WPS3648

Insurance and Liquidity: Panel Evidence

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Abstract

This paper presents evidence that balance sheet effects are critical determinants of both the likelihood of a crisis and of income losses following a crisis. The paper tests the validity of "insurance" and "liquidity" models of currency crisis. Both models predict that the occurrence of a balance of payments crisis is conditional on the health of the nation's accounts vis-à-vis the rest of the world. Problems in the balance sheet either cause a financial crisis that develops into a run on the Central Bank, or generate a run on the Central Bank once contingent liabilities exceed reserves and the yield differential moves against domestic assets. Estimations of crisis likelihoods based on several specifications of single and simultaneous equation probit models confirm that output losses following the crisis are persistent and conditional on the balance sheet indicator, i.e. the ratio of the stock of gross external liabilities to assets. Measures of contingent liabilities, capital flight, and financial depth perform well as crisis predictors, and the marginal effects on the probability of a crisis are of the expected sign. The panel data set covers the time period 1973 through 2003 for 90 countries.

Keywords: insurance, liquidity, currency crises, panel estimation
JEL Classification: F3,F4,E6

World Bank Policy Research Working Paper 3648, June 2005

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1: Introduction

Two questions are raised in this paper: how well currency crises are predicted by external asset-liability mismatches, and whether these balance sheet effects also generate persistent output losses following a crisis. The theoretical literature supports the idea that asset-liability mismatches underpin currency crises (Chang and Velasco, 1998 and 1999; Calvo and Mendoza, 2000; Dooley, 2000). Liquidity models place the responsibility for the crisis on a mismatch between short-term assets and liabilities. Insurance models emphasize that Central Bank's contingent liabilities determine the timing of the crisis. According to both theories, the interaction between easy borrowing and the Central Bank's role as lender of last resort generates moral hazard and a financial crisis that drains, as one of its final symptoms, reserve assets. A crisis of this nature must generate output losses while the financial sector struggles to recover its footing and the authorities institute regulatory reforms. In order to clarify the transmission effects of the balance sheet indicators used, this paper applies single and simultaneous equation probit techniques to a model-based specification of the crisis. The panel data set includes gross external asset and liability stocks over the period 1973-98 for 90 developed and developing countries. Out-of-sample likelihood forecasts are generated for the period 1998-2003 and are a good fit with observed probabilities.

The relevant theoretical literature has largely grown out of the Asian crisis of 1997-98. Models emphasize that imperfect financial structures combined with borrowing booms and asset price bubbles in emerging markets lead to large inflows of capital as long as yield differentials favor domestic assets (Chang and Velasco, 1998 and 1999; Dooley, 2000). The Central Bank, in its capacity as lender of last resort, insures these growing domestic liabilities, which are denominated in terms of the reserve currency. This insurance function creates a moral hazard problem as incentives facing domestic financial intermediaries are inconsistent with preserving the high rates of return on domestic assets. As the Central Bank's contingent liabilities grow and exceed Central Bank reserves, returns on domestic currency denominated assets fall. Once the yield differential moves against domestic assets, excess demand for foreign assets leads to a collapse in the value of domestic currency or to a balance of payments crisis. The crisis in turn manifests as an explosion in the value of reserve currency denominated liabilities and pushes the consolidated banking sector deeper in the red. Cespedes, Chang, and Velasco (2004) present a model in which this fear of financial collapse engenders "fear of floating" (Calvo and Reinhart, 2002) and thus postpones the cessation of intervention in exchange markets.

The crisis therefore weakens the financial sector's ability to perform its essential function of growth facilitation through intermediation. It also has an adverse effect on foreign investors' ratings of the country's ability to absorb and repay lending, which causes a "sudden stop" in capital inflows at a time when they are most needed (Calvo et al, 2004). The result is a credit crunch at a time when the Central Bank should be and generally is raising real interest rates. Thus we expect to some persistence in output losses following a crisis, and the likelihood of output losses should be a function of the external liability-asset mismatch, since this is precisely what determines the cost of recovery.

Common prescriptions include imposing temporary capital account restrictions and relying on IMF lending to bolster international reserves while implementing financial reforms to reduce potential imbalances. Clarifying the transmission mechanisms is a prerequisite to establishing the validity of such policy advice for developing countries as well as the cost of ignoring it. This is especially true given that many developing countries (Mexico in 1994, Malaysia and Indonesia in 1997, Brazil and Russia in 1998, Argentina in 2000, Turkey in 2002, and Antigua-Barbuda in 2004) have experienced crises over the last decade and a half, and many others are in the process of capital account liberalization, or fear it because of the implicit threat of an increase in external exposure and vulnerability to exogenous shocks.

A central feature of these models is the conflict between the policy objectives of stabilization and the desire to facilitate borrowing. This may take the form of easing restrictions on financial intermediaries or providing insurance. The other important difference between these models and the first and second generations of currency crisis models (Krugman, 1979; Obstfeld and Rogoff, 1994), is the implicit output cost of the crisis. A third distinguishing feature is the active role of the Central Bank, as lender of last resort and provider of financial insurance, as opposed to the passivity of monetary authorities in the earlier models. All of these point to modeling the crisis through the interaction between the Central Bank and the domestic financial sector, and also emphasize the importance of institutional reform as a crisis preventive measure. Institutional reform is slow and expensive, and in many developing countries involves dealing with people who have never really experienced it. This paper contributes to the literature by explicitly identifying the costs of financial booms and busts and by providing firm evidence that output losses following the crisis are conditional on balance sheet indicators, and that financial reform and regulation is therefore a prerequisite to, and not merely something to think about a little bit, before capital account liberalization is to be considered.

The rest of the paper is organized as follows: the next section presents a generic model based on the most influential post-1997 crisis theories, Section 2 outlines the empirical model, Section 3 has

the results of the probit analysis on crises and output losses, while Section 4 concludes. Table 1A in the appendix summarizes the key empirical literature for the interested reader.

2: *The Underlying Theoretical Model*

The theoretical motivation presented here is based on combined features of the liquidity (Chang and Velasco, 1998 and 1999; Cespedes et al, 2004), and insurance (Dooley, 2000; Chinn and Kletzer, 1999) models.

The economy is small, credit constrained, and open, with a domestic currency that has been pegged to the US dollar in order to stabilize domestic inflation and the value of the US dollar denominated debt owed to foreign residents. Exchange rate targeting is based on the monetarist model of exchange rates (Girton and Roper, 1977). Pressure in exchange markets can therefore only be the result of disequilibrium between the demand for and supply of domestic assets.

Purchasing power parity is assumed to hold, though it is not a critical assumption. Domestic and foreign interest rates are linked through the risk premium, which therefore determines the relative demand for domestic assets according to a covered parity relationship. There are four agents: foreign creditors, financial intermediaries, borrowers who generate income from capital assets, and the Central Bank, which is the lender of last resort. All investments mature within one period, and there is no stock of inherited capital, though creditors can renew their commitment to this economy if they choose to do so. If a crisis occurs, it happens between time t and t+1.

Equations 1a through 6 describe the economy. Equations 7 and 8 derive the crisis index. Equations 9 and 10 state that the likelihood of a crisis followed by output losses increases with the government's contingent liabilities and with the ratio of liabilities to assets.

Domestic output and employment depends only on the supply of capital, from both domestic and foreign sources, as in equations 1a and 1b.

$$y_t^D = (A_{t+1} - \eta_T)(k_{t+1}^D) + (1 + i_t^F).s_t.k_{t+1}^F; T \le t+1, \eta_{t+1} = 0 \quad (1a)$$

$$k_{t+1}^D = l_{t+1}.s_t + d_{t+1} \quad (1b)$$

$$k_{t+1}^D + m_t^d = l_{t+1}.s_t + d_{t+1} + m_t^s \quad (1c)$$

$$m_t^d = \phi(-i_t^D, y_t^D) \quad (1d)$$

"y" is domestic output per period and "A" is the time-varying productivity coefficient on capital supplied, or the promised rate of return on domestic assets held by creditors, domestic and foreign that will mature in t+1. This return, net of borrower's and financial intermediary's economic profit rate, must be higher that on foreign assets. "I" and "d" represent the respective flow of foreign and domestic finance of capital in the home economy in period t, and "η" is the proportion of capital lost to capital flight, adjusted for the cost of liquidating capital assets before they mature (assumed to be a deadweight loss that benefits no one). If creditors wait for the full term, no capital flight occurred, and η = 0. Thus, the crisis must occur, if at all, between t and t+1.

"i^F" is the risk-free interest rate on endowed foreign assets, "k^F", held by domestic residents, and "k^D" is the total flow of capital that can be put to work at home in period t, but has to be repaid at the beginning of t+1. The net marginal product of capital in this economy is therefore given by equation 2.

Equation 1(c) defines equilibrium in the domestic asset market. "m^d" and "m^s" denote the demand for and supply of domestic currency respectively.

$$\frac{dy_t^D}{dk_{t+1}^D} = (A_{t+1} - \eta_T), T < t+1 \tag{2}$$

$$l_t = f(-r_t^p); \eta_t = g(r_t^p) \tag{3}$$

Where f() and g() are specified to be monotonically increasing. Equation 3 states that new investment and capital "destruction" both depend on the risk premium.

$$r_t^p = i_t^D - i_t^F + E_t(\varepsilon_{t+1}) \tag{4}$$

Where r_t^p is the risk premium on domestic assets in time "t". "i^D" is the domestic interest rate and "ε" is the rate of depreciation. As the risk premium rises, either the domestic interest rate increases, or there must be an expectation that the domestic currency will depreciate, or a combination of both.

The risk premium links domestic and foreign asset markets and therefore is the key determinant of the expected price of domestic assets, on which the supply of foreign capital (or the demand for domestic assets) depends. It is an increasing function of the cost of monitoring financial intermediaries in the given regulatory environment (Cespedes et al, 2004) and of the probability of default on loan repayments, which in turn is proxied by the size of external liabilities relative to external assets. Since foreign lenders cannot observe the effectiveness of domestic financial intermediation, the Central Bank

of this credit-constrained economy provides insurance (Dooley, 2000) equivalent to the difference between the dollar purchase price of the asset and the dollar sale price of the asset, if this difference is positive. Equation 5 is an expression for this liability at time T, in terms of expectations formed in time t, where "L^F" is contingent insurance on foreign-owned domestic assets.

$$E_t(L_T^F) = l_t.s_t - (A_T - \eta_T)l_t.\frac{s_t}{E_t(s_T)} \quad if \ > 0 \tag{5}$$

Where, $E_t(L_T) = E_t(L_T^D) + E_t(L_T^F)$

In equation 5, "s" is the spot rate at the time of purchase/sale of the asset, "$s_t / E_t(s_T)$" reflects the expected exchange risk on domestic asset returns, and T<t+1. "$E_t(L_T^D)$" is the expectation formed in time t of the Central Bank's contingent liability in T on domestic currency holdings. Given the huge volume of the domestic currency component of the overall contingent liability, ratios such as total bank credit relative to national output and/or quasi money relative to reserve assets can be used as proxies in the empirical implementation.

This insurance cost is therefore increasing in expected devaluation and in the risk premium, through l and ŋ. Expectations of devaluations are based on creditors' estimate of exchange market pressure , which in turn is their observation of the Central Bank's level of intervention activity in exchange markets. As intervention increases, estimates of the Central Bank's contingent liabilities, L, are revised up, and creditors must determine if the time path of L is sustainable given holdings of reserve assets. The structural equation can be written as follows:

$$r_t^p = h(L_t), E_t(\varepsilon_{t+1}), {}^{l_t}\!/_{k_t^F}) \tag{6}$$

Where h(.) is monotonically increasing.

The demand for domestic assets therefore depends on the mismatch between external liabilities and assets and the Central Bank's contingent liabilities. This is because of the informational asymmetry that foreign lenders cannot observe the true nature of financial regulation. They can however estimate the burden and sustainability of insurance by observing the size of the contingent claims on the Central Bank, and they can estimate exchange risk exposure by observing intervention activity.

Domestic financial intermediaries' are the middleman between foreign creditors and domestic borrowers. Their profits are increasing in the purchase of domestic assets, on which they charge fees and commissions and earn a returns spread. Foreign lenders purchases are insured because of the informational asymmetry underlying equation 6, which encourages a lending boom, and an increase in the profits of domestic banks, which can rely on the Central Bank to monetize their losses (Chinn and Kletzer, 1999). This leads to the moral hazard problem: domestic banks have little incentive to screen domestic borrowers.

As the ratio of external liabilities to external assets increases, both domestic and foreign residents revise their estimates of the risk premium upward. This reduces relative demand for domestic assets and increases pressure in the exchange market. Meanwhile, as contingent liabilities increase, expected devaluation increases also, which further reduces demand for domestic assets. Creditors start "flying" their capital out of the country[1], not just to avoid exchange risk exposure, but also to avoid appropriation of assets or additional penalties associated with "emergency" capital controls.

Fearing the output consequences of a "sudden stop" in capital flows and the destabilizing effect on dollarized external debt of a devaluation (Cespedes et al, 2004), the Central bank defends the exchange rate by purchasing domestic assets with foreign reserve assets. Observation of heightened intervention activity raises questions as to the sustainability of insurance provision, given the backdrop of an increasing liability to asset ratio. Fearing an increase in domestic interest rates, foreign lenders sell their domestic assets. The Central Bank can try to negotiate with lenders and with the IMF, but exchange market pressure continues to build, raising the risk of default on foreign currency denominated loans, which would balloon as a result of the devaluation. The result is an acceleration of the "run" on the Central Bank, leading to the currency crisis.

In order to tie the pieces together, we need to motivate the crisis. The nominal exchange rate is targeted through the usual policy instruments – changes in reserves and in interest rates. We assume that the Central Bank's exchange market intervention activity follows the monetarist convention (Weymark, 1995, Eichengreen et al, 1996; Kaminsky and Reinhart; 1999). The build up of exchange market pressure is therefore motivated through asset market disequilibrium. The fall in the relative

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[1] In some cases, this can be interpreted literally. During the Argentine crisis, foreign banks' were accused of loading billions of dollars onto 385 armored trucks, which transported the cash to Ezeiza International airport in Buenos Aires at the end of November, to be sent to the United States. Money sent to smaller airports is alleged to have ended up in Paraguay and Uruguay.

demand for domestic assets generates excess demand for foreign assets as in equation 7, which can only be absorbed through changes in asset prices - exchange rates and interest rates – or through quantitative adjustments in the relative supplies of foreign and domestic assets. Since the only reserve currency denominated assets at the Central Bank's disposal are foreign reserves, which are strictly finite, the scope for quantitative adjustment is limited – asset price realignments become unavoidable. The Central Bank's policy reaction function is given by equation 8.

$$EMP_t = \tilde{\varepsilon}_t - \varepsilon_t ; \tilde{\varepsilon}_t = \tilde{\varepsilon}_t(r_t^p) = \Delta s_t + \theta(\Delta r + \Delta i^D)_t \quad (7)$$

$$I_t = \frac{\theta(\Delta r + \Delta i^D)_t}{EMP_t} = \frac{\theta(\Delta r + \Delta i^D)_t}{\Delta s_t + \theta(\Delta r + \Delta i^D)_t} \quad (8)$$

Where "EMP" is exchange market pressure, and "$\tilde{\varepsilon}$" indicates the "shadow" exchange rate at which the asset market would be in equilibrium, i.e., demand for domestic assets (including currency) would equal supply. This shadow exchange rate is typically modeled as a function of everything that determines relative yield on domestic assets – growth, change in money supply, and the risk premium, and is measured by actual changes in the exchange rate and the policy instruments.

"I" is the share of exchange market pressure relieved through changes in the policy instruments, and "r" represents Central Bank's foreign reserves. "θ" is the weight on changes in the policy instruments and converts these changes into units equivalent to the change in the exchange rate ($\theta = d\,EMP / d(\Delta r + \Delta i^D)$). "θ" can also be interpreted as the policy instrument elasticity with respect to exchange market pressure.

As reserve assets start to dwindle relative to contingent liabilities, and external liabilities grow relative to "appropriable" external assets, foreign creditors estimate that there is an increased probability of default on loans and that the Central Bank will find it costlier to provide insurance. This reduces external financing, or even reverses its direction. Ultimately, the demand for domestic assets could reach a point at which the Central Bank is forced to let the exchange rate float, at least until a new, and hopefully more credible, commitment can be made. The crisis occurs between t and t+1, at some threshold value of the EMP, say EMP*.

The probability of a crisis is therefore a function of the cost of insurance, the probability of default as proxied by the ratio of external liabilities to assets, domestic credit to the private sector (which reflects the "easy lending" lending environment), capital flight, and reserve assets, as in

equation 9. Capital flight is typically a measure of private expectations regarding the exchange rate and the future relative price of domestic and foreign assets. In this context, it becomes a measure of domestic agents' ability to prevent expropriation of their assets once the Central Bank runs out of reserves.

Since output depends only on capital, a sudden stop in inflows and pressure on financial intermediaries, will increase the likelihood of a recession. The likelihood of an output loss following a crisis therefore is conditional on the risk premium, or on the "burden" of providing insurance to holders of domestic assets and currency, and the ratio of external assets to liabilities.

$$\Pr(Crisis) = \psi(L, l/k^F, d, \eta_T k^D_{t+1}, -r) \tag{9}$$

$$\Pr(\Delta y < 0) = \phi(L, l/k^F) \tag{10}$$

3*: Empirical Methodology and Data*

The empirical methodology is to try various specifications of single and simultaneous equation probit models. This allows testing for the timing of the crisis as well as for threshold levels of fundamentals in a very transparent manner. Several authors have used similar estimation techniques (for example, Eichengreen *et al*, 1995; Glick and Hutchison, 2001; Tornell, 1999). Three events are considered: the occurrence of a crisis, the occurrence of a recession, and the occurrence of a persistent output losses following a crisis. The marginal impact of the independent variables on the probability of the event taking place can be calculated from the estimated coefficients.

The intuition behind the identifying equations is as follows. The ability of the policymaker to ward off the crisis (*Crisis**) is not something that can be observed directly. The actual event of a crisis at time "T" can however be directly observed. The intervention index of equation 8 can then be used to calculate the impact of a 1% change in the explanatory variables in equation 9 on the likelihood of a crisis. We can also observe whether or not a crisis was followed by persistent output losses (recession in T+1 and T+2) and whether or not a recession occurred unconditional on the event that there was a crisis. There are therefore three events around which the probit estimations are set up.

The notation is as follows:

$Dummy_j$ = 0 if event "j" did not occur; =1 if event "j" did occur.

"j" = 1, 2, 3; j = 1 when event = crisis in period T; j = 2 when event = recession in periods t+1 and t+2; j = 3 when event=recession in periods T+ 1 and T+ 2. In the second event, we are measuring

the unconditional probability of a recession as opposed to event 3, which only considers output losses post-crisis.

"i" indexes the countries in the sample; *t* refers to the time subscript. In sample estimation was implemented for 1973-98 (not reported) and 1973-2003 as a robustness check.

"*v*" is the matrix of variables and is based on equations 9 and 10. The expected likelihood of the event is therefore modeled as a non-linear function of the variables included in "*v*".

β is the vector of parameters that reflect the impact of *"v"* on the probability that the event occurs.

Single Equation Specifications:

$$\Pr(Crisis)_{iT} = F(\beta' v_{iT}) + \varepsilon_{iT} \quad (11a)$$

$$\Pr(\Delta y < 0)_{iT+n} = F(\beta' v_{iT}) + \varepsilon_{iT} \text{ ; n = 1, 2} \quad (11b)$$

$$\Pr(\Delta y < 0)_{it+n} = F(\beta' v_{it}) + \varepsilon_{it} \quad (11c)$$

The solution method is based on maximum likelihood estimation. The joint probability or likelihood function follows a normal distribution. Each observation is a single draw from a Bernoulli distribution, and the probability of a success is *F (β'v).*

Inference in the probit framework is based on predicted probabilities from which we can estimate marginal effects. The marginal effects capture the individual variables' impact on the likelihood of the occurrence of the dependent variable and are interpreted as in equation 12.

$$\frac{\partial E[Event\ "\ j"_{it}]}{\partial v_{it}} = \phi(\beta' v)\beta \quad (12)$$

Where $\phi(t)$ is the standard normal density. Similarly, we can derive the likelihood of a recession, the probability of persistent output losses conditional on a crisis having occurred, and the impact on these probabilities and conditional probabilities of a change in our regressors.

Simultaneous Equation Model:

The probability of a crisis and the impact on growth are jointly estimated in a simultaneous equation framework. As a robustness check, two models are specified. This accounts for the possibility

that a crisis generates persistent output losses, as opposed to the likelihood that output losses following a crisis depend on balance sheet indicators, as in equation 11b.

$$P(Crisis_{it}) = F(\beta_1^{'} v_{it1}) + \varepsilon_{it1} \quad (13a)$$

$$P(\Delta y < 0 / Crisis_{it})_{it+2} = F(\beta_2^{'} v_{it2}) + \varepsilon_{it2} \quad (13b)$$

Where, $[\boldsymbol{\varepsilon_{it1}}, \boldsymbol{\varepsilon_{it2}}] \sim N(0, 1)$, and both regression equations (13a and 13b) include common regressors – measures of contingent liabilities, and the ratio of external liabilities to external assets. In addition to the seemingly unrelated bivariate specification, the joint conditional probabilities are estimated based on the specification contained in equation 14.

$$P(Crisis_{it}, y_{it}) = F(\alpha X_{it}) + \varepsilon_{it} \quad (14)$$

Equations 13a, 13b, and 14 jointly test for output losses and the likelihood of a crisis and for whether the single equation results are biased because of endogeneity.

The specification is based on equations 9 and 10. All variables are in 1990 US dollars. The sample includes 90 developed and developing countries over a wide variety of geographical regions with a great deal of heterogeneity in their political and institutional environments. In addition, countries with total M2 (money + quasi-money) less than 2 billion in 1998 are classified as small (Bossone, Honohan and Long, 2001).

The right-hand side variables include stock of external liabilities to assets, measures of capital flight, domestic credit to the banking sector, liabilities as a proportion of non-gold reserves, M2 as a proportion of non-gold reserves, a dummy that captures whether there was a decline in output in the previous period, and change in current account. The methodology used to update the balance sheet items can be found in Kraay et al (2000) . Capital flight is calculated as a cumulation of "errors and omissions" starting from the first available date, adjusted for differences between net non-equity liability flows, minus the foreign debt stock as reported by the World Bank. The expected signs on the coefficients are summarized in Table 1.

(Insert Table 1 here)

The crisis index, based on equation 8, is computed in two ways. The first, as in equation 15a, is the measure developed in Kaminsky and Reinhart (1996). The idea here is to capture periods when intervention activity in the domestic exchange market was relatively intense, and not just events that are recorded as a crisis. As interest rate data is not available for a number of countries in the sample, the only policy instrument considered is changes in reserve assets of the Central Bank. Since exchange rates are more volatile than reserves, the weight on the latter is higher as can be seen from equation 15a. Reserves adjust in the opposite direction to exchange rates when there is pressure to intervene. The second measure (equation 15b) does not use country specific weights, but generates a very similar looking measure of crisis.

$$EMP_{it} = \Delta s_{it} - \frac{\sigma_{\Delta s}}{\sigma_{\Delta r}} \Delta r_{it} \qquad (15a)$$

$$EMP_{it} = .2 * \Delta s_{it} - .8 * \Delta r_{it} \qquad (15b)$$

The standard deviations of the exchange rate and reserve changes are taken over the estimation sample, and changes in reserves are measured as excess over the corresponding change in the US. The crisis is then recorded as the event that intervention activity exceeds the average by a half standard deviation.

$Crisis_{it}$ = 1 if $EMP_{it} > mean(EMP_{sample}) + .5.stdev(EMP_{sample})$ (16)

Typically, higher thresholds – up till 2.5 standard deviations – are used for higher frequency data.

4: *Empirical Results*

Table 2 presents the results of the simultaneous equation probit model (equation 14). The SURE (equations 13(a) and 13(b)) results provide a robustness check that this specification is appropriate. It is important to note the question being asked here is are output losses preceded by crises, affected by the health of the balance sheet? The econometric analysis suggests that the answer is yes. There is strong evidence of endogeneity between crises and persistent output losses in

(Insert Table 2 here)

countries (with persistent defined as two years into the future). The Wald test rejects the null hypothesis of zero endogeneity at 1 percent.

As suggested by the theoretical motivation outlined in Section 2, a worsening (increase in) balance sheet – as indicated by the ratio of external liabilities outstanding to the stock of external assets – raises both the probability of a "costly" crisis and the likelihood of a persistent output loss in the afflicted country. The other key determinant of the cost of the crisis is financial depth as measured by domestic credit to the banking sector. Higher domestic credit cushions the economy from the output loss and reduces the likelihood of a crisis, suggesting that the transmission mechanism of the crisis also determines its cost, i.e., the extent of the credit crunch.

Exposure on contingent liabilities, as measured by the ratio of M2 to non-gold reserves, does significantly increase the likelihood of a crisis, but while entering with the expected sign in the output-loss equation is not significant there. This is also true of capital flight: it is a significant crisis predictor but, while entering with the correct sign, is not a significant determinant in the output loss equation. As a control, output loss in the preceding period (one period following the crisis) is included and is highly significant, but the financial variables still play a key role in determining the output cost of the crisis. Deterioration in the current account significantly increases the likelihood of a crisis. All standard errors are heteroskedasticity-corrected.

(Insert Table 3)

The single equation estimation results support these conclusions (Tables 3 and 4). The evidence is that while it is unclear that external debt to asset ratios are a strong or consistent predictor of crises, they do signal that a crisis followed by persistent output losses is likely.

(Insert Table 4)

4: *Conclusions*

The empirical evidence presented in this paper suggests that "costly" currency crises are predicted by the contingent liability-asset mismatch and that these balance sheet effects determine the likelihood that the crisis will be followed by persistent output losses. The theoretical motivation for the

analysis is that the crisis transmits through the interaction between the Central Bank's provision of insurance, the "easy lending" environment this fosters, and the probability of default being endogenous to the mismatch between external liabilities and assets. The evidence on whether crises themselves are predicted by debt to asset ratios is mixed: however liquid contingent liabilities relative to liquid reserves show up as a consistent signal that a crisis is likely to occur.

Table 1: The Explanatory Variables: Natural logs/changes

Control variables	Expected relationship with likelihood of a crisis
Stock of external liabilities/stock of external assets (+)	As the ratio of liabilities (stock outstanding) rises relative to assets, the likelihood of a currency crisis increases (and output losses are likely to persist)
Change in stock of "capital flight" (+)	Symptom of the reversal of foreign lending and the fall in demand for domestic assets and should increase the likelihood of a crisis.
Change in domestic credit to the private sector (-)	The banking sector maintains liquidity, avoiding a credit crunch, and postponing or helping avoid the crisis.
M2/nongoldreserves (+)	Easy lending compounds the moral hazard problem. As the ratio of contingent liabilities rises relative to assets, the likelihood of a run on the Central Bank increases.
Change in current account surplus (-)	As long as lending continues, the crisis does not occur.

Table 2: Bivariate Probit Results

Dependent Variables: (1) Crisis in t followed by negative growth in t+2, Negative growth in GDP in t+2
(2) Crisis in t, Negative growth in GDP in t+2

	(1)		(2)	
Simultaneous Equation	Crisis in t and negative growth in t+2	Negative growth in GDP in t+2	Crisis† in t	Negative growth in GDP in t+2
No. of successes out of total (5177) observations: panel is unbalanced	165	1594	556	1594
Fall in output (t+1)	0.158	0.432	-0.097	0.429
	(1.65)*	(7.64)***	(1.39)	(7.62)***
Fall in output (concurrent)	0.124	-0.039	0.133	-0.038
	(1.28)	(0.68)	(1.93)**	(0.67)
Ratio of external liabilities to external assets (t-1)	0.049	0.034	0.047	0.033
	(1.66)*	(1.85)*	(2.06)**	(1.79)*
Share of domestic credit to the banking sector in GDP	-0.132	-0.056	-0.047	-0.055
	(2.74)***	(1.68)*	(1.09)	(1.58)†
Change in current account surplus (t-1)	-0.004	0.000	0.000	0.000
	(5.07)***	(0.03)	(0.25)	(0.08)
Increase in capital flight (t-1)	0.0002	0.006	-0.005	0.006
	(7.98)***	(1.07)	(1.01)	(1.35)
Change in ratio of M2 to non-gold reserves	0.189	0.046	0.262	0.046
	(2.72)***	(1.00)	(3.97)***	(0.98)
Constant	-1.452	-0.300	-1.062	-0.300
	(7.09)***	(2.17)**	(5.98)***	(2.09)**
Overall Fit	<1%	<1%	<1%	<1%
SURE				
Wald Test (H_0 : no endogeneity)	H_0 rejected***	H_0 rejected***	H_0 accepted	H_0 accepted
Observations included in probit analysis	2253	2253	2253	2253

Robust z statistics in parentheses

*significant at 10%;** significant at 5%; *** significant at 1%; † Significant at 11% only;

† Without country-specific weights

Table 3: Single Equation Probit Results

	(1)	(2)
Dependent Variable	Crisis in t	Crisis in t
Ratio of external liabilities to external assets (t-1)	0.005	0.006
	(1.16)	(1.48)
Share of domestic credit to the banking sector in GDP	-0.021	-0.025
	(2.59)**	(3.07)**
Change in current account surplus (t-1)	-0.001	-0.001
	(1.80)*	(1.81)*
Increase in capital flight (t-1)	0.00002	0.00002
	(7.73)**	(7.60)**
Change in ratio of M2 to non-gold reserves	0.054	0.055
	(4.44)**	(4.55)**
Fall in output (t+1)		0.004
		(0.30)
Overall fit	<1%	<1%
Observations	2341	2298

Robust z statistics in parentheses
*significant at 10%;** significant at 5%; *** significant at 1%
† Without country-specific weights

Table 4: Single Equation Probit Results

	(1)	(2)	(3)	(4)
Dependent Variable	Fall in output (t+2)	Crisis in t and fall in output (t+2)	Crisis in t and fall in output (t+2)	Crisis in t and fall in output (t+2)
Fall in output (t+1)	0.176		0.016	
	(9.26)**		(1.91)*	
Fall in output (concurrent)	-0.011			
	(0.60)			
Ratio of external liabilities to external assets (t-1)	0.016	0.005	0.004	
	(2.80)**	(1.77)*	(1.60)*	
Share of domestic credit to the banking sector in GDP		-0.013	-0.013	-0.014
		(2.84)**	(2.84)**	(3.43)**
Change in current account surplus (t-1)		-0.0001	-0.0001	-0.0001
		(1.85)*	(1.87)*	(1.83)*
Increase in capital flight (t-1)		0.00002	0.00002	0.00002
		(6.04)**	(6.24)**	(9.37)**
Change in ratio of M2 to non-gold reserves		0.019	0.017	0.019
		(2.89)**	(2.68)**	(3.48)**
Ratio of external liabilities to reserve assets (t-1)				0.005
				(2.28)*
Overall Fit	<1%	<1%	<1%	<1%
Observations	2936	2253	2253	2657

Robust z statistics in parentheses
*significant at 10%;** significant at 5%; *** significant at 1%
† Without country-specific weights

Appendix

Table A1: Summary of Previously Used Crisis Predictors and the Underlying Rationale

Type of Model	*Transmission Mechanism*	*Empirical Implications*	*Predictors used in previous studies*	*My Variables*
A. Links output and currency crises: example: Mendoza and Uribe (1999)	Firms, individuals and the government interact in a framework in which the probability of a crisis enters an equilibrium business cycle model	Reserves and demand for money are crisis predictors; Currency crises are followed by Recessions	Numerical calibration using Mexican data	Volatility in government spending, M2/ reserves, control "fundamentals" , measures of capital flight, gross external liabilities, and GDP growth.
Links output and financial crises: example Hutchison and McDill (1999), Hutchison (2001)	Failure of domestic financial sector	Banking crises are accompanied by prolonged recessions	Deposit Insurance, Financial Liberalization, Moral Hazard dummies, growth in GDP & real credit, nominal and real interest rates, inflation, movements in stock prices, fiscal deficit, M2/Reserves, rate of nominal depreciation.	n.a

Table A1 continued

Type of Model	Transmission Mechanism	Empirical Implications	Predictors used in previous studies	My Variables
B. Standard First-generation Model Example: Krugman (1979)	Worsening fundamentals causes fall in government reserves	Fall in international reserves, worsening fiscal deficit pre-crisis, no policy change post-crisis	Fiscal Deficit, real GDP, government consumption, measures of domestic credit: examples: Collins, 1995; Kaminsky and Reinhart, 1996.	Same
First-Generation Stochastic Models and target zone models: Krugman and Rotemberg (1991), Flood and Marion (1996)	There is a stochastic element either to the demand for domestic money or to the nominal exchange rate	The nominal exchange rate has a random walk component	Volatility in M2/reserves: example: Maloney and Galindo, 1998.	Volatility in M2/reserves, fiscal deficit, demand for domestic assets, government consumption, measures of capital flight.
Second Generation Models. Examples: Flood and Garber (1984), Obstfeld (1994,1996)	Worsening exchange rate expectations manifest in either higher wage demands or increased burden of servicing government debt through seignorage.	Expectations become self-fulfilling as devaluation is one of many possible equilibria: higher interest rates and expansionary monetary policy post-crisis	Expectations proxies such as interest differentials growth in real wages, net government debt, both domestic and foreign, net errors and omissions as proxy for capital flight: examples: Kaminsky *et al*, 1997.	Expectations; net external debt; public debt

(Table A1 continued)

Type of Model	Transmission Mechanism	Empirical Implications	Predictors used in previous studies	My Variables
Third - Generation Models: (a) Liquidity crises or bank runs (b) Insurance Models (c) Moral Hazard Examples: Dooley (2000), Chinn and Kletzer (1999), Chang and Velasco (1998, 1999).	(a) Domestic economy is perceived as being over-extended causing a run on the banks as investors want out before the expected devaluation; adverse shocks are amplified by the weakness of the domestic financial sector. (b) In insurance models, expectations do not jump, but central bank is monetizing the banking sector's deficit: the government is lender of last resort to domestic financial sector. (c) Imperfect information/ informational asymmetries lead to a financial crisis that spill over into a currency crisis	Increase in inflows pre-crisis; drawing down of reserves once this is reversed; higher domestic banking activity pre-crisis; increase in domestic credit to the banking sector; worsening exchange rate expectations as in second-generation models; possibly worsening fundamentals; coincidence of financial and currency crises	Expectations proxies such as interest differentials growth in real wages, net government debt, both domestic and foreign, net errors and omissions as proxy for capital flight; domestic credit to the banking sector; increase in bank activity; various macro fundamentals: examples: Corsetti *et al* 1998; Chinn and Dooley, 1999;	Gross external liabilities (loans, equity and FDI) as well as net external short-term debt.

Data Sources:

Various issues of the Balance of Payments Yearbook

Balance of Payments, Version 5

International Financial Statistics

World Development Indicators

Global Development Finance

Country Specific Sources: Various Issues of

IMF: Recent Economic Developments

World Bank: Country Economic Memorandums

Central bank Bulletins

Rider, Mark (1994), "External Debt and Liabilities of Industrial Countries", Reserve Bank of Australia Discussion Paper 9405.

Kraay, Aart, Norman Loayza, Luis Serven, Jaume Ventura, 2000. Country Portfolios. NBER Working Paper No.7795.

Balance of Payments (IFS line no. in parentheses):

Current Account (78ald): *ca*
Capital Account balance (78bcd): *ka*
Direct Investment Abroad (78bdd): *fdia*
Direct Investment in country (78bed): *fdil*
Portfolio Investment Assets (78bfd): = Portfolio Investment Debt Assets +
Portfolio Investment Equity Assets = *equa*
Portfolio Investment Liabilities (78bgd): = Portfolio Investment Debt Liabilities +
Portfolio Investment Equity Liabilities = *equl*
Other Investment Assets (78bhd): *la*
Other Investment Liabilities (78bid): *ll*
Financial account (78bjd): *fa= fdia-fdil+equa-equl+la-ll*
Net errors and omissions (78cad): *eo=ca+ka+fa+fin*
Reserves and related items (financing items) (79dad): *fin=fx+ef+imf*
Reserve assets (79ded): *fx*
Exceptional financing (79ded): *ef*
Fund Credit and Loans (79dcd): *imf*

List of Countries

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