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A Qualitative Response Analysis

Abstract*: The global financial unrest over the last decade has shifted the attention of banking regulators (Basel II, 2001) in estimating default probabilities for a variety of borrowers. Within a binary choice panel data framework, the current study analyzes various models and cross-examines their performance in identifying financial crises in emerging markets. Using financial ratios, macroeconomic variables, and international factors, the paper identifies a set of warning indicators and discriminates among the three estimators employed. The most important determinants of commercial/official arrears and reschedulings are the debt-to-GDP ratio, inflation, trade liberalization, and the variability of GNP per capita growth. In addition to that, changes in financial flows from foreign investors do affect default frequencies, while external developments are found to be insignificant. Cross-modeling comparison indicates the presence of different exogenous risk factors, depending on the approach employed. Further analysis indicates the presence of heterogeneity, but pertinent estimators fail to perform well. Unlike the fixed- and random-effects estimators, the pooled-logit model yields the minimum number of misclassifications. When past credit performance is taken into account, the significance of some signals is reduced, but the model's misclassification performance is markedly enhanced.*

Key words: *credit risk, international lending, panel data estimation, sovereign default.*

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The recent emerging market crises have sparked a notable wave of attention to the determinants of international lending. In many regions, through a spillover mechanism, various countries have experienced at least one serious bout of financial trouble over the past fifteen years. Such economic turmoil has caused enormous problems for U.S. banks lending to Eastern Europe, Latin America, and Asia (Saunders and Cornett 2003). The January 2001 proposal for a new Basel Capital Accord[1] has renewed the interest in obtaining loan default probabilities. Banks are expected to apply the new risk management concepts not only to domestic borrowers, but also to international lending in the next few years. Although not yet extensively dealt within the Basel II proposal, country and transfer risk are major sources of credit risk in international lending.[2] Multinational banks still remember the major and long-lasting effects of the 1980s, which led various banks to increase their loan-loss reserves, with Citicorp alone setting aside $3 billion (Grammatikos and Saunders 1990). For the standardized Basel II approach, sovereign ratings by credit-rating agencies are expected to play an important role in the measurement of credit risk. The quality of sovereign ratings, however, has received much criticism, particularly for emerging markets, and following the East Asian financial crisis.

Emerging markets have increased their borrowing from the West considerably in order to modernize their economies and improve the competitiveness of their goods in Western markets. The degrees of liberalization of convertible-currency imports and borrowing in the individual countries differed depending upon internal political choices. In the late 1970s and early 1980s, it was expected that the resulting debts would be repaid through increased exports. However, economic mismanagement, the oil price shocks, and the weaknesses of the international lending system led to serious debt problems. Eastern Europe's aggregate gross convertible-currency debt grew rapidly, increasing from $8 billion in 1970 to $77 billion in 1979, peaking at $93 billion in 1983. Poland and Romania suspended payments in 1981, while Hungary and the former Democratic Republic of Eastern Germany experienced serious liquidity crises in 1982. The Eastern European debt problem marked the beginning of an international debt crisis that, by the end of 1982, had engulfed many other countries, especially in Latin America. Regulators have become painfully aware of the potential risk exposure, through international lending, to emerging markets. In 1983, the U.S. Congress responded to the crisis by passing the International Lending Supervision Act, which subsequently led to an increase of the ratio of bank capital to international loans.[3]

In the early 1990s, the European and Central Asian debt alone was $220 billion, reaching $486 billion in 1999. The role of early warning indicators of financial crises and contagion has been the subject of analysis in many recent studies (Chang and Velasco 2000; Detragiache and Spilimbergo 2001; Kalotychou 2004; Kalotychou and Staikouras 2004a, 2004b; Moghadam and Samavati 1991; Somerville and Taffler 1995). As sovereign lending continues to be a major concern for multinational banks and economic policy makers, this paper launches an

investigation into the determinants and a cross-modeling analysis of sovereign credit risk. There are a number of reasons why sovereign default merits particular attention. First, financial crises have serious consequences for the local economies and their future welfare. Second, there are inevitable spillover effects on other countries due to the integration of international financial markets. Third, major banking problems (or even failures) in developed economies, due to international lending, are presumed to generate serious negative externalities.[4] Fourth, sovereign analysis is a screening device for assessing capital budgeting/financing decisions and monitoring the performance of existing loans and other investments (e.g., debt and equity claims).[5] Fifth, research in this area could help organizations such as the International Monetary Fund (IMF) and the World Bank to effectively support countries exhibiting signs of financial unrest or even prevent crises. Finally, it is sensible that foreign direct investment in emerging markets is necessary for the prosperity and welfare of global financial markets.

Financial institutions use default probabilities to feed their value-at-risk models, to price loans, and to determine concentration limits. The Basel II proposal will allow banks to use default rates to determine the regulatory capital against their credit exposure. Therefore, sovereign crises play a crucial role in international capital allocation. The problem they face, however, is the nonavailability of sovereign default probabilities. Moreover, the importance of sovereign risk analysis was recently emphasized by U.S. economist Kristin Forbes (MIT, U.S. Treasury), speaking at a 2001 IMF economic forum, "What we should care about and what I would like to see more work go into is models predicting things such as external financing difficulties and financial systems vulnerabilities, just as a few examples."[6] Thus, the overarching objective of the present work is to empirically investigate the risk factors of sovereign creditworthiness. More specifically, the paper aims to contribute to the literature by (1) identifying a set of relevant systemic factors that have been associated with the most recent financial unrests, (2) bringing previous research and empirical findings into the current analysis, (3) comparing different estimators in terms of the risk signals they propose, and (4) contrasting the performance of those estimators in identifying debt crises. The latter is important, as the literature is deficient in evaluating the performance of various modeling frameworks. By addressing the above issues, the paper intends to add further evidence to the existing research.

A Brief Review on Sovereign Risk

Despite various financial unrests, sovereign ratings were overall slightly more stable in 1999 than the historical average. Looking back, three different regimes can be identified over the last two decades. The deterioration of the external debt-servicing capacity of less-developed countries accelerated throughout 1981–92, peaked around 1993, and then remained stable but at very high levels to the end of the decade. The phenomenon is apparent when studying the proportion of countries

experiencing some sort of repayment difficulties. A graphical illustration of arrears and external debt is presented in Appendix A. It is obvious from Figures A1 and A2 that the three regions examined in this paper (Eastern Europe, Southeast Asia, Latin America) have experienced considerable changes in their debt obligations. Toward the end of the last decade, a number of sovereigns, such as Ecuador, Indonesia, Pakistan, Argentina, and Russia, experienced serious financial problems. The lattermost is probably one of the most striking examples of how political power can be connected to the distribution of economic rewards in a new market-based economy. The events of the 1990s and the misjudgment of credit-rating agencies have brought the topic of sovereign risk analysis to the forefront of academic and policy conclusions.

The necessity of systematic factors driving a country's external debt repayment capacity was first mentioned by Avramovic (1958; 1964), whose analysis established a key set of short-term liquidity and long-term macroeconomic attributes. Subsequently, other researchers employed discriminant analysis identifying liquidity signals and long-term economic and growth indicators (Abassi and Taffler 1984; Frank and Cline 1971). The logit function was first employed by Feder and Just (1977) to reinvestigate the significance of the various signals reported by others. Feder et al. (1981) were the first to introduce the element of arrears on interest/principal in their definition of default, which was later adapted by various studies. Studies representing the so-called ability-to-pay (or credit rationing) approach try to derive the binary-dependent variable as well as the relevant signals from theoretical models (Hajivassiliou 1987, 1989; McFadden et al. 1985). They modeled the occurrence of a debt-servicing difficulty as a situation of disequilibrium in international credit markets, where the demand for new loans exceeds the supply at the upper ceiling at which bankers are willing to lend.[7] Heffernan (1985) identified factors for the demand and supply of sovereign loans, and within that framework, credit rationing and default probabilities are discussed. Lee (1991), on the other hand, applied a "willingness-to-pay" approach, pioneered by Eaton and Gersovitz (1981) and Eaton et al. (1986). Under this scenario, despite that the resources are available to honor any debt obligations, the borrower decides to declare default. Retracting on debt-service obligations is modeled as a function of the discounted utility of consumption at each payment period. A detailed review of the theory and modeling of sovereign risk can be found in Saini and Bates (1984), Eaton et al. (1986), and Staikouras (2005). Elsewhere, various economic fundamentals were found to explain a large amount of the variation in credit rating (Haque et al. 1996). Aylward and Thorne (1998) sought to distinguish between IMF financing and other creditors, while the effect of macroeconomic volatility shocks was considered by Catao and Sutton (2002).[8] The aforementioned studies are by no means exhaustive, and a plethora of other papers can be found in their references. They clearly indicate, however, the various aspects and implications of sovereign risk analysis for financial institutions, sovereign borrowers, and national planning.

Data and Methodology

This section discusses issues related to the empirical tools and data employed to analyze determinants of sovereign crises. The description of the data is first introduced, followed by the definition of the dependent variable. Then, the methodology of modeling sovereign default is briefly presented. The empirical work is based on annual data for 20 emerging markets spanning the time period between 1990 and 2000. A balanced sample of countries from the three regions is employed—eight East European (EE), six Southeast Asian (SEA), and six Latin American (LA) countries. The sample includes a relatively diverse set of economies, each of which had to experience some sort of volatility in honoring its external debt obligations in order to qualify for this research. Each country is then represented by the binary variable, indicating cases of default and nondefault, as well as by a set of factors that explain these two cases. Annual data on external debt are obtained from the 2001 electronic version of the World Bank's Global Development Finance (GDF) report. They comprise data on total external debt, arrears on principal and interest to official and private creditors,[9] and reschedulings of principal to official and private creditors. Data on macroeconomic and financial variables are extracted from the 2001 electronic version of the World Bank's World Development Indicators (WDI) database. The selection of variables is mainly guided by the theory underlying sovereign risk so as to cover a wide range of indicators from five categories, such as (1) debt ratios, (2) financial and trade resources, (3) domestic economic conditions and performance, (4) financial flows, (5) external developments (international factors), and (6) credit history. The wide selection of risk factors is also driven by the need for cross-study analysis, where necessary, which will provide us with a better insight, and by the fact that different regions exhibit different characteristics. A more detailed description of the data, along with some graphical illustrations, are presented in Appendixes B and C, respectively. Looking at the graphs, SEA exhibits major changes around the 1997 crisis. Among the three regions, EE seems to be the most liberalized based on the trade-to-GDP ratio. Furthermore, EE seems to experience the highest output variability, while the net bond flows in LA have a quite erratic pattern. All these variables are expected to exert some influence in determining the credit standing of a sovereign state.

Another technical aspect worth noting is the definition of the dependent variable. Credit-rating agencies and the literature on international lending usually consider debt arrears and reschedulings as the main incidents that trigger default. Earlier studies have mainly concentrated on rescheduling as the key indication of credit-quality decline. The present study makes use of the following two conditions as indications of default: (1) accumulated arrears as a proportion of total external debt that exceeds a certain threshold,[10] and (2) a debt-rescheduling agreement with official and/or private creditors is established.[11] The latter serves the purpose of including cases where debtor countries avoided falling into arrears by early re-

questing the rescheduling of their debt obligations. In this case, the rescheduling technically occurs independently of arrears. Accumulated arrears are set as country-specific figures rather than employing a universal threshold. An adaptation of a common limit would be problematic in the sense that it maps the credit performance of a country to that of the rest of the sample. The threshold is set equal to the ratio's mean value over the sample period. The above criterion has a quite distinctive rationale behind it. A country-specific boundary facilitates consideration that small amounts of debt in arrears may occur out of short-term illiquidity or shocks in the availability of foreign exchange to a financially sound borrower, which do not endanger international credit markets.[12] Besides, in some cases, the share of debt in arrears is negligible compared to the total outstanding debt of the particular country. Furthermore, one needs to recognize that some countries may be under distress for a considerable amount of time. In these cases, economic indicators are quite stagnant, and by incorporating them in the analysis, they might undermine the significance of variables whose deterioration is generally acknowledged to be important in anticipating crises. Thus, country-specific thresholds aim to avoid default episodes of such nature. The last argument is very important in the sense that since analysts are interested in analyzing crises, the default definition should reflect only new episodes and not perpetuating ones.

The next step is a brief description of the methodology used to identify any significant risk signals. The logit model employed in this study is formulated as follows:

$$Pr\left(y_t = 1\right) = \left[1 + \exp\left(-x_t'\beta\right)\right]^{-1}$$

$$Pr\left(y_t = 0\right) = \exp\left(x_t'\beta\right)\left[1 + \exp\left(-x_t'\beta\right)\right]^{-1},$$

where β is a $k \times 1$ vector of unknown parameters, and x_t is the set of k explanatory signals. The binary endogenous variable y_t takes the value of 1 when a country experiences debt-servicing problems and 0 otherwise. The function is estimated using maximum likelihood, which provides consistent and asymptotically efficient parameters. In addition, *t*-tests can be applied, because estimators are known to be asymptotically normal, while for a subset or all the coefficients, a likelihood ratio test can be employed. The above shortly summarizes the logit approach,[13] along with all the necessary information for the data set employed.

Empirical Results

The current section explores the modeling of international lending jitters and aims to identify signals that can provide information with respect to the credit quality of a borrower. The objective is to find a parsimonious set of warning indicators that

Table 1

Mean Values of Variables Between Default and Nondefault Cases

	Nondefault	Default	*t*-value
Debt to GDP	0.433	0.527	2.81***
Debt-service ratio	0.249	0.205	2.41***
Variability of export growth	0.077	0.038	2.37***
Trade to GDP	0.583	0.351	2.39***
Trade balance to GDP	–0.023	–0.019	0.37
Credit to private sector to GDP	0.327	0.268	2.22**
Government expenditure to GDP	0.130	0.132	0.40
Inflation	2.823	3.667	5.03***
Real exchange rate overvaluation	–0.121	–0.062	0.48
Variability of GNP per capita growth	0.035	0.048	4.19***
Gross capital formation to GDP	0.242	0.227	1.85*
Bond flow	11.034	3.533	4.11***

Notes: The results are based on the whole sample, that, all twenty countries, over the eleven-year period; * significant at the 10 percent level; ** significant at the 5 percent level; *** significant at the 1 percent level.

can effectively discriminate between default and nondefault cases, as well as to compare and contrast the results of the available estimators. Taking into account the previous literature and the availability of data, the empirical analysis starts with the identification of a wide range of exogenously specified factors. Variables with significant differences in means are those that have, on average, significantly different values in tranquil and distress periods, and are usually expected to determine credit-quality declines. The results of such analysis, between distress and nondistress instances, are presented in Table 1.

It is worth noting that the debt-service ratio has a lower value during financial distress, a point also mentioned by other studies and discussed later in this paper. The same analysis is also performed for each region separately, and different variables exhibit different sensitivities depending on the region examined. The models, however, are estimated for the whole sample to benefit from the increased degrees of freedom; while for a variable to be included in the analysis, it has to exhibit significant differences in at least one region. The first model examined is the logit estimator that pools data across countries (pool-logit henceforth), taking into account a wide range of indicators including external developments—Model A (see Table 2). Looking at the graphical illustrations for the three different regions (see Appendix C), one can observe the high inflation in the region of LA countries. Inflation clearly has a distinctive role in determining financial distress. Inflation is also linked with other factors in the economic system, such as interest

Table 2

Determinants of Sovereign Crises via Pool-Logit Estimation

	Model A		Model B	
	Coefficient	*t*-value	Coefficient	*t*-value
Constant	–0.94	–0.49	–0.91	–0.45
Debt to GDP	1.95	1.70*	2.13	1.79*
Debt-service ratio	–5.33	–2.40***	–6.41	–2.83***
Variability of export growth	–1.68	–0.77	–1.30	–0.59
Trade to GDP	–2.30	–2.07**	–1.94	–1.72*
Trade balance to GDP	0.84	0.24	–0.35	–0.10
Credit to private sector to GDP	0.90	0.66	–0.40	–0.26
Government expenditure to GDP	5.35	0.91	7.79	1.31
Inflation	0.39	2.03**	—	—
Real exchange-rate overvaluation	0.05	0.13	0.18	0.48
Variability of GNP per capita growth	26.06	2.67***	21.77	2.17**
Gross capital formation to GDP	4.63	1.02	7.21	1.49
Bond flow	–0.05	–2.93***	–0.05	–2.88***
Interest rates	–0.27	–1.36	–0.30	–1.46
OECD growth	–2.34	–1.45	–2.53	–1.50
INF(LA)	—	—	0.57	2.62***
INF(non-LA)	—	—	0.17	0.77

Notes: Model A: This model is estimated with the sample inflation variable. Model B: This model aims to capture the regional inflation effects through inflation dummies. INF(LA): Inflation dummy for the Latin American region. INF (non-LA): Inflation dummy for all non–Latin American countries. * significant at the 10 percent level; ** significant at the 5 percent level; *** significant at the 1 percent level.

rates, level of investment, credit-quality shocks, and so on. Thus, a second model is estimated by incorporating the regional effect of inflation—Model B (see Table 2). Two dummies are created to distinguish between inflation effects in LA and the other continents.

It is established by now that in many financial data an equation may be part of a larger system of simultaneous equations. Thus, if signals are dependent on this system, and correlated with the residuals in the stochastic part of the model, then statistical estimates would probably be inconsistent, because the likelihood function obtained conditional on these variables invalidates the estimation process. This issue is also known as simultaneity bias problem. Harvey (1989) suggests that, in order to avoid endogeneity, a lagged value of the signal should be used that is automatically characterized as predetermined. Therefore, the paper proceeds

with the estimation of the equations using the lagged values (one year) of the mixing variables. The estimation results are presented in Table 2.

The results indicate a number of significant variables whose coefficient signs, with one exception, are in line with the literature. An interesting result is the "wrong sign" of the debt-service ratio. Although a number of studies have indicated that the sign should be positive, there is evidence that the ratio may not be positive or even significant, as one might have expected. This issue is also discussed by Frank and Cline (1971) and Moghadam and Samavati (1991) in the context of sovereign creditworthiness. The importance of domestic economy is evident, as the variability in the GNP per capita can increase the probability of default. To our knowledge, Lee (1991) was the only one who tested this variable and found it insignificant. Similarly, the flow of international funds and openness of an economy exhibit an inverse relationship with the probability of financial distress. The inflation in general seems to be significant, with a greater impact on the default probability of LA countries compared to the other two regions. The signals identified, in Table 2, along with their significance, have not changed with the inclusion of the inflation dummies in Model B. Interestingly, external developments do not seem to exhibit a significant coefficient and, thus, do not play an important role in determining crises. Kumar et al. (2003) have also found insignificant international factors when considering currency devaluations.

One question usually raised by academics and practitioners is whether certain indicators are expected to be common or have the same magnitude across countries and time periods. Regarding this issue, empirical evidence indicates quite diverse findings (Aylward and Thorne 1998; Kalotychou 2004). Country heterogeneity mirrors the fact that different countries exhibit different sensitivities to the relevant factors with respect to their debt repayment ability. An interpretation of this lies in the different economic, political, and cultural structures of the various countries/regions. In response to that, the paper introduces two regional dummies for EE and LA countries. The proposed estimators aim to control for persistent unobservable effects that are different across regions.[14] In addition, the paper employs two other approaches to deal with the issue of unobservable random and fixed effects within a panel framework.[15] The fixed-effect estimator allows for heterogeneity across countries by recognizing that differences across countries can be captured by differences in the constant term. This is usually acceptable, as long as differences between countries can be viewed as parametric shifts of the regression function. On the other hand, the random-effect estimator allows the country-specific term to be stochastic. That is, the time-invariant country-specific effect is randomly distributed and uncorrelated with the vector of the exogenous variables. The results of the three different approaches are presented in Table 3.

The significance of the LA regional dummy, in the pool-logit approach, indicates the heterogeneity of our sample. The emphasis is on LA countries, which seem to have a higher average probability of default. A homogeneity test (HT) is

Table 3

Panel Data Estimators for Debt-Servicing Problems

	Pool logit		Fixed effects		Random effects	
	Coefficient	*t*-value	Coefficient	*t*-value	Coefficient	*t*-value
Constant	–1.12	–0.53	—	—	—	—
Debt to GDP	2.16[a]	1.77*	12.44[a]	2.95***	4.80[a]	4.67***
Debt-service ratio	–6.95[a]	–2.82***	–6.06	–1.12	–6.93[a]	–4.18***
Variability of export growth	–1.50	–0.68	–3.73	–0.87	–3.13[a]	–1.82*
Trade to GDP	–2.18[a]	–1.74*	–15.75[a]	–2.82***	–4.14[a]	–4.87***
Trade balance to GDP	–0.75	–0.20	4.08	0.39	2.87	1.02
Credit to private sector to GDP	0.46	0.29	6.59	1.40	1.17	0.88
Government expenditure to GDP	6.34	0.97	–41.69[a]	–2.50***	–8.86	–1.95*
Inflation	0.31	1.31	1.39	1.95*	0.78	4.00***
Real exchange rate overvaluation	0.16	0.42	0.24	0.26	0.32	0.79
Variability of GNP per capita growth	21.50	2.11**	66.31	2.40***	47.71	5.76***
Gross capital formation to GDP	6.81	1.41	16.89	1.28	12.65[a]	3.08***
Bond flow	–0.06	–3.06***	–0.03	–0.79	–0.05	–3.49***
Interest rates	–0.30	–1.44	–0.59[a]	–1.92*	–0.39[a]	–2.30**
OECD growth	–2.63	–1.57	0.71	0.28	–2.27	–2.01**
EE	0.20	0.25	—	—	—	—
LA	1.38	2.10**	—	—	—	—
HT (χ^2)	79.65	—	—	—	—	—
SDCE	—	—	—	—	1.48	8.61***

Notes: EE—Eastern Europe dummy variable; LA—Latin America dummy variable; SDCE—standard deviation of country effect; HT—homogeneity test distributed as χ^2 with $(r-1)\,k$ degrees of freedom, where r is the number of groups/regions and k is the number of regressors; [a] These variables lose their statistical significance when state dependence is taken into account; * significant at the 10 percent level; ** significant at the 5 percent level; *** significant at the 1 percent level.

also performed,[16] confirming the heterogeneity of the sample employed. Comparing the results of the pooled regression with the ones in Table 2, it is observed that the overall significance of the variables has not changed upon the inclusion of the regional dummies. In fact, it is only the inflation factor that has become insignificant. It is, therefore, sensible to argue that the regional dummies and inflation reflect essentially the same underlying factors, at least for the current sample and period under consideration. Experimentation, using a reduced pool-logit model (excluding inflation) produces similar results to the ones reported in Table 3. As far as the global factors are concerned, when the model is estimated either separately for each region or pooled as above, none is found to exert a significant impact on the probability of default. The fixed-effects estimator shows some "consistency" with the results reported for the pooled regression with respect to the variable significance. It is interesting, however, that when the effect is considered as being stochastic (random effects), the impact of some variables is significantly reduced, while new variables emerge as equally important signals. Unlike the pool-logit model, in the fixed- and random-effects approaches, inflation and global liquidity seem to emerge as important warning signals. Furthermore, the random-effects estimator has a $\pi^2/3$ variance of the period-by-period error term, and thus 30.4 percent of the variance underlying repayment problems is due to the persistence of the unobserved country effect.[17] Thus, the existence of heterogeneity is further supported by this estimator. Another issue worth noting is that the coefficients in the random (fixed) effect estimator may suffer from an upward (downward) bias. So far, the models have been estimated without the lagged dependent variable to avoid the possible bias introduced in dynamic specifications (Hajivassiliou 1994). Further analysis reveals that when credit history is included, the models show a strong state dependence. Moreover, some of the coefficients lose their significance, as indicated in Table 3, and the overall goodness of fit, in terms of prediction accuracy, increases. The latter is clearly evident when the model is employed for the in-sample misclassification analysis, as discussed below. With respect to the coefficients that remain significant, the inclusion of state dependence does not seem to affect their values considerably.

At this stage, it is important to mention that the nonlinearity of the regression model complicates the interpretation of the estimated coefficients. Actually, they do not represent the marginal effect of the independent variables on the probability of default. To compute the marginal effects, the magnitude of the estimated coefficient has to be weighted by a factor that depends on the values of all the independent variables, usually set at their mean value. The marginal effects measure the relative changes in the probabilities for changes in the independent variables. That is, small changes, such as 1 percent, in these exogenous signals can increase/decrease the default probability by a percentage equal to the reported marginal effects. The marginal effects of the significant variables across the three estimators are presented in Table 4.

The external solvency position of a particular country can be captured by the

Table 4

Marginal Effects of Significant Indicators

	Pool logit	Fixed effects	Random effects
Debt to GDP	0.496	1.929	0.840
Debt-service ratio	–1.598	—	–1.733
Variability of export growth	—	—	–0.593
Trade to GDP	–0.501	–1.422	–0.729
Trade balance to GDP	—	—	—
Credit to private sector to GDP	—	—	—
Government expenditure to GDP	—	–4.897	–0.315
Inflation	—	0.120	0.141
Real exchange rate overvaluation	—	—	—
Variability of GNP per capita growth	4.943	12.417	9.834
Gross capital formation to GDP	—	—	2.521
Bond flow	–0.014	—	–0.013
Interest rates	—	–0.113	–0.089
OECD growth	—	—	–0.624
EE	—	—	—
LA	0.323	—	—

EE—Eastern Europe dummy variable; LA—Latin America dummy variable.

debt-to-GDP ratio. The ratio reflects the financial obligation to external creditors. It is sensible that an increase in a country's debt burden, compared to its output, will increase the likelihood of default, hence the positive sign. A controversial signal in the area of international lending is the debt-service ratio, although the indicator is one of the most widely used signals in the analysis of creditworthiness. The present analysis reports an ambiguous negative algebraic sign, which is not surprising. Other studies in the literature found similar results (Elmore and McKenzie 1992; Moghadam and Samavati 1991) or provided evidence that the particular indicator was insignificant (Aylward and Thorne 1998; Hajivassiliou 1989; McFadden et al. 1985; Saini and Bates 1984). The ambiguity of the particular indicator has also been previously mentioned by Frank and Cline (1971), and recently by Kalotychou (2004). Another controversial issue is the volatility of per capita income growth. There are two theoretical approaches in the literature of international lending that endeavor to explain debtor behavior, namely, as regards ability and willingness to pay. According to the latter, the expected relation between the signal and the probability of default is negative. If the ability-to-pay approach prevails, then the relation is expected to be positive.[18] The particular

variable seems to increase the default probability by 4.9 percent, 12.4 percent, and 9.8 percent for the three models, respectively, every time the signal changes by 1 percent. The bond flow and the trade/GDP indicators bear plausible signs, and in line with the economic expectations; that is, the higher the signal, the lower the possibility of distress. As far as the LA dummy is concerned, it clearly shows that the region is more susceptible to financial crises than the other two over the period under consideration.

Cross-Modeling Analysis

So far, the findings identify a number of risk factors that can be exploited as early warning signals of financial distress. Obviously, everything depends on the approach that an analyst is prepared to adopt. Yet, there is no technique to navigate us through the Scylla of correlated effects and the Charybdis of stochastic terms and dynamic selection. It is, therefore, sensible to compare each estimator's classification performance within the data set available. It is the relative performance and choice of the estimator(s) that is of most interest to various international banks and lending institutions. Thus, the paper proceeds to a further cross-modeling analysis by comparing and contrasting the three classes of estimators. One of the notable characteristics of international lending data is the autocorrelation induced by the credit history of each country. Therefore, the ratio of the lagged value of arrears to external debt is included in the forecast to account for such interdependence due to debt repayment history (Aylward and Thorne 1998). This is also consistent with the results of Hajivassiliou (1994), providing evidence of "short memories" in international credit markets. Any possible changes in the significance of the coefficients, due to the inclusion of state dependence, were previously discussed. The results of the in-sample, cross-modeling analysis are reported in Table 5. The total numbers of errors are also presented, in parentheses, when the estimation excludes past repayment performance. The frequencies of errors, using the pool-logit model, are reported in panel A, while panel B presents the results using the fixed- and random-effects estimators.

The prior probability of default (in-sample default frequency of 39.55 percent) has been used as the cut-off point for the classification. Some studies have used the value that minimizes the type I or type II error, but since we do not have information about the cost of misclassification errors, the historical default probability is a more objective criterion. The reported results indicate the primacy of the pool-logit approach. Its overall predictive ability is quite high, reaching 82.72 percent of the cases considered. The fixed and random estimators report values reaching 77.42 percent and 78.53 percent, respectively. When the state dependence is excluded, however, the aforementioned values reduce significantly, to 69 percent, 69 percent, and 63 percent for the three estimators, respectively. Based on the above results, it is clear that the inclusion of the past repayment performance improves the predictive power of the model. One should note that the fixed-effects estimator

Table 5

Cross-Estimator Examination for 1990–2000

Panel A. Pool model results

	Predicted		
Actual	0	1	Total
0	97	18[a]	115
1	15[b]	61	76
Total	116	75	191
	Errors = 33 (58)		

Panel B. Fixed and random estimators results

	Fixed effects				Random effects		
	Predicted				Predicted		
Actual	0	1	Total	Actual	0	1	Total
0	96	19	115	0	101	14	115
1	23	48	71	1	27	49	76
Total	119	67	186[c]	Total	128	63	191
	Errors = 42 (57)				Errors = 41 (70)		

Notes: Predicted outcome has maximum probability. Errors: the total number of type I and type II errors. The numbers in parentheses indicate the errors when past credit performance is excluded from the in-sample forecasting. [a] Type II error: a noncrisis case is predicted crisis. [b] Type I error: a crisis case is predicted noncrisis. [c] The reduced number of observations is due to sample bias (see comment in text).

suffers from sample bias. That is, if there is not enough variation in the dependent variable (i.e., a country that was rarely under distress), then the estimator drops the particular country, hence, the reduced number of observations under panel B. Another issue of interest is that although econometric inferences support the adequacy of the fixed and random approach, the estimators seem to lack in their predictive ability. Others also report similar qualitative results when various forecasting approaches are compared and assessed (Fuertes and Kalotychou 2004). This is very interesting, as heterogeneity is overwhelmingly supported by the data, but the provision of the relevant estimator in terms of identifying crises remains weak. Based on the last set of results favoring the pool-logit approach, the paper proceeds to examine this estimator in an out-of-sample framework covering the 1999–2000 period. The results of the out-of-sample misclassification analysis are presented in Table 6.

Table 6

Pool Logit Misclassification Analysis for 1999–2000

Panel A. 1999

	Predicted		
Actual	0	1	Total
0	11	1[a]	12
1	2[b]	6	8
Total	13	7	20

Panel B. 2000

0	10	2[a]	12
1	2[b]	6	8
Total	12	8	20

Notes: [a] Type II error: a noncrisis case is predicted crisis; [b] type I error: a crisis case is predicted noncrisis.

The default probabilities are evaluated by applying the pool model over the last two years with the parameters kept at the values estimated until 1998 to generate one- and two-step ahead forecasts. Similar methodologies have been employed by Feder et al. (1981) and Somerville and Taffler (1995), while Fuertes and Kalotychou (2004) use a rolling window. The above results show that the classification performance of the model is quite satisfactory. They also confirm the stability of the estimated parameters over the two periods, based on the current out-of-sample projection. The model's predictive ability for 1999 and 2000 reaches 85 percent and 80 percent, respectively, for the cases considered. The findings are reported on an individual basis in Appendix D. Note that three of the EE countries (Czech Republic, Romania, and Slovakia) had an actual nondefault status in recent years. These misclassification problems are quite common in the literature as a result of the various endogenous criteria employed to define a state of crisis. Their status misclassification comes as a result of recent abrupt changes in their arrears as compared with their previous credit history. Thus, in that case, the prediction for 1999 is correct for the Czech Republic but not for Romania and Slovakia if a nondefault status is assumed. The latter should not be considered as an absolute statement, however, because changing the actual status of the country in the data sample might produce a different prediction. Finally, Korea had financial difficulties during that period due to its short-term credit exposure, which resulted in significant liquidity problems. The actual nondefault status stems from the fact

that our modeling takes into account only the long-term credit exposure. The root cause of the recent Asian crisis was a situation in which reserves were lower than the short-term hard-currency obligations.

Conclusion

Anxiety in the international investment community, caused by recent financial turmoil, has renewed the interest in worldwide debt crises. The paper sets out to give some insight into the naturally complex phenomenon of modeling sovereign default. The main question raised, but not easily answered, is whether recent financial jitters can be modeled as a function of various economic signals. If successfully modeled, and accurate predictions are achieved, then multinational banks and credit-rating agencies can exploit them for policy and management purposes. We hope that the paper adds another shred of evidence and possibly will trigger further research. To explore the link between debtors' financial profiles and default, the paper employs a sample of different emerging markets and different econometric methodologies.

Through a panel data analysis, some interesting results have emerged. The research initially reveals a number of variables determining the frequency of recent defaults. Debt ratios and trade resources seem to be important through the impact of the debt-to-GDP ratio and market integration indicator, respectively. Domestic economy determines crises via inflation changes, with a significant impact on LA countries in particular, while the variability of GNP per capita growth, unlike in other studies, seems to play a vital role. In addition to that, changes in financial flows from foreign investors affect default frequencies, while external developments are found to be inconsequential. When cross-model examination is conducted, the pool-logit, fixed- and random-effects estimators do not provide a consistent set of crisis warning indicators. Heterogeneity effects are present and, in some cases, depending on the model employed, exert a strong influence in determining crises. When past credit performance is taken into account, the findings indicate strong state dependence with changes in significance for some of the indicators. The final examination takes into account the in-sample goodness of fit and further tests the out-of-sample misclassification performance of the three models. The analysis clearly highlights that (1) the goodness of fit of all three models is notably increased by including the credit history as an exogenous factor, (2) the pool-logit estimator yields the minimum number of misclassifications among the three approaches, (3) the fixed-effects model yields the worst performance, and (4) one- and two-year ahead forecasts enjoy empirical support with the current data set. Future research is needed to enhance our understanding about the triangular relationship among external debt, warning signals, and probability of default. In the absence of nonpayment penalties, lenders usually exclude borrowers from their clientele. A worth-investigating aspect of such action is the determinants of the length of the exclusion period. Another area of future research is the

factors underlying the demand and supply of debt. From an econometric point of view, estimating dynamic discrete-choice models is not an easy task. Simultaneity problems and dynamic effects need to be embraced in a well-defined econometric framework. Recent research by Honore and Kyriazydou (2000) sheds some light on the complexity of the panel data within a binary choice framework.

The experience so far shows that the development of a stable, market-orientated financial system is one of the forthcoming challenges. The current study highlights the importance for emerging markets to ensure that financial crises are minimized if they wish to avoid borrowing restrictions or untenable borrowing costs, or to strengthen their credit ratings. For that reason, policy implications (for moving forward) could involve managing fluctuations of per capita income; increasing and maximizing domestic income with respect to debt obligation, or minimizing the latter; opening the domestic economy (in terms of exports and imports) to international markets; and encouraging international investors to direct their funds into the domestic economy. On the other hand, one could easily argue that the effects of negative externalities, through the failure of multinational financial institutions, need to be considered as well. To the extent that banks are viewed as special, governments may seek political and economic avenues to reduce defaults of sovereign borrowers (Saunders and Cornett 2003). Equally important, the sovereign states themselves should vigorously pursue broad systemic reforms. Unless both lenders and debtors change their approach to international lending, debt forgiveness or further capital inflows would only tempt some borrowers to postpone economic adjustment and development.

Notes

1. Basel Committee on Banking Supervision (2001).

2. Transfer risk is actually defined as the inability of private agents to fulfill their debt obligations due to government actions, e.g., prohibiting a currency exchange for payment of debts (hence the term transfer risk). Transfer risk could be one of the most important drivers of country risk. For an excellent discussion on the sovereign risk of banks, see Heffernan (1984; 2004) and Saunders and Cornett (2003).

3. For more details on the examination and supervision of international lending, see Martinson and Houpt (1989).

4. The use of public money to recapitalize insolvent banks can seriously handicap efforts to control budget deficits. See Edwards (1995) on how large-scale public bailouts of banks have complicated efforts at fiscal consolidation in Latin America over the past two decades. Moreover, if recapitalization takes the form of weak banks cutting back lending and widening spreads, the lower availability and higher cost of bank credit can undermine the real economy, particularly for small and medium-sized firms, which have fewer alternative sources of financing. Finally, banking problems can also create difficulties for monetary policy.

5. In 1996, banks in the Bank for International Settlements reporting area had outstanding claims against developing countries of over $717 billion (about $46 billion more than their liabilities to these countries). See Goldstein and Turner (1996).

6. Economic Forum organized by the IMF, 2001.

7. See Stiglitz and Weiss (1981) for the theory of credit rationing.

8. They do not provide, however, any information on what they assume to trigger default and, consequently, on how the dependent variable is defined.

9. Official creditors consist of multilateral lending institutions (IMF, World Bank, etc.), governments, and other official agencies. Private creditors comprise commercial banks and private financial institutions.

10. The data encompass arrears on interest and principal to official and private creditors. Arrears above that threshold would be considered as an alarming indication of default. The certain threshold is defined for each country separately.

11. The agreement is listed in the World Bank GDF 2001 file. The World Bank assigns the date for rescheduling to the year in which it was publicly announced that the rescheduling negotiations were concluded.

12. This is in line with the credit-rationing approach proposed by McFadden et al. (1985).

13. For a more detailed analysis, see Maddala (1983).

14. Each of the regional groups is assigned the variable of 1, with Southeast Asia serving as the reference group. Inclusion of all three regional dummies would result in what is known as the multicolinearity problem.

15. For a more rigorous discussion on the technical aspects of panel data estimation, see Greene (1997) and Johnston and Dinardo (1997).

16. It is calculated as the difference between the sum of the log likelihoods using the three individual regions, when estimated separately, and the one obtained from the whole sample.

17. The formula is $SDCE^2/(VR + SDCE^2)$, where VR stands for the variance of the disturbance.

18. A possible explanation could be that the more shocks on a country's income, the higher the probability that the country might experience output ranges that diminish the resource availability for debt repayment. However, there is little empirical evidence on the income shocks' effect.

19. This is a smoothing method that is widely used among macroeconomists to obtain a smooth estimate of the long-term trend component of a series. Technically, the Hodrick–Prescott filter is a two-sided linear filter that computes the smoothed series x of y by minimizing the variance of y around x, subject to a penalty that constrains the second difference of x. That is, the HP filter chooses x to minimize:

$$\sum_{t=1}^{T}\left(y_t - x_t\right)^2 + k\sum_{t=2}^{T-1}\left(\left(x_{t+1} - x_t\right) - \left(x_t - x_{t-1}\right)\right]^2.$$

The penalty parameter (k) controls the smoothness of the series x_t. The larger the penalty, the smoother the x_t, and as $k \to \infty$, x_t approaches a linear trend.

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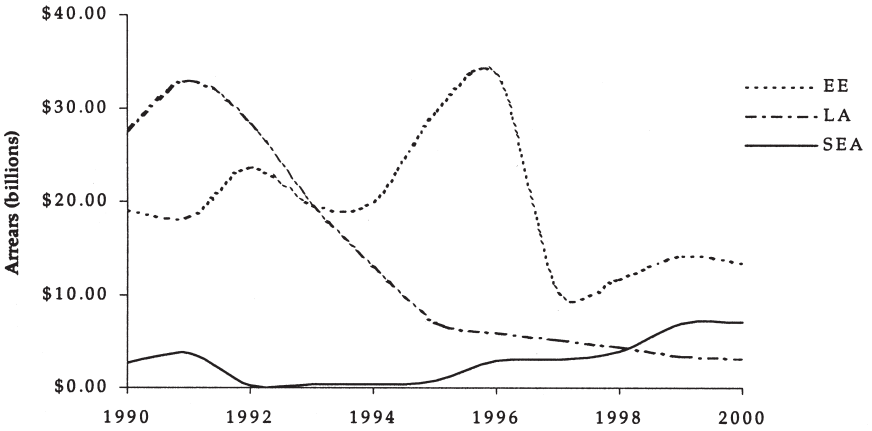
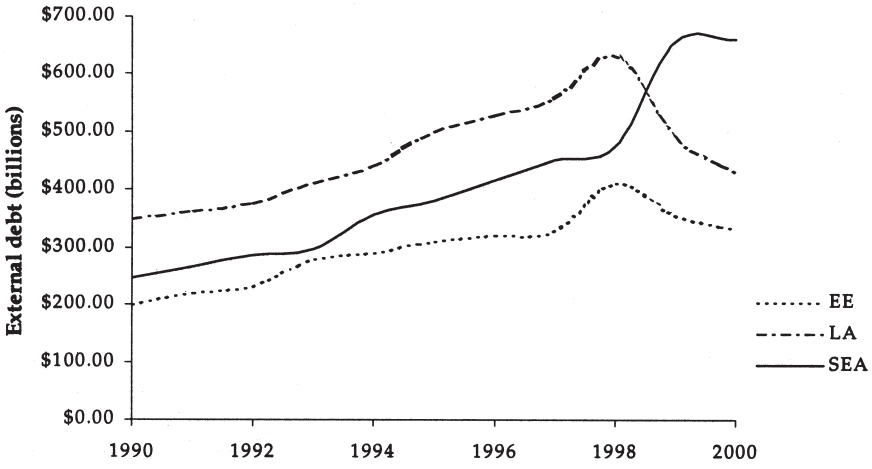
Appendix A. Graphical Illustration of Sovereign Debt Obligations 1990–2000 (EE—Eastern Europe; LA—Latin America; SEA—Southeast Asia)

Figure A1. **Arrears for 1990–2000**



Prior to 1997, arrears for the SEA region are multiplied by 10. This is simply for clearer illustration.

Figure A2. **External Debt for 1990–2000**



Appendix B. Definitions of Signals

Debt Ratios

Debt over GDP: Total external debt relative to GDP. Total external debt includes public and publicly guaranteed, private nonguaranteed, and long- and short-term debt and loans from the IMF and the World Bank.

Debt-service ratio: Total debt service relative to exports. Total debt service is the sum of principal repayments and interest paid in foreign currency on long-term debt, interest paid on short-term debt, and repayments to the IMF.

Financial and Trade Resources

Variability of export growth: Standard deviation of export growth over the past five years.

Trade over GDP: It is the sum of imports and exports relative to the value of GDP converted to international currency using PPP rates. It indicates the degree of trade openness/integration/liberalization of an economy.

Trade balance over GDP: Trade balance relative to GDP. Trade balance is defined as the difference between exports and imports.

Domestic Economy

Credit to private sector (CPS) over GDP: CPS includes the domestic financial resources provided to the private sector, such as loans, purchases of nonequity securities, trade credits, and other accounts receivable, that establish a claim for repayment.

Government expenditure over GDP: Government spending on consumption, national security, and defense.

Inflation: Annual percentage change in the CPI. This is calculated as $Log(1 + \%\Delta CPI)$. The transformation aims to alleviate the problem of hyperinflation in some countries or regions.

Real exchange rate overvaluation: Deviation of real exchange rate from the long-run trend. Our measure of the long-run trend is the Hodrick–Prescott (1997) filtered[19] real exchange-rate index, calculated as the logarithm of the nominal exchange rate vis-à-vis the USD adjusted for relative changes in the price levels. The idea of this proxy for FX misalignment is similar to the ones in Frankel and Rose (1996) and Kaminsky and Reinhart (1999), except for the calculation of the trend.

Variability of GNP per capita growth: Standard deviation of GNP per capita growth over the past five years.

Gross capital formation over GDP: Gross capital formation (gross domestic investment) consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories. Fixed assets include land improvements (fences, ditches, drains, etc.); plant, machinery, and equipment purchases; and the construction of roads, railways, etc., including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. Inventories are stocks of goods held by firms to meet temporary or unexpected fluctuations in production or sales, and "work in progress." According to the System of National Accounts 1993 (SNA93), net acquisitions of valuables are also considered capital formation.

Financial Flows

Bond flow: The bond portfolio investment consisting of bond issues purchased by foreign investors.

External Developments

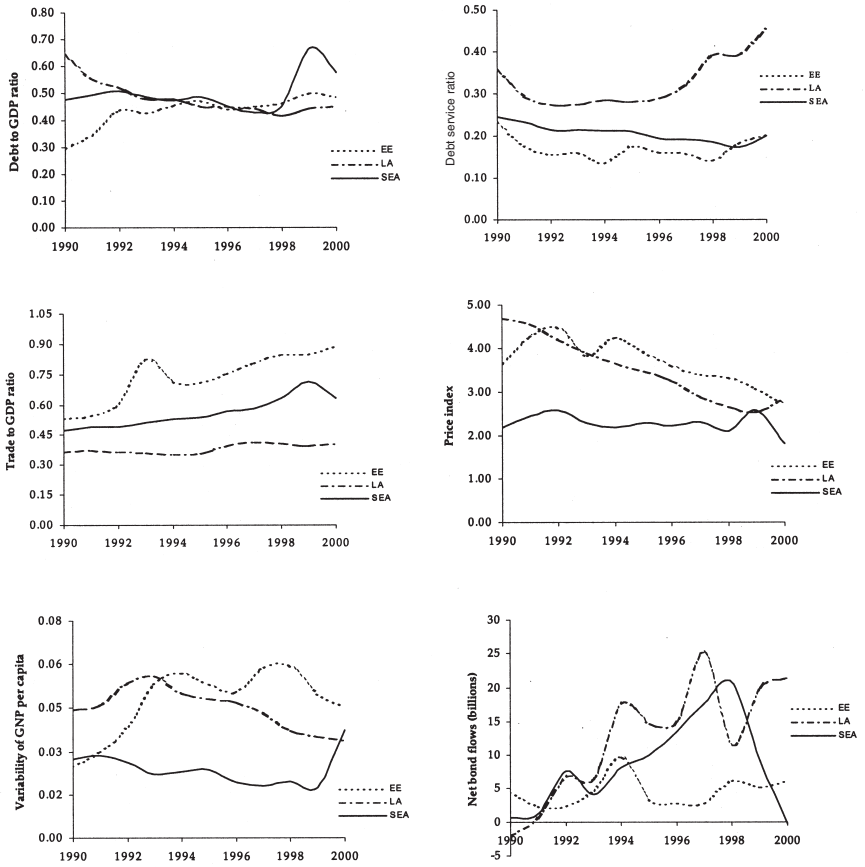
Long-term interest rates: The yield on a ten-year U.S. Treasury bond. It aims to capture global liquidity and interest rate effects.

OECD growth: The real GDP per capita growth of high-income OECD countries. High-income economies are those in which 1999 GNP per capita is $9,361 or more.

Debt Repayment History

Arrears over debt—lagged one year: Amount of debt in arrears (interest and principal repayments) to official and private creditors relative to total external debt at the end of the previous year.

Appendix C. Graphical Illustrations (EE—Eastern Europe; LA—Latin America; SEA—Southeast Asia)



Appendix D. Forecasts on a Country-by-Country Basis for 1999 and 2000

	Year 1999			Year 2000		
	Probability of default	Status	Forecast	Probability of default	Status	Forecast
Eastern Europe						
Bulgaria	63.70%	ND	~~D~~	87.50%	ND	~~D~~
Czech Republic*	7.40%	D	~~ND~~	27.80%	D	~~ND~~
Hungary	4.30%	ND	ND	3.70%	ND	ND
Poland	29.50%	ND	ND	21.40%	ND	ND
Romania*	62.90%	D	D	61.70%	D	D
Russia	97.30%	D	D	91.80%	D	D
Slovakia*	55.80%	D	D	12.30%	D	~~ND~~
Turkey	24.50%	ND	ND	2.70%	ND	ND
Latin America						
Argentina	1.20%	ND	ND	1.20%	ND	ND
Brazil	11.00%	ND	ND	16.80%	ND	ND
Colombia	20.30%	ND	ND	12.30%	ND	ND
Ecuador	80.90%	D	D	91.30%	D	D
Mexico	14.20%	ND	ND	3.10%	ND	ND
Venezuela	29.50%	ND	ND	21.95%	ND	ND
Southeast Asia						
India	0.60%	ND	ND	22.50%	ND	ND
Indonesia	1.60%	D	~~ND~~	93.50%	D	D
Korea	1.90%	ND	ND	67.00%	ND	~~D~~
Pakistan	74.80%	D	D	72.10%	D	D
Philippines	4.40%	ND	ND	0.20%	ND	ND
Sri Lanka	91.00%	D	D	95.80%	D	D

Notes: D—default case; ND—nondefault case. Strikethrough forecasts indicate type I or type II errors; * These cases bear actual status misclassification. See discussion in text. Threshold value for predicting default is 39.55 percent.