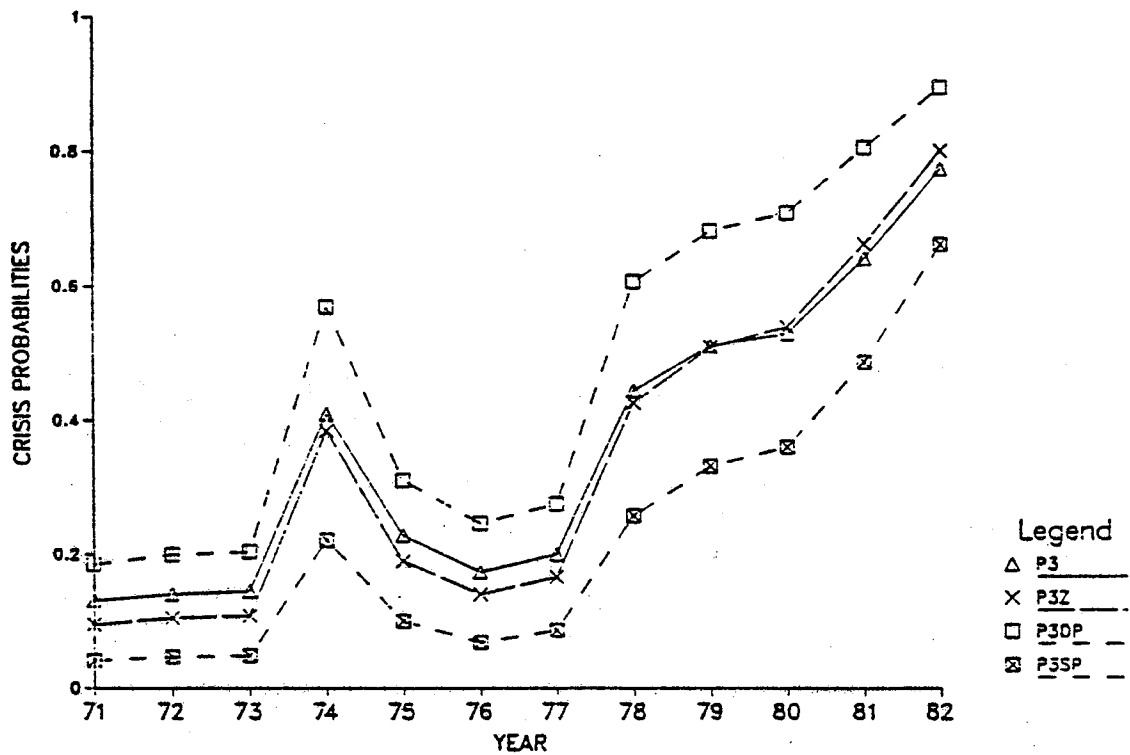


Figure 5b  
JAMAICA

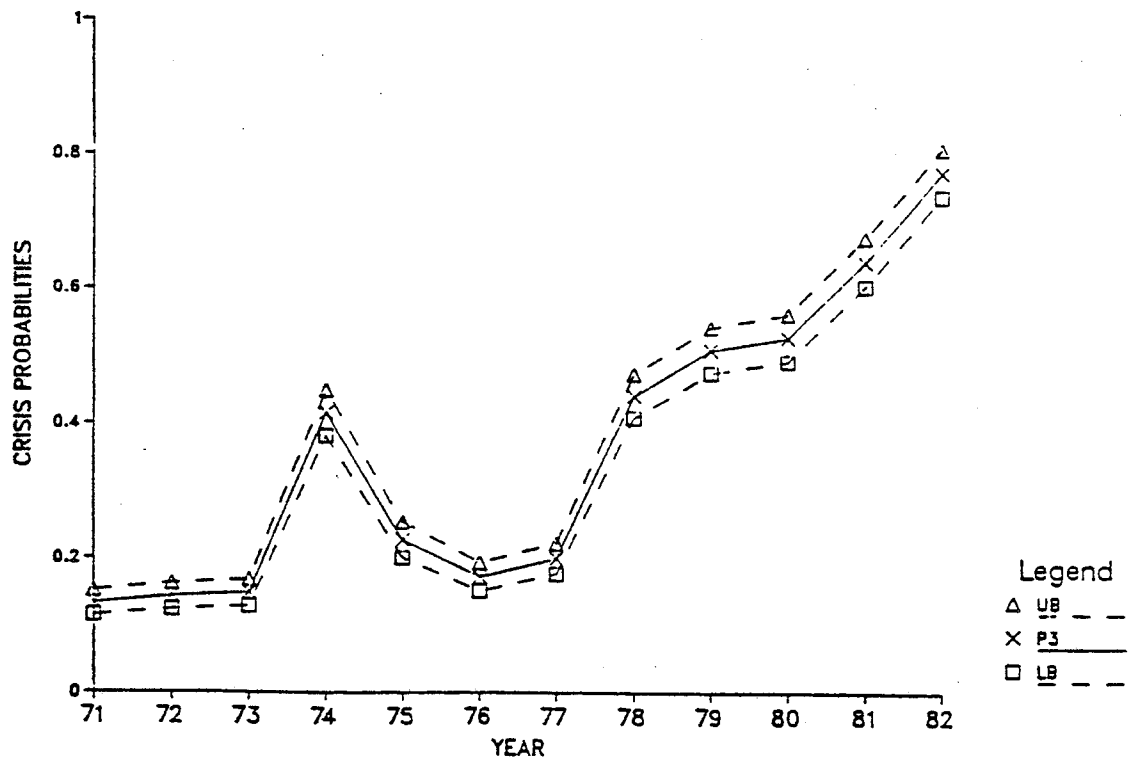


Figure 6a  
MEXICO

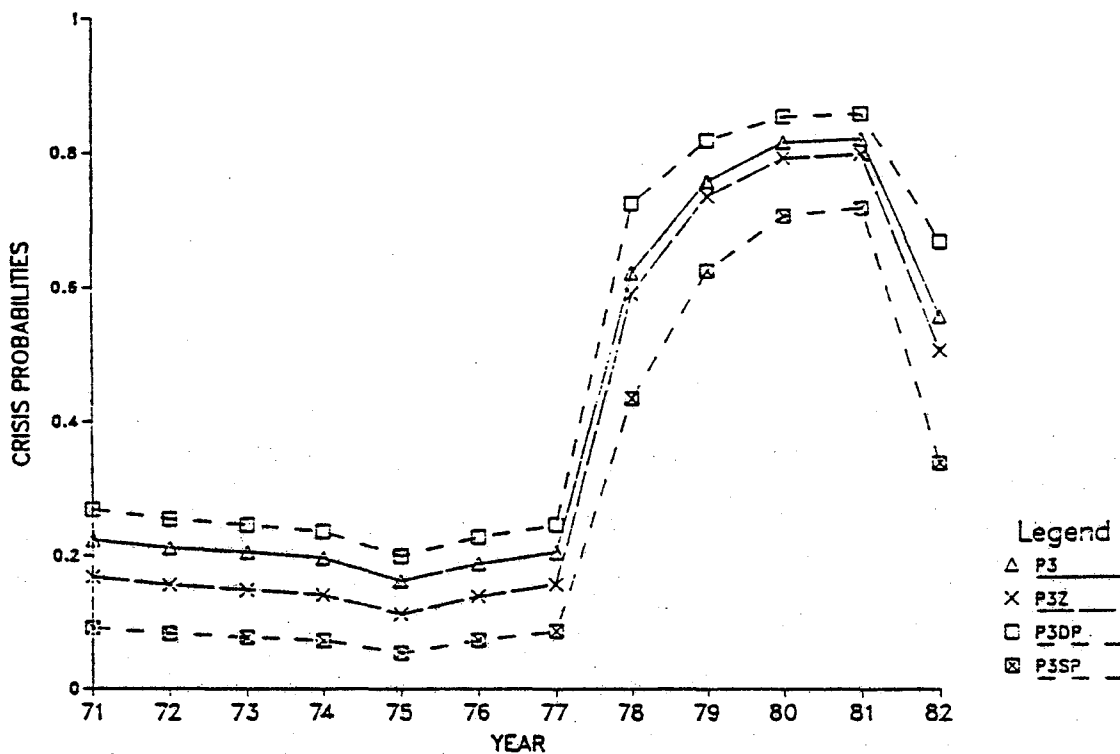


Figure 6b  
MEXICO

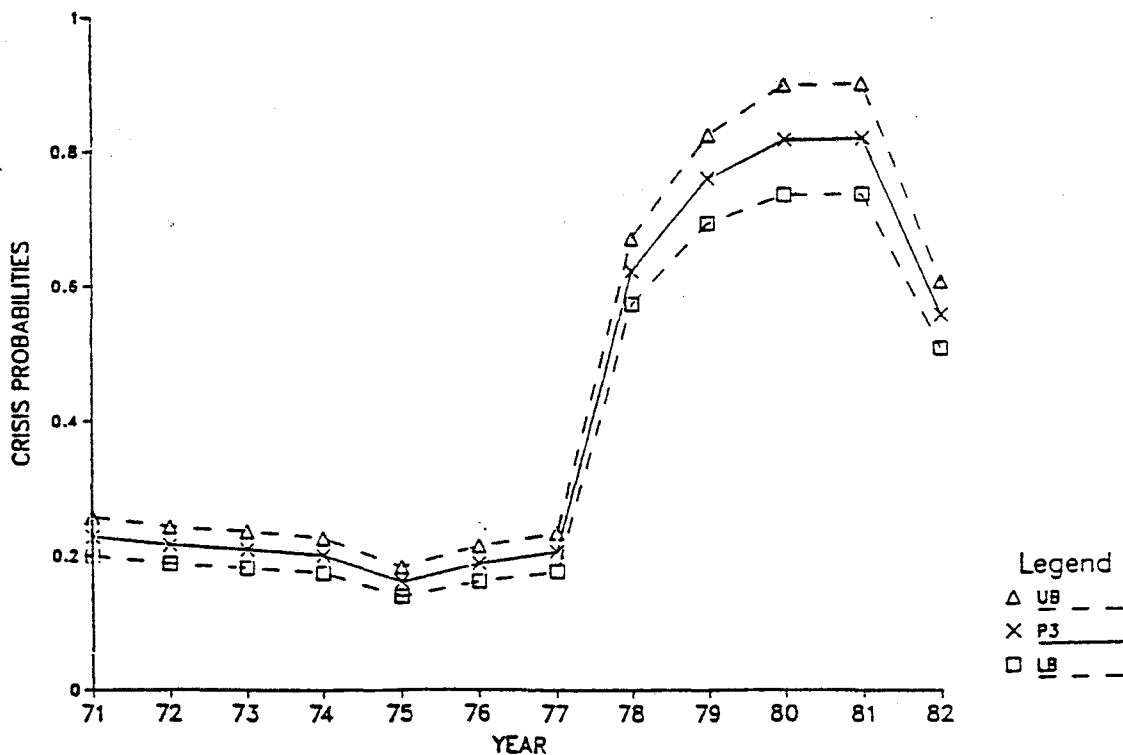


Figure 7a  
VENEZUELA

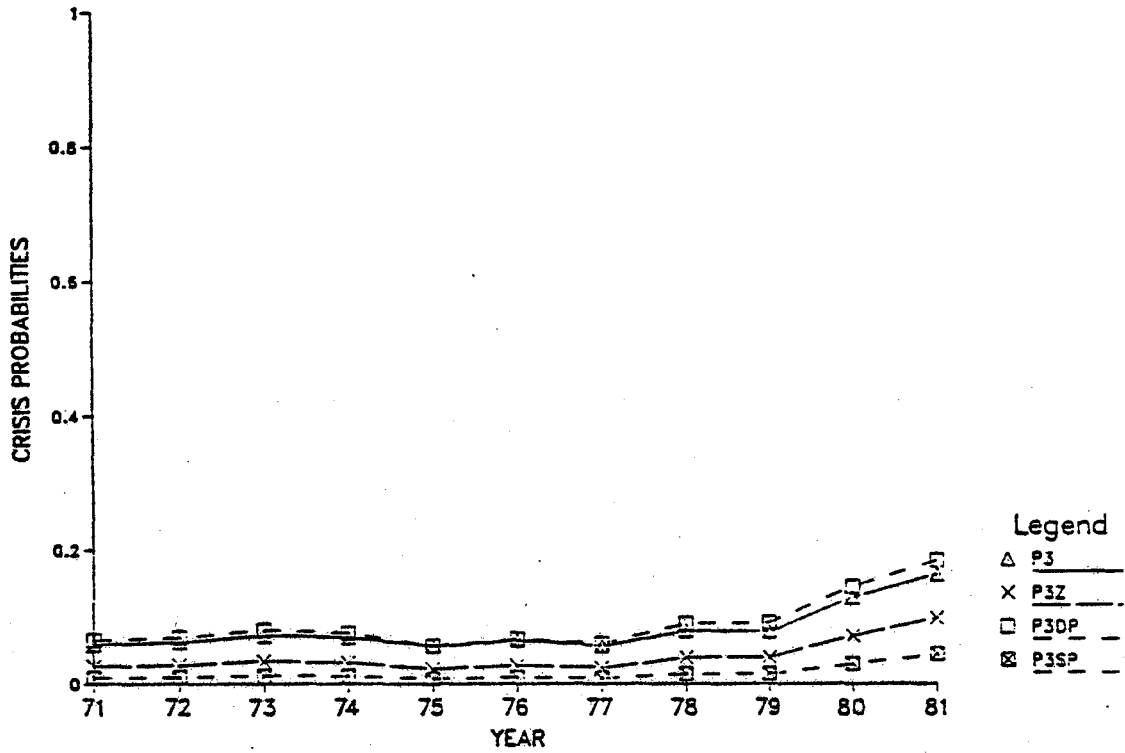
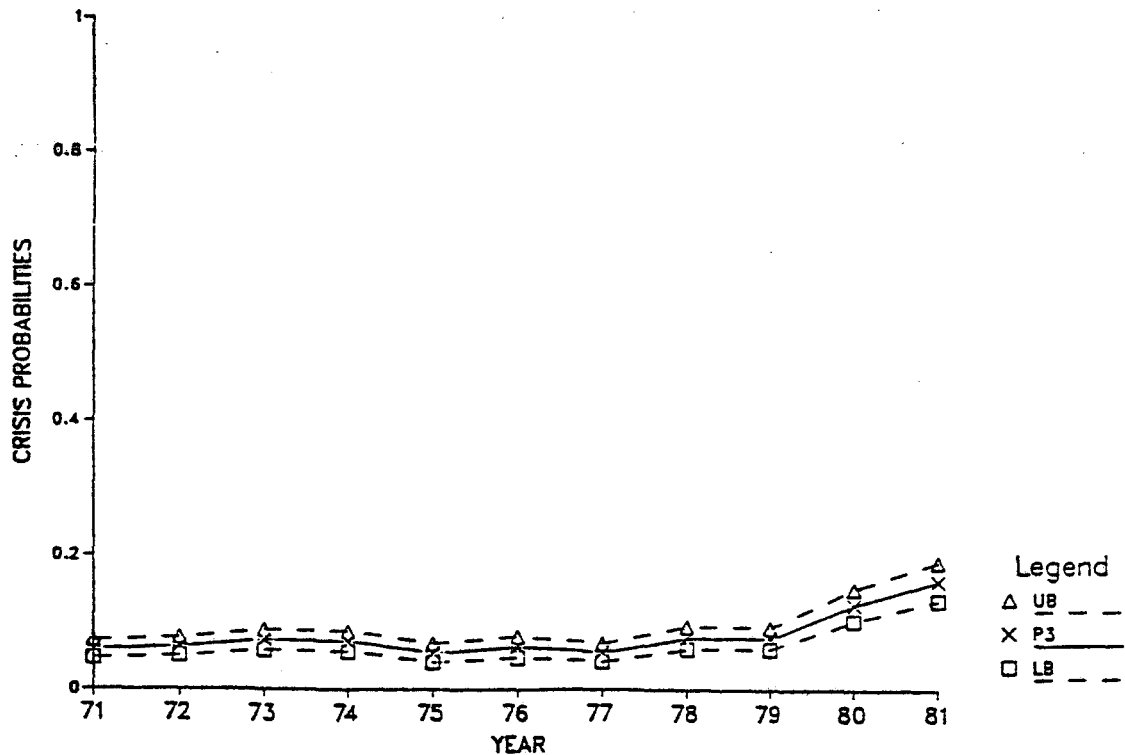


Figure 7b  
VENEZUELA



Footnotes

<sup>1</sup>We agree with [10] that "disequilibrium" is a very laden and actually misleading word to use in this context. What we more accurately mean should better be called "Non Walrasian" equilibrium - prices failing to move not because they are arbitrarily fixed, nor because there are menu-type of adjustment costs in doing so, but because it is not in the rational interest of the agents to actually move them from their current values. See [11]. In the context of credit markets, lenders might find it unprofitable to raise the cost of funds charged to their borrowers because the probability that they would default on their loans could go up. On the other hand by raising the price in times of shortage of credit, the bankers would attract an unprofitably high share of "bad" risks (less creditworthy borrowers) who have a higher propensity to default.

<sup>2</sup>The consequences of such misspecification are discussed in [14], where it is shown that estimation techniques that work under the assumption of Normality of the errors yield consistent but inefficient estimates for the coefficients, and wrong (inconsistent) estimates for the standard errors. Further, methods that impose Logistic distributional assumptions on the errors generally produce inconsistent coefficient estimates as well. In either case, the presence of lagged dependent variable(s) would also cause inconsistent coefficient estimates. The important point is that, in such models, inferences drawn under false i.i.d. assumptions may be seriously misleading.

<sup>3</sup>As it is well known ([18]), these effects introduce persistence over time that may be practically indistinguishable from state dependence arising due to the past debt performance of a country being important in affecting the bankers' assesment of its creditworthiness. The two questions have distinct economic implications: unobserved by the econometrician country heterogeneity needs to be modelled so as to ensure correct inferences, while ideally one would like to be able to distinguish it from persistence arising from actual (and thus observable) past performance. There is a long controversy in the econometric literature concerning the possibility of distinguishing the two types of persistence over time.

<sup>4</sup>Caution must be exercised in using information about regimes-classification, though. As shown in [20], the estimator that uses such information (OR) will in general fail to be consistent in case the regime classification employed is not exact. On the other hand, even though the estimator (NOR) that does not employ such information would be inefficient in case the information is correct, its consistency does not rest on the accuracy of the regime classification the analyst has. [13] discusses these issues and shows how comparisons between the OR and NOR estimators through Hausman tests ([16]) can be used to examine the accuracy of such information.

<sup>5</sup>This 2-stage optimization problem is analogous to Jorgenson's investment function model. Instead of solving the (very hard) multi-period optimization problem, a partial-adjustment mechanism is

postulated in the single-period version of the model. As a result, our model suffers from at least the same well-known theoretical problems.

<sup>6</sup>All explanatory variables are lagged one year in order to attenuate simultaneity issues. The details of the construction of variables and description of data sources can be found in Appendix C of [23].

<sup>7</sup>Specifically we obtained the following test results:

<u>Ho</u>	<u>H1</u>	<u>LM</u>	<u>LR</u>	<u>Wald</u>
MNLI	NMNLII	0.187	0.201	0.186
MNLII	NMNLII	0.782	0.650	0.746

The 10 percent critical level for a  $\chi^2(1)$  variate is 2.706. One should note that the dissimilarity parameter is very poorly determined in NMNLII: not only we cannot reject the MNL value of 1 ( $t=0.864$ ), but we are also unable to reject the hypothesis of a THETA equal to 0.

<sup>8</sup>The Likelihood Ratio  $\chi^2$  statistic was equal to 2.1849 and the Lagrange Multiplier  $\chi^2$  statistic equal to 2.2454 against a critical value  $\chi^2(3)=7.815$  at 0.05 significance level, thus neither rejecting the null hypothesis that the three coefficients are insignificantly different from zero.

<sup>9</sup>To lessen tractability problems, we make the assumption that the random effects on the supply- and demand- sides are uncorrelated. This assumption would be violated in case part of the observed country heterogeneity arises because of common factors on the D and S sides that we fail to model explicitly.

<sup>10</sup>It is well known that the analogue of the "fixed effects" estimator that treats  $\eta_i$  and  $\theta_i$  as fixed unknown parameters and attempts to estimate them, is in general inconsistent in the non-linear case due to the "incidental parameters" problem ([24]). A conditional MLE might suggest itself for the "fixed effects" case along the lines of [1], which would sacrifice asymptotic efficiency but would, unlike "random effects", still be appropriate in case there is non zero correlation between the regressors and the random effects  $\eta_i$  and  $\theta_i$ . Unfortunately the non-linearity of the models due to the minimum condition takes the likelihood contributions, (despite the initial assumption of normality), outside the linear exponential family which is the prerequisite for conditional MLE estimators to exist. See [5].

<sup>11</sup>The crucial assumption, noted in the previous footnote, of independence of the regressors and the random effects is implicit here, with  $f(\eta, \theta)$  not depending on the X's. A Lagrange multiplier test of such assumptions in the context of disequilibrium models is presented in [13].

<sup>12</sup>This exponential distributional assumption, though offering the additional advantage of tractability, creates a subtle problem pointed

out by Dan McFadden: As will be seen below, all parameters in the 3-regime model (with- or without- heterogeneity effects) are econometrically identified. This identification, however, may be a direct consequence of the assumption that while  $e^d$ ,  $e^s$ ,  $\eta$  and  $\theta$  are Normally distributed,  $L^*$  is exponential. To investigate the importance of these issues we plan to modify the distributional assumption on  $L^*$  to one of Normality.

<sup>13</sup>Each evaluation of the likelihood requires  $I$  numerical integrations over two variables, which can be prohibitively expensive. Hence we applied a computationally efficient quadrature method that significantly enhances the feasibility of Maximum Likelihood Estimation. The method is discussed in [4] and [12].

<sup>14</sup>For computational simplicity, the method was implemented in three steps: First, consistent estimates of the parameters  $\delta$  of the reduced form equations of the dependent variables  $y_0$  are obtained. Second, these consistent estimates are substituted in the  $f(y_0|\theta)$  expression in (A.9) and the Likelihood function is maximized over the structural parameters, thus providing consistent but inefficient estimates. We finally take a single Newton-Raphson step from the complete set of initial estimates using the first order conditions of the full maximum likelihood problem. The resulting estimates would have the same asymptotic distribution as the full maximum likelihood ones, provided the assumption of same functional form for  $f(y_0|\theta)$  and  $f(y_t|y_{t-1}, \theta)$ ,  $t \neq 1$  were correct.



REFERENCES

- [1] Andersen, E.B. (1970): "Asymptotic Properties of Conditional Maximum Likelihood Estimators," Journal of the Royal Statistical Society, B 32.
- [2] Bhargava, A. and J.D. Sargan (1983): "Estimating Dynamic Random Effects from Panel Data covering Short Time Periods," Econometrica 51.
- [3] Binmore, K. and M. Herrero (1984): "Frictionless Non Walrasian Markets" ICERD discussion paper, London School of Economics.
- [4] Butler, J.S. and R. Moffit (1982): "A Computationally Efficient Quadrature Procedure for the One-Factor Multinomial Probit Model," Econometrica 50.
- [5] Chamberlain, G. (1980): "Analysis of Covariance with Qualitative Data," Review of Economic Studies XLVII.
- [6] Eaton, J. and M. Gersovitz (1980): "LDC Participation in International Financial Markets: Debt and Reserves," Journal of Development Economics 7.
- [7] Eaton, J. and M. Gersovitz (1981): "Debt with Potential Reputiation: Theoretical and Empirical Analysis," Review of Economic Studies 48 (February).
- [8] Edwards, S. (1984): "LDC Foreign Borrowing and Default Risk: An Empirical Investigation (1976-1980)," American Economic Review 74 (September).
- [9] Goldfeld, S.M. and R.E. Quandt (1975): "Estimation of a Disequilibrium Model and the Value of Information," Journal of Econometrics, 3.
- [10] Hahn, F. (1973): "Keynesian Economics and General Equilibrium Theory: Reflections on Some Current Debates," in The Microfoundations of Macroeconomics by Harcourt, J. (ed.). Boulder, Colo. : Westview Press.
- [11] Hahn, F. (1978): "On Non Walrasian Equilibria," Review of Economic Studies, 45 (February).
- [12] Hajivassiliou, V.A. (1984): "A Computationally Efficient Quadrature Procedure for the One Factor Multinomial Probit Model: A Comment," MIT mimeo.
- [13] Hajivassiliou, V.A. (1985a): "Misspecification Tests for the Simple Switching Regressions Disequilibrium Model," MIT mimeo.

- [14] Hajivassiliou, V.A. (1985b): "Temporal Dependence in Non-Linear Models: A Theoretical and Monte-Carlo Analysis of ML Estimators for Certain Limited Dependent Variable Models," MIT mimeo.
- [15] Hajivassiliou, V.A. and S. O'Connell (1984): "An Optimizing Model of Borrowing and Default in International Capital Markets," University of Pennsylvania mimeo.
- [16] Hausman, J.A. (1978): "Specification Tests in Econometrics," Econometrica, 46 (November).
- [17] Hausman, J.A. and D.L. McFadden (1984): "Specification Tests for the Multinomial Logit Model," Econometrica, 52 (September).
- [18] Heckman, J.J. (1981a): "Dynamic Discrete Models," in Structural Analysis of Discrete Data with Econometric Applications by Manski, C. and D. McFadden (eds.). Cambridge: MIT Press.
- [19] Heckman, J.J. (1981b): "The incidental parameters problem and the problem of initial conditions in estimating a discrete-time, discrete-data stochastic process," in Structural Analysis of Discrete Data with Econometric Applications by Manski, C. and D. McFadden (eds.). Cambridge: MIT Press.
- [20] Lee, L.-F. and R. Porter (1984): "Switching Regression Models with Imperfect Sample Separation Information - with an Application on Cartel Stability," Econometrica 52.
- [21] McFadden, D. (1973): "Conditional Logit Analysis of Qualitative Choice Behaviour," in Frontiers in Econometrics, P. Zarembka (ed.), New York, Academic Press.
- [22] McFadden, D. (1981): "Econometric Models of Probabilistic Choice," in Structural Analysis of Discrete Data with Econometric Applications by Manski, C. and D. McFadden (eds.). Cambridge: MIT Press.
- [23] McFadden, D., R. Eckaus, G. Feder, V. Hajivassiliou and S. O'Connell (1985): "Is There Life After Debt? An Econometric Analysis of Creditworthiness of Developing Countries," in International Debt of the Developing Countries, by Smith, A. and J.T. Cuddington (eds.). Washington DC: World Bank.
- [24] Neyman, J. and E.L. Scott (1948): "Consistent Estimates using Partially Consistent Observations," Econometrica, 16.
- [25] O'Connell, S. (1984): "Optimal Consumption with Stock and Flow Borrowing Constraints," MIT mimeo.
- [26] Shaked, A. and J. Sutton (1984): "Involuntary Unemployment as a Perfect Equilibrium in a Bargaining Model," Econometrica 52.
- [27] Stiglitz, J. and A. Weiss (1981): "Credit Rationing in Markets with Imperfect Information," American Economic Review 71 (June).

