FACTORS UNDERLYING THE CREDIT RISK EXPOSURE OF SOVEREIGN LOANS

Elena KALOTYCHOU and Sotiris K. STAIKOURAS*

Risk Institute & Emerging Markets Group
Cass Business School, City University
106 Bunhill Row, London EC1Y 8TZ.
email: e.kalotychou@city.ac.uk - sks@city.ac.uk

ABSTRACT

The paper sets out to explore the factors affecting the credit quality of the Latin American region. Specifically, a logit framework is employed based on macroeconomic and financial data to determine the causes of Latin American debt crises in the last two decades. The analysis uses a modification of the default indicator to explicitly incorporate country arrear capacity. A number of domestic and international signals are found to be important in determining earlier as well as recent incidents. Domestic fundamentals, however, bear a much heavier weight than global conditions, implying that policy-makers still enjoy some freedom in preventing crises by monitoring country vulnerability. Furthermore, the study focuses on the out-of-sample classification accuracy of the proposed estimator using various criteria and provides one-, two- and three-year-ahead forecasts for country default probabilities. Predictive performance is satisfactory with a reasonable reduction in accuracy in the out-of-sample period. Nevertheless, the findings indicate an upward bias towards type II errors.

Key Words: Credit risk, Sovereign default, Financial crises, Logit modeling, Forecast evaluation.

JEL classification: F34, G15, G21.

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I. INTRODUCTION

The global financial upheaval triggered by the recent Asian meltdown (1997-99) has evidently spread throughout the Latin American continent. As Asian markets collapsed financial institutions in countries such as Japan and Hong-Kong failed and they were either forced to merge or reconstruct. Commercial banks that had lent heavily in those regions failed in record numbers [Saunders & Cornett (2006)[1]]. Multinational banks still remember the major and long lasting effects of the 1980s, which lead various banks to increase their loan loss reserves [Grammatikos & Saunders (1990)]. According to the Federal Reserve, the credit exposure of US banks to Latin American loans was mounting to $27.2 billion. Latin American countries have broadly relied on international capital to finance their developments. The largest exposure was retained by Citicorp with $15.5 billion. In 1998, Chase Manhattan Corporation, which has been the biggest lender in Latin America, took off its books $2.6 billion aiming to reduce its credit exposure to the continent. In January 1999, European stock markets plunged as Brazil devalued its currency by 7.5%. The same year, the stock market in Madrid fell by 6% while the Paris Bourse and Frankfurt were down by 4.1% and 4.3% respectively. In Southern China Guangdong International Trust and Investment Company (GITIC), one of the largest banking corporations, was exposed to over $3 billion in debts. Finally, Deutsche Bank and Dresdner Bank, with huge outstanding loans to Brazil, watched their stock plummeting by 6.5% and 4.43% respectively. These cases highlight the importance of loan concentration risk and contagion with the subsequent effects on the multinational banking system. Heffernan (1984, 2004) provides a thorough analysis of country risk and Martinson & Houpt (1989) discuss the importance of examination and supervision of international lending.

Over the last two decades several costly lessons have led to a new emphasis on international credit risk [Sachs, Tornell & Velasco (1996), Chang & Velasco (2000)]. The issue has attracted considerable attention with particular emphasis on the ability of statistical models and credit ratings to provide early default warnings. If sovereign credit ratings are forward looking, it follows that downgrades in credit ratings should systematically precede defaults. Historical observations, however, suggest that credit rating agencies many times fail to predict default within an adequate window of time-lead, as downgrades take place once the debt crisis has begun. Recent evidence suggests that downgrades appear to have followed not preceded the crisis [Kochan (1999), Reinhart (2001)]. As a result of the proliferation of uncertain foreign debt, analysts have struggled with methods of measuring

and predicting sovereign credit exposure. Various financial and non-financial institutions constantly analyze these issues, but obviously from different perspectives[2]. Finding reliable signals for ex-ante risk is difficult, if not impossible, because it depends on the complex interaction of numerous factors. Measuring that with any degree of confidence is indeed exigent, yet it is indispensable to associate the level and types of risk with the required return.

An important consideration when constructing a credit rating model is the definition of default. The choice of the most appropriate event to represent the latent default variable has been the impetus of a recently growing literature. Leading rating agencies define debt crises in terms of any missed/delayed payment of interest/principal or any restructuring of debt. On this basis, it seems reasonable to focus on these credit events for identifying foreign debt crises. In the past, the default indicator was only represented by each country's rescheduling incidents. The latter were the main signals (depending on their scale and frequency) as to whether a country was running into repayment difficulties or not. At that time, there were not any databases with detailed information regarding loan arrears. The lack of information in the area of credit risk is noticeable, as it is only since the early 1990s that loan data has become widely available. In addition to that, rescheduling data had to be tediously complied from various sources along with any descriptive material from the World Bank and/or the International Monetary Fund. Thus, the limited definition of default is apparent in previous empirical studies. More recent studies incorporate arrears [Detragiache & Spilimbergo (2001)], large IMF loans [Manasse, Roubini & Schimmelpfennig (2003)] or sovereign bond spreads [Pescatori & Sy (2004)]. In addition to the above, gaps and inconsistencies in time series of macroeconomic indicators resulted in the use of diverse and possibly heterogeneous country samples. Previous research has flagged concerns about the potential challenge that country heterogeneity poses with regards to the implementation of early warning models for sovereigns. Berg, Borensztein, Milesi-Ferretti & Pattillo (1999) stress that the key determinants of financial crises may not be the same across countries and/or their relative impact may differ; which in turn implies the use of a fairly homogeneous group of countries in the design of a credit measurement device. The discussion clearly shows the challenges emerging, both at theoretical and practical level, and that further research in that area is warranted.

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[1] For an excellent discussion on the sovereign risk of financial institutions the interested reader is referred to Heffernan (1984, 2004) and Saunders & Cornett (2006).

[2] Industrial firms are more interested in the current and future investment climate, while financial institutions are more concerned about the country's ability to service its foreign debt.

The present work seeks to provide and test a framework that can facilitate a formal assessment of the sovereign risk exposure of multinational banks to Latin America. The paper contributes to the finance literature in various fronts. First, the analysis employs a modified version of the default dependent variable by explicitly incorporating both reschedulings and long-term debt arrears that exceed a country-specific threshold. Second, the study explicitly focuses on the credit quality of Latin America and uses an extended recent dataset to facilitate an early warning system. Regional homogeneity that is assumed in many studies may be problematic. Differences in credit quality problems may be the result of religious attitudes, types of governments, colonial histories and possibly other attributes not easily measured [Hajivassiliou (1989)]. In this regard, using a heterogeneous sample is likely to negate the effectiveness of a cross-country analysis. The choice of the particular sub-continent aims to reduce heterogeneity[3] present in more diverse samples [Fuertes & Kalotychou (2004a), Kalotychou & Staikouras (2005)], and thus uncover region specific risk signals. Third, based on a number of forecasting accuracy indicators, the issue of prediction biases is also examined; something that previous studies failed to address[4]. Finally, the proposed estimator is assessed from the standpoint of country rankings based on up to three-year-ahead default probabilities. The latter aims at providing "early warnings", as one year might be relatively short from an investment viewpoint; as well as investigating whether current economic fundamentals can signal distress up to three years ahead.

The rest of the paper is structured as follows. Section II presents a brief overview of the foreign indebtedness of the Latin American region. Section III, introduces the data and the methodology employed and Section IV discusses the empirical findings and comparisons are made with other studies. Finally, Section V overviews the findings along with some concluding remarks.

[3] There are a few examples justifying a quite homogeneous region, without obviously precluding any idiosyncratic patterns. According to the OECD 2003, there is an element of commonality in the legal, economic/financial, political and social aspects of the various economies in the region. The OECD paper reports some commonalities such as the concentration of ownership, the reduction (restructuring) of state ownership in domestic banking, the common control and ownership of large firms by industrial/financial enterprises, the emergence (in some countries) of international banks, the recent tendency for privatization, and until recently the importance of domestic capital markets. Furthermore, looking at the history of the region (section II) one could observe commonalities such as government intervention, high import tariffs etc.

[4] What one observes in the literature is that although many studies acknowledge (even implicitly) any potential problems with forecasting techniques, in the particular area; we are not aware of any papers that actually report any noise/bias in their empirical findings. Previous research mainly concentrates on the prediction accuracy of their models.

II. THE LATIN AMERICAN DEBT HISTORY

From the great recession until the 1980s, the Latin American import substitution strategy produced a steady increase in the GDP per capita of an average 3% per annum. Until then, centrally planned economies were controlling domestic prices, imposing high import tariffs, providing government subsidies and nationalizing major industries. In 1961, more than half of the Latin America's foreign debt was owed to foreign governments or international agencies. During the 1970s Argentina, Brazil, Chile and Peru continued the build-up of debt to finance military expenditure, but the loans were small relative to the private sector. It is worth noting that since Latin America's independence from Spain and Portugal in 1820s, foreign capital was the main force that allowed the region to expand and develop[5]. Yet, it has also placed a heavy debt burden on its still emerging economies. The obvious trend was a shift from government borrowing towards commercial borrowing, which by 1980 comprised most of Latin America's debt. Although the collapse of Bretton Woods in 1971 played an important role in the activity of multinational banks; it was the 1973 oil shocks that provided commercial banks with an abundant supply of petrodollars through the OPEC nations.

Unlike the IMF, the World Bank and OECD, commercial banks offered high-interest short-term loans with far fewer restrictions. By 1982, only 12% of Latin America's foreign debt was owed to governments or international agencies. It was the decade before when among others, Argentina, Chile and Uruguay adopted a set of substantial economic reforms such as open up to foreign trade, privatize and deregulate firms and dismantle capital and exchange controls. In the mean time, the 1979 oil shock forced the US and other OECD countries to raise their interest rates. When the 1981 recession struck the US economy and oil prices softened, interest rates did not fall significantly from their 1980 peak of 19%. In the wake of Mexico's default, in 1982, billions in short-term loans that previously would have been refinanced were now due immediately. In 1983, Latin America's external debt was 50% of its GDP, mounting to $314 billion compared with the $75 billion eight years ago. The crisis continued to spread engulfing Brazil, Chile and Argentina with such devastation that the 1980s became known as "the lost decade". GDP per capita declined at an average annual rate of 0.7% during that period, while by 1986 three out of four Latin American countries had inflation rates above 30%.

Since then, reforms have swept across Latin America's economic landscape. The economic systems that emerged in the 1930s, stifled by heavy government intervention and

protectionism, have given way to new ones based on market orientation, openness and competition. What started as a slow process in Chile, in the mid 1970s, has then spread to virtually every country in the region. By the end of 1997, Argentina, Chile, El Salvador, Mexico and Peru had transformed their economies. Important changes have been made by Bolivia, Brazil, Colombia, Costa Rica and Nicaragua but still had a way to go, while Ecuador, Venezuela, Guatemala and Honduras lagged behind. The economic changes were radical and the drive to market reforms was the result of harsh economic realities rather than ideological considerations. On the eve of the Asian turmoil, the region was beginning to reap the benefits of a decade of hard work and reforms. The recent international crisis, however, put a lot of pressure on the Latin American economies, starting with Brazil. George Soros, having heavily invested in the region and being the largest real estate owner in Argentina, pointed out that the crisis had provoked a general economic panic that is now ravaging Latin America. He warned that this tendency is quickly turning into an international credit blockade against less developed countries. In brief, the external crisis resulted in a) a sharp drop in the commodity terms of trade, b) a substantial increase in borrowing spreads and c) a credit rationing shock.

Latin America's situation in mid 1998 is simple: old debts have been re-programmed through the Brady Plan and the Paris Club, new debts are directed towards the private sector and those directed to the public sector are channeled towards multilateral banking. Despite debt relief efforts in low-income economies, the burden of debt has not improved. Ecuador was the newcomer in sovereign defaults in 1999, with the first-ever Brady Bonds default. In August and October it defaulted on about $6 billion in Brady Bonds and $500 million in government Eurobonds respectively. In December 2001, Argentina defaulted on $130 billion in government issued debt and, in 2002, passed legislation that led to defaults of $30 billion of corporate debt owed to foreign creditors. In July 2001, Argentinean sovereign bonds were trading at spreads of over 15% above US Treasury rates, with the JP Morgan Emerging Market Index showing a spread nearly 10% over the US Treasuries. Alas, in March 2005, Argentina began talks with the IMF on the outcome of its $100 billion debt restructuring. The deal to reduce its debt by 70% in net present value has been accepted by 76% of the country's creditors; leaving the remaining 24% to hold $20 billion debt. These reflected the serious economic problems in Argentina and the possible contagion effects on the sovereign bonds of other emerging markets. At the time of the Asian crisis, Peru's debt servicing represented 25.4% of exports of goods and services; and by June 1998, this figure

[5] Most of the financial information, in this study, was taken from: The debt crisis in Latin America, Institute of

had risen to 31.5%. These cases demonstrate the effect of the various crises in global financial markets[6]. Nevertheless, when the crisis hit Latin America, the region was better prepared than at the time of the 1980s where the unstable economies sowed the seeds of financial jitters. The policy response to theses shocks was more appropriate and did not seal the economies off.

In the economic history of Latin America, unfortunate events have seemed to repeat themselves endlessly. A review of the region's history unveils a consistent pattern of long expansions followed by sharp protracted recessions, culminating in debt crises and years of debt negotiations. Like the 1825 turmoil, the debt defaults followed the 1873 market crash were caused mostly by exogenous factors and unsustainable debt burdens. The 1930 crisis is marked by the collapse of enterprises much like the crisis of the 1980s. All the aforementioned economic crises follow three inter-related exogenous shocks: steep fall in commodity prices, instability in financial markets and recession abroad. In all Latin American crises, international commercial banks were the main sources of capital.

III. BRIEF OVERVIEW OF THE LITERATURE

The very early research in the area of debt-servicing problems in emerging markets has its roots in official lending institutions and approaches developed by commercial banks. A wave of theoretical and empirical papers on sovereign debt crises followed. There is by now a number of review studies [McDonald (1982), Saini & Bates (1984), Eaton, Gersovitz & Stiglitz (1986), Rogoff & Zettelmeyer (2002), Staikouras (2004)] and others that focused on empirical cases [Feder, Just & Ross (1981), Moghadam & Samavati (1991), Avery & Fisher (1992), Hajivassiliou (1994), Kalotychou (2004), Staikouras (2005)]. The rest of this section distinguishes among the three main approaches in evaluating the debt repayment problems.

Discriminant analysis

The necessity to explore systematic factors, driving a country's external debt repayment capacity, became apparent in the 1960's [Avramovic (1964)]. Avramovic establishes a key set of short-term liquidity and long-term macroeconomic attributes that impact a country's ability to service external debt obligations. The results of his research seem to have guided the selection of variables in subsequent empirical work [Aylward & Thorne (1998)]. In a simplified discriminant analysis framework, Frank & Cline (1971) derive a credit score for each country, representing the probability of encountering debt-

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Latin American Studies.

servicing difficulty. Their sample comprises data on 8 factors for 26 countries over the 1960-68 period. Their best linear discriminant function is reported to produce a Type I error of 23%, correctly classifying 10 out of the 13 rescheduling cases. Type I error arises when a crisis case is wrongly predicted as non-crisis and vice versa for the type II error. In a similar manner, Abassi & Taffler (1984) employ a sample of 70 countries for the period 1967-78, containing 50 rescheduling cases in 14 countries. The dependent variable includes only rescheduling cases. Although robust and innovative, their results raise problems of interpretation.

Limited dependent variable models

The logit approach possesses more appropriate statistical properties (in terms of robustness to statistical assumptions) for limited dependent variable modeling than discriminant analysis. Feder & Just (1977) apply this technique for the investigation of the binary dependent variable of rescheduling and non-rescheduling cases. Although, the sample examined and the indicators identified are similar to those found significant in earlier studies, their method shows lower error rates. Mayo & Barrett (1978) experiment with some methodological refinements. The study considers other instances of debt-servicing difficulties other than formal rescheduling (US export-import bank rescheduling and claims) and assesses the predictive power of the variables five years into the future. The achieved error rates are somewhat higher than those of other studies. The lack of large dataset is somehow overcome by Feder, Just & Ross (1981). To avoid the problem of model bias towards default and non-default cases, the dataset is expanded to include 56 countries covering the period between 1965 and 1976. The classification performance is maintained at acceptable levels in the out-of-sample forecast (1977-79) with 20% type I error rate. A new definition of the dependent variable, which departs from the binary structure employed of others, is introduced by Edwards (1984). Specifically, the study analyzes the determinants of the spread over LIBOR of the interest rate charged to a particular country in the Eurodollar market. The data sample comprises 19 countries over 1976-80, and the fitted default probabilities show substantial variation both across countries and over time. McFadden, Eckaus, Feder, Hajivassiliou & O'Connell (1985) and Hajivassiliou (1987,1989) further examine the fundamental factors that trigger debt-servicing problems. The distinctive feature of their analysis is that the dependent variable includes three elements (arrears, rescheduling and IMF assistance), while the independent variables are those

[6] Gardner, Mills & Cooperman (2000) provide a detailed review of the crises during the last decade.

driving the demand/supply of new loans. Their findings indicate the strong presence of state dependence and country-specific persistent unobservable effects. Elsewhere, Heffernan (1985) examines the international financial situation and identifies factors for the demand and supply of sovereign loans. Within that framework credit rationing and default probabilities are discussed.

Using a different theoretical framework, Lee (1991) models the event of a sovereign default as the outcome of the willingness-to-pay (utility cost-benefit comparison) by a sovereign debtor. The sample is extended to 75 countries over the 1970-85 period. He concludes that interest rates on international lending, GDP per capita growth, debt/GNP and domestic credit of government/GDP are significant in explaining repayment performance both for official and commercial debt. Somerville & Taffler (1995) contrast the ability of the Institutional Investor credit ratings and that of multivariate statistical models to predict external debt-service capacity. Covering the period 1979-89 for 54 countries, their findings suggest that a) statistical models have a higher overall predictive accuracy, but their dominance is less pronounced if allowance is made for differential misclassification costs and b) the Institutional Investor ratings are biased towards a more pessimistic view of creditworthiness. In a different vein, Aylward & Thorne (1998) pursue a separate analysis of countries' repayment performance to the IMF through logit modeling. Their sample consists of 138 countries that had obligations to the IMF in any year during the period 1976-93. They find a small number of financial/macroeconomic factors along with the IMF recent repayment history and the existence of substantial state-dependence. In an in-depth econometric analysis, Fuertes & Kalotychou (2004a,b) attempt i) a cross modeling comparison based on forecasting performance and ii) to establish the optimal threshold rate and warning horizon in the design of early warning systems. Finally, Staikouras (2005) shows that debt ratios, trade resources, domestic factors and financial flows are the most prominent leading indicators. He also reports significant regional heterogeneity across Eastern Europe, Latin America and Asian countries. International risk factors are not found that important in determining financial crises.

Analysis of political factors

The relative importance of political instability on creditworthiness is analyzed by Li (1992) and Lee (1993). They both look into various factors that link the political environment to financial instabilities. The study by Berg & Sachs (1988) attempts to explain the role of socio-political factors in repayment behavior. Their sample consists of 35 countries over the period 1982-87. They shed some light on the explanatory power of deeper structural characteristics of an economy, which are the possible sources of deterioration of financial ratios and of the eventual arrival at financial distress. They argue that greater income inequality, lower share of agriculture in GNP and less outward oriented trade regime are significant predictors of a higher probability of rescheduling. All these are signals of political instability and lack of effective political management. Balkan (1992) introduces two political risk proxies and tests their impact on rescheduling through a probit model, controlling for the classical economic variables. The sample consists of 33 countries over 1970-84. The political variables considered are the level of democracy and political instability. The former captures two components of the political system, participation and competitiveness[7], while the latter includes the degree of social unrest that occurred in a given year in the form of strikes, anti-government demonstrations, assassinations, revolutions, coups, government crises and so on. The findings suggest significant, opposite effects of democracy and political instability (negative and positive respectively) on the likelihood of rescheduling. He further supports the inclusion of the two quantified proxies of political circumstances for improving the in-sample forecasting performance of the model. Haque, Kumar & Mathieson (1998) expand the set of variables to include political variables (coups, purges, government crises, revolutions and strikes) alongside the identified economic variables. Noticeably, political variables do not add significantly to the explanatory power of the regression; while creditworthiness appears to be determined primarily by economic events and the exclusion of political attributes does not seriously bias the estimated coefficients. All the aforementioned literature is by no means exhaustive and a plethora of other studies can also be found in their references. They clearly show the challenges both at theoretical and practical level, which emerge for further research in that area.

[7] Participation refers to the extent to which the executive and legislative branches of government reflect popular will. Competitiveness refers to the degree of exclusion of political parties from the system or the dominance of a particular party.

IV. DATA & METHODOLOGY

The current analysis is based on a panel dataset for 26 Latin American countries spanning the period from 1983 to 2000. In order to pursue an out-of sample forecast evaluation the sample period is split into estimation (1983-1997) and holdout (1998-2000) years. Annual data on financial and macroeconomic factors as well as on external debt obligations are obtained from the World Bank electronic database. Debt obligations comprise data on total external debt, arrears on principal and interest to official and private creditors[8] and amounts of principal to official and private creditors that were rescheduled over the last decade. The final set of exogenous risk factors is selected on the basis of an in-sample stepwise general to specific methodology. At each step the least significant variable is eliminated and the process continues until all variables are significant at the 5% level. The impact of two international factors, namely the growth of OECD countries and US interest rates, is also considered. It is known by now that financial ratios exhibit a degree of skewness and kurtosis and thus the study employs a transformation to allay the problem. The exogenous signals are transformed as $Log(1+x)$ where x is the variable itself expressed as a proportion. In cases where ratios exhibit negatives values the figure is transformed to $-Log(1+|x|)$. The effect of inflation is calculated as $Log(1+\%\Delta CPI)$ in order to alleviate the problem of hyperinflation in some countries. Finally, in order to dampen the effect of any remaining outliers the variables are winsorized, where excessive values are replaced by limiting values of 2.5 standard deviations from the mean. The countries employed for this study along with the risk indicators are presented in appendix 1.

One distinctive feature of the international lending analysis, using panel data, is the construction of the dependent variable, which distinguishes between crisis and non-crisis states. So far the formation of this binary variable has been driven by data availability. The present study monitors the following two events as representatives of the latent variable behind default: accumulated arrears as a proportion of total external debt, and debt-rescheduling agreements with official and/or private creditors[9]. Incorporating reschedulings serves the purpose of accounting for countries that avoided falling into arrears by early requesting rescheduling of their debt obligations. In this case, the rescheduling technically occurs independently of arrears. Arrears above a certain threshold

[8] 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.
[9] World Bank assigns rescheduling dates to the year in which it was publicly announced that the rescheduling negotiations were concluded.

would be considered as an alarming indication of default[10]. The frequency and scale of arrears to external creditors, as reflected in the World Bank database, raises concerns about the use of any amount of arrears as an appropriate indication of default. This paper argues that negligible shares of sovereign debt in default do not necessarily imperil international credit markets, and may simply reflect short-term illiquidity and unavailability of reserves. Our default definition aims at capturing outright defaults and semi-coercive restructuring, but not liquidity crises. The current approach goes one step further and differentiates between country arrear capacities, by employing a country-specific threshold that is equal to the ratio's (arrears/external debt) mean value over the sample period[11]. Thus, a large deviation of arrears from the long-run trend will capture irregular country behavior, as compared to its historical record. To understand the benefit of country specific thresholds, consider two countries with totally different economic profiles. The first one has very high economic ratios, while the second one has very low ratios. Taking the average will increase the tolerance level of the second one, while lower the tolerance level of the first. Subsequently, this will hide possible risky high variations in the ratios of the first country, while exaggerate moderate and usually expected variations for the second one.

Under the current framework the functional relationship between the dependent variable and its attributes is modeled via a logit function. Panel limited dependent variable approaches are used to estimate the coefficients of this model. The logit estimator directly computes for all panel country observations the probability of a sovereign default at time t (P_t) conditional on the vector of explanatory variables (x_t) that are supposed to determine a sovereign's ability/willingness to service external debt. The two quantities are linked via the logistic function, where the values of a latent variable (y_t^*) determine the outcome observed for a zero-one dummy (y_t). This is mathematically expressed as follows

$$y_t^* = x_t'\beta + u_t \qquad (1)$$

where β is a $k \times 1$ vector of unknown parameters, x_t is the set of k explanatory signals and u_t is $iid(0,\sigma^2)$ with a logistic distribution and

$$y_t = 1 \quad \text{if } y_t^* > 0$$
$$y_t = 0 \quad \text{otherwise} \qquad (2)$$

[10] The definition of default follows the one adapted by leading commercial credit rating agencies and market specialists in sovereign debt problems. Default is defined as "the failure to meet a principal and/or interest payment on the due date or any exchange offer of new debt agreed to by creditors at terms less favorable than those contained in the original terms of the debt issue" [Standard & Poor's *Creditweek* 1999, Moody's Investors Service 2000]. This is assumed to be reflecting the perception of default by the international capital markets.

[11] An alternative specification is also tested, where values of one standard deviation away from the mean are employed. Note that this approach is more lenient in terms of identifying fewer cases of default. The results obtained, however, are similar to the ones reported here.

In (2) the probability that $y_t = 1$ is equal to the probability that $x_t'\beta + u_t$ is greater than 0. In essence the value of 1 is taken when a country experiences debt servicing problems and 0 otherwise. Hence

$$P_t = Pr\,(y_t = 1) = Pr\,(y_t^* > 0) = Pr\,(x_t'\beta + u_t > 0)$$
$$= Pr\,(u_t > -\,x_t'\beta) = 1 - F(-\,x_t'\beta) \qquad (3)$$

where $F(.)$ is the cumulative distribution function (*cdf*) for u_t. If the chosen *cdf* is symmetric about zero, then $F(.)$ has the property $1 - F(-\,x_t'\beta) = F(x_t'\beta)$. It follows that

$$P_t = Pr\,(y_t = 1) = F(x_t'\beta) \qquad (4)$$

Equation (4) shows that the latent variable model (2) maps values of $x_t'\beta$ onto probabilities. The standard logistic *cdf* is given by the expression

$$F(x_t'\beta) = [1 + exp\,(-x_t'\beta)]^{-1} \qquad (5)$$

Having observed countries with debt servicing problems and others without and knowing that $Pr\,(y_t = 1)$ depends on the unknown parameter vector β, the likelihood function is

$$L(\beta) = L(\beta\,;\, y_1, \ldots\ldots, y_n)$$
$$= Pr\,(y_1, \ldots\ldots, y_n \mid x_1', \ldots\ldots, x_n'\,;\,\beta)$$
$$= \Pi_1\, P_t \times \Pi_0\,(1 - P_t) \qquad (6)$$

where Π_i (i=0,1) signifies a product over observations for which y = 0 or 1 respectively. The log likelihood function is

$$ln\,L(\beta) = \Sigma_1\, ln(P_t) + \Sigma_0\, ln(1 - P_t) \qquad (7)$$

where Σ_i (i=0,1) signifies the sums relating to observations for which y = 0 or 1 respectively. The desirable properties of the maximum likelihood are that the parameters are consistent and efficient asymptotically. The interested reader can find the maximum likelihood estimation of the proposed model in appendix 2. In addition, *t*-tests can be applied since estimators are known to be asymptotically normal, while for a subset or all the coefficients a likelihood ratio test can be employed. The above presentation briefly summarizes the logit approach[12], along with all the necessary information for the dataset employed.

[12] For a more detailed analysis the interested reader is referred to Maddala (1983).

V. EMPIRICAL RESULTS

The empirical analysis starts by considering a wide range of exogenous factors that are usually held responsible for timely debt servicing. In particular, the potential explanatory variables include indicators of external debt, domestic private debt, proxies of solvency and liquidity, as well as various measures of domestic and global macroeconomic conditions. The variable-distilling process has identified eight economic factors that could shed light to potential credit quality problems. A graphical depiction of these indicators is provided in appendix 3, which evidently illustrates the wavering pattern in all eight signals over the 17-year period examined. Splitting the sample period into crisis and non-crisis years, unveils that the signals uncovered from our in-sample (1983-1997) stepwise regression procedure exhibit a statistically significant change between the two groups. Under skewed distributions, such as of ratios, the variable mean is not the most representative central tendency measure, and thus the paper looks at the median of the signals instead. The comparison of the indicator distributions within the two groups focuses on the whole sample period and table 1 presents the results of such analysis. Precise definitions of the economic signals are provided in appendix 1.

Table 1. Descriptive statistics for the identified warning signals.

	Median: Crisis ~ Non-crisis state	Wilcoxon test	Volatility
Debt over DGP	0.435 ~ 0.344	5.32	4.95%
Export growth	0.044 ~ 0.061	2.98	2.41%
Credit to private sector over GDP	0.250 ~ 0.295	3.04	3.05%
Inflation	0.131 ~ 0.110	2.12	18.73%
Real exchange rate overvaluation	0.088 ~ 0.068	2.99	9.67%
Reserves over imports	0.025 ~ 0.031	3.47	0.33%
OECD growth	-0.793 ~ 0.305	6.51	135.47%
Long-term interest rates	7.210 ~ 7.210	0.64 °	199.36%

The results are based on the whole sample i.e. all 26 countries over the 1983-2000 period.

° Insignificant differences based on the reported statistic.
The Wilcoxon test statistic tests the difference in medians. This is a nonparametric alternative to the two-sample *t*-test; in fact, the test requires only that the population is continuous but not necessarily normal.

Volatility is measured as the standard deviation of the annual figures over the entire period.

Looking at the volatility it is clear that almost all signals exhibited notable deviations from their expected values over the last decade. The volatile pattern is more pronounced for the two international variables (OECD, interest rates) due to considerable changes in global markets over the last two decades. The changes in worldwide financial markets had both economic and structural roots. The results of the univariate analysis show that the selected indicators have some power in discriminating between countries that honor their debt

obligations and those experiencing problems. Their significance and predictive ability is examined in a multivariate setup by means of a logit regression on the pooled data. Before proceeding with the estimation results, it is worth noting that in financial data an equation may be part of a larger system of simultaneous equations. Thus, if signals are dependent to this system and correlated with the residuals in the stochastic part of the model, then statistical estimates would probably be inconsistent. 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 which automatically is characterized as predetermined. Therefore, the mixing variables are lagged one year and the results of the panel logit estimation are presented in table 2.

Table 2. Pool-logit estimates for the Latin American sample over 1983-1997

	Coefficient	*t-ratio*	*Marginal effect*
Constant	3.996	4.86	0.900
Indebtness			
Debt over GDP	1.721	2.66	0.387
Trade resources			
Export growth	-3.638	-2.61	-0.819
Domestic signals			
Inflation	0.861	2.59	0.194
Reserves over imports	-18.547	-3.22	-4.174
Real exchange rate overvaluation	0.764	2.11*	0.172
Credit to private sector over GDP	-2.940	-2.53	-0.662
International factors			
OECD growth	-0.552	-4.71	-0.124
Long-term interest rates	0.419	5.18	0.094
McFadden R^2	0.569		

* Significant at the 5% level. The rest of the coefficients are significant at the 1% level.

Alongside the estimated coefficients and their corresponding *t*-values, the table reports the marginal effects of the economic signals. The non-linearity of the model complicates the interpretation of the estimated coefficients, which no longer represent the marginal effects of the independent variables on the probability of default. To compute the latter the magnitude of each estimated coefficient is weighted by a factor that depends on the values of all the independent variables, usually set at their sample means. As an alternative interpretation to the coefficients, one could simply say that their ratios measure the relative changes in the probabilities for changes in the independent variables. All signals are highly significant and bear signs that can be explained theoretically. The credit to private sector appears to have a negative effect on the probability of default which

contradicts previous empirical evidence. Alternative explanations can, however, justify the plausibility of both signs for this particular ratio[13]. Regarding the negative impact, one may wish to argue that if the size of the economy is high relative to external debt, then a high value of such ratio can be sustained. In that case cash flows are shifted towards the private sector for further development and hence lowering the probability of credit problems. The latter assumes that growth and prosperity in the private sector is realized[14] – Bekaert, Harvey & Lundblad (2005) advocate the use of this ratio as a proxy for economic growth. On the other hand, the higher the indebtedness of the private sector relative to the size of the economy, the higher the likelihood of mass private defaults (large banks, corporations etc.) in case of a cyclical downturn; hence the higher the probability of a banking crisis, which may force the government to bail out large banks and, thereby, to slither itself into payment difficulties.

Some of the signals seem to exert more influence in predicting credit quality problems than others. The results suggest that a traditional indicator such as the ratio of reserves to imports has the most prominent effect on debt servicing of Latin American countries (a 5% decrease in the ratio results to 20% increase in the probability of a crisis). As earlier discussed in section II, imports are considered as a key element in the region. Emerging markets usually rely quite heavily on imports and thus reserves level plays an important role in facilitating imports and honoring debt obligations especially in years of distress. Similarly, changes in export growth and the credit to private sector have on average four times more influence in determining the probability of financial distress than the rest of the identified signals. The former stresses the export oriented nature of Latin America, whereas the latter is linked with increased economic growth. The effect of global interest rates is quite small, probably as a result of the low interest rate environment over the last decade. Similar warning indicators have been found by Moghadam & Samavati (1991) in a probit approach and by Haque, Kumar, Mark & Mathieson (1996) using multivariate regression analysis. Experimentation using dynamic specifications to account for state dependence showed results qualitatively similar to the ones reported here. The significance of the factors, however, was reduced because much of the variation in repayment performance was explained by default history as proxied by the lagged value of arrears to

[13] For the twofold interpretation of other ratios, the interested reader is referred to Acharya & Diwan (1993) and Saunders & Cornett (2006) for the real investment to GNP ratio.

[14] An alternative, but similar interpretation, is that the negative sign might indicate more efficient resource allocation under the assumption that private enterprises are more efficient than governments. Thus, a higher ratio increases the inflow to the private sector and implies more efficient resource allocation, which in turns lowers the probability of default. The authors are grateful to Professor Ephraim Clark for suggesting and commenting on this issue.

external debt ratio. The strong significance of the latter, when included, verified the marked presence of autocorrelation in the credit history of each country. The latter is consistent with evidence of "short memory" in international lending [Hajivassiliou (1994), Aylward & Thorne (1998), Kalotychou (2004), Staikouras (2005)]. Finally, based on the goodness of fit as measured by the McFadden R^2 the estimator seems rather promising.

The analysis so far has focused on the identification of risk factors for Latin America's creditworthiness. The importance of correctly specifying these models lies mainly upon their ability to predict future debt distress cases. As earlier discussed, however, credit rating downgrades were preceded by financial crises over the last decades. Thus, banks and other multinational financial institutions value and rely on the ability of various quantitative approaches as complementary tools for accurately gauging financial unrest. The paper proceeds with an out-of-sample forecasting analysis of the proposed estimator. The out-of-sample period spans the three years between 1998 and 2000 and the predictions are generated using a fixed estimation window (1983-97). This aims to assess the extent to which economic fundamentals can signal distress up to three years prior to the actual default. Adopting a rolling-window instead would have implied inclusion of the most current distress years in the estimation sample, which is what one aims to predict. The approach currently employed presumes that there is no structural break that will alter either the causes of default or the impact of country fundamentals on the default probability, i.e. temporal stability of the model parameters.

In the present context, a crisis is predicted if the estimated probability exceeds a certain threshold. The in-sample default frequency has been used as the cut-off probability for classification. The latter indicates the percentage of defaults relative to the total number of cases in the estimation sample. It can be argued that one should use as a cut-off probability the value that minimizes the expected cost of misclassification. Nonetheless, introducing distinct misclassification costs would imply formal specification of the user's decision process. In essence, this would amount to specifying the utility function of the investor, which is not that obvious in the present setup. The choice of the historical default frequency as a cut-off rate is in line with the consensus that type I errors are more costly [Somerville & Taffler (1995)] than type II, from the point of view of international investors. The forecast evaluation using a range of criteria is presented in table 3.

Table 3. Out-of-sample forecasting analysis.

Panel A.	Year 1998	Year 1999	Year 2000
Type I error	16.7%	None	28.6%
Type II error	30.0%	41.2%	23.5%
Overall misclassification error [a]	26.9%	28.0%	25.0%
False alarms ratio [b]	54.6%	46.7%	44.4%
Noise to signal ratio [c]	36.0%	41.2%	32.9%

Panel B.	1983-1997 In-sample	1998-2000 Out-of-sample
Type I error	9.3%	14.3%
Type II error	19.5%	31.5%
Overall misclassification error	16.2%	26.7%
False alarms ratio	36.1%	48.6%
Noise to signal ratio	21.5%	36.7%

[a] This is the percentage of incorrectly predicted cases.

[b] False alarm over total alarms, which is the number of type II errors divided by the number of predicted crises (alarms).

[c] Calculated as the percentage of false alarms (%Type II) over the percentage of correctly predicted crises (1-%Type I).

Panel A reports the out-of-sample predictive performance on a year-to-year basis, while panel B reports the goodness of fit for the in- and out-of-sample periods. It is evident from table 3, panel B, that the performance of the proposed estimator deteriorates in the out-of-sample period. Comparing the predicted and the in-sample results, it is verified that the both the overall and the group-wise (type I and type II errors) misclassification rates have increased. More specifically, the percentage of correctly predicted crises and non-crises, in the out-of-sample period, have reduced by 5% and 12%respectively[15]. The false alarms and noise to signal ratios illustrate the same thing from a different perspective. In particular, 48.6% of total alarms are false in the out-of-sample years as compared to 36.1% in the estimation sample, while the noise to signal also increases from 21.5% to 36.7%. A closer look indicates that the increase in the two ratios is attributed more to the rise in false alarms rather than the decrease in the correctly predicted crises. In summary, two findings emerge from the out-of-sample forecast analysis. First, the overall performance of the model is satisfactory, but it is better in anticipating crises relative to tranquil periods. Second, the model's performance deteriorates in the out-of-sample period in terms of misclassifying tranquil periods as defaults – evident through the increase in the noise to signal ratio.

[15] The percentage of correctly predicted crises and non-crises is found by subtracting the percentage of type I and type II errors from unity, respectively.

The year-by-year predictions reveal that it is in 1999 when the prediction accuracy suffers most, with a noticeable increase in the overall misclassification error and the noise to signal ratio. Interestingly, during that year the type I error is non-existent and the type II error has increased by 37.3% relative to the previous year. Put differently, the success in capturing all debt crises in 1999 comes at the expense of substantially more false alarms with a subsequent drop in prediction accuracy. Nevertheless, the estimator performs rather well in 2000 notwithstanding the "lengthy" span of the prediction horizon. Looking at panel A, both ratios exhibit their lowest values during this period. This might suggest that, despite the period being characterized by the development of international financial markets, there is no structural break in Latin American debt servicing as the model estimated until 1997 captures reasonably well the debt crises in 2000.

With regards to 1999, it is actually during this year when the first wave of debt crises struck the Latin American region and the proposed model predicts all crisis cases. The turmoil was mainly a combination of the Asian spillover effects and in few cases flawed financial infrastructure. It is worth noting that contagion until recently was attributed to two conduits namely the correlated information assumption [King & Wadhwani (1990)] and/or the correlated liquidity shock channel [Calvo (1999), Yuan (2000)][16]. Interestingly, a third route may be responsible for those spillovers known as the cross-market rebalancing channel [Kordes & Pritsker (2002)]. The latter associates the crises in two unrelated markets via a third market, which acts as the missing link between the two. Furthermore, Kordes & Pritsker (2002) show that information asymmetry[17] makes a country more vulnerable to contagion from abroad. Using a two-year forecasting period Kalotychou & Staikouras (2004, 2005) and Staikouras (2005) find qualitatively similar results to the ones reported here using a more diverse sample of sovereign states. In order to provide further insight into the model's predictive ability a detailed analysis of the year-by-year forecast for each country is also presented. Table 4 illustrates the latter by separating the sample in actual crisis and non-crisis country-year cases.

[16] Under the correlated information theory, prices in one market have power in changing the value of assets in other markets. Under the correlated liquidity approach, the need for asset liquidation by some market participants may take place in various markets simultaneously, resulting in transmitting the shock. Schinasi & Smith (2000) discuss the liquidity issues in the context of portfolio management.

[17] Their study defines asymmetry the amount of private information that informed traders have about a country's assets' liquidation value. They suggest that excess price movements due to information asymmetry can be reduced by transparency and more open access to information underlying the values of assets.

Table 4. Country specific forecasted status for the period 1998-2000.

Panel A. **Crisis cases**

1998		1999		2000	
Dominican Rep.	1 ¦ 63.6%	Bolivia	1 ¦ 51.5%	Ecuador	1 ¦ 52.5%
Guatemala	1 ¦ 59.1%	Grenada	1 ¦ 56.8%	Grenada	0 ¦ 37.0%
Jamaica	1 ¦ 84.5%	Guatemala	1 ¦ 70.4%	Guatemala	1 ¦ 52.2%
Nicaragua	1 ¦ 82.2%	Guyana	1 ¦ 88.3%	Honduras	1 ¦ 57.1%
Peru	0 ¦ 32.1%	Honduras	1 ¦ 74.4%	Nicaragua	1 ¦ 79.2%
Trinidad & Tobago	1 ¦ 53.3%	Jamaica	1 ¦ 87.0%	St. Kitts & Nevis	0 ¦ 42.9%
		Nicaragua	1 ¦ 92.8%	Trinidad & Tobago	1 ¦ 52.1%
		Trinidad & Tobago	1 ¦ 51.3%		

Panel B. **Non-crisis cases**

1998		1999		2000	
Argentina	0 ¦ 38.6%	Argentina	0 ¦ 48.4%	Argentina	0 ¦ 35.7%
Belize	1 ¦ 59.0%	Belize	0 ¦ 42.3%	Belize	0 ¦ 45.3%
Bolivia	0 ¦ 44.6%	Brazil	1 ¦ 53.2%	Bolivia	0 ¦ 43.2%
Brazil	0 ¦ 37.6%	Chile	0 ¦ 32.0%	Brazil	0 ¦ 33.5%
Chile	0 ¦ 19.5%	Colombia	1 ¦ 52.6%	Chile	0 ¦ 16.4%
Colombia	0 ¦ 42.0%	Costa Rica	0 ¦ 38.5%	Colombia	0 ¦ 34.2%
Costa Rica	1 ¦ 64.2%	Dominican Rep.	0 ¦ 34.5%	Costa Rica	0 ¦ 42.4%
Ecuador	0 ¦ 46.9%	Ecuador	1 ¦ 81.0%	Dominican Rep.	1 ¦ 51.4%
El Salvador	0 ¦ 34.8%	El Salvador	0 ¦ 33.7%	El Salvador	0 ¦ 23.7%
Grenada	0 ¦ 40.3%	Mexico	0 ¦ 36.0%	Jamaica	1 ¦ 69.9%
Guyana	1 ¦ 81.3%	Panama	0 ¦ 33.9%	Mexico	1 ¦ 59.7%
Haiti	1 ¦ 80.4%	Paraguay	1 ¦ 79.3%	Panama	0 ¦ 36.4%
Honduras	1 ¦ 74.5%	Peru	1 ¦ 53.0%	Paraguay	1 ¦ 67.3%
Mexico	0 ¦ 40.5%	St. Kitts & Nevis	0 ¦ 33.4%	Peru	0 ¦ 32.0%
Panama	0 ¦ 33.4%	St. Lucia	0 ¦ 33.9%	St. Lucia	0 ¦ 38.3%
Paraguay	1 ¦ 67.2%	Uruguay	1 ¦ 53.7%	Uruguay	0 ¦ 37.0%
St. Kitts & Nevis	0 ¦ 37.0%	Venezuela	1 ¦ 64.5%	Venezuela	0 ¦ 48.8%
St. Lucia	0 ¦ 43.1%				
Uruguay	0 ¦ 48.5%				
Venezuela	0 ¦ 46.8%				

1 and 0 are the forecasted status i.e. crisis and non-crisis cases respectively.

·¦% Figures after the predicted status (vertical segmented line) indicate the probability of crisis.

The threshold value for predicting default is estimated to be 47%.

The results in table 4 endorse the satisfactory performance of the model in terms of correctly predicting crises. Comparing the mispredicted crisis (panel A) and tranquil period cases (panel B) it becomes apparent that the particular estimator is biased towards a higher type II error, i.e. wrong default classification[18]. The relatively larger number of false alarms in this period may not necessarily imply predictive failure of the model, but rather advanced

[18] Testing the statistical significance of the prediction bias using the Diebold-Mariano (1995) test requires normality for the distribution of the test statistic, an assumption that may not hold in the case of ordinal forecasts.

indication of pending problems. If one looks at the patterns in timing of errors the model's false alarms may not be as worrisome. For example in 1998, both Honduras and Guyana have type II errors, but are in trouble the following year[19]. This is also true in Ecuador in the following year, while Paraguay is always misclassified. Haiti has a type II error in 1998, but it is subsequently removed due to missing data. On the other hand, all eight debt crisis incidents are anticipated in 1999, whereas overall the model only misses three crises (Peru in 1998, Grenada and St. Kitts & Nevis in 2000). Nonetheless, it is worth saying that during the same year credit rating agencies downgraded a number of countries in the Latin American region. It is actually that year that Brazil, the main growth engine in the region, declared a moratorium on the state's debt to the federal government. With dwindling foreign-currency reserves, Brazil devalued its currency and allowed it to float. Brazil started negotiating its economic program with the IMF. With reference to some downgrades[20], these were motivated by deteriorating fiscal conditions (Brazil), by slow progress, reversals on structural reforms and political uncertainty (Venezuela, Paraguay). The government that slipped out of investment grade was Columbia, while Ecuador was the newcomer in sovereign defaults in 1999. On the other hand, El Salvador enjoyed an upgrade due to its deepened structural reforms, and the model captures this positive development in all three years. At this point, it is important to mention that these estimators are not intended to be a panacea, but rather are complementary tools and act as a filtering device for banks and/or other financial institutions to see where they should be looking. Statistical models should be part of a broader approach to international credit risk that embraces all aspects and complex dynamics likely to drive a country to the brink of financial turmoil.

VI. CONCLUSION

In international banking literature, sovereign risk analysis includes any political, economic, social, cultural[21] or legal variables that could prevent the timely fulfillment of a country's debt obligations. The current study sets out to explore the economic forces behind debt repayment problems in Latin American countries. The region has a long-standing

[19] Note that this could also be interpreted as a good sign, since the model predicts problems well in advance. We should not forget, however, that all these cases are examined in an *ex-post* framework. In our *ex-ante* world, at the time the misclassification takes place, this is a wrong prediction (hopefully less costly than a type I error) and hence its classification as a type II error.

[20] Standard & Poor's Credit Week, December 1999 and January 2000.

[21] An interesting example of country risk occurred after the price of crude oil fell dramatically in 1986. Many Islamic borrowers with significant indebtness to US banks invoked the doctrine of *sharia*, which holds that the payment of interest is against the teachings of Koran.

history of financial turmoil arising from many sources, such as social unrest, economic decline, civil conflict or even changes in political ideology.

The paper identifies financial signals that adequately explain much of the variation in creditworthiness of the specific region. Debt levels, trade recourses, internal economic environment and international factors do play an important role in determining default. In particular, net international reserves account for much of the variation in debt repayment followed by changes in exports. Another important sovereign fundamental is the domestic financial resources provided to the private sector, which seems to explain equally well credit irregularities. Global economic conditions such as interest rates and growth rate are also notable, but their relative impact is smaller. It appears that policymakers in Latin American countries still enjoy a substantial degree of freedom to reduce country risk and affect economic growth. On the other hand, monitoring certain indicators of country vulnerability, such as reserves levels and domestic private debt, can give important insights when developing credit evaluation models or early warning systems for debt crises.

The forecasting ability of the proposed model is scrutinized on a year-to-year basis under several criteria. Overall, the results indicate a reasonable number of future crises being anticipated. Nevertheless, the performance of the model weakens during 1999 when a relatively larger percentage of false alarms are detected. The latter is also endorsed by the prediction accuracy criteria, which point towards a type II error bias. This is translated into relatively fewer missed crises at the expense of issuing more false alarms. Finally, the pattern in timing of errors suggests that the false alarms usually precede crises, and thus possibly reduce the false-alarm associated costs.

The evaluation throughout this paper illustrates that the development of a stable, market-orientated financial system is one of the forthcoming challenges. On this should be added policy challenges related to debt management and contingent liabilities stemming from weak monitoring systems and lack of fiscal discipline. It is also worth noting that the emerging economies' debt is not the only mispriced market, but it is one of the most likely to flatten when long-term US interest rates eventually turn. Both creditors and debtors have realized that the healing properties of rescue packages have been hugely exaggerated. Yet, can one argue that sovereign debt restructuring mechanisms maybe harmful, as they make default seem more normal? The international community in general and the IMF in particular need to rethink their approach to life after a default. The discussion simply portrays the various aspects and implications of sovereign risk analysis for multinational financial institutions, global economic stability and national planning designs.

Appendix 1 Exogenous risk factors & the Latin American sample.

Debt ratios

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

Trade resources

Export growth: Annual percentage change in exports.

Domestic economy

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

Inflation: Annual percentage change in the consumer price index - CPI.

Real exchange rate overvaluation: Deviation of real exchange rate from the long-run trend. The idea of this proxy for FX misalignment is similar to the ones in Frankel & Rose (1996) and Kaminsky & Reinhart (1999) except for the calculation of the trend.

Reserves over imports: Net international reserves in weeks of imports. Net international reserves comprise special drawing rights, reserves of IMF members held by the IMF and holdings of foreign exchange under the control of monetary authorities. Data are in current USD and gold holdings are excluded.

External developments

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

Long-term interest rates: The yield on a 10-year US Treasury bond. It aims to capture global liquidity and interest rate effects.

Latin American sample

Argentina	Haiti
Belize	Honduras
Bolivia	Jamaica
Brazil	Mexico
Chile	Nicaragua
Colombia	Panama
Costa Rica	Paraguay
Dominican Rep.	Peru
Ecuador	St. Kitts & Nevis
El Salvador	St. Lucia
Grenada	Trinidad & Tobago
Guatemala	Uruguay
Guyana	Venezuela

Appendix 2 Maximum likelihood estimation of the logit model.

Due to the non-linear nature of the logit approach an iterative procedure is required for the attenuation of a solution that will give the maximum likelihood (ML) parameter estimates[22]. It has been established that under general conditions the ML estimators are consistent and asymptotically normal[23]. A number of numerical techniques are available for the solution of such equations. The most commonly used being the Newton-Raphson (NR), the Scoring (SC) and the Goldfeld-Quandt[24] (GQ) algorithms. All of the techniques are based on the use of the matrix of second derivatives of *lnL* and their expectation in forming iteration updates and in computing the asymptotic estimated variance-covariance matrix of the coefficients. The actual matrix of second derivatives (*H*) for the logit model is as follows

$$H = \frac{\partial^2 \ln L}{\partial \beta \, \partial \beta'} = -\sum_{i=1}^{NT} f(\beta' x_i)\, x_i x_i' = -\sum_{i=1}^{NT} F(\beta' x_i)\,[1 - F(\beta' x_i)]\, x_i x_i' \qquad (8)$$

H is negative definite[25] $\forall \beta, x_i$. It follows that *lnL* is globally concave, which implies the existence of a unique maximum. Since the second derivatives are independent of y_i we have

$$E\frac{\partial^2 \ln l}{\partial \beta \partial \beta'} = \frac{\partial^2 \ln L}{\partial \beta \partial \beta'} \qquad (9)$$

Therefore, the asymptotic variance-covariance matrix of the parameters is *V*, where

$$V = -\left(E\frac{\partial^2 \ln L}{\partial \beta \partial \beta'} \right)^{-1} = -(H)^{-1} = \sum_{i=1}^{NT} \left\{ F(\beta' x_i)\,[1 - F(\beta' x_i)]\, x_i x_i' \right\}^{-1} \qquad (10)$$

Therefore, given a starting value β_0, the first iteration for the ML estimator of β in each of the three methods is given by the following expressions

$$\hat{\beta}_1 = \beta_0 - \left(H_{\beta_0}\right)^{-1} \frac{\partial \ln L}{\partial \beta_{(\beta_0)}} \qquad \text{(NR)}$$

$$\hat{\beta}_1 = \beta_0 - \left[E(H_{\beta_0})\right]^{-1} \frac{\partial \ln L}{\partial \beta_{(\beta_0)}} \qquad \text{(SC)}$$

Equation (9) implies that for the logit model the two methods coincide.

$$\hat{\beta}_1 = \beta_0 - \left(\frac{\partial^2 \ln l}{\partial \beta \partial \beta'_{(\beta_0)}} + \gamma \cdot I \right)^{-1} \frac{\partial \ln L}{\partial \beta_{(\beta_0)}} \text{ (GQ)}$$

where *I* is the identity matrix and γ is a positive constant picked by the algorithm. In essence GQ provides a slight modification to the NR by adding a correction matrix γI to *H* to speed up convergence[26]. The procedure is repeated until the algorithms converge to the parameter estimates β that maximize the log-likelihood[27]. A detailed analysis of this method is beyond the scope of this study and the interested reader is referred to the relevant econometric textbook.

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[22] Note that equation (12) implies that if x_i includes a constant term, then $\sum_{i=1}^{NT} y_i x_i = \sum_{i=1}^{NT} F(\beta' x_i) x_i$ holds if $\sum_{i=1}^{NT} y_i = \sum_{i=1}^{NT} F(\hat{\beta}' x_i)$. This means that the average of the predicted probabilities must equal the proportion of observations in the sample with $y_i = 1$.

[23] Proof for the consistency and asymptotic normality of the ML estimators for the logit model is provided in Amemiya (1985), p270-273.

[24] Sometimes referred to as Quadratic Hill Climbing algorithm.

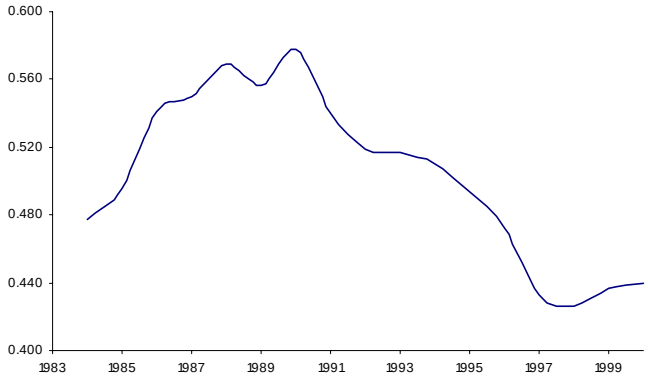
[25] It is assumed that $\{x_i\}$ are uniformly bounded in *i* and the matrix $\lim_{n\to\infty} \frac{1}{n} \sum_{i=1}^{N} x_i x_i'$ is finite and non-singular.

[26] GQ was the algorithm employed for carrying out the estimations in this paper. For a further discussion see Goldfeld and Quandt (1972).

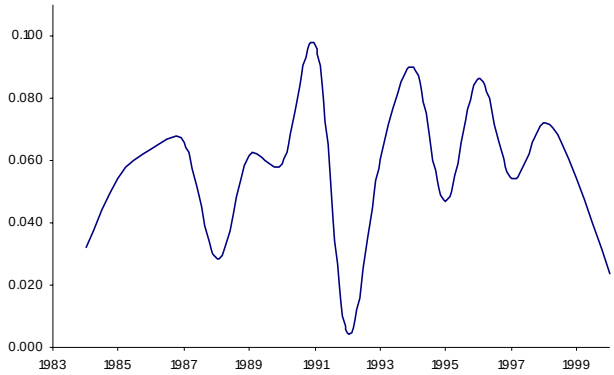
[27] The NR, SC and GQ algorithms normally converge to the unique maximum of the log-likelihood in a few iterations, unless the solution is unbounded. An example of an unbounded solution might arise if there was no variation in y_i, i.e. $y_i = 0$ or $y_i = 1 \; \forall \; i$.

Appendix 3 Illustrations of Latin America's economic indicators.

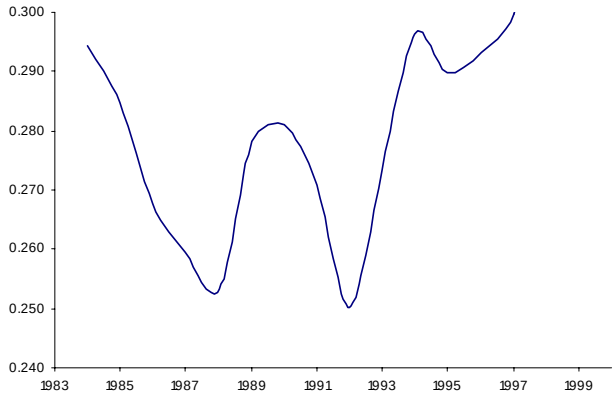
DEBT TO GDP RATIO



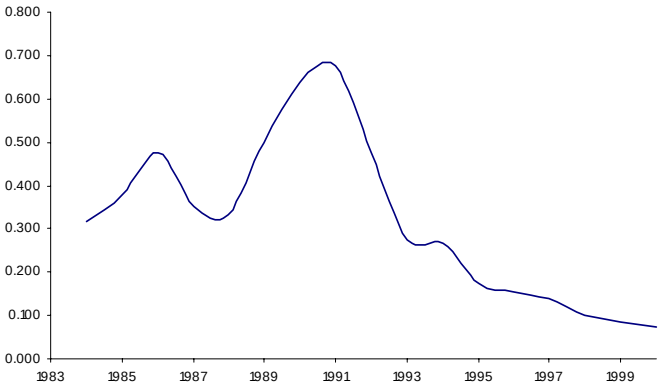
EXPORT GROWTH



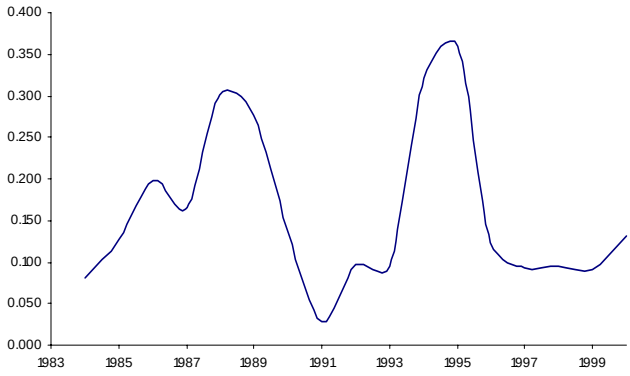
CREDIT TO PRIVATE SECTOR TO GDP RATIO



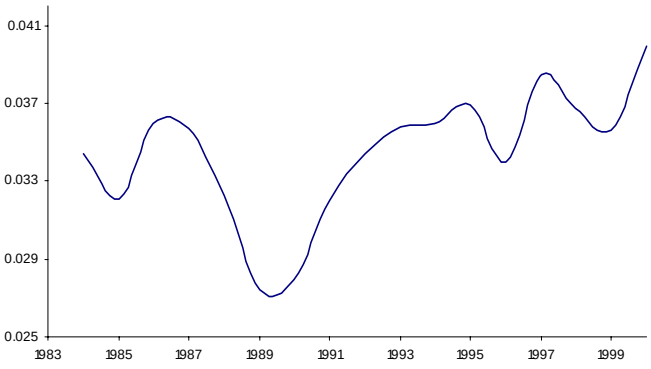
INFLATION



REAL EXCHANGE RATE



RESERVES TO IMPORTS RATIO



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