IMF Working Paper

WP/97/164 INTERNATIONAL MONETARY FUND

Research Department

Speculative Attacks, Forward Market Intervention and the Classic Bear Squeeze

Prepared by Subir Lall[1]

Authorized for distribution by Donald J. Mathieson

December 1997

Abstract

A typical strategy used by speculators to launch an attack on a fixed exchange regime is the use of forward markets. Central banks also intervene in forward markets to counter speculation. This paper addresses the question of how an attack is launched on the forward market, and what the optimal policy response to such speculation is in the forward and spot markets. The paper also demonstrates how central banks can impose a bear squeeze on speculators. Recent events in South East Asian currency markets are interpreted within the framework of the model's predictions.

JEL Classification Numbers: E44, F31, G12, G13, G15, G20

Keywords: Speculative Attacks, Forward Markets, Exchange Rates, Market Corners.

Author's E-Mail Address: slall@imf.org

[1]I would like to thank Peter Garber for insightful discussions. I would also like to thank Donald Mathieson, Bankim Chadha and Timothy Bond for valuable comments. The discussion of recent events in currency markets in this paper is based solely on anecdotal evidence, press reports, and conversations with market participants.

SUMMARY

This paper analyzes the role of the forward market in the mounting of a speculative attack on a fixed exchange rate regime and in its defense by the central bank. It discusses both the mechanics and the economics of such an attack and of the defensive strategy, and the implications for speculators, the domestic banking system, and the central bank. The paper also analyzes the conditions for the imposition of a bear squeeze on short sellers in the foreign exchange market, and analyzes recent events in Asian currency markets to draw inferences.

Forward markets are one of the primary channels for speculators to attack a fixed exchange rate regime as well as for central banks to defend the exchange rate. An optimal intervention strategy for a central bank averse to the imposition of a classic interest rate defense—due to the effect of the defense on the domestic banking system and the real economy—is to use the forward market to buy the domestic currency, but only up to the limit of its own net nonborrowed foreign exchange reserves. To limit the capital losses resulting from forward market intervention, intervention should be switched to the spot market and accompanied by interest rate increases once net nonborrowed reserves have been committed in the forward market.

Central banks can impose a classic bear squeeze on speculative short sellers in the foreign exchange market if they have sufficient power in the market for domestic credit. This can be done through a set of exchange and capital controls that is implemented through the domestic banking system and allows the central bank to corner the market in domestic credit. However, evidence suggests that such a bear squeeze is not successful in the long run in defending the exchange rate regime.

I. Introduction

In an era of increasingly mobile capital flows, speculative attacks on exchange rate regimes have become frequent and at times spectacular[2]. In the literature on international finance, the interest in speculative attacks and exchange rate crises has led to the development of a considerable body of literature which analyzes such phenomena[3]. The seminal models developed by Krugman (1979) and Flood and Garber (1984) analyze how domestic credit policies inconsistent with a fixed exchange rate regime lead to speculative attacks and the collapse of the exchange rate regime. This basic framework has been extended in several directions such as through the incorporation of uncertainty (e.g., Flood and Garber (1984), Grilli (1986)) , different assumptions on the post-collapse exchange rate (e.g., Blanco and Garber (1986), Dornbusch (1987), Obstfeld (1984)) and the presence of imperfect asset substitutability and sticky prices (e.g., Willman (1988)). There have also been models analyzing policy options to avoid the collapse of an exchange rate regime and the effects of imposing controls (e.g., Wyplosz (1986)). Other models have attempted to address empirical issues such as the fundamental causes of speculative attacks (e.g., Kaminsky, Lizondo and Reinhart (1997) and Kaminsky and Reinhart (1996)) and the effectiveness of balance-of-payments rescue packages in preventing crises (Fernandez-Arias (1996)).

A relatively new strand of the literature has focused on the micro-structure of foreign exchange and financial markets and the roles they play in the end-game scenario of a speculative attack (see Lall (1994), Garber and Spencer (1995), Garber and Lall (forthcoming)). This branch of the literature seeks to analyze issues that the existing literature has not satisfactorily addressed, in particular many of the phenomena associated with recent exchange rate crises and the optimal policy responses of the defenders of the exchange rate regime. For instance, the traditional literature did not shed light on financial operations that take place in an exchange rate crisis and the precise roles played by central banks, commercial banks and speculators. The institutional structure of financial markets is crucial to understanding aspects of exchange rate crises that the traditional literature has failed to explain satisfactorily.

In the traditional literature, for example, Obstfeld (1986) suggests that unlimited official external borrowing would be able to sustain a fixed exchange rate regime indefinitely as long as the government's intertemporal budget constraint is not violated. While correct in theory, the design of the Very Short Term Financing Facility (VSTFF) of the EMS does allow for unlimited financing of intervention at the margin of the exchange rate band whenever currencies come under attack. But events since September 1992 have established that even the

---

[2] In the last few years, several well documented attacks have taken place, with varying results, such as in the United Kingdom, Sweden, Spain, France (all in 1992) and Mexico (1994). More recently, in 1997, speculative attacks have taken place in the Czech Republic and Thailand.

[3]Agenor, Bhandari and Flood (1992) and Blackburn and Sola (1993) provide surveys of recent developments in the analysis of speculative attacks and exchange rate crises.

existence of the VSTFF (and its facility for joint and unlimited intervention) has been unable to deter speculative pressure and prevent the collapse of the exchange rate regime. It has emerged that central banks do face limits on the amount of financing they can access on any given day, although they may be able to borrow larger amounts across time.

This paper attempts to fill this gap in the literature on speculative attacks by incorporating the mechanics of speculative attacks and the institutional structure of foreign exchange markets. In particular, this paper presents a stylized model of how an attack is launched through forward markets, how financial market prices and volumes evolve as a result, and what the optimal central bank response is to such speculation. The paper also determines the necessary conditions for a classic bear squeeze—reminiscent of market corners and bear squeezes in commodity and securities markets—to be successful. In the context of the South East Asian currency crisis in the summer of 1997, this paper discusses how the imposition of capital controls—and the fact that the central bank is the ultimate provider of credit in a currency crisis—can create an environment with asset price movements in foreign exchange markets consistent with an implied bear squeeze on short sellers.

This paper models the micro-level behavior of the three main classes of participants in an exchange rate crisis, namely, speculators, commercial banks, and the central bank. Speculators are any agents in the market who believe that the current exchange rate regime will collapse in the near future and so take short positions against the currency.[4] Commercial banks are important because they are the market-makers in the foreign exchange market and supply liquidity through their presence. Central banks follow the objectives of maintaining exchange rate and interest rate targets, as well as maintaining the soundness of the banking financial system by—among other means—being a lender of the last resort and preventing systemic banking crises.

The analytical section of this paper separately models the behavior of each of the above-mentioned three classes of market participants. It divides the trading day in foreign exchange markets into two parts. The first part is the period involving short position-taking transactions between speculators and commercial banks, and the second part is the period wherein the central bank intervenes in the foreign exchange markets. Speculation in foreign exchange markets involves considerable uncertainty regarding the possible future policy actions of the central bank, and the behavior of speculators and commercial banks is conditioned on the expected response of the central bank. The asynchronization of trading activities of speculators and central banks in the forex market highlights the role that banks play by providing liquidity—defined as immediacy of transactions—to market participants. The role of banks in transmitting an attack to the central bank, while at the same time fulfilling their market-making roles and minimizing their own foreign exchange open position, is underlined by the asynchronized nature of foreign exchange market operations.

---

[4]In analytical terms, agents wishing to hedge their foreign exchange short positions (such as on account of import payables or external debt service payments) would undertake similar strategies.

The model first formulates the demand function for forward contracts by speculators wishing to take short positions against the currency. This transaction will take place in the first period of the day. However, since the actual outcome in the first period—determined by the interaction between commercial banks and speculators—is conditioned on the expected behavior of the central bank in the following period, the optimal behavior of the central bank in the second period is then developed in the model. Finally, the behavior of commercial banks—who are active in both periods unlike speculators and the central bank—is determined, which is dependent on the explicitly determined expected central bank response in the second period. Equilibrium in the foreign exchange markets, in terms of the actual trades between all classes of agents, and the determination of prices and volumes, is then derived within the model.

The paper, by examining the strategies of speculators, commercial banks and the central banks, determines the sources of inefficiencies in an exchange rate crisis. By examining how the bid-ask spread in forward contracts are determined, and how speculative activity affects the spread, the paper analyzes the illiquidities in the forward markets that emerge in an exchange rate crisis. The paper also develops the optimal activities of central banks in intervening in the forward and spot markets, in order to best achieve their multiple objectives and to allow foreign exchange markets to continue trading in an orderly manner. In particular, the model determines bounds on the level of forward market intervention, the amount of spot and swap market activity of the central bank, and the interest rate policy of the central bank. This paper also endogenizes the path that domestic credit must follow to maintain the fixed exchange rate regime, and to optimize the trade-off between interest rate changes and capital losses of the central bank.

An application of the model is in the examination of bear squeezes. Bear traders in a typical asset market are those market agents who believe that the price of the asset is expected to decline, and hence sell the asset short i.e., sell by borrowing it rather than owning it, hoping to profit from the decline in prices. As the price declines over the period of their short position, they are able to close out their short position at a lower market price and make a profit. Other market participants may try to manipulate upwards the price of the asset being sold short, in the process imposing losses on the bear traders. Bear squeezes are market operations wherein one market participant takes a large net long position on an asset, and hence causes the rest of the market to have a net short position with respect to that commodity or asset, and then manipulates the price of the asset upwards.[5] This cornering of the market is, however, only possible if the party wishing to impose a squeeze has a significant control on the stock of the

---

[5]The history of securities markets is replete with episodes of markets corners and short squeezes. In October 1907, for example, a syndicate in New York attempted to corner the stock in a copper company. In response to the failed corner, the demand for liquidity increased and J.P. Morgan was able to implement a bear squeeze in the cash market on those short sellers attempting to access liquidity. See Garber and Weisbrod (1992) for an analytical treatment of market corners and Jordan and Jordan (1996) for a 1991 episode of a market corner in the U.S. Treasury market.

short asset, so as to be able to demand higher prices from short sellers needing the asset to close out their positions. In that sense, the squeezers need to be able to have control of both the demand and supply of the asset. In foreign exchange markets, speculators betting on a decline of the currency and taking short forward positions are bear traders, and the central bank wishing to maintain the fixed exchange rate regime may attempt to squeeze the bear traders by cornering the market in the weak currency. Applying the analytical framework of this paper to bear squeezes, the model determines the conditions under which—and the mechanics of how—the central bank can successully defend its currency by implementing a bear squeeze on speculators who are attempting to engineer a collapse of the exchange rate regime. Looking at reports of central bank intervention used in the currency turmoil in South East Asia, [6]and the movement of exchange and interest rates consistent with the predictions of this model, the paper suggests that the exchange rate defense employed by the Bank of Thailand, using a combination of forward market intervention and controls on capital movements and exchange, created movements in asset prices in the foreign exchange market that is analogous to an implied environment of a bear squeeze on short sellers in securities markets, for a brief period of time.

The paper is structured as follows. Section 2 briefly discusses the role of speculators, commercial banks and central banks in the foreign exchange market and the alternative forms that speculative activity can take. The instruments available to central banks for intervening in the foreign exchange market are also described. Section 3 explicitly models the behavior of speculators and derives a demand function for forward contracts by speculators. Section 4 models the behavior of central banks and commercial banks. Section 5 examines the equilibrium in the foreign exchange market and the implications thereof in a generalized environment with no capital controls.[7] Section 6 extends the model to discuss techniques and policy implications of a market corner against bear raiders by the central banks, with an illustration using the South East Asian case of May, 1997. Section 7 offers conclusions.

II. FORMS OF SPECULATIVE POSITION-TAKING

In a speculative attack, when agents believe that a currency will be devalued in the near future, the strategy followed, to hedge against this currency or to speculate against it, is to go short in the currency.[8] Once the exchange rate is abandoned, a profit can be realized by unwinding the short position at the new (cheaper) post-collapse rate.

---

[6] Reports include Reuters and other press reports, communication with market participants, and analyst reports.

[7]The model is derived from Lall (1994) which develops the approach to speculative attacks with forward markets in a monetary model of exchange rate determination.

[8] In an exchange rate crisis, taking short positions may be part of hedging activities or may be simply speculation for profit. Both activities imply taking an open position in currencies but the distinction between speculation and hedging may be somewhat blurred.

The most common form of speculative position-taking is by means of forward contracts.[9] This is an off-balance sheet item for banks, and whenever speculators see a deviation of the market forward rate from their expectation of the future spot rate, they buy forward contracts to deliver the weak currency in the future. Banks, as market-makers, will be the counterparty to such position-taking. However, banks—due to prudential regulations imposed on them and/or their risk-aversion—try to offset the currency and maturity mismatches acquired as a result of their market-making activities. They balance their currency and maturity positions by writing off-setting forward contracts (real or synthetic) with other counterparties, but since the banking system as a whole attempts to do the same, the ultimate counterparty is the central bank as it is the only market participant willing to buy the weak currency in the future. Given certain expectations of the extent of central bank intervention—and hence banks' ability to balance their positions—banks limit their positions with speculators.

An alternative form of position-taking is by borrowing the weak domestic currency, selling it for the strong currency, and placing the funds in a bank deposit. If the domestic currency then depreciates, the speculator can unwind the position and make a profit. This set of transactions is on-balance sheet, and therefore requires the use of bank reserves. It is therefore inherently more expensive than an off-balance sheet item such as forward contracts. This strategy is therefore less preferred and is only undertaken once forward markets have been saturated.

For holders of domestic-currency denominated assets, a third form of speculation is to switch to foreign denominated assets until the currency has collapsed, and then switch back to the domestic currency assets. Such liquidation of positions has been known to have occurred in the EMS crisis of 1992 (IMF (1993), pp.42-43), but this is not pure speculation to the extent that such actions are taken by agents already holding assets in the domestic currency.

In summary, it is known that the primary form of position-taking in a speculative attack is through forward markets. On-balance-sheet strategies become important if the forward markets dry up, as such strategies are costlier.

Central banks can intervene in the forward markets or in the spot markets. If net forward positions taken by the speculators and the banking system against the currency are exactly matched by an equal number of off-setting forward contracts offered by the central bank, then all positions cancel each other out and there is no need for spot intervention. If, however, the central bank does not intervene fully in the forward market, then activity spills over to the spot market and the central bank will have to undertake sterilized spot market intervention to balance the net short positions taken against its currency.[10]

III. The Behavior of Speculators

As described in the previous section, speculators typically take short positions in a currency facing possible devaluation by entering into forward contracts for the sale of such currency.

---

[9]See, for instance, IMF (1993).

[10]These concepts are developed analytically in Section 6.

This is an off-balance sheet transaction which is preferred by speculators to on-balance sheet position-taking such as holding the strong currency by borrowing and selling he weak currency. Speculators typically enter into relatively long-dated forward contracts (e.g., 30 days) for delivery of the currency under attack. For purposes of this paper, one defines a speculator to be any agent who takes a short position against a currency when it is expected to be devalued. Whether this agent is doing so for hedging or pure speculative profit is not distinguished in terms of this model.

To examine the determination of equilibrium between speculators and their counter-parties (commercial banks), the demand function for forward contracts by speculators first needs to be specified. Let

$f_{t,i} \equiv$ the bid forward rate at time t for contracts maturing at t+i

$Q_{t,i} \equiv$ the number of contracts entered into by the speculator at time t for contracts maturing at t+i (in units of foreign currency)

$e_{t+i} \equiv$ the expected spot exchange rate at time t+i

Both the spot and the forward rate are given in terms of the domestic price of one unit of foreign currency. Expected profits of speculators in entering into $Q_{t,i}$ number of forward contracts at time t are given by:

$$E[\pi_{spec}(t)] = (e_{t+i} - f_{t,i})Q_{t,i} \tag{1}$$

If speculators observe that $e_{t+i} > f_{t,i}$, i.e., the future expected spot rate is higher [11] than the current market forward rate,[12] then they demand an infinite number of forward contracts to maximize their profits. If $e_{t+i} < f_{t,i}$, i.e., the future spot rate is lower, then their demand for forward contracts is zero.[13] The demand function of profit-maximizing speculators for forward contracts can then be represented as:

[11]Higher expected spot rate, in terms of the definition used in this paper, implies that the domestic currency price of unit foreign currency has *increased.*

[12]The market forward rate means the bid-rate at which speculators can write forward contracts to deliver the weak currency to the commercial banking system.

[13]e_{t+i} will be determined explicitly in Section 6, but the derivation has no bearing on the results of this section.

$$Q_{t,i}(d) = \begin{cases} \infty & \text{if } e_{t+i} > f_{t,i} \\ 0 & \text{if } e_{t+i} < f_{t,i} \\ [0,\infty) & \text{if } e_{t+i} = f_{t,i} \end{cases} \tag{2}$$

If the expected collapse of the current exchange rate regime is driven by an expansionary domestic credit policy (see Krugman (1979) and Flood and Garber (1984), for instance), then it is arguable that the currency will continue to depreciate after the collapse because of steadily expanding domestic credit.[14] The exchange rate expectations in a currency crisis can be characterized, without loss of generality, as:

$$e_{t+i''} > e_{t+i'} \tag{3}$$

for $i'' > i'$.

The implications of this assumption will become clear in the computation of equilibrium between banks and speculators.

IV. The Behavior of Commercial Banks and the Central Bank

A. The Role of the Commercial Banking System

Commercial banks, by virtue of their mandate and the regulations imposed upon them, act in a risk-averse manner when dealing in the foreign-exchange market. As market-makers, they enter into the opposite side of forward contracts engaged in by speculators, subject of course to the condition that it is profitable for them to do so. This creates a short position for them in the strong currency and a long position in the weak currency. Being risk-averse, they balance their currency and maturity mismatches by taking offsetting positions and not holding open overnight positions. During an exchange rate crisis, market agents outside the banking system are not willing to enter into contracts with commercial banks by taking short positions in the strong currency. Commercial banks, if they are counterparties to speculators, will thus have difficulty in balancing their own positions. It is at this point that central banks intervene if they do not want to forward rate to depart from the spot rate they are defending, and they are the agents who take positions to correct the banking system's imbalance in forward contracts. Central banks can also intervene in the spot market by taking off-setting positions to the commercial banks' simultaneous spot and swap transactions.[15]

[14]This is an assumption often made in the speculative attack literature.

[15] A currency swap consists of a spot transaction resulting in the exchange of two principals (continued...)

The expectation of central bank action in the forward and spot markets to maintain the exchange rate is a key determinant in the banks' willingness to provide contracts to speculators. If commercial banks are not able to enter into offsetting forward contracts with the central bank, they move to the spot market. A net short position in the strong currency in the forward market is balanced by a spot sale of the weak currency to counter the currency mismatch, and a swap transaction, to counter the maturity mismatch. The domestic currency required for spot delivery is usually financed through borrowing at the discount window. This is so because in a currency crisis, lenders of the weak currency are very few. Commercial banks would therefore be forced to borrow at the discount window. If the central bank does not then intervene in the spot market, having failed to do so in the forward market, this triggers downward pressure on the spot exchange rate and causes the immediate collapse of the exchange rate.

To demonstrate the linkage between the discount rate and the implied forward rate, suppose that the discount rate that applies to a loan to borrow domestic currency from the central bank is r_t. Thus, if a commercial bank delivers $\bar{e}$ units of domestic currency for one unit of foreign currency in the spot sale, it will then have to borrow $\bar{e}$ at the discount window. Through a swap, it then acquires an equivalent amount of domestic currency. The swap transaction will be reversed in i days from now and it will get back $1+r^*$ units of foreign currency and it will have to deliver $\bar{e}(1+r_t)$ units of domestic currency as r_t is the equivalent domestic interest rate. Thus, the implied forward rate, from the open leg of the swap transaction, is given by:

$$f_{t,i}^{+} \equiv \bar{e}\frac{1+r_t}{1+r^*} \tag{4}$$

As shown above, the implied forward discount increases as the discount rate r_t rises.

---

[15](...continued)
and an offsetting reverse transaction some time in the future. A swap transaction by itself does not, therefore, imply an open position in a currency. However, if it is combined with an independent spot transaction in the opposite direction, there is a net delivery of currency forward and a net open position. In this sense, a spot and a swap transaction can be used simultaneously to create a synthetic forward contract. Figure 1 illustrates this point.

Figure 1: Creation of Synthetic Forward Contracts using Spots and Swaps

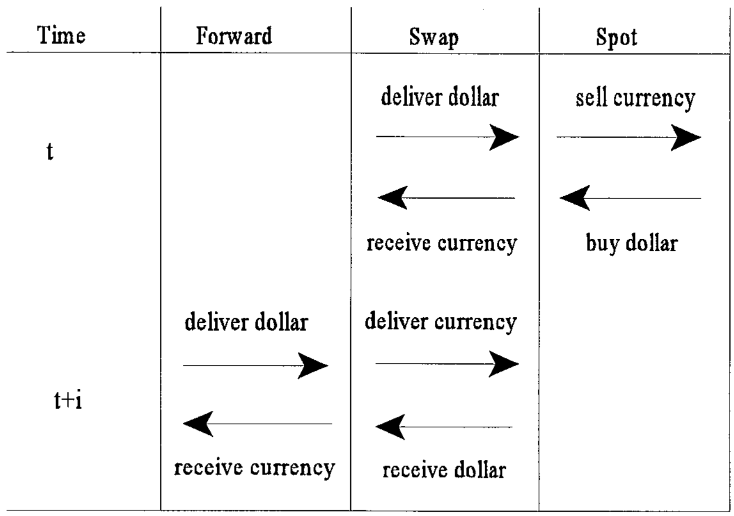
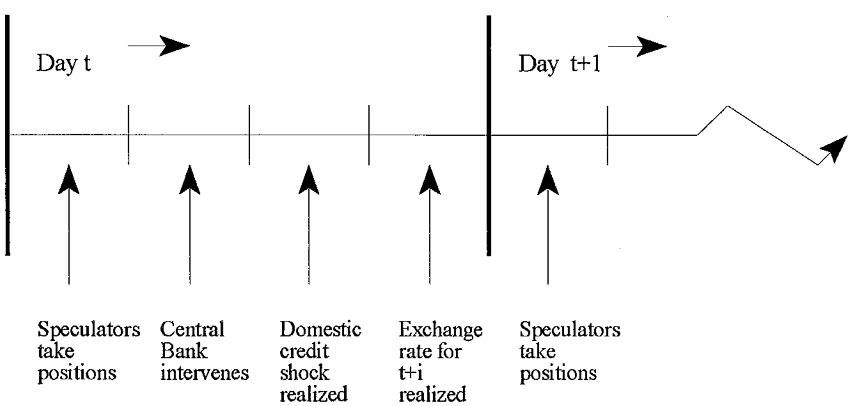


Figure 2: The Sequence of Events



Since commercial banks interact with speculators and then with the central bank, their optimal behavior with speculators is dependent upon their expectation of central bank action. This paper models the interaction between banks and other market players as a sequential process. Commercial banks offer forward contracts to speculators based upon the expectation that central banks will intervene in the foreign exchange market. However, because the reserve levels and credit lines available to central banks are not known to other market participants, this expectation is imprecise.

Commercial banks try to minimize the risk they face of not being able to balance their forward positions because central bank intervention is not adequate. If the exact amount of central bank intervention were known, then commercial banks would offer an exactly equal amount of contracts to speculators and take no currency or interest rate risk. Since, however, the exact amount of central bank intervention is not known, banks will limit the amount of contracts as the extent of expected central bank intervention becomes smaller. The lower the expected central bank intervention, the smaller will be the volume transacted in the retail forward market before the market is saturated.

A spot sale of domestic currency and a swap of foreign currency for domestic currency with the same maturity as the original forward contract is essentially the creation of a synthetic forward contract, as was explained above. However, a spot sale of domestic currency by a commercial bank exerts downward pressure on the spot rate because there are few buyers of a failing currency in the spot market. The central bank will thus have to become a buyer in the spot market if it wants to maintain the spot exchange rate. The spot sale by commercial banks is financed by borrowing at the discount window, in a crisis, because few other parties would be willing to lend the weak currency. If the central bank has an interest rate policy, then it will supply domestic funds at this ceiling rate, which it will then be forced to buy spot. In this sense, it is fueling an attack on its own currency which will deplete reserves.

Because of the importance of central bank intervention (and the expectation thereof) in the determination of optimal commercial bank behavior, the central bank's policies are examined in the following section.

B. Central Bank Behavior

In this model it is assumed that the central bank has an optimal exchange rate target e and an optimal interest rate target $\bar{r}$, which had been determined jointly at the beginning of the exchange rate regime. The exchange rate target can be viewed as the official parity rate to which the central bank made a commitment prior to the attack. The loss of this target involves a high fixed cost δ. One interpretation for such a fixed cost is that once the decision has been made to let the currency collapse, the credibility of the central bank towards maintaining a fixed exchange rate regime has been destroyed.[16] An optimal interest rate target

[16]In addition, in the case of emerging markets, the devaluation of the currency can increase the domestic currency equivalent of foreign indebtedness of domestic entities, in particular the financial institutions. A devaluation may thus render many financial institutions insolvent or at (continued...)

reflects the central bank's aversion towards high interest rates. High short-term interest rates make the financing of bank positions expensive and reduce the efficiency in the functioning of financial markets[17]. If the structure of financial markets is such that short-term interest rates quickly filter through to other borrowing rates such as mortgages, then the impact of a high interest rate policy has long-term effects on the domestic economy as well.

Central banks are also concerned about capital losses from foreign exchange operations. If central banks have to go short on foreign exchange reserves to intervene, and if there is a subsequent collapse of the currency, then they are taking a capital loss which is directly proportional to the level of their short positions.

C. The Sequence of Events

The trading day n this model is divided into several periods. In the first period, speculators enter into forward contracts with the commercial banking system. In the next period, commercial banks enter into off-setting transactions with the central bank, either through forward contracts or through spot-swap transactions. These off-setting transactions enable commercial banks to balance their currency and maturity mismatches. The model assumes that central banks are able to borrow fully against these known speculative positions, i.e. the lines of credit are large enough to accommodate normal foreign exchange market intervention.

If the total amount of speculation is Q_t and the levels of forward and spot intervention by the central bank are, respectively, X_t and Y_t, then at the point of intervention, $Q_t = X_t + Y_t$. All speculative positions are absorbed by central bank intervention. At this point in the day, once central banks have matched all short positions against the currency, it is assumed that the retail markets for foreign exchange close. Any further foreign exchange market activity can only be undertaken on the next day. However, there is now only a limited credit line available to the central bank against which it can borrow foreign reserves for the rest of the day. If, at this point, there is a shock to the demand for domestic credit which central banks accommodate fully, it will lead to a stochastic increase in the level of domestic credit.[18]

An example of such a shock would be the potential bankruptcy of a large domestic financial institution, which requires the immediate extension of credit by the central bank, causing a

---

[16](...continued)
the least illiquid, and require a costly financial bail-out from the central bank or the authorities. This is one of the important reasons why countries with fragile financial systems wish to avoid a devaluation that may overwhelm the financial system.

[17]This again is related to the fragility of the financial system. Stronger financial systems are better able to withstand increases in interest rates whereas weaker ones will not be able to tolerate interest rate increases. Given the central banks' roles as preserver of an orderly financial system, the central bank's aversion to movements from a target interest rate is directly related to the resilience of the financial system.

[18]Such a stochastic shock to the level of domestic credit was first introduced by Flood and Garber (1984).

discrete rise in the level of domestic credit. Implicit in such a scenario is the readiness of the central bank to absorb such increases in the demand for domestic credit which, if not met, would threaten the stability of the financial sector. The central bank would then have to maintain equilibrium in the demand and supply of money through a sale of foreign reserves. If the central bank faces a limited line of credit at the end of the day for accommodating stochastic shocks to the demand for domestic credit, then it is possible that the exchange rate collapses at this point, because of an expansion in the money supply. This collapse is only effective the next trading day because the foreign exchange markets have closed at the time of the realization of the domestic credit shock. This sequence of events is demonstrated in Figure 2. The underlying assumption here is that while lines of credit are large enough to maintain the current currency regime in the face of exchange market speculation, a very large shock to the demand for domestic credit may cause central banks to exhaust these lines.[19]

D. Foreign Exchange Losses

The central bank intervenes in the forward market to the extent X_t and intervenes in the spot market to the extent Y_t. Forward market intervention is done at the rate $f_o = \bar{e}$ and sterilized spot market intervention is done at an implicit forward rate f_t^+, which is determined by the central bank's interest rate policy[20]. Sterilized spot market intervention is similar to forward intervention for the central bank if it has to borrow reserves for such intervention. This is because it borrows reserves which it will have to return, and it extends domestic credit simultaneously to the commercial banking system. The net result is that it will receive domestic currency and deliver foreign currency in the future. The crucial difference between outright forward intervention and sterilized spot intervention is that central banks can control the implicit forward rate on the latter while the rate on the former is a constant.

If the central bank has to go short on reserves to be able to intervene fully, i.e., if $R_{t-1} - Q_t < 0$, where r_{t-1} is the net level of reserves of the central bank at the beginning of day t, then there is a potential foreign exchange loss. If the amount gone short is contracted at the rate f_o, then the expected losses are:

$$\text{expected foreign exchange losses} = [Q_t - R_{t-1}] \cdot [e_{t+i} - f_o] \tag{5}$$

If the amount gone short is contracted at the rate $f_t^+ > f_o$, then the expected losses are:

[19]While the empirically more relevant constraint may be that a central bank may not, in fact, have access to unlimited lines of credit, the collapse of a fixed exchange rate regime under those circumstances is hardly surprising. One intends to show in this model that even with unlimited access to credit over time, the exchange rate may collapse if central banks may face daily line limits on access to credit.

[20]Forward market intervention is done at the target spot rate because central banks do not want to generate signals about future exchange rate policies. If central banks explicitly sell their own currency forward at a discount, it may affect expectations of speculators adversely and exacerbate an exchange rate crisis.

$$\text{expected foreign exchange losses} = [Q_t - R_{t-1}] \cdot [e_{t+i} - f_t^+] \tag{6}$$

All else being equal, one finds that if the central bank has to go short on reserves, its losses are reduced if it moves to the spot market and increases the implicit forward rate to f_t^+. In summary, whenever the central bank's intervention requires it to go short on reserves, it will engage in sterilized spot intervention at an implicit forward rate which it can determine through its interest rate policy.[21]

E. The Central Bank's Loss Function

This paper models the behavior of central banks in response to a speculative attack and the subsequent equilibrium in a simplifying two period framework. In terms of the notation used in the previous sections, take $i = 1$ so that the forward contracts engaged in at time t are for delivery at time $t + 1$. This specification allows some simple results to be derived which can then be extended to longer dated forward contracts. It is assumed that central banks absorb all the short positions taken against the currency in the current period. Within the context of the foreign exchange market, the operational goal is to absorb all short positions taken by speculators against the currency. However, after the foreign exchange market has closed, the central bank is committed to accommodating those changes in the demand for domestic credit which, if not met, would threaten the stability of financial markets. This may lead to the inability to defend the exchange rate for all future periods causing the central bank to incur the fixed cost δ. Within the framework of this model, the currency collapses after the foreign exchange market has stopped trading on one day and before it opens for trading the next day.

The central bank will try to continuously minimize its loss function. Since the day, from the central bank's point of view, has been split into two distinct periods (the foreign exchange intervention period and the domestic credit intervention period), the central bank will try to optimize its actions in each period. In the foreign exchange intervention stage, it will minimize:[22]

---

[21]The implicit forward rate f_t^+ is linked to the interest rate r_t as follows :

$$f_t^+ = \bar{e}\frac{1+r_t}{1+r^*}$$

[22]If intervention does not require shorting of reserves, the central bank can maintain the exchange rate and interest rate targets without facing foreign exchange losses, and the loss of (continued...)

$$L_t = \beta(r_t - \bar{r})^2 + [X_t + Y_t - R_{t-1}][e_{t+1} - f_t^+] \qquad (7)$$

This assumes that the cost of intervention is always lower than the fixed cost δ of abandoning the regime by not intervening in the foreign exchange market. In this model, the highest level to which the interest rate needs to be raised to eliminate foreign exchange losses altogether is a level $\tilde{r}$ such that

$$f_t^+ = e_{t+1} = \frac{\bar{e}(1+\tilde{r})}{1+r^*}$$

which is some finite level. The loss associated with such a squeeze on borrowing rates will then be $\beta(\tilde{r}-\bar{r})$. The assumption in this model is that:

$$\delta > \beta(\tilde{r}-\bar{r}) \qquad (8)$$

What this implies is that the central bank will never abandon the fixed exchange rate regime unless it runs out of reserves.

In the last period when the central bank is intervening in the domestic credit market, it is assumed that failure to intervene there will have an infinite cost. As a result, those domestic credit shocks which are encapsulated in ε will be fully accommodated even if this results in the loss of the exchange rate target in the next period causing a fixed cost δ to be incurred.

The above specification assumes that while central banks may be able to absorb all positions taken against the home currency in the foreign exchange market (by borrowing unlimited amounts of foreign reserves), they may not be able to finance additional sales of reserves in the foreign exchange market (through an additional line of credit) which a shock in the demand for domestic credit may require. In other words, while known speculative positions against a currency may be financed by borrowing, random fluctuations in demand arising from domestic credit shocks may not be fully offset by borrowing through an additional line of credit. As demonstrated later in this section, the presence of limited lines of credit in the event of stochastic shocks may cause the collapse of a currency effective the next period.

The objectives of the central bank can be summarized as follows:

(1) In the foreign exchange intervention period, it will absorb all short sales of its own currency, i.e. $X_t + Y_t = Q_t$, and minimize the loss function L_t given in (4.7).

---

[22](...continued)
the peg due to a stochastic shock will only cost the fixed amount associated with the loss of the exchange rate target.

(2) In the domestic credit market, it will absorb all changes in the demand for domestic credit at the end of the day (its failure to do so would incur an infinite cost), but this may cause it to lose its exchange rate target for the next period.

While the above assumptions above are somewhat restrictive, they enable us to illustrate the main points of this model in a simple framework. A more complicated framework would not change the results qualitatively.

F. Optimal Central Bank Response to Speculation

In the foreign exchange intervention stage, the central bank will optimize its trade-off between the distaste for interest rate deviations and the expected foreign exchange losses. The central bank takes Q_t as given and intervenes in an amount X_t in the forward market to absorb forward positions against its currency. If it has to go short on reserves, it will move to the spot market and intervene by borrowing reserves through established lines of credit with other central banks or off-shore banks to the extent $Y_t = R_{t-1} - X_t$ (as discussed in the previous subsection). The optimal strategy in this period would be to minimize (7) above, which would lead to the following interest rate policy:

$$r_t = \frac{\bar{e}(Q_t - R_{t-1})}{2\beta(1 + r^*)} + \bar{r} \tag{9}$$

According to this policy function, the extent of the interest rate squeeze is in proportion to the amount by which the central bank has to go short on its reserves. The squeeze is inversely related to the distaste (β) for interest rate deviations from the target. This interest rate squeeze will imply a concomitant squeeze in the level of domestic credit. The extent of this squeeze is determined by the equilibrium of money supply and demand in a fixed exchange rate regime:

$$M_t = M_{t-1} - C_t \tag{10}$$

$$\frac{M_t}{P_t} = a_0 - a_1 r_t \tag{11}$$

where C_t is the decrease in the level of domestic credit required to get to an interest rate as determined in (9) above.

Equation (10) shows that the money stock in period t is the sum of the money stock at the end of period $t-1$ and the decrease in the level of domestic credit consistent with an interest rate r_t (which is determined in (9) above). The domestic price level $P_t = \bar{P}$ which is assumed to be a constant if the exchange rate is fixed at $\bar{e}$. If M_{t-1} was the money stock consistent with the interest rate $\bar{r}$, then domestic credit will be decreased by the amount C_t, which is given by:

$$\begin{aligned} C_t &= M_{t-1} - \bar{P}a_0 + \bar{P}a_1 r_t \\ &= \lambda_0 + \lambda_1 r_t \end{aligned} \tag{12}$$

where

$$\begin{aligned} \lambda_0 &\equiv M_{t-1} - \bar{P}a_0 \\ \lambda_1 &\equiv \bar{P}a_1 \end{aligned}$$

Domestic credit has to be shrunk by C_t as given in (12) to attain the interest rate r_t.

G. Central Bank Response to Domestic Credit Shocks

In the last period of the day, a shock ε to the level of domestic credit demand is realized, which will be fully accommodated by the central bank. However, if there is an increase in the level of domestic credit, the central bank will be forced to make an offsetting sale of reserves in the foreign exchange market, since the expansion of credit creates an excess supply of money at the beginning of the next day. This sale will cause the central bank to draw down the line of credit L_t which is limited. It is possible that the shock ε is larger than the line limit, causing a discrete rise in the money stock which leads to the collapse of the exchange rate regime.

To compute the probability of the collapse of the exchange rate and the exchange rate after a collapse, this paper uses the standard monetary model of the exchange rate. Define the subscript t' to refer to the value of all aggregates in the last period of the day, and $\overset{+}{e}_{t+1}$ as the value of the post-collapse exchange rate. To compute the shadow exchange rate, the system of equations is as follows:

$$M_{t'} = M_t + \varepsilon - L_t \tag{13}$$

$$\frac{M_{t'}}{P_{t'}} = a_0 - a_1 r_t \tag{14}$$

$$\overset{+}{e}_{t+1} = \frac{P_{t'}}{P^*} \tag{15}$$

Equation (13) shows that the change in money stock at the end of the day is the net shock to domestic credit after the whole line-limit has been exhausted in financing the sale of reserves. Equation (14) is the real demand for money and (15) is the purchasing power parity condition. If the exchange rate were to collapse at t', then the central bank will set the interest rate at its target level. The shadow exchange rate is given by:

$$\overset{+}{e}_{t+1} = \frac{M_t + \varepsilon - L_t}{P^*[a_0 - a_1\bar{r}]} \tag{16}$$

The probability of a collapse $\psi(t)$ is the probability that the shadow exchange rate is greater than the fixed rate:

$$\psi(t) = Pr[\frac{M_t + \varepsilon - L_t}{\lambda_2} > \bar{e}] \tag{17}$$

where

$$\lambda_2 = P^* \cdot [a_0 - a_1\bar{r}]$$

The probability function (17) can be rewritten as :

$$\psi(t) = Pr[\varepsilon > L_t] \tag{18}$$

The probability of the collapse of the exchange rate regime is simply the probability that the random shock to the demand for domestic credit is greater than the access to financing that the central bank has on that day. The expectation at time t of the exchange rate at $t+1$ will then be given by:

$$e_{t+1} = (1-\psi(t)) \cdot \bar{e} + \psi(t) \cdot \overset{+}{e}_{t+1} \tag{19}$$

where $\overset{+}{e}_{t+1}$ is given in (16) above.

H. Optimal Commercial Bank Behavior

Assume that banks are risk-averse agents. To model their behavior, a general form of the utility function is chosen where the absolute risk-aversion of the agent is given by a parameter a. Banks are assumed to maximize a utility function of the form:

$$U(W) = -e^{-aW}$$

where

$W \equiv$ the market-making revenue (wealth) generated by the bank
$a \equiv$ the absolute risk-aversion of the bank

In this formulation,

$$E[U(W)] = -e^{-a[\mu - \frac{1}{2}a\sigma^2]}$$

where μ and σ^2 are the first and second moments of the wealth function and $E[\cdot]$ is the expectations operator.

The wealth of the commercial bank is a function of the number of contracts that the commercial bank can unwind through outright forwards and the number of contracts it has to unwind via spot and swap combinations. The outright forwards are unwound at the rate f_o $(=\bar{e})$ and the spot-swap combinations are unwound at the rate $f^{+}_{t,i}$ [23].

In subsection 4.5, it has been shown that the central bank will offer outright forwards up to the level of its non-borrowed reserves. Commercial banks have an expectation of the level of these non-borrowed reserves but do not know the precise level because this information is not publicly revealed by the central bank. The level of reserves R_{t-1} is treated as a random variable from the point of view of the banking system. The commercial banks know the first and second moments of this random variable. The variance of R_{t-1} is a measure of the degree of imprecision of information that the banks have on the level of reserves. A higher variance would imply that banks know less about the exact level of reserves. This will have important implications for the equilibrium outcome in the foreign exchange market.

---

[23]Central banks intervene in the forward market at the official spot rate, because any other rate would be perceived by the market as a signal of future monetary policy and may therefore jeopardize the credibility of the monetary regime.

If X_t is the amount of forward market intervention, then $E[X_t] = E[R_{t-1}]$. The wealth of the commercial bank is then:

$$W = [f_{t,i} - \bar{e}] \cdot R_{t-1} + [f_{t,i} - f_{t,i}^{+}] \cdot [Q_{t,i} - R_{t-1}] \tag{20}$$

where $f_{t,i}$ is the rate at which commercial banks write contracts with speculators. As seen from the section on speculative behavior, since speculators have an elastic demand curve for forward contracts at e_{t+i}, equilibrium between speculators and banks will be at this rate. This is illustrated in Figure 3. Thus,

$$f_{t,i} = e_{t+i} > \bar{e}$$

To determine the implicit forward rate, some results from the section on central bank activity are needed.

Figure 3: The Equilibrium between Speculators and Banks

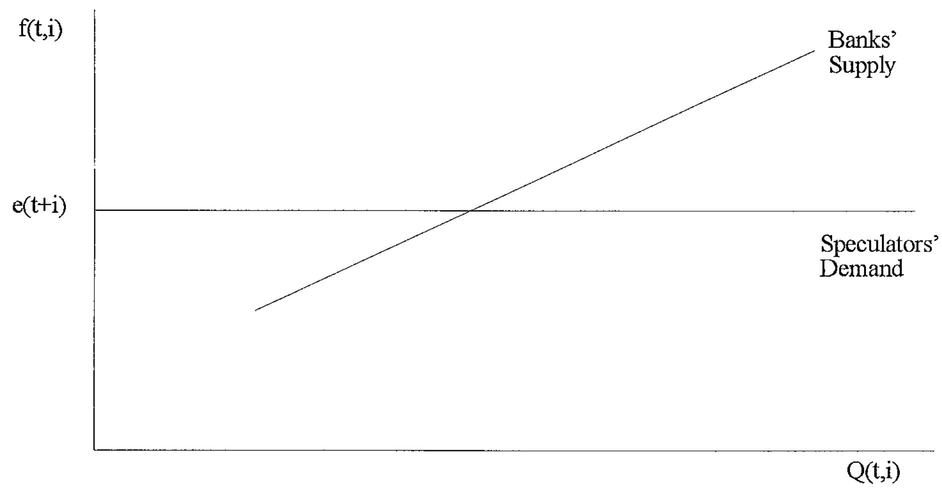
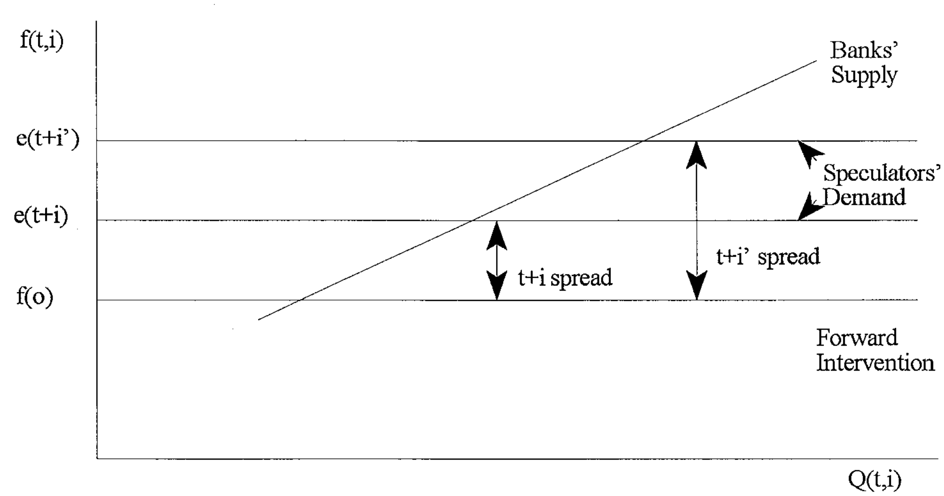


Figure 4: Long- and Short- term Spreads



$$f^{+}_{t,i} = \bar{e}\frac{1+r_t}{1+r^*} \tag{22}$$

$$= \frac{\bar{e}}{1+r^*}\cdot(1+r_t)$$

$$= \frac{\bar{e}}{1+r^*}\cdot\left(1+\bar{r}+\frac{\bar{e}(Q_t-R_{t-1})}{2\beta(1+r^*)}\right) \tag{23}$$

The expression (22) is the same as (4) above, and (23) is derived by substituting (9) in (22). By substituting (23) in (20), one can rewrite the bank's wealth function as:

$$W = \phi_1 R_{t-1} + \phi_2(Q_t - R_{t-1}) - \phi_3(Q_t - R_{t-1})^2 \tag{24}$$

where

$$\phi_1 \equiv f_{t,i} - \bar{e}$$
$$\phi_2 \equiv f_{t,i} - (1+\bar{r})\frac{\bar{e}}{1+r^*}$$
$$\phi_3 \equiv \frac{(\bar{e})^2}{2\beta(1+r^*)^2}$$

It may be noted that in a speculative attack, where the future expected spot rate is higher than the fixed exchange rate, $\phi_1 > 0$. Of course, it is clear that $\phi_3 > 0$.

Assuming that the domestic target interest rate is equal to the world interest rate, [24] i.e,

$$\phi_1 = \phi_2$$

one finds that

[24]This condition has to hold, in general, in a fixed exchange-rate regime because fixed exchange rates would imply similar domestic and world monetary policies.

$$\bar{r} = r^*$$

in which case the wealth function is simply

$$W = \phi_1 Q_t - \phi_3 (Q_t^2 + R_{t-1}^2 - 2Q_t R_{t-1}) \tag{25}$$

The mean of wealth is given by:

$$E[W] = \phi_1 Q_t - \phi_3 Q_t^2 + 2\phi_3 Q_t \bar{R} - \phi_3 Var(R_{t-1}) - \phi_3 (\bar{R})^2 \tag{26}$$

The variance of wealth is given by:

$$Var[W] = 4(\phi_3)^2 (Q_t)^2 Var(R_{t-1}) \tag{27}$$

Maximizing the expected utility is equivalent to maximizing[25]

$$E[W] - \frac{1}{2} a \, Var[W] \tag{28}$$

The optimal number of forward contracts that commercial banks will supply to the speculators (which determines the size of the attack) in any given period is then given by:

$$Q_t = \frac{\phi_1 + 2\phi_3 \bar{R}}{2\phi_3 + 4a\phi_3^2 Var[R_{t-1}]} \tag{29}$$

[25] This result is from Dixit (1991).

where

$$\bar{R} \equiv E_t[R_{t-1}]$$

V. Equilibrium in the Foreign Exchange Market

In this section, the results from the previous two sections are tied together to analyze the outcome of a speculative attack in the foreign exchange market.

Speculators will take positions against a currency whenever they expect the future expected spot rate to be different from the current fixed exchange rate. In a two-day framework, the expectations will be given by:

$$e_{t+1} = (1-\psi(t))\bar{e} + \psi(t)\overset{+}{e}_{t+1} \tag{30}$$

and

$$\psi(t) = Pr[\varepsilon > L_t] \tag{31}$$

$$\overset{+}{e}_{t+1} = \frac{M_t + \varepsilon - L_t}{P^*[a_0 - a_1\bar{r}]} \tag{32}$$

where $\overset{+}{e}_{t+1}$ is the shadow exchange rate at time $t+1$ and $\psi(t)$ is the probability of collapse of the exchange rate regime. As shown, the probability of a collapse depends upon the lines of credit that the central bank has access to relative to the shocks to domestic credit that the country faces.

What is seen from expressions (30) and (31) is that speculators will mount an attack on a fixed exchange rate regime whenever the shadow exchange rate exceeds the fixed rate. This shadow exchange rate is determined by the size of the credit lines that central banks have with other sources of foreign exchange (such as the EMS's Very Short Term Financing Facility) relative to the size of shocks that they are subjected to. The presence of intra-day line limits (or, equivalently, credit caps) can thus lead to an attack on a currency even if infinite borrowing facilities are present over time. Thus, central banks' institutional limits to liquid funds denominated in a foreign currency may be the cause of a speculative attack.

It has been shown that equilibrium contracts are supplied by the banking system at the rate e_{t+i}. If the expectation of a devaluation increases with time, i.e if $e_{t+i''} > e_{t+i'}$ for $i'' > i'$ (see expression (3)), and if forward intervention is at $\bar{e}$ and sterilized spot intervention at $f^{+}_{t,i}$, it will be seen that longer-term forward contracts have wider spreads than relatively short-dated ones. This is illustrated in Figure 4. Data supporting this hypothesis is presented in Table 1.

It has been shown in the discussion on foreign exchange losses of central banks that the extent of forward market intervention that is undertaken by central banks is limited by the level of *non-borrowed* reserves that central banks hold. Thus, commercial banks will expect forward market intervention to the same extent, i.e.:

$$E[X_t] = E[R_{t-1}] \tag{33}$$

The total size of the attack is given by:

$$Q_t = \frac{\phi_1 + 2\phi_3\bar{R}}{2\phi_3 + 4a\phi_3^2 Var[R_{t-1}]} \tag{34}$$

From (34), one can see that as the probability of a devaluation increases, which would imply a higher value for ϕ_1, the equilibrium level of forward contracts offered by the commercial banking system increases. This is consistent with empirical evidence such as in the ERM crises of 1992, where forward market activity was very heavy in the days leading up to the collapse of the currency. ϕ_1 is the spread that commercial banks charge on outright forwards and that increases with a higher probability of collapse. Since this spread determines the revenue, one can observe that banks can make huge profits in an exchange rate crisis without taking open positions.

One also observes from (34) that the activity in the forward market increases with an increase in the expected value of central bank reserves. This is true because banks know that the forward intervention in such a situation will be greater, allowing banks to earn higher revenues with lower risk. This, in turn, will give banks an incentive to supply a greater amount of forward contracts to speculators. It is important to remember, however, that in this model the probability of a collapse independent of the level of non-borrowed reserves. If, in fact, a higher level of non-borrowed reserves improve the probability of survival of the regime, then the effect of the expected reserve levels on the volume of forward contracts will be ambiguous. This is because the two factors will act in opposite directions on the volume of contracts.

One also observes that as the variance of the level of reserves increases, the volume of forward contracts is reduced. That is because a greater variance implies that banks' information on central bank reserves is less precise, which means the risk they undertake while unwinding forward positions is greater. Therefore, risk-averse banks will offer fewer forward contracts to speculators when their information on central bank reserves is relatively imprecise.

VI. Bear Squeezes on Speculators

The history of commodity and securities markets is replete with examples of situations where market players have been able to corner the market in a security or commodity and then impose a squeeze on those market participants who have been bearish on the price of the security/commodity.[26] By cornering the market, and then allowing the bear players to go short the scarce asset, they are able to manipulate upwards the price of the asset at the expense of the bear player, since they control the supply of the asset to the bear players, while at the same time demanding delivery of this asset.

Conceptual analogies to bear squeezes can be drawn in the foreign exchange markets. The bear raiders is this case would be speculators betting on the collapse of an exchange rate regime, and a resultant devaluation. In other words, they are betting on a fall in the price of the domestic currency in terms of foreign currency. As with bear players in other markets, the ability to profit from a correctly realized expectation is to go short the asset (in this case, domestic currency), hoping to unwind the position at a lower price, for a profit. In other asset markets, bear raiders typically borrow and sell the asset short, promising to make good to the lender at a future date. As the model in this paper has shown, in the foreign exchange market, speculators typically sell the currency short by engaging in forward contracts demanding delivery of the currency at a future date.

Typically, bear squeezes in the foreign exchange market are not feasible because it requires the ability of one market player to corner the market in the asset under attack—in this case the domestic currency—and to take long positions against those bear players selling the asset short in large quantities. One candidate to impose a bear squeeze on speculators would be the central bank. However, with the presence of a large banking system willing to supply credit in the domestic market, as shown in this model, it would be near impossible for the central bank to mount an effective bear squeeze to quell speculation and drive the price of the domestic currency upwards.

The model of this paper can be applied to determine the conditions for a successful bear squeeze. One condition is the ability to take large long positions in the asset. This would imply

---

[26]See, for instance, Jordan and Jordan (1996) for a description of Salomon Brother's May 1991 attempt to corner the market in 2-year Treasury notes and its squeeze of that Treasury issue.

the central bank should be able to sell a large volume of forward contracts promising to deliver dollars for its domestic currency, and therefore allow commercial banks to sell a large number of contracts to speculators, as given in equation (29). As can be seen from the equation, this requires central banks to have large non-borrowed foreign exchange reserves. As shown in this model, if central banks do face the possibility of a devaluation due to domestic credit shocks, their ability to take long positions in the currency is circumscribed by their level of non-borrowed foreign exchange reserves.

The other important condition for a successful bear squeeze is that central banks be able to control the supply of credit to the banking system and the speculators. This requires a switching policy by the central bank, because if credit were controlled outright, then the volume of short positions taken by speculators would be small (given that their ability to balance their currency positions based on expectations of the interest rate is influenced). Thus, central banks would first supply credit at a ceiling interest rate (as given in expression (9)), and then restrict the supply of credit to the banking system altogether (after large positions have been taken against its currency), making it difficult for speculators to deliver on their forward contracts at the future date when the contracts come due. Moral suasion on banks generally to restrict the supply of credit is more feasible in emerging markets, given the structure of the banking system and its access to credit. In other words, speculators will not be able to access pass-through credit from the central bank except, possibly, at very high rates of interest. As a result of a bear squeeze, one would see very high overnight borrowing rates in the markets where speculators may attempt to access credit, a very large forward discount (as derived from expression (4)) and an appreciation of the exchange rate as speculators scramble to acquire the weak currency to close out their short positions.

As shown in this model, credit is supplied through either spot markets, overnight markets or through foreign exchange swaps. Therefore, an effective squeeze on speculators would require that:

(a) spot market credit is unavailable;

(b) overnight credit is either unavailable or at very high borrowing rates; and

(c) swap transactions are either unavailable or are available at large forward discounts.

Available reports on intervention and asset prices from the attack on Thailand suggests that the defense mechanism employed by the Bank of Thailand in May, 1997 appears to have temporarily met some important—though by no means all—conditions necessary for a successful bear squeeze, and the data on prices is consistent with the theory, as is described below.

A. Asian Currency Markets, May 1997

The Thai baht had been under pressure for several months leading up to the attack in May 1997. Market commentators suggest that, in particular, a large attack on the baht's peg was mounted in late January/early February, which was successfully defended at the time. However, an even stronger attack was mounted, reportedly by offshore speculators, in May.

Discussions with market participants suggests that in the first phase of the attack on the baht, speculators began shorting the baht through the forward market starting May 7 along the lines of the model of this paper.[27] From May 8 to May 14, baht sellers reportedly took large forward positions with Thai banks as counterparties. At the same time, the central bank is said to have absorbed large amounts of short positions against the baht in the forward market by writing exactly offsetting forward contracts with the banking system. This allowed Thai banks to close out their currency positions without pressure spilling over into the spot market. This is reflected in market views that the stock of official reserves remained relatively stable through this phase of the attack. As a result of the forward market intervention, forward rates did not reflect a heavy discount, and interbank interest rates remained relatively stable as well. Thus, the attack and defense both primarily took place in the forward market, with the net result being that speculators acquired large short baht positions in the forward market, in anticipation of a devaluation before the contracts matured some time in the future.

The second phase of the attack (and defense) began on May 15. To strengthen the defense of the baht, the BOT took several steps to stem speculative pressure. First, having sold a large volume of forward contracts, the BOT reportedly stopped intervening—to a large extent—in the forward market. This would be consistent with the predictions of the model that there is a bound on the extent to which central banks would engage in forward market intervention. This would normally have pushed selling pressure immediately into the spot market, i.e. the banking system would have created synthetic offsetting forwards using spot and swap transactions, as described in the model. Given the adverse effect this would have on the spot rate, the BOT prevented the cessation of forward intervention from from affecting the exchange rate by: (a) restricting local banks (from May 15) from extending credit to offshore banks;[28] (b) asking local banks (from May 16) not to conduct swaps with off-shore counterparties deemed speculators, and to quote only one-sided swap prices; and (c) restricting banks (from May 16) from conducting spot baht transactions with counterparties deemed speculators in the off-shore market.

The effect of this three-pronged strategy was multifold. First, it prevented additional speculative activity from spilling over to the spot market when forward intervention was ceased. Second, the BOT, having acquired a long baht position, had effectively cornered the market in scarce baht, since no other sources of baht credit were available, raising the costs for the speculators who had to cover their short baht positions using overnight baht. Those offshore players seeking to cover their short baht positions over the three-day weekend after

---

[27]Short positions on the baht are more easily taken in the forward market because credit in the spot market is more difficult to access. The two primary sources of baht credit for the banking system from the central bank are the discount window and the repurchase facility. Both require collateral from a set of eligible securities which consist mostly of BOT bills and the bills of some state-owned enterprises (SOE). A small set of banks have assets in the form of BOT bills and SOE bills, and these banks pass credit through to the rest of the financial system.

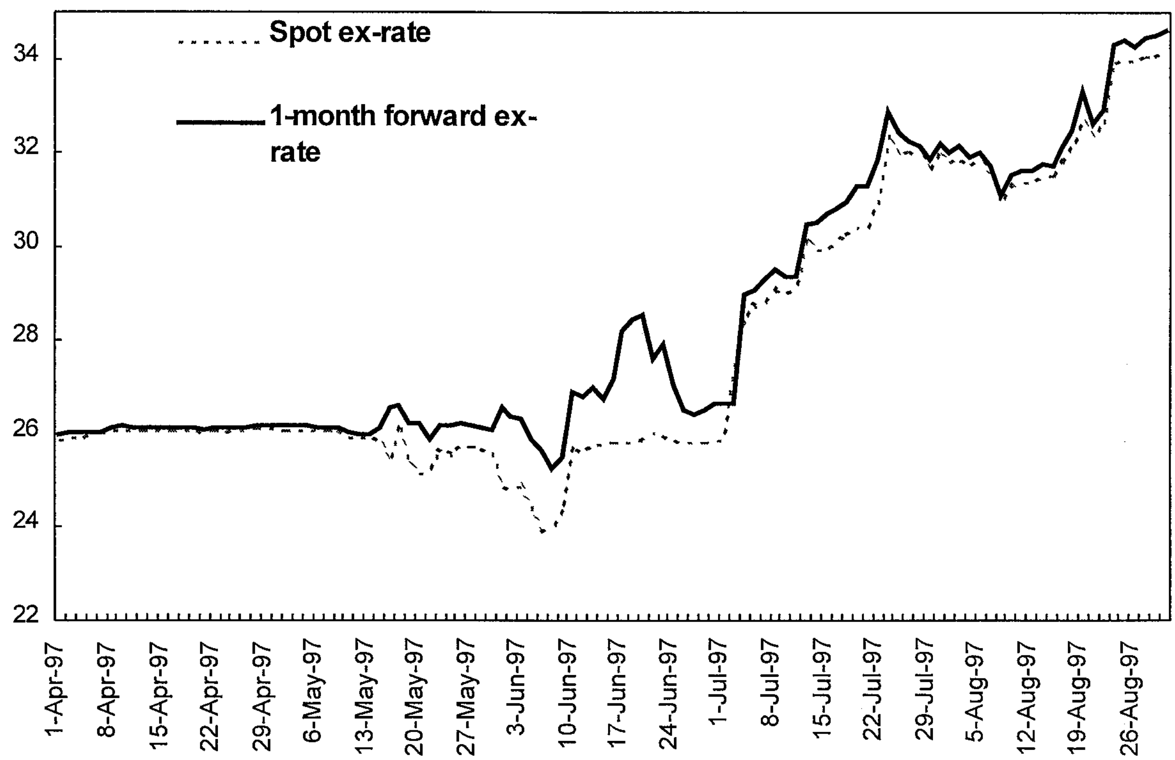
[28]The exception was if the banks could provide evidence of a documented trade or investment transaction for which credit was required by the off-shore counterparty. All cross-border transactions had from that date on to be reported to the BOT daily.

May 15 bid up the price of acquiring spot baht for delivery: three-day borrowing rates rose dramatically, and well in excess of 1000 percent per annum.

Once speculators understood that the market for baht liquidity was tight given the lack of baht credit, those needing to close out the short baht forward positions attempted to sell their dollars for baht, deliverable in the conventional two days, which the BOT would absorb. While this is supported by market reports that the BOT became a buyer of dollars after May 15—and was able to replenish part of its reserves at a rate better than at which forwads were sold—the restriction on spot sales continued to force them to bid for the scarce baht credit available even after May 16. As a result, the extremely high overnight off-shore rates for baht credit continued. Speculators against the baht therefore continuously closed out their positions at high rates after May 15. In addition, the offshore spot baht rate traded at a premium relative to the onshore rate—the off-shore baht rate having become the strongest it had been in two years—because the spot transactions restrictions implied that banks were not permitted to arbitrage between the two markets by selling to offshore speculators.

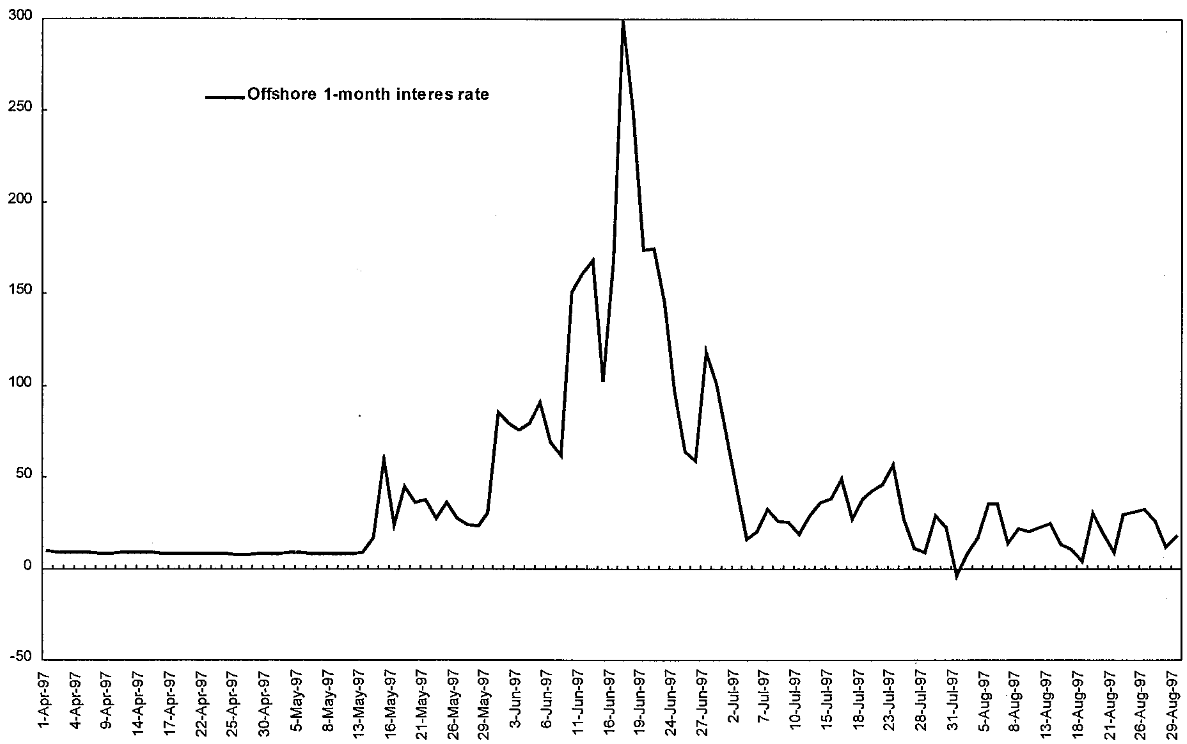
The behavior of baht spot rates as speculators closed out their positions was consistent with the theory outlined in this paper that under some circumstances, market conditions can generate an implied bear squeeze on the foreign exchange market. The dynamic behavior of both the spot and baht forward rates, as well as off-shore overnight rates, were consistent with the predictions of price movements in this model under the conditions of a market corner and a bear squeeze (see Figures 5 and 6). One adverse impact of the measures imposed to segment the onshore and offshore currency, swap, and forward markets was that it led to a collapse in swap market activity subsequently, potentially reducing hte availability of forward cover to domestic entities including importers. In any event, subsequent to the imposition of the measures, ongoing developments led the authorities to decide to let the baht value be determined by market supply and demand on July 2.

Figure 5: Thai Baht Spot and Forward Exchange Rates.



Source: Reuters.

Figure 6: Thai Off-shore 1 Month Interest Rates



Source: Bloomberg, Reuters, and staff estimates.

VII. Conclusions

In this paper, the speculative attacks against a currency have been analyzed by examining the optimizing behavior of the three broad classes of participants in the foreign exchange market: speculators, commercial banks and central banks.

Speculators enter into forward contracts for the sale of the domestic currency whenever the future expected spot rate exceeds the exchange rate peg. Such expectations arise when the economy is subjected to stochastic shocks to the level of domestic credit and the available lines of credit to the central bank may not be large enough to finance the required sale of reserves.

Commercial banks are modeled as risk-averse market-makers who take on neither exchange rate risk nor interest rate risk. They supply the forward contracts to speculators with the expectation that they will be able to balance their positions by the end of the day by entering into offsetting forward contracts with the central bank or through spot sales and currency swaps. Banks charge a bid-ask spread on forward contracts which is the difference between the price they charge speculators and the expected price at which they will be able to unwind their positions. The bid-ask spread that commercial banks charge on forward contracts with speculators allows them to earn revenues from dealing in the market without taking open positions themselves. We find that the greater the probability of collapse of the currency, the higher the spread that the banks charge. If countries are known to follow an expansionary domestic credit policy (often the cause of speculative attacks), then one implication derived from this model is that longer-dated forward contracts will have a wider maturity than short-dated ones. This is consistent with empirical evidence.[29]

The volume of forward contracts that commercial banks are willing to supply to speculators depends on their expectations of forward market intervention. Central banks will intervene in forward markets until their net reserves position becomes zero and then will move into the spot market by borrowing reserves. The greater the imprecision of commercial banks' information on central bank reserves, the smaller the volume of forward market contracts that the banking system will transact with speculators. The likelihood of an interest rate squeeze, where central banks increase their overnight lending rates, also reduces the equilibrium volume of speculation in the market.

Central banks are concerned about maintaining their exchange rate target and deviations of the interest rate from a target rate, but are also concerned about potential capital losses from intervention in the event that the currency ultimately does collapse. Sterilized spot market intervention allows the central bank to control the implicit forward rate and reduce the extent of such capital losses by choosing the interest rate at which they lend domestic currency. The optimal central bank interest rate policy and the accompanying domestic credit policy are both

---

[29]The result that longer-dated forward contracts have wider spreads than short-dated ones has been explained in this model even with risk-neutrality which is a significant departure from the existing literature which tries to explain it using risk-aversion of agents and a time-varying risk premium.

derived in this model as the outcome of a loss minimizing decision of the central bank. The greater the central bank's sensitivity to interest rate fluctuations, the smaller the increase in interest rates that they impose in an exchange rate crisis. The larger the level of reserves relative to the size of the attack, the smaller is the likely increase in interest rates that central banks will impose.

An important conclusion of this paper is that while an interest rate increase may not be of the order of magnitude required to deter speculation, it can still help central banks control their expected foreign exchange losses. With the presence of limits to the amount of foreign reserves that central banks can borrow on any given day, unlimited financing facilities over longer time horizons are not enough to ward off speculative activity and the possibility of collapse of the fixed exchange rate regime.

Finally, this model can be used to illustrate how a central bank may be able to mount an effective bear squeeze against speculators betting on a devaluation of the currency. By going long in the domestic currency, through a big forward book, the central bank is able to establish deliverables in domestic currency at a future date. By then demanding delivery of the domestic currency, while at the same time restricting the supply of available credit through a combination of restrictions on access to overnight credit, spot sales of domestic currency, and restrictions on swap transactions, the central bank can effectively squeeze speculators and drive the value of its own currency higher.

REFERENCES

Agenor, Pierre-Richard, Jagdeep Bhandari, and Robert Flood (1992), "Speculative Attacks and Models of Balance of Payments Crises," *IMF Staff Papers*; 39 (2), pp. 357-394.

Blackburn, Keith, and Martin Sola (1993), "Speculative Currency Attacks and Balance of Payments Crises," *Journal of Economic Surveys*; Vol. 7 No. 2, pp. 119-144.

Blanco, Herminio, and Peter Garber (1986), "Recurrent Devaluation and Speculative Attacks on the Mexican Peso," *Journal of Political Economy*; Vol.94, pp. 148-166.

Dixit, Avinash (1990), *Optimization in Economic Theory* (2nd ed.); Oxford University Press, pp. 129-130.

Dornbusch, Rudiger (1987), "Collapsing Exchange Rate Regimes," *Journal of Development Economics*; Vol.27, pp. 71-83.

Fernandez-Arias, Eduardo (1996), "Balance of Payments Rescue Packages: Can They Work?," *Inter-American Development Bank Working Paper*; Series 333, December.

Flood, Robert, and Peter Garber (1984), "Collapsing Exchange-Rate Regimes: Some linear examples," *Journal Of International Economics*; 17(1), pp. 1-13.

Garber, Peter, and Subir Lall (forthcoming), "Derivative Products in Exchange Rate Crises," in Reuven Glick (ed.) *Managing Capital Flows and Exchange Rates: Perspectives from the Pacific Basin*; Cambridge University Press.

Garber, Peter, and Michael Spencer (1995), "Foreign Exchange Hedging and the Interest Rate Defense," *IMF Staff Papers*; 42(3), pp. 490-516.

Garber, Peter, and Steven Weisbrod (1992), *The Economics of Banking, Liquidity and Money*; D. C. Heath, pp. 509-517.

Grilli, Vittorio (1986), "Buying and Selling Attacks on Fixed Exchange Rate Systems," *Journal of International Economics*; Vol.20, pp. 143-56.

International Monetary Fund (1993), *International Capital Markets: Part 1*; April.

Jordan, Bradford and Susan Jordan (1996), "Salomon Brothers and the May 1991 Treasury Auction: Analysis of a Market Corner," *Journal of Banking and Finance*; Vol. 20, No.1, pp. 25-40.

Kaminsky, Graciela, Lizondo, Saul and Carmen Reinhart (1997), "Leading Indicators of Currency Crises," *International Monetary Fund Working Paper*; WP/97/79, July.

Kaminsky, Graciela, and Carmen Reinhart (1996), "The Twin Crises: The Causes of Banking and Balance-of-Payments Problems," *International Finance Discussion Paper No. 544, Board of Governors of the Federal Reserve*; March.

Krugman, Paul (1979), "A Model of Balance-of-Payments Crises," *Journal of Money, Credit and Banking*}; Vol.11, pp. 311-325.

Lall, Subir (1994), "Bank Behavior in an Exchange Rate Crisis," Chapter 4 of *Essays in Banking, Liquidity and Speculative Attacks on Fixed Exchange Rate Regimes*, unpublished Ph.D. dissertation; Brown University, pp. 55-87, August.

Obstfeld, Maurice (1986), "Speculative Attack and the External Constraint in a Maximizing Model of the Balance of Payments," *Canadian Journal of Economics*; Vol.19, pp. 1-22, March.

Obstfeld, Maurice (1984), "Balance of Payments Crises and Devaluation," *Journal of Money, Credit and Banking*; Vol.16, pp. 208-217, May.

Willman, Alpo (1988), "The Collapse of the Fixed Exchange Rate Regime with Sticky Wages and Imperfect Substitutability Between Domestic and Foreign Bonds," *European Economic Review*}; Vol.32, pp. 1817-1838, November.

Wyplosz, Charles (1986), "Capital Controls and Balance of Payments Crises," J*ournal of International Money and Finance*; Vol.5, pp. 167-179, June .