Fundamental determinants of the Asian crisis: a preliminary empirical assessment*

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Abstract

A leading interpretation of the Asian meltdown focuses on structural problems and fundamental weaknesses as crucial elements of the genesis of the crisis, as well as of its spread across countries. In support of this thesis, in this paper we present some preliminary formal evidence on the links between indicators of currency instability in 1997 and a number of indicators of real and financial fragility at the onset of the crisis. The proposed tests provide a set of baseline results according to which weak cyclical performances, low foreign exchange reserves, and financial deficiencies resulting in high shares of non-performing loans were at the root of the Asian collapse.

J.E.L. classification F31, F34, G15, G18.

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1 Introduction

Episodes of speculative attacks on currencies in the 1990s (such as the 1992-93 crises in the European Monetary System, the 1994 Mexican peso collapse, and especially the Asian turmoil of 1997-98) have generated a considerable — and finely balanced — debate on whether currency and financial instability should be attributed to arbitrary shifts in market expectations and confidence, rather than to weaknesses in the state of economic fundamentals.[1] Yet, advocates of both the 'fundamentalist' and the 'non-fundamentalist' view agree in principle that a deteriorating macroeconomic outlook is a necessary condition for an economy to be vulnerable to a crisis. In fact, it is well understood that multiple instantaneous equilibria — which provide the theoretical preconditions for self-fulfilling crises to occur as rational events — are only possible in a region of parameters in which the current or anticipated economic performance of a country is sufficiently weak.

The problematic economic and financial conditions in Southeast Asia in the years preceding the crisis have been documented in a number of recent studies (including our own contributions in Corsetti, Pesenti and Roubini (1998a,b,c)).[2] A widespread view holds that, while the extent of the plunges in asset prices went beyond what was necessary to restore external balance, weak economic fundamentals were certainly a crucial element of the genesis of the crisis, as well as of its spread across countries. In support of this thesis, in this paper we present some preliminary formal evidence on the links between indicators of currency instability in 1997 and a number of indicators of real and financial fragility at the onset of the crisis. The proposed tests do not aim at discriminating among alternative explanations — rather, the goal here

[1] Among recent studies focusing on the large-scale speculative episodes in the 1990s before the Asian crisis, see Eichengreen and Wyplosz (1993) and Buiter, Corsetti and Pesenti (1998a, b) on the European Monetary Systyem crisis of 1992-93, and Sachs, Tornell and Velasco (1996) on the Mexican peso crisis of 1994. A number of recent contributions on financial and balance of payments crises provide a discussion of the issues introduced in this paper — among others see Dornbusch, Goldfajn and Valdes (1995), Milesi-Ferretti and Razin (1996), Mishkin (1996), Kaminsky, Lizondo and Reinhart (1998) and Roubini and Wachtel (1998).

[2] A partial list of recent studies providing empirical evidence on the Asian crisis includes Alba *et al.* (1998), Dornbusch (1998), Feldstein (1998), Goldstein (1998), IMF (1998), OECD (1998), Pomerleano (1998), and Radelet and Sachs (1998). A large number of contributions on the crisis are available online on Nouriel Roubini's Asian Crisis Homepage at www.stern.nyu.edu/~nroubini/asia/AsiaHomepage.html.

is to provide a set of baseline results to complement and integrate previous analyses pointing at the fragile state of the Southeast Asian economies before the eruption of the crisis.

One of the most widely quoted pieces of evidence that corroborates the fundamental interpretation of the crisis is that well-performing countries were spared its most pervasive consequences. Taiwan, Singapore, and Hong Kong were, relatively speaking, less affected by the regional turmoil. The Hong Kong currency parity was maintained despite strong speculative attacks. Taiwan and Singapore decided to let their currency float rather than lose reserves by attempting to stabilize the exchange rate; however, the depreciation rates of their currencies were modest, and, most importantly, these countries did not experience drastic reversals in market sentiment, financial panic and large-scale debt crises.

The three countries that were only mildly affected by the turmoil shared a number of characteristics: first, their trade and current account balances were in surplus in the 1990s; second, their foreign debt was low (Taiwan was a net foreign creditor towards BIS banks); third, their financial and banking systems did not suffer from the same structural weaknesses and fragility observed in the crisis countries; fourth, they had a relatively large stock of foreign exchange reserves compared to the crisis countries; fifth, they were to a large extent immune from forms of 'crony capitalism', that is, from the system of intermingled interests among financial institutions, political leaders and corporate elites that was characteristic of Korea, Indonesia, Malaysia and Thailand.[3] In principle, China also falls in the category of countries that were not too exposed to disruptive speculative pressure — the Chinese currency did not depreciate in 1997. However, the presence of constraints on capital mobility make it difficult to compare the performance of this country with the other three.

Conversely, as a group the countries that came under attack in 1997 had the largest current account deficits throughout the 1990s. While the degree of real appreciation over the 1990s differed widely across Asian countries, with the important exception of Korea all the currencies that crashed in 1997 had experienced a real appreciation.

[3]Note that the crisis of the Philippines, a country with better fundamentals and a less fragile financial system than other countries in the region, was also relatively contained. Even though the exchange rate plunged and the stock market dropped by over 30% in 1997, this country did not experience the extent of the turmoil and financial panic that hit Korea, Thailand, Indonesia and Malaysia.

The literature has pointed out several factors that contributed to the deterioration of fundamentals in the region. The region experienced significant negative terms of trade shocks in 1996, with the fall in price of semi-conductors and other goods. For most countries hit by the crisis, the long stagnation of the Japanese economy had led to a significant slowdown of export growth. Close to the onset of the crisis, the abortive Japanese recovery of 1996 was overshadowed by a decline in activity in 1997. Last but not least, the increasing weight of China in total exports from the region enhanced competitive pressures over the period.

On the financial side, there is a large body of evidence showing that the corporate, banking and financial systems of the crisis countries were very fragile — poorly supervised, poorly regulated, and already in shaky conditions before the onset of the crisis. The evidence suggests a sustained lending boom in the Philippines, Thailand and Malaysia – strikingly, these were also the first countries to be hit by currency speculation in 1997. It also suggests a severe mismatch between foreign liabilities and foreign assets of Asian banks and non-bank firms. Domestic banks borrowed heavily from foreign banks but lent mostly to domestic investors.[4]

By the end of 1996, a share of short-term foreign liabilities above 50% was the norm in the region. By the same date, in most Asian countries the ratio between M2 and foreign reserves was dangerously high: in the event of a liquidity crisis — with BIS banks no longer willing to roll-over short-term loans — foreign reserves in Korea, Indonesia and Thailand were insufficient to cover short-term liabilities, let alone to service interest payments and to repay the principal on long-term debt coming to maturity in the period. One could certainly hold the view that the creditors' 'panic' in Korea and Indonesia purely resulted from a standard 'collective action' problem faced by a large number of creditors in their decisions whether to roll-over existing credits or call in their loans.[5] But then it should also be recognized that market reactions took place under conditions of extreme political uncertainty, low credibility of the existing governments, and skepticism about the direction of, and the commitment to, structural reforms.

Although Asian countries were characterized by very high savings rates throughout the 1990s, the deficiencies of their financial sector posed a severe

[4] On the role of moral hazard in generating such 'overborrowing' syndrome, see McKinnon and Pill (1996), Krugman (1998) and Corsetti, Pesenti and Roubini (1998a).

[5] See *e.g.* Chang and Velasco (1998a,b).

burden on the fiscal balances of the affected countries. Such costs represented an implicit fiscal liability, a liability not reflected by data on public deficits until the eruption of the crisis but large enough to affect the sustainability of the pre-crisis current account imbalances. The size of this liability contributed to generate expectations of drastic policy changes (a fiscal reform required to finance the costs of financial bailouts) or currency devaluations (as a result of higher recourse to seigniorage revenues).[6]

This paper reports and discusses a number of tests of the empirical relevance of the set of macroeconomic factors recalled above. In our tests we compare the performance of all the Asian countries subject to pressures in 1997 with the performance of other emerging economies, for a total sample of 24 countries whose selection has been determined by data availability.[7]

The paper is organized as follows. Adopting the methodology suggested in previous studies,[8] in Section 2 we first construct a 'crisis index' as a measure of speculative pressure on a country currency. Then, we compute a set of indexes of financial fragility (Section 3), external imbalances (Section 4), official reserves adequacy and fundamental performance (Section 5). In Section 6 we report the results of the regressions of the crisis index on the above indexes. Section 7 concludes.

2 The crisis index

Our crisis index (IND) is a weighted average of the percentage rate of exchange rate depreciation relative to the US dollar — if such depreciation can be deemed as abnormal, as explained below — and the percentage rate of change in foreign reserves between the end of December 1996 and the end of December 1997.[9] The logic underlying the index IND is quite simple. A

[6] See Corsetti, Pesenti and Roubini (1998a) and Burnside, Eichenbaum and Rebelo (1998).

[7] The countries are Argentina, Brazil, Chile, China, Columbia, Czech Republic, Hong Kong, Hungary, India, Indonesia, Jordan, Korea, Malaysia, Mexico, Pakistan, Peru, Philippines, Poland, Singapore, Sri Lanka, Taiwan, Thailand, Turkey and Venezuela.

[8] See *e.g.* Eichengreen, Rose and Wyplosz (1996), Sachs, Tornell and Velasco (1996), and Kaminsky, Lizondo and Reinhart (1998).

[9] The weights assigned to exchange rate and reserves changes in IND are respectively 0.75/0.25. For the purpose of sensitivity analysis, we consider alternative crisis indexes with different weights, and find that the choice of the weight coefficients is not crucial to our results. Also, alternative tests with different samples of shorter size provide similar

speculative attack against a currency is signalled either by a sharp depreciation of the exchange rate or by a contraction in foreign reserves which prevents a devaluation.[10] We present the values for IND in Table 1: a large negative value for IND corresponds to a high devaluation rate and/or a large fall in foreign reserves, *i.e.* a more severe currency crisis.

In evaluating the crisis index we need to control for the fact that, in some countries, a high rate of depreciation in 1997 may reflect a past trend rather than severe speculative pressures. For example, the fact that the Turkish currency depreciated by over 50% in 1997 should not be interpreted as a signal of 'crisis,' as chronically high inflation rates in Turkey over the 1990s have been associated with 'normally' high depreciation rates.[11]

There is no obvious way to purge the sample of the effects of trend depreciations not associated with a crisis. In this study, we take the following approach: if a currency in 1997 has fallen in value by less than its average depreciation rate in the 1994-1996 period, we consider this as being part of a trend depreciation and set the 1997 depreciation rate equal to zero in constructing the index.[12] In our sample, such screening procedure leads to a significant re-sizing of the crisis index for two high-depreciation countries: Turkey and Venezuela.

As Table 1 shows, the countries that in 1997 appear to have been hit by the most severe crises are, in order, Thailand, Malaysia, Korea, Indonesia, Philippines and the Czech Republic. Among Asian countries, the currencies of Singapore and Taiwan were also moderately devalued in 1997, but these two countries were not subject to such extensive and dramatic financial turmoils as the ones affecting other East Asian economies. Conversely, outside the Asian region the Czech Republic appears as a crisis country since its currency, which had been pegged since 1992, suffered a severe speculative attack in the spring of 1997 leading to a devaluation.[13]

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results. All tests are available upon request.

[10] While of course an increase in domestic interest rates may also signal a frustrated speculative attack, our crisis index excludes changes in interest rates. This is because an increase in interest rates in the presence of speculative pressures is highly correlated with non-sterilized foreign exchange intervention leading to a fall in reserves.

[11] Note that Turkey exhibited a satisfactory economic performance in 1997, with GDP growing over 6% and its stock market being a leading performer among emerging countries.

[12] Other authors use a different approach to the same problem. For example, Sachs, Tornell and Velasco (1996) control for the variance of the exchange rate and reserves in the last 10 years.

[13] The Czech Republic shared many symptoms with the Asian crisis countries: a fixed

3 Indexes of financial fragility

Measures of banking system weakness are provided by the stock of non-performing loans as a share of total assets in 1996 (NPL)[14] and an index of 'lending boom' (LB), defined as the growth of commercial bank loans to the private sector (as percentage of GDP) in the period 1990-96. The latter is an indirect measure of financial fragility suggested by Sachs, Tornell and Velasco (1996).[15] Both variables (NPL and LB) are reported in Table 1.

We adopt two indicators of domestic financial fragility. The first one encompasses the information in both NPL (non-performing loans) and LB (lending boom) and is defined as follows: if the sign of the lending boom in the 1990s is positive, we assign to the new indicator $NPLB$ the original value of NPL; if the lending boom in the 1990s is negative, we set $NPLB$ equal to zero:[16]

$$NPLB = \begin{cases} NPL & \text{if} \quad LB > 0 \\ \\ 0 & \text{if} \quad LB \leq 0 \end{cases}$$

As regards the second indicator, note that according to the theoretical model presented in Corsetti, Pesenti and Roubini (1998a) the vulnerability of a country to currency and financial crises increases with the implicit fiscal costs of financial bailouts. Under the maintained hypothesis that the time series of NPL provides information about the size of the overall bailout in the event of a crisis, we can obtain a statistical *proxy* for the associated fiscal costs by taking the ratio of non-performing loans to GDP in 1996.

Such series is denoted $NPLY$, and is defined as the product of NPL and commercial bank loans to the private sector as a share of GDP in 1996. This variable allows us to properly assess the performance of those countries with low ratios of bank loans to GDP but relatively large non-performing loans

exchange rate regime maintained for too long, a severe real appreciation, a dramatic worsening of the current account, and a weak banking system with large shares of non-performing loans.

[14] In the Appendix we describe in detail our methodology to estimate the series NPL.

[15] These authors argue that such a measure is a proxy for financial fragility as the quality of bank loans is likely to deteriorate significantly — and a large fraction is likely to become non-performing — when bank lending grows at a rapid pace in a relatively short period of time.

[16] The logic of the $NPLB$ variable is straightforward: non-performing loans represent a source of severe tension only when observed in tandem with excessive bank lending that enhances the vulnerability of the country to a crisis.

as a share of banking assets (*e.g.* India and Pakistan). In those countries, the contingent fiscal liabilities related to bailout costs are smaller relative to countries with a similar NPL, but have a higher ratio of bank lending to GDP.

4 Indexes of current account imbalances

Table 1 reports the average current account balance as a share of GDP in the 1994-1996 period (CA) and the real exchange rate appreciation in the 1990s (RER). There is no simple way to assess when a current account balance is sustainable (*e.g.*, when it is driven by investment in sound projects) and when it is not (*e.g.*, when it reflects a structural loss of competitiveness), or to what extent a real appreciation is due to misalignment, as opposed to an appreciation of the fundamental equilibrium real exchange rate. However, the consensus in the empirical literature on crisis episodes is that the *combination* of a sizable current account deficit and a significant real appreciation represents a worrisome signal of external imbalance.

Consistent with this view, we construct an index of *current account imbalance*, CAI, defined as follows: if the rate of real exchange rate appreciation is above a given threshold T, CAI is equal to the current account balance (as a share of GDP); if the real appreciation is below the threshold (or there is a real depreciation), CAI is set equal to zero:[17]

$$CAI = \begin{cases} CA & \text{if } RER \text{ appreciates by more than } T \\ & (T = 0,\ 10\%) \\ \\ 0 & \text{otherwise} \end{cases}$$

5 Indexes of foreign reserves adequacy and fundamentals performance

In Section 6 below, we are interested in testing whether the effects of external imbalances and financial fragility are magnified by the inadequate availability of foreign exchange reserves and by the weak performance of other fundamental variables. Other things being equal, the vulnerability of a country to

[17] In the tables, we present regression results for the 10% threshold, but similar results are obtained for the zero threshold.

a currency crisis is higher when reserves are low relative to some measure of domestic liquid assets or short-term foreign debt. To assess the role played by reserves availability, we construct three different measures: the ratio of $M1$ to foreign exchange reserves ($M1/RES$), the ratio of $M2$ to foreign reserves ($M2/RES$), and the ratio of the foreign debt service burden (i.e. short-term foreign debt plus interest payments on foreign debt) to foreign reserves (STD/RES). The values of these variables are reported in Table 1.

To test for the joint role of fundamentals and foreign reserves in determining a currency crisis, we classify the countries in our sample as being *strong* or *weak* with regards to these two dimensions using dummy variables. Regarding foreign reserves, we use a broad classification according to which a country is strong if the ratio of $M2$ to reserves is in the lowest quartile of the sample. The resulting dummy variable for low reserves, $D2^{LR}$, is defined as:

$$D2^{LR} = \begin{cases} 1 & \text{if } M2/RES \text{ above lowest sample quartile} \\ \\ 0 & \text{otherwise} \end{cases}$$

Similar dummies are created by replacing $M2/RES$ with $M1/RES$ and STD/RES; such dummy variables are labelled $D1^{LR}$ and $D3^{LR}$.

In regards to fundamentals, we focus on current account imbalances and financial fragility. Countries are classified as being *strong* or *weak* according to the scheme:

$$D^{WF} = \begin{cases} 1 & \text{if either } CAI \text{ in highest sample quartile} \\ & \text{or } NPLB \text{ in lowest sample quartile} \\ \\ 0 & \text{otherwise} \end{cases}$$

A similar dummy can be obtained by replacing $NPLB$ with $NPLY$.[18]

[18] In this case, the dummy variable would be equal to zero for countries with our index of current account imbalance (CAI) in the highest quartile of the sample, or with a rate of non-performing loans as a share of GDP, *i.e.* $NPLY$, in the lowest quartile of the sample; it would be equal to one otherwise.

6 Testing for the role of fundamentals imbalances in the crisis

6.1 Financial fragility and external imbalances

The results of the regression of IND on CAI and $NPLB$ are shown in column (1) of Table 2. The coefficients of the two regressors have the expected sign and are statistically significant at the 5% level: both a large current account deficit associated with a real appreciation and a larger rate of non-performing loans associated with a lending boom worsen the crisis index. In columns (2)-(4) we interact the two regressors with the dummies for low reserves. The coefficients β_2 and β_3 measure the effects of CAI and $NPLB$ on the crisis index in countries with high reserves ($D^{LR} = 0$); conversely, the sums of the coefficients $\beta_2 + \beta_4$ and $\beta_3 + \beta_5$ measure the impact of fundamental imbalances on the crisis index in countries with low reserves ($D^{LR} = 1$).

Looking at the regression results shown in columns (2)-(4), the coefficients β_2 and β_3 are not significant on their own, but rather only when reserves are low. In fact, for the case in which we use the reserve dummy $D2^{LR}$, based on $M2$ data, the Wald tests indicate that the hypotheses $\beta_2 + \beta_4 = 0$ and $\beta_3 + \beta_5 = 0$ can be rejected at the 1% and 10% significance levels[19]. Similar or stronger results are obtained when we use the other two low-reserves dummies, $D1^{LR}$ and $D3^{LR}$. As a whole, these results suggest that structural imbalances (current account deficits/currency appreciation and non-performing loans/lending boom) play a role in the onset of a crisis to the extent that there is insufficient availability of foreign reserves — that is, in the light of both fundamental and non-fundamental models of currency crises, low reserves enhance the vulnerability of the economy to speculative attacks.

In Table 3 we test whether the effects of current account imbalances CAI on the crisis index depend on weak fundamentals D^{WF} and low reserves $D2^{LR}$. Relative to column (2) of Table 2, in column (1) of Table 3 we consider an additional regressor, namely an interaction term equal to CAI times $D2^{LR}$ times D^{WF}. In this case, the sum of the coefficients $\beta_2+\beta_4+\beta_6$ captures the effects of current account imbalances on the crisis index in countries with low reserves and weak fundamentals. If $\beta_2+\beta_4+\beta_6$ is positive while $\beta_2+\beta_4$ is not significantly different from zero, the crisis index worsens when a high-deficit

[19] Their *p-values* are 0.005 and 0.09 respectively.

country with an appreciated currency meets both 'weak fundamentals' and 'low reserves' criteria, but the crisis index does not respond to the reserves indicator if such a country is in the 'strong fundamentals' region. The results of the Wald tests show that $\beta_2+\beta_4+\beta_6$ is indeed significantly positive at the 1% significance level, while $\beta_2+\beta_4$ is not significantly different from zero.[20]

Column (2) of Table 3 includes a similar test for the role of non-performing loans. Here we add an additional regressor to those of column (2) in Table 2, which is an interaction term equal to $NPLB$ times $D2^{LR}$ times D^{WF}. Thus, the sum of the coefficients $\beta_3+\beta_5+\beta_7$ captures the effects of non-performing loans on the crisis index in countries that meet both 'low reserves' and 'weak fundamentals' criteria. Our tests show that $\beta_3+\beta_5+\beta_7$ is negative at the 5% significance level while $\beta_3+\beta_5$ is not significantly different from zero. The crisis index depends on non-performing loans in countries with weak fundamentals and weak reserves, but not in countries with strong fundamentals and weak reserves. The implication of these results is that a crisis need not be related to current account imbalances or bad loans *per se*: such imbalances represent a source of severe tension only when they are observed in parallel with fundamental *and* reserve weaknesses.[21]

6.2 Fiscal implications of financial fragility

Next, in Tables 4 and 5 we perform regressions similar to those in Tables 2 and 3, but now we move our focus away from financial fragility per se, and onto the role of the fiscal implications of financial fragility. We therefore substitute $NPLB$ — the non-performing loans ratio adjusted to account for the lending boom — with $NPLY$ — a more direct *proxy* for the implicit fiscal costs of banking sector bailouts.

The results are very similar and, if anything, even stronger than those obtained in Tables 2 and 3. First, as Table 4 column (1) shows, both $NPLY$ and CAI are statistically significant regressors of the crisis index (at the 5%

[20] Note also that the coefficient on $NPLB$ (β_3) is still significantly different from zero in this regression.

[21] In column (3) of Table 3, we consider interactions of both CAI and $NPLB$ with the dummies for weak fundamentals and low reserves. The results for $NPLB$ are similar to those in column (2). For the current account, instead, we fail to reject the hypothesis that both $\beta_2+\beta_4+\beta_6$ and $\beta_2+\beta_4$ are equal to zero. Formal tests such as the variance inflation test suggest that this is due to multicollinearity between the two interaction terms: when they both appear in a regression, the effects of CAI are swamped by those of $NPLB$.

level and 1% level respectively). Second, columns (2)-(4) of Table 4 confirm that the effects of current account deficits are more relevant when reserves are low.[22] The results of columns (2)-(3) in Table 4 are worth emphasizing. Note that the coefficient on $NPLY$, β_3, maintains the predicted sign and is statistically significant on its own at the 5% level. This suggests that non-performing loans as a share of GDP — that is, as a measure of the intrinsic fiscal burden — affect the crisis index regardless of whether reserves are low or high.

In Table 5 we present results of regressions equivalent to those in Table 3, again using $NPLY$ instead of $NPLB$. Once again, current account deficits and non-performing loans matter if both reserves and fundamentals are weak.[23] However, observe that the coefficient on $NPLY$ tends to maintain the expected sign and be statistically significant on its own, affecting the crisis index *regardless* of whether reserves are low or high, as well as *regardless* of whether fundamentals are weak or not.[24]

6.3 Real and financial weaknesses

Finally, we attempt to test whether direct measures of capital productivity have explanatory power as regressors of the crisis index. Conventional wisdom holds in that borrowing from abroad is less 'dangerous' for external sustainability if it finances new investment (leading to increased productive capacity and to higher future export receipts) rather than consumption (which implies lower saving). For these reasons, a current account deficit that

[22] The *p-values* on the Wald tests for $\beta_2 + \beta_4 = 0$ are 0.001, 0.002 and 0.016 respectively in columns (2), (3) and (4), under the three different measures of low reserves.

[23] These are the implications of the Wald tests on $\beta_2 + \beta_4 + \beta_6 = 0$ in column (1) and $\beta_3 + \beta_5 + \beta_7 = 0$ in columns (2) and (3). The failure to reject $\beta_2 + \beta_4 + \beta_6 = 0$ in column (3) is again due to multicollinearity between 'CAI times $D2^{LR}$ times D^{WF}' and '$NPLY$ times $D2^{LR}$ times D^{WF}'.

[24] To test for the robustness of our results we perform a number of other tests. First, we use two other indicators of crisis that give more weight to reserve losses relative to exchange rate depreciation; our qualitative results remain the same. As reported in Tables 2-5, the results are also robust to the use of three alternative definitions of low reserves. Next, we test whether the significance of CAI is sensitive to the threshold for the real exchange rate appreciation; instead of a 10% trigger we use a 0 trigger and obtain the same qualitative results. The significance of the two non-performing loans measures $NPLB$ and $NPLY$ is also invariant with respect to modification of the definitions of these variables. All these results are available upon request.

is accompanied by a fall in savings rates is regarded as more problematic than a deficit accompanied by rising investment rates.

Underlying such 'conventional' conclusions, however, is the implicit assumption that the return on investment is at least as high as the cost of the borrowed funds.[25] As evidence on the profitability of the investment projects we employ a standard measure of investment efficiency, the $ICOR$ or 'incremental capital output ratio' defined as the ratio between the investment rate and the output growth rate. In Corsetti, Pesenti and Roubini (1998b), we document that, for all the Asian countries except Indonesia and the Philippines, the $ICOR$ had increased sharply in the 1993-96 period relative to the previous three years 1987-1992. This evidence suggests that the efficiency of investments in South East Asia was already falling in the four years prior to the 1997 crisis.

Here, we derive a measure of the $ICOR$ for all the countries in our sample in the period 1993-1996. We then test for its significance in our basic regression model.[26] We find that the $ICOR$ variable is generally not significant; however, a simple transformation of the $ICOR$ is significant in some regressions. We then define a new variable, $ICORLB$, which is equal to the original $ICOR$ when the lending boom variable is positive, and is equal to zero when the lending boom is negative. The idea here is that low capital profitability is not problematic in itself if the corporate and financial sectors are able to properly assess the characteristics of the investment projects, but may significantly contribute to the build-up of tensions in the financial markets if there is a lending boom and excessive credit growth – perhaps driven by moral hazard and implicit guarantees on investment by the public sector. When we regress the crisis index on the $ICORLB$ variable and $NPLY$ we find that both variables have the expected sign and are statistically signifi-

[25] Also implicit is the assumption that high investment rates contribute to the enhancement of productive capacity in the traded sector. If the investment boom is confined to the non-traded sector (commercial and residential construction, as well as inward-oriented services), in terms of sustainability analysis the contribution of such investment projects to future trade surpluses — thus to the ability of the country to repay its external debt obligations — is limited to their indirect impact on the productivity of the traded sector. The two 'implicit' assumptions above need not hold in the Asian case.

[26] Recall that the $ICOR$ measures the ratio of the share of investment in GDP to the growth rate of output.

cant.[27]

7 Conclusions

The results of our empirical analysis provide evidence in support of the thesis that crises are systematically related to the fundamental weaknesses in the real and financial sectors of the economy. The recent turmoil in Asia does not seem to represent an exception in this respect. External imbalances, as measured by the current account deficits associated with real exchange rate appreciation, are significantly correlated with the crisis index. So are measures of financial fragility (non-performing loans in the presence of a lending boom) and measures of the fiscal costs associated with financial bailouts (non-performing loans as a share of GDP). The effects of these variables on the crisis index are found to be stronger in countries with low reserves.

The empirical analysis presented in this paper is quite preliminary. Yet, it complements other analyses showing the extent of the deterioration of fundamentals in Asia in the years before the crisis. Per se, these results cannot discriminate across alternative explanations of currency crises based on self-fulfilling speculative attacks, as opposed to fundamental factors. They do, however, identify a set of variables that appear to enhance the vulnerability of an economy to a crisis.

The indicator that seems to be more robust in our analysis is the indirect measure of the implicit costs of bailouts in the presence of a financial crisis, *i.e.* non-performing loans before the crisis as a share of GDP. In related work (Corsetti, Pesenti and Roubini (1998a)) we have provided a consistent theory of the role that contingent public debt plays in generating 'twin' financial and currency crises. We interpret the empirical evidence presented in this paper as an indication that this is the right direction to pursue in a comprehensive research agenda on the Asian crisis.

[27] Specifically, our regression yields:

$$IND = \underset{(5.28)}{11.3} - \underset{(0.77)}{2.21}\ NPL3 - \underset{(1.25)}{2.94}\ ICOR2 \qquad R^2 = 0.48$$

Appendix

In this appendix we describe in detail the construction of the variables used in the empirical analysis.

Crisis index (IND)

The index is a weighted average of the percentage rate of exchange rate depreciation relative to the US dollar and the percentage rate of change in foreign reserves between the end of December 1996 and the end of December 1997. A large negative value for IND corresponds to a high devaluation rate and/or a fall in foreign reserves, *i.e.* a more severe currency crisis. All data are from the International Financial Statistics of the International Monetary Fund (IFS-IMF).

Real exchange rate appreciation

This variable measures the percentage rate of change of the real exchange rate between the end of 1996 and an average over the 1988-1990 period. The real exchange rate measure is based on wholesale price indexes, using trade weights of OECD countries (excluding Mexico and Korea). For the three transition economies — Czech Republic, Hungary and Poland — whose real exchange rates exhibit large fluctuations in the early transition years, the appreciation is calculated between 1996 and 1992. For Argentina, whose real exchange rate experienced large swings in the hyperinflation period, the real exchange rate is computed between 1996 and the end of 1990.

Current account deficits and the CAI index

The current account deficit as a share of GDP is an average over the 1994-96 period. Data are from IFS-IMF. The index of current account imbalances CAI is computed as follows: for countries where the real exchange rate appreciated more than 10% over the period defined above, CAI takes the value of the average 1994-96 current account balance (as a share of GDP); for all other countries, CAI is set equal to zero.

Lending boom (LB)

This variable is the rate of growth between 1990 and 1996 of the ratio between the claims on the private sector of the deposit money banks (line 22d in IFS-IMF) and nominal GDP. All data are from IFS-IMF. In the case of transition economies whereas either data since 1990 are not available or the ratio is very unstable in the early transition years, we take 1992 (rather than 1990) as the starting date.

Non-performing loans as a share of total bank assets (NPL).

As there are no homogeneous series for non-performing loans, we need to

build our dataset relying on several sources. For most of the Asian countries in our sample (Korea, Indonesia, Hong Kong, Taiwan, Malaysia, Thailand) there are two available estimates of NPL in 1996; one from the 1997 BIS Annual Report, the other from Jardine Fleming. Both estimates are biased: the former underestimates non-performing loans before the onset of the crisis (for instance, the end-of-1996 figure for Korea is 0.8%); the latter is based on data from the third quarter of 1997, when non-performing loans are already reflecting the consequences of the currency crises on the financial conditions of banks and corporate firms (for instance, Korean non-performing loans are estimated to be 16%). We take the average of the two figures as a reasonable estimate of the non-performing loans before the onset of the crisis, *i.e.* end 1996-early 1997. For the remaining countries, we proceed as follows: for India, Argentina, Brazil, Chile, Colombia, Mexico, Peru, Venezuela we use the estimates for 1996 in the BIS 1997 Annual Report. For China, Singapore and the Philippines, we use estimates from Jardine Fleming. For the other countries in the sample, we rely on information derived from IMF country reports. It is worth emphasizing that our estimates do not appear to be systematically biased towards the countries that suffered a crisis in 1997. Note in fact that non-crisis countries such as Mexico, China, India and Pakistan all show a very large fraction of non-performing loans (over 10% of total loans).

Fiscal cost of the bailout of the banking system as a share of GDP ($NPLY$)

This variable is computed as follows. We take the estimate of the non-performing loans as a share of bank assets (NPL) derived above and we multiply it by the ratio of claims on the private sector by deposit money banks at the end of 1996 to GDP. The latter variable is computed from IFS-IMF data.

The NPLB index

In deriving $NPLB$, we interact the lending boom variable with the non-performing loans variable: for countries where the sign of the lending boom variable is positive, we set $NPLB$ equal to NPL; for countries with a negative lending boom, we set $NPLB$ equal to zero.

Reserve adequacy ratios

We compute three ratios for reserve adequacy at the end of 1996. The first is the ratio of $M1$ to foreign exchange reserves ($M1/RES$); the second is the ratio of $M2$ to foreign reserves ($M2/RES$); the third is the ratio of the foreign debt service burden (*i.e.* short-term foreign debt plus interest payments on foreign debt) to foreign reserves (STD/RES). Foreign exchange reserve data are from the IFS-IMF (line 1l.d). Data on short term debt and

interest payments on foreign debt are from Datastream.

Taiwan

Taiwan is not included in the IMF data base. Our data for Taiwan are from Datastream and rely on Taiwan national data sources.

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Table 1. Crisis and Economic Indicators
Percentage or percentage change

Country	*Crisis Index (IND)*	*Real Appreciation (RER)*	*Current Account (CA)*	*Lending Boom (LB)*	*Non-Performing Loans (NPL)*	*Reserves Adequacy (M2/RES)*	*Reserves Adequacy (M1/RES)*	*Reserves Adequacy (STD/RES)*
Argentina	4.9	38.6	-1.9	16.5	9.4	351.0	108.2	147.8
Brazil	-0.5	75.8	-2.0	-26.3	5.8	345.9	66.8	78.3
Chile	-1.4	37.5	-1.7	24.1	1.0	188.2	41.9	53.3
China	7.6	4.9	0.8	6.9	14.0	828.9	334.0	26.7
Columbia	-9.1	26.6	-5.0	35.0	4.6	209.4	104.3	73.9
Czech	-19.5	50.7	-4.4	22.7	12.0	356.9	139.5	42.9
Hong Kong	5.7	31.8	-1.6	25.5	3.4	411.9	34.2	20.0
Hungary	-1.6	-38.8	-6.5	-56.5	3.2	167.1	83.3	52.3
India	5.7	-29.1	-1.2	-2.3	17.3	860.0	296.5	37.2
Indonesia	-38.3	17.5	-2.9	9.6	12.9	614.8	114.3	188.9
Jordan	9.8	6.1	-4.5	1.4	6.0	437.8	141.4	33.9
Korea	-38.6	11.1	-2.5	11.2	8.4	665.4	147.6	217.0
Malaysia	-38.8	19.9	-6.4	31.1	9.9	364.8	115.6	45.3
Mexico	10.9	8.9	-2.7	-10.9	12.5	444.8	129.3	142.9
Pakistan	11.4	-2.0	-5.3	-3.7	17.5	3369.9	1822.8	399.0
Peru	0.7	-20.4	-6.2	177.2	5.1	123.6	32.4	61.6
Philippines	-29.8	38.9	-4.6	150.8	14.0	465.6	91.8	849.3
Poland	3.5	30.0	0.9	38.5	6.0	262.3	95.9	14.2
Singapore	-15.7	4.7	16.5	16.7	4.0	103.5	25.0	20.0
Sri Lanka	-1.0	17.7	-5.7	28.4	5.0	236.4	72.9	26.8
Taiwan	-11.4	-7.0	2.9	43.4	3.9	575.1	141.0	22.8
Thailand	-47.8	20.0	-7.2	58.0	13.3	380.5	43.3	121.5
Turkey	4.3	-16.1	-0.1	43.2	0.8	302.6	48.9	76.0
Venezuela	4.9	2.2	6.8	-51.5	3.8	102.4	58.5	28.2

Table 2. Explaining the Crisis Index[a]

Estimated coefficient and summary statistic	*Independent variable*	*(1)*	*(2)* *Regression with M2/RES*	*(3)* *Regression with M1/RES*	*(4)* *Regression with STD2/RES*
β_1	constant	6.877	7.073	7.437	5.324
		(3.755)	(4.094)	(3.956)	(3.552)
β_2	*CAI*	3.768	0.849	2.210	0.569
		(1.254)	(2.869)	(3.677)	(1.971)
β_3	*NPLB*	-1.338	-2.888	-2.805	-0.476
		(0.605)	(2.073)	(1.946)	(0.782)
β_4	$CAI \times D2^{LR}$		3.613		
			(3.191)		
β_5	$NPLB \times D2^{LR}$		1.761		
			(2.035)		
β_4	$CAI \times D1^{LR}$			1.467	
				(3.982)	
β_5	$NPLB \times D1^{LR}$			1.534	
				(1.929)	
β_4	$CAI \times D3^{LR}$				3.571
					(2.564)
β_5	$NPLB \times D3^{LR}$				-0.864
					(0.986)
Summary statistic					
$\overline{R}^2$		0.555	0.541	0.536	0.622
R^2		0.594	0.621	0.616	0.688
Addendum: Wald tests					
Null hypothesis		*p values*	*p values*	*p values*	*p values*
$\beta_2 + \beta_4 = 0$			0.005	0.018	0.023
$\beta_3 + \beta_5 = 0$			0.099	0.057	0.091

[a] The dependent variable is the crisis index, *IND*. See Table 1 and Appendix for definition of variables. Standard errors are shown in parentheses.

Table 3. Explaining the Crisis Index[a]

Estimated coefficient and summary statistic	*Independent Variable*	(1)	(2)	(3)
β_1	constant	-2.861	5.535	5.602
		(2.138)	(3.887)	(4.082)
β_2	*CAI*	0.841	0.762	0.766
		(2.946)	(2.694)	(2.771)
β_3	*NPLB*	-1.338	-2.569	-2.583
		(0.605)	(1.954)	(2.017)
β_4	$CAI \times D2^{LR}$	2.851	1.118	1.559
		(6.650)	(3.274)	(6.293)
β_5	$NPLB \times D2^{LR}$	1.769	2.448	2.446
		(2.091)	(1.945)	(2.000)
β_6	$CAI \times D2^{LR} \times D^{WF}$	0.834		-0.497
		(6.337)		(6.004)
β_7	$NPLB \times D2^{LR} \times D^{WF}$		-2.120	-2.131
			(1.123)	(1.164)
Summary statistic				
$\overline{R}^2$		0.516	0.596	0.572
R^2		0.621	0.684	0.683
Addendum: Wald tests				
Null hypothesis		*p values*	*p values*	*p values*
$\beta_2 + \beta_4 = 0$		0.547	0.337	0.688
$\beta_2 + \beta_4 + \beta_6 = 0$		0.009		0.388
$\beta_3 + \beta_5 = 0$		0.146	0.883	0.875
$\beta_3 + \beta_5 + \beta_7 = 0$			0.017	0.026

[a] The dependent variable is the crisis index, *IND*. See Table 1 and Appendix for definition of variables. Standard errors are shown in parentheses.

Table 4. Explaining the Crisis Index[a]

Estimated coefficient And summary Statistic	*Independent variable*		(1) *Regression with M2/RES*	(2) *Regression with M1/RES*	(3) *Regression with STD2/RES*
β_1	constant	6.682	8.142	6.289	5.491
		(3.699)	(3.951)	(3.789)	(3.492)
β_2	*CAI*	4.156	2.288	-1.402	0.845
		(1.158)	(2.394)	(4.511)	(1.963)
β_3	*NPLY*	-1.630	-6.579	-4.817	-0.597
		(0.724)	(3.263)	(2.419)	(0.874)
β_4	$CAI \times D2^{LR}$		2.594		
			(2.657)		
β_5	$NPLY \times D2^{LR}$		5.133		
			(3.170)		
β_4	$CAI \times D1^{LR}$			5.760	
				(4.660)	
β_5	$NPLY \times D1^{LR}$			3.481	
				(2.497)	
β_4	$CAI \times D3^{LR}$				3.487
					(2.530)
β_5	$NPLY \times D3^{LR}$				-1.185
					(1.248)
Summary statistic					
$\bar{R}^2$		0.558	0.578	0.634	0.618
R^2		0.596	0.651	0.557	0.684
Addendum: Wald tests					
Null hypothesis		*p values*	*p values*	*p values*	*p values*
$\beta_2 + \beta_4 = 0$			0.001	0.002	0.016
$\beta_3 + \beta_5 = 0$			0.074	0.105	0.107

[a] The dependent variable is the crisis index, *IND*. See Table 1 and Appendix for definition of variables. Standard errors are shown in parentheses.

Table 5. Explaining the Crisis Index[a]

Estimated coefficient and summary statistic	*Independent variable*	(1)	(2)	(3)
β_1	constant	9.060	3.754	3.677
		(4.233)	(2.731)	(3.026)
β_2	*CAI*	2.438	1.570	1.557
		(2.439)	(1.577)	(1.633)
β_3	*NPLY*	-6.912	-4.985	-4.957
		(3.347)	(2.164)	(2.263)
β_4	$CAI \times D2^{LR}$	-7.295	-2.753	-2.085
		(14.900)	(2.033)	(9.972)
β_5	$NPLY \times D2^{LR}$	5.425	5.287	5.267
		(3.246)	(2.081)	(2.160)
β_6	$CAI \times D2^{LR} \times D^{WF}$	9.905		-0.685
		(14.676)		(10.005)
β_7	$NPLY \times D2^{LR} \times D^{WF}$		-5.420	-5.436
			(1.060)	(1.117)
Summary statistic				
$\overline{R}^2$		0.566	0.818	0.808
R^2		0.660	0.858	0.858
Addendum: Wald tests				
Null hypothesis		*p values*	*p values*	*p values*
$\beta_2 + \beta_4 = 0$		0.741	0.424	0.957
$\beta_2 + \beta_4 + \beta_6 = 0$		0.001		0.633
$\beta_3 + \beta_5 = 0$		0.073	0.626	0.445
$\beta_3 + \beta_5 + \beta_7 = 0$			0.000	0.000

[a] The dependent variable is the crisis index, *IND1*. See table 1 and Appendix for definition of variables. Standard errors are shown in parentheses.