

Structural Vulnerabilities and Currency Crises

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This paper examines the role of structural factors—governance and rule of law, corporate sector governance (creditor rights and shareholder rights), corporate financing structure—as well as macroeconomic variables in currency crises. Using a technique known as a binary recursive tree allows for interactions between the various explanatory variables. It is found that structural vulnerabilities play an important role in the occurrence of “deep” currency crises (those with a real GDP growth decline of at least 3 percentage points) and that there are complex interactions between these structural vulnerabilities and macroeconomic imbalances. [JEL F31, F41, F47]

There is a growing body of literature that seeks to identify, or even predict, circumstances under which countries may suffer balance of payments crises. Much of this literature, inspired by the theoretical models of Krugman (1979) and Flood and Garber (1984), emphasizes the role of macroeconomic imbalances—large fiscal deficits or excessive rates of credit expansion—as the underlying cause of currency crises (while the proximate triggers may be contagion effects or imprudently low levels of foreign exchange reserves).

Yet the Asian crisis countries, in particular, do not readily fit this mold. Exchange rates in these countries were not especially overvalued, fiscal deficits were small, and macroeconomic performance had generally been exemplary. Rather, structural weaknesses in the corporate and financial sectors appear to have been at play. This paper seeks to complement much of the existing literature on currency crises by examining the role of structural factors and vulnerabilities.¹

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¹In recent, parallel work, Mulder, Perrelli, and Rocha (2001) examine the role of structural factors in currency crises using a probit framework; see also Stone and Weeks (2001).

At least in East Asia, weak corporate and public sector governance appears to have encouraged an environment of excessive risk taking by the corporate and financial sectors, resulting in highly vulnerable corporate financing structures, with too much reliance on debt rather than equity issuance, and a large fraction of short-term rather than long-term borrowing.² But such vulnerable corporate financing structures, while a feature of the East Asian experience, are by no means unique to it and may have been at play in other currency crises as well.³

Identifying such structural determinants of currency crises is important for at least two reasons. First, inasmuch as these weaknesses, like macroeconomic imbalances, contribute to the probability of a currency crisis, eliminating them is clearly a priority. Second, if structural factors are at play, then faced by a such crisis, announcing and implementing structural reforms may be crucial in restoring confidence to the markets.

We examine the role of corporate sector vulnerabilities in currency crises using a panel dataset covering some 40 industrialized and emerging market countries, over the period 1987–1999. Our list of crises is taken from Glick and Hutchison (1999), except that, for the bulk of our analysis, we focus on “deep” currency crises—that is, those in which there was an appreciable decline in real GDP growth.⁴ In addition to the usual macroeconomic suspects, we consider four broad categories of structural indicators. The first pertains to what might be termed the country’s overall “rule of law,” including ratings on public sector corruption, risk of government expropriation or contract repudiation, and efficiency of the judicial system and legal and accounting standards. The second and third categories concern corporate governance directly, and pertain to the rights and responsibilities of shareholders and creditors, respectively.⁵ Weak corporate governance, resulting, in part, from inadequate shareholder and creditor rights, may be manifested in a risky financing structure of corporations (e.g., with an overreliance on short-term debt). As a final category, therefore, we also include corporate debt-equity ratios and maturity structure of debt (medians for a sample of firms in each country).

Much of the literature on currency crises to date has used probit analysis to relate the probability of a crisis to a vector of explanatory variables. Such probit models underlie most of the “early warning systems” for currency crises being implemented in both the private and public sectors.⁶ Although the precise explana-

²In addition, the lack of deep domestic bond markets in many of these countries contributed to a reliance on bank borrowing as a source of finance.

³For instance, in the sample below, in addition to East Asia, other countries in which the corporate sector had a relatively high proportion of short-term debt include Turkey, Hungary, Greece, Poland, and Peru, while debt-equity ratios were high in the Nordic countries.

⁴Glick and Hutchison (1999) define a currency crisis as a “large” change (more than two standard deviations from the country-specific mean for the country) of an index of currency pressure, defined as the weighted average of monthly real exchange rate changes and monthly (percent) reserve losses. To focus on cases in which there is an appreciable decline in real GDP growth, we use two cutoffs: those currency crises involving a decline in real GDP growth of at least 3 percentage points, and those involving a decline of at least 5 percentage points (relative to the previous five years).

⁵Note that some elements of the “rule of law” such as accounting standards and efficiency of the judicial system also have a direct bearing on the exercise of corporate governance.

⁶See, for instance, the proceedings of the Economic Forum on Early Warning Systems, hosted by the IMF on November 1, 2001 (reported in the *IMF Survey*, November 12, 2001).

tory variables differ across models, they normally include indicators of macroeconomic imbalances—current account deficits, real exchange rate overvaluation, rapid rates of credit growth, and budget deficits—and, in some recent studies, various indicators of structural vulnerability as well.

These probits give the marginal effect on the probability of a crisis of each of the explanatory variables, holding the others constant at their mean values. While this “other things being equal” (*ceteris paribus*) assumption is common in economics, it is not the most natural assumption to make when assessing the risk of an event because it does not readily allow for *interactions* between the various explanatory variables; indeed, in many other contexts, the *ceteris paribus* assumption would be considered quite odd.

Take, for instance, a doctor diagnosing a patient’s risk of a heart attack, and suppose that both a history of heart problems in the immediate family (hereditary factors) and high (LDL) cholesterol levels are known to be contributory factors. The equivalent of a “probit” approach would be one in which the doctor considers the marginal effect of the patient’s cholesterol level, holding constant his family history at the (population) mean. But no doctor would do this. Rather, it would be much more natural to *first* ascertain whether there was any history of heart attacks among the patient’s relatives. If the answer was *yes*, then the “danger” level of cholesterol may be 130, and the patient’s cholesterol assessed in relation to this level. On the other hand, if the answer to a family history of heart attacks was *no*, a higher level of cholesterol, say 150, may be tolerable.⁷

In much the same vein, a country may be vulnerable to a crisis because of structural deficiencies but only suffer a currency crisis when macroeconomic imbalances become sufficiently severe. Such “context-dependence” is also reflected in the theoretical literature on currency crises. First-generation models emphasize the inconsistency of policies—governments intent on money-financing their deficit while trying to maintain a fixed exchange rate—as the underlying cause of the crisis. Second-generation models emphasize the cost of maintaining the pegged exchange rate regime, for instance in the face of high unemployment, which under certain circumstances (when the country is within a “zone of vulnerability”) can trigger a speculative attack. Third-generation models are built around potential structural vulnerabilities—especially foreign currency debt exposure of the corporate and financial sectors—leading to a self-fulfilling run on the currency. In any panel dataset, it is likely that each of these various generations (or variants thereof) is represented. If these are simply lumped together, factors that are important in determining one type of crisis may not be identified because they do not help explain the other types of crises.

As a methodological innovation of this paper, therefore, we go beyond standard probit analysis and use a decision-theoretic classification technique known as a *binary recursive tree* (BRT). This technique is particularly well suited to situations in which there may be “context dependence” and threshold effects. To the extent that there are different types of crises represented in the dataset, for instance, the classification tree can separate these and then examine the interaction

⁷The figures used here are purely illustrative.

of the various variables in determining a currency crisis. Such interactions could be especially important here because structural factors typically do not change very rapidly, so their ability to predict crises in a panel (or time series) context may be limited. Rather, we would expect the interaction of relatively long-standing structural vulnerabilities and high(er)-frequency movements in macroeconomic variables to account for currency crises. For instance, the East Asian crisis countries had structural vulnerabilities for a number of years prior to the onset of the crisis; there must have been a confluence of events—structural vulnerabilities, macroeconomic imbalances, and perhaps contagion—to have actually triggered the crisis. Not only does the binary recursive tree help identify factors that may trigger (various types) of currency crisis, it can also be used to refine traditional probit models.

Our main results may be summarized briefly. First, we confirm that macroeconomic imbalances, most notably a large current account deficit, are often the proximate trigger of a crisis. Second, we find that a weak “rule of law” may make countries particularly vulnerable to the effects of macroeconomic imbalances. Third, a risky corporate finance structure—high debt-equity ratios and short maturity of corporate debt—is an important determinant of currency crises. When these debt-equity ratios and maturity composition of corporate debt are included, the indicators of shareholder and creditor rights figure less prominently, suggesting that the effect of the latter on the probability of a crisis is manifested mostly *through* the financing structure of corporations. Finally, we find that the *interaction* between structural vulnerabilities and macroeconomic imbalances in determining crises is often highly complex, highlighting the difficulties of undertaking effective surveillance and monitoring of countries’ potential vulnerability to crises.

I. Corporate Governance and Structural Vulnerabilities

Although structural factors may have been at play in previous crises, it was the Asian currency crises at end-1997 and 1998 that brought them to the fore.

A key hypothesis put forward in the context of the East Asian crisis is that the corporate incentive structure encouraged a rapid pace of investment that was of increasingly uncertain quality.⁸ The rapid pace of investment and, in some cases, progressively lower returns on these investments made it necessary for firms to seek financing outside of retained earnings. Given the corporate governance environment and a traditional reluctance to dilute family shareholdings, this demand for outside financing took the form of borrowing rather than equity issuance.

Corporate governance refers to the rules, standards, and organizations that govern the behavior of corporate owners, directors, and managers and that define their duties and accountabilities to outside investors (Prowse, 1998). It is thus a key element in exercising discipline on firms and defining the overall incentive framework for firms, and is therefore essential for efficient, productivity-driven investments and safeguards against excessive risk taking.⁹

⁸See, for example, Alba and others (2000).

⁹Competition in the product markets is another channel through which discipline is exercised on firms.

Mechanisms that facilitate good corporate governance may be grouped into those that govern the rights of (especially minority) shareholders, those that govern the rights of creditors, and those that facilitate enforcement of these rights as well as monitoring and disciplining.¹⁰

Within the first category, there are measures that strengthen shareholders' rights in general, those that strengthen minority shareholders' abilities to exercise governance, and those that strengthen the rights of "strategic" investors. If the minimum percentage of ownership of share capital required to call an emergency shareholders' meeting is relatively low, for instance, this makes it easier for minority shareholders to organize a meeting to challenge or oust the management. (The percentage varies around the world from 1 percent of share capital in the United States to 33 percent in Mexico). Or, if proxy by mail is allowed, (any) shareholders' ability to exercise their voting rights is considerably facilitated. For strategic investors, the right to hostile takeovers may be an important disciplining mechanism.

Creditor rights are conceptually more complex because creditors exercise their power in several ways. Perhaps the most basic creditor right is the right to repossess and then liquidate—or keep—the collateral (La Porta and others, 1998). Creditor rights are strengthened if, for example, the bankruptcy or reorganization laws stipulate restrictions on reorganization, such as the need for creditors' consent to file for reorganization; or if secured creditors are ranked first in the distribution of the proceeds that result from the disposition of assets of a bankrupt firm. Also important, however, is the incentive structure of creditors or financial institutions themselves, which is shaped not only by their own corporate governance, prudential norms, and regulatory and supervisory framework, but also by the perception of implicit government guarantees. Strong creditor rights without the corresponding good governance of financial institutions will still result in weak disciplining of corporations.

Finally, there is a set of rules and regulations that facilitate monitoring and disciplining, including the legal framework (enforcement and insolvency/bankruptcy or exit mechanisms), accounting standards, transparency, and disclosure, etc.

Weak corporate governance is often reflected in a divergence between "control rights" and "cash-flow rights,"¹¹ in turn, encouraging excessive risk taking in investments. Through control-enhancing mechanisms such as pyramiding,¹² cross-holdings, or having a chief executive officer, board chairman, or vice chairman related to the controlling family, cash-flow rights can deviate

¹⁰Until recently, the literature on corporate governance focused on the potential conflicts between shareholders and managers. In East Asia, however, major shareholders and managers have tended to be one and the same, giving them almost complete discretionary power to commit company resources. In the East Asian context, therefore, the issue has been of having a few inside owner/managers on the one hand, and outside minority shareholders and financiers on the other. The contention, therefore, is that the mechanisms to exercise corporate governance over the insider shareholders were weak in the region.

¹¹"Cash-flow rights" refers to the claim on the profits of the corporation associated with the ownership of the stock; however, under certain circumstances, a group owning less than a majority of the cash-flow rights may, nevertheless, exercise "control rights," for instance by stock pyramids, cross-ownership structures, and dual class equity structures.

¹²Pyramiding is defined as owning a majority of the stock of one corporation that, in turn, owns a majority stock of another—a process that can be repeated a number of times.

substantially from control rights. Such deviations, if significant, can provide incentives for greater risk taking (both in the nature of investments and in their volume and pace), as corporate owners have less to lose if the project goes wrong (since their cash-flow stake is relatively small), but can benefit if the project is successful—because, through their effective control, they can more easily expropriate the gains. Particularly in East Asia, these perverse incentives were exacerbated because management was generally not separated from ownership control.¹³ The combination of concentrated family control rights that exceeded cash-flow rights, and close control of management by family owners, provided corporate owners both greater incentives for risk taking and the means for effecting this.

Excessive risk taking, in turn, can result in a fast pace of investment (often with progressively declining rates of return), necessitating financing outside of firms' retained earnings. This financing often takes the form of debt, because of the incentive structure of debt, where default allows the borrower to limit the downside risk (particularly in countries where creditors' recourse to bankruptcy proceedings is limited), while capturing the gains if the project is successful. Beyond this, however, particularly in the East Asian context, there is often a general reluctance by family owners to dilute their share of ownership as well.

Greater integration of the world capital markets allows for easier access to foreign borrowing by domestic corporations—be it directly or indirectly through the intermediation of domestic financial institutions—so that a sizable proportion of this borrowing may be external. Moreover, the macroeconomic policy mix used to deal with capital inflows and attendant macroeconomic overheating, can itself further encourage unhedged short-term borrowing,¹⁴ exacerbating the accumulation of large short-term external liabilities. At the micro level, this can result in highly leveraged corporations and *sizable currency and maturity mismatches in the balance sheets of both corporations and financial institutions.*

¹³See Claessens, Djankov, and Lang (1999).

¹⁴The macroeconomic policy mix in the East Asian crisis countries tended to encourage the accumulation of external liabilities, mainly on a short-term and unhedged basis. Macroeconomic overheating and capital inflows tended to move in tandem (e.g., Indonesia in 1990 and 1994–96, Korea in 1994–95). In dealing with the overheating, countries often relied on monetary policy as the primary instrument, which reinforced the upward movement of domestic interest rates and provided further incentives to borrow abroad. Since short-term capital flows tend to be most responsive to interest rate differentials, this accumulation was primarily in the form of short-term liabilities. Moreover, given the managed exchange rate system in these countries, the buildup of net foreign assets of the central banks was largely sterilized in order to limit the growth of reserve money and maintain monetary aggregates, which meant that the large interest rate differentials were sustained. And, although the East Asian countries' fiscal position was sound—entailing low levels of government debt and high savings—the fiscal impulse tended to be positive at a time when domestic demand pressures picked up. Thus the fiscal position added to aggregate demand and interest rate pressures. Finally, their exchange rate policy reduced incentives to hedge the external borrowing. Although, in principle, all countries adopted some form of managed exchange rates (which—to differing degrees across countries—were allowed to fluctuate within bands), in practice, the nominal exchange rates did not tend to vary much, and the exchange rate policy resulted in relatively predictable nominal exchange rates.

II. Methodology

The standard approach in the currency crisis literature is to estimate a probit of the occurrence of a crisis on a set of explanatory variables.¹⁵ Such an approach has the benefit of being familiar, with well-known statistical properties, and of being able to isolate the *marginal* effect of each individual explanatory variable, *holding the others constant at their mean values*. This “other things being equal” (or “partial derivative”) assumption is such a standard part of an economist’s toolkit that it is seldom questioned. As noted in the introduction, however, it is not the only approach, and not necessarily the best approach for analyzing crises.

In particular, standard economic analysis implicitly assumes some continuity in the relationships between economic variables. That is, if increasing variable x elicits a certain response in variable y , then doubling the increase in x should induce a correspondingly large response in y . Currency crises differ in that they are fundamentally discontinuous; that is, they represent a confluence of factors that trigger a discrete event (the crisis), but only once certain thresholds have been crossed. For instance, in Indonesia and Korea, there were long-standing weaknesses in the financial (and, in Korea, the corporate) sector. It required a particular confluence of events—terms of trade shocks, contagion, and political uncertainty—interacting with these weaknesses to trigger the crisis.

Accordingly, analyzing crises requires a technique that allows both for thresholds in the effects of an independent variable on the probability of a crisis and, moreover, for the thresholds themselves to depend on interactions between the variables.¹⁶

In principle, it would be possible to capture such interactions within a probit framework by including sufficiently many interactive dummy variables—for instance, estimating the probit with an interaction term between corporate governance indicators and the current account deficit. When there are several explanatory variables, and if they are continuous, however, such an approach soon becomes impractical.

Fortunately, more systematic methods are available. One such technique is known as a *binary recursive tree* (BRT).¹⁷ Formally, it is a sequence of rules for predicting a binary variable, y , on the basis of a vector of explanatory variables, $x_j, j=1, \dots, J$. At each branch of the tree, the sample is split according to some threshold value, \hat{x}_j , of one of the explanatory variables into two sub-branches. The splitting is repeated along the various sub-branches until a terminal node is reached.

To illustrate, let y be the event of a crisis (equal to 1 if there is a crisis, and 0 otherwise). The sample is randomly separated into a core sample and a smaller test sample, which is used for “out-of-sample” robustness checks. For the core sample, the algorithm searches for sequential splits, each consisting of the explanatory variable and its threshold value, which best discriminates between the groups.

¹⁵For probit or regression-based studies of currency crises, see Frankel and Rose (1996); Eichengreen, Rose, and Wyplosz (1996); Sachs, Tornell, and Velasco (1996); Tornell (1999); Kaminsky and Reinhart (1999); and Berg and Pattillo (1999).

¹⁶In the analogy of heart attack risks, the danger threshold for cholesterol level might itself depend on the patient’s family history.

¹⁷See Breiman and others (1984); implementation of the BRT was undertaken using Salford System’s CART program.

Suppose, for example, that a large current account deficit is associated with currency crises and is thus a potentially useful discriminator variable. There will, however, be countries that have a small current account deficit yet suffer a currency crisis (a type I error), and others that have a large current account deficit but (nonetheless) do not have a crisis (a type II error). The algorithm searches over all observed values of the current account deficit in the sample until it finds that threshold value, \hat{x}_j , which best discriminates between crisis and noncrisis countries in the sense of minimizing the sum of the type I and type II errors.¹⁸

The minimum sum of errors provides a natural gauge of the ability of the current account deficit variable to predict crises. The same procedure is applied to each of the explanatory variables; then, sorting these variables by their minimum error scores provides a ranking of their ability to discriminate between crisis and noncrisis countries. (To check robustness, the threshold value for each variable is also applied to the test sample, yielding a second error score.) The variable (together with its associated threshold value, \hat{x}_j) that has the lowest error score is used to form the first node of the decision tree. All observations with a current account deficit less than \hat{x}_j are classified on the left sub-branch of the tree; all observations with a current account deficit greater than \hat{x}_j go to the right.

For each sub-branch, the algorithm is repeated; once the initial data is partitioned into two subsamples, each part of the tree is analyzed separately, so that the discovery pattern becomes progressively more local. Thus the methodology is very good at discovering local—context-dependent—data structures. In principle, the process of progressive subdivision could continue until every observation has been placed into its own branch. This would be akin to including as many explanatory variables as observations in a standard regression and thus getting a “perfect,” if meaningless, fit. Some termination rule is required. The rule used is roughly the same as an adjusted R^2 rule. After each split, the improvement in the overall fit (which, just like the change in the raw R^2 on adding another variable in a regression, is always non-negative) is combined with a penalty on the number of branches, which promotes parsimony. If the penalty exceeds the improvement, the branch is terminated at the prior node; otherwise, the branching continues.

Several aspects of the algorithm are noteworthy. First, the algorithm automatically establishes orderings among explanatory variables both globally (toward the top of the tree) and locally (along each of the various sub-branches). Although an explanatory variable that appears toward the top of the tree is more “important” in discriminating between crisis and noncrisis countries, an explanatory variable may appear several times along various sub-branches. To return to the heart attack example, if the critical levels of cholesterol differ across men and women, one branching of the tree might split the sample according to gender, then along *each* sub-branch the level of cholesterol might be the next discriminator (albeit at different threshold levels). Second, by its very nature, the algorithm captures interactions between explanatory variables. Third, the algorithm is good at capturing threshold effects, which may be particularly important in looking at the effects of structural variables. By the same token, however, if the effect is truly continuous, the algorithm simply

¹⁸It is also possible to weight the type I and type II errors in the loss function if, for example, it is judged to be more costly to miss predicting a crisis than it is to call a false positive.

finds the value that best discriminates between crisis and noncrisis countries. For example, if the probability of a crisis increases linearly in the current account deficit, the algorithm would still try to find the best “threshold” value for discriminating between crisis and noncrisis countries. (This is relatively easy to detect, however, because, when the effects are continuous, they tend to show up by repeated branchings by the same explanatory variable *along the same branch*.¹⁹) Fifth, the procedure is very robust to outliers since it splits on an interior threshold (rather like using medians instead of means). Finally, the decision tree is invariant to *any* monotone transformation of the variables. Again, this is a very important property when looking at structural variables, several of which are rank indexes.

But the methodology is also not without its own limitations. Most importantly, the statistical properties are not yet well known, and formal statistical tests are not available. As such, the only way to assess the model is in terms of its ability to predict crises (more exactly, the likelihood that the model makes either a type I or type II error). Second, as noted above, the procedure is less well suited when the effects are genuinely continuous. Third, at each branch, the procedure picks out the explanatory variable that *best* discriminates between crisis and noncrisis countries; this is not to suggest, however, that others may not be important (i.e., beaten by only a small margin).²⁰ Fourth, toward the lower branches of the tree, the number of crisis cases may become very small, sometimes leading to counterintuitive results,²¹ though this can be avoided by more stringent stopping or pruning rules to limit the number of sub-branches.

In our view, these limitations do not preclude the usefulness of this technique, at least as a complement to the more standard probit/regression analysis. As discussed below, the resulting decision trees require careful interpretation but, if nothing else, they make clear that currency crises occur as a result of a complex confluence of factors—an insight that is perhaps lost in the simplicity of the standard probit output. Indeed, the binary recursive tree methodology can be used to refine the probit analysis.

III. Macroeconomic and Structural Data

Our dataset covers 42 industrialized and mainly emerging market countries over the period 1987–99; with missing data, there are 624 observations.²² There are 52 currency crises, of which 19 involve a fall in real GDP growth of at least 3 percentage points, and 14 involve a fall in real GDP growth of at least 5 percentage points.²³

¹⁹For instance, a branch would first divide on whether the current account deficit was greater than 2 percent of GDP, and then (at least one) of the sub-branches would divide on whether the current account deficit was greater than 3 percent of GDP, etc.

²⁰In a standard regression or probit, multicollinearity may imply that individual *t*-statistics are insignificant; a binary recursive tree, however, simply picks the variable that best discriminates between crisis and noncrisis countries from the vector of explanatory variables (if any at all).

²¹For instance, if there is only one crisis observation remaining, and it happens, e.g., to be a country with a current account surplus (and the only country remaining at that node with a current account surplus), the algorithm will—at that node—pick out a current surplus as being a determinant of the country having a crisis.

²²Some of the “rule of law” data were extended from 1995 assuming that they have been constant.

²³The swing is defined as $\frac{g(t) - \text{avg}(g(t-1) \dots g(t-5))}{1 + \text{avg}(g(t-1) \dots g(t-5))}$, where *g* is the growth rate of real GDP.

The traditional currency crisis literature has suggested a smorgasbord of both macroeconomic policy and performance indicators (in addition to “vulnerability indicators” such as the external debt ratio or the level of foreign exchange reserves). Following this literature, but with a view to parsimony, we select five “macroeconomic” indicators: (i) the percentage real exchange rate appreciation over the previous three years (i.e., $t-3$ to $t-1$); (ii) the current account balance as a ratio to GDP, averaged over the previous three years; (iii) the central government balance as a ratio to GDP, averaged over the previous three years; (iv) the growth of the ratio of banking system credit to GDP, averaged over the previous three years; and (v), the ratio of total external debt to reserves.²⁴ While not exhaustive, this set captures most of the variables that have been identified in the literature as relatively robust predictors of currency crises: external vulnerability, fiscal laxitude, and excessive rates of credit growth.²⁵

As noted above, for our structural variables, we include four broad categories, each with a number of separate indicators.²⁶

The first category consists of six indicators pertaining to the country’s rule of law. These concern both broad governance issues—corruption and property rights (such as risk of expropriation or contraction repudiation by the government, efficiency of judicial system)—and those more narrowly related to the corporate and financial sector such as accounting standards.

The second category consists of eight indicators related to shareholders’ rights. These include investor protection (such as whether ordinary shares carry one vote per share) as well as indicators of the ease with which investors can exercise their rights (whether proxy by mail is allowed; whether firms can block shares prior to a general stockholders-meeting; whether minority shareholders have a judicial venue to challenge the decisions of management; whether minority shareholders can name a proportional number of directors to the board). Of the two remaining indicators, one is a composite index of shareholders’ rights vis-à-vis company directors, while the other is the percentage of mandatory dividend.

The third category consists of five indicators of creditors’ rights. These include the legal requirement for a firm to seek its creditors’ consent prior to filing for reorganization; the requirement that management not stay during the period of reorganization (with management in the hands of an official appointed by the court instead); the requirement that secured creditors be paid first in any bankruptcy proceedings; and legal reserve requirements (which can force automatic liquidation before all the capital is wasted or stolen).

Finally, we include the ratio of short-term to total corporate debt, and the ratio of debt to (common) equity for a sample of nonfinancial firms in each country, taken from the WORLDSCOPE database.

In general, within each category, the indicators tend to be correlated across countries. The correlations are greatest for the “rule of law” indicators, ranging

²⁴While the ratio of short-term debt to reserves would have been preferable, consistent series for a large sample of countries over this time period are not available.

²⁵See, for example, Berg and Pattillo (1999).

²⁶The main source of these indicators is La Porta and others (1998) and the WORLDSCOPE database; detailed descriptions of individual indicators are provided in the Appendix.

from 0.6 to 0.9, with a single principal component capturing almost 80 percent of the total variation. The creditor rights variables are somewhat less correlated, but a single principal component captures more than 50 percent of the total variation, while the shareholder variables are the least correlated, with a single principal component capturing only 35 percent of the variation.

The correlation among the various indicators seems intuitive, since countries that have stronger creditor or shareholder rights along one measure are likely to have strong rights along other measures. But it also means that these indicators are subject to multicollinearity, and econometrically it may be difficult to isolate which among them matters (especially since the indicators are qualitative scores along arbitrary scales). Accordingly, in interpreting the results, if it is found that one or more of the indicators (or the first principal component) of a given category is significant, it is perhaps more useful to take this to mean that “shareholder rights” or “creditor rights” broadly construed may be important, and not just the individual indicator that happens to be significant.

There is also the correlation across categories. The first principal component of the shareholder rights category has a correlation of 0.29 (t -statistic: 3.29**) with the (first principal component of) the creditor rights category; it is rather less correlated with the “rule of law” category (correlation = 0.05). Stronger shareholder rights are also (negatively) correlated with higher debt-equity ratios or a larger fraction of short-term debt (with t -statistics of 3.67** and 6.13**). Again, this makes intuitive sense. Countries with strong shareholder rights are also likely to have strong creditor rights²⁷ and, as a result of the better corporate governance and matching of cash flow and control rights, lower debt-equity ratios and a better maturity of debt. By the same token, however, to the extent that better shareholder and creditor rights affect the probability of a crisis *through* their effect on corporate debt-equity ratios and financing structure, they are unlikely to be significant in a probit or binary recursive tree once the short-term debt and debt-equity ratios are included directly.

IV. Empirical Results

Probit Results

Since probit analysis is generally familiar, we begin by estimating standard probits for three dependent variables: (i) the occurrence of a balance of payments (BOP) crisis; (ii) a BOP crisis with at least a 3 percentage point growth swing; and (iii) a BOP crisis with at least a 5 percentage point growth swing.

We begin, in panel [1] of Table 1, with only the macroeconomic indicators. These are mostly consistent with intuition: a greater real exchange rate appreciation is associated with a higher probability of a crisis, while a larger current account

²⁷This is not to suggest that there are not differences within a country between creditor rights and shareholder rights. Indeed, the corporate governance literature often emphasizes these differences in discussing, for instance, the rather different corporate control mechanisms between Germany (creditor-based) and the United States (shareholder-based). Nonetheless, in comparing very diverse countries, one might expect some to be stronger in terms of both shareholder and creditor rights, while others are weak in terms of their corporate governance more generally.

**Table 1. Probit Estimation of Probability of a Currency Crisis
with Various GDP Growth Swings**

	Balance of Payments Crisis		Crisis with GDP Growth Swing of at Least 3 Percentage Points		Crisis with GDP Growth Swing of at Least 5 Percentage Points	
	Coefficient	<i>t</i> -stat	Coefficient	<i>t</i> -stat	Coefficient	<i>t</i> -stat
[1] Macroeconomic determinants only						
Constant	-1.541	-11.01***	-2.059	-9.49***	-2.283	-9.10***
ΔREER ¹	0.027	2.30**	0.035	2.06**	0.036	1.86*
CAB/GDP ¹	-0.086	-3.18***	-0.119	-2.79***	-0.122	-2.46**
GovB/GDP ¹	0.012	0.51	0.039	1.08	0.066	1.52*
Δ(DC/GDP) ¹	0.004	0.65	0.001	0.14	0.006	0.69
Ext. Debt/Reserves ²	0.000	0.97	0.000	0.32	0.000	0.89
Number of observations:						
positive observations	536	48	536	17	536	12
Loglikelihood:						
percent correct predicted	-152.2	91.0	-67.7	96.0	-49.8	97.0
[2] Macroeconomic and structural determinants						
Constant	-3.513	-0.962	-80.341	-0.001	-67.933	-0.007
ΔREER ¹	0.014	0.682	0.058	1.224	0.109	1.428
CAB/GDP ¹	-0.136	-2.723***	-0.543	-2.867***	-0.358	-1.809*
GovB/GDP ¹	0.037	0.745	0.163	0.870	0.094	0.467
Δ(DC/GDP) ¹	0.035	3.402***	0.045	1.413	0.067	1.474
Ext. Debt/Reserves ²	0.000	1.574	0.001	2.182**	0.001	2.035**
Mcorp1 (one share, one vote)	-0.149	-0.306	17.725	0.003	20.425	0.014
Mcorp2 (proxy by mail allowed)	-1.089	-0.886	-18.059	-0.001	-33.372	-0.009
Mcorp3 (shares blocked before meeting)	0.789	0.570	26.504	0.002	34.426	0.009
Mcorp4 (cumulative voting rights)	-0.333	-0.255	-16.770	-0.001	-28.712	-0.007
Mcorp5 (oppressed minority)	-0.331	-0.306	-40.733	-0.004	-49.677	-0.015
Mcorp6 (percent share capital to call meeting)	3.353	0.590	125.194	0.002	159.188	0.012
Mcorp7 (anti-director rights)	0.490	0.413	24.253	0.002	35.330	0.011
Mcorp8 (mandatory dividend)	0.849	0.658	31.068	0.001	7.901	0.001
Mcred1 (restrictions on reorganization)	-0.007	-0.029	-7.913	-0.007	-9.754	-0.018
Mcred2 (automatic stay on assets)	0.748	1.709*	-13.653	-0.010	-14.578	-0.013
Mcred3 (secured creditors paid first)	1.004	1.824*	14.885	0.001	8.357	0.003
Mcred4 (management stays in reorganization)	-1.397	-2.167**	11.377	0.001	9.558	0.005
Mrule1 (efficiency of judicial system)	-0.340	-2.096**	-1.937	-0.002	-1.970	-0.006
Mrule2 (rule of law)	0.161	0.685	2.668	0.000	7.114	0.006
Mrule3 (corruption in government)	0.003	0.019	-0.843	0.000	-2.096	-0.004
Mrule4 (risk of expropriation)	0.532	1.200	9.863	0.004	4.010	0.004
Mrule5 (risk of contract repudiation)	-0.545	-1.366	-13.077	-0.006	-10.912	-0.009
Mrule6 (accounting standards)	0.015	0.673	0.421	0.001	0.120	0.002
Corporate short-term debt ratio	-0.288	-0.278	-1.011	-0.287	-1.944	-0.409
Corporate debt-equity ratio	0.338	1.514	-1.028	-1.348	-1.105	-1.436
Number of observations:						
positive observations	420	37	420	13	420	9
Loglikelihood:						
percent correct predicted	-95.8	91.7	-27.5	96.4	-18.8	97.6

Table 1. (concluded)

	Balance of Payments Crisis		Crisis with GDP Growth Swing of at Least 3 Percentage Points		Crisis with GDP Growth Swing of at Least 5 Percentage Points	
	Coefficient	<i>t</i> -stat	Coefficient	<i>t</i> -stat	Coefficient	<i>t</i> -stat
[3] Macroeconomic and structural determinants (principal components)						
Constant	-2.488	-5.35***	-3.518	-4.50***	-3.902	-4.12***
Δ REER ¹	0.007	0.37	0.010	0.36	0.005	0.17
CAB/GDP ¹	-0.101	-2.62***	-0.190	-2.64***	-0.149	-1.95*
GovB/GDP ¹	-0.010	-0.28	0.022	0.37	0.060	0.86
Δ (DC/GDP) ¹	0.029	3.52***	0.024	2.01**	0.027	2.13**
Ext. Debt/Reserves ²	0.000	1.20	0.000	0.94	0.000	1.14
Shareholder rights principal component	0.078	0.68	-0.065	-0.37	-0.105	-0.55
Creditor rights principal component	0.101	0.89	0.169	0.95	0.049	0.22
Rule of law principal component	-0.252	-1.86*	-0.364	-1.73*	-0.253	-0.93
Corporate short-term debt ratio	0.130	0.19	0.520	0.49	1.243	0.90
Corporate debt-equity ratio	0.408	2.82***	0.461	2.25**	0.439	1.89*
Number of observations:						
positive observations	420	37	420	13	420	9
Loglikelihood:						
percent correct predicted	-107.2	91.2	-44.9	96.9	-33.1	97.9

Note: Asterisks denote significance at the 10 (*), 5 (**), and 1 (***) percent levels.

¹Average for years $t-3$, $t-2$, $t-1$.

²End-year $t-1$.

balance (i.e., smaller deficit) is associated with a lower probability of a crisis. A rapid expansion of banking system credit (relative to GDP) and a higher ratio of external debt-to-reserves are positively correlated with crises, but the coefficients are not statistically significant. Counterintuitively, a larger fiscal balance is also positively related to a crisis, although the coefficient is generally not significant.

Next, we turn to the structural factors, augmenting the probit with our structural indicators (Panel [2] of Table 1). While it is possible to obtain sensible parameter estimates for the “occurrence of crisis” dependent variable (column 1)—though most of the coefficients are insignificant—for the crises with growth swings of 3 or 5 percent, there are simply too many individual structural variables to be included simultaneously (the probit estimation does not converge).

One approach is to use the principal components of the three categories of structural indicators: corporate governance, creditor rights, and rule of law²⁸; the debt-equity and short-term debt ratios are included directly (Panel [3] of Table 1). Of the macroeconomic variables, the current account balance continues to be highly significant, while the real exchange rate appreciation loses its statistical significance.

²⁸The number of principal components to include for each category was chosen to ensure that at least 70 percent of the variation of the underlying indices is captured. Since principal components are orthogonal, excluding a principal component cannot affect the coefficients on those that are included.

The rate of credit growth in the economy, however, now becomes highly significant. Turning to the structural variables, the results are decidedly mixed. The principal components of better shareholder rights and better creditor rights are insignificant, while better rule of law is associated with a lower probability of a crisis. Finally, a higher proportion of corporate short-term debt or a higher debt-equity ratio is correlated with higher probabilities of a crisis (the latter being statistically significant).²⁹

The statistical significance of the latter two variables suggests that they may be masking the effects of stronger shareholder and creditor rights (i.e., the effect of better shareholder and creditor rights on the probability of a crisis happens mostly through the corporate financing structure). Dropping the short-term debt and debt-equity variables confirms this in that the shareholder rights variable now has a negative, and statistically significant, coefficient.³⁰

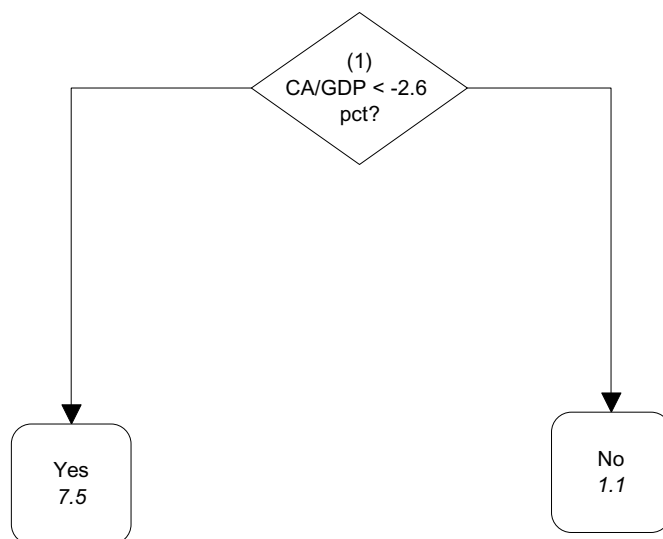
One interpretation of the results is that structural factors are not very important determinants of currency crises. In a sense, this should be none too surprising, particularly in the context of a *panel* dataset. Most structural variables change very slowly (some are constant for the country) so they have difficulty in explaining why a crisis occurs *when* it does, though they may do better at explaining where crises occur (i.e., in a purely, or largely, cross-country dataset). Put differently, Korean corporations have had high debt-equity ratios for a number of years—why did the crisis occur in 1997 and not in 1995? This leads to a second interpretation, however, namely that there may be important interactions between structural vulnerabilities and macroeconomic performance (which can change rapidly) that *can* explain currency crises. In principle, this can be done within the probit framework by interaction terms between the structural and macroeconomic variables. In practice, deciding which interactions to include in the probit estimation is difficult because there are potentially many. Therefore, we turn next to an approach that allows for such interactions more systematically.

Binary Recursive Trees

As discussed above, a binary recursive tree is simply a technique for classifying observations on a binary dependent variable (in our case, the occurrence of a currency

²⁹Mulder, Perrelli, and Rocha (2001) report probit results using almost identical explanatory variables (but a different definition for the dependent variable) using monthly data for a panel of developing and emerging market countries. Among their corporate vulnerability indicators, a higher ratio of current assets/liabilities and greater profitability are associated with a lower probability of a crisis (and the coefficients are statistically significant). Less intuitively, a larger share of short-term debt in total corporate debt is associated with a lower probability of a crisis, and greater operational cash flow is associated with a higher probability of a crisis (again, both coefficients are significant); among their legal and institutional variables, strong creditor and shareholder rights are associated with lower probabilities of a crisis, although higher scores on contract enforcement and accounting standards are positively correlated with crises; finally, they find that greater bank and corporate external debt/exports and greater public/total debt to foreign banks ratios are associated with higher probabilities of a crisis, but a higher ratio of bank credit/GDP and a greater ratio of short-term/total external debt is associated with a lower probability of a crisis. Structural variables have also been used in the growth literature: see Barth and others (1999); Levine (1998); Mauro (1995); and in the literature on banking crises, Hutchison (1999).

³⁰The coefficient on the first principal component becomes -0.3 (t -stat. 1.78*) to -0.4 (t -stat. 1.89*) for the 3- and 5-percentage-point real GDP growth swings, respectively; for the simple occurrence of a currency crisis, the coefficient is -0.1 (t -stat. 1.00).

Figure 1. Macroeconomic Determinants of Currency Crises¹

¹Probability of a currency crisis involving a decline in real GDP growth of at least 3 percentage points. Figures in italics refer to within-node (i.e. conditional) probabilities of a crisis (in percent).

crisis) on the basis of a set of explanatory variables (in our case, the macroeconomic and structural variables). Since the resulting trees can be quite involved, requiring some interpretation, and in order to avoid a tedious taxonomy, we focus on the case of crises with at least a 3 percentage point swing in the real GDP growth rate.³¹

Again, we begin with only the macroeconomic variables. Figure 1 illustrates the resulting binary recursive tree, where the dependent variable is a currency crisis with a 3 percentage point real GDP growth swing, and the explanatory variables are (i) the current account balance; (ii) the real exchange rate appreciation; (iii) the government balance; (iv) the growth in the credit-to-GDP ratio; and (v) the ratio of external debt to reserves.

The tree turns out to be particularly simple as there is a single node, with the current account balance being the explanatory variable at threshold level of about 2½ percent of GDP. The tree branches to the left node when the current account balance is less than –2.6 percent of GDP (i.e., the *deficit* is greater than 2½ percent of GDP), and to the right node, otherwise. Along the lefthand branch, the probability of a crisis is 7.5 percent; along the righthand branch (countries with current account balances above –2.6 percent of GDP), the probability of a crisis is only 1.1 percent.³² In other words, countries with current account deficits above 2½ percent of GDP have a seven-fold greater probability of a crisis than countries with smaller deficits.

³¹Binary trees for the other cases are available from the authors.

³²Recall that there are 19 crisis observations in the sample, so the unconditional probability of a crisis is only 3 percent.

Among the macroeconomic variables, the algorithm thus picks out the current account balance as the most important variable distinguishing crisis from noncrisis countries. Note that nothing prevents the algorithm from further splitting the tree (using either the current account balance or any of the other potential explanatory variables); however, the improvement in the fit is not sufficient to justify the additional complexity of the tree, given the stopping rule.

Within sample, the tree misclassifies 179 out of 624 observations (about 30 percent); of these, 5 of the 19 crisis observations would have been missed by the tree, and 174 out of 605 noncrisis observations would have been incorrectly called crises. The “out-of-sample”³³ statistics are very similar: 180 out of 624 observations are misclassified, corresponding to 7 crisis observations and 173 noncrisis observations.

Structural and macroeconomic determinants

Next, we add the various structural variables (individually, not in terms of their principal components). The resulting tree, again with the conditional probabilities of a crisis at each node, is illustrated in Figure 2.

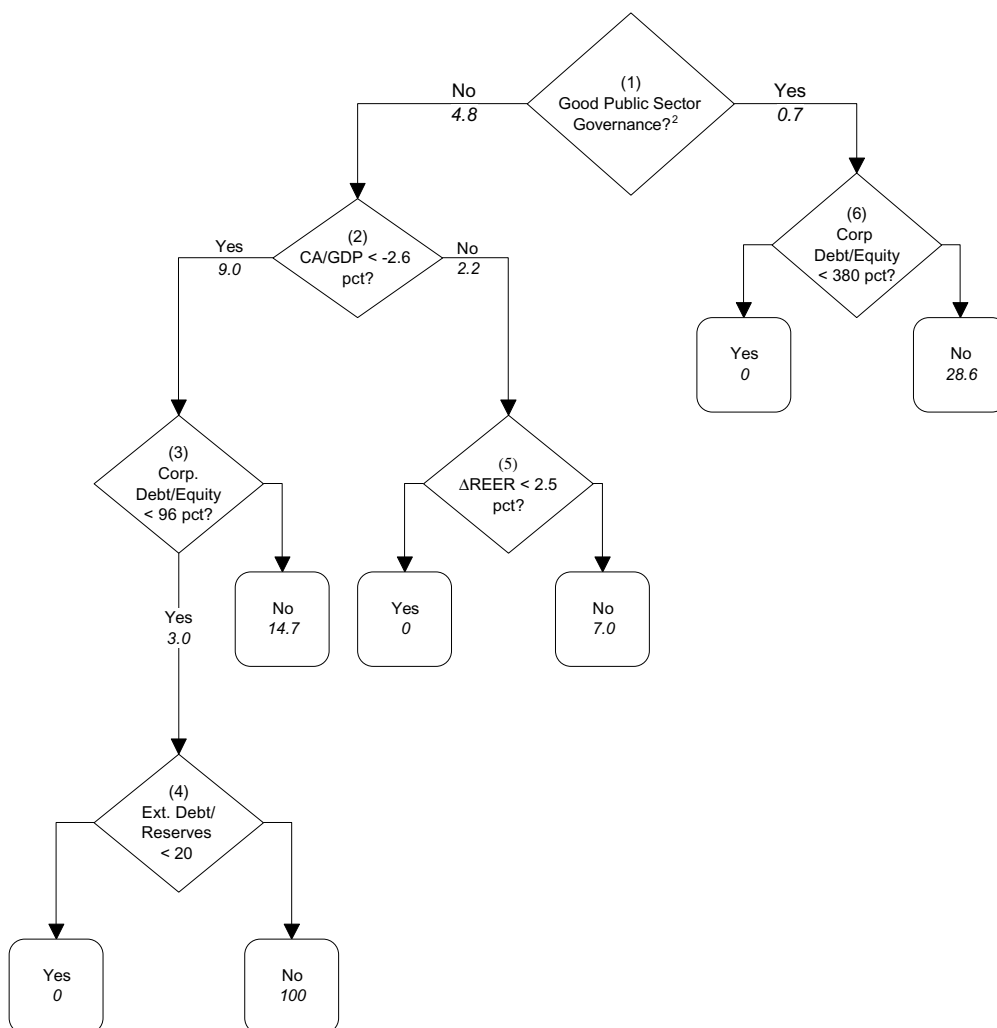
The first branching of the tree is now the index of public sector governance, with lower scores indicating greater corruption or that “high government officials are likely to demand special payments” and “illegal payments are generally expected throughout lower levels of government in the form of bribes connected with import and export licenses, exchange controls, tax assessment, policy protection or loans.” The conditional probability of a crisis in countries that score in the lower half of this governance index (across our sample of countries), i.e., that have worse public sector governance, is 4.8 percent, versus 0.7 percent for countries that score well. Hence, countries with low governance scores are almost seven times more likely to have a crisis than countries with high scores.

Continuing along the lefthand branch of the tree, the second node (2) depends on the current account balance; again with a threshold value of a deficit of about 2½ percent of GDP. The conditional probability of a crisis in countries with larger deficits is 9 percent compared to 2.2 percent in countries with smaller current account deficits. Continuing along the lefthand branch (node (3)), the next variable is the corporate debt-equity ratio (with a threshold at about 100 percent), and a conditional probability of crisis of 14.7 percent for countries that exceed this threshold (compared to a 3 percent probability of crisis for countries below that threshold). Finally, at node (4), countries that have a high level of total external debt to reserves have a much higher conditional probability of a crisis (though it should be noted that, by this point, there are only two crisis observations remaining).

Returning to the righthand branch of node (2) (countries that score badly on the governance index but have a current account balance greater than 2.6 percent

³³When there are relatively few observations, as in the present case, the out-of-sample results are generated using a technique known as “cross-validation.” Under cross-validation, the sample is broken into ten approximately equal-sized subsamples, with subsamples determined by random sampling stratified on the dependent variable. The tree-growing process is then undertaken from scratch, using nine-tenths of the data, with the final one-tenth of the data being used for “out-of-sample” prediction and the computation of the error rate. This process is then repeated using each of the ten subsamples, and the out-of-sample error rate reported is the average for the ten runs.

Figure 2. Macroeconomic and Structural Determinants of Currency Crises¹



¹Probability of a currency crisis involving a decline in real GDP growth of at least 3 percentage points. Figures in italics refer to within-node (i.e. conditional) probabilities of a crisis (in percent).

²Country scores in the top half of the sample countries on the International Country Risk assessment of public sector governance (low levels of public sector corruption).

of GDP), it is the real exchange rate that matters (node (5)), with a conditional probability of a crisis of 7 percent for countries whose average real exchange rate appreciation exceeds 2¹/₂ percent.

Finally, returning to the righthand branch of node (1) (countries that score well on the governance index), it is the corporate debt-equity ratio that matters; those with very high debt-equity ratios have a much higher conditional probability of a crisis.

How should the tree be interpreted?

The algorithm seems to identify two broad groups of crisis countries. For one group, which consists mainly of the advanced industrialized countries and that scores well on the public sector corruption index—probably a proxy for stronger “rule of law” or governance generally—the distinguishing characteristic of countries that suffer currency crises are their banking and corporate sector vulnerabilities (rather than macroeconomic imbalances). Put differently, these countries can better support macroeconomic imbalances, such as current account deficits or real exchange rate appreciations, with relatively less risk of crisis.

The other group, mainly emerging market and developing countries, which tend to score worse on the public sector corruption index, are more vulnerable to macroeconomic imbalances. For this latter group of countries, the most crucial variable is the current account deficit. Even if the current account deficit is modest (less than 2½ percent of GDP), however, they may still be vulnerable to the effects of real exchange rate appreciations.

Again for this group of countries, when the current account deficit is large, the corporate debt-equity ratio matters, with a cutoff at about 95 percent. Notice that these countries can support a much lower corporate debt-equity ratio (95 percent) compared to the advanced industrialized countries, with good governance, who can support much higher debt-equity ratios (the threshold at node (6) is 380 percent).

How well does the tree perform?

A simple metric of the tree’s performance is the number of misclassified observations (either crisis countries predicted to be noncrisis, or vice versa). Recall that, using only the macroeconomic variables, 179 out of 624 observations are incorrectly classified (in-sample); out-of-sample, 180 out of 624 observations are incorrectly classified. Once the structural variables are added, the number of incorrectly classified observations drops to 130 out of 624 observations, in-sample. In fact, *all* of the 19 crisis observations are correctly classified (so that all of the 130 incorrect classifications correspond to “false positives”). In the out-of-sample predictions, 156 out of 624 observations are incorrectly classified (of which 10 correspond to crisis cases, and 146 are “false positive” noncrisis cases). Taking the least favorable results, therefore, about 75 percent of all observations are correctly classified, and about one-half of the currency crises that occurred would have been predicted by the tree.³⁴ The score on predicting crises could, presumably, be improved by weighting type I errors more heavily in the algorithm’s objective function, albeit at the cost of calling more false positives.

Two additional points are worth noting. First, if the short-term debt and debt-equity ratios are dropped from the list of explanatory variables, the resulting tree

³⁴Note that since all the macroeconomic variables are lagged (mostly averages over the past three years), while the structural variables are either constant or move very slowly, it would be fair to treat the tree’s out-of-sample results as genuine predictions (rather than just fitted values).

(not shown) again branches on the index of public sector corruption and the current account deficit, but also on accounting standards, and the composite index of shareholders' rights vis-à-vis company directors (MCORP7).³⁵ As above, this suggests that the impact of corporate governance on the probability of a crisis occurs mostly *through* the corporate financing structure. Second, if the Asian crisis countries (Indonesia, Korea, Thailand) are dropped from the panel (to see whether the results are being driven by them), structural variables continue to be included in the tree. In particular, node (1) again splits on public sector governance, and node (6) splits on the debt-equity ratio, and a sub-branch of node (5) splits on the corporate short-term debt ratio; however, node (3) no longer exists. As a further robustness test, the upper-income countries were excluded from the dataset to check whether the structural variables are really only picking up the distinction between developing/emerging market countries and industrialized countries. Dropping these countries leaves the tree virtually unchanged, except that the new tree begins with the 2½ percent of GDP current account deficit threshold (i.e., the first node of this tree corresponds to node (2) of Figure 2, and nodes (1) and (6)—which, as discussed above, reflect the “industrialized country” crises—do not appear in this tree); the tree misclassifies 120 out of 468 observations.

Naturally, different crisis definitions yield somewhat different trees. For instance, if currency crises with the larger swing in real GDP growth is used as the dependent variable instead, the first node no longer splits on the public sector corruption index, simply because there are no observations with such deep crises among the group of advanced industrialized countries that score well on the public sector governance index (i.e., corresponding to node (6) in Figure 2). The tree therefore starts with the current account balance (again picking the threshold of about 2½ percent of GDP). Among countries with large current account deficits, it is then the structure of corporate short-term debt and the debt-equity ratio that matter, especially in an environment in which credit has been growing rapidly. In-sample, of the 619 noncrisis observations, 10 are misclassified; of the 5 crisis observations, none are misclassified. Out-of-sample, 14 noncrisis observations are misclassified and 3 crisis observations are misclassified.

Alternatively, if the dependent variable is simply the occurrence of a balance of payments crisis, the resulting tree is highly complex, involving some 17 different nodes. The main explanatory variables are the current account balance, the scores on the indices of public sector corruption, risk of government expropriation and contract repudiation, the debt-equity ratio, the short-term debt ratio, the composite index of shareholders' rights vis-à-vis company directors, the minimum percentage of ownership of share capital required to call an emergency shareholders' meeting, and the percentage of mandatory dividends. In-sample, of the

³⁵MCORP7 is La Porta and others' aggregate measure of shareholders' rights over company directors, formed by adding 1 when (i) the country allows shareholders to mail their proxy vote; (ii) shareholders are not required to deposit their shares prior to a general shareholders meeting; (iii) cumulative voting or proportional representation is allowed; (iv) oppressed minorities mechanisms are in place; (v) the minimum percentage share capital that entitles a shareholder to call for an extraordinary meeting is less than or equal to 10 percent (the sample median in La Porta and others; or (vi) shareholders have preemptive rights that can be waived only by a shareholders' vote (the measure ranges from 0 to 6).

572 noncrisis observations, 92 are misclassified, and of the 52 crisis observations 3 are misclassified; out-of-sample, these become 130 and 25, respectively.³⁶

The precise structure of the trees, therefore, is perhaps of less importance than the general conclusions that emerge. Of these, three bear emphasizing. First, currency crises come in a variety of flavors: occurring both in advanced industrialized countries, with generally sound governance and stronger regulatory frameworks, and in emerging market and developing countries, with much weaker records of governance. Second, there are complex interactions between governance, macroeconomic, and corporate indicators that may contribute to the likelihood of a crisis, and that are not easily captured with the very linear structure of a standard probit. Third, given differences in the overall “rule of law” or governance, countries’ resilience to either macroeconomic imbalances or corporate sector vulnerabilities may differ markedly.

Finally, the tree structure can also be used to refine the probit analysis, allowing for context-dependence within the probit framework. As an illustration, Table 2 reports a probit of a 3 percent real GDP growth swing on the macroeconomic and structural variables identified in the tree above (Figure 2). The first column reports the probit results for the full sample, while the second and third columns report the coefficients for two samples, separated according to the current account balance node (i.e., whether the deficit is greater or less than 2.6 percent of GDP, corresponding to node (2) in Figure 2).³⁷ Splitting the sample according to the current account node shows that there are qualitative differences between the corresponding crises. For countries with large current account deficits, for instance, the corporate debt-equity ratio becomes highly significant, in contrast to countries with smaller current account deficits.

V. Conclusion

In this paper, we have examined the role of structural factors in currency crises. Given that structural variables typically do not change much, their ability to predict crises—especially in a panel or time-series context—is necessarily limited. Nonetheless, the findings suggest that weak governance may make countries particularly vulnerable to the effects of macroeconomic imbalances and corporate sector weaknesses.

These interactions mean that standard regressions or probits may not be able to identify vulnerabilities arising from a confluence of legal, macroeconomic, and corporate factors. To this end, we have proposed the use of an alternative technique, known as a binary recursive tree, that is better suited to identifying such interactions. While we consider our results to be mostly illustrative and, at best, preliminary, we believe that this approach shows some promise.

The interactions also have implications for monitoring and country surveillance work. In particular, they suggest that assessing countries according to a

³⁶These trees are available from the authors.

³⁷Alternatively, the sample could be split at node (1), corresponding to the rule-of-law node. This was not done because the number of crises in the RHS node is too small to obtain useful results using the probit analysis.

Table 2. Macro and Structural Determinants of Currency Crisis¹

	Full sample	Conditional on:	
		CA/GDP < -2.65	CA/GDP > -2.65
Constant	-1.667	-2.953	-0.782
<i>t</i> -stat	-3.86***	-2.69***	-1.24
Δ REER ²	0.033	0.052	0.025
<i>t</i> -stat	1.84*	1.17	1.13
CAB/GDP ²	-0.149	-0.427	-0.157
<i>t</i> -stat	-2.97***	-2.47**	-1.72*
Ext. Debt/Reserves ³	0.000	-0.001	0.000
<i>t</i> -stat	-0.60	-2.00**	0.17
Mrule3 (corruption in government)	-0.110	-0.308	-0.143
<i>t</i> -stat	1.90*	-2.02**	-1.58
Corporate debt-equity ratio	0.256	1.393	-0.232
<i>t</i> -stat	1.74*	3.30***	-0.87
Number of observations	469	139	329
Positive observations	18	9	9
Percent correctly predicted	96.2	95.0	97.3
Log Likelihood ratio	-64.4	-20.4	-34.0

Note: Asterisks denote significance at the 10 (*), 5 (**), and 1 (***) percent levels.

¹Currency crisis with at least a three percentage point swing in real GDP growth rate.

²Average for years $t-1$, $t-2$, and $t-3$.

³End-year $t-1$.

given list of vulnerability indicators is unlikely to suffice. Rather, the “danger” thresholds depend very much on the particular *combination* of institutional, macroeconomic, and corporate governance/financial structure indicators, and each country must be assessed in light of these.

APPENDIX

Structural Indicators

In the text, reference is made to a number of structural indicators. This appendix provides a detailed description of them.

We consider four broad categories of structural indicators: rule of law; corporate governance (shareholder rights); corporate governance (creditor rights); and corporate performance.

1. Rule of Law (MRULE)

MRULE1 AND *MRULE2* are measures that pertain to law enforcement. A strong system of legal enforcement could even substitute for weak rules, to some extent, since active and well-functioning courts can step in and rescue investors abused by the management.

MRULE1 This measures the **efficiency of the judicial system**. The assessment of efficiency and integrity of the legal environment as it affects business, particularly foreign firms, is produced by the country risk-rating agency, Business International Corp. The index is the

average between 1980 and 1983, and the scale ranges from 10 (most efficient) to 0 (least efficient). *A higher score indicates a better rule of law.*

MRULE2 This variable is an assessment of the law-and-order tradition or **rule of law** produced by the international rating agency International Country Risk (ICR). The index is an average of the months of April and October of the monthly index between 1982 and 1995. La Porta and others change the scale of the index from its original range which went from 6 to 0) into one that ranges from 10 (greatest tradition for law and order) to 1 (least tradition for law and order). *A higher score indicates a better rule of law.*

MRULE3 and **MRULE4** are variables that reflect how government affects businesses.

MRULE3 This variable is an assessment by ICR of **corruption in government**. The scale ranges from 10 to 0 (again La Porta and others changed the original range, which went from 6 to 0), with lower scores indicating greater corruption or that “high government officials are likely to demand special payments” and “illegal payments are generally expected throughout lower levels of government in the form of bribes connected with import and export licenses, exchange controls, tax assessment, policy protection, or loans.” *A higher score indicates a better rule of law.*

MRULE4 This is ICR’s assessment of the risk of outright confiscation or forced nationalization, i.e., **risk of expropriation**. The score ranges from 10 (low risk) to 0 (high risk of expropriation). *A higher score indicates a better rule of law.*

MRULE5 This variable is ICR’s assessment of the “risk of a modification in a contract taking the form of a repudiation, postponement, or scaling down” due to “budget cutbacks, indigenization pressure, change in government, or a change in government economic and social priorities” or **repudiation of contracts by government**. The scale ranges from 10 (lowest risk) to 0 (highest risk). *A higher score indicates a better rule of law.*

MRULE6 This is an index of **accounting standards** created by examining and rating companies’ 1990 annual reports on their inclusion or omission of 90 items. These items fall into seven categories (general information, income statements, balance sheets, funds flow statements, accounting standards, stock data, and special items). A minimum of three companies in each country were studied. These companies represent a cross section of various industry groups: industrial companies represented 70 percent, and financial companies represented the remaining 30 percent. The index ranges from 100 (highest) to 0 (lowest). *A higher score indicates better rule of law.*

2. Corporate Governance: Shareholders’ Rights

MCORP1 This reflects investor protection. If the law stipulates that **ordinary shares carry one vote per share**, La Porta and others assign it a value of one. In general, investors are better protected when dividend rights are tightly linked to voting rights, i.e., one share, one vote: when votes are tied to dividends, insiders cannot appropriate cash flows to themselves by controlling only a small share of the company’s cash flows but still maintaining voting control. Equivalently, this variable equals 1 if the law prohibits the existence of both multiple voting and nonvoting shares, and does not allow firms to set a maximum number of votes per shareholder irrespective of the number of shares owned (all of which are ways in which the one share, one vote principle can be circumvented). It is set to zero otherwise. *A higher score indicates stronger shareholder rights.*

The measures **MCORP2** through to **MCORP5** measure the *ease* with which shareholders can exercise their voting rights. Because these rights measure how strongly the legal system favors shareholders vis-à-vis managers in the voting process, La Porta and others refer to them as anti-director measures.

MCORP2 This is assigned a value of one if **proxy by mail is allowed** and zero otherwise. Clearly proxy by mail facilitates shareholders’ ability to exercise their voting rights. In fact,

when proxy by mail is not allowed, it can render it considerably more difficult and onerous for shareholders to exercise their votes (unless they go through the legal procedure of designating proxies at meetings), especially if companies hold their annual meetings around the same time (as tends to be the case in Japan, where about 80 percent of companies tend to hold their annual meetings in the same week). *A higher score indicates stronger shareholder rights.*

MCORP3 This is assigned a value of one if the company law or commercial code **does not allow firms to block shares prior to a general shareholders' meeting** and zero otherwise. In some countries the law requires that shareholders deposit their shares with a company or financial intermediary prior to a shareholder meeting. The shares are kept in custody until a few days after the meeting, which prevents shareholders from selling their shares for several days around the time of the meeting. *A higher score indicates stronger shareholder rights.*

MCORP4 This is assigned a value of one if the company law or commercial code allows shareholders to cast all their votes for one candidate standing for election to the board of directors or allows for a mechanism of proportional representation in the board by which minority interests may name a proportional number of directors to the board—i.e., if it **allows cumulative voting or proportional representation**—and is assigned a value of zero otherwise. *A higher score indicates stronger shareholder rights.*

MCORP5 This is assigned a value of one if the company law or commercial code grants minority shareholders either a judicial venue to challenge the decisions of management (including the right to sue directors as in American derivative suits) or of the assembly, or the right to step out of the company by requiring the company to purchase their shares when they object to certain fundamental changes such as mergers, asset dispositions, and changes in the articles of incorporation. Thus this variable reflects **minority shareholders' legal mechanisms against perceived oppression** by directors. The variable is set to zero otherwise. (Minority shareholders are defined as those shareholders who own 10 percent of share capital or less.) *A higher score indicates stronger shareholder rights.*

MCORP6 This is the **minimum percentage of ownership of share capital required to call an emergency shareholders' meeting**. Clearly, the higher this percentage, the harder it is for minority shareholders to organize a meeting to challenge or oust the management. (The percentage varies around the world from 1 percent in the United States to 33 percent of share capital in Mexico.) *A higher score indicates weaker shareholder rights.*

MCORP7 La Porta and others construct an aggregate measure of **shareholders' rights vis-à-vis company directors**, formed by adding one when (i) the country allows shareholders to mail their proxy vote; (ii) shareholders are not required to deposit their shares prior to a general shareholders' meeting; (iii) cumulative voting or proportional representation is allowed; (iv) oppressed minorities mechanisms are in place; (v) the minimum percentage of share capital that entitles a shareholder to call for an extraordinary meeting is less than or equal to 10 percent (the sample median in La Porta and others; or (vi) shareholders have preemptive rights that can be waived only by a shareholders' vote. The index ranges from zero (low protection) to six (high protection). *A higher score indicates stronger shareholder rights.*

MCORP8 This variable equals the percentage of firms' declared earnings that the company law or commercial code requires them to distribute as dividends among ordinary shareholders, i.e., **the percentage of mandatory dividend**. Although earnings can, of course, be misrepresented within the limits allowed by the accounting system, it at least prevents declarations of high earnings by firms (which might be needed to raise additional funds) without requiring dividend payouts. The mandatory dividend right (which is slightly different from the other shareholder rights listed above) may be needed when other rights of shareholders are too weak to induce them to invest. The variable is assigned a value of zero when no such requirement exists in the law or commercial code. *A higher score indicates stronger shareholder rights.*

3. Corporate Governance: Creditors' Rights (MCRED)

MCRED1 If the bankruptcy or reorganization laws stipulate **restrictions on reorganization** such as the need for creditors' consent to file for reorganization, the variable is assigned a value of one. It equals zero if no such restrictions exist. *A higher score indicates stronger creditor rights.*

MCRED2 This variable is assigned a value of one if there is **no automatic stay on assets**. In some countries, the reorganization procedure imposes an automatic stay on the assets upon filing the reorganization petition. An automatic stay prevents secured creditors from gaining possession of their security. It is assigned a value of zero if the law stipulates an automatic stay on assets. *A higher score indicates stronger creditor rights.*

MCRED3 This variable is assigned a value of one if secured creditors are ranked first in the distribution of the proceeds that result from the disposition of assets of a bankrupt firm, i.e., if **secured creditors are paid first**. In some countries secured creditors are not assured the right to collateral in reorganization (although this is rare). In Mexico, for example, various social constituencies need to be repaid before the secured creditors, often leaving the latter with no assets to back up their claims. The variable is set to zero if nonsecured creditors, such as the government and workers, are given absolute priority. *A higher score indicates stronger creditor rights.*

MCRED4 If an official appointed by the court or by the creditors is responsible for the operation of the business during reorganization, this variable is assigned a value of one. Equivalently, the variable is assigned a value of one if the debtor does not keep the administration of its property pending the resolution of the reorganization process, i.e., if **management does not stay in reorganization**. In some countries management stays pending resolution of the reorganization procedure, whereas in other countries, such as Malaysia, management is replaced by a party appointed by the court or creditors. The threat of dismissal may enhance creditors' power. The variable is given a value of zero if no such threat exists. *A higher score indicates stronger creditor rights.*

MCRED5 This variable is the percentage of total share capital needed to avoid the dissolution of an existing firm as mandated by the corporate law, i.e., the **legal reserve requirement**. This requirement forces firms to maintain a certain level of capital to avoid automatic liquidation. As with the mandatory dividend in the case of shareholders, the legal reserve requirement protects creditors when they have few other powers in that it forces an automatic liquidation before all the capital is stolen or wasted. The variable takes the value of zero for countries without such a legal reserve requirement. *A higher score indicates stronger creditor rights.*

4. Corporate Performance

Finally, we construct a set of corporate vulnerability and performance indicators.³⁸

CorpStDebt The ratio of short-term corporate debt to total corporate debt and, as such, measures a firm's vulnerability to liquidity squeeze. It is the median of all (nonfinancial) firms in the WORLDScope database.

CorpDtEq The debt to (common) equity ratio, which provides an indication of a firm's vulnerability to interest rate spikes. It is the median of all (nonfinancial) firms in the WORLDScope database.

³⁸Other variables, such as corporate earnings, are also available from WORLDScope. These two were chosen because they better capture the structural vulnerability to a crisis, rather than the (more) endogenous variables, such as corporate earnings, that might be expected to move in *response to* the crisis.

REFERENCES

- Alba, Pedro, and others, 2000, "The Role of Macroeconomic and Financial Sector Linkages in East Asia's Financial Crisis," in *The Asian Financial Crisis: Cause, Contagion and Consequences*, ed. by Pierre-Richard Agenor, Marcus Miller, David Vines, and Axel Weber (Cambridge: Cambridge University Press), pp. 9–64.
- Barth, James, and others, 1999, "Financial Regulation and Performance: Cross-Country Evidence," World Bank Development Research Working Paper No. 2037 (Washington: World Bank).
- Berg, Andrews, and Catherine Pattillo, 1999, "Are Currency Crises Predictable? A Test," *IMF Staff Papers*, Vol. 46, No. 2, pp. 107–38.
- Breiman, Leo, Jerome Friedman, Richard Olshen, and Charles Stone, 1984, "Classification and Regression Trees" (Pacific Grove, California: Wadsworth).
- Claessens, Stijn, Simeon Djankov, and Larry Lang, 1999 "The Separation of Ownership and Control in East Asian Corporations" (unpublished; Washington: World Bank).
- Claessens, Stijn, Simeon Djankov, and Tatiana Nenova, 2000, "Corporate Risk around the World," World Bank Policy Research Working Paper No. 2271 (Washington: World Bank).
- Eichengreen, Barry, Andrew Rose, and Charles Wyplosz, 1996, "Contagious Currency Crises," NBER Working Paper No. 5681 (Cambridge, Massachusetts: National Bureau of Economic Research).
- Frankel, Jeffrey, and Andrew Rose, 1996, "Currency Crises in Emerging Markets: Empirical Indicators," NBER Working Paper No. 5437 (Cambridge, Massachusetts: National Bureau of Economic Research).
- Flood, Robert, and Peter Garber, 1984, "Collapsing Exchange-Rate Regimes: Some Linear Examples," *Journal of International Economics*, Vol. 17 (August), pp. 1–13.
- Glick, Reuven, and Michael Hutchison, 1999, "Banking and Currency Crises: How Common Are Twins?" Pacific Basin Working Paper Series (United States), No. PB99-07 (San Francisco: Federal Reserve Bank of San Francisco. Center for Pacific Basin Monetary and Economic Studies).
- Hutchison, Michael, 1999, "European Banking Distress and EMU: Institutional and Macroeconomic Risks," UCSC Working Paper No. 452 (Santa Cruz, California: University of California, Santa Cruz, Department of Economics).
- Kaminsky, Graciela, 1999, "Currency and Banking Crises: The Early Warnings of Distress," IMF Working Paper No. 99/178 (Washington: International Monetary Fund).
- Kaminsky, Graciela, and Carmen Reinhart, 1999, "The Twin Crises: The Causes of Banking and Balance of Payments Problems," *American Economic Review*, Vol. 89 (June), pp. 473–500.
- Krugman, Paul (1979), "A Model of Balance-of-Payments Crises," *Journal of Money, Credit, and Banking*, Vol. 11 (August), pp. 311–25.
- La Porta, Rafael, Florencio Lopez-de-Silanes, Andrei Shleifer, and Robert Vishny, 1998, "Law and Finance," *Journal of Political Economy*, Vol. 106 (December), pp. 1113–55.
- Levine, Ross, 1998, "The Legal Environment, Banks and Long-Run Growth," *Journal of Money, Credit and Banking*, Vol. 30 (August), pp. 596–620.
- Mauro, Paolo, 1995, "Corruption and Growth," *Quarterly Journal of Economics*, Vol. 110 (August), pp. 681–712.
- Mulder, Christian, Roberto Perrelli, and Manuel Rocha, 2001, "The Role of Corporate, Legal, and Macro Balance Sheet Indicators in Crisis Detection and Prevention" (unpublished; Washington: International Monetary Fund).

- Prowse, Stephen, 1998, "Corporate Governance: Emerging Issues and Lessons from East Asia," background paper for the Program of Seminars for the 1998 Annual Meeting of the International Monetary Fund and the World Bank Group, Washington.
- Sachs, Jeffrey, Aaron Tornell, and Andres Velasco (1996). "Financial Crises in Emerging Markets: The Lessons from 1995," *Brookings Papers on Economic Activity: 2*, Brookings Institution, pp. 147–99.
- Stone, Mark, and Melvyn Weeks, 2001, "Private Sector Balance Sheets and the Financial Crises of the 1990s" (unpublished; Washington: International Monetary Fund).
- Tornell, Aaron, 1999, "Common Fundamentals in the Tequila and Asian Crises," NBER Working Paper No. 7139 (Cambridge, Massachusetts: National Bureau of Economic Research).

