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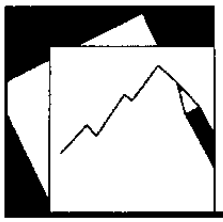

IMF Working Paper

The Role of Corporate, Legal and Macroeconomic Balance Sheet Indicators in Crisis Detection and Prevention

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The Role of Corporate, Legal and Macroeconomic Balance Sheet Indicators in Crisis Detection and Prevention

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Abstract

This study tests the recent balance sheet explanations of external crises in emerging market countries and the role of standards in these crises. Using several unique data sets, it finds that corporate sector balance sheets have a very significant impact on both the likelihood and depth of external crises. The indicators supplement, rather than substitute for traditional macroeconomic variables with standards playing potentially an important role. The results have implications for strategies to limit external vulnerability: they suggest that policymakers need to promote sound private sector financial structures, support sound shareholder rights, in addition to employing prudent macroeconomic policies to reduce exposure to crises. In sample predictions point to potentially large improvements in the predictive power of models that include these indicators.

JEL Classification Numbers: F34, F42, G18.

Keywords: External Vulnerability, Currency Crises, Balance Sheet Effects, Corporate Sector

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I. INTRODUCTION

The devastating and unexpected impact of the Asian crisis on the economies of the affected countries has often been attributed to weaknesses in corporate sector balance sheets. This was not a feature that existing crisis models could explain. Early models of currency crises emphasized inconsistent macroeconomic policies leading to an erosion of reserves and eventual attack on the exchange rate. A second generation of models emphasized a combination of weak fundamentals and insufficient political stamina to fight politically costly currency crises, which provide an invitation to speculative attacks (see Flood and Marion 1999 for an overview).

The countries at the core of the Asian crisis did not suffer from the traditional macroeconomic imbalances and weak fundamentals: inflation was low and fiscal balances about neutral. Banking and corporate weaknesses, however, were widespread. This core observation inspired a "third" generation of external crisis models. These third generation crisis models center on the existence of incomplete financial markets, which cause an over-reliance by firms on debt and foreign financing. Domestic financing is assumed to depend on limited domestic collateral, whose value collapses when the external financing constraint is tightened, for example due to a drop in investors' confidence. As a result loans are called and companies sharply curtail productive new investment or close, contributing to a sharp fall in demand and further declines in the value of collateral (Krugman 1999, Bris and Koskinen 2000, Caballero and Krishnamurthy 2000a and 2000b).

These explanations have testable implications. The worse the corporate balance sheets, the more vulnerable countries are to external crises. A number of studies have tried to explain the differences in corporate financial structure, notably Claessens, Djankov and Xu (2000) and Claessens, Djankov and Nenova (2000), including by the prevailing legal and tax regimes. Stylized facts (see Stone 2000) indeed suggest that crises with a corporate element lead to sharp falls in investment and output. However, thus far little systematic empirical research has been undertaken to examine the impact of corporate balance sheets on the incidence and depth of crises.

This paper seeks to fill the void by using *corporate sector indicators*, derived from individual balance sheets of corporations from the Worldscope database, to test whether these affect the likelihood and depth of external crises in emerging market economies.

This paper also seeks to find evidence of *the role of the corporate sector through the banking sector.* Using data on corporate sector balance sheets allow us to study indirectly the impact that banks' balance sheets have on external crises. We do this by testing whether a large

exposure of the banking sector to the corporate sector, in combination with weak corporate indicators, enhances the vulnerability to crises.[2]

In addition, we empirically investigate the effects of macroeconomic balance sheet and macro institutional indicators, and indicators of legal regimes. The main reason for studying *macroeconomic balance sheet* indicators is that important details are still not available at the corporate level. In particular there are usually no data on breakdowns by residency or currency available at a micro level, as the reporting of corporations in their annual reports does not focus on breakdowns that are more relevant for balance of payment analysis.

We examine the impact of macro institutional indicators and indicators of the legal regime because the quality of lending decisions arguably plays an important role in the incidence and depth of crises (IMF 2000) and the quality of such decisions is, in turn, affected by the overall institutional framework. The potential for government bail-outs is, for example, often considered a prime indicator of the quality of the decisions. We use *macro institutional indicators* that may be indicative of the likelihood that the government will allow the private sector to service its debts without imposition of exchange restrictions, on the reason that the potential imposition of such restrictions may lead to uncertainty and an early withdrawal of capital.

Finally, we test the importance of the implementation of *corporate governance standards*, which the international community has highlighted in the wake of these crises, by including indicators of the legal regime, including *creditor and shareholder rights.* Such variables may affect how soundly the private sector conducts its business, and their exposure to sudden large-scale withdrawal of external finance, and more generally may be indicative of the government's desire to let the private sector be responsible for its own business.

To test the impact of these sets of indicators, we examine their explanatory power in several existing models, so as to have a clear test of their impact over and above existing explanations. The first is a probit model of the *likelihood* of external crises over the coming 24 months (Berg and Pattillo 1999a, 1999b, Borensztein et. al. 1999) used in the IMF and which outperformed several other models (notably Kaminsky, Lizondo and Reinhart 1998, and Frankel and Rose 1996). The second is an estimation of the *depth* of crises (Bussiere and Mulder 1999), which applies the methodology of Sachs, Tornell and Velasco (1996) and selects variables based on an out of sample 'horse race' of variables for the Tequila, Asian crisis and out-of sample performance for the Russian crisis. The latter approach lends itself to

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[2] Many have also focused on the role of the banking sector in causing or exacerbating such crises (e.g. Kaminsky and Reinhart 1999). But, perhaps surprisingly, only limited evidence has been found thus far of the relevance of data on the balance sheet of the banking sector (Evans, Leone, Gill and Hilbers 2000). This may be due to the fact that cross country data on bank balance sheets are particularly weak, in part reflecting incompatibility of recording standards across countries, and that data on pertinent detail such as currency mismatches by maturity are not widely available.

evaluate policies to limit the impact of systemic emerging market crises on individual countries.

The paper is organized as follows. In section 2 we discuss the basic theory behind the indicators and their selection. In section 3 we present and evaluate the estimations results for the crisis probability, followed by those for the crisis depth in section 4. The concluding remarks and suggestions of future works are given in section 5. Sources and technical considerations of each variable are given in the Appendix.

II. "LAWSON" INDICATORS

The financial structure, legal regime, and macro institutional indicators all affect whether the environment for private sector decision making is sound, or should be considered a reason for concern and a possible source of external viability. We will refer to the entire set of indicators as "Lawson indicators" after the former United Kingdom Chancellor of the Exchequer. Lawson (e.g. Lawson 1992) emphasized the creation of an enabling environment, but beyond that suggested that it was preferable to let the private sector sort out its own problems without government bailout or intervention, i.e., in a "framework of firm financial discipline". Private sector problems would then be resolved through bankruptcy, avoiding the spill-over into external vulnerability. This would allow the government to focus on its own solvency and the general macroeconomic conditions. Beyond the usual macroeconomic factors, we therefore test not only for indicators of the financial structure, at a micro and macro level, but also institutional factors indicative of the Lawson doctrine.

Corporate balance sheet indicators

Good data on corporate sector balance sheets are hard to come by. They are not part of the usual statistical data collection sets. To overcome this problem, we have tapped, for this study, a large private database, Worldscope. This database contains data on corporations that publish annual reports for a range of countries, including most important emerging market economies from 1991 onward. Table 5 reports the availability of these indicators and the sample of countries used in the paper. From this database we selected all the non-financial corporations and computed median observations for each year. Using the median rather than the average limits the risk of data pollution by removing large outliers caused by misclassification, or the presence of near defunct corporations.

The Worldscope database contains a vast list of corporate variables. From this list we select a core set that are common in the business literature, and which are investigated for example by Claessens, Djankov, and Xu (2000) in their study of corporate financial structure. They can be classified in four categories, variables that reflect (1) the degree of financial leverage (debt over equity); (2) the maturity structure of debt financing; (3) the availability of liquidity, and (4) the profitability and cash flow of a company. The variables are detailed and defined in Table 3a. Only the first three categories belong strictly speaking to the balance sheet variables highlighted in the third-generation of crises literature.

The impact of these variables on the likelihood and depth of crisis is broadly as follows. The more a corporation's financing is leveraged, the more likely it is that a shock to its asset value will severely erode its balance sheet and result in the call of loans or the postponement of profitable investment. The maturity structure, as measured e.g. by a high ratio of short-term debt to total debt will, ceteris paribus, exacerbate cash flow problems. The availability of assets can offset liquidity risks, and these are captured by liquidity ratios, such as the quick and current ratios. These provide an indication of the extent to which an otherwise solvent corporation could run into problems because of lack of liquid assets to meet obligations.

Financial institutions are the most leveraged of the private sector. To the extent they are exposed to corporations that are themselves highly geared or vulnerable to liquidity problems, this can exacerbate crises. To estimate the impact of the corporate sector through the banking sector we use composite variables: we multiply key financial structure variables of the corporate sector by the size of lending to the corporate and other private sector borrowers. This allows us to study indirectly the impact that the usually hard to measure banks' balance sheets have on external crises.

Macroeconomic balance sheet and institutional indicators

Many have argued that foreign currency borrowing by companies that do not have commensurate foreign currency receipts (such as real estate companies in Thailand) exposes these companies to large exchange rate risks. In the absence of universal micro data for corporations on the extent of foreign currency financing and revenue, we construct variables based on macroeconomic statistics (see Table 3b). For this purpose we tapped BIS data, the only universal database with a corporate breakdown of external debt.[3]

Using these data we construct a ratio of corporate foreign debt (to banks) over exports (as a proxy for revenue), with a higher ratio expected to make countries and corporations more vulnerable to crises. We use these BIS data also to calculate the maturity structure of overall debt (to test if short maturity exacerbate cash flow problems), and augment the corporate debt ratio with bank debt to test if bank debt exacerbates the exposure. Finally, we calculate the share of the public sector in external borrowing, to test if a lower share of government debt reduces its incentive to default—it could run against a larger private sector interest to maintain access to financing.

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[3] Official data on debt often underreport corporate sector debt, which is particularly hard to collect, and are not yet universally available—although part of new IMF standards on data dissemination. Also note that while the BIS's locational statistics are superior from a BOP perspective, we have used here the consolidated statistics because these provide both a suitable breakdown of debt by sectors and a maturity breakdown.

Legal indicators

The search for the origins and cures of currency crises has highlighted the importance of creditor and shareholder rights and legal regimes supportive of contract enforcement for the financial structure of enterprises. Strong creditor and debtor rights may not only improve the corporate financial structure, but also lend increased confidence to creditors in the country's ability to resolve potential financial crises. However, the information on the nature of the legal regimes that affects the financial structure of corporations has only recently been systematically collected.

Thanks to the seminal work of La Porta, Lopez-de-Silanes, Shleifer, and Vishny (1998) such variables are now more readily available. Of the many detailed indicators collected by La Porta et. al. we consider five variables representing: (1) creditor's rights; (2) shareholder's rights; (3) the ability to enforce contracts; (4) accounting standards; and (5) the origin of the legal regime.

All variables except the origin of the legal regime are composite variables of specific characteristics of the legal regime (see Table 3c for a description and Table 4 for the size of the indicators). These composite legal indicators reflect a series of underlying legal and other institutional features that affect the interest of creditor and shareholders, whether contracts are enforceable, and whether published annual reports in 1990 met certain accounting standards. In general, the higher the indexes the better is the corporate sector operational environment. However, a key drawback of the data is that no time series are available, but only individual observations, which reduces their discriminatory power.

III. The Impact of Lawson Indicators on the Likelihood of Crises

To test the implications and relevance of these variables and assertions on the incidence of currency crisis we use the model of Berg and Pattillo (1999a, BP). BP extended the path braking work by Kaminsky, Lizondo and Reinhart (1998, KLR), who employed a probit model to estimate separate thresholds for each of the independent variables. BP extended this approach by estimating a parametric probit model for the occurrence of currency crises. Instead of employing fixed thresholds, BP estimate the impact of all the independent variables combined, depending on the range of the independent variable observed in each country.[4] BP's best results (Borensztein et. al. 1999) are quite parsimonious: just five variables explain the probability of a crisis (see Table 1 for these variables) out of 26 variables tested.

BP use a dummy for the existence of a currency crisis in the next 24 months, as the dependent variable. This dummy assumes a value 1 (one) when a crisis occurs in this period,

[4] Berg and Pattillo transform the data into percentiles instead of using thresholds and thereby limit the need to impose arbitrary cut-off points.

Table 1. The Macroeconomic Variables in the Benchmark Equations

Variable	Description	Estimation	Source
STD/R	Short-term debt by remaining maturity/ reserves	BP, BM	BIS, IFS
REER	Real effective exchange rate	BP, BM	IMF INS
CA/GDP	Current account over GDP	BP, BM	IFS
ΔR	Change in reserves	BP	IFS
ΔXGR	Change in export growth	BP	IFS

and 0 (zero) otherwise. The impact of the Lawson indicators can be tested simply by adding them to BP's parsimonious core equation as in Equation (1) below.

$$\Pr(CC=1 \mid t=T)_r = p(X_{it})_r' \beta_i + p(Y_{jt})_r' \delta_j + p(Z_{kt})_r' \lambda_k + \varepsilon_{tr} \qquad (1)$$

Where Pr(CC=1|t=T) is the time-t probability of a currency crisis in the next 24 months, and r is the specific emerging market economy. The independent variables are all transformed into percentiles by the function p(..), and allocated in three distinct groups: X_i is the group of macroeconomic variables used in the BP original estimation (Table 1); Y_j is the group of corporate sector indicators, including composite, macroeconomic balance sheet and macro institutional indicators, and Z_k is the group of time invariant indicators of the legal regime. The group of Y_j collectively is referred to as balance sheet indicators. The groups Y_j and Z_k together are referred to as the Lawson indicators.[5]

Empirical Results and in Sample Predictive Quality

Thanks to the provision of the data by BP we could reproduce the results of the original paper, with minor differences because of data updates. However, given that consistent corporate data in emerging markets are only available for the last decade, and that the BP methodology requires a minimum of 24 months ahead of time to validate a crisis indicator, our tests for additional variables use the sample period of December 1991 through March 1999. Noteworthy is that two of the five BP variables are not significant when the model is estimated for the shorter period and with a smaller sample of 19 countries, as the estimation

[5] Data on corporate sector balance sheets are only available for 19 out of the 26 countries included in the original BP sample. These data are available on an annual basis, whereas BP use high frequency (monthly) data. To solve this problem, we use the annual information on the corporate sector from the first time they could be observed until the next data is published. For the legal indicators, no time series are available, so we employ them as fixed effects and present final results for estimations including and excluding these indicators.

results in Table 6 show. The fit and the Akaike and other selection criteria are nevertheless slightly better. The two variables that become insignificant are the export growth and reserves change. These two variables are the variables that are the least prone to policy interpretation as they pick up negative or positive trends. The three core variables that remain highly significant (probabilities of insignificance are less than 1/1000th of a percent) in explaining the *likelihood of crises* are the short-term debt to reserves ratio, the external current account deficit and real effective appreciation. Interestingly they are the same as those that were found to explain the *depth of the crises* (see Bussiere and Mulder 1998 and below).

The Lawson variables, when included in the baseline estimation, turn out to be very powerful contributors to predicting the probability of a crisis and supplement rather than substitute for the macroeconomic variables. The core macroeconomic variables remain highly significant, and the size of their contribution remains very similar to the original estimation. The Lawson indicators add quite substantially to the explanatory power of the equation, with the McFadden R-squared increasing from 0.17 to 0.33-0.40 for the final results, which is quite high for a Probit model with 1476 observations. This is prima facie evidence of the importance of these types of variables for the promulgation of crises. [6]

Of the many variables the following are highly significant in the joint estimation:

- Corporate financial structure: financial leverage (using the book value) and short-term debt over working capital;
- Composite corporate/banking sector: financial leverage (using the book value), multiplied by the share of the corporate sector in bank lending;
- Macroeconomic balance sheet variable: the overall indebtedness of the corporate and banking sectors in relation to exports;
- Macro institutional indicator: the ratio of public debt to total debt
- Legal/institutional indicators: shareholder rights.

All the variables are significant at the 99 percent level. Shareholder rights and the indebtedness of the banking and corporate sectors have the most significant impact on the probability of crisis, outweighing even the macroeconomic variables.

The strong significance of the macro balance sheet effect, the financial leverage, and the liquidity ratio support the balance sheets explanations of external crises. The fact that financial leverage multiplied by bank lending to the corporate sector supports the notion that

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[6] One of the complications in estimating the impact is the multi-colinearity among a number of variables that are close substitutes, and the fact that not all observations are available for all variables. Only one version of close substitutes has been included. Despite that there is still significant colinearity, contributing to some changes in signs and significance of variables depending on the specification.

leveraged financing of the corporate sector through the banking sector is especially risky. Another interesting result is that the profitability and interest coverage of corporations did not significantly impact the results. This suggest that corporate balance sheet factors are more important for crises than the corporate flow variables and lends further support to the theories that focus on the balance sheet as the channel through which the corporate sector affects external crises. Interestingly also, the significance of debt to export ratio suggests that currency mismatches play an important role in increasing the likelihood of a crisis. High debt to export ratios often indicate such currency mismatches which cause balance sheet effects in case of exchange rate movements.

Interesting is as well, that the institutional or bail-out indicators of the Lawson doctrine are significant: A high share of public debt worsens the crisis probability, suggesting that the quality of public external debt is poorer or, given the significance of the private debt to export ratio, that it enhances the overall currency mismatch. The solid significance of shareholder rights suggest there is an important role for minority shareholders in promoting sound corporate governance beyond promoting a sound financial structure. However, it should be born in mind that this variable might be closely related to other sound institutional policies, which together with such shareholder rights may be responsible for the overall favorable result.

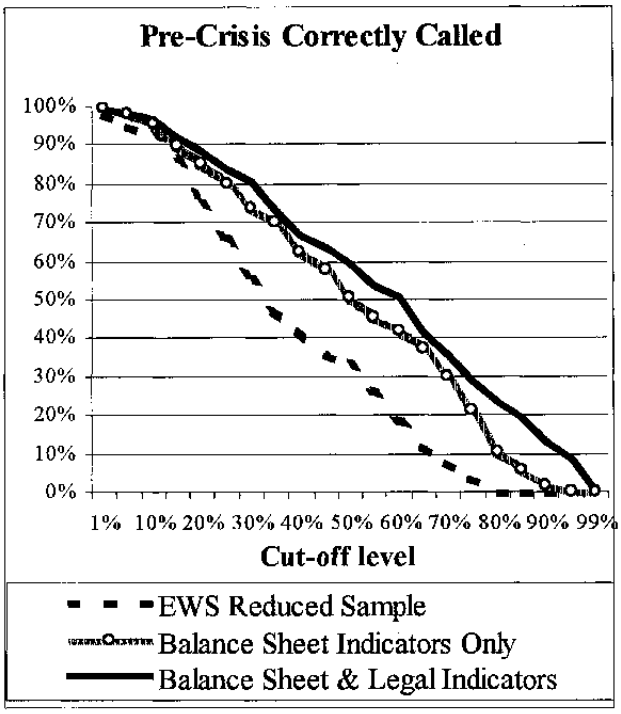
Evaluation of the improvements in predictive power

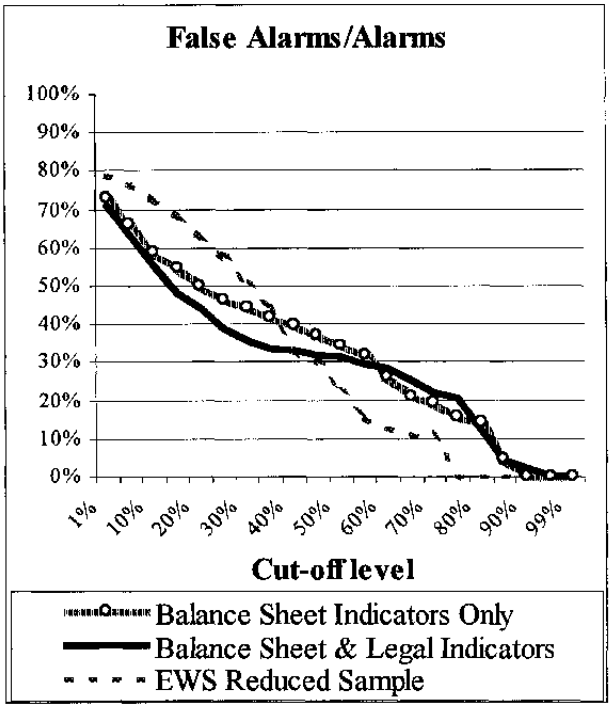
The in sample explanatory power increases considerably when the Lawson indicators are added, but does this also mean improved predictive power? The usual focus in evaluating probit models is whether they predict crises that occur and avoid predicting crises that do not occur (false alarms).[7] The first panel of Figure 1 shows the first element of this evaluation: the percentage of (pre-) *crisis periods called correctly as percent of the number of (pre-) crisis periods.* From this panel we can see that the reduced sample EWS calls fewer crises correctly in sample than the models including balance sheet indicators for all cut-off points. The second panel shows the second element of the evaluation: the percentage of *false alarms over the number of alarms.* The panel shows that there is no monotonic relationship among the models for all cut-offs. At cut-off levels lower than about 40 percent, the reduced sample EWS calls a higher percentage of false alarms than the models with Lawson/balance sheet indicators. For cut-offs equal or higher than about 40 percent, this relation is reversed.

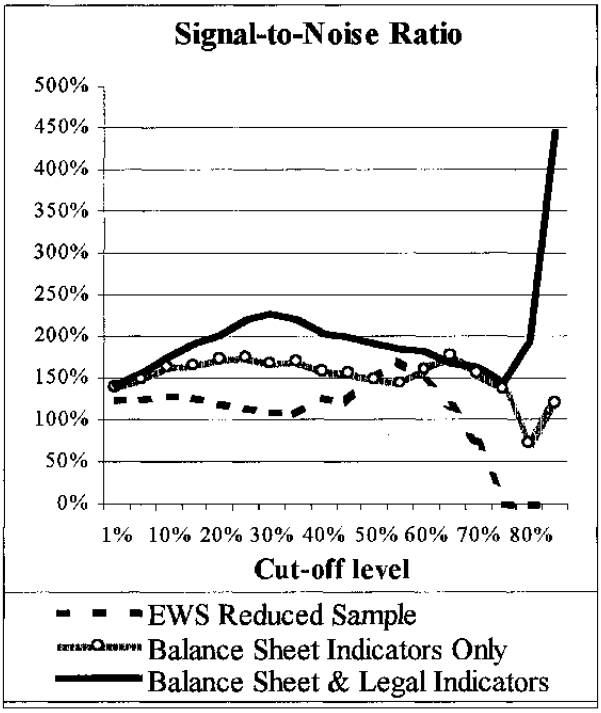
In terms of global performance, a good model should balance the two components above, and present a reasonable measure of efficiency. The commonly used efficiency index, proposed by Kaminsky, Lizondo, and Reinhart (1998), considers the ratio of crises periods called

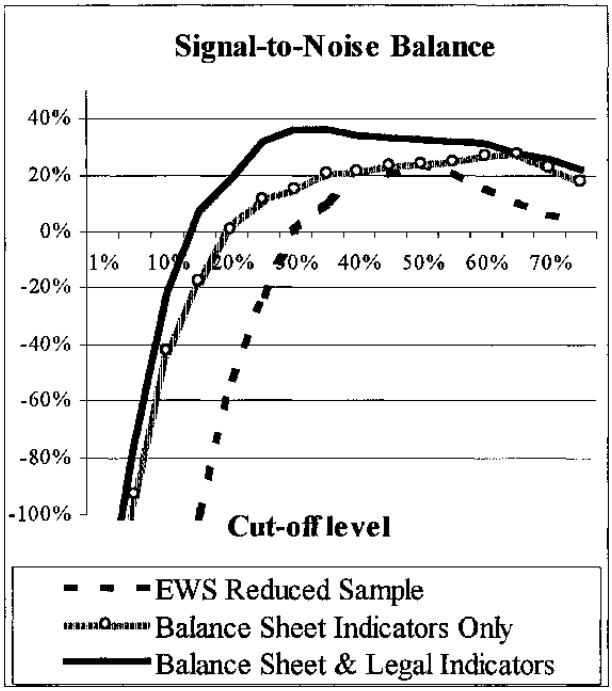
[7]Instead of taking just one or two cut-off points (e.g. 25 percent and 50 percent as in BP 1999), this evaluation of the predictive power is best conducted by examining their performance through the entire range of possible cut-off points, i.e., the thresholds beyond which a crisis is called.

Figure 1: In-Sample Performance of Various Early Warning Models









correctly to the number of false alarms (also known as signal-to-noise ratio). Despite its simplicity, this measure is problematic because it does not differ between a model that calls, for example, 90 percent of crises correctly but results in 10 percent of false alarms, and another model that has ratios of 9 and 1 percent, respectively.[8] Indeed, panel 3 shows that the signal-to-noise ratios for models with the Lawson/balance sheet indicators show more than one local maximum and very high absolute maxima for cut-off points where barely any crisis is called, because the false alarm ratio tends to zero while these models still call crises correctly. The panel also highlights that the model with balance sheet and legal indicators displays noise-to-signal ratios that are superior to the reduced sample EWS model over the entire trajectory of cut-off points, if the noise-to-signal ratio is used as evaluation criterion.[9]

Despite the favorable outcome for the models with Lawson/balance sheet indicators, these results underscore that the noise-to-signal ratio is not that useful in deriving the optimal cut-off points. What is a more meaningful way of selecting the cut-off points? In panel 4, we present the signal-to-noise balance as an alternative measure of efficiency. We define this signal-to-noise balance as the difference between the percentage of pre-crisis periods called correctly and the percentage of false alarms, where both are expressed in terms of the number of (pre-) crisis periods. The benefit of expressing both in terms of the same denominator is that the relative number of crises, alarms or tranquil periods does not affect them. Moreover, unlike the false alarm over alarm ratio the ratio of alarms to crisis does not depend on the method for calling alarms. This measure is easily interpretable in the sense that it can reach a maximum value of 100 percent, when all crises are called, and no false alarm is sounded. If the balance is negative, the models call more false alarms per observed (pre-) crisis period than they call (pre-) crisis periods correctly. Thus it provides a direct indication of whether the models achieve a minimum degree of success. Finally this measure provides the same signal as a loss function that gives equal weight to correctly calling crises as it does to providing a false signal.

Arguably, the noise-to-signal balance can help policymakers choose the best model and the focus on the range of cut-off points that are most useful. Using this criterion, panel 4 shows first that all the models are able to achieve a positive signal-to-noise balance and second that the models including balance sheet indicators (with and without legal indicators) present a superior in-sample performance than the reduced sample EWS model at every cut-off point.

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[8] If false alarms are calculated over the percent of alarms this problem is compounded as the number of alarms declines dramatically when the cut-off point increases. I.e. a false alarm ratio of just 10 percent may sound good, but it can mean that only 10 (pre-crisis) crisis episodes were called, of which one was false, out of a very large number (e.g. 350) of pre-crisis periods.

[9] The reduced EWS model does not call any crises for cut-off points above 75 percent.

At the same time this panel shows that the noise-to-signal balance is relatively flat and that the optimal cut-off point using this criterion differs significantly by model. Especially, if the signal-to-noise balance is relatively flat (and thus sensitive to errors and relative weights) policy makers may better select a cut-off point using "constrained optimization" i.e. maximizing the correct calls given a limit on false alarms or minimizing falls alarms for a given target on correct calls. Table 2 illustrates the outcomes of such a constrained optimization for various target levels.

Table 2. In Sample Accuracy of Crisis Probabilities: Correct Crisis Calls and False Alarms

	EWS Reduced Sample	Balance Sheet Indicators Only	Balance Sheet & Legal Indicators
15 percent false alarms over (pre-)crisis periods 1/			
Cut-off probability	45%	60%	64%
Percentage of crisis periods called correctly	36%	42%	44%
Signal-to-noise balance	21%	27%	29%
75 percent of (pre-)crisis periods called correctly			
Cut-off probability	20%	29%	34%
Percentage of false alarms over (pre-)crisis periods	127%	61%	39%
Signal-to-noise balance	-42%	14%	36%
90 percent (pre-)crisis periods called correctly			
Cut-off probability	11%	15%	18%
Percentage of false alarms over (pre-)crisis periods	228%	107%	77%
Signal-to-noise balance	-138%	-17%	13%

1/ A false alarm occurs when the estimated crisis probability exceeds the cut-off probability and no crisis ensues within 24 months.

The overall results point to a much higher degree of accuracy, even for the benchmark reduced EWS equation, than reported by BP for their earlier model (BP 1999b) and for KLR's model. The latter models did not perform too well when comparing predicted crisis with false alarms. The percent false alarms actually exceeded the percent of crises called correctly with a fairly wide margin especially for KLR (Table 7).

The results also suggest that the models have power in explaining crisis depth (Table 8). If the crisis probabilities ahead of the Asian crisis are compared with the depth of the ensuing crisis, the models with the Lawson/balance sheet indicators show a very high correlation both between the rank orders and between the absolute probabilities and depth. This correlation is much closer for these models than for the both the reduced sample EWS model and the original EWS and KLR models.

The out of sample predictive power remains to be tested, given that the BP methodology can only after 24 months confirm if a period can be considered a tranquil period. Nevertheless, the preliminary results are promising in the sense that crises that have occurred are registered with high probability in the pre-crisis periods. The crisis that was registered in Turkey in early 2001 was registered in nearly all pre-crisis periods with probabilities in excess of the threshold indicated by the signal-to-noise balance, in contrast to the reduced sample EWS

model. The other crisis registered (Colombia in mid-1999) was also picked up in most pre-crisis periods. The models also signal a number of crises that have not (yet) occurred. In general the models including the Lawson indicators generate more pronounced out-of-sample crisis probabilities (i.e. both higher and lower probabilities) than the models without these variables. This is also to some extent evident from the illustrative crisis probabilities for June 1997 (Table 8).

IV. The Impact of Lawson Indicators on the Depth of Crises

Sachs, Tornell and Velasco (1996) explored an empirically very tractable methodology for analyzing crises that focused on the depth rather than the likelihood of crises.[10] Their work only covered the period of the Mexico crisis, but was extended by Tornell (1998) to the Asian crisis, and by Bussiere and Mulder (1998) to the Russia crisis episode. The latter executed a horse race between the variables used by Sachs, Tornell and Velasco and the variables in the BP model and found a core set of the latter variables to far outperform in out of sample predictions. This core set of variables—the real appreciation over the previous 4 years, the current account balance over GDP, and the ratio of short-term debt to reserves—provided a very good fit and proved hard to improve upon. As noted above, these variables are the same as those that are significant in BP's benchmark equation for the shorter and smaller sample.

The estimation results, presented in Table 9, support the conclusion that Lawson indicators are also strong contributors to explaining the depth of crises. The adjusted R-squared, which is relatively low for this sample compared to the larger original sample, increases from about 0.3 to 0.4. The Akaike and Schwarz criteria improve, but remain somewhat high, implying that other factors contribute to the depth of crises.

As in the estimation of the probability of crisis, the Lawson indicators are supplementary to the macroeconomic variables. Financial leverage and the ratio of short-term debt over working capital are similarly the core corporate sector indicators. The estimations suggest that the banking channel, as measured by banking sector credit to the private sector (bnk) in conjunction with corporate indicators, is especially important in explaining the depth of the crises and more so than for the probability of crisis. Short-term debt over working capital is especially significant when multiplied by the ratio of private credit to GDP. The size of the coefficient implies very significant exacerbating or mitigating impacts of low company liquidity.

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[10] The depth of crisis is measured as the weighted loss in reserves and the exchange rate, were the weights are equal to the precision, so that the depreciation gets (near) full weight under a fixed exchange rate regime and the loss in reserves a high weight under a floating regime with limited intervention.

Another liquidity variable, the quick ratio, is also significant when multiplied by the ratio of private credit to GDP. Indicators of legal rights are not sufficiently significant to pass normal tests, and this is a fortiori the case with macroeconomic balance sheet and institutional indicators.

Interestingly, a number of standard variables that feature in corporate analysis notably the profit margin and interest coverage ratio were not significant in either the likelihood or depth of crisis estimations. This again suggests that balance sheet variables are more important than the flow variables. Also surprising is that the quick ratio often showed the wrong sign while being fairly significant. This may be due to measurement problems for inventories, the pricing of which is a tricky issue and leaves much room for reporting differences, especially during downturns.

V. Conclusions

The empirical results find support for balance sheet explanations of external crises. The results suggest that the financial structure of the corporate sector and the legal regimes of countries, along with key macroeconomic variables found in other studies, play a particularly important role in predicting the probability of crisis, and can also help to explain the depth of crises. There is a fair degree of similarity between the variables that help to predict the probability and those that explain the depth of crises. Corporate balance sheet variables such as leveraged financing and a high ratio of short-term debt to working capital are key significant indicators of external vulnerability. Their impact, especially on the depth of the crisis, depends on the total size of credit by the banking sector to the economy. This suggests that corporate weaknesses are transmitted through the banking system, and that having a financially weak corporate sector is especially costly if it is financed through the banking system.

The estimates of the crisis probability highlight the role of macroeconomic balance sheet and institutional indicators. The ratio of bank and corporate debt to exports is especially significant, and its presence strengthens the impact of key corporate indicators, suggesting that crises are more likely if banks and corporations are more exposed to foreign financing in relation to exports, likely on account of currency mismatches and the balance sheet effects caused by currency movements. Moreover the likelihood of a crisis is higher for countries whose public sector share in external borrowing is larger, although it has no impact on the depth of crises. This could mean that a small share of public borrowing reflects a stronger private constituency in favor of continued debt-service and integration in world markets or, in conjunction with the private debt ratio, points to the overall currency mismatches.[11] The fact that these variables are significant in explaining the probability of crises, rather than the depth of crises, may be due to the fact that the former sample extends over a longer period over which more structural changes in these ratios have taken place.

[11] It could also be a proxy for political regimes that adhere to more market oriented policies.

Of the various legal indicators, shareholders rights have by far the greatest impact, especially on the probability of crises. In the crisis probability estimations several legal/institutional indicators, notably the indicator of accounting standards and contract enforcement, have incorrect signs. This may be due to the fact that time series data are not available for these series.

These results also have important policy implications. They suggest that both macroeconomic and microeconomic policies affect external vulnerability: the stronger the microeconomic policies, the less are macroeconomic policies a constraint. The impact of the microeconomic policies is such that they are broadly at par with the economic fundamentals in explaining the probability of crises. The depth of crises during periods of systemic emerging market crises, while significantly influenced by the microeconomic policies, is still dominated by the core economic variables, notably the ratio of short-term debt to reserves. The existence of a tradeoff is in line with the approach advocated in IMF (2000) to closely examine private sector risk management in assessing reserve adequacy, and consistent with the fact that the advanced industrial countries manage well with limited reserves and sizable external short-term debt exposure.

Ideally, we would have tested for the balance in the foreign currency cash flow of corporations and the quality and maturity mismatch in the banks foreign book, but such data are not widely available. However, there is scope for further exploration of composite variables to seek out the interaction of macroeconomic balance sheet and institutional indicators on the one hand and corporate financial indicators on the other. Moreover, it could be worthwhile to test the relevance of banking sector indicators. In addition, it would be useful to explore the impact of these indicators on the incidence and cost of banking crisis, and spreads or ratings. The latter would provide evidence about the affect of such micro level information on market perceptions.

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Table 3a. Corporate Balance Sheet and Composite Indicators (Y_i group)

Nature	Name	Source	Description
Financial Leverage	FlevMV	Worldscope Databasis	Total Debt/Market Value of Common Equity
Financial Leverage	FlevBV *	Worldscope Databasis	Total Debt/Book Value of Common Equity
Debt maturity Structure	STD/LTD *	Worldscope Databasis	Short-term Debt/Long-term Debt
Debt Structure	STD/WC *	Worldscope Databasis	Short-term Debt/Working Capital
Liquidity	CurrentR *	Worldscope Databasis	Current Assets/Current Liabilities (Current Ratio)
Liquidity	QuickR	Worldscope Databasis	Current Assets net of Inventory/ Current Liabilities (Quick Ratio)
Liquidity	WC/TA	Worldscope Databasis	Net Working Capital/Total Assets
Profitability	IntCver *	Worldscope Databasis	Operational Cash-flow (i.e. before interest and taxes) / Interest Payments (Interest Coverage)
Profitability	Margin *	Worldscope Databasis	Net Income before Preferred Dividends / Net Sales or Revenues

Composite Variables		
Leverage	FlevMV*Bnk	Balance sheet indicators are multiplied by *Bnk*, i.e. Domestic Credit to Private Sector and Public Enterprises / GDP
Leverage	FlevBV*Bnk	
Liquidity	STD/WC*Bnk	
Liquidity	QuickR*Bnk	

Table 3b. Macroeconomic-Balance Sheet –and Institutional Variables (Y_i group)

Function	Name	Source	Description
Private sector dominance	PubD/TotD *	BIS	Public Debt to Foreign Banks / Total Debt to Foreign Banks
Repayment Capacity	CorpD/X	BIS, IFS	Corporate Debt to Foreign Banks / Exports
Repayment Capacity	BkCorpD/X *	BIS, IFS	Bank and Corporate Debt to Foreign Banks / Exports
Repayment Capacity	TotD/X	BIS, IFS	Total Debt to Foreign Banks / Exports
Repayment Capacity	StD/TotD *	BIS	Short-Term Debt over Total Debt to Foreign Banks
Private credit Importance	Bnk *	IFS	Domestic Credit to the Private Sector / GDP

Table 3c. The Institutional Variables (Z_i group)

Variable	Name	Source	Description
Legal origin	LegOrig *	La Porta et al. (1998)	Dummy for Countries with Common Law (0) or Civil/Roman Law (1)
Creditor Rights	CredRight *	La Porta et al. (1998)	Index of Creditors Rights, from 0 (low) to 4 (high). Reflects administration of property by debtor during bankruptcy, automatic stay, restrictions on filing for debt reorganization, ranking of secured creditors in distribution of bankruptcy proceeds
Shareholder Rights	ShareRight *	La Porta et al. (1998)	Index of Shareholders Rights, from 0 (low) to 6 (high). Reflects aspects such as proportional representation, shares needed to call shareholder meeting, antidirector rights, voting by mail.
Enforcement	ContrEnfor *	La Porta et al. (1998)	Index of Contract Enforcement Level. Index from 0 (low) to 10 (high) corresponding to the average of five main variables of similar scale: the efficiency of the judicial system, the rule of law, the inverted level of corruption, the risk of expropriation, and the risk of contract repudiation.
Accounting Standards	AccStan*	La Porta et al. (1998)	Index of Accounting Standards based on inclusion of 90 items in annual reports for 1990, such as balance sheet detail.

Table 4. Values of the Legal Indexes

Country	Creditors Rights	Shareholders Rights	Enforcement Index	Accounting Standards	Legal Origin
Argentina	1	3	5.64	45	1
Brazil	1	3	6.46	54	1
Chile	2	5	6.77	52	1
Colombia	0	3	5.66	50	1
Egypt	4	1	5.38	24	1
India	4	4	6.12	57	0
Indonesia	4	1	4.38	Na	1
Israel	4	2	7.79	64	0
Jordan	Na	2	5.88	Na	1
Korea	3	2	6.71	62	1
Malaysia	4	4	7.71	76	0
Mexico	0	1	5.99	60	1
Pakistan	4	5	4.30	Na	0
Peru	0	4	4.83	38	1
Philippines	0	3	4.08	65	1
South Africa	3	4	6.70	70	0
Thailand	3	2	5.93	64	0
Turkey	2	1	5.46	51	1
Venezuela	Na	1	6.15	40	1

Source: La Porta et al., 1998.

Table 5: Country Samples for the Various Estimations

Crisis Probability (EWS)		Depth of Crisis	
Original	With corporate indicators	Original	With corporate indicators
Argentina	Argentina	Argentina	Argentina
Bolivia		Brazil	Brazil
Brazil	Brazil	Chile	Chile
Chile	Chile	Colombia	Colombia
Colombia	Colombia	Hungary	
Cyprus		India	India
Egypt	Egypt	Indonesia	Indonesia
India	India	Jordan	Jordan
Indonesia	Indonesia	Korea	Korea
Israel	Israel	Malaysia	Malaysia
Jordan	Jordan	Mexico	Mexico
Korea	Korea	Pakistan	Pakistan
Lebanon		Peru	Peru
Malaysia	Malaysia	Philippines	Philippines
Mexico	Mexico	Poland	
Pakistan	Pakistan	South Africa	South Africa
Peru	Peru	Sri Lanka	
Philippines	Philippines	Thailand	Thailand
South Africa	South Africa	Turkey	Turkey
Sri Lanka		Venezuela	Venezuela
Thailand	Thailand	Zimbabwe	
Turkey	Turkey		
Uruguay			
Venezuela	Venezuela		
Zimbabwe			

Table 6. Probit Estimations of External Crisis Probability 1/ 2/

	Sign	EWS		Testing Lawson Indicators								Selection			
		Reduced Sample		Corporate		Macro B/I		Legal		All		Without Legal		With Legal	
		(1)		(2)		(3)		(4)		(5)		(6)		(7)	
Macro Benchmark															
CA/GDP	+	0.010	(6.99)	0.011	(6.13)	0.006	(4.26)	0.013	(7.49)	0.010	(3.95)	0.009	(4.89)	0.013	(6.44)
REER	+	0.010	(5.37)	0.010	(5.17)	0.014	(7.99)	0.010	(4.79)	0.009	(3.61)	0.011	(5.71)	0.009	(4.70)
STD/R	+	0.018	(9.69)	0.011	(6.42)	0.015	(8.34)	0.017	(8.56)	0.013	(5.96)	0.011	(6.10)	0.011	(6.06)
XGR	+	0.001	(0.39)												
RGR	+	0.000	(0.02)												
Corporate															
FlevBV	+			0.004	(2.23)					0.004	(1.59)	0.008	(4.05)	0.009	(4.18)
STD/LTD	+			-0.005	(-3.30)					-0.008	(-4.21)				
STD/WC	+			0.014	(3.49)					0.015	(2.49)	0.015	(8.17)	0.018	(9.06)
CurrentR	-			-0.001	(-0.32)					-0.007	(-2.79)				
IntCover	-			0.003	(1.30)					0.008	(2.55)				
Margin	-			-0.005	(-2.27)					-0.004	(-1.42)				
Composite															
FlevMV*Bnk	+			0.012	(4.86)					0.006	(1.68)	0.008	(3.70)	0.007	(2.71)
STD/WC*Bnk	+			0.001	(0.28)					-0.001	(-0.21)				
QuickR*Bnk	-			0.010	(5.52)					0.017	(4.00)				
Macro-Balance/Institutional															
PubD/TotD	+					0.007	(4.45)			0.003	(1.17)	0.011	(6.32)	0.006	(3.61)
BkCorpD/X	+					0.016	(10.16)			0.018	(7.96)	0.022	(11.42)	0.020	(9.83)
BnkCredGDP	+					0.008	(5.14)			-0.015	(-2.80)				
StD/TotD	+					-0.004	(-2.76)			-0.004	(-1.97)				
Legal															
CredRight	-							-0.125	(-2.88)	-0.250	(-4.03)				
ShareRight	-							-0.254	(-7.22)	-0.354	(-7.97)			-0.413	(-12.43)
ContrEnfor	-							0.158	(2.06)	0.213	(2.54)				
AccStan	-							0.025	(5.68)	0.030	(4.61)				
Costant		-2.728	(-13.48)	-4.013	(-13.09)	-3.919	(-14.77)	-4.226	(-11.85)	-5.671	(-7.96)	-5.518	(-19.28)	-4.357	(-15.81)
Statistics															
Log Likelihood			-698.87		-577.27		-657.25		-515.24		-383.72		-546.12		-483.52
Akaike Criterion			0.87		0.81		0.81		0.81		0.69		0.75		0.67
Schwartz Criterion			0.89		0.86		0.84		0.84		0.78		0.78		0.70
McFadden R-squared			0.17		0.28		0.24		0.25		0.40		0.33		0.40
Crisis Periods (A)			347		353		365		288		276		353		353
Tranquil Periods (B)			1281		1103		1279		1007		900		1123		1123
Sample Size (A+B)			1628		1456		1644		1295		1176		1476		1476

1/ Heteroskedasticty-consistent (QML Huber/White) z-statistics underlined.

2/ Type I error probasbility of 1% corresponds to z-statistics of about 2.57, 5% to 1.96, and 10% to 1.64.

Table 7: In Sample Accuracy of Crisis Probabilities for the Next 24 Months for various EWS Models

	KLR 1/	BP 2/	EWS Reduced Sample	Balance Sheet Indicators Only	Balance Sheet & Legal Indicators
Cut-off Probability of 50% 3/					
A Total correctly called observations (over total observations)	82%	84%	84%	82%	84%
B Pre-crisis periods correctly called (over total pre-crisis periods)	9%	7%	33%	50%	59%
C Tranquil periods correctly called (over total tranquil periods)	98%	100%	98%	92%	92%
D False alarms (over total alarms)	44%	11%	22%	34%	31%
E Signal-to-noise ratio (B/D)	**0.20**	**0.64**	**1.50**	**1.47**	**1.89**
F False alarms (over pre-crisis periods)			9%	26%	26%
G Signal-to-Noise Balance (B-F)			0.24	0.24	0.36
Cut-off Probability of 25%					
A Total correctly called observations (over total observations)	77%	78%	74%	79%	84%
B Pre-crisis periods correctly called (over total pre-crisis periods)	41%	48%	66%	80%	84%
C Tranquil periods correctly called (over total tranquil periods)	85%	84%	76%	78%	84%
D False alarms (over total alarms)	63%	63%	57%	46%	38%
E Signal-to-noise ratio (B/D)	**0.65**	**0.76**	**1.15**	**1.73**	**2.18**
F False alarms (over pre-crisis periods)			88%	69%	52%
F Signal-to-Noise Balance (B-D)			-0.22	0.11	0.32
Root Mean Squared Error (Bias & Variance)			0.36	0.35	0.32

1/ Kaminsky, Lizondo, and Reinhart original specification as reported in BP (1999, Table 2).

2/ As reported in Berg and Pattillo (1999b), linear model (Table 2). This model uses reserves over broad money rather than reserves over short-term debt used in the benchmark model reported in Borensztein et. al. (1999) and detailed in Table 1 above.

3/ See Table 2 for definitions.

Table 8: Comparing the 24 Months Crisis Probabilities as of June 1997 with the Depth of the Asian Crisis

Country	KLR 1/		BP 2/		EWS Reduced Sample		Balance Sheet Indicators Only		Balance Sheet Plus Legal Indicators		Actual	
	Prob	Rank	Prob	Rank	Prob	Rank	Prob	Rank	Prob	Rank	Crisis Index 3/	Rank
Indonesia	11%	15	26%	7	49%	5	83%	3	97%	1	94.	1
Korea	25%	3	26%	7	47%	6	58%	4	75%	3	66.	2
Thailand	12%	14	38%	1	79%	1	84%	2	91%	2	48.	3
Malaysia	17%	6	38%	1	67%	2	87%	1	74%	4	45.	4
Philippines	41%	1	22%	11	32%	7	53%	5	43%	5	33.	5
Colombia	17%	7	36%	4	60%	4	39%	7	33%	8	15.	6
Turkey	17%	5	14%	15	21%	10	8%	14	23%	9	14.	7
Brazil	37%	2	25%	9	24%	9	38%	8	35%	6	11.	8
India	11%	17	14%	15	7%	16	18%	11	8%	12	9.	9
Pakistan	15%	8	28%	5	62%	3	51%	6	22%	10	8.	10
South Africa	22%	4	23%	10	9%	15	15%	13	4%	16	6.	11
Chile	11%	15	18%	13	18%	12	34%	9	7%	13	4.	12
Mexico	14%	11	6%	18	9%	14	1%	16	6%	15	1.	13
Jordan	14%	13	21%	12	10%	13	NA	NA	NA	NA	-0.	14
Peru	15%	9	27%	6	30%	8	17%	12	9%	11	-1.	15
Venezuela	14%	11	9%	17	5%	17	0%	17	1%	17	-4.	16
Argentina	15%	10	15%	14	19%	11	5%	15	6%	14	-8.	17
Israel	11%	17	37%	3	2%	18	27%	10	33%	7	N	NA
Egypt	NA	NA	NA	NA	13%	NA	NA	NA	NA	NA	N	NA
Linear Regression (R-square)		0.05		0.35		0.46		0.71		0.82		
Pearson Correlation		0.22		0.59		0.68		0.84		0.90		

1/ The probabilities of Kaminsky, Lizondo, and Reinhart original specification are as reported in BP (1999, Table 5), divided by 100. The ranks above reported correspond to countries' classification within the reduced sample considered here.

2/ The probabilities are reported as in Berg and Pattillo (1999b), linear model (Table 5). The ranks above reported correspond to countries' classification within the reduced sample considered here.

3/ As reported in BM (2000). This crisis index covers the core 5 months crisis period.

Table 9: OLS Estimations of Crisis Depth 1994, 1997, 1998 1/

	Sign	BM Reduced Sample		Testing Lawson Indicators: Corporate		Macro B/I		Legal		All		Selection: With legal		Selection: Without legal	
		(2)		(3)		(4)		(5)		(6)		(7)		(8)	
Macro benchmark															
REER	-	-0.33	(-3.4)	-0.36	(-3.3)	-0.36	(-2.9)	-0.49	(-3.3)	-0.54	(-2.4)	-0.31	(-2.4)	-0.32	(-2.7)
CA/GDP	+	1.43	(2.4)	2.17	(2.3)	1.78	(2.4)	2.25	(1.6)	2.01	(0.7)	2.20	(2.4)	1.69	(2.5)
STD/R	+	0.23	(2.7)	0.23	(2.3)	0.26	(2.6)	0.21	(2.3)	0.27	(1.6)	0.17	(2.2)	0.20	(2.3)
Corporate															
FlevBV	-			12.67	(1.4)					-0.27	(-0.0)	8.49	(1.5)	8.41	(1.5)
STD/LTD	+			-4.46	(-0.8)					-8.12	(-0.6)				
STD/WC	+			1.33	(0.1)					-5.12	(-0.3)	12.89	(1.3)	12.51	(1.3)
CurrentR	-			24.95	(1.1)					21.03	(0.7)				
IntCover	-			-1.56	(-0.8)					-4.66	(-1.2)				
Margin	-			37.02	(0.4)					78.75	(0.6)				
Composite															
FlevBV*Bnk	+			0.02	(0.3)					0.57	(0.0)				
STD/WC*Bnk	+			0.56	(2.9)					-0.54	(-0.1)	0.50	(3.5)	0.62	(8.0)
QuickR*Bnk	-			-0.18	(-1.4)					1.52	(0.2)	-0.13	(-2.4)	-0.17	(-3.3)
Macro-Balance/Institutional															
PubD/TotD	+					-2.98	(-0.1)			6.62	(0.2)				
BkCorpD/X	+					-1.84	(-1.0)			0.46	(0.1)				
StD/TotD	+					-0.01	(-0.2)			-1.57	(-0.4)				
BnkCredGDP						-16.89	(-0.8)			4.74	(0.1)				
Legal															
CredRight	-							2.02	(0.7)	5.59	(1.0)				
ShareRight	-							-3.83	(-1.4)	-0.53	(-0.1)	-2.29	(-1.0)		
ContrEnfor	-							0.45	(0.1)	-1.69	(-0.3)				
AccStan	-							0.42	(1.7)	0.69	(1.0)				
Constant		-16.47	(-2.7)	-53.97	(-1.4)	-5.23	(-0.3)	-37.76	(-1.4)	-75.35	(-0.7)	-14.75	(-1.7)	-22.45	(-2.7)
R-squared				0.539		0.365		0.541		0.722		0.504		0.495	
Adjusted R-squared		0.307		0.386		0.262		0.437		0.413		0.405		0.408	
Durbin-Watson stat		1.60		1.643		1.86		1.706		1.569		1.476		1.5	
Akaike info criterion				8.804		8.876		8.472		8.636		8.714		8.692	
Schwarz criterion				9.306		9.179		8.814		9.532		9.062		9.001	
F-statistic				3.512		3.536		5.212		2.339		5.083		5.734	
Prob(F-statistic)				0.002		0.004		5E-04		0.038		2E-04		2E-04	

1/ Huber/White heteroskedastic consistent z-statistics in brackets. Probability of under 5 percent corresponds to a Z-statistics of about 2, 10% to about 1.6, 1 percent to 2.5, 0.1 percent to 3.2