Sharp Increase in Interest Rate as a Signal of the Resolve to Defend Currencies*

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Abstract

There is little if any research that explicitly models or tests the *positiv*e effects of temporary high interest rates as a signal of the resolve of a central banker to maintain or strengthen the value of the currency.

- Joseph E. Stiglitiz in *Annual World Bank Conference on Development Economics 1998*

Does an increase in interest rate defend the value of a currency? A (one-shot) sharp increase does. In this paper, we start with a game-theoretical model in which a monetary authority increases the interest rate and wins a reputation of being strong. The speculators are thus stopped from continuing the attack. The model is a variant of the reputation game that originates from the discussion of market signalling. As with other models of credible policies, the reputation of being strong hinges on the significant costs incurred to the monetary authority. Unlike the existing models of currency defence, we consider some general opportunity costs of foregone investments, and the depletion of foreign reserves is not a necessary ingredient. Speculators infer the unknown type of the monetary authority solely from high interest rates. This signalling mechanism applies well to reserves-abundant economies, where other interest-sensitive fundamentals are more relevant. Finally, we provide evidence to show that the model is consistent with the events in some emerging market amidst the Asian crisis.

KEYWORDS Double-market play, Emerging market, Foregone investments, Incomplete information, Partially separating equilibrium, Signalling mechanism

JEL Classification C72, E42, F33

1 INTRODUCTION

Do high interest rates defend the value of a currency under a fixed exchange rate system? In principle, the interest rates rather than the exchange rates adjust to external shocks. More precisely, money supply expands when there is a capital inflow; that is, foreign currencies are sold to the monetary authority for the domestic currency. Similarly, money contracts when there is a capital outflow. This monetary expansion or contraction lowers or raises the domestic interest rates respectively, while the exchange rate is kept stable.

Although this automatic mechanism may work well in "normal" times, its reliability is in doubt when an economy faces a currency attack. In practice, a monetary authority may respond to a currency attack by raising the interest rates artificially. Recently, Drazen (1999, 2000) and Lahiri and Végh (2000) provide theoretical justifications on why this is possible. Among many other things, these papers share one theme: the monetary authority raises the interest rate and imposes a borrowing cost to the speculators who borrow domestic currency in a large-scale speculation. As pointed out in Stiglitz (1999) and Drazen (1999), should this mechanism work, the interest rate needs to be extremely high when the period of currency attack is extremely short, such that the high cost of borrowing is offset by the expectedly high return of devaluation.

Raising the interest rates, however, is not costless. From the viewpoint of the monetary authority, high interest rates have negative impact on consumption, investment, budget deficit, and possible stabilization of the banking system. Precisely because of these costs to the monetary authority, speculators infer its willingness to defend the peg on the exchange rate. In other words, one should expect a model with incomplete information on the monetary authority. In the context of unemployment-inflation tradeoff, models of credible policy are developed in Backus and Driffill (1985), Barro (1986) and Vickers (1986). On the other hand, as a deliberate application of Drazen and Masson (1994), Drazen (1999) constructs a dynamic game-theoretic model. In the model, speculators solve a signal extraction of the monetary authority's type, with some observable

macroeconomic fundamentals notably the amount of foreign reserves. While this model may be applicable to the exchange rate mechanism (ERM) and Mexican currency crises, it may not be useful in explaining some currency attacks during the recent Asian crisis. Simply put, Drazen's model is good in explaining time-to-time attacks in economies where foreign reserves are scarce. [1]

In contrast, we construct a one-shot static game-theoretical model and confine our attention to the signalling mechanism. The cost incurred to the monetary authority is general as long as it is related to the interest rate. While existing models of currency crisis concentrate on the depletion of foreign reserves as the trigger of a crisis, our model does not require such an ingredient. Our model thus allows us to study the behaviors of the monetary authorities in reserves-abundant economies that nevertheless have to encounter currency attacks.[2] Moreover, the cost incurred to the speculators is also very general and the borrowing cost plays no role in driving the results.

The model in this paper is inspired by the actions taken by the Hong Kong Monetary Authority (HKMA). It raised the interest rate drastically in a major event of currency attack in October 1997 while it was the third large foreign reserves holder in the world at the end of 1997. [3] During the Asian crisis, the Hong Kong dollar (apart from the Chinese yuan which is not fully convertible) was the only currency that resisted devaluation. In Section 3 below, we will argue how the model explains these facts.

This paper is organized in the following way. In the next section, we develop a model of reputation game and argue that the monetary authority can use high interest rate as a way

[1] Using an empirical sample of many attacks, Kraay (1998) concludes that high interest rates do not play an important role in defending against currency attacks. However, it is argued in Rebelo (2000) that the attacks included in Kraay (1998) by and large involve moderate interest-rate increases.

[2] Hong Kong, Singapore and Taiwan were holding abundant amount of foreign reserves (USD81.6 billion, USD 79.4 billion and SDR 65.8 billion respectively) when the Asian crisis broke out in July 1997. While the former continued to defend for the ongoing exchange rate, the latter two eventually depreciated their currencies.

[3] Hong Kong's exchange rate system from October 1983 to September 1998 was a pseudo-currency board system under which the monetary authority guaranteed convertibility undertaking with bank notes (but not the whole monetary base). Detailed historical accounts of the system can be found in Schwartz (1993), Jao

to drive away speculators. In Section 3, we will discuss how the model helps to clarify some issues around the currency board arrangement in some emerging market. We conclude the paper in Section 4.

2 THE MODEL OF A REPRESENTATIVE SPECULATOR

In this section, we present a model to explain the action of raising interest rate taken by the monetary authority to defend the fixed exchange rate. The model is based on the idea that the authority uses the high interest rate as an allusion to its will to defend the currency. The speculators get the message and stop from continuing the attack. The idea of using costly actions to signal one's private information is first formulated in Spence (1973) and has been extensively applied in the fields of industrial organization, macroeconomics, public economics, financial economics and international economics.

Throughout the paper, for simplicity, we assume that there is only one type of speculators in this model. The action of a representative speculator, γ, is an element of a set $\Lambda = \{a,o\}$, where a refers to (continuing to) attack and o refers to staying out of the foreign exchange market. The payoff for the speculator is represented by $V = V(t,i,\gamma)$, where t denotes the type of the authority (to be elaborated below) and i is the domestic interest rate. The speculator's payoff is a common knowledge of the authority as well as the speculator.

Alternatively, the type of the authority t can be interpreted as the time to de-peg. [4] Note the set of t, $. = \{1,2,...,\infty\}$. $t = \infty$ means that the authority never de-pegs. The type t is the authority's private information. The payoff for the authority is denoted as $U = U(t,i,\gamma)$.

(2000), Tsang, Sin and Cheng (2000) and Tse and Yip (2001). Also see the discussion in Section 3.

[4] Note the time to de-peg is exogenous throughout this paper. It may in turn depend on some other

We first consider the assumptions on the payoff for the speculator.

Assumption 1: For all t and i, $V(t,i,o) = V'$, where V' is a finite constant, which does not depend on t or i.

Assumption 2: $V(t,i,a)$ is strictly decreasing in t.

Assumption 3:

(a) For some $t \in .$, $V(t,i_0,a) \geq V'$, where i_0 is the market interest rate.

(b) For some $t \in .$, $V(t,i_0,a) < V'$, where i_0 is the market interest rate.

Note if the speculator stays out of the market, the time to de-peg and the interest rate are irrelevant to the speculator's payoff. That is why in Assumption 1, V' does not depend on t when $\gamma = o$. V' may or may not depend on i. For simplicity we ignore the dependence and this simplification will not affect the results that follow.

Assumption 2 states that the longer the authority holds the peg, the lower the payoff for the speculator is, as the speculator needs to pay for the opportunity cost of foregone investments (such as attacking other currencies). This opportunity cost is not necessarily a cost of borrowing, which is prevalent in many other models (see, for instance, Section 2 in Rebelo, 2000). As a result, the payoff may not decrease with interest rate. We will come back to this point in the discussion of Theorem 3.

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exogenous economic factors.

Assumption 3(a) states that for at least one type of the authority, it is beneficial for the speculator to attack at the market interest rate i_0. (For instance, if $t = 0$, the speculator immediately benefits.) Otherwise she/he is not called a speculator. Assumption 3(b) states, on the other hand, that for at least one type of authority, it is beneficial for the speculator to stay out, otherwise no signalling mechanism is effective.

In the following theorem, we will see how strong and weak authorities are implicitly defined.

Theorem 1: Suppose Assumptions 1-3 hold. There exists a threshold T, $0 < T < \infty$, such that:

For all $t \leq T$, $V(t,i_0,a) \geq V'$, and
for all $t > T$, $V(t,i_0,a) < V'$.

Hence, we classify the authority into two groups of types. An authority is weak if $t \leq T$ and it is strong if $t > T$. Correspondingly, define the set of weak authorities $W \equiv \{t: t \leq T\}$ and the set of strong authorities $S \equiv \{t: t > T\}$.

Proof of Theorem 1: Let $.1 \subseteq .$ such that for all $t \in .1$,

$V(t,i_0,a) \geq V'$.

Define $T \equiv sup\{t, t \in .1\}$. Given Assumption 3(a), $0<T$. On the other hand, $T<\infty$. Otherwise, Assumption 3(b) does not hold. The conclusion holds in view of Assumption 2.

Next we turn to the assumptions on the authority's payoff.

Assumption 4: For all i,

(a) $U(t,i,a)$ is strictly decreasing in t; and

(b) $U(t,i,o)$ is strictly increasing in t.

Assumption 5: Consider T defined in Theorem 1. There exists $\hat{i} > i_0$ such that:

$$U(T,i_0,a) = U(T, \hat{i}, o).$$

Assumption 4(a) states that if the speculator attacks, the stronger the authority is (t is higher) and the later it de-pegs (if not never), the lower utility it attains. This is simply because the economy suffers more as the attack lasts longer. Assumption 4(b) states that if the speculator stays out, the stronger the authority is and the later it de-pegs, the higher utility it attains. This is because there will be an unstable transitional period after the peg is abandoned. The economy gains more from a fixed exchange rate, when it stays longer.

Assumption 5 plays a crucial role in the proof of Theorem 2 below. In essence, there is some sort of tradeoff between suffering from high interest rate and being attacked. As we show in the next lemma, this assumption is an immediate consequence of some interpretable primitive assumptions.

Lemma 1 Consider T defined in Theorem 1. Suppose

(a) $U(T,i_0,o) > U(T,i_0,a)$.

(b) For all i, $U(T,i,o) = U(T,i_0,o) - k(i-i_0)$, where $k > 0$.

Then Assumption 5 holds.

Proof of Lemma 1: The result follows if we let $\hat{i} = [U(T,i_0,o) - U(T,i_0,a)]/k + i_0$.

Assumption (b) above is stronger than what we need. It can be weakened substantially. Define $u(i) \equiv U(T,i,o)$ and $X \equiv [U(T,i_0,a), U(T,i_0,o)]$. We may simply assume that $u^{-1}(X)$ exists and is strictly decreasing.

Furthermore, Assumption (a) above looks rather weak on its surface; one may want to assume it for all t. The next lemma provides some ideas.

Lemma 2 Suppose Assumption 4 and Assumption (a) in Lemma 1 hold.

For all $t \in S$, $U(t,i_0,o) > U(t,i_0,a)$.

Proof of Lemma 2: For $t > T$, $U(t,i_0,o) > U(T,i_0,o)$ by Assumption 4(b),
$> U(T,i_0,a)$ by Assumption (a) in Lemma 1,
$> U(t,i_0,a)$ by Assumption 4(a).

Thus, at least when the interest is at its market rate, a strong authority prefers not to be attacked. Note it may not be the case for a weak authority. A weak authority, in our setting, may not even want to defend against the attack.

After interpreting the assumptions on the authority's payoff, we now turn to the main theorems.

Theorem 2 Suppose Assumptions 4 and 5 hold. There exists $\tilde{i} > i_0$ such that:

For all $t \in W$, $U(t, i_0, a) \geq U(t, \tilde{i}, o)$; and
for all $t \in S$, $U(t, \tilde{i}, o) > U(t, i_0, a)$.

Proof of Theorem 2: Consider $\tilde{i} = \hat{i}$. Then,

$$\begin{aligned}
\text{for all } t \in W,\ U(t,i_0,a) &\geq U(T,i_0,a) && \text{by Assumption 4(a),}\\
&= U(T,\hat{i},o) && \text{by Assumption 5,}\\
&\geq U(t,\hat{i},o) && \text{by Assumption 4(b),}\\
&= U(t,\tilde{i},o).
\end{aligned}$$

$$\begin{aligned}
\text{for all } t \in S,\ U(t,\tilde{i},o) &= U(t,\hat{i},o)\\
&> U(T,\hat{i},o) && \text{by Assumption 4(b),}\\
&= U(T,i_0,a) && \text{by Assumption 5,}\\
&> U(t,i_0,a) && \text{by Assumption 4(a).}
\end{aligned}$$

One can easily see from the proof of Theorem 2 that $\tilde{i}$ may not be unique and it may be the same for different types, as long as $t \in S$. In view of the latter property, we say there is a partially separating equilibrium. If the authority is strong, the optimum strategy is to raise the interest rate to $\tilde{i} > i_0$, while the optimum strategy for the speculator, in view of this signal, is leaving the market. If the authority is weak, the optimum strategy is to maintain the prevailing rate i_0, while the speculator continues with the attack. This equilibrium is formally shown in the next theorem.

Theorem 3 Suppose Assumptions 1-5 hold,

(a) If $t \in W$, $i = i_0$ and $\gamma = a$.

(b) Suppose in addition, $V(t,i,a)$ is decreasing in i. If $t \in S$, $i = \hat{i}$ and $\gamma = o$.

Proof of Theorem 3

(a) If $t \in W$, by Theorem 2, $U(t,i_0,a) \geq U(t,\hat{i},o)$. By Theorem 2 and Theorem 1, in view of the revealed type, $V(t,i_0,a) \geq V' = V(t,i_0,o)$. The result follows.

(b) If $t \in S$, by Theorem 2, $U(t,\hat{i},o) > U(t,i_0,a)$. By Theorem 2 and Theorem 1, in view of the revealed type and the additional assumption, $V(t,\hat{i},a) \leq V(t,i_0,a) < V' = V(t,i_0,o)$. The result follows.

In Theorem 3(b), we do not assume that $V(t,i,a)$ is strictly decreasing in i. It can well be invariant to i, as in the case of no cost of borrowings. Note that this interest cost is assumed in Drazen (1999). Nevertheless, we preclude the scenario that $V(t,i,a)$ is strictly increasing in i, a possible scenario when there is double-market play. We will come back to this point in Section 4.

It is interesting to note that, at least in certain circumstances (see the next section), the resolution of the monetary authority to stick to the fixed exchange rate becomes more credible, due to some discretion on the interest rate. Our result contrasts vividly with the advocacy of rules in Kydland and Prescott (1977) and Barro and Gordon (1983), both ignoring the incomplete information of the government's type.

3 DISCUSSION

Under a fixed exchange rate system, in "normal" times of no potential speculative attacks, automatic interest rate arbitrage may be sufficient to maintain the value of a currency. For reference, see Ghosh, Gulde and Wolf (2000). However, in times of "crisis", a different mechanism is required. In the previous section, we argue that a strong government will need only to keep the speculators off the market by setting a sufficiently high interest rate $\tilde{i}$. In order to drive away the speculator, most costly measures such as issuing insurance instruments on domestic currency are not necessary and may not even

be sufficient. Tsang (1999) arrives at a similar conclusion from a different angle.

In Bensaid and Jeanne (1997), they presented a model similar to ours on defending the fixed exchange rate by raising interest rate. However, their main result is quite different from ours. A vicious circle may arise when the market goes on testing the 'nerve' of the government until the cost of defending the currency is so high that the government chooses to devalue. However, as they notice in the article:

> "The model presented above is rather pessimistic about the ability of the country to maintain a fixed parity. When a currency crisis begins, the government is hopelessly led to devaluation. In the real world, such a dramatic dead end can be avoided. The currency crisis can stop by itself if for example speculators are financially exhausted. ……"

They have not put this possibility into their models though. Contrastly, we formally assume that there exists some opportunity cost for the speculator and this cost is crucial to the defence. The Hong Kong case in fact provides evidence to support this point. [5]

Since 1983, Hong Kong has been adopting a currency board system, under which the interest rate will increase automatically when there is capital outflow. Along with this currency board arrangement, however, the HKMA (at least since its establishment in 1993) also provides overnight inter-bank liquidity through the so-called Liquidity Adjustment Facility (LAF). By tightening or loosening the liquidity, the HKMA is able to influence the inter-bank interest rate.

Amidst the Asian crisis, the Hong Kong dollar was not immune to speculative attacks. Heavy selling of Hong Kong dollars in foreign exchange markets on October 21-22, 1997 was documented. As transactions in spot exchange were settled on a T+2 basis, it was not until October 23-24 that there was a huge demand in Hong Kong dollar, to which the

[5] Some of the following materials are drawn from Cheng, Chia and Findlay (2000) and Meredith (1999).

HKMA did not respond. Rather, it circulated a note in the banking sector, announcing that repeated borrowers at its LAF would be charged penalty, without specifying the definition of "repeated borrowers". In effect, the circular created panic in the inter-bank money market. [6] The overnight inter-bank offered rate (HIBOR) once shot up to 280 per cent, with a closing rate of over 100 per cent on October 23. With the soaring interest rates, speculators could not but stopped the attack. Seen from the perspective of our model, what the HKMA did was to push up the inter-bank interest rate to a level that was sufficiently high to signal its type. Speculators could then infer from the action of the HKMA that it belonged to the strong type. [7] Moreover, for a certain time period that followed, the HIBOR went down.

4 CONCLUSION

In this paper, we start with a game-theoretical model in which a monetary authority increases the interest rate and wins a reputation of being strong. The speculators are thus stopped from continuing the attack. Speculators infer the unknown type of the monetary authority solely from high interest rates. This signalling mechanism applies well to reserves-abundant economies, where other interest-sensitive fundamentals are more relevant. Finally, we provide evidence to show that the model is consistent with the events in some emerging market amidst the Asian crisis.

In our model, the monetary authority dislikes high interest rates while the speculators may be indifferent. In other words, we assume that the monetary authority cares about the

[6] Though in hindsight, the administration declared that the note is "in very much the same spirit as the earlier circular in 1992" (See Paragraph 3.7, p.13 in Financial Services Bureau, 1998).

[7] It should be noted that the HKMA, unlike the Fed in the U.S., is closely linked to the administration. The chief executive of the HKMA is under the Financial Secretary, a key figure in the administration who is responsible for the fiscal, monetary and economic policies. See, for instance, http://www.info.gov.hk/fso/fs.htm. In other words, our example here is immune to the irony discussed in Stiglitz (1999), "…… as central bank have become more independent and less politically accountable, they, the decision makers in raising interest rates, bear less and less cost." (p.24)

impacts of high interest rate such as low economic growth and high unemployment rate; while the speculators may bear no or very minor cost of borrowing. Nevertheless, we preclude the scenario that the utility of the speculator strictly increases with interest rates. An interesting event is another wave of attacks to the Hong Kong dollars which was launched in an entirely new fashion in mid 1998. As explained in Cheng, Chia and Findlay (2000), "[The speculators] could borrow and sell Hong Kong Dollar in the spot market, leading to higher interest rates and consequently the stock prices and stock futures would fall. People holding short positions would gain." (Footnote 15, p.248). Yam (1998) argues that this type of "double-market play" invites no policy but intervention in the stock market.

On the other hand, in a small open economy, flows of capital and potential speculative attacks may result in volatile demand and supply for liquidity, as one can see in Section 3. Under a fixed exchange rate, efficient liquidity management is crucial for the stability of interest rates. This topic is under investigation by the authors.

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