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by Filippo Di Mauro and Fabio Mazzola

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The purpose of the «Temi di discussione» series is to promote the circulation of working papers prepared within the Bank of Italy or presented in Bank seminars by outside economists with the aim of stimulating comments and suggestions.

The views expressed in the articles are those of the authors and do not involve the responsibility of the Bank.

ABSTRACT

The paper shows how a PROBIT model of the probability of repayment problems for a panel data set of LDCs can be utilized to discriminate among economic factors of external and internal origin. The estimation of the univariate binary PROBIT model for the period 1973-1986 is confronted with multinomial and bivariate extensions in order to better specify the nature of repayment difficulties. Some tentative utilization of the model for policy purposes in the context of the debt strategy is also presented.

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I. Introduction and summary of the main findings[1]

Most econometric literature on the determinants of LDCs' repayment difficulties has focussed on standard indicators of creditworthiness (debt, interest, reserves and export ratios) and tended to disregard domestic macroeconomic indicators. The aim of this paper is to estimate the probability of encountering repayment problems for a group of LDCs during the period 1972-1986 and to determine explicitly how external versus domestic factors affect the probability of encountering repayment problems.

As in Feder, Just and Ross(1981) and McFadden et al.(1985), the probability of encountering repayment problems is estimated directly by defining a dummy variable with a value of one when a problem of repayment occurs, and zero otherwise. The existence of a repayment problem is indicated by the presence of arrangements with the IMF, rescheduling agreements with commercial banks and official creditors, and accumulation of external arrears. With respect to past literature (McFadden et al.(1985)), we extend the analysis to the period after the 1982 explosion of the debt crisis; we derive significant parameters for both "policy controlled" and "externally determined" macroeconomic explanatory variables; we estimate a multinomial version of the model by distinguishing among various kinds of indicators of repayment difficulties and we utilize the results of the simulation analysis to propose some tentative schemes in the context of the debt strategy.

The outline of the paper is the following. Section II describes the binary univariate and multinomial version of the PROBIT model that we have estimated from a panel data set of 18 LDCs. A discussion of the main econometric issues concerning panel data PROBIT estimation is also provided. Section III summarizes the results of the simulations of the two versions of the basic model with respect to "domestically controlled" and "externally determined" variables. Finally, some tentative policy applications of the model are presented in the concluding section. Three appendices complete the paper.

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[1]) Special thanks to Giuseppe Tullio and an anonymous referee for their helpful comments to an earlier version of the paper and to Ms Kathy Delauder and Mr.Juan Carlos Murillo for their patient and skillful computer assistance. The usual disclaimer applies.

II. Econometric Estimation of Repayment Problems.

II.1 The basic binary PROBIT model

Early econometric literature on debt repayment problems (see McDonald(1982) for a review) primarily used multivariate techniques such as principal components (Dhonte(1975)) and discriminant analysis (Frank and Cline(1971), and Sargen(1977)), by comparing countries with and without repayment problems. Since such techniques lacked choice-theoretic foundations, subsequent studies turned to models of choice behavior such as LOGIT or PROBIT. We will utilize this literature as a starting point and, along the lines of McFadden et al.(1985), Feder, Just and Ross(1981) and Cline(1983), we will try to assess the probability that a country will face "payment difficulties" on its external liabilities, as shown by inability to satisfy its financing requirements by borrowing in the capital markets.

II.1.1 The Dependent Variable

The "probability of repayment problems" (PRP), the dependent variable, is defined as a dummy variable with a value of 1 when the problem of repayment occurs and zero otherwise. The reason for this formulation is the difficulty of finding a single quantitative variable that by itself would summarize the occurrence of repayment problems, as the phenomenon is more of a qualitative nature. Problems of repayment can be signaled, in fact, by various indicators. In our case they are defined as the occurrence of at least one of four events: commercial bank debt rescheduling, Paris Club rescheduling, IMF financial support under stand-by arrangement and extended IMF facilities (table 1) and accumulation of external arrears.([2])

The functional form chosen can be generally expressed as:

$$\mathrm{Prob}(y_i=1)=F(\beta' x_i) \qquad i=1,\ldots\ldots n \qquad [1]$$

where the set of y_i is a sequence of independent not identically distributed (binary) random variables, taking value 1 when at least one of the four types of repayment problems occurs and 0 otherwise, β' is a vector of unknown parameters and x_i is a $k*1$ vector of explanatory variables. The PROBIT model, which assumes that F is the cumulative normal distribution, is found, in our analysis, more

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[2]) For the exact definition of the events included in the specification of the dependent variable, see Appendix C.

Table 1

Stand-By and Extended IMF Arrangements (EA)
(Millions of SDRs)

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
ARG						260.0	159.5						1500.0	1419.0		1182.5
BOL			27.3							66.4						SAF 42.6
BRA	50.0	50.0											EFF4239.4			
CHI				79.0	79.0								500.0		EA 750.0	
COL	38.0	40.0	20.0													
COS						11.6				60.5	EA 276.7	92.2			54.0	
DOM													EA 371.2		78.5	
ECU		16.5											157.5		105.5	75.4
IVO											EA 484.5			82.7	66.2	100.0
JAM			26.5				64.0	EA200.0	EA 260		EA 236.4			64.0	115.0	
											EA 477.7					
MEX							EA518.0						EA3410.6			1400.0
MOR	30.0									EA810.0	EA 817.0	281.2	300.0		200.0	230.0
NIC		10.7							34.0							
NIG																
PER							90.0	184.0	285.0			EA 650.0		250		
PMI	45.0	45.0	45.0	38.7	29.1	EA217.0			105.0	410.0			315.0	615.0		198.0
VEN																
YUG	83.5								69.2	339.3	1662.0			370.0	300.0	
URU		20.0			17.2	25.0	25.0		21.0	21.0	31.5		378.0		122.8	

Source: IMF - Transactions of the Fund.

appropriate than linear-probability or LOGIT models.([3])

This "direct" specification of the dependent variable is considered preferable to the one adopted in Feder and Just(1977)), Sachs(1984) and Edwards(1984) where the probability of default is computed in an "indirect" way, deriving it from data on the spreads over Libor.([4]) By assuming that the spread is competitively determined in the international lending markets, this procedure is likely to undervalue the risk of default (Folkerts-Landau(1985)), as the actual spread is lower than the one implied by the equilibrium of perfect competition.([5]) The lack of information on the utilization of borrowed funds and the emergence of adverse selection phenomena and credit rationing, affects the capacity of the market to generate an interest rate on borrowed funds able to balance demand and supply. The theoretical model underlying the econometric estimation is thus a disequilibrium model in which the probability of repayment problems reflects the level of excess demand in the loan market.

II.1.2 The Explanatory Variables

The explanatory variables are chosen from a set of macroeconomic indicators through a "model selection" analysis aimed at deriving the best model by successively eliminating the least significant variables from the most unrestricted specification.

Standard macroeconomic indicators of creditworthiness

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[3]) The use of a linear probability model generates estimated (fitted) probabilities that can lie outside the admissible range (0-1) of actual values for the dependent variable, thus introducing a bias in prediction from OLS estimation. The LOGIT model caused computational problems in the maximization of the likelihood function.

[4]) The spread is defined by:

$$s=[p/(1-p)](1+i^{*})$$

where s is the spread over LIBOR, i^{*} is LIBOR and p is the probability of default.

[5]) The equilibrium spread should tend to infinity as the probability of default is close to 1. Under such circumstances, the observation of non-zero lending in the market can be justified only by assuming that the lender's strategy is not based upon current risk perception but on a more complex forward looking model. In particular, lenders could be assumed to view a continuous flow of lending as the only way to insure later repayment of future obligations.

(export and GDP growth, debt service, reserves/import ratios to mention but a few) have been supplemented by other variables which are more indicative of the domestic policy stance. In so doing it was possible to accomplish two main goals: first, to estimate, given the stance of macroeconomic policies and financial indicators, the probability of encountering payment difficulties, thereby assessing individual country "creditworthiness"; second, to distinguish explicitly, among the causes of repayment problems, the "policy controlled" from the external factors, thereby allowing us to devise some tentative suggestions in the context of the debt strategy (at the end of the paper).

The explanatory variables we use can be distinguished conceptually into three major groups, even if for some the distinction is not clearcut.[6]

1) Variables mostly out of the debtor's control:
   a) Terms of trade (TOTIPRB);
   b) Real demand growth in the industrialized countries (GROWTHPR);
   c) Interest rates in the international capital markets as expressed by the LIBOR (LIBORPRB);
   d) Rate of growth of exports (EXPGPRB);

2) Variables affecting the "creditworthiness" of the debtor and the supply of credit:
   a) Total debt service/export (TDSEPRB);
   b) Rate of growth of publicly guaranteed debt (DODGPRB);
   c) Total international reserves/imports (RESIPRB);
   d) Rate of growth of real GDP (GDRGPRB);

3) Domestic policy indicators mostly under the control of the authorities:
   a) Rate of growth of money supply (MONGPRB);
   b) Rate of growth of government expenditure (GOVGPRB);
   c) Consumer price index (CPIPRB);

---

[6]) A larger original set was reduced by eliminating the least significant variables among similar alternatives. See Appendix C for the sources and definition of the explanatory variables used.

II.1.3 Model Validation

The PROBIT analysis has been performed using a Maximum Likelihood estimator ([7]) on a panel data set of 18 LDCs for the period 1973-1986.([8]) The countries included in the study are the 15 comprised in the "Baker initiative" except Uruguay ([9]) (Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Ivory Coast, Mexico, Morocco, Nigeria, Peru, Philippines, Venezuela and Yugoslavia), plus four other Latin American countries (Costa Rica, Dominican Republic, Jamaica and Nicaragua). The choice of the Baker Plan countries was due to the need to consider the largest debtors. The other four Latin American countries have been included to test at a later stage the stability of the estimated parameters of the model by considering that geographic area on its own. It will be shown that the results are quite insensitive to the sub-sample of countries selected.

Table 2 presents the results of the PROBIT analysis (all explanatory variables have a one-year lag). The most unrestricted model is model 1. The most relevant restricted models (2-7) are the ones having, with respect to the full model, a higher number of correct cases and/or lower values for the Akaike Information Criterion (AIC).([10]) Table 2 also includes information concerning the values and the significance of the coefficients together with

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[7]) OLS estimators are inefficient and inconsistent as the error terms are not identically and normally distributed.

[8]) The likelihood function was maximized using the Newton-Raphson iterative procedure described in Appendix A. The PC packages utilized (RATS and LIMDEP) evaluate successive values for the β's starting from the initial OLS estimates.

[9]) The exclusion was due to data problems.

[10]) The correct cases are those forecasted correctly (i.e. whose fitted values are larger than .5 when the actual are equal to 1 and smaller than .5 when the actual are equal to 0). The Akaike Information Criterion has been computed by:

$$AIC=[-2(\log L+K)]/N$$

where L is the likelihood function, K the number of parameters and $\underline{N}$ the number of observations. The AIC represents the equivalent of $\bar{R}^2$ in comparing models with different numbers of parameters when maximum likelihood estimation is performed.

Table 2

Model validation of the probit model predicting the probability of repayment problem

	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5	MODEL 6	MODEL 7	MODEL 8
1 CONSTANT	-0.7473 (-1.09)	-0.2504 (-0.58)	-0.5857 (-1.51)	-0.5315 (-1.34)	-0.6000 (-1.06)		-0.759 (-2.07)*	-0.618 (-1.72)
2 EXPGPRB	-0.0183 (-3.12)**	-0.0142 (-2.78)**	-0.0144 (-2.84)**	-0.0152 (-3.05)**	-0.0152 (-3.05)**	-0.0158 (-3.21)**	-0.015 (-3.04)**	-0.0207 (-4.23)**
3 GDRGPRB	-0.0567 (-2.13)*	-0.0556 (-2.19)*	-0.0552 (-2.12)*	-0.0451 (-1.85)	-0.0456 (-1.85)	-0.0540 (-2.26)*	-0.044 (-1.84)	-0.051 (-2.21)*
4 GOVGPRB	0.0084 (2.32)*	0.0077 (2.29)*	0.0071 (2.15)*	0.0030 (2.12)*	0.0030 (1.99)*	0.0026 (1.93)*	0.0031 (2.16)*	0.0039 (1.45)
5 CPIPRB	0.0041 (2.88)**	0.0043 (3.08)**	0.0044 (3.23)**	0.0045 (3.16)**	0.0045 (3.15)**	0.0043 (3.04)**	0.0046 (3.27)**	
6 LIBORPRB	0.1053 (2.70)**	0.0805 (2.35)*	0.0900 (2.64)**	0.0906 (2.69)**	0.0905 (2.69)**	0.0577 (2.54)*	0.097 (2.88)**	
7 RESIPRB	-0.0242 (-4.61)**	-0.0241 (-4.64)**	-0.0245 (-4.72)**	-0.0240 (-4.76)**	-0.0239 (-4.72)**	-0.0252 (-5.01)**	-0.024 (-4.81)**	
8 DODGPRB	-0.0084 (-1.54)	-0.0089 (-1.67)		-0.0070 (-1.34)	-0.0070 (-1.32)	-0.0097 (-2.02)*		
9 TOTIPRB	0.0012 (0.29)				0.0007 (0.17)			
10 MONGPRB	-0.0089 (-1.75)	-0.0084 (-1.77)	-0.0069 (-1.51)					0.0006 (0.17)
11 TDSEPRB	-0.0025 (-1.09)							
12 GROWTHPR	0.0811 (1.21)							
LOG LIKELIHOOD	- 96.37	- 97.69	- 99.31	- 99.48	- 99.47	-100.39	-100.57	-113.76
AIC (1)	0.8601	0.8468	0.8517	0.8530	0.8608	0.8523	0.8537	0.9584
Number of correct cases (2)	213	210	211	215	216	212	213	205
Wald tests (2)	9-11 (1.28) 9-12 (1.50) 8-9 (2.53) 11-12(2.57) 9-11-12(2.62) 8-11-12(3.82)	1-10 (4.71) 1-8 (4.75)	1-10 (4.72)	1-8 (4.98)	1-9 (1.82) 8-9 (1.83 1-4 (3.45) 4-8-9(5.20)		1-3(10.53)**	1-10 (2.98) 1-4 (5.15) 4-10(9.77**) 1-4-10(10.79*)

(1) See footnote (11)
(2) Least significant values of the Wald test on non significant explanatory variables.
(*) significant at 95% level.
(**) significant at 99% level.

the Wald tests pertaining to the simultaneous non significance of particular coefficients.[11]

Model 7 turned out to be the best by considering simultaneously all the selection criteria and was the one utilized to perform the simulations of section IV. In this model all the explanatory variables are significant and have the correct signs. The final specification is shown below:

```
PRP=-.759-.015*EXPGPRB-.044*GDRGPRB+.0031*GOVGPRB+.0046*CPIPRB
     (-2.07)(-3.04)  (-1.84)       (+2.16)         (+3.27)
     -.024*RESIPRB+.097*LIBORPRB.
     (-4.81)     (+2.88)                                    [2]
```

where:
PRP=Probability of encountering "repayment problems"
EXPGPRB=Rate of growth of annual export earnings
GDRGPRB=Rate of growth of real GDP
GOVGPRB=Rate of growth of Government expenditure
CPIPRB=Consumer price index(1980=100)
RESIPRB=International reserves/Imports
LIBORPRB=London Interbank offered rate on three-month deposits

Log-likelihood = -100.58
AIC=.8537
Correct cases=213 out of 252.

Among the other models, Model 5 gives the best prediction according to the number of correct cases. However, the debt growth variable (DODGPRB) and the terms of trade variable (TOTIPRB), although not significant, have the wrong sign ([12])([13]).

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[11]) Given a R*1 vector of restrictions $\beta_r=0$, the Wald test is defined as:

$$W= \hat{\beta}'[\delta^2 \log L/\delta\beta*\delta\beta']_{\beta=\hat{\beta}}]^{-1}\hat{\beta}\sim CHI^2_R$$

where L is the likelihood function and $\hat{\beta}$ is the MLE for β.

It must be recalled that in the linear case, a Wald test is always less conservative than the likelihood ratio test, while in the non-linear cases this is not always true. Table 2 reports some Wald test values for the non significant coefficients to show how the model validation procedure can be carried out by progressively eliminating the least significant variables.

[12]) The negative sign of the public guaranteed debt variable (DODGPRB) might be explained by arguing that the larger involvement of public authorities in lending operations reduces the risk of default (Eaton and Gersovitz (1981)).

[13]) The information included in TOTIPRB is presumably contained in the export growth variable and in the constant term. Various attempts have been made to construct a country specific indicator for terms of trade that could fit the dependent variable satisfactorely. First, an aggregate index (TOTPRB), equal for all

Unlike some other studies (McFadden et al.(1985)), debt service (TDSEPRB) is not significant in any estimation. On the contrary, "external variables" like LIBORPRB and export growth (EXPGPRB), appear to be highly significant.([14])
As for "policy variables", government expenditure growth (GOVGPRB) is significant in all models as is CPIPRB, which was chosen as a proxy for domestic monetary conditions.([15]) The coefficient of the money growth variable (MONGPRB), instead, turns out to have the wrong sign even though it reduces the value of AIC with respect to other specifications (see model 2). Since a high collinearity with the inflation rate emerges, different models, excluding one of the two variables at a time, were examined. The specification with CPIPRB appears to be always superior according to both prediction criterion and significance of coefficients (compare models 3, 7 and

---

countries, was constructed by deflating the price index of LDC commodity exports by that of developed countries exports of manufactures. In the estimates, the coefficient of TOTPRB turned out to be significant at the expense of the constant, with the expected negative sign. This result was expected because TOTPRB has a very low variability across the sample. Second, country specific indicators of terms of trade (TOTIPRB) were constructed, despite the lack of detailed information for most of the LDCs considered, by using export-weighted commodity price averages of major exports for export prices and region-specific import prices indicators computed by the IMF.

The literature is not unanimous on the expected sign of the terms of trade variable. For instance, in a bargaining framework a negative effect would also be possible.

[14]) However, as in previous empirical work, the rate of growth of demand in industrialized countries (GROWTHPR) does not have much explanatory power. It is implied here, however, that the export growth variable, although not completely out of the debtor's control, may capture most of the effect of world demand growth.

[15]) Although the rate of growth of government expenditure is considered in nominal terms, the fact that CPIPRB and GOVGPRB are both significant implies that a real effect on PRP is also at work. Analogously for the potential collinearity between EXPGPRB e GDRGPRB.

8).[16] Models which exclude the constant term were also considered (model 6), but the results did not justify its exclusion from the preferred model.

For the whole sample, the percentage of correct cases is about 85% for most of the models. In chart 1 the actual versus fitted values of the largest debtors are reported as an example. Only in 1977 for Mexico and in 1982 for Brazil did the fitted model fail to predict correctly the occurrence of a repayment problem.

II.1.4 The importance of country and time effects

From an econometric point of view, the basic model of repayment problems, as specified in the previous sections, may be subject to two main critiques. On the one hand, it imposes a homogeneous macroeconomic setting (absence of country effect) and, on the other, it ignores the fact that the probability of incurring repayment problems may be systematically different over time (absence of time effects). In particular, this probability may depend on the occurrence of the problem in the previous period (state dependence). Indeed, if country-specific and/or time-specific components are important in the panel data estimation, the assumption of independence of y_i in equation [1] does not hold any

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[16]) In order to take account of the strong effect of hyperinflation on the whole estimation and on the forecasting properties of the model, a dummy variable for Argentina,Bolivia and Brazil was introduced for the period 1983-1986. The dummy turned out to be significant when the constant was omitted. The results of the estimation were:

```
PRP= -.015*EXPGPRB-.044*GDRGPRB+0.0031*GOVGPRB+.0045*CPIPRB
     (-3.04)      (-1.84)      (+2.16)         (+3.26)
     -.024*RESIPRB+.096*LIBORPRB-.759*DUMMY
     (-4.82)       (+2.88)       (-2.07)
```

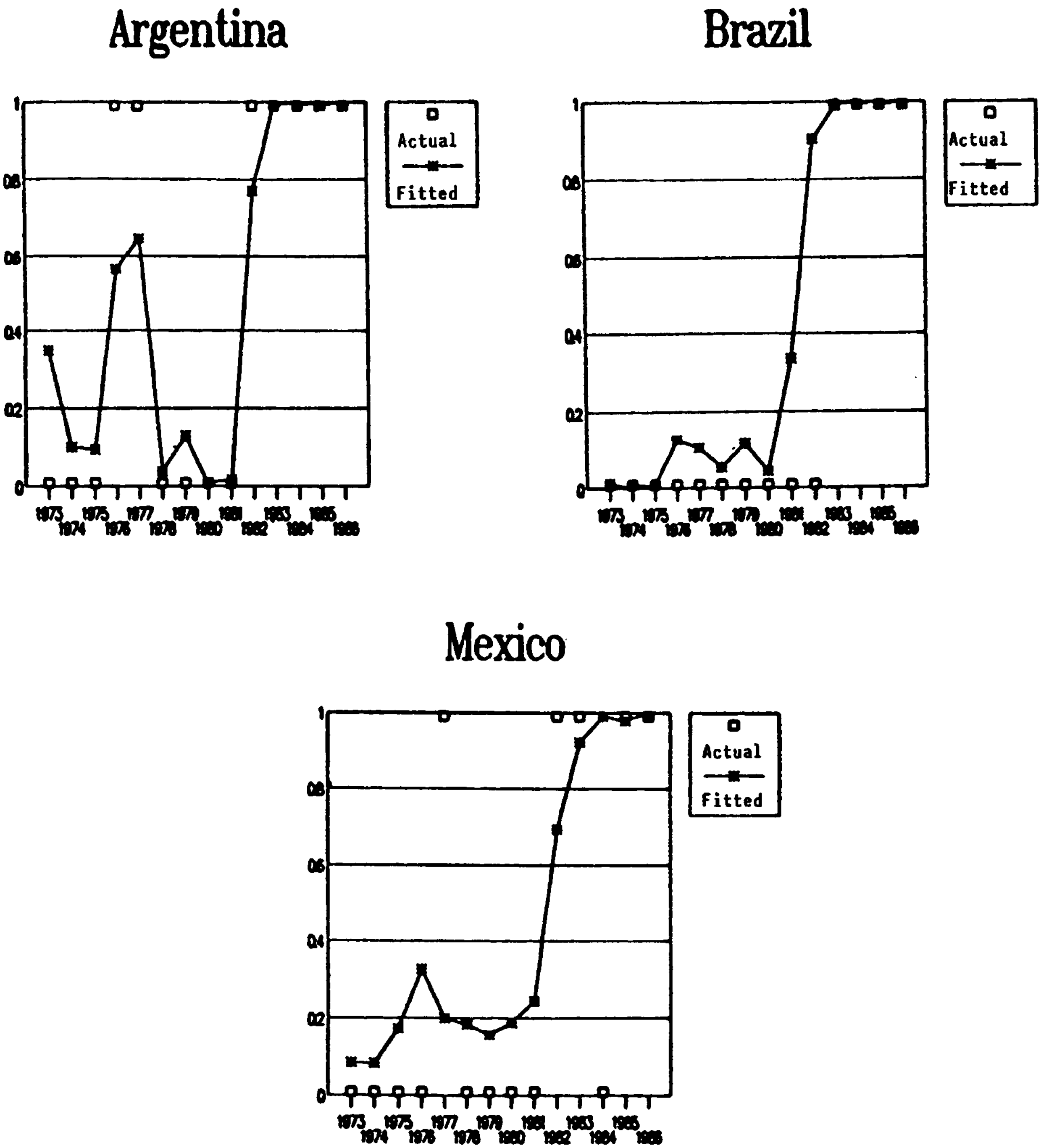
where DUMMY is a vector defined as equal to 0 for the period 1983-86 for Argentina, Bolivia and Brazil and 1 otherwise.

Loglikelihood = -100.58
AIC = .8538
Correct cases = 213 out of 252.

As shown, the significance of the remaining explanatory variables was generally confirmed.

Chart 1

PRP - Actual vs. fitted



longer.[17][18] In what follows we will show that the estimated model is not affected by a significant country effect, while it suffers from time effects.

The importance of "country" and "time" effects was assessed through the following experiments :

a) Change of sample size. The importance of the "country effect" was first tested by reducing the sample size of the chosen model (model 7), first to 13 countries by excluding all non Latin-American nations and then to 9 countries by considering only the South American countries. The results were fairly reassuring, since neither the values of the coefficients or the accuracy of the fit changed significantly with respect to the original model.[19]

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[17]) More specifically, in the event of a specific country effect (so called "heterogeneity") and/or state dependence it is likely that:

$$P(y_{it}=1\,|\,y_{it-s}=1,x_{it}) \neq P(y_{it}=1\,|\,x_{it}) \qquad i=1,2.....N \quad t=1,2.....T$$

where subscript i refers to a country and t to time.

[18]) Some of the literature has considered this problem. Feder,Just and Ross(1981) and McFadden et al.(1985) explicitly include the country-specific effect in the specification of their model through the use of country dummies or one-way random effect estimators. In other cases (Nunnenkamp and Picht(1988)), the non consideration of the country effect is invoked as the main reason for the lack of significance of the coefficients when an ordinary qualitative response model is estimated.

[19]) The estimation of the model for the 13 Latin-American countries gave the following results:

```
PRP = -.0138*EXPGPRB-.0705*GDRGPRB+.0016*GOVGPRB+.0034*CPIPRB
     (-2.34)         (-2.52)         (+1.09)          (+2.57)
     +.0610*LIBORPRB-.0267*RESIPRB
     (+2.39)         (-4.57)
```

Loglikelihood = -72.00
Correct cases = 155 out of 182

b) Analysis of variance tests . OLS residuals were derived from a linear estimation of model 7.([20]) The residuals from the estimation of the model with a pure random error term were then compared with the ones derived from a model allowing both random and individual (country) components inside the error term.([21]) The result of the test gave an F value equal to .8687, which is highly insignificant, thus supporting the hypothesis of a weak country effect.([22]) On the contrary, an analogous analysis of variance test showed the existence of the time effect.([23]) Moreover, a one-way time random effect estimation of the linear model using transformed variables, improved the fit of the original model.([24])

c) Likelihood ratio tests. This is the most satisfactory testing procedure as it explicitly takes account of the non-linear nature of the qualitative response model. The test has the following general form:

$$LR=-2*[\log L(R) - \log L(U)] \sim CHI^2(r) \qquad [3]$$

where L is the likelihood function respectively of the restricted (R) and unrestricted (U) model and r is the number of restrictions.

The presence of country specific effects or state dependence can be detected by a likelihood ratio test [3] comparing the likelihood function of an unrestricted model which includes the lagged dependent variable among the regressors to a

[20]) OLS estimates may generate fitted values that are outside the range 0-1. As a matter of fact, the OLS estimates of model 7 turned out to be quite accurate as they predicted only 25 out of 252 cases incorrectly.

[21]) Details of the test are given in Appendix B.

[22]) In addition, the estimation of the linear model through individual (country) fixed and random effect estimators which explicitly take account of the country effect did not improve the original OLS.

[23]) The computed F turned out to be equal to 3.397, which is significant with an error of .2%.The test was also significant for the case of simultaneous occurrence of both country and time effects.

[24]) The R^2 of the new model was equal to .401, against the original .355.

restricted model which excludes it. If the test does not give significant results it can be concluded that:

$$\text{Prob}(y_{it}=1 \mid y_{it-1}=1, x_{it}) = \text{Prob}(y_{it}=1 \mid x_{it}) \qquad [4]$$

In our case, model 7 was used as the restricted model, while the estimation of the unrestricted model gave the following result:

$$\begin{aligned}
PRP = & -1.0106 -0.0149{*}EXPGPRB -0.0320{*}GDRGPRB +0.0026{*}GOVGPRB \\
& (-2.65) \quad (-2.89) \qquad (-1.30) \qquad (+1.75) \\
& +0.0033{*}CPIPRB +0.0872{*}LIBORPRB -0.0197{*}RESIPRB \\
& (+2.51) \qquad (+2.58) \qquad (-3.82) \\
& +0.8156{*}PRP1 \\
& (+3.58)
\end{aligned} \qquad [5]$$

where PRP1 is the lagged value of PRP and the estimation is carried out on the whole period 1973-1986 (explanatory variables are all lagged one period).

Test [3] confirms the existence of heterogeneity and/or state dependence in the model.([25])

In order to discriminate between the hypotheses of heterogeneity (country effect) and state dependence, we estimated a fixed effect panel data LOGIT ([26]) as in Chamberlain (1985), which allows the existence of country effects to be taken directly into account.([27]) A likelihood ratio test of type [3] was then performed on the results of the estimation for the period 1982-1986,([28]) taking the specification in model 7 (baseline model) as the restricted model and the specification with the inclusion of the lagged dependent variable as the unrestricted one. The hypothesis

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[25]) The calculated CHI^2 from [3] was equal to 12.666 while the tabulated $CHI^2_{(1,\alpha=0.01)} = 6.635$.

[26]) The logit specification is preferred to the probit one since the maximization of the conditional likelihood function yields consistent estimators only in the logit case. In the univariate case, the change in specification does not affect, in the univariate case, the qualitative results of the statistical tests.

[27]) This estimator is described in detail in Appendix B (equation [B.12]).

[28]) In order to satisfy package requirements, it was possible to estimate the fixed effect panel data LOGIT model only for small T (not greater than five) and the period 1982-1986 was chosen in view of the greater occurrence of LDC debt repayment problems.

of heterogeneity was rejected at the 5% significance level ([29]) and

$$\text{Prob}(y_{it}=1 \mid y_{it-1}, x_{it}, \alpha_i) \neq \text{Prob}(y_{it}=1 \mid x_{it}, \alpha_i) \qquad [6]$$

where α_i is the generic effect for country i.

Thus, the non-independence of the y cannot be entirely attributed to unobserved country effects that persist over time but must be due to an apparent state dependence.

More refined test procedures (see Appendix B.2) have shown that the state dependence is mostly due to the autocorrelation of the residuals conditional on the individual (country) component (so-called "spurious" state dependence).
A direct influence of lagged explanatory variables on the current dependent variable (true state dependence) was shown to be not present.

The design of more appropriate estimation procedures dealing with a more complex structure of the error term should be assessed in a much broader context which takes the dynamic nature of the phenomenon explicitly into account (see equation [B.15]). The correct implementation of such a framework requires, however, the availability of data for a larger set of countries and it is not pursued at this stage of the analysis.

II.2 Multinomial PROBIT

The estimation of a PROBIT model is based on the assumption that there exists an unobservable quantitative dependent variable whose values generate the occurrence of a dichotomous observable event. For values of the variable below a certain threshold, the event (in our case the repayment problem) does not occur, while for values above the threshold the event is observed. The model of McFadden et al.(1985) uses, as the unobservable variable, the "desired arrears" and the achievement of a threshold level of this variable determines the occurrence of repayment problems. In such a model, the debtor country, as it enters into a liquidity problem and faces credit rationing on the lending market, starts to first accumulate arrears. When the arrears exceed the "desired" level the country asks the Paris Club and/or the commercial banks for rescheduling, and/or the IMF for a program. The accumulation of arrears is therefore seen as the first sign of excess demand for (new) loans. In reality, however, the country will try its best to avoid accumulating arrears due to the very negative consequences that this has on its creditworthiness. Thus,

[29]) The calculated CHI^2 was 4.088 while $CHI^2_{(1,\alpha=0.05)}=6.635$ and $CHI^2_{(1,\alpha=0.01)}=3.841$.

it will try to obtain financing through rescheduling or IMF agreements and only as a last resort will incur arrears.([30])

In the present section we have tested which "ranking" of repayment difficulties is best supported by the data, utilizing an ordered multinomial version of our basic PROBIT model. In this context, we have also examined whether the accumulation of arrears is determined in a model which is significantly different from the one explaining the rescheduling and the IMF financing.

Unlike the binary case (section II.1), in which the dependent variable can assume values of 0 or 1, depending upon the occurrence non-occurrence of the repayment problem, here the dependent variable can assume an integer value between 0 and 3 depending upon the different nature of the repayment problem. A multinomial PROBIT model has the general specification:

$$P(y_{i=j})=F(\beta' x_i)=F_{ij} \qquad i=1........n \quad j=0,1......r \qquad [7]$$

where r is the number of choices (which, for the sake of simplicity, is considered the same for all the countries of the sample ([31])),

and can assume an ordered or unordered form:

a) in the <u>ordered</u> form, the repayment difficulties are ranked with respect to their effect on country creditworthiness (a higher figure indicates a more damaging event for a country's creditworthiness). Various rankings have been tested. In all experiments, the dummy was set equal to 0 when no problem occurs.

---

[30]) It should be noted that, at a point in time, payment difficulties, as we had defined them, could not always be seen as a deterioration of creditworthiness. Two examples can make the point. First, the IMF financing, although it signals the presence of current repayment difficulties, will be accompanied by an adjustment program which could foster debtor country's future solvability and also be considered per se by creditors as a sign of good will. Second, solid financial status and creditworthiness could be treated in some circumstances by the debtor country as mutually exclusive policy goals (Mohr,1988). For instance, exhaustible natural resources producers could face a trade-off between the increase in current production, which increases liquidity, and depletion of stocks which reduces creditworthiness.

[31]) The main econometric issues concerning multinomial PROBIT estimation are discussed in this section and in Appendix A.

Alternative formulations included, in one case the dummy=1 with IMF financing, dummy=2 when reschedulings occur, dummy=3 when arrears have been accumulated; or, in another, dummy=1 when arrears occur, dummy=2 with rescheduling; and so forth.

The results reported in Table 3 show the general validity of model 7 estimated in a multinomial setting. Only government expenditure and GDP growth seem to lose explanatory power in some models. The best model appears to be model 13, in which the accumulation of external arrears is viewed as the most severe occurrence (dummy=3), while IMF support represents the least damaging event for the debtor (dummy=1), in contrast with the ranking implied in the analysis by McFadden et al. (1985).

b) in the unordered form the chosen ranking does not count and this specification has been carried out to check whether a specific ranking actually improves the unordered specification.

Computer package limitations, however, did not allow a direct estimation of a multinomial unordered PROBIT. Nevertheless, since a bivariate PROBIT model is a special case of a four-choice multinomial PROBIT model (Amemiya(1981)), a bivariate version of model 10 was estimated. This model consists of a system of two simultaneous equations which represent a binary choice for two different repayment categories. The first equation refers to the occurrence or not of reschedulings and IMF financing(0,1) as a function of the usual explanatory variables. The second, to the occurrence of external arrears (0,1) again as a function of the same set of variables (although this is not necessary). As a first step, two independent univariate PROBIT models were computed for the two above-mentioned equations. The resulting MLE estimates were used as the base for the simultaneous estimation of the two equations through a non-linear-full-information-maximum-likelihood(NLFIML) iterative procedure based on the Davidson-Fletcher-Powell optimization method. The following results emerge from the estimation of the two independent equations in PROBIT form:

```
IMFRS=-.1990-.0092*EXPGPRB-.0531*GDRGPRB
     (-.596) (-2.208)      -2.560)
     -.0004*GOVGPRB+.0001*CPIPRB+.0490*LIBORPRB-
     (-.557)        (+1.202)     (+1.68)
     .0176*RESIPRB                                        [8]
     (-3.969)
```

Loglikelihood=-130.84
Total correct cases = 187 out of 252

where IMFRS is the probability of asking (and obtaining) IMF support and/or rescheduling; and

Table 3

Multinomial ordered probit models of the probability repayment problems

	MODEL 9	MODEL 10	MODEL 11	MODEL 12	MODEL 13	MODEL 14	MODEL 15
Definition of the Dependent variable	0=Ø 1=A and/or F 2=R 3=1 and 2	0=Ø 1=A 2=F and/or R 3=1 and 2	0:Ø 1:F 2:R and/or A 3:1 and 2	0:Ø 1:A 2:A and F;F 3:R; R+1 and/or 2	0:Ø 1:F 2:F and R;R 3:A; A+1 and/or 2	0:Ø 1:F 2:F and A;A 3:R; R+1 and/or 2	0:Ø 1:F and/or R 2:A; A+1
Explanatory variables							
CONSTANT	-0.0233	-0.3302	-0.4856	-0.1145	-1.1316	-0.2947	-1.0831
	(-0.749)	(-1.080)	(-1.526)	(-0.367)	(-3.456)**	(-0.924)	(-3.301)**
EXPGPRB	-0.0133	-0.0150	-0.0144	-0.0116	-0.0200	-0.0128	-0.0208
	(-3.878)**	(-4.106)**	(-4.036)**	(-3.379)**	(-4.572)**	(-3.750)**	(-4.495)**
GDRGPRB	-0.0556	-0.0428	-0.0563	-0.0699	-0.0267	-0.0778	-0.0208
	(-3.439)**	(-2.406)**	(-3.579)**	(-3.568)**	(-1.346)	(-3.883)**	(-1.057)
GOVGPRB	-0.0004	-0.0002	0.0003	-0.0006	0.0030	-0.0006	0.0030
	(-0.686)	(-0.478)	(0.660)	(-1.009)	(2.192)*	(-1.102)	(2.061)*
CPIPRB	0.0002	0.0002	0.0001	-0.0002	0.0002	-0.0002	0.0019
	(2.355)*	(2.264)*	(1.066)	(2.237)*	(3.840)**	(2.667)**	(3.395)**
LIBORPRB	0.0960	0.0994	0.1255	0.0849	0.1612	0.1102	0.1533
	(3.570)**	(3.957)**	(4.652)**	(3.131)**	(6.459)**	(4.049)**	(6.118)**
RESIPRB	-0.0196	-0.0185	-0.0203	-0.0191	-0.0242	-0.0198	-0.0233
	(-4.376)**	(-3.919)**	(-4.831)**	(-4.204)**	(-4.800)**	(-4.379)**	(-4.474)**
LOG LIKELIHOOD	-233.57	-236.60	-231.45	-253.44	-201.26	-244.06	-167.65
Number of total correct cases (1)	158	155	153	152	170	149	175
Number of 0/1-2-3 correct cases (2)	203	203	205	204	216	204	214

Ø: No repayment problem.
A: Accumulation of external arrears.
F = IMF support.
R = Rescheduling or Paris Club Restructuring.
(1) Total number of correct cases among the choices.
(2) Number of correct cases between the choice 0 and all the other ones. The mismatches between observed and predicted values concerning the choices 1, 2, 3 are not considered.

```
ARR=-2.5058-.0251*EXPGPRB
     (-5.502) (-3.832)
     -.0026*GDRGPRB+.0024*GOVGPRB+.0015*CPIPRB+.1857*LIBORPRB
     (-.112)         (+1.474)      (+2.651)     (+5.001)
     -.0177*RESIPRB
     (-3.156)                                                     [9]
```

Loglikelihood=-79.755
Total correct cases = 208 out of 252

where ARR is the probability of accumulating external arrears.

The results of the estimates of the two separate equations are quite interesting as they show that the determinants of the external arrears (ARR) differ coonsiderably from the ones of IMF financing and/or rescheduling (IMFRS). Both dependent variables are highly related to export growth (EXPGPRB) and international reserves (RESIPRB). IMFRS is more dependent on GDP growth, while the significance of GOVGPRB and CPIPRB improves quite sharply for the arrears, owing to their greater relevance in signaling the solvency position of the borrower.([32]) There is also a notable improvement in the significance of the coefficient of the Libor variable in the equation for the arrears.

Turning now to the simultaneous estimation of equations [8] and [9], the following results were obtained:

```
IMFRS=-.1964-.0092*EXPGPRB-.0534*GDRGPRB
     (-.562) (-2.115)       (-2.394)
     -.0004*GOVGPRB+.0001*CPIPRB+.0489*LIBORPRB-.0176*RESIPRB
     (-.636)        (+1.202)      (+1.630)      (-3.330)          [10]


ARR=-2.4972-.0248*EXPGPRB-.0019*GDRGPRB+
     (-4.662) (-3.488)    (-.075)
     +.0025*GOVGPRB+.0015*CPIPRB+.1840*LIBORPRB-.0176*RESIPRB
     (+1.105)       (+2.281)      (+4.450)      (-2.473)          [11]
```

Loglikelihood=-210.43
Correct cases=166 out of 252.
RHO=-.0789
(-.563)

where RHO is the correlation of the bivariate normal

[32]) This result may imply that the accumulation of arrears is an indicator of a "solvency" problem, while rescheduling or IMF financing indicates a "liquidity" problem.

distribution.

On the basis of the total number of correct cases, the multinomial unordered model is slightly superior to model 10 (multinomial ordered). Moreover, since the correlation coefficient is not significant, it would be reasonable to consider external arrears and the request for financial support from the IMF or rescheduling as quite independent phenomena.

Three main results stem from the estimates of this section:

1) since the unordered model is slightly superior to the ordered one, a specific ranking of repayment difficulties does not help to improve the fit of the model;

2) however, when a ranking among the different indicators of repayment problems is assumed, the arrears must be considered the most damaging event for debtor creditworthiness;

3) arrears and rescheduling-IMF support seem to have different determinants and might better be analyzed in the context of different model specifications. This can be explained with the increasingly common practice of making IMF support almost contemporaneous with debt rescheduling; and with the legal restrictions (only recently somewhat relaxed) preventing the Fund from granting financial assistance to countries which are accumulating external arrears. In such circumstances, although a liquidity problem does exist, the accumulation of external arrears and the related loss in creditworthiness are strongly constrained.([33])

[33]) For some countries, the accumulation of external arrears is substituted by the accumulation of domestic arrears which tend to affect a country's creditworthiness to a lesser extent.

III. Model Simulation

In the following we use the estimates of the panel data model in binary (model 7) and in multinomial (model 10) form to derive information, through model simulation, on individual countries' reaction to shocks. By simulating model 7 we evaluate the change in PRP of individual countries in the period 1981-86, which derives from shocks of an external and domestic nature; moreover, we rank the countries of the sample with respect to their sensitivity to changes in LIBOR which is a pure "externally determined" variable. Finally, by simulating model 10, we try to assess how similar shocks affect the probability of incurring arrears or rescheduling-IMF support.

III.1 Simulations by country

The simulation startegy adopted is fairly straightforward. After estimating the basic repayment problems model (equation 7), simulations were performed by assuming in turn alternative scenarios for four explanatory variables:

a) Variables mostly under the control of the authorities:
  1) CPI.The variable was chosen as a proxy for monetary conditions as various types of monetary aggregates were not significant.
  2) Rate of growth of Government Expenditure(GOVG).

b) Variables mostly out of the control of the authorities:
  3) LIBOR. The variable was chosen as an index of borrowing conditions.
  4) Rate of export growth(EXPG). Though this variable is only partly exogenous, it had to be chosen as a proxy for foreign aggregate demand, since various alternative indices of the latter turned out to be insignificant.

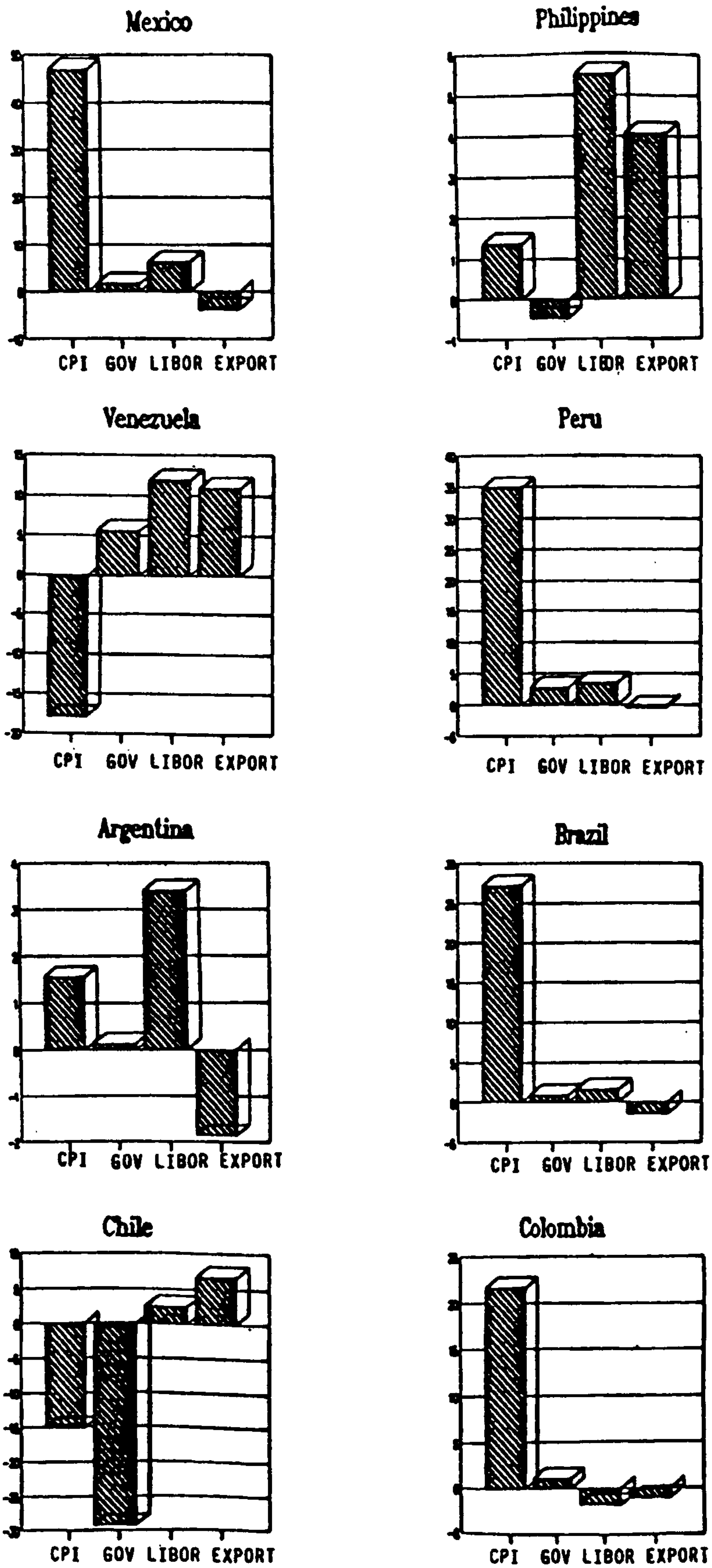
Taking the start of the debt crises in the early 1980s, the values of the four above-mentioned variables were assumed to follow, in the period 1980-85, the same path followed in the period 1972-79. In particular CPI was reconstructed by assuming an inflation rate equal to the period average 1972-79. Government expenditure and export growth were assumed to grow at the same average rate of the period 1972-79. LIBOR was assumed to be equal to the average level of the period 1972-79. Model 7 was therefore re-estimated for every single hypothesis. The results of the fitted PRP using the historical values (baseline) were then compared with the four alternative fitted scenarios.

As is shown in Chart 2, which reports the average individual response to the four shocks in the period 1981-86, all

Shocked simulations

Chart 2

1981–86, period average (% points)



the countries tend to react fairly strongly to CPI shocks.([34]) As many of them experienced high and rising inflation in the period of the outbreak of the debt crisis (1980-85) with respect to the preceding period, the baseline estimates of the probability of incurring repayment problems tend to be much higher than the fitted ones. Brazil, Ecuador, Ivory Coast, Peru, Mexico, Yugoslavia show for instance an increase of more than 25% on average.

Excluding CPI the reaction to all shocks is similar through time across the major debtor countries (Chart 3). Argentina's PRP is dramatically less responsive to CPI shocks than are Brazil's and Mexico's, since its over-100% average inflation rate during the 1970s meant that the shock imposed in the 1980s was relatively minor with respect to historic values. Hyperinflation is nonetheless a general problem of the estimation. As mentioned earlier, the occurrence of hyperinflation causes the estimate of the PRP (baseline in Chart 3) to stick to values very close to 1 (see for instance Argentina and Brazil in 1983-86 and Mexico during 1984-86).

The sample countries show, on average, less reaction to the growth of export and government expenditure (EXPG and GOVG), although the first is particularly relevant for oil and natural resource producers and the second for Chile (Chart 2). In this latter case, however, following the drastic containment of government expenditure in the 1980s, the alternative scenario yields a fitted PRP above the baseline one.

The highly negative values for government expenditure shocks for Chile suggest that the simulation results have to be taken with care as they are influenced by the choice of the baseline period. This is obviously crucial as far as comparisons across countries of shocks of an internal nature are concerned; while for the external shocks, this is not the case as the latter affect all the countries in the same period and by the same amount. Nonetheless, alternative simulations for the same shock variables, though conducted shifting the baseline period, have shown that for individual country analysis, the relative response to shocks is fairly stable.

Turning to the comparative analysis of internal (CPI and GOVG) versus external shocks (LIBOR an EXPG) the probability of

---

[34]) The average reaction to shocks is:

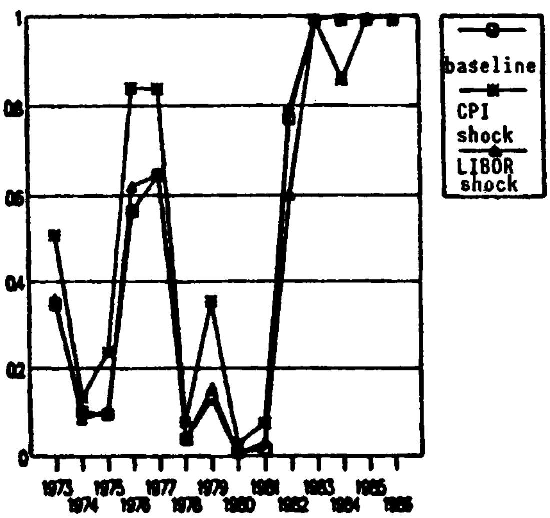
$$[1/6*\Sigma(PRP_B-PRP_S)/1/6*\Sigma(PRP_S)]*100,$$

where B=baseline and S=shock. The Σ sign refers to the period 1981-86. A positive value therefore indicates a reduction of the probability of encountering repayment problems (PRP) with respect to the baseline.

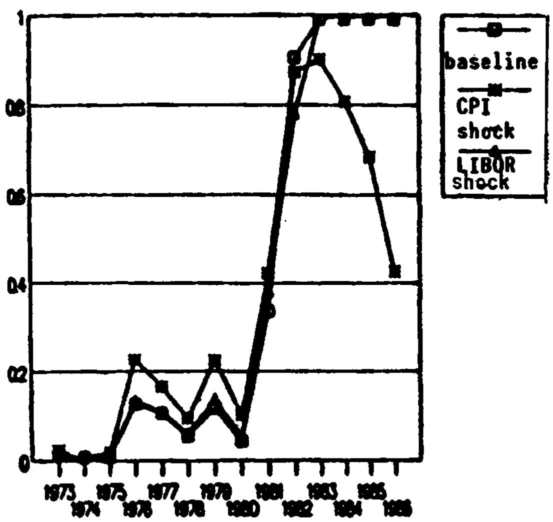
Chart 3

PRP under alternative scenarios

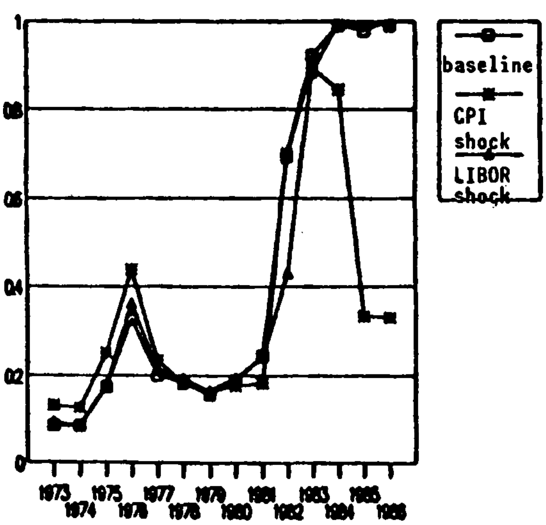
Argentina



Brazil



Mexico



repayment problems is significantly affected by the different nature of the shock. Excluding Argentina, Ecuador, Morocco and Nigeria, since their PRPs were reactive to every kind of shock, most of the countries tend to be affected by a single type of shock. Brazil, Colombia, Costa Rica, Ivory Coast, Mexico, Nicaragua, Peru and Yugoslavia are more sensitive to "internal" factors, and the remaining ones (Bolivia, Chile, Dominican Republic, Jamaica, Philippines and Venezuela) to "external" ones (Libor and/or Export growth).

III.2 LIBOR shocks and country ranking

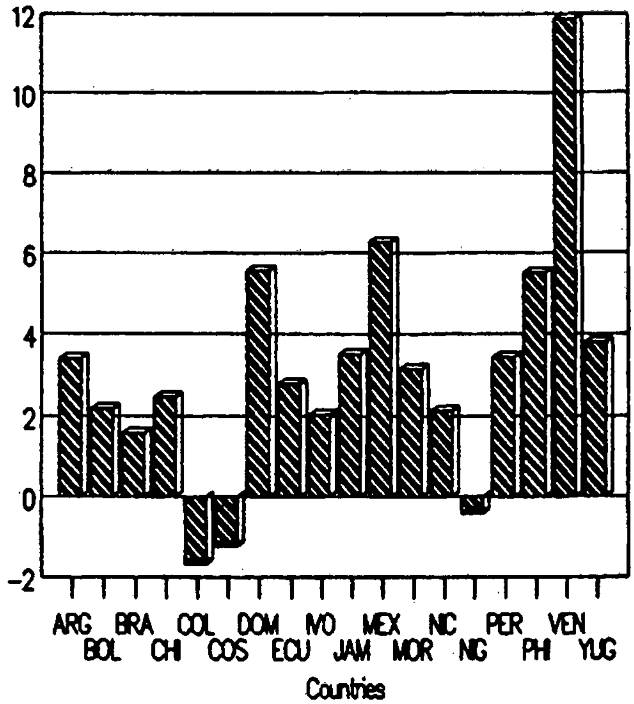
Chart 4 reports the average reaction to the LIBOR shock in the period 1981-86 for the 18 countries of the sample.([35]) Venezuela, Mexico and the Dominican Republic have the greatest sensitivity to LIBOR shocks, as their PRP decreases on average by between 5% and 12% if LIBOR is assumed to have the same average values in the 1970s, in the 1980s. As LIBOR rose dramatically in the early 1980s, one would have expected the reaction to the shock of all the countries to have had a positive sign. The negative values recorded for Nigeria, Colombia and Costa Rica are due to the repayment situation of 1982-83, i.e. periods of very high Libor, with respect to the period 1984-86, i.e. periods of declining Libor. Since those countries did not have particularly acute repayment problems in the first period but did in the second, the percentage reduction of the PRP after the LIBOR shock of the first period was not able to compensate the percentage increase of the second period.

[35]) The ranking of countries with respect to their relative reaction to shocks is appropriate only in the case of LIBOR since for the other shocks previously considered the period which is chosen as a baseline is crucial.

Chart 4

Sensitivity to LIBOR shocks

1981-86, period average (% points)



III.3 Simulations on the multinomial model

Along the lines of the procedure adopted in section III.1, a simulation analysis based on alternative scenarios was performed using the results of the separate estimation of the two equations on rescheduling-IMF support (equation 10) and on the accumulation of external arrears (equation 11). The simultaneous estimation of the two equations was used as a baseline and the same hypotheses were made regarding the shock variables and the period of simulation (1981-86).

Chart 5 reports the 1981-86 average reaction to shocks of the fitted probability for six major debtor countries of the sample (Argentina, Brazil, Mexico, Peru, Philippines and Venezuela). Only the results from the CPI and LIBOR shocks are reported, assuming them to be the most appropriate examples of, respectively, internal and external shocks. The sensitivity is on average much higher for arrears (ARRCPI and ARRLIBOR) than for rescheduling (RESCPI and RESLIBOR). The only exception is Argentina in the case of CPI shocks.

The LIBOR shock on arrears (ARRLIBOR) is particularly important for Venezuela and the Philippines, thus confirming the results of the ordinary PROBIT estimation. Instead, the CPI shock on arrears (ARRCPI) is particularly important for Brazil and Peru. For Mexico, both the internal and the external components seem to be important.

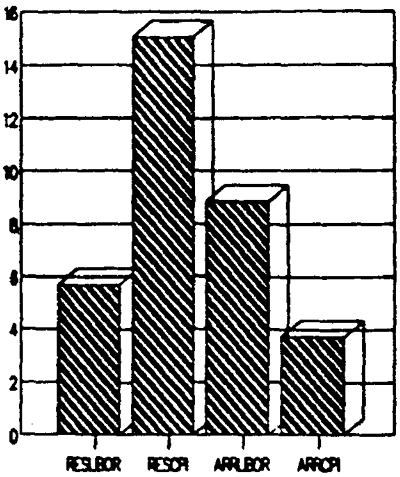
Interestingly enough, for some countries, only the LIBOR shocks seem to modify the probability of accumulating external arrears. A possible explanation could be as follows. During the 1980s the widespread increase in international interest rates forced the spread-adjusted rates for LDC countries to unacceptable levels. Instead of imposing very high interest rates on LDC loans, creditors preferred to ration the supply by restricting the available amount of new loans acording to the level of country risk. As a consequence, most debtor countries increased the accumulated level of arrears. This occurrence, by strongly reducing their creditworthiness, aggravated the tendency towards rationing in the lending market. The increase in external arrears thus became self-fulfilling.

Reaction to shocks

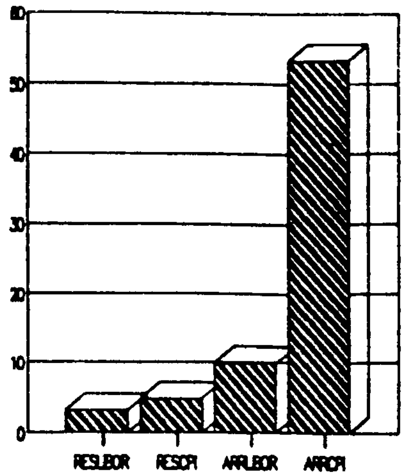
Chart 5

Rescheduling vs. Arrears

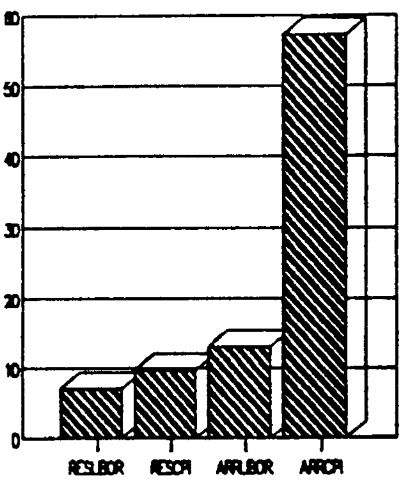
Argentina



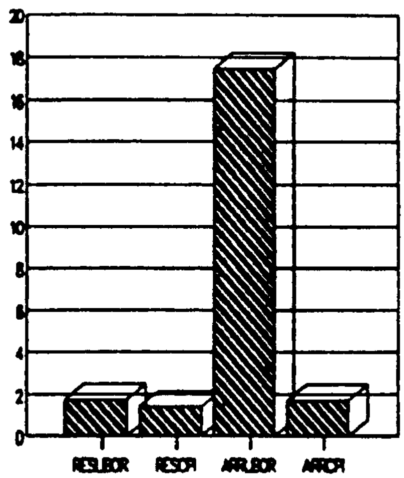
Peru



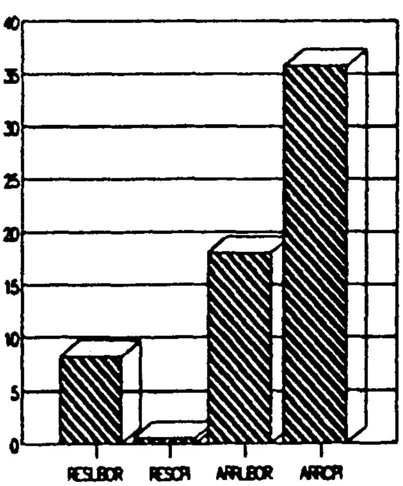
Brazil



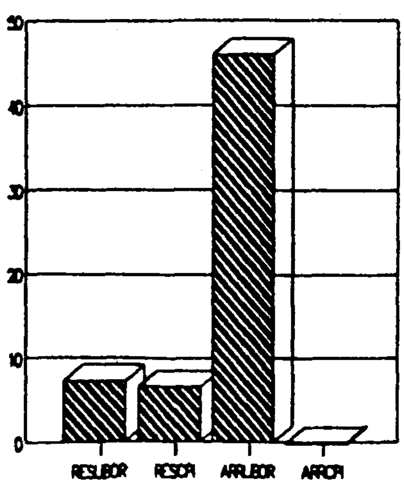
Philippines



Mexico



Venezuela



IV Concluding Remarks and Policy Suggestions

All the debt strategies currently under study aim at devising ways of sharing the burden of servicing foreign debt between creditors and debtors. This mutual effort strategy relies primarely, however, on the market evaluation of the debt or left to bilateral and multilateral negotiations, which could lead to unfair discrimination between countries. State contingent clauses or debt relief plans should, in theory, be derived from country specific structural models which take account of the structure and the institutional setting of the economy. Although case-by-case scrutiny can hardly be avoided in many circumstances, problems of coordination of forgiveness among the creditors, in addition to consideration of equity and moral hazard, may strengthen the argument for a coordinated supranational plan based on objective criteria.

In this context, a panel data analysis allows a more homogeneous treatment of the countries in the sample as far as their relative reaction to shocks is concerned, so that what is lost in terms of accuracy in examining the individual economic structure could be gained in terms of comparability of shock responses. Moreover, some features of the model (although in a more comprehensive specification) may turn out to be useful in a policy perspective.

The need to find some objective criteria for sharing the burden of debt servicing could be initially satisfied by taking account of the distinction between shocks of a "mostly external" versus a "mostly internal" nature. Two tentative applications in the setting of the debt strategy are outlined here, drawing on this distinction.

The first application could be to the design of state contingent clauses in the context of an adjustment program.In this scheme both creditors and debtors would be made mutually "responsible" for the occurrence of unexpected deviations from the program baseline. Creditors, for exogenous external circumstances, such as LIBOR increases or slowing down of international demand; debtors, for slippages in variables under their control. The degree of "responsibility", however, would depend on the order of magnitude in which similar shocks have influenced PRP in the past compared with other shocks. Such a procedure would guarantee that the consequences of the different shocks would be "weighted" starting from their estimated effects on creditworthiness, rather than being appraised by looking solely to the accounting consequences on the debt burden (for the interest rate increase) or to their consequences for the consistency of the adjustment program (for a policy slippage). In the event of deviation of exogenous variables, like the international interest rates, from the baseline, the country would receive extra financing in the form, for instance, of extra interest payment relief, in proportion to the computed responsiveness of its PRP to such a shock relatively to other shocks. Analogously, a policy slippage should reduce the agreed financing in proportion to the computed responsiveness to the corresponding variable.

This application is subject to the problem of moral hazard. If a country shows less responsiveness than other countries to domestic policies, the incentive to comply with the agreed policies will diminish as the cost in terms of diminished debt relief or new financing would be relatively minor. In turn, this could hamper the success of the adjustment strategy. Such a problem, however, could be solved by recalculating periodically the relative sensitivity and readjusting the agreement accordingly.

The second policy application could be to use the results of the country ranking we derived with respect to LIBOR shocks (section III.2) to develop a plan of interest rate relief, like the one proposed by Dornbusch(1988). In this plan the author proposes a partial "recycling" of interest payments into productive investment. More specifically, interest payments that are due should be partially capitalized, while the rest should be converted into the currency of the debtor country to finance local investments. Dornbusch, however, does not clearly states the extent to which interest payments should be capitalized rather than converted into domestic currency. Moreover, he applies the plan across debtor countries without distinguishing between economic realities. Drawing from the country ranking which we have derived from the LIBOR shocks, the plan could have the following format. An agreed percentage of the interest payable should be paid by all countries involved in the plan. The remaining interest payments would be relieved in accordance with the relative sensitivity of the sample countries to the LIBOR shocks. Countries with the greatest sensitivity would receive the maximum relief and the others proportionately less.

Finally, the multinomial version of the PROBIT model could be useful for policy implementation inside the bargaining framework followed by recent theoretical literature on debt recontracting (Bulow and Rogoff, 1989). In this context, the occurrence of rescheduling and arrears could be seen as a possible indication of the relative strength of the players involved in the bargaining process. More specifically, since in the absence of private information, the outcome of the process is to recontract immediately (rescheduling agreement), the occurrence of arrears might be viewed as a signal of "tough" bargaining by one of the parties, although it could not be determined a-priori whether the creditor or the debtor is currently in a stronger position. This information can be used for policy purposes since strong bargaining by the players, can sometimes lead to an incorrect evaluation of a country's creditworthiness.

APPENDIX A - Estimation of PROBIT Models

The univariate binary PROBIT model (Amemiya, 1985) is defined as:

$$Prob(y_i=1)= \Phi(\beta'x_i)= \int_{-\infty}^{\beta'x_i} (1/\sqrt{2\pi})\ e^{-(t^2/2)}\ dt \qquad [A.1]$$

where y_i are independently distributed, β and x_i are k*1 vectors of unknown parameters and explanatory variables, respectively.

The underlying model (Maddala, 1983) implies that an unobservable variable y_i^* exists such that

$$y_i^*=\beta'x_i+u_i \qquad [A.2]$$

where u_i are independent and normally distributed with mean 0 and variance σ^2;
and

$$y_i=1 \quad \text{if } y_i^*>0$$
$$y_i=0 \text{ otherwise} \qquad [A.3]$$

Hence:

$$Prob(y_i=1)=Prob(y_i^*>0)=Prob(\beta'x_i>-u_i)=Prob(u_i>-\beta'x_i)=$$

$$=1-\Phi(-\beta'x_i)=\Phi(\beta'x_i) \qquad [A.4]$$

where $\Phi(\cdot)$ is the cumulative distribution for u, and, in [A.1], $\sigma=1$.

The logarithm of the likelihood function of [A.1] is given by:

$$\log L= \Sigma_{i=1}^{N}\ y_i\log[\Phi(\beta'x_i)]+\Sigma_{i=1}^{N}(1-y_i)\log[1-\Phi(\beta'x_i)] \qquad [A.5]$$

Under some mild assumptions on the behavior of the x_i's ([36]), it is possible to show that maximum likelihood estimates (MLE) are consistent and asymptotically normal. Moreover, if the likelihood function is globally concave, i.e. $\delta^2\log L/\delta\beta * \delta\beta'$ is

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[36]) $\{x_i\}$ must be such that $\lim_{n\to\infty} \Sigma_{i=1}^{N} x_i x_i'/N$ is a finite non singular matrix. In addition the empirical distribution of $\{x_i\}$ must converge to a distribution function.

a concave definite matrix, the unique MLE is given by the solution of:

$$\delta \log L/\delta\beta = \Sigma_{i=1}^{N}\{(y_i-\Phi(\beta' x_i))/\Phi(\beta' x_i)[1-\Phi(\beta' x_i)]\}*f_i x_i'=0 \qquad [A.6]$$

$$\text{where } f_i=\delta\Phi(\beta' x_i)/\delta(\beta') \text{ or the p.d.f. of } \beta' x_i \qquad [A.7]$$

The maximum likelihood estimation is actually carried out through iterative procedures given the non-linearity of the model.

The Newton-Raphson procedure has been adopted. The first estimate, $\hat\beta_{(1)}$ is obtained by a general Taylor series expansion

$$\text{Log } L(\beta)\approx \log L(\hat\beta_{ij})+(\delta \log L/\delta\beta)|_{\beta=\hat\beta_{(1)}} * (\beta-\hat\beta_{(1)})$$

$$+1/2\ (\beta-\hat\beta_{(1)}*(\delta^2 \log L/\delta\beta\,\delta\beta')|_{\beta=\hat\beta^{(1)}} * (\beta-\hat\beta_{(1)}) \qquad [A.8]$$

where $\hat\beta_{(1)}$ stands for an initial estimate and subsequent round estimators are obtained according to the following relation ([37]):

$$\hat\beta_{(t)}=\hat\beta_{(t-1)}-[(\delta^2 \log L/\delta\beta\,\delta\beta')|_{\beta=\hat\beta^{(t-1)}}]^{-1}*(\delta \log L/\delta\beta)|_{\beta=\hat\beta^{(t-1)}} \qquad [A.9]$$

A multinomial PROBIT model allows y_i in [A.3] to take more than two values and may be defined as:

$$P(y_i=j)=\Phi_{ij}(\beta' x_i) \qquad i=1,2,3...N \quad j=0,1,2,...r \qquad [A.10]$$

We may refer to the binary case by defining (r+1) binary variables:

$$y_{ij}=1 \text{ if } y_i=j \qquad i=1,2,...N \qquad [A.11]$$
$$y_{ij}=0 \text{ if } y_i\neq j \qquad j=0,1,2,...r$$

In this case the loglikelihood function becomes:

$$\log L = \Sigma_{i=1}^{N}\ \Sigma_{j=0}^{r} \log \Phi(\beta' x_i) \qquad [A.12]$$

and,in principle, most of the results about MLE still hold.

[37]) A valid alternative to the second element in [A.9], which is the inverse of the Hessian matrix of the loglikelihood function, is the inverse of the information matrix (method of scoring).

The literature makes a general distinction between ordered and unordered PROBIT models (McFadden,1985). In the ordered PROBIT model it is assumed that the unobserved continuous random variable y_i^* is related to the observed discrete random variable y_i (which takes r values) through the rule:

$$y_i=j \text{ if } \alpha_{j-1}< y_i^* \leq \alpha_j \qquad \text{for } j\neq 0,r \qquad [A.13]$$
$$y_i=0 \text{ if } y_i^* \leq \alpha_0$$
$$y_i=r \text{ if } y_i^* > \alpha_{r-1}$$

where for j $\neq$0,r the α_i's are parameters to be estimated.

Ordered PROBIT models have been estimated using the package LIMDEP which derives MLE estimators from a maximization process utilizing the Davidson,Fletcher and Powell iterative method (DFP) for nonlinear optimization. This method corresponds to a modified Newton-Raphson procedure since:

$$\hat{\beta}_{(t)}= \hat{\beta}_{(t-1)} - \tau_{(t-1)} \left[(\delta^2 \log L/\delta \beta \delta \beta')\,|_{\beta=\hat{\beta}_{(t-1)}}\right]^{-1} *$$
$$* \ (\delta \log L/\delta \beta)\,|_{\beta=\hat{\beta}_{(t-1)}} \qquad [A.14]$$

where $\tau_{(t-1)}$ is the step length found by cubic interpolation of the likelihood function along the current search direction.

In the unordered model we assume that:

$$y_i=j \text{ if,jointly, } y_i^*>y_s^* \text{ for all } y_s \text{ and } s\neq i \qquad [A.15]$$

or,equivalently,for $u_i=u_s$ and for all s,

$$\beta' x_i^* > \beta' x_s^* \qquad [A.16]$$

This assumption yields, for a three-choice case (Amemiya,1981):

$$P(y_i=1) = P(y_1^*> y_2^*;\ y_1^*> y_0^*) = \qquad [A.17]$$
$$= \int_{-\infty}^{+\infty} \int_{-\infty}^{y1^*} \int_{-\infty}^{y1^*} \Phi\ (y_0^*,y_1^*,y_2^*)\,dy_0^* dy_1^* dy_2^*$$

where Φ is a trivariate standard normal density whose computation is quite cumbersome.

The difficulty in estimating unordered PROBIT models have forced us to concentrate more on ordered ones. It must be stressed that the incorrect use of an ordered model instead of the true unordered one gives rise to bias in estimation of probabilities while the opposite mispecification results only in a loss of efficiency.

On the other hand, it can be shown that a multinomial four-choice unordered model is in general equivalent to a bivariate simultaneous equation model defined by:

$$P(y_1=1) = \Phi(\beta_1' x_1)$$
$$P(y_2=1) = \Phi(\beta_2' x_2) \qquad [A.18]$$
$$P(y_1=1,y_2=1) = F_\mu \ (\beta_1' x_1, \beta_2' x_2)$$

where β_1, β_2 ,x_1 and x_2 are,respectively, k_1*1 and k_2*1 vectors of parameters and explanatory variables and F_μ is the bivariate normal distribution function with mean zero, variance equal to one and correlation equal to μ (Amemiya,1981). The set of parameters β_1, β_2 and μ has been estimated through LIMDEP by using iterative procedures for NFIML estimation which generate efficient estimates with all the desirable asymptotic properties. A high level of μ would indicate a high correlation between the two choices independently from the order while a μ close to zero would detect the existence of two independent binary PROBIT models.

APPENDIX B - Panel Data Estimation

B.1 Linear model

When panel data are utilized, as observations are taken both across individuals and over time, individual and/or time specific effects may affect the estimates.

The static linear model with individual-specific (in our case, country-specific) effect may be written (Hsiao,1986):

$$y^*_{it} = \alpha_i + \beta' x_{it} + u_{it} \qquad i=1,2,\ldots N \quad j=1,2,\ldots T \qquad [B.1]$$

where y^*_{it} is a quantitative response dependent variable, α_i is a scalar which is constant over time, is a k*1 vector of parameters and x_{it} is a k*1 vector of explanatory variables.

If we allow for time-specific effects or for both effects, the specifications become:

$$y^*_{it} = \tau_t + \beta' x_{it} + u_{it} \qquad i=1,2,\ldots N \quad j=1,2,\ldots T \qquad [B.2]$$

$$y^*_{it} = \alpha_i + \tau_t + \beta' x_{it} + u_{it} \qquad i=1,2,\ldots N \quad j=1,2,\ldots T \qquad [B.3]$$

Under specifications [B.1], [B.2] and [B.3] ordinary least squares have all the desirable properties even though the constant term cannot be estimated. For the estimation of the fixed country effect model we have actually calculated the difference between individual observations and the country means over time, i.e.:

$$\bar{y}_{it} = y_{it} - \Sigma_{t=1}^{T} y_{it} \qquad i=1,2,\ldots N \quad j=1,2,\ldots T \qquad [B.4]$$

and then applied OLS to the transformed model.

Assuming that country and/or time specific effects are themselves random variables (random-effect models) we may have the following specifications:

a) $y^*_{it} = \beta' x_{it} + \mu_{it}$ $\quad$ $i=1,2,\ldots N$ $\quad$ $j=1,2,\ldots T$ $\quad$ [B.5]

$\mu_{it} = u_{it} + \alpha_i$

if only country-specific effects are allowed;

b) $y^*_{it} = \beta' x_{it} + v_i t$ $\quad$ $i=1,2,\ldots N$ $\quad$ $j=1,2,\ldots T$ $\quad$ [B.6]

$v_{it} = u_{it} + \tau_t$

if only time-specific effects are taken into account;

c) $y^*_{it} = \beta' x_{it} + \delta_{it}$ $\quad$ $i=1,2,\ldots N$ $\quad$ $j=1,2,\ldots T$ $\quad$ [B.7]

$\delta_{it} = u_{it} + \alpha_i + \tau_t$

if both effects are considered.

An analysis of variance test can be conducted from [B.5] to verify the existence of country effect by computing:

$$F = [(\Sigma_i \Sigma_t\ u^2_{it} + T\Sigma_i\ \alpha^2_i)/(N-1)]/[(\Sigma_i \Sigma_t\ u^2_{it}/(NT-N)] \qquad [B.8]$$

where the denominator refers to the estimation of the classical regression model and the numerator the estimation of model [B.5], and the test has an F distribution with N-1 and NT-N degrees of freedom.

The same type of test may be conducted on [B.6] and [B.7] to test the existence of time effect and the simultaneous existence of both effects.

The estimation of models [B.5] and [B.6] has been conducted through the generalized least squares (GLS) method which permits the derivation of BLUE estimates. GLS has been implemented by first calculating:

$$\bar{y}_{it} = y_{it} - \vartheta\ y_{i\cdot} \qquad [B.9]$$

$$\vartheta = 1 - (\hat{\sigma}^2_u\ /\ \hat{\sigma}^2_u + T\ \hat{\sigma}^2_\alpha) \quad ;\ y_{i\cdot} = \Sigma^T_{t=1}\ y_{it}/T$$

for the random "country effect" and

$$\bar{y}_{it} = y_{it} - \vartheta\ y_{\cdot t} \qquad [B.10]$$

$$\vartheta = 1 - [\hat{\sigma}^2_u/(\ \hat{\sigma}^2_u + N\ \hat{\sigma}^2_\tau)] \ ;\ y_{\cdot t} = \Sigma^N_{i=1}\ y_{it}/N$$

for the random "time effect".

In the second stage, an OLS has been applied to the transformed models [B.9] and [B.10].

B.2 Qualitative response model

The model of probability of repayment problems analyzed in the text is actually both a panel data and a qualitative response model. Under these circumstances the inclusion of country specific (fixed) effects yields (Hsiao,1986):

$$\text{Prob}\ (y_{it}=1) = \Phi\ (\beta' x_{it} + \alpha_i) \qquad \begin{array}{l} i=1,2,\dots N \\ t=1,2,\dots T \end{array} \qquad [B.11]$$

in which y_{it} is a binary choice variable, β is a k*1 matrix of parameters and x_{it} is a k*1 matrix of the explanatory variables.

In model [B.11] both α_i's and β's must be estimated. Unconditional MLE may be suitable for estimation only when $T \to \infty$. If T is small, the MLE for α_i is inconsistent and, since MLE estimates for α_i and are dependent on each other, the MLE for β is also inconsistent.

A consistent estimator has been found only for a LOGIT model by maximizing the likelihood function conditional on a sufficient statistic for α_i (Chamberlain(1985)).

For T=2 the conditional loglikelihood function is:

$$\log L_c = \Sigma_{i\ B1} \{w_i \log \Phi\ [\beta'(x_{i2} - x_{i1})] +$$

$$+(1-w_i) \log[1 - \Phi(\beta'(x_{i2}-x_{i1}))]\} \qquad [B.12]$$

where $B_i = \{ i \mid y_{i1} + y_{i2} = 1 \}$ and $w_i=1$ if $(y_{i1}=0; y_{i2}=1)$

and $w_i=0$ if $(y_{i1}=1; y_{i2}=0)$.

The conditional likelihood does not depend on the incidental parameter α_i and the conditional ML estimator of β is consistent if the likelihood function satisfies some mild conditions on α_i.

For T>2 analogous models can be derived and the basic properties are maintained.

Estimations from the conditional LOGIT model have been used for the testing procedure constructed to discriminate between the hypotheses of heterogeneity and state dependence. As reported in section II.1.4, state dependence turned out to be more likely. Following Hsiao(1986), state dependence can have two origins. First, it can be due to the fact that past values of the dependent variable contain information on the error terms which are serially correlated. Second, to the fact that past experience of the event determines the current occurrence. In this second case we expect that lagged values of the explanatory variables have a direct influence on the current value of the dependent variable. Whereas the first case is called "spurious state dependence" with serial correlation, the second is the "true state dependence". If:

$$\mathrm{Prob}(y_{it}=1 \mid y_{it-1}, x_{it}, \alpha_i) \neq \mathrm{Prob}(y_{it}=1 \mid x_{it}, \alpha_i) \qquad [B.13]$$

but:

$$\mathrm{Prob}(y_{it}=1 \mid x_{it}, x_{it-1}, \alpha_i) = \mathrm{Prob}(y_{it}=1 \mid x_{it}, \alpha_i) \qquad [B.14]$$

then, the state dependence is mainly due to serial correlation of the error terms. If also this second relation holds with inequality, "true state dependence" is detected and a distributed lag model may be more appropriate.

The testing procedure, limited to the period 1982-1986 and performed through a panel data fixed effect LOGIT estimation, was derived from a comparison between the baseline (restricted) model and an unrestricted model including lagged values for all the explanatory variables. The calculated CHI^2 was equal to 8.7488 while $CHI^2_{(6,\alpha=0.05)} = 12.592$. Hence, the value of the likelihood ratio test seemed to reject the hypothesis of true state dependence.

A more general framework for the analysis of panel data discrete choice models in a dynamic setting has been suggested by Heckman (1981a). A possible specification assumes that there exists an unobservable continuous variable y^*_{it} such that:

$$y^*_i = \ 'x_{it} + \Sigma^{t\ 1}_{r=1}\ \delta_r\ y_{i,t-r} + \Sigma^{t-1}_{s=2}\ \Phi_s\ \prod^{s}_{r=1}\ y_{i,t-r} + \mu_{it}$$

$$\mu_{ti} = \tau_t\ \alpha_i + \Sigma^{q}_{p=1}\ \vartheta_p\ \ _{i,t-p} + u_{it} \qquad [B.15]$$

where δ_r and x_{it} are k*1 vectors of parameters and explanatory variables, δ_r and Φ_s are scalars, ϑ_p is the coefficient of the p^{th} order of autocorrelation, u_{it} satisfies the classical assumptions on the error term and:

$$y_{it} = 1 \text{ if } y^*_{it} > 0 \qquad [B.16]$$
$$y_{it} = 0 \text{ if } y^*_{it} \leq 0$$

The second term in the first equation of [B.15] takes into account the separate effect of each single period state dependence while the third term the cumulative effect of past experience of the event. In the second equation of [B.15] the first term allows for a more general (time variant) form of heterogeneity and the second term for the presence of serial correlation of the error terms independent from country specific effects.

The procedures suggested by Heckman for inference in this framework consist in the estimation of T single equations PROBIT models for each cross-section from which is possible to estimate the ratios among disturbance variances in different time periods and the temporal correlation pattern originated from each particular specification. Such ratios and correlation coefficients are then included in the likelihood function to maximize. Likelihood ratio tests can be performed in order to discriminate between heterogeneity, spurious state dependence and true state dependence. In most simpler cases the specification can be reduced to a one factor random effect PROBIT model which is the type of model estimated in McFadden et al. (1985). However, when serial correlation is present and T>3 the error scheme in [B.15] cannot be transformed in the one-factor model.

In addition, as pointed out by Heckman (1981b), particular attention must be given to the specification of the pre-sample history of the process generating the y_{it}^*'s (initial conditions), namely to y_{i0}^* and y_{i0}. If the process has been in operation prior to the time which have been sampled or if there is serial correlation in the residuals, then estimates obtained from the maximization of a likelihood function which takes into account state dependence and heterogeneity but neglects the stochastic determination of the initial conditions are inconsistent. Also, a fixed effect PROBIT estimator is biased and the bias is higher when the individual effect is very high. For these cases Heckman suggests the use of an approximate procedure which has shown to reduce the bias in Montecarlo studies.

The implementation of the Heckman framework in our context is deferred to further analysis. The limited number of countries included in the sample hampers the cross-section single PROBIT estimations for which an insufficient number of degrees of freedom is left over.

APPENDIX C - Data Set

Dependent variable

The dependent variable in ordinary **binary** probit models (PRP) is defined as a dummy variable assuming value 1, whenever at least one of the following four variables assumes a value different from zero, and 0 otherwise:

a) Bank debt rescheduling. It includes the total amount (principal and interest) of external commercial debt which has been rescheduled at a certain date regardless of the period in which the consolidation referred in the agreement will actually take place. Existing lines of credit whose terms have been extended are also included. Sources for these data are internal reports of the IMF on commercial debt renegotiation. Data are available for the period 1971-86.

b) Paris Club Restructuring. It includes the total amount of external official debt as it has been rescheduled in the context of the Paris Club at a certain date. Even in this case one refers to the total capital and interest rescheduled regardless of the period in which the consolidation referred in the agreement will actually take place. Sources for the data are various reports from the IMF on debt renegotiation. Data are available for the period 1971-87.

c) IMF support. It includes the total amount of drawings under the upper credit tranche from Stand-by arrangements, Structural Adjustment Facility loans and Extended Fund Facility loans as they have been agreed to at a certain date regardless of the actual phasing of the drawings. Sources for these data are the monthly reports on the "Transactions of the IMF". Data are available for the period 1971-1987.

d) Accumulation of external arrears. It comprises the net annual accumulation at the end of the year. Sources for these data are the balance of payments statistics contained in various issues of the Recent Economic Development country reports of the IMF and other confidential IMF sources. Data availability is unequal among the countries considered especially for the early '70 period.

For the definition of the dependent variable in **ordered multinomial** models see table 3. In the **unordered multinomial (bivariate)** model IMFRS comprises one of the events under a), b) and c).

Explanatory variables

CPIPRB = Consumer price index. Source: IFS.

DODGPRB = Rate of growth of Public Guaranteed External Debt. Source: World Bank - World Debt Tables, various issues.

EXPGPRB = Export growth. Source:IFS.

GDRGPRB = GDP Growth. Source: IFS.

GOVGPRB = Rate of growth of government expenditure in nominal terms. Sources: IFS and internal reports of the IMF.

GROWTHPR = Industrial Countries Demand Growth. Source: IFS.

LIBORPRB = London Interbank Offer Rate. Source: World Bank. World Debt Tables.

MONGPRB = Rate of Growth of Money Supply (M3, when available). Source: IFS.

RESIPRB = International Reserve/Imports. Source: IFS.

TDSEPRB = Total Debt Service over Exports. World Bank - World Debt Tables.

TOTIPRB = Individual countries terms of trade (Unit export values/unit import values). Index, 1980=100. Sources=IFS. For the criteria adopted in case of missing values see footnote (15).

The complete data set is available upon request from the authors.

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