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DUAL RESOURCE TRANSFERS AND INTERRUPTIONS IN EXTERNAL DEBT SERVICE

AFONSO S. BEVILAQUA
(e-mail asb@econ.puc-rio.br)

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Afonso S. Bevilaqua*

Departamento de Economia

PUC - Rio

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ABSTRACT

External debt service requires a dual resource transfer. Trade surpluses have to be generated in order to make foreign exchange revenues available for debt repayment. In addition, with developing countries' external debt being largely a public liability, debt service requires that resources can be effectively transferred from the private to the public sector. This paper derives a statistical model for dealing with dual constraints in the presence of binary dependent variables and applies it to the dual resource transfer problem. The results from the estimation of the model for a sample of 31 middle-income developing countries in the period of 1980 to 1990, strongly support the hypothesis that both external and fiscal constraints are important in explaining external debt service disruptions.

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1. Introduction

During the 1980s, many developing countries had recurrent problems with maintaining external debt service. The search for the determinants of these debt repayment problems has motivated numerous econometric studies. The majority of the existing studies concentrate on explaining debt service disruptions by exploring their correlation with variables that describe the balance of payments constraint of a country.[1] After all, in the absence of foreign capital inflows, trade surpluses have to be generated in order to make foreign exchange available for debt repayment.

However, the ability to generate foreign exchange revenues is not the only binding constraint in the repayment decisions of developing countries. With most of their external debt being either public, or guaranteed by the public sector, the economy's capacity to make an external transfer of resources is a necessary but not sufficient condition for debt repayment. In addition to the external transfer, an internal resource transfer, from the private to the public sector, has to be effected. External debt service therefore depends also on the ability of the public sector to secure resources domestically, which is limited.[2]

With a dual resource transfer, the empirical analysis of debt repayment

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[1] McDonald (1982), and Saini and Bates (1984) present extensive surveys of the earlier literature. Recent studies are reviewed in Bevilaqua (1993).

[2] The additional complications that arise for external debt service when most of the debt is held by the public sector have been analyzed by Cohen (1987), Fishlow (1988), Reisen and van Trotsenburg (1988), Easterly (1989), Reisen (1989), Rodrik (1990), and van Wijnbergen et al. (1992), among others.

problems requires econometric models that allow for two different regimes. For some countries, the ability to make an external resource transfer can be the binding constraint, while for others, the internal resource transfer can be the critical constraint.

A major difficulty with using two regimes in implementing a statistical model of debt repayment problems is that standard econometric models cannot be used. In econometric analyses of repayment problems, the dependent variable generally has a binary nature. If an interruption in debt service is observed, the dependent variable takes the value of 1; if not, it is equal to 0. In this case, standard switching regime models cannot be used, since they do not handle binary dependent variables adequately.

This paper derives a bivariate probit model with partial observability that allows for endogenous switching between two different regimes to deal with binary dependent variables, and uses it for analyzing the empirical importance of external and internal (or fiscal) constraints for interruptions in external debt service. The econometric evidence supports the hypothesis that both constraints explain the existence of arrears in external debt payments in a sample of middle-income developing countries between 1980 and 1990, a period during which many developing countries had no access to international capital markets and the resources for external debt service had to be obtained from domestic sources of finance.

A fundamental result that comes out of the estimation, and that can only

be obtained in the context of a model with two regimes, is that some of the variables that explain interruptions in external debt service actually have opposite effects in the two resource constraints. Many developing countries tried to increase foreign exchange revenues during the 1980s targeting a more devalued level of the real exchange rate and implementing contractionary policies to reduce the rate of real GDP growth. The estimation results show that both an undervalued real exchange rate and a slower rate of real GDP growth reduce the probability of repayment problems because of external constraints, but increase this probability because of fiscal constraints. In fact, the obtained coefficients indicate that the negative effects of these variables on the fiscal constraint outweigh their positive effects on the external constraint.

The paper is structured as follows. The next section discusses a framework for analyzing interruptions in external debt service by taking into consideration that external debt repayment requires a dual resource transfer. Section 3 derives the statistical model designed for dealing with binary dependent variables in the context of switching regimes. The implementation of the model to the dual resource transfer problem and the estimation results are discussed in section 4. Some concluding remarks are offered in section 5.

2. A Framework of Analysis

In order to analyze the empirical occurrence of repayment problems, it is useful to state the government budget and balance of payments constraints of a country in terms of the sources of finance for debt repayment.[3] The change in the external debt stock in any given period can be written as:

$$(1)\ (D_t - D_{t-1}) = (\textit{disbursements})_t - (\textit{principal repayments})_t + (\textit{arrears accumulation})_t$$

Subtracting the amount of interest payments on the external debt ($i_t^* D_{t-1}$) from both sides of the above equation gives

$$(2)\ (D_t - D_{t-1}) - i_t^* D_{t-1} = NTD_t + (A_t - A_{t-1})$$

where NTD_t represents net transfers on the external debt and A_t stands for arrears on the external debt payments.

Similarly, and without introducing arrears in this case, one can write the change in the domestic debt stock as:

$$(3)\ (B_t - B_{t-1}) - i_t B_{t-1} = NTB_t$$

where NTB_t represents net transfers on the domestic debt.

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[3] The derivation of a theoretical model of sovereign default is beyond the scope of this paper. A formal analysis of sovereign borrowing incorporating the role of fiscal constraints can be found, for example, in Sachs (1984).

Using equations (2) and (3), one can restate the government budget and balance of payments constraints, respectively, as:

$$(4)\quad G_t - e_t NTD_t = NTB_t + (H_t - H_{t-1}) - e_t(F_t - F_{t-1}) + e_t(A_t - A_{t-1})$$

and

$$(5)\quad NTD_t = (F_t - F_{t-1}) - (A_t - A_{t-1}) - NX_t$$

According to equation (4), unless the economy runs a primary budget surplus of the same magnitude, net transfers on debt to external creditors must be financed by increases on domestic debt, money creation, or by a loss of foreign exchange reserves. If the resources that can be obtained from these three sources fall short of the required transfers, the resulting gap will be closed by arrears accumulation. In situations of repayment difficulties there is rarely room for a loss of reserves. Hence, the resources for external debt repayment must come either from increases in domestic debt or from money creation. As it is well known, both forms of finance face clear limitations with respect to the maximum amount of resources that can be collected.[4]

Therefore, repayment problems because of fiscal constraints occur whenever the required net transfers on external debt exceed the resources that can be obtained through domestic debt or money creation without generating domestic interest rates or inflation rates that undermine the stability of the

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[4] Buiter (1985), and Fischer and Easterly (1990) provide detailed discussions of the analytics of government budget constraints.

economy. Whenever debt repayment becomes too costly in domestic terms, arrears on external debt may become a temporary solution for closing the resource gap in the public sector accounts - at least until a rescheduling with external creditors may be negotiated, or reductions in the primary budget deficit can be implemented.

From equation (5), it can be inferred that external debt repayment also depends on the economy's ability to generate sizeable trade surpluses. In the absence of additional external finance, repayment problems due to external constraints will arise whenever the economy cannot produce trade surpluses of the same magnitude as the required net transfers. Controlling for the size of the external transfer, the likelihood of having a repayment problem because of external constraints will consequently be determined by variables such as the degree of openness of the economy, exchange rate management, and other standard determinants of the trade balance.

Equations (4) and (5) then describe the nature of the two constraints that must be met in order to implement debt repayment in an economy where the public sector undertakes all the external debt. As the discussion in this section indicates, in order to prevent repayment problems from arising, these two resource constraints have to be satisfied.[5] Therefore, the empirical

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[5] In addition to its ability to make payments, a country's repayment prospects will also depend on its willingness to meet its obligations. That, however, is essentially an unmeasurable variable and its omission in the empirical analysis can account for some of the variation in the dependent variable that cannot be explained by the other variables.

implementation of a model of repayment problems requires two regimes being specified: an internal (or fiscal) constraint and an external constraint. If any of the two constraints becomes binding, interruptions in debt service will take place.

Since the dependent variable, the occurrence of repayment problems, has a binary nature, standard econometric models cannot handle adequately empirical specifications that allow for dual constraints. The next section derives a statistical model appropriate for dealing with this problem.

3. A Model with Switching Regimes for Binary Dependent Variables

In this section, a model with two regimes for binary dependent variables is derived with a structure that allows for endogenous switching for one of the two values assumed by the dependent variable. Whenever the dependent variable takes a value of 1, thereby indicating that a given event is observed in the sample, the model takes into consideration that the corresponding observation can be explained by either one of the two regimes. This information is then used to estimate the coefficients in the equations representing the two regimes.

It is assumed that the dependent variable takes a value of 1, i.e. that an interruption in external debt service is observed, whenever external debt repayment becomes too costly. That, in turn, will take place when domestic

sources of finance are under strain, i.e., when any of the two resource constraints becomes binding.

The constraints associated with each one of the two regimes are described by the underlying response variables Y_i^* and W_i^*, defined by the following equations

$$(6)\quad Y_i^* = x_i'\beta + e_i$$

$$(7)\quad W_i^* = z_i'\delta + u_i$$

where ß and δ are k_1x1 and k_2x1 vectors of unknown parameters; x_i' is a $1xk_1$ vector of explanatory variables corresponding to a particular observation in the first regime; z_i' is a $1xk_2$ vector of explanatory variables corresponding to an observation in the second regime; and e_i and u_i are jointly distributed error terms, with zero means, variances σ_e^2 and σ_u^2 and covariance σ_{eu}.

Both Y_i^* and W_i^* are unobservable. Instead, we observe a dummy variable Y_i defined by

$$(8)\quad Y_i = 1 \quad \textit{if } Y_i^* > 0 \textit{ or } W_i^* > 0$$
$$0 \quad \textit{otherwise}$$

Therefore, $Y_i = 1$ is observed whenever Y_i^* or W_i^* are greater than some threshold level normalized to zero. A positive value for Y_i indicates that either one or both constraints are binding and since debt repayment becomes too costly whenever any resource constraint is binding, a country has stopped

servicing its external debt. From equations (6), (7), and (8), the probability of observing $Y_i = 1$ can be derived as

$$(9)\ Prob(Y_i = 1) = Prob(Y_i^* > 0) + Prob(W_i^* > 0) - Prob(Y_i^* > 0 \ \& \ W_i^* > 0)$$

$$= Prob(e_i > -x_i'\beta) + Prob(u_i > -z_i'\delta) - Prob(e_i > -x_i'\beta \ \& \ u_i > -z_i'\delta)$$

$$= Prob(\frac{e_i}{\sigma_e} < \frac{x_i'\beta}{\sigma_e}) + Prob(\frac{u_i}{\sigma_u} < \frac{z_i'\delta}{\sigma_u}) - Prob(\frac{e_i}{\sigma_e} < \frac{x_i'\beta}{\sigma_e} \ \& \ \frac{u_i}{\sigma_u} < \frac{z_i'\delta}{\sigma_u})$$

where the probability functions for e_i and u_i are assumed to be symmetric.

The observed values of Y_i are realizations of a binomial process in which the probabilities are given by (9). The probability that any particular value of Y_i is observed, is then given by

$$(10)\ Prob(Y_i = y_i) = Prob(Y_i = 0)^{(1-y_i)} \cdot Prob(Y_i = 1)^{(y_i)}$$

If e_i and u_i are jointly normally distributed, (9) can be written as

$$(11)\ Prob(Y_i = 1) = \Phi(\frac{x_i'\beta}{\sigma_e}) + \Phi(\frac{z_i'\delta}{\sigma_u}) - \Phi_2(\frac{x_i'\beta}{\sigma_e}, \frac{z_i'\delta}{\sigma_u}, \varrho)$$

where

$$(12)\ \Phi(u) = \int_{-\infty}^{u} \frac{1}{(2\pi)^{1/2}} \exp(-t^2/2)\, dt$$

denotes the distribution function of the standard normal, and ϱ is the correlation coefficient between e_i and u_i.

In the particular case in which the correlation between e_i and u_i is zero, the last term in equation (11) will just be the product of the two associated marginal distribution functions. Using (10) and (11), the log-likelihood function for a sample of n independent observations, in the more general case in which the error terms are not independently distributed, can be expressed as

$$(13)\ Log\ L = \sum_{i=1}^{n} (1-y_i) \left[1 - \Phi\left(\frac{x_i'\beta}{\sigma_e}\right) - \Phi\left(\frac{z_i'\delta}{\sigma_u}\right) + \Phi_2\left(\frac{x_i'\beta}{\sigma_e}, \frac{z_i'\delta}{\sigma_u}, \varrho\right) \right]$$

$$+ \sum_{i=1}^{n} (y_i) \left[\Phi\left(\frac{x_i'\beta}{\sigma_e}\right) + \Phi\left(\frac{z_i'\delta}{\sigma_u}\right) - \Phi_2\left(\frac{x_i'\beta}{\sigma_e}, \frac{z_i'\delta}{\sigma_u}, \varrho\right) \right]$$

From (12) and (13), it can be seen that, as in the case of a standard probit model, only the ratios $ß/\sigma_e$ and δ/σ_u can be estimated. The parameters ß and δ cannot be estimated separately from their variances. Therefore, in the estimation procedure the variances σ_e^2 and σ_u^2 are assumed to be equal to 1.

Differentiating (13) with respect to ß and to δ yields a set of first-order conditions. The values of ß and δ that solve these first order-conditions are the maximum likelihood estimates of the parameters in the model described by

equations (6), (7), and (8).[6] As in other maximum likelihood problems, the function in (13) has to be maximized by numerical methods, since its first derivatives are highly nonlinear functions of ß and δ.

After the maximum likelihood estimates of the parameters are obtained, they can be used for calculating the probabilities of regime classification for each one of the observations for which Y_i is equal to 1. For example, the probability that a particular observation is determined by equation (6), given that $Y_i = 1$ is observed, can be written as

$$(14)\ Prob\ [\ (\ Y_i^* > 0\ \&\ W_i^* \leq 0\ )\ |\ Y_i = 1\ ]$$

$$= \frac{Prob\ (\ Y_i^* > 0\ \&\ W_i^* \leq 0\ ,\ Y_i = 1\ )}{Prob\ (\ Y_i = 1\ )}$$

$$= \frac{Prob\ [\ Y_i = 1\ |\ (\ Y_i^* > 0\ \&\ W_i^* \leq 0\ )\ ]\ .\ Prob\ (\ Y_i^* > 0\ \&\ W_i^* \leq 0\ )}{Prob\ (\ Y_i = 1\ )}$$

$$= \frac{Prob\ (\ Y_i^* > 0\ \&\ W_i^* \leq 0\ )}{Prob\ (\ Y_i = 1\ )}$$

using Bayes' rule and the fact that the probability of observing $Y_i = 1$ conditional

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[6] Identification conditions for bivariate probit models have been discussed by Heckman (1976, 1978), and Amemiya (1978). Poirier (1980) derives the conditions under which the parameters of bivariate probit models with partial observability, like the one derived in this section, are identified. Global identification requires that at least one of the elements in ß can be distinguished from its corresponding element in δ. The loss of asymptotic efficiency of the parameter estimates in bivariate probit models with partial observability, relative to the full observability case, is discussed in Meng and Schmidt (1985).

on $Y_i^* > 0$ & $W_i^* \leq 0$ is equal to 1.

Finally, as with other models with limited dependent variables, the coefficients in the model derived here do not directly transform the explanatory variables into the probability of the event occurring. In order to obtain the effect on the dependent variable of a unit increase in an explanatory variable, one has to partially differentiate equation (11) with respect to the variable of interest and evaluate the resulting expression at given data values. Thus, the increase in the probability of the event occurring depends on the values of all the explanatory variables and their respective coefficients.

4. Model Implementation and Estimation Results

In the estimation of the model the matrix X_i of explanatory variables in the internal constraint [equation (6)] was designed with basis on proxies of the public sector's ability to collect revenues. The probability of occurrence of a repayment problem because of a high cost of satisfying the internal constraint was assumed to be a function of the following variables: the public or publicly guaranteed debt to GNP ratio (PUBLIC), the budget deficit of the consolidated public sector (BUDGET)[7], the average inflation rate in the last three years (INF),

[7] Due to the lack of comprehensive data on primary budget deficits for developing countries, overall public sector deficits were used in the estimations. See Blejer and Cheasty (1991) for a survey of the many alternative deficit measures.

the rate of growth of real GDP (RGDPGR), gross domestic savings as percent of GDP (GDS), and the real exchange rate (EXRATE).

Controlling for the other relevant variables, a large public external debt to GNP ratio should increase the probability of a repayment problem, since it requires a higher degree of mobilization of internal resources for debt service. The same happens with large budget deficits, which cause additional pressure on domestic sources of finance. The average inflation rate in the last three years is intended to serve as a proxy for the recent history of inflation in a country. In countries with a history of high inflation rates, people find ways of reducing their currency holdings and it becomes more difficult for the public sector to obtain resources through money creation. Consequently, this variable should be positively related to the probability of having a repayment problem. A higher rate of growth of GDP facilitates the collection of revenues through taxation, money creation, and domestic debt, and reduces the probability of a repayment problem due to fiscal constraints. The share of savings in GDP determines the availability of savings to be captured by the public sector through domestic debt. Therefore, it should be negatively related to the probability of having a debt repayment problem. Finally, an overvalued real exchange rate directly reduces the domestic cost of external debt service and should also reduce the probability of repayment problems because of fiscal constraints.

The explanatory variables in the matrix Z_i in equation (7), that intend to

capture the ability of the economy to transfer resources abroad, are the debt to exports ratio (DEBTEXP), the real exchange rate (EXRATE), the degree of openness of the economy (OPEN), the real interest rate (INT), the rate of change in the terms of trade (TOT), and the rate of growth of real GDP (RGDPGR).

A higher debt to exports ratio implies that substantial trade surpluses have to be achieved in order to maintain debt service. Hence, it increases the probability of repayment problems. With an overvalued real exchange rate it is more difficult to generate trade surpluses and the probability of repayment problems because of external constraints becomes higher. The degree of openness of the economy, improves the economy's ability to obtain trade surpluses and reduces the probability of debt repayment problems. Increases in the real interest rate, defined as the difference between the LIBOR and the annual rate of change in a country's export price index, are expected to raise the probability of having repayment problems. An improvement in the terms of trade should have a positive effect on a country's external accounts and, therefore, should reduce the probability of debt repayment problems. Finally, the rate of growth of real GDP should increase the probability of repayment problems since it tends to worsen the trade balance.

In order to convert trade deficits into substantial surpluses in a short period of time, large nominal exchange rate devaluations were undertaken in many developing countries after 1982 in order to target a more devalued level

of the real exchange rate. The statistical model developed in this paper presents an adequate tool for analyzing the effect of this real exchange rate targeting policy on the external debt repayment perspectives of highly indebted countries.

From equation (4), it can be inferred that real exchange rate devaluations have a perverse effect on the "transferring" economy by increasing the cost of external debt service in domestic currency. Unless the public sector itself is a very important exporter, as in the case of Mexico, for example, the net effect of real devaluations on the budget is likely to be negative. Rodrik (1990) derives a theoretical model where, as long as the non-traded goods sector is a net source of revenues for the public sector, real devaluations introduce a secondary burden for the domestic economy. In addition to the transfer itself, there is an additional burden represented by the deterioration of the internal terms of trade against the public sector.[8] Fiscal adjustment then becomes more costly.

Therefore, the real exchange rate variable, defined so that an increase in the index represents a real appreciation, should have a negative coefficient for the internal constraint and a positive coefficient for the external constraint. Similarly, the rate of growth of real GDP should have a negative coefficient in the internal constraint and, controlling for exports growth, a positive coefficient

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[8] Reisen (1989) also examines the fiscal effect of real exchange rate devaluations in the context of external debt service.

in the external constraint. These are results that can only be obtained in a model that allows for two different regimes through which the same variable can affect the probability of occurrence of a repayment problem.

In the estimation of the model, the occurrence of interest arrears on long-term debt was used as a proxy for the existence of a repayment problem. That differs from other econometric studies of repayment problems that use the occurrence of debt rescheduling as the dependent variable. The main reason for using arrears and not rescheduling as the dependent variable is that arrears arise naturally as a likely response of a fiscally or externally constrained economy to an increased cost of debt service. If the costs of using other financing alternatives for satisfying the public sector budget constraint or the costs of generating sizable trade surpluses to meet external debt service become too high, a country may choose to use arrears as an additional source of resources while a rescheduling is negotiated or more significant policy actions are undertaken.

Another motivation for using arrears and not debt rescheduling is that the latter is not a very accurate source of information about repayment problems for empirical studies that use time-series data. The information on "Debt Relief Agreements", regularly published in the World Banks' World Debt Tables, classifies the reschedulings according to the date in which the agreements between countries and their creditors are signed. However, in many situations a rescheduling agreement is the final outcome of a long process initiated when

the country began having difficulties to fully service its debt. In other situations, a rescheduling agreement is not an indication of the emergence of a new repayment problem but a symptom that a former rescheduling was not achieved on a realistic basis. Interest arrears on long-term debt, on the other hand, are registered according to the year in which they occur and recently have started being published in the World Debt Tables.

A potential drawback in using arrears as a proxy for repayment problems is that the World Bank data identifies only the stock of interest arrears on long-term debt. Therefore, countries that have principal in arrears or any type of arrears in respect of short-term debt end up being regarded as without having any problems. For that reason, the occurrence of a rescheduling was used as a proxy for repayment problems for the few countries in the sample that rescheduled their debt during the 1980s but do not show any interest arrears in the World Bank data. In order to establish the precise timing of the repayment problems of these countries and deal with the potential shortcomings that arise when reschedulings are used, the information from the World Debt Tables was combined with additional information obtained in country studies.

The statistical model described by equations (6), (7), and (8) was estimated using a pooling of cross-section and time-series data for the period of 1979 to 1990. During these years most developing countries were not able to borrow on a voluntary basis on international capital markets and had to

finance external debt service out of domestic resources. After 1991, the access to international capital markets was reestablished for many countries and, for that reason, the analysis in this paper, which applies to a credit constrained economy with a binding credit constraint, refers to the earlier period. The sample consists of 31 middle-income developing countries for which it was possible to obtain consistent information on the budget deficit variable. Table 1 presents the means of the explanatory variables in the two constraints for all countries in the sample. The appendix describes the sources and presents the definitions of all variables used in the estimations.

Given that the equations which motivated the specification of the two constraints (equations 4 and 5) were derived from accounting identities, the explanatory variables were all lagged by one period in order to deal with their potential simultaneity with the dependent variable. Therefore, the model is estimated for repayment problems that occurred between 1980 and 1990.

Table 2 presents the results of the maximum likelihood estimation of equation (13) for the case in which the error terms in the two equations are not correlated.

Model 1 displays the results for the baseline switching regimes' model. Almost all the estimated coefficients in the equations describing the two resource constraints have their hypothesized signs, and many of them are statistically different from zero at high confidence levels. The only coefficient that does not have the expected sign is the coefficient on the rate of change

Table 1

Means of the Explanatory Variables, 1979-1989[1].

Country	PUBLIC	BUDGET	INF	RGDPGR	GDS	EXRATE	DEBTEXP	OPEN	INT	TOT
Argentina	0.45	-9.18	347.69	-0.10	18.19	110.13	5.30	0.13	7.48	-1.25
Bolivia	1.01	-10.70	1258.68	-0.45	10.97	83.95	4.26	0.27	8.69	-2.29
Brazil	0.26	-4.82	200.37	3.38	22.33	131.00	4.16	0.08	8.73	-0.47
Chile	0.52	0.06	26.19	4.02	16.59	105.53	2.77	0.28	3.73	0.80
Colombia	0.25	-4.55	23.23	3.59	20.47	103.43	1.79	0.16	12.06	-5.54
Cote d'Ivoire	0.74	-8.99	8.18	0.90	20.15	123.97	2.71	0.38	11.62	-3.17
Dominican Rep.	0.43	-5.23	17.04	3.05	17.31	151.65	1.40	0.32	8.49	-2.19
Ecuador	0.62	-3.60	26.56	2.69	22.31	86.48	2.82	0.24	7.50	-0.35
Honduras	0.60	-8.56	7.69	2.58	13.57	97.98	1.93	0.35	7.78	-0.25
India	0.15	-7.76	8.61	4.75	20.83	98.81	1.61	0.09	6.00	0.48
Indonesia	0.33	-1.35	10.42	5.74	32.02	104.65	1.64	0.23	3.88	0.97
Jamaica	1.06	-12.60	18.15	0.25	15.42[2]	125.50	1.79	0.60	6.88	-0.61
Kenya	0.42	-5.84	11.18	4.55	19.77	92.19	1.66	0.31	9.87	-1.06
Korea	0.23	-1.97	9.93	8.02	30.85	114.36	0.78	0.36	6.52	-0.31
Malawi	0.71	-8.15	17.21	2.33	11.69	95.28[3]	2.22	0.33	8.80	-2.97
Malaysia	0.41	-9.43	3.87	6.10	33.45	95.60	0.85	0.58	7.62	-1.71
Mexico	0.39	-5.94	61.68	2.75	25.02	87.45	3.83	0.12	6.58	-0.56
Morocco	0.82	-8.71	8.35	4.31	15.52	106.04	2.72	0.31	8.95	-2.14
Nigeria	0.41	-6.25	19.06	0.72	15.34	62.31	2.38	0.18	5.49	1.22
Panama	0.79	-6.01	3.96	2.14	19.59	100.37	2.06	0.41	5.69	2.66
Paraguay	0.34	-2.35	19.82	4.70	16.70	92.51	1.34	0.26	7.07	-1.69
Peru	0.45	-6.48	222.09	0.70	24.51	135.05	2.94	0.18	6.21	-2.79
Philippines	0.39	-4.06	14.95	2.44	20.17	98.33	1.99	0.24	6.20	0.21
Sierra Leone[4]	0.40	-8.42	55.50	1.67	6.75	73.62	1.92	0.24	12.43	-3.81
Sri Lanka	0.45	-10.12	12.28	4.42	12.86	99.76	1.18	0.41	8.27	-1.57
Thailand	0.19	-5.35	6.45	7.14	22.61	105.40	0.88	0.30	8.09	-2.94
Turkey	0.36	-6.45	49.56	3.92	18.55	104.17	1.88	0.20	3.49	-1.05
Venezuela	0.31	-0.31	16.75	-0.06	26.52	90.00	2.08	0.21	3.32	5.21
Zaire	0.58	-4.18	59.53	1.59	14.09	165.16	2.45	0.23	4.83	1.23
Zambia	1.22	-14.53	27.84	0.96	14.15	102.60	3.10	0.39	2.38	3.30
Zimbabwe	0.29	-11.41	12.94	4.39	18.81	101.45	1.04	0.29	8.31	-2.03
Countries with problems[5]	0.56	-6.69	104.86	2.21	17.58	105.12	2.53	0.27	7.47	-0.78
Countries without problems	0.30	-6.06	14.45	5.73	24.45	103.25	1.26	0.31	6.27	-0.87
All Countries	0.51	-6.50	99.42	2.95	19.34	102.90	2.24	0.28	6.78	-0.74

1. See the appendix for sources and definitions.
2. 1979-1988.
3. 1980-1989.
4. The means of DEBTEXP, and OPEN refer to 1979-1988.
5. Countries with interest arrears on long-term debt on any year during the 1979-1980 period, or countries without arrears but with reschedulings during the same period.

Table 2

Maximum Likelihood Estimates of the Coefficients in the Model with Two Regimes, 1980-1990.

Variable	1	2	3	4
- Internal Constraint -				
CONSTANT	3.059 (3.260)	3.539 (3.291)	2.975 (2.143)	2.316 (1.750)
PUBLIC	2.067 (4.190)	1.792 (3.515)	1.844 (2.729)	1.668 (2.683)
BUDGET	0.551 E-02 (0.237)	-	0.111 E-02 (0.034)	-
INF	0.115 E-03 (0.022)	-	-0.961 E-02 (-0.929)	-
RGDPGR	-0.082 (-3.738)	-0.069 (-3.036)	-0.073 (-2.398)	-0.057 (-2.294)
GDS	-0.064 (-3.120)	-0.071 (-2.985)	-0.057 (-1.698)	-0.051 (-1.552)
EXRATE	-0.026 (-3.898)	-0.030 (-3.811)	-0.038 (-3.852)	-0.034 (-3.793)
LA	-	-	1.183 (2.817)	1.251 (2.760)
AF	-	-	2.175 (4.538)	2.173 (4.300)
- External Constraint -				
CONSTANT	-7.061 (-2.940)	-5.433 (-3.616)	-5.071 (-3.818)	-5.149 (-5.125)
DEBTEXP	0.702 (3.170)	0.700 (4.446)	0.680 (4.897)	0.663 (5.713)
EXRATE	0.039 (2.959)	0.028 (3.343)	0.027 (3.696)	0.026 (4.125)
OPEN	-3.491 (-0.900)	-	-2.351 (-0.907)	-
INT	0.039 (1.037)	-	0.025 (1.226)	-
TOT	0.014 (0.338)	-	-0.877 E-03 (-0.034)	-
RGDPGR	0.103 (1.446)	-	0.030 (0.644)	-
Log likelihood	-142.400	-145.732	-122.779	-125.616
Number of observations	332	332	332	332
Number of positive obs.	190	190	190	190

Asymptotic T-statistics in parentheses.

in the terms of trade variable. However, it is not statistically significant. Similar results were obtained for the other three specifications in Table 2, which introduce changes in the original set of explanatory variables used in the baseline model.

The explanatory variables that do not have coefficients significantly different from zero in model 1 were dropped from the two equations in model 2. The exclusion of these variables, however, does not substantially alter the results obtained for model 1.

In order to control for possible region specific effects, dummy variables for Latin-American (LA) and African (AF) countries were used as additional explanatory variables in the fiscal constraints equation in model 3. The coefficients for the region dummies are highly significant, and the results for the other explanatory variables remain basically the same when they are added to the baseline model. The coefficient on the average inflation rate does not have the expected sign but it is not statistically significant.

The results obtained for the coefficient on the average inflation rate might be reflecting the fact that the negative effect of inflation on seignorage revenues through reduced money holdings can be compensated by a positive effect through a higher inflation tax.

Finally, model 4 combines models 2 and 3 and adds region dummies to the model that excludes the non statistically significant variables. As before, there are no substantial changes in the results.

For all the specifications shown in Table 2, likelihood ratio tests strongly reject the null hypothesis of all coefficients, except a constant term, being equal to zero.

A central econometric result of this paper is obtained in the four different specifications presented in Table 2: the estimated coefficients of the real exchange rate variable have opposite signs in the two constraints and are significantly different from zero at high confidence levels. A likelihood ratio test rejects at very high significance levels the null hypothesis that the coefficients on the exchange rate variable are the same in both constraints. The estimated coefficients for the rate of growth of real GDP also have the expected signs in each of the constraints. However, the coefficient for the external constraint is not significantly different from zero at standard confidence levels.

According to the previous discussion, an overvalued real exchange rate increases the probability of a repayment problem because of external constraints and reduces the probability of a repayment problem because of fiscal constraints. In the first case, it becomes harder to generate sizable trade surpluses; in the second, an overvalued exchange rate has a favorable impact since real devaluations increase the cost of external debt service in domestic currency.

In contrast, if a model with a single regime is used to estimate the probability of occurrence of a repayment problem, a different sort of statistical inference is obtained about the real exchange rate. Table 3 presents the

Table 3

Single Regime Model[1].

Variable	Maximum Likelihood Estimate
CONSTANT	0.875 (1.484)
PUBLIC	2.937 (3.935)
BUDGET	0.056 (0.266)
INF	0.032 (1.212)
RGDPGR	-0.034 (-1.652)
GDS	-0.054 (-3.601)
EXRATE	0.008 (0.314)
DEBTEXP	-0.068 (-0.041)
OPEN	-3.853 (-2.830)
INT	0.063 (0.745)
TOT	0.025 (0.250)
Log likelihood	-154.499
Number of observations	332
Number of positive observations	190

1. Probit model with all explanatory variables from model 1 in Table 2. Asymptotic T-statistics in parentheses.

estimation results for a probit model using all explanatory variables from model 1 in Table 2. The coefficient on the real exchange rate turns out to be positive, but it is not significantly different from zero at standard confidence levels. Therefore, if a model with a single regime is estimated, the results could lead one to conclude that the real exchange rate is not an important determinant of external debt repayment problems.

Table 4 presents the effect on the dependent variable of unit increases in the explanatory variables, obtained by evaluating the partial derivatives of equation (11) at the sample means. The results show that, controlling for the other explanatory variables, a real exchange rate devaluation increases the probability of a debt repayment problem in the fiscal constraint by more than the amount the same probability is reduced in the external constraint. The immediate implication of this result is that the net effect of real exchange rate devaluations in developing countries is likely to be an increase in the probability of external debt repayment problems.

Finally, the estimated coefficients from the four models in Table 2 were used to calculate probabilities of regime classification for all the repayment problems observed in the sample. Tables 5 to 8 present the average probabilities of regime classification for each country that had repayment problems during the 1980-1990 period. The results indicate that for most of the countries in the sample, the observed repayment problems are, on average, more likely to be related to fiscal (or internal) than to external constraints.

Table 4

Effect on the Dependent Variable of Unit Increases in the

Explanatory Variables, for Model 1 in Table 2[1].

Variable	
- Internal Constraint -	
CONSTANT	1.161
PUBLIC	0.785
BUDGET	0.002
INF	4.385 E-05
RGDPGR	-0.031
GDS	-0.024
EXRATE	-0.010
- External Constraint -	
CONSTANT	-0.333
DEBTEXP	0.033
EXRATE	0.002
OPEN	-0.165
INT	0.002
TOT	0.001
RGDPGR	0.005

1. Partial derivatives of equation (6) with respect to each explanatory variable (conditional on being in a particular regime), evaluated at the sample means.

Table 5

Average Probabilities of Regime Classification for Countries with

Repayment Problems during the 1980s for Model 1 in Table 2.

Country	Probability of Internal Constraints	Probability of External Constraints	Probability of Both Internal and External Constraints
Argentina	0.217	0.266	0.517
Bolivia	0.734	0.003	0.263
Brazil	0.028	0.863	0.109
Chile	0.329	0.295	0.376
Colombia	0.852	0.113	0.035
Cote d'Ivoire	0.739	0.089	0.172
Dominican Republic	0.397	0.600	0.003
Ecuador	0.854	0.054	0.092
Honduras	0.976	0.006	0.018
Jamaica	0.857	0.111	0.032
Kenya	0.969	0.020	0.011
Malawi	0.943	0.023	0.034
Mexico	0.505	0.339	0.156
Morocco	0.868	0.025	0.107
Nigeria	0.943	0.031	0.026
Panama	0.988	0.004	0.008
Paraguay	0.862	0.108	0.030
Peru	0.262	0.643	0.095
Philippines	0.872	0.097	0.031
Sierra Leone	0.980	0.007	0.013
Venezuela	0.711	0.199	0.090
Zaire	0.521	0.463	0.016
Zambia	0.931	0.020	0.049
Zimbabwe	0.977	0.017	0.006

Table 6

Average Probabilities of Regime Classification for Countries with Repayment Problems during the 1980s for Model 2 in Table 2.

Country	Probability of Internal Constraints	Probability of External Constraints	Probability of Both Internal and External Constraints
Argentina	0.105	0.321	0.574
Bolivia	0.464	0.013	0.523
Brazil	0.020	0.892	0.088
Chile	0.192	0.361	0.447
Colombia	0.789	0.152	0.059
Cote d'Ivoire	0.365	0.277	0.358
Dominican Republic	0.348	0.622	0.030
Ecuador	0.744	0.095	0.161
Honduras	0.860	0.035	0.105
Jamaica	0.663	0.159	0.178
Kenya	0.879	0.078	0.043
Malawi	0.778	0.045	0.177
Mexico	0.315	0.389	0.295
Morocco	0.628	0.076	0.296
Nigeria	0.912	0.015	0.073
Panama	0.808	0.046	0.146
Paraguay	0.783	0.171	0.046
Peru	0.149	0.746	0.104
Philippines	0.724	0.174	0.102
Sierra Leone	0.910	0.022	0.068
Venezuela	0.637	0.270	0.093
Zaire	0.416	0.493	0.091
Zambia	0.603	0.097	0.300
Zimbabwe	0.893	0.070	0.037

Table 7

Average Probabilities of Regime Classification for Countries with Repayment Problems during the 1980s for Model 3 in Table 2.

Country	Probability of Internal Constraints	Probability of External Constraints	Probability of Both Internal and External Constraints
Argentina	0.062	0.877	0.060
Bolivia	0.403	0.434	0.164
Brazil	0.001	0.991	0.008
Chile	0.160	0.461	0.379
Colombia	0.685	0.215	0.100
Cote d'Ivoire	0.558	0.066	0.375
Dominican Republic	0.374	0.614	0.012
Ecuador	0.662	0.127	0.211
Honduras	0.896	0.028	0.075
Jamaica	0.803	0.163	0.033
Kenya	0.932	0.017	0.051
Malawi	0.856	0.013	0.130
Mexico	0.236	0.493	0.271
Morocco	0.713	0.010	0.276
Nigeria	0.860	0.015	0.126
Panama	0.900	0.026	0.074
Paraguay	0.734	0.219	0.047
Peru	0.056	0.912	0.033
Philippines	0.471	0.474	0.056
Sierra Leone	0.906	0.015	0.079
Venezuela	0.547	0.320	0.133
Zaire	0.467	0.471	0.061
Zambia	0.806	0.022	0.172
Zimbabwe	0.955	0.015	0.030

Table 8

Average Probabilities of Regime Classification for Countries with Repayment Problems during the 1980s for Model 4 in Table 2.

Country	Probability of Internal Constraints	Probability of External Constraints	Probability of Both Internal and External Constraints
Argentina	0.107	0.352	0.541
Bolivia	0.463	0.026	0.511
Brazil	0.020	0.895	0.086
Chile	0.180	0.425	0.396
Colombia	0.777	0.157	0.067
Cote d'Ivoire	0.443	0.108	0.448
Dominican Republic	0.336	0.631	0.032
Ecuador	0.737	0.090	0.173
Honduras	0.835	0.053	0.112
Jamaica	0.643	0.182	0.175
Kenya	0.923	0.022	0.055
Malawi	0.790	0.015	0.195
Mexico	0.330	0.361	0.310
Morocco	0.659	0.018	0.323
Nigeria	0.915	0.006	0.080
Panama	0.787	0.057	0.156
Paraguay	0.755	0.200	0.045
Peru	0.142	0.761	0.097
Philippines	0.402	0.535	0.063
Sierra Leone	0.915	0.007	0.078
Venezuela	0.646	0.250	0.104
Zaire	0.431	0.466	0.104
Zambia	0.639	0.040	0.321
Zimbabwe	0.934	0.018	0.048

For the baseline model, the only countries that are classified as externally constrained are Brazil, Dominican Republic, and Peru. Argentina and Chile are classified as both internally and externally constrained. When the baseline model is changed, the probabilities of regime classification remain fairly consistent. The most notable exceptions occur with Bolivia, that moves from internally to externally constrained when region dummies are added to the baseline model, and Philippines, that has a similar change in both models with region dummies. In addition, some borderline cases such as Mexico and Zaire move from being internally to externally constrained.

Therefore, the econometric results obtained in the empirical analysis - both with the estimation of the coefficients in the switching regimes' model and with their use to calculate probabilities of regime classification - give support to the hypothesis that fiscal constraints play a significant role in explaining interruptions in external debt service by developing countries.

5. Conclusions

This paper has derived and tested a statistical model designed for dealing with dual regimes in the presence of binary dependent variables. The application of the model to the dual resource transfer problem of developing countries' external debt indicates that both fiscal and external constraints explain the occurrence of interest arrears in a sample of middle-income

developing countries during the 1980s. In fact, the probabilities of regime classification calculated with the estimated coefficients of the model suggest that many countries that experienced debt service difficulties during the period were, on average, more likely to be fiscally than externally constrained.

In addition, the econometric analysis shows that policy measures designed to assure that the economy implements an external transfer may end up increasing the probability of repayment problems because of fiscal constraints in economies with public external debts. The results obtained for the real exchange rate, with highly significant coefficients with the opposite signs in each constraint, certainly suggest that this can be the case.

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DATA APPENDIX

Sources and definitions of the data series used in the paper:

Dependent Variable: if a country had interest arrears on long-term debt in a particular year, a value of 1 was assigned to the observation; a value of 0 was assigned to the non-arrears observations. Data from World Debt Tables 1991-92, Data on Diskette.

Public or Publicly Guaranteed Debt to GNP Ratio (PUBLIC): ratio of year-end public and publicly guaranteed debt outstanding and disbursed, to Gross National Product. All Data from World Debt Tables 1991-92, Data on Diskette.

Consolidated Public Sector Budget Deficit (BUDGET): overall budget balance as % of Gross Domestic Product. Data from Easterly and Schmidt-Hebbel (1991), except for the following observations: all years for Panama, and 1989 for Argentina, Ecuador, and Peru (Inter-American Development Bank, Economic and Social Progress in Latin America, 1990 Report); 1989 for Brazil (Banco Central do Brasil, Brasil: Economic Program); 1986 for Korea (Collins and Park, 1989); and 1989 for Korea (Korea Statistical Yearbook). For the cases in which it was not possible to obtain the budget balance figures, a standard technique was used for dealing with missing values. They were forecasted by the following regression of the budget balance variable on the other explanatory variables:

Method of estimation = Ordinary Least Squares

Dependent variable: BUDGET
Number of observations: 323

Mean of dependent variable	= -6.5464	Adjusted R-squared	= .26874
Std. dev. of dependent var.	= 5.0948	Durbin-Watson statistic	= .61013
Sum of squared residuals	= 5979.0	F-statistic (zero slopes)	= 17.905
Variance of residuals	= 18.981	Schwarz Bayes. Info. Crit.	= 3.0615
Std. error of regression	= 4.3567	Log of likelihood function	= -929.63
R-squared	= .28464		

Variable	Estimated Coefficient	Standard Error	t-statistic
C	-4.4346	1.5874	-2.7936
PUBLIC	-0.2031	1.3585	-0.1495
EXPGR	0.0465	0.0153	3.0335
RGDPGR	0.1725	0.0575	2.9977
GDS	0.1686	0.0403	4.1813
EXRATE	-0.0146	0.7760E-02	-1.8871
DEBTEXP	-0.3462	0.3053	-1.1341
OPEN	-13.7780	3.2186	-4.2807

Average Inflation Rate (INF): average of the yearly rate of change in the Consumer Price Index during the last three years. Data from World Bank (1992).

Rate of Growth of Real GDP (RGDPGR): yearly growth in real GDP. Data from World Bank (1991).

Gross Domestic Savings (GDS): gross domestic savings as % of Gross Domestic Product. Data from World Bank (1991).

Real Exchange Rate (EXRATE): multilateral effective real exchange rate index, 1985 = 100, constructed as a weighted average of the country's bilateral exchange rate with respect to its 10 most important trading partners for which it was possible to obtain price data. The choice of trading partners was based on average export weights over the 1983-1985 period. Consumer price index and nominal exchange rate data are from IMF's International Financial Statistics. Data on exports to each of the trading partners were obtained from IMF's Direction of Trade Statistics, 1990 Yearbook.

Debt to Exports Ratio (DEBTEXP): ratio of year-end long-term debt outstanding and disbursed to exports of goods and non-factor services in the same year. Debt figures are from World Debt Tables 1991-92, Data on Diskette. Exports from World Bank (1991), except for 1990 exports that are from International Financial Statistics.

Degree of Openness of the Economy (OPEN): average of exports and imports of goods and non-factor services as % of Gross National Product. Exports and Imports data from World Bank (1991a), except for 1990 data that are from International Financial Statistics. Gross National Product figures are from World Debt Tables 1991-92, Data on Diskette.

Real Interest Rate (INT): difference between the London interbank offered rate (LIBOR) and a export price index. LIBOR figures from IFS. Export price index from World Bank (1992).

Rate of Change in the Terms of Trade (TOT): annual change in the terms of trade. Data from World Bank (1992).

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