Currency Crisis Models and Speculative Attacks

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1. Currency Crisis Models and the Problem of Contagion

1-1. Theoretical Introduction

Most leading indicator models or warning systems employ economic theory to guide them in the selection of the indicators to be included. At this point, the literature is sufficiently rich in theories on the causes of currency crises to separate them into first- and second-generation models.

First-generation models focused on imbalances in macroeconomic fundamentals, often citing the role of excessive public-sector deficits. The seminal paper in the first-generation category is that of Krugman[1]. In his model, under a fixed exchange rate regime, domestic credit expansion in excess of money demand growth leads to a gradual but persistent loss of international reserves and ultimately to a speculative attack on the currency. This suggests that expanding money supply to finance fiscal deficits may cause excessive credit growth, which in turn brings pressure to bear on a currency in a fixed exchange rate regime, and eventually causes its collapse. Variables like the fiscal deficit and the monetary base grow faster and beyond a certain size before a crisis. A number of papers have extended Krugman's basic model to suggest that the evolution of the real exchange rate, the trade or current account balance and domestic interest rates could be used as leading indicators of crises.

While the traditional approach stresses the role played by declining international reserves in triggering the collapse of a fixed exchange rate, some recent

1) Paul Krugman, "A model of balance-of-payments crises", Journal of Money, Credit, and Banking, vol. 11, No. 3 (August 1979), pp. 311–325.

models have suggested that the decision to abandon the parity may stem from the authorities' concern about the evolution of other key economic variables. For example, the presence of banking problems reflected in the relative price of bank stocks, the proportion of non-performing loans, central bank credit to banks or a large decline in deposits could also indicate the high likelihood of a crisis. Leading indicators may also include political variables.

Second-generation models allow the possibility of crises even though an economy does not suffer continuous deterioration in its economic fundamentals. These models underscore the role of expectations of economic agents in a crisis. Some of these models introduce the concepts of herding behaviour and contagion effects. In herding behaviour, "information costs may lead foreign investors to take decisions based on limited information and therefore to be more sensitive to rumours"[2]. Further, as financial markets are now much more interrelated than they were a decade ago, individual investors now have many more ways to cover risks, and losses in one market may force liquidations in others. Thus, a loss by investors in country A may cause them to liquidate in country B (or a set of countries B, C etc.), possibly triggering a crisis, if not at least putting some stress on the financial system of country B. These models have the unpleasant implication that crises arising in financial markets are likely to be unpredictable; if a crisis can occur in a country even without poor fundamentals, then it will not be reflected in its usual macroeconomic variables since it is merely guilty by association.

There are three variants of the contagion effects hypothesis[3]. The first hypoth-

2) Gerardo Esquivel and Felipe Larrain, "Explaining currency crises", Development Discussion Paper, No. 666 (Massachusetts, Harvard Institute for International Development, November 1998).

3) There may be several reasons for expecting crises to be contemporaneous in time. See, for example, the discussion in Paul R. Masson, "Contagion: monsoonal effects, spillovers, and jumps between multiple equilibria", *IMF Working Paper*, No. 142 (Washington DC, 1998).

esizes that trade links may be the channel through which attacks on one currency are transmitted to another. If a country's competitor in exports suffers a devaluation of the currency, then the country itself may also suffer a currency attack owing to the perceived need to maintain export competitiveness with the other country. It has been found that the greater the correlations of export shares, the greater is the tendency of these countries' currencies to depreciate by more or less the same amount.

The second channel of contagion is related to financial market linkages. There is a demonstration effect on the part of borrowers; when domestic borrowers saw what was happening in other Asian countries where the exchange rate peg had given way they tried to cover themselves to avoid the same fate. This only served to increase the downward pressure on their own currencies. Another financial channel saw the crisis spread through the action of international lenders; heavy losses in one market by retail investors forced liquidation in several markets. It is still typical for investors to calculate historical correlations between rates of return on investments in different countries; high correlations would thus lead to immediate selling of all investments should one of them come under pressure.

A third variant relates to a common cause. For instance, policies undertaken by industrial countries may have similar effects on emerging markets. An interest rate increase in the United States may decrease the attractiveness of several other markets at the same time, leading to a sudden and unexpected outflow of short-term capital, which is highly sensitive to interest rate differentials, or a change in tax rates in a developed country may affect the savings behaviour and so the size and composition of international capital flows.

These theories of contagion provide important reasons why the empirical relationship between economic data and the occurrence of crises is likely to be imperfect.

1-2. Recent empirical studies

Most recent empirical studies on early warning systems follow one of the three models outlined in this chapter: the signals approach, probit or logit models, and regression models. A few additional studies belonging to each category are described briefly below.

(a) Signals approach

Work by Lawrence Lau and Jung-Soo Park[4] (which preceded that of Salvatore) sought to identify signals of fundamental vulnerability in selected Asian countries similar to those which existed in the economy of Mexico prior to the Mexican crisis. This work was initially carried out in September 1995 and is therefore certainly a prescient one. Selected economic indicators for China; Hong Kong, China; Indonesia; Malaysia; Philippines; Republic of Korea; Singapore; Taiwan Province of China; and Thailand were compared with those of Mexico. The paper itself provides sparse details on the authors' criteria for determining whether the indicators are at problematic levels, that is, sufficiently similar to Mexico.

Most of the countries that were later hit by the Asian crisis were found to have several of the following commonalities with Mexico (though not necessarily all at the same time): falling real exchange rates; low or lowered rate of growth of real GDP; high relative rate of inflation; high interest rate differential; rising interest rate differential; high real rate of interest; large negative trade balance; large negative current account balance; and high ratio of foreign portfolio to foreign direct investment.

(b) Probit or logit models

A study by Dongchul Cho and Kiseok Hong[5] examined the cause of the Asian

4) Lawrence J. Lau and Jung-Soo Park, "Is there a next Mexico in East Asia?", paper presented at the project LINK World Meeting, Pretoria, South Africa, 25–29 September 1995.

5) Dongchul Cho and Kiseok Hong, "The Asian currency crisis: domestic fundamentals and international linkage", Working Paper (Korea Development Institute, August 1999).

crisis empirically. The study first identified the general causes of a currency crisis using a comprehensive data set, and then applied the result to the Asian case. The study then compared various international linkages of currency crises with each other and determined which one was most relevant.

The study used a probit equation that related crisis episodes to standard macroeconomic fundamentals along with various contagion measures to determine which variables were most significant. The dependant variable for probit estimation was a crisis index, which took the value 1 if a currency crisis occurred and 0 otherwise. A currency crisis was defined as a depreciation of the nominal exchange rate of at least 25 per cent, which was also at least a 10 per cent historical increase in the rate of depreciation for the country. Three sets of variables were used in the model: (i) macroeconomic indicators: GDP growth rate, real domestic credit growth rate, inflation rate, fiscal deficit/GDP ratio; (ii) external variables: current account/GDP ratio, changes in the terms of trade, changes in the real exchange rate, foreign reserves/short-term debt ratio, FDI/GDP ratio, total foreign debt/GDP ratio, short-term debt/total foreign debt ratio; and (iii) foreign conditions: GDP growth rate, interest rate in developed countries, crisis incidents of foreign countries. Data covered 103 developing countries, including the crisis-hit Asian and Latin American countries, for the years 1980 through 1996.

The results of the estimation suggested that in general a country might undergo a currency crisis even when its domestic fundamentals were not particularly weak. The contagion of crises was found to take place most often among countries that were in geographical proximity; economic linkages such as international trade and finance turned out to be insignificant once geographical proximity was taken into account. This pattern of contagion implied that intra regional cooperation was critical in preventing future currency crises.

A study by Daniel Hardy and Ceyla Pazarbasioglu[6] used a multinomial logit model to identify the role of the macroeconomic, banking sector and real sector indicators in the emergence of banking system difficulties. The data sample covered 50 countries, 38 of which suffered a total of 43 episodes of banking system crisis and comprised 323 observations for the period 1980–1997. Three groups of explanatory variables were used: real-sector variables (rate of growth, consumption growth, investment growth and capital-output ratio); banking-sector variables (deposit liabilities, credit to private sector, and foreign gross liabilities); and potential shocks (inflation, real interest rate, real exchange rate, real growth in imports and terms of trade).

The empirical findings suggested that banking distress was associated with a fall in real GDP growth, boom-bust cycles in inflation, rapid credit expansion, rapidly increasing capital inflows, rising interest rates, a declining capital/output ratio, and a sharp reduction in real exchange rates with an adverse trade shock. The paper also found that in Asian countries, variables such as credit growth and rising foreign liabilities, which were proxies for vulnerability of the banking and corporate sector, were more important than traditional macroeconomic indicators. This suggests that the construction of early warning systems should not focus solely on macroeconomic indicators. In fact, this seems to have been the story of the Asian crisis: everyone was preoccupied with the "nice" macroeconomic picture but missed seeing the weaknesses at the micro level, for example, banking system flaws.

(c) Regression models

Kaminsky and Schmukler[7] conducted a regression analysis to determine the

6) Daniel C. Hardy and Ceyla Pazarbasioglu, "Leading indicators of banking crises: was Asia different?", IMF Working Paper, No. 91 (Washington DC, June 1998).

7) G.L. Kaminsky, and S.L. Schmukler, "What triggers market jitters? A chronicle of the Asian crisis", World Bank Working Paper (April 1999).

reaction of financial markets to news - either rumours or fundamentals - in crisis episodes. The test was conducted for the Asian crisis for the period beginning in 1997 until the end of 1998. Nine economies were included: Hong Kong, China; Indonesia; Japan; Malaysia; Philippines; Republic of Korea; Singapore; Taiwan Province of China; and Thailand. The analysis concentrated on the 20 largest one-day swings in stock prices.

The results indicated that the source of the largest one-day swings could not be explained by any apparent substantial news - either economic or political - but seemed to be driven by herd instincts of the market itself. The results also indicated that rumours, or concerns unrelated to the actual information, affected foreign markets as strongly as they affected domestic financial markets, suggesting the presence of important contagion effects. There was also some evidence that investors overall reacted instantaneously and more strongly to bad news than to good news.

Dadush, Riordan and Wolfe[8] used a regression model to identify the main sources of error in World Bank forecasts completed at the end of 1997. Recognizing that the evolution of a crisis was inherently impossible to anticipate with accuracy, the authors sought to draw some lessons for macroeconomic modelling and prediction which might improve the understanding of the forces at work.

Analysis of forecast errors was carried out for GDP growth, domestic demand, private consumption, total investment, exports, imports and current account balance. The substantial forecast errors for these variables were attributed to four factors: a failure to appreciate fully the interactions of foreign credit with the domestic banking sector and highly indebted domestic firms; underestimation of the extent of spillover effects within the region; inadequate forecast of the decline in regional import volumes and in prices of traded goods induced in part by the

8) U. Dadush, M. Riordan, and B. Wolfe, "Some lessons from forecasting errors in the recent crisis", Development Prospects Group (World Bank, May 1999).

downturn in regional activity; and failure to anticipate the depth of the continued recession in Japan.

The study suggested that in the light of the foregoing, the following lessons can be drawn: (i) more careful and frequent monitoring of balance-sheet effects is called for, particularly for the accumulation of short-term foreign currency liabilities in the banking system and changes in corporate leverage; (ii) in determining the severity of a crisis, it is clear that expectations matter; the light of this, investors ought to hedge their exposures; (iii) since the advent of contagion is an important factor, analysis and forecasting of developments should be conducted in a regional or global context; (iv) forecasting models should incorporate interactions between the banking and non-financial corporate sectors; and (v) in the projection of the effects of external stocks, there is a need to account for the special nature of developing countries as marginally creditworthy borrowers.

To conclude, although each of the above models does make some contribution to understanding the causes of crises and contagion, none of them can accurately predict the timing of a crisis. Hence, these models have a useful but limited role in formulating an early warning system.

2. An Alternative Approach to Fiscal Deficits and Currency Crisis

(Accounting Model of Currency Crisis)

2-1 Introduction

The alternative approach to fiscal deficits and currency crisis has been proposed by Homi Kharas and Deepak Mishra. They proposed an alternative approach to measure fiscal balance of a country, they call it the actuarial budget deficit, which is easy to estimate, includes all levels of government, comparable across countries and differs from 'augmented budget deficit' in three ways:
First, they include all expenses, including financial assistance for bank restructuring and other capital account transactions, which directly affect the government's

stock of liabilities as part of budget deficit;

Second, they calculate the deficit for a more broader definition of government which includes central bank and public corporations (where available);

Finally, they use econometric techniques to demonstrate that the actuarial deficit better proxies the fiscal situation of a country than the conventional deficit, especially when the country in question is experiencing financial crises. The quantitative difference between the two measures of deficit will be referred to as the hidden deficit.

If occurrence of currency crises are affected by the size of current and future government liabilities, then over a long time horizon (say 15–20 years), countries with more currency crises should be observed to have higher average deficits. They subject this hypothesis to a number of tests using data from nearly 30 developing and developed countries, including five East Asian countries, for the period from 1980–1998 and make the following observations:

1 In developing countries, the reported budget deficits do not accurately reflect the actual change in total government liabilities. The same is however not true for developed countries like the United States.

2 Budget deficits or surpluses constitute only a small portion of the changes in total government liabilities. Contribution of other factors like realization of contingent liabilities, changes in exchange rates, domestic prices, and quasi-fiscal costs on government liabilities sometimes exceed the contribution of budget deficit to the debt.

3 The size of the hidden deficit is found to be systematically linked to currency crises. It tends to increase around crisis periods and decrease in the tranquil periods.

4 The results from cross-country regressions suggest that the increase in average implied deficit is strongly associated with higher number of successful speculative attacks. No such relationship is found to exist between the

size of average conventional budget deficit and number of currency crises. Kharas and Mishra make three important points. First, the association between budget deficits (properly defined and estimated) and currency crises has not been made completely invalid by recent currency crises. Second, the actuarial deficits reflect the fiscal situation of an economy much more accurately than the conventional deficits. The hidden deficits are large and do not necessarily vanish even when averaged over a long period of time. Third, having a small budget deficit or surplus is only one part of a successful public debt management strategy; others include, timely provision for contingent liabilities, minimization of the effect of cross-currency valuations, avoidance of large quasi-fiscal cost through sterilization, financial bail-outs and so on.

Their method to estimate budget deficit is easy to compute, encompasses all levels of government, and is amenable to cross-country comparison. By advocating that the total current liabilities of all public sector entities, whether they are in the form of cash, loan or bond transfer be included in their totality and contemporaneously in the budget, it removes some of the incentive on part of the developing countries' governments to indulge in any sort of creative accounting and sleight of hand. Although the proposed actuarial deficit is shown to provide a more accurate fiscal position of a country than its counterpart, conventional deficit, it suffers from some of the same limitations as the 'augmented deficit' proposed by Daniel, Davis and Wolfe (1997). For example, it does not capture the fiscal impact of future changes in macroeconomic conditions. Further, their measure of deficit is based on gross liabilities and not on net liabilities of the government, although whether this aspect should be interpreted as a limitation is debatable[9].

9) Inclusion of government assets into budget accounting is extremely difficult as price information on many of these assets is simply not available and the assets themselves are not liquid enough. For example, while official reserves of Bank of Korea were ↗

2-2 Operational Definition of Hidden Deficits in the Accounting Approach to Currency Crisis

In this approach the flow and stock definition of deficits are clearly distinguished. The estimation of the actuarial deficit is rather simple if one has access to data on public sector debt. The total stock of outstanding foreign and domestic public sector debt (central government + central bank + public corporations, where available) for each country (source: GDF for external and GFS, IFS and WDI for domestic debt respectively) is estimated and then the actuarial deficit in period t is computed as the change in the stock of public sector debt plus the change in the stock of base money between period t and t-1.

The actuarial deficit is then decomposed into various components to find how much of it is attributable to price fluctuations, real growth, seignorage revenue, conventional budget deficits and a residual component (the extra-budgetary expenses). Theoretically speaking, the two definitions should yield similar numbers. But since budget flows do not distinguish between current and capital accounts, measures of surplus and deficits may be inconsistent with changes in the real value of net debt. Capital transactions, gains and losses in the capital account arising from fluctuations in relative prices (real exchange rate, domestic inflation, change in cross-currency exchange rate) are excluded from budgetary accounts even when they affect the total stock of government debt. Further, many financial and corporate restructuring and realized contingent claims are sometimes excluded from budget deficit even when they contribute to a rise in government's liabilities.

Fiscal impacts of sterilization of capital inflows and other quasi-fiscal costs are

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↘ reported to be $24 billion by early December 1998, 'usable' reserves were reported to be only $6 billion. The discrepancy arose as a result of foreign currency deposits being placed by Bank of Korea with foreign branches of domestic banks that became illiquid. [Ref: Box 2.5, page 20, International Capital Markets, IMF, Sept 1998].

sometimes categorized as capital account expenditures and thus excluded from the flow definition of budget deficit. Thus the actuarial deficit, which is estimated from the total stock of government's liabilities is expected to be different from the conventional cash flow accounting of budget deficit.

In order to demonstrate that the actuarial and conventional deficits are in fact different for developing countries, we conduct a very simple exercise. We plot in Figure 1, the actual debt-output ratio along with the debt-output ratio that is implied from past reported budget deficits and seignorage revenue. Specifically, the implied debt is obtained as,

$$B_t^i = B_{t-1}^i - (H_t - H_{t-1}) + D_t; \quad \text{and} \quad B_o^i = B_o^a$$

where B_t^i and B_t^a are the stock of implied and actual debt in period t respectively, H_t is the stock of high powered money, D_t is the reported deficit (in this terminology conventional deficit) and all variables are expressed in local currency unit. The two sides are divided by the nominal output to get the debt-output ratio. The implied debt-output ratio is set as equal to the actual in the first year, i.e. in period 0, which is 1979 in most countries. If countries in fact do not have large extra-budgetary expenses and the capital gains and looses are relatively small in magnitude, then the difference between actual and implied debt-output ratio will be small. The difference between the two lines is the hidden liabilities that the government has accumulated overtime. The change in the hidden liabilities is the hidden deficits.

In Kharas/Mishra model while for United States and to a certain extend in Sweden the implied and actual debt-output ratio tracks quite closely one another, the story is lot different in the four developingcountries. For Indonesia and Philippines, the difference between actual and implied isenormous and there is little sign of convergence (The picture is not too different in the other 3 East Asian countries, namely Malaysia, Korea and Thailand). In Argentina, there appears to be some mild convergence, especially after the big surge in the actual-debt ratio

during 1988–89. In Mexico the convergence is almost complete, although interestingly it is one of the few countries where the actual debt-output ratio is invariably smaller than the implied debt-output ratio (part of it may be because of debt forgiveness, use of privatization revenue and IMF funds to amortize foreign currency debt). Dooley (1999) conducts a similar exercise as done above and comes to the same conclusion that there is a wide deviation between stock of debt and the accumulated deficits, which he calls the 'alligator's mouth'.

3. Three Strategies to Prevent Currency Crisis

There are at least three policy strategies that are thought to be possible measures to prevent a currency crisis. Krugman called two of them the "benign neglect" strategy and the "Caesal's wife" strategy (Krugman 1998a: 150–151). The remaining one is a restriction on capital movements.

The benign neglect strategy is one in which the monetary authority doesn't commit to any exchange rate targeting, leaving the exchange rate to fluctuate with the market. Naturally, the exchange rate continues to fluctuate as long as expectations and the circumstances surrounding the market continue to change. As proponents of flexible exchange rates represented by Friedman used to stress, however, these exchange rate fluctuations must be distinguished from a currency crisis it occurs in fixed exchange rate regimes. The latter is not a reflection of a fluctuation inherent in the market, but rather a consequence of the efforts made by a monetary authority to contain this fluctuation.

To understand why currency crises do not occur under the flexible exchange rate system, we should remember how difficult it is for speculators to obtain foreign exchange gains under a free float. If a monetary authority made no intervention in the foreign exchange market, and the exchange rates were left to fluctuate, any new information and the accompanying shifts in expectations would be immediately reflected in current exchange rates. Suppose that, for example, the

unemployment rate were rising in a country, and that the monetary authority was sure to execute expansionary monetary policy to reduce it. If this information suddenly appeared, the exchange rate would begin to depreciate, and would continue to do so until most speculators regarded it as sufficiently lowered. If new information is always reflected in current exchange rates in this manner, it would be almost impossible for speculators to predict with certainty the direction of subsequent exchange rate movements. In this sense, allowing exchange rates to fluctuate is by itself the most potent safeguard against speculative attack and a currency crisis.

In contrast, the pegged exchange rate regime is always characterized by successions of two completely different phases, the calm period of no exchange rate fluctuation and a devastating period of sudden downfall. The pegged exchange rate system has many variations that differ slightly from each other. Usually this system of exchange rate pegging has some margins within which exchange rates can fluctuate. These are called "exchange rate bands." The Exchange Rate Mechanism (ERM) of the European Monetary System (EMS) before the European Currency Crises is an example of this system. Countries that later became victims of speculative attacks, for example Latin America countries, East Asian countries, and Russia, adopted a similar arrangement in principle, although the currency to which their national currencies were pegged was usually the US dollar. However, exchange rate bands differed country by country.

In such settings, two scenarios may emerge according to whether the commitment of each country to its particular exchange rate band is credible or not. If the commitment of a monetary authority to defend its exchange rate is sufficiently credible, the country can enjoy what Eichengreen calls a "target zone honeymoon" (Eichengreen 1994: 18). If this commitment becomes suspect, however, the target zone honeymoon may be replaced by a "target zone divorce" (Eichengreen 1994: 20).

In a "honeymoon" situation, market forces usually operate as a self-stabilizing automatic mechanism to ensure the exchange rate remains in the band. Suppose that there were no suspicion about the capability and the intention of a monetary authority to stay within the exchange rate band. Then people would anticipate that the slightest deviation of exchange rates over the band would be immediately corrected. This anticipation itself would urge speculators to make currency transactions that would move the exchange rate into the band. In this situation, therefore, we may imagine that maintaining exchange rate targeting becomes possible even without any intervention.

On the contrary, once suspicion arises over the capability and the intention of a monetary authority to maintain the exchange rate, the situation is turned into a "divorce". Suppose again that the unemployment rate rises, and that the monetary authority wants to execute expansionary monetary policy so as to reduce it. In this case, however, we should remember that a policy of expanding the money supply and a policy of maintaining the exchange rate target are in conflict with each other. Therefore, if the monetary authority prefers to reduce unemployment and perform monetary expansion, its only choice would be to abandon its exchange rate targeting, and to allow it to depreciate in the market. Then speculators would be sure to engage in speculative attacks on the currency before its actual depreciation, since they can easily foresee that it will depreciate sooner or later. Once a speculative attack begins, no country can escape from enormous capital outflows and the rapid reduction of foreign exchange reserves. If the monetary authority wants to defend the exchange rate target of its currency after the beginning of the speculative attack, the only measures available would be to raise interest rates and contract the money supply. Once a speculative attack begins, therefore, the monetary authority must take policy measures that are completely contrary to its original intention, and thus the cost of maintaining the exchange rate target increases even more. This additional cost helps to make currency cri-

ses "self-fulfilling".

This consideration necessarily leads to the next policy strategy to prevent currency crises. If a country wants to reduce a risk of inviting a speculative attack, but does not want to abandon exchange rate pegging, it must make its commitment to the peg credible. This is what Krugman calls the Caesal's wife strategy. An example of this is the Dutch policy of pegging the guilder to the German mark, whose commitment in this case is so credible that no one tries to attack the guilder. The ultimate implementation of this strategy is, of course, currency unification through monetary union as is actually taking place in the EU.

The last strategy to prevent currency crises is the well-known one of regulating capital movements. As argued in the previous section, a speculative attack is just like an option in which speculators make deals with the monetary authority. Therefore, speculators' incentives to attack a currency may be somewhat suppressed by increasing the option price, which is the cost of currency transactions in this case. A device such as the "Tobin tax" may be interpreted as an intentional attempt to increase this cost.

4. Currency Attack Modelling – An Introduction

Transparency and the optimal way to disclose central bank information are among the main topics within the current discussion on financial architecture. Speculative attacks and market overreactions are often interpreted as evidence for systemic indeterminacy and instability. Recent theories attribute these instabilities to self-fulfilling beliefs caused by public information and suggest that stability can be increased by more sophisticated schemes of information disclosure.

Obstfeld (1996) models speculative attacks as a coordination game with strategic complementarities and common knowledge (public information) about fundamentals among traders. The expected payoff to speculating on devaluation depends positively on the amount of capital that follows the same strategy: A

central bank pegs the exchange rate of its currency to some other currency or currency basket. A realignment is associated with fixed costs. Economic decisions by private agents depend on their expectations about future exchange rates. Agents who expect a devaluation sell the currency, they "attack" as we say. This increases supply and thereby raises costs for the central bank to maintain the peg. If a sufficient number of traders expects a devaluation, market pressure may raise costs of maintaining the peg above the costs of realignment. Here, the central bank devaluates its currency and traders' expectations are correct. If traders expect the exchange rate to hold, they do not sell the currency. Market pressure is lower and the rate can be sustained as expected. The model has multiple equilibria with self-fulfilling beliefs and attacks are unpredictable.

Applying the global games approach of Carlsson and van Damme (1993a,b), Morris and Shin (1998, 1999) have shown that there may be a unique equilibrium if traders have private instead of public information on the reactions of the central bank. A global game embeds a coordination game with strategic complementarities in a stochastic environment, where the true game is selected randomly out of a class of possible games with differences in the payoff function. Players get private signals on the true game, but lack knowledge of other players' signals. Private information lets different traders hold different beliefs about payoffs and reduces the degree of common knowledge that is responsible for multiplicity of equilibria. Morris and Shin (1999) and Hellwig (2000) observed, when agents get both, public and private information, uniqueness requires private information to be sufficiently precise compared to public information. This has triggered a discussion on optimal mechanisms to release information to financial markets in order to prevent crises with self-fulfilling features.

Applications of global games have been used to explain speculative attacks (Morris and Shin, 1998), bank runs (Goldstein and Pauzner, 2000), liquidity crises (Morris and Shin, 2001; Hubert and Schlier, 2001) and competition for order

flow (Dodges and Heinemann, 2001). One line of theoretical research concentrates on the impact that different modes of releasing information have on uniqueness versus multiplicity of equilibria and thereby on stability of financial markets. Heinemann and Illing (1999) showed that the probability of speculative attacks is reduced when precision of private information is increased. Metz (2001) observed that precisions of public and private information may have opposing effects on the probability of crises. While policy makers often claim that a more transparent policy increases financial stability , these results raise doubts by academic researchers who emphasize the endogeneity of default risks and the sensitivity with respect to the modes of information disclosure (Danielson et al. 2001).

A different kind of modelling procedure that imitates the game structure of the speculative attack models by Obstfeld (1996) and Morris and Shin (1998) has been proposed by Corsetti. He compared sessions with public and private information. In all sessions, subjects used threshold strategies, i.e. attacked whenever the fundamental state or signal was beyond some critical state or signal. These critical values were surprisingly stable within a session and their variance across sessions was the same for both information conditions. His evidence suggests that there is no difference in predictability that could be related to self-fulfilling features of the game with public information. For practical purposes, the interpretation of multiple equilibria as an indication of a destabilizing effect of public information is not warranted.

The main differences in behavior between the two treatments are that with public information, subjects rapidly coordinated on thresholds, attacked more successfully and achieved higher payoffs than with private information. In the model's interpretation this means that a commitment to provide public information increases the prior probability of devaluation. He concluded that transparency of the central bank may increase the probability of speculative attacks, and

it does not reduce their predictability.

Bhatti and al (2002) use the experiment to test the predictive power of various refinement concepts. In the game with public information, different refinement criteria select different critical states (thresholds) beyond which attacks occur. In all sessions with public information he observed that subjects coordinated on thresholds somewhere between those associated with payoff dominant and risk dominant equilibrium. Observed thresholds are never close to the one associated with maximin strategies. Using treatments with different parameters, we observe that thresholds depend on exogenous parameters as predicted by comparative statics of the risk dominant equilibrium and by the theory of global games, even though we can reject their numerical predictions. In sessions with public information, observed strategies can be explained by independent beliefs on other subjects attacking with a given (estimated) probability.

Previous experiments on coordination games with strategic complementarities carried out by Van Huyck, Battaglio and Beil (1990, 1991) have shown that with perfect information subjects coordinate rather quickly on an equilibrium between maximin strategies and payoff dominant equilibrium. Efficiency depends on group size and experience. While groups of two players coordinate on the payoff dominant equilibrium even in unfavorable set-ups, groups of 14 to 16 players reach the payoff dominant equilibrium only after experiencing efficient coordination in other treatments. Cabrales, Nagel and Armenter (2002) tested the global game approach by Carlson and Van Damme (1993a) comparing treatments with either common (=public) or private information about payoffs. They found no significant difference in behavior between the two information scenarios. In both cases subjects converged to the equilibrium of the private information game, which (in their experiment) coincides with maximin strategies and with the risk dominant equilibrium.

Speculative attacks are sometimes triggered without warning, and without any

apparent change in the economic fundamentals. Commentators who have attempted to explain episodes of speculative crises have pointed to the self-fulfilling nature of the belief in an imminent speculative attack. That is, if speculators believe that a currency will come under attack, their actions in anticipation of this attack precipitate the crisis itself, while if they believe that a currency is not in danger of imminent attack, their inaction spares the currency from attack, thereby vindicating their initial beliefs.

However, merely pointing to the self-fulfilling nature of beliefs leaves open a number of crucial questions. First, such an account leaves unexplained the actual onset of a currency crisis when it occurs. By most accounts, both the ERM and the Mexican peso were "ripe" for attack for a long time before the crises that brought them down - at least two years in Europe and perhaps a year in Mexico. At any point in those periods, concerted selling by speculators would have raised the costs of maintaining the exchange rate sufficiently high that the abandonment of the parity would have been forced on the monetary authorities. Once they were abandoned even temporarily, governments would not have had the incentives to restore the pre-crisis parities. Thus attacks would have created profits. Why did the attacks not happen sooner? Conventional accounts have been forced to resort to forces which operate outside the theoretical model in trying to explain the shift of expectations which precipitated the attack. Some of these informal accounts are more persuasive than others, but none can be fully compelling as a theoretical model of the onset of a currency crisis.

Secondly, merely pointing to the self-fulfilling nature of beliefs in a speculative attack leaves open the policy issues associated with curbing speculative attacks. For example, it is often argued that increased capital mobility induced by lower transaction costs increases the likelihood of currency crises, and that judicious 'throwing of sand' into the excessively well-oiled wheels of international finance will play a role in curbing speculative attacks. However, an account

which merely points to the self-fulfilling nature of beliefs of a speculative crisis cannot contribute to this debate, since the question of how such beliefs are determined is beyond the scope of such an account. Any argument for or against such a proposal has to resort to forces outside the formal theory.

Corsetti and Mackowiak[10] argue in their paper that the apparent multiplicity of equilibria associated with self-fulfilling beliefs is the consequence of assuming too simple a picture of the role played by information in a speculative episode. Although market participants each have a window on to the world, the imperfect nature of such a vantage point generates a failure of common knowledge of the fundamentals. Thus, everyone may know that the fundamentals are sound, but it may not be that everyone knows that everyone knows this. Still higher orders of such uncertainty may be relevant. Uncertainty concerning other participants' beliefs are crucial to a speculative episode, since the onset of a speculative attack relies to a large extent on the coordinated attack of a currency by speculators.

They propose a more realistic modelling of the information structure underlying speculative situations which enables us to pinpoint the forces which determine the onset of a speculative attack. We do this by eliminating the apparently arbitrary dependence of the market outcome on the initial beliefs of the market participants. Moreover, we can say something about how this unique outcome depends on the parameters of the problem, such as the costs of speculation, the underlying 'strength' of the underlying economy, and the size of the pool of 'hot money' in circulation.

Information plays a very subtle role in speculative crises. What is important in staving off currency attacks is not the amount of information made available to the market, per se, but rather how public and transparent this information is. If

10) Corsetti, G. and Mackowiak, B. 2001. 'Nominal Debt and the Dynamics of Currency Crises'. CEPR Discussion Paper no. 2929. London, Centre for Economic Policy Research.

market participants are well informed about the fundamentals, but they are unsure of the information received by other participants, and hence unsure of the beliefs held by others, speculative attacks may be triggered even though everyone knows that the fundamentals are sound. The analysis highlights the importance of the transparency of the conduct of monetary policy and its dissemination to the public. If it is the case that the onset of currency crises may be precipitated by higher order beliefs, even though participants believe that the fundamentals are sound, then the policy instruments which will stabilize the market are those which aim to restore transparency to the situation, in an attempt to restore common knowledge of the fundamentals.

The most effective means towards this would be a prominent public announcement which is commonly known to convey information to all relevant participants. The canonical case of a communication arrangement which would be conducive to achieving common knowledge is the 'town hall meeting' in which an announcement is made to an audience gathered in a single room, where everyone can observe that all other participants are in an identical position. In contrast, if the audience is fragmented, and must communicate in small groups, common knowledge is extremely difficult to achieve. In short, we believe that the crucial factor in preventing speculative attacks is the timely and effective dissemination of information on the part of policy makers, and the smooth functioning of a reliable and transparent set of communication channels between market participants and the policy makers, as well as between the market participants themselves.

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