IMES DISCUSSION PAPER SERIES

A Large Speculator in Contagious Currency Crises: A Single "George Soros" Makes Countries More Vulnerable to Crises, but Mitigates Contagion

Kenshi Taketa

Discussion Paper No. 2004-E-23

IMES

INSTITUTE FOR MONETARY AND ECONOMIC STUDIES

BANK OF JAPAN

C.P.O BOX 203 TOKYO
100-8630 JAPAN

IMES Discussion Paper Series 2004-E-23
December 2004

A Large Speculator in Contagious Currency Crises: A Single "George Soros" Makes Countries More Vulnerable to Crises, but Mitigates Contagion

Kenshi Taketa*

Abstract

This paper studies the implications of the presence of a large speculator such as George Soros during a contagious currency crisis. The model shows that the presence of the large speculator makes countries more vulnerable to crises, but mitigates the contagion of crises across countries. The model presents policy implications of financial disclosure and size regulation of speculators such as hedge funds. First, financial disclosure by speculators eliminates contagion, but may make countries more vulnerable to crises. Second, regulating the size of speculators (e.g., prohibiting hedge funds from high leverage and thereby limiting the amount of short selling) makes countries less vulnerable to crises, but makes contagion more severe.

Key words: Contagion; Currency Crises; Global Game
JEL classification: F31; E58; D82; C72

*Economist, Institute for Monetary and Economic Studies, Bank of Japan (E-mail: kenshi.taketa@boj.or.jp)

This paper is a revised version of chapter 3 of my doctoral dissertation submitted to the University of Wisconsin – Madison in May, 2004. The author is deeply grateful to Steven N. Durlauf for his invaluable advice and constant encouragement. The author also thanks Yeon-Koo Che, Charles Engel, Bruce Hansen, Graciela L. Kaminsky, Bob Staiger and the staff of the Bank of Japan for helpful suggestions. Any remaining errors are mine. The views expressed in this paper are those of the author and do not necessarily reflect the official views of the Bank of Japan or IMES.

"Has anyone noticed just how small a player the IMF really is? That $18 billion U.S. contribution to the IMF, which has finally been agreed upon after countless Administration appeals and conservative denunciations, is about the same as the short position that [George] Soros single-handedly took against the British pound in 1992—and little more than half the position Soros' Quantum Fund, Julian Robertson's Tiger Fund, and a few others took against Hong Kong last August [in 1997]."

—Paul Krugman, Soros' Plea: Stop Me![1]

1 Introduction

The very names of recent financial crises, such as the Mexican *Tequila* crises in 1994, the Asian *Flu* in 1997, the Russian *Virus* in 1998, and the Brazilian *Sneeze* in 1999, suggest a common feature. Clearly a common feature is "contagion", whereby a financial crisis begins locally in some region, country, or institution, and subsequently spreads elsewhere. Of course, the international transmission of financial shocks *per se* is not always a surprising phenomenon. What is surprising in recent contagion episodes, however, is that the financial crises in small economies like Thailand or Russia have devastating effects on economies of very different sizes and structures, thousands of miles apart, with few direct trade or financial links, and in very severe and unexpected ways.[2] Put another way, it is quite surprising that severe contagion of crises has occurred across seemingly "unrelated" countries, originating from crises in small economies. Why did Australian and South African stock market indices fall by 14% in the turmoil over the Asian Flu?[3] Why did the Brazilian stock market fall by over 50% and the sovereign spreads of Brazil rise sharply during the Russian Virus?[4] While several contagion channels have been proposed in the literature, none seems able to explain entirely the extent of contagion. This paper provides

[1]See Krugman (1998).

[2]Regarding the Russian Virus, Calvo, Izquierdo, and Talvi (2003) argue that "it was hard to even imagine, ex ante, that a crisis in a country that represents less than 1 percent of world output would have such devastating effect on the world capital market." (p.4)

[3]See Forbes (2004).

[4]See Forbes and Rigobon (2001).

a complement to the growing literature by extending the model presented in Taketa (2004).

Closely related to the issue of contagion is the issue of "large" speculators. Large speculators, like George Soros or Julian Robertson, have been blamed not only for destabilizing the market unnecessarily during the turmoil of contagious currency crises but also for triggering these contagious crises by themselves. For instance, during the turmoil of the Asian Flu, the then prime minister of Malaysia, Mahathir Mohamad, accused George Soros and others of being "the anarchists, self-serving rogues and international brigandage".[5] There are two main reasons that these large speculators are often blamed. First, they are considered to be able to affect the whole market to some degree. As opposed to small traders, they can exercise a disproportionate influence on the likelihood and severity of a financial crisis by fomenting and orchestrating attacks against weakened currency pegs, as the opening quote of this paper suggests. Second, their personal funds are often registered in so-called tax havens, typically small islands in the Caribbean, Europe, and the Asia Pacific region. These "offshore" funds typically do not forward financial information about themselves to other tax and financial authorities, since regulation in the tax havens is often less stringent than that of major industrialized countries. Therefore, these speculators are often thought of as "monsters" whose true nature is unknown. Regardless of whether this is factually correct, it is important to investigate how such speculators can affect the market during contagious currency crises.

Following recent financial crises, the issue of contagion and that of large speculators have been arguably the most serious concerns for policy makers in international finance. Recent international policy discussions have revolved around questions on how to stop, mitigate, or prevent contagion of financial crises in the presence of George Soros-like speculators. In order to answer these questions, it is important to clarify two things: the possible channels for contagion, and the influence of large speculators on the spread of financial crises.

This paper attempts to answer these questions. To the author's knowledge, this work is the first to investigate within a unified framework the issue of contagion across unrelated countries and that of a large speculator. By investigating these issues together, it

[5] Financial Times, July 25, 1997.

becomes clear that the presence of the large speculator, who typically does not disclose financial information about himself to the regulatory authorities or to the market, plays an important role during a contagious currency crisis. The large speculator's financial information (i.e., his "type") is private information. However, under some special situations such as financial crises, this private information is revealed to the market to a limited degree. This revealed information about his "type" can change the optimal behavior of other speculators who did not know the information before the crisis, which in turn can cause contagion of crises across unrelated countries.

The main findings of this paper are summarized as follows.

First, a single large speculator ("George Soros") *mitigates* contagion compared with small speculators, because he makes other small speculators more aggressive in attacking the currency peg. This seems paradoxical, but can be explained as follows. I model contagion using Bayesian updating to portray each speculator's belief about other speculators' types. When other speculators' behavior differs greatly, the change in behavior due to Bayesian updating becomes quite large, which in turn makes the contagion more severe. Because one "George Soros" makes other small speculators more aggressive in attacking the currency peg, speculators' behavior converges even when their types are different. This means that Bayesian updating in each speculator's belief about other speculators' types does not matter much. Even when a speculator can distinguish between different types of speculator, it is inconsequential since speculators of different types behave in a similarly aggressive way owing to the presence of a single "George Soros".

Second, if the regulatory authorities can have large speculators such as George Soros disclose their financial information, they can eliminate contagion but may make countries *more vulnerable* to crises. This follows immediately from point two above. If small speculators know the exact type of Soros from the beginning owing to financial disclosure, there is no room for Bayesian updating in beliefs about the Soros' type. In my model, no Bayesian updating means no contagion. However, if small speculators initially know that Soros is truly the most aggressive type, they can mimic this aggression by attacking the currency peg, which makes countries more vulnerable to crises.

Third, if the regulatory authorities can limit the size of speculators by regulating the amount of short selling, they can make countries less vulnerable to crises but may make contagion *more severe*. This is a mirror image of the finding that one large "George Soros" makes countries more vulnerable to crises, but mitigates contagion.

The remainder of this paper is organized as follows. Section 2 reviews the literature. Section 3 presents the model and Section 4 concludes. All proofs are presented in the Appendix.

2 Related Literature

In the literature, several studies argue that contagion across seemingly unrelated countries may be explained as jumps between multiple equilibria: a crisis in one country may work as a sunspot that leads to a self-fulfilling crisis in another unrelated country.[6] Multiple equilibria models of crises, however, provide only a feeble explanation of contagion, as they are consistent with other outcomes, including the absence of contagion. In contrast with multiple equilibria models, Taketa (2004) uses the global game approach pioneered by Carlson and van Damme (1993). They propose methods of equilibrium refinement that enable us to explain how and why a particular equilibrium can be selected. Using this type of equilibrium refinement technique, Taketa (2004) provides a new explanation for contagion. However, Taketa (2004) does not consider the implications of the presence of a large speculator. This paper extends Taketa (2004) to study this issue.

The closest studies to this paper are Corsetti, Pesenti, and Roubini (2002) and Corsetti, Dasgupta, Morris, and Shin (2004). They use the global game approach to consider implications of the existence of a large speculator in a currency crisis. One of the important differences between their papers and this one is that this paper studies the implications of the presence of a large speculator in a *contagious* currency crisis.

[6]See Furman and Stiglitz (1998), Tornell (1999), Krugman (1999) and Masson (1999a,b) among others.

3 The Model

Assume that there are two countries: country A and country B. The government of each country pegs the currency at some level. The economy in each country is characterized by a state of underlying economic fundamentals, θ_j $(j = A, B)$. A high value of θ_j refers to good fundamentals while a low value refers to bad fundamentals. I assume that θ_j is randomly drawn from the real line, with each realization equally likely. Also, there is no linkage of economic fundamentals between country A and country B: θ_A and θ_B are independent.

Now assume that there are two groups of speculators, group 1 and group 2. Group 1 consists of a single large speculator, "George Soros".[7] Group 2 consists of a continuum of small speculators, so that each individual speculator's stake is negligible as a proportion of the whole. The distinguishing feature of the large speculator is that he has access to a sufficiently large line of credit in the domestic currency to take a short position up to the limit of λ: he can change speculative pressure independently. On the other hand, each small speculator in group 2 cannot do so. Because Soros does not disclose financial information about himself (i.e., his "type"), his type is private information.[8] There are two possible types: one type is the "bull Soros" with probability q while another type is the "chicken Soros" with probability $1 - q$. The size of group 1 is λ while that of group 2 is $1 - \lambda$, where $0 \leq \lambda \leq 1$.

Receiving the possibly noisy private signal about economic fundamentals, a speculator decides whether to short sell the currency, i.e., to attack the currency peg. I envisage short selling as consisting of borrowing domestic currency and selling it for dollars . If the attack is successful (i.e., the peg is abandoned), he gets a fixed payoff D (> 0). Attacking the currency, however, also incurs a cost $c + \mu_1$ (> 0). The cost $c + \mu_1$ can be viewed as the borrowing cost of domestic currency, plus the transaction cost. If a speculator refrains from attacking the currency, he neither gains nor loses. (See Table 1.) μ_1 captures the idiosyncratic difference of the cost between the bull and the chicken: $\mu_1 = 0$ for the bull

[7] In Taketa (2004), group 1 consists of a continuum of small speculators, rather than a single Soros.

[8] Remember that large speculators, either hedge fund or offshore fund, do not typically reveal financial information.

and $\mu_1 = \mu > 0$ for the chicken. To make the model more interesting, I assume that a successful attack is profitable for any speculator: $D - c - \mu_1 > 0$.

Whether the current exchange rate parity is viable depends on the strength of the economic fundamentals and the incidence of speculative attack against the peg. The incidence of speculative attack is measured by the mass of speculators attacking the currency in the foreign exchange market. Denoting by l_j the mass of speculators attacking the currency peg of country j, the currency peg fails if and only if

$$l_j \geq \theta_j. \tag{1}$$

So, when the economic fundamentals are sufficiently strong (i.e., $\theta_j > 1$), the currency peg is maintained irrespective of the actions of the speculators. When $\theta_j \leq 0$, the peg is abandoned even in the absence of a speculative attack. The most interesting range is the intermediate case when $0 < \theta_j \leq 1$. Here the government is forced to abandon the peg if a sufficient proportion of speculators attacks the currency, whereas the peg will be maintained if a sufficient proportion of speculators choose not to attack. This tripartite classification of fundamentals follows Obstfeld (1996). Following, I call it a crisis if the government abandons the peg and no crisis if the government defends the peg. Although I do not model explicitly the decision of the monetary authorities to relinquish the peg, it may be useful to think of the above rule as indicating that the government defends the currency peg if and only if the cost of this action is not too high. This cost is increasing in l_j and decreasing in θ_j. If, for instance, speculative pressure is very high (i.e., l_j is very large), the government may need to increase interest rates quite sharply in order to defend the peg, which will be detrimental to the country. Thus the cost of defending is increasing in l_j. However, if the economic fundamentals are good, the government may have sufficient foreign reserves to defend the peg so that it may not have to raise the interest rates as sharply. This means that the negative effect of defending the peg on the country will be relatively mild. Therefore the cost of defending is decreasing in θ_j. $l_j - \theta_j$ can be thought of as the net cost of defending the peg such that the peg is abandoned if and only if the net cost is positive.

Although speculators do not observe the realization of θ_j, they receive informative private signals about it. When the true state is θ_j, a speculator i observes a signal $x_{ji} = \theta_j + \epsilon_{ji}$ that is drawn uniformly from the interval $[\theta_j - \epsilon, \theta_j + \epsilon]$, for some small positive ϵ. Conditional on θ_j, the signals are i.i.d. across individuals. Note that there is no difference, at least in terms of precision, between Soros' private signal and small speculators' private signals. In the model, the only difference between one Soros and the small speculators is their size. In order to focus on the size effect as clearly as possible, I exclude the possibility that Soros has "better" information about economic fundamentals than the small speculators.

As regards speculators' preferences, the expected utility of attacking the currency of the country j conditional on her private signal is the following.

$$U = \begin{cases} \text{Prob}\,[l_j \geq \theta_j |\, x_{ji}]\, D - c - \mu & \text{if a speculator is the chicken.} \\ \text{Prob}\,[l_j \geq \theta_j |\, x_{ji}]\, D - c & \text{if a speculator is the bull.} \end{cases}$$

Here $\text{Prob}\,[l_j \geq \theta_j |\, x_{ji}]$ is the probability that her attack is successful conditional on her private signal.

The timing of the game is structured as follows.

- Period 1
  - Nature chooses each value of θ_A and θ_B independently, as well as Soros' type. Soros is chosen to be a bull with probability q or a chicken with probability $1-q$ $(0 < q < 1)$. The value of θ_j is known to the government of country j. The type of Soros is known to Soros himself, but is not known to any speculator in group 2.
  - Each speculator receives a *private* signal $x_{Ai} = \theta_A + \epsilon_{Ai}$.
  - Each speculator decides whether or not to attack the currency of country A.
  - The government of country A abandons the peg if $l_A - \theta_A \geq 0$ and defends the peg otherwise.

- The aggregate outcome in country A and the value of θ_A are known to all speculators. If the attack is successful, those who attacked get $D - c - \mu_1$. If the attack is not successful, their payoff is $-c - \mu_1$. The payoff of those who did not attack is zero.

- Period 2

  - Each speculator receives a private signal $x_{Bi} = \theta_B + \epsilon_{Bi}$.
  - Each speculator decides whether or not to attack the currency of country B.
  - The government of country B abandons the peg if $l_B - \theta_B \geq 0$ and defends the peg otherwise.
  - The aggregate outcome in country B and the value of θ_B are known to all speculators. If the attack is successful, those who attacked get $D - c - \mu_1$. If the attack is not successful, their payoff is $-c - \mu_1$. The payoff of those who did not attack is zero. (See Figure 1.)

Before investigating the case $\epsilon > 0$, consider the case where there is no noise in the signal: $\epsilon = 0$. Two observations are worth noting.

First, as mentioned earlier, there are multiple equilibria when $0 < \theta_j \leq 1$. In this case, the crisis is the equilibrium in country A if all the speculators coordinate an attack, while no crisis is the equilibrium in country A if no speculator attacks.

Second, there is no significant difference in terms of equilibrium selection between the chicken Soros and the bull Soros. If Soros' attack is successful, he earns positive profits regardless of his type: the chicken Soros earns $D - t - \mu > 0$ and the bull Soros earns $D - t > 0$. Therefore, if every speculator in group 2 attacks the peg, it is optimal for Soros to attack regardless of his type, as long as $\theta_A \leq 1$.

Both of these observations raise obstacles to the objective of this paper. The multiplicity of equilibria in the first observation is not well suited to determining whether crises in two countries are due to coincidence or contagion. Even worse, the second observation means that, as long as $D - t - \mu > 0$, multiple equilibria models cannot capture any implications about the fact that the large speculator does not disclose his type information.

For the purpose of this paper, it must be determined which particular equilibrium, the crisis or no crisis, will arise—and under what conditions.

A feature already familiar from the discussion of global games in the literature is that when $\epsilon > 0$, the realization of θ_j will not be common knowledge among the speculators. The global game approach has shown that in this case the switching strategy is the only equilibrium strategy.[9] The equilibrium strategy consists of the following five switching values conditional on group 1's type and the information structure: a switching value of economic fundamentals below which an attack by the small speculators alone is sufficient to break the peg ($\underline{\theta}_j$), a switching value of economic fundamentals at which an attack is successful if and only if Soros as well as the small speculators participate in the attack ($\bar{\theta}_j$), a switching signal conditional on Soros' type below which he attacks the peg ($\bar{x}_{j1}(\mu_1 = 0)$ and $\bar{x}_{j1}(\mu_1 = \mu)$) and a switching signal below which the small speculator attacks the peg ($\bar{x}_{j2}$).

In order to explain intuitively how and why the crisis in country A triggers the crisis in country B, I explain first what occurs in country A and then what occurs in country B. In the following, I explain as if I derive the Nash equilibrium in each period, rather than the subgame perfect equilibrium in two periods. This will turn out to be a useful building block to prove the subgame perfect equilibrium in two periods, because the sequence of what is explained in Subsection 3.1 and 3.2 is indeed the subgame perfect equilibrium. Of course, I can explain the game by the usual method of backward induction, proceeding from what occurs in country B to what occurs in country A. Rather than giving such an explanation in the main text, I give the proof by backward induction in the appendix.

3.1 Equilibrium in Country A

Suppose that each small speculator in group 2 follows a symmetric trigger strategy around a switching signal $\bar{x}_{A2}$ below which he attacks the currency peg of country A. Because there is a continuum of small speculators in group 2, conditional on θ_A, there is no aggre-

[9] Heinemann, Hagel, and Ockenfels (2004) conduct an experiment to test the predictions of the theory of global games. They conclude that the global game solution (the switching strategy) is an important reference point and provides correct predictions for comparative statics with respect to parameters of the payoff function.

gate uncertainty about the proportion of small speculators attacking the currency. Since $\text{Prob}\,[x_{A2} \le \bar{x}_{A2} |\, \theta_A]$ is the proportion of small speculators observing a signal lower than $\bar{x}_{A2}$ and therefore attacking country A at θ_A, an attack by small speculators alone is sufficient to break the peg at θ_A if $(1-\lambda)\text{Prob}\,[x_{A2} \le \bar{x}_{A2} |\, \theta_A] \ge \theta_A$. From this, I can define a critical value of economic fundamentals below which an attack by the small speculators alone is sufficient to break the peg. Let $\underline{\theta}_A$ be defined as follows.

$$\begin{aligned} \underline{\theta}_A &= (1-\lambda)\text{Prob}\,[x_{A2} \le \bar{x}_{A2} |\, \underline{\theta}_A] \\ &= (1-\lambda)\frac{\bar{x}_{A2} - \underline{\theta}_A}{2\epsilon} \end{aligned} \tag{2}$$

Notice that I exploit here the assumption of a uniform noise distribution. When θ_A is below $\underline{\theta}_A$, the attack is successful regardless of Soros' action.

Next, consider the additional speculative pressure due to Soros. If the small speculators follow the trigger strategy around $\bar{x}_{A2}$, the incidence of attack at θ_A attributable to the small speculators is $(1-\lambda)\text{Prob}\,[x_{A2} \le \bar{x}_{A2} |\, \theta_A]$. If Soros also chooses to attack, then there is an additional λ to this incidence. Hence, when Soros participates in the attack, the peg is broken if $\lambda + (1-\lambda)\text{Prob}\,[x_{A2} \le \bar{x}_{A2} |\, \theta_A] \ge \theta_A$. Thus, the critical value of economic fundamentals at which an attack is successful if and only if Soros participates in the attack is defined as follows.

$$\begin{aligned} \bar{\theta}_A &= \lambda + (1-\lambda)\text{Prob}\left[x_{A2} \le \bar{x}_{A2} |\, \bar{\theta}_A\right] \\ &= \lambda + (1-\lambda)\frac{\bar{x}_{A2} - \bar{\theta}_A}{2\epsilon} \end{aligned} \tag{3}$$

As is evident from (2) and (3), $\bar{\theta}_A$ lies between $\underline{\theta}_A$ and 1. (See Figure 3.)

Although the notations do not make it explicit, both $\underline{\theta}_A$ and $\bar{\theta}_A$ are functions of the switching signal $\bar{x}_{A2}$. In turn, $\bar{x}_{A2}$ will depend on Soros' switching signal $\bar{x}_{A1}(\mu_1)$—which is conditional on Soros' type. The task is to solve for these three switching signals ($\bar{x}_{A1}(\mu_1 = 0)$, $\bar{x}_{A1}(\mu_1 = \mu)$, and $\bar{x}_{A2}$) simultaneously from the respective optimization problems of the speculators.

To do this, first consider Soros' optimal switching strategy. Soros observes signal x_{A1}

and assigns probability Prob $\left[\theta_A \leq \bar{\theta}_A \middle| \, x_{A1}\right]$ to the event that $\theta_A \leq \bar{\theta}_A$. Therefore, his (gross) expected payoff to attacking conditional on x_{1A} is Prob $\left[\theta_A \leq \bar{\theta}_A \middle| \, x_{A1}\right] D$. His optimal strategy is to attack if and only if $x_{A1} \leq \bar{x}_{A1}(\mu_1)$, where $\bar{x}_{A1}(\mu_1)$ is defined by:

$$\text{Prob}\left[\theta_A \leq \bar{\theta}_A \middle| \, \bar{x}_{A1}(\mu_1)\right] D = c + \mu_1 \tag{4}$$

From (4) and the assumption that the noise is distributed uniformly, the two equations for the two possible values of μ_1 are as follows.

$$\frac{\bar{x}_{A1}(\mu_1 = 0) - \bar{\theta}_A}{2\epsilon} = 1 - \frac{c}{D} \tag{5}$$

$$\frac{\bar{x}_{A1}(\mu_1 = \mu) - \bar{\theta}_A}{2\epsilon} = 1 - \frac{c + \mu}{D} \tag{6}$$

Second, consider the small speculators' optimal switching strategy. Note that the speculators in group 2 do not know Soros' type. Let p_h $(1 - p_h)$ be their belief in period h $(h = 1, 2)$ that Soros' type is $\mu_1 = 0$ $(\mu_1 = \mu)$. It can be shown that the indifference condition for the small speculators implies the following.

$$\begin{aligned} 1 - \frac{\bar{x}_{A2} - \underline{\theta}_A}{2\epsilon} &+ \frac{p_1}{4\epsilon^2}\left(\bar{x}_{A1}(\mu_1 = 0)\bar{\theta}_A - \frac{(\bar{\theta}_A)^2}{2} - \bar{x}_{A1}(\mu_1 = 0)\underline{\theta}_A + \frac{(\underline{\theta}_A)^2}{2}\right) \\ &+ \frac{1 - p_1}{4\epsilon^2}\left(\bar{x}_{A1}(\mu_1 = \mu)\bar{\theta}_A - \frac{(\bar{\theta}_A)^2}{2} - \bar{x}_{A1}(\mu_1 = \mu)\underline{\theta}_A + \frac{(\underline{\theta}_A)^2}{2}\right) = \frac{c}{D} \end{aligned} \tag{7}$$

There are five equations, (2), (3), (5), (6), and (7) and there are five switching values, $\underline{\theta}_A$, $\bar{\theta}_A$, $\bar{x}_{A1}(\mu_1 = 0)$, $\bar{x}_{A1}(\mu_1 = \mu)$, and $\bar{x}_{A2}$. One can solve these five equations for five switching values explicitly. (See Figure 2 and Figure 3.)

Clearly all five switching values are functions of p_1, the belief of the small speculators about Soros' type. As it turns out, the following lemma is particularly important in considering contagion.

Lemma 1 *All the switching values are increasing in p_1.*

The intuition behind Lemma 1 is simple. Because of the strategic interaction between Soros and the small speculators, the optimal behavior of the small speculators depends on the aggressiveness of Soros. In particular, it is optimal for the small speculator to be more aggressive in attacking the peg when Soros is more aggressive. It can be shown that Soros is more aggressive in attacking the currency when $\mu_1 = 0$ than when $\mu_1 = \mu$: $\bar{x}_{A1}(\mu_1 = 0) > \bar{x}_{A1}(\mu_1 = \mu)$. Therefore, the small speculators are more aggressive when they assign the larger probability p_1 to the event that Soros is more aggressive. Thus $\bar{x}_{A2}$ is increasing in p_1. In turn, when the small speculators are more aggressive, Soros becomes more aggressive because of the strategic interaction between Soros and the small speculators. It implies that $\bar{x}_{A1}(\mu_1 = 0)$ and $\bar{x}_{A1}(\mu_1 = \mu)$ are increasing in p_1. When both the small speculators and Soros become more aggressive, country A is more vulnerable to the currency crisis. Thus $\underline{\theta}_A$ and $\bar{\theta}_A$ are increasing in p_1.

In the rational expectation equilibrium, $p_1 = q$. Using this, the equilibrium in country A can be described as follows. (See Table 2)

Proposition 1 (Unique Equilibrium in Country A)
The unique switching strategy equilibrium in country A consists of the switching values evaluated at $p_1 = q$.

The model has considered the "one-Soros" case where group 1 consists of a single Soros. In order to study how a large Soros makes a difference, consider the "no-Soros case" where group 1 consists of a continuum of small speculators, instead of a single Soros. In the no-Soros case, all the speculators in group 1 are bulls with probability q and chickens with probability $1 - q$.

Definition 1 (One-Soros Case)
The one-Soros case is the case where group 1 consists of a single large Soros and he is a bull (a chicken) with probability q $(1 - q)$.

Definition 2 (No-Soros Case)
The no-Soros case is the case where group 1 consists of a continuum of small speculators and all of them are bulls (chickens) with probability q $(1 - q)$.

Thus the only difference in set-up between the one-Soros case and the no-Soros case is whether group 1 consists of a single large speculator or a continuum of small speculators.

It is the same for both cases that all the speculators in group 1 are bulls (chickens) with probability q $(1-q)$ and their type is private information.

The equilibrium differences between the one-Soros case and the no-Soros case can be clarified by comparing the switching values. The difference can be summarized as follows.

Proposition 2 (Soros Makes Country A More Vulnerable to Crisis)

(i) Each speculator is more aggressive in attacking the currency in the one-Soros case than in the no-Soros case.

(ii) Country A is more vulnerable to the crisis in the one-Soros case than in the no-Soros case.

Proposition 2 is essentially the same finding in the absence of contagion, as that of Corsetti, Pesenti, and Roubini (2002) and Corsetti, Dasgupta, Morris, and Shin (2004). This paper shows that this finding leads to a surprising result in terms of contagion, which is explained next.

3.2 Equilibrium in Country B and Contagion

In this subsection, I show the equilibrium in country B and how contagion can occur under certain conditions. Contagion occurs owing to group 2's Bayesian updating of Soros' type.

In period 2, Soros and the small speculators observe what occurred in country A and the economic fundamentals θ_A. What occurred in country A reveals partial information about Soros' type. Thus after observing what occurred in country A, the small speculators sometimes, if not always, update their belief about Soros' type. Their Bayesian updating can be summarized as follows.

Lemma 2 (Bayesian Updating about the Type of Soros)

(i) For any $\theta_A \notin \left[\underline{\theta}_A, \bar{\theta}_A\right]$, no Bayesian updating occurs: $p_2 = p_1 = q$.

(ii) For any $\theta_A \in \left[\underline{\theta}_A, \bar{\theta}_A\right]$, Bayesian updating occurs.

(a) If a crisis occurred in country A, $p_2 = p_2^C > p_1 = q$.

(b) If a crisis did not occur in country A, $p_2 = p_2^{NC} < p_1 = q$.

Here p_2^{C} is the updated belief of group 2 about Soros' type when a crisis occurred in country A and p_2^{NC} is the updated belief of group 2 about Soros' type when no crisis occurred in country A. For any $\theta_A \leq \underline{\theta}_A$, a crisis occurs in country A with probability one, regardless of Soros' type. Therefore, what occurred in country A when $\theta_A \leq \underline{\theta}_A$, provides no information about Soros' type. For any $\theta_A \geq \bar{\theta}_A$, the crisis will never occur in country A, regardless of Soros' type. Therefore, what occurred in country A when $\theta_A \geq \bar{\theta}_A$ provides no information about Soros' type either. This leads to no Bayesian updating for any $\theta_A \notin [\underline{\theta}_A, \bar{\theta}_A]$. However, for any $\theta_A \in [\underline{\theta}_A, \bar{\theta}_A]$, the crisis occurs in country A *only if Soros attacks.* Soros attacks country A if and only if he observes a private signal smaller than or equal to a type-conditional switching signal. Notice that Soros is more likely to attack when $\mu_1 = 0$ than when $\mu_1 = \mu$. Therefore, the occurrence of the crisis in country A tells the small speculators that if Soros attacks, he is more likely to be the bull ($\mu_1 = 0$). In other words, the occurrence of the crisis in country A provides some information about Soros' type for any $\theta_A \in [\underline{\theta}_A, \bar{\theta}_A]$. Thus Bayesian updating occurs for any $\theta_A \in [\underline{\theta}_A, \bar{\theta}_A]$. Substituting p_2 in switching values, one can obtain the equilibrium in country B. (See Table 3 and Table 4.)

Proposition 3 (Unique Equilibrium in Country B)

The unique switching strategy equilibrium in country B consists of the switching values evaluated at p_2 given in Lemma 2.

It is worth noting that the switching strategy equilibrium in country B depends on what has occurred in country A, even though these countries are totally unrelated in terms of the economic fundamentals.[10] Under a certain range of economic fundamentals of country A, the small speculators update their beliefs of Soros' type. The optimal behavior of the small speculators depends on their beliefs about Soros' type, so that Bayesian updating of their beliefs leads to the change in their optimal behavior. When their optimal behavior changes, Soros' optimal behavior also changes because of the strategic interaction between

[10]See the appendix for proof that the sequence of Proposition 1 and Proposition 3 is indeed the subgame perfect equilibrium.

the small speculators and Soros. It is this fact that leads to contagion from country A to country B, despite the fact that the economic fundamentals are unrelated. Proposition 4 describes the conditions under which contagion occurs and how the optimal behavior of Soros and the small speculators changes.

Proposition 4 (Contagion across Unrelated Countries)

(i) For any $\theta_A \notin \left[\underline{\theta}_A, \bar{\theta}_A\right]$, contagion does not occur.

(ii) For any $\theta_A \in \left[\underline{\theta}_A, \bar{\theta}_A\right]$, contagion occurs.

It can be shown that $\bar{\theta}_B(p_2 = p_2^{\mathrm{NC}}) < \bar{\theta}_B(p_2 = p_2^{\mathrm{C}})$. Proposition 4 states that when $\theta_B \in [\bar{\theta}_B(p_2 = p_2^{\mathrm{NC}}), \bar{\theta}_B(p_2 = p_2^{\mathrm{C}})]$, contagion can occur: the crisis can occur in country B if and only if the crisis occurs in country A. On the one hand, if the crisis did not occur in country A for any $\theta_A \in \left[\underline{\theta}_A, \bar{\theta}_A\right]$, Soros did not attack—implying that Soros is more likely to be the chicken. Therefore, the small speculators become less aggressive. In this case, the switching economic fundamentals are $\bar{\theta}_B(p_2 = p_2^{\mathrm{NC}})$. Thus the crisis cannot occur in country B if $\bar{\theta}_B(p_2 = p_2^{\mathrm{NC}}) < \theta_B$. On the other hand, if the crisis occurred in country A for any $\theta_A \in \left[\underline{\theta}_A, \bar{\theta}_A\right]$, Soros attacked—implying that Soros is more likely to be the bull. So the small speculators become more aggressive. In this case, the switching economic fundamentals are $\bar{\theta}_B(p_2 = p_2^{\mathrm{C}})$. Thus the crisis can occur in country B if $\theta_B < \bar{\theta}_B(p_2 = p_2^{\mathrm{C}})$. In fact, the crisis occurs if Soros attacks. (See Figure 4.)

Proposition 4 gives an explanation as to what kind of currency crisis is contagious. That is, it shows that not all currency crises are contagious. Moreover, it explains why one currency crisis is contagious and another is not contagious. For any $\theta_A \leq \underline{\theta}_A$, the crisis occurs in country A, but it is not contagious. Put another way, if the crisis occurs in both country A and country B for any $\theta_A \leq \underline{\theta}_A$, it is just a coincidence. This is because, in this case, the Bayesian updating does not occur. That is, the crisis in country B is not triggered by the crisis in country A. In sum, the model can distinguish between a coincidence and contagion when the crisis occurs in both countries.

This contrasts sharply with the literature. The common implication in the literature is that poor economic fundamentals in the originating crisis country (country A) lead to increased risk of contagion. This is because the literature has been exploring the transmission mechanism through which *the negative effect of bad economic fundamentals* of the originating crisis country would spread. If countries are related in terms of economic fundamentals such as financial or trade linkages, the negative effect of the crisis would hit them through these linkages. In each of the causes studied to date, the worse the economic fundamentals of country A, the larger the negative effect of the crisis on linked countries. However, this fails to explain why the Argentine financial crisis in 2002 was *not* very contagious. This is a puzzle, because the economic fundamentals of Argentina during and after the crisis were arguably much worse than those of the Asian countries during the Asian Flu. According to the common implication of the literature, the Argentine financial crisis should have been contagious if the Asian Flu were contagious. As it turned out, the Argentine financial crisis was not very contagious. The model in this paper gives a possible answer to this puzzle: the *better* the economic fundamentals of the originating crisis country (country A), the more contagious the crisis. If the currency crisis occurs where economic fundamentals are very poor (e.g., in Argentina in 2002), nobody is surprised by the crisis, so that no Bayesian updating occurs, and no contagion occurs. However, if the currency crisis occurs where economic fundamentals are considered to be good (e.g., in Asia in 1997), it is a big surprise and the crisis can even spread to unrelated counties. In sum, the model shows that if there is no surprise, there is no contagion. Hausmann and Velasco (2003) argue that

> "Argentina's was not a crisis that caught people surprise. Instead, it was a protracted affair that, as it was marched inexorably towards a catastrophic demise, attracted the attention of some of the best minds in Washington, Wall Street and Buenos Aires for months on end. During this long agony, many well-trained economists proposed various diagnostics and innovative policy initiatives; the country's much-maligned politicians and parties supported austerity policies (such as cutting nominal public sector wages) that would be very hard to swallow in most democratic societies; and, until late in the game, the international community provided ample financial support. Yet the catastrophe

proved impossible to avoid." (p.59)

The model adds "Bayesian updating by speculators" to the argument of Hausmann and Velasco (2003) and thereby gives a potential answer to the puzzle: because the Argentine financial crisis did not surprise the market (i.e., it caused no Bayesian updating in the market), it was not very contagious.

Notice that contagion can occur even when group 1 consists of small speculators rather than a single large speculator.[11] The contagion channel is the Bayesian updating of group 2, so that contagion occurs as long as the currency crisis in country A reveals the type of group 1 to some degree, regardless of whether group 1 consists of one Soros or small speculators. However, contagion in the one-Soros case is not necessarily identical to that in the no-Soros case. In the next subsection, I explain the difference.

3.3 Severity of Contagion

In this subsection, I consider the severity of contagion and how Soros' presence affects it. To my knowledge, this paper is the first to study the severity of contagion theoretically.

First of all, a definition of severity of contagion is needed. Thus I propose the following two definitions.

Definition 3 (Relative Severity of Contagion)
Contagion is more severe in relative terms, when $\tilde{\theta}_B(Y_A = 1) - \tilde{\theta}_B(Y_A = 0)$ *is larger.*

Definition 4 (Absolute Severity of Contagion)
Contagion is more severe in absolute terms, when $\tilde{\theta}_B(Y_A = 1)$ *is larger.*

The relative severity of contagion looks at an *additional increase* in the switching value of the economic fundamentals below which the crisis occurs in country B, owing to the occurrence of the crisis in country A. The larger the additional increase, the more likely it is that country B suffers from contagion. Therefore, the additional increase is thought of as a criterion for the severity of contagion. The absolute severity of contagion looks at the *size* of the switching value of the economic fundamentals below which the crisis occurs in

[11] See Taketa (2004).

country B, after the crisis occurs in country A. The larger the size, the more likely it is that country B suffers from contagion. Therefore, the size is also thought of as a criterion for the severity of contagion. According to these two criteria and contrary to common intuition, the model shows that Soros mitigates contagion. (See Figure 5.)

Proposition 5 (Soros Mitigates Contagion)

(i) Contagion is more severe in relative terms in the no-Soros case than in the one-Soros case.

(ii) Contagion is more severe in absolute terms in the no-Soros case than in the one-Soros case, provided that Soros is not too large.

To see the intuition, first note that the speculators as a whole, in groups 1 and 2, affect the market, but their behavior is conditional on their types. Thus what occurs in country A provides information about group 1's type. It is important to note that $\bar{\theta}_A$ *is unique as long as* $\bar{x}_{A2}$ *is unique—as evident from (3).* Put another way, $\bar{\theta}_A$ is the same regardless of nature's choice of μ_1. This is the distinguishing feature of the one-Soros case. On the other hand, in the no-Soros case, there are *two* counterparts to $\bar{\theta}_A$. To see this, note that, in the no-Soros case, group 1 does not consist of a single large speculator, but rather many small speculators. Thus, a counterpart to $\bar{\theta}_A$ in the no-Soros case, $\bar{\bar{\theta}}_A$, is defined by

$$\begin{aligned}\bar{\bar{\theta}}_A(\mu_1) &= \lambda \text{Prob}\left[x_{A1} \leq \bar{\bar{x}}_{A1}(\mu_1) | \; \bar{\bar{\theta}}_A(\mu_1)\right] + (1-\lambda)\text{Prob}\left[x_{A2} \leq \bar{\bar{x}}_{A2} | \; \bar{\bar{\theta}}_A(\mu_1)\right] \\ &= \lambda \frac{\bar{\bar{x}}_{A1}(\mu_1) - \bar{\bar{\theta}}_A(\mu_1)}{2\epsilon} + (1-\lambda)\frac{\bar{\bar{x}}_{A2} - \bar{\bar{\theta}}_A(\mu_1)}{2\epsilon} \qquad (8)\end{aligned}$$

where $\bar{\bar{x}}_{A1}(\mu_1)$ is the switching signal *conditional on the type of group 1* ($\mu_1 = \mu$ or 0), and $\bar{\bar{x}}_{A2}$ is the switching signal of group 2 in the no-Soros case, respectively. Clearly, $\bar{\bar{\theta}}_A$ takes a different value when the switching signal of group 1 takes a different value: $\bar{\bar{\theta}}_A(\mu_1 = 0)$ and $\bar{\bar{\theta}}_A(\mu_1 = \mu)$. Therefore, there are *two* values of $\bar{\bar{\theta}}_A$, depending on the type of group 1 in the no-Soros case. Thus in the no-Soros case, group 1 as a whole would affect the market proportionately to its type, as can be seen in (8). However, if it consists of the single large speculator Soros (i.e., the one-Soros case), it would affect the market *disproportionately* to its type, as can be seen in (3). Therefore, *what occurs in country A provides more information about group 1's type in the no-Soros case than in the one-Soros case*. Remember that the contagion channel in the model is the Bayesian updating by group 2 about group 1's type. Large Bayesian updating leads to large $p_2 - p_1$. In turn, the large $p_2 - p_1$ leads to severe contagion. Owing to events in country A, more information is available about group 1's type in the no-Soros case than in the one-Soros case. In other words, $p_2 - p_1$ is larger in the no-Soros case than in the one-Soros case. This fact leads to Proposition 5.

3.4 Policy Implications

Recently two policy issues have concerned international financial policy makers: financial disclosure and size regulation of hedge funds. These issues correspond to two distinguishing features of hedge funds: they are not required to report financial information and they are highly leveraged. However, these features have rarely been investigated. Thus in this subsection, I consider the implications of financial disclosure and size regulation.

Proposition 6 (Financial Disclosure) *Financial disclosure of the type of Soros eliminates contagion, but may make countries more vulnerable to crises.*

The intuition behind Proposition 6 is the following. Notice that the contagion channel in this paper is the small speculators' Bayesian updating about the type of Soros. If financial disclosure reveals Soros' type completely in period 1, no Bayesian updating occurs in period 2 because the small speculators already know Soros' type in period 1. Therefore no contagion occurs. However, if financial disclosure reveals that Soros is the bull, the small speculators do not need to worry about the possibility that Soros is the chicken. Thus they become aggressive, which makes countries more vulnerable to crises.

Proposition 7 (Size Regulation) *Regulating the size of speculators makes countries less vulnerable to crises, but makes contagion more severe.*

Proposition 7 is a direct result of Proposition 2 and Proposition 5. Owing to the mere presence of Soros, small speculators become more aggressive, which makes countries more vulnerable to crises. Therefore, if the size of Soros is regulated such that group 1 consists of the small speculators like group 2 (i.e., the no-Soros case), both groups 1 and 2 are less aggressive, which makes countries less vulnerable to crises. However, because Soros mitigates contagion, contagion becomes more severe.

3.5 An Application of the Model to the LTCM Story

The financial crisis partially reveals the large player's "type" under certain conditions and thereby changes the optimal behavior of other players—potentially leading to contagion. These are precisely the circumstances surrounding the Long-Term Capital Management (LTCM) during the Russian Virus. LTCM is perhaps the most infamous hedge fund[12] in history. On the one hand, it was famous because it had on staff a group of people soon dubbed the "dream team". For example, it was made up of two Nobel prize-winning economists, several legendary Wall Street traders, and a prior vice-chairman of the U.S. Federal Reserve. On the other hand, it was infamous because the world financial market was on the verge of complete meltdown during the Russian Virus owing to the near-bankruptcy of LTCM. This was because LTCM was unbelievably large. According to Dunbar (1999),

> "LTCM's derivatives positions amount to a total of $1.25 trillion.... How big is $1.25 trillion? It is roughly the size of Italy's national debt, ... , the same as the entire annual budget of the US government." (pp.190–191)

Given the astronomic size of LTCM's position, the Fed thought that if LTCM went bankrupt, "markets would ... possibly cease to function" (William J. McDonough, the then President of Federal Reserve Bank of New York).[13] Thus, the Fed finally orchestrated the private-sector bail-out of LTCM. No doubt LTCM was one of the key players during the Russian Virus. It was also one of the reasons why the Russian Virus became so contagious. For example, before the Russian Virus, LTCM had been a secrecy-obsessed

[12] Hedge funds are typically organized as private investment vehicles for wealthy individuals and institutional investors. Often, if not always, hedge funds are offshore funds that register themselves in tax havens. Both hedge funds and offshore funds are mostly unregulated. Since they circumvent financial disclosure regulations, little is known about them.

[13] See Lowenstein (2000, p.185).

hedge fund. Nobody outside of LTCM knew much about its inner workings. However, during the Russian Virus, the situation changed. Lowenstein (2000) reported that

> "... the partners [of LTCM] noticed an ominous pattern: *their* trades were falling more than others'. There was a rally in junk bonds, for instance, but the specific issues that Long-Term owned stayed depressed.... Wall Street traders were running from Long-Term's trades like rats from a sinking ship.... all Wall Street knew about Long-Term's troubles. Rival firms began to sell in advance of what they feared would be an avalanche of liquidating by Long-Term. 'As people smelled trouble, they started getting out,' ... a trader at Salomon remarked. 'Not to attack LTCM—to save themselves." (pp.163–164)

This is an important point. Before the Russian Virus, traders in the market did not really know how LTCM was going to behave to earn profits or to avoid losses. Thus they were not quite sure whether they should sell securities in which LTCM had positions, because they did not know how and when LTCM would dispose of the positions of those securities. But during the Russian Virus, they learned some new information. LTCM needed to liquidate many of its positions to avoid further losses—meaning that prices would be deeply depressed in those positions. Thus they rushed to sell the same securities before prices fell further. This depressed the prices of securities that seemed totally *unrelated* to Russia. This is one of the contributing factors that translated the Russian financial crisis into the contagious one, the Russian Virus.

Although the model seems distant from the LTCM story, in this subsection I explain how the model of this paper can be applied to capture one aspect of the LTCM story. Before the crisis, no trader outside LTCM knew the "type" of LTCM. But a crisis in some country revealed LTCM's type to some degree and led to Bayesian updating of other traders, which in turn caused the problem to spread to unrelated countries. I do not claim that this "Bayesian updating by speculators" is the sole reason why the Russian financial crisis became contagious or the single factor that triggered contagion. Another contagion channel might have triggered contagion first and several contagion channels could work simultaneously. I claim, however, that this "Bayesian updating about a player's type by other players" may be one of the contributing factors that made contagion more severe in the Russian Virus.

To apply the model to the LTCM case, rename the speculators in the model as foreign creditors (i.e., traders). Soros in the model is now "LTCM". Foreign creditors have invested in both a firm in country A and another firm in country B and have financed a project in each firm. Observing the private signal, a creditor decides whether or not to liquidate her position. If she decides to liquidate, her payoff is $c+\mu_1$ with certainty. Liquidation is a safe choice (corresponding to refraining from attacking the peg in the model). If she decides not to liquidate (i.e., roll over), her payoff depends on two factors: the economic fundamentals, θ_j, and the degree of disruption caused to the project by the early liquidation by creditors. The latter is measured by the proportion of creditors who liquidate, l_j. The project yields the payoff D (i.e., rollover is successful) if $\theta_j \geq l_j$. I call this "No Crisis". If $\theta_j < l_j$, the payoff of rolling over is zero (i.e., roll over fails). That is, if a sufficient proportion of creditors refuse to roll over relative to the economic fundamentals ($\theta_j < l_j$), the project is liquidated entirely and yields nothing.[14] I call this "Crisis". Rollover is a risky choice in that the payoff is uncertain (corresponding to attacking the peg in the model). Notice the similarity of the payoff structure between the speculators' game and the creditors' game (see Table 1 and Table 5).

Indeed, all the reasoning of the speculators' game applies to the creditors' game: the switching strategy equilibrium arises and contagion occurs owing to Bayesian updating about the type of group 1 (LTCM). For any $\theta_A \in \left[\underline{\theta}_A, \bar{\theta}_A\right]$, Crisis occurs in the firm in country A *only if LTCM chooses not to roll over*.[15] LTCM choosing not to roll over is more likely when LTCM is in trouble (owing to the Russian financial crisis, for instance) than otherwise. Observing this, traders in group 2 assign larger probability to the event that LTCM would not roll over in country B (i.e., Bayesian updating occurs). Through the Bayesian updating, Crisis in one country can trigger Crisis in another country even when the economic fundamentals are unrelated.[16]

[14] This formulation is similar to Diamond and Dybvig (1983).
[15] Notice that country A does not have to be Russia.
[16] For the relationship between the speculators' game and the creditors' game, see the appendix.

4 Conclusion

The presence of the large speculator and contagion of currency crises are among the more serious concerns of international financial policy makers. The model in this paper extends that presented in Taketa (2004), where there is no large speculator (the "no-Soros" case), to the "one-Soros" case where there is a large speculator. Distinct from multiple equilibria models, this model endogenously derives a unique threshold value of economic fundamentals of a country below which a currency crisis occurs. It shows that the threshold value depends on events in another *unrelated* country: the threshold value of one country (country B) can increase when a currency crisis occurs in another country (country A), even when those countries do not have related economic fundamentals. This means that the currency crisis can be contagious even when those countries are unrelated. The large speculator is more aggressive in attacking the currency peg than he would be if he were small. Moreover, the mere presence of the large speculator makes other small speculators more aggressive in attacking the currency peg, which in turn makes countries more vulnerable to a currency crisis. However, surprisingly, the presence of the large speculator *mitigates* contagion of crises across countries. The model presents policy implications for financial disclosure and size regulation of speculators such as hedge funds. Two main conclusions are derived. First, financial disclosure of speculators eliminates contagion, but may make countries more vulnerable to crises. Second, regulating the size of speculators (e.g., prohibiting hedge funds from high leverage) makes countries less vulnerable to crises, but makes contagion more severe.

A Derivation of equation (7)

For $\theta_A \leq \underline{\theta}_A$, the speculative attack by the small speculators is successful regardless of Soros' action. For $\underline{\theta}_A \leq \theta_A \leq \bar{\theta}_A$, the peg breaks if and only if both Soros and the small speculators attack. For $\bar{\theta}_A \leq \theta_A$, the peg withstands the attacks, regardless of the action of the small speculators and Soros. Note that the speculators in group 2 do not know Soros' type. Let p_h $(1-p_h)$ be their belief in period h $(h=1,2)$ that Soros' type is $\mu_1 = 0$ $(\mu_1 = \mu)$.

$$
\begin{aligned}
p_1 \times & \text{Prob}\left[\text{Attack is successful when } \mu_1 = 0\right] \\
&\qquad\qquad + (1-p_1) \times \text{Prob}\left[\text{Attack is successful when } \mu_1 = \mu\right] \\
= {} & p_1 \times \Big\{ \text{Prob}\big[\theta_A \leq \underline{\theta}_A \big|\, x_{A2}\big] \\
&\qquad\qquad + \text{Prob}\big[\underline{\theta}_A \leq \theta_A \leq \bar{\theta}_A \text{ and Soros attacks when } \mu_1 = 0 \big|\, x_{A2}\big] \Big\} \\
& + (1-p_1) \times \Big\{ \text{Prob}\big[\theta_A \leq \underline{\theta}_A \big|\, x_{A2}\big] \\
&\qquad\qquad + \text{Prob}\big[\underline{\theta}_A \leq \theta_A \leq \bar{\theta}_A \text{ and Soros attacks when } \mu_1 = \mu \big|\, x_{A2}\big] \Big\} \\
= {} & \text{Prob}\big[\theta_A \leq \underline{\theta}_A \big|\, x_{A2}\big] \\
&\qquad\qquad + p_1 \int_{\underline{\theta}_A}^{\bar{\theta}_A} f(\theta_A |\, x_{A2}) \text{prob}\big[\text{Soros attacks when } \ \mu_1 = 0\big] d\theta_A \\
&\qquad\qquad + (1-p_1) \int_{\underline{\theta}_A}^{\bar{\theta}_A} f(\theta_A |\, x_{A2}) \text{prob}\big[\text{Soros attacks when } \ \mu_1 = \mu\big] d\theta_A \\
= {} & 1 - \frac{x_{A2} - \underline{\theta}_A}{2\epsilon} + p_1 \int_{\underline{\theta}_A}^{\bar{\theta}_A} \frac{1}{2\epsilon} \frac{\bar{x}_{A1}(\mu_1 = 0) - \theta_A}{2\epsilon} d\theta_A \\
&\qquad\qquad + (1-p_1) \int_{\underline{\theta}_A}^{\bar{\theta}_A} \frac{1}{2\epsilon} \frac{\bar{x}_{A1}(\mu_1 = \mu) - \theta_A}{2\epsilon} d\theta_A \\
= {} & 1 - \frac{x_{A2} - \underline{\theta}_A}{2\epsilon} + \frac{p_1}{4\epsilon^2} \left(\bar{x}_{A1}(\mu_1 = 0)\bar{\theta}_A - \frac{(\bar{\theta}_A)^2}{2} - \bar{x}_{A1}(\mu_1 = 0)\underline{\theta}_A + \frac{(\underline{\theta}_A)^2}{2} \right) \\
&\qquad + \frac{1-p_1}{4\epsilon^2} \left(\bar{x}_{A1}(\mu_1 = \mu)\bar{\theta}_A - \frac{(\bar{\theta}_A)^2}{2} - \bar{x}_{A1}(\mu_1 = \mu)\underline{\theta}_A + \frac{(\underline{\theta}_A)^2}{2} \right)
\end{aligned}
$$

Because the expected payoff to attacking country A net of costs must be zero conditional on the switching signal $\bar{x}_{A2}$, the following must hold from the above.

$$1 - \frac{\bar{x}_{A2} - \underline{\theta}_A}{2\epsilon} + \frac{p_1}{4\epsilon^2}\left(\bar{x}_{A1}(\mu_1 = 0)\bar{\theta}_A - \frac{(\bar{\theta}_A)^2}{2} - \bar{x}_{A1}(\mu_1 = 0)\underline{\theta}_A + \frac{(\underline{\theta}_A)^2}{2}\right)$$
$$+ \frac{1-p_1}{4\epsilon^2}\left(\bar{x}_{A1}(\mu_1 = \mu)\bar{\theta}_A - \frac{(\bar{\theta}_A)^2}{2} - \bar{x}_{A1}(\mu_1 = \mu)\underline{\theta}_A + \frac{(\underline{\theta}_A)^2}{2}\right) = \frac{c}{D} \tag{9}$$

B Solutions for $\underline{\theta}_A$, $\bar{\theta}_A$, $\bar{x}_{A1}(\mu_1 = 0)$, $\bar{x}_{A1}(\mu_1 = \mu)$, and $\bar{x}_{A2}$.

$$\underline{\theta}_A = \frac{1-\lambda}{2\epsilon + (1-\lambda)}\left[(4\epsilon+1)(1-\frac{c}{D}) - \frac{\mu}{D}\lambda(1-p_1) + \frac{1}{2}\frac{\lambda}{2\epsilon+(1-\lambda)}\right] \tag{10}$$

$$\bar{\theta}_A = \frac{1-\lambda}{2\epsilon + (1-\lambda)}\left[(4\epsilon+1)(1-\frac{c}{D}) - \frac{\mu}{D}\lambda(1-p_1) + \frac{1}{2}\frac{\lambda}{2\epsilon+(1-\lambda)}\right] + \frac{2\epsilon\lambda}{2\epsilon+(1-\lambda)} \tag{11}$$

$$\bar{x}_{A1}(\mu_1 = 0) = \frac{1-\lambda}{2\epsilon + (1-\lambda)}\left[(4\epsilon+1)(1-\frac{c}{D}) - \frac{\mu}{D}\lambda(1-p_1) + \frac{1}{2}\frac{\lambda}{2\epsilon+(1-\lambda)}\right] + \frac{2\epsilon\lambda}{2\epsilon+(1-\lambda)} + 2\epsilon(1-\frac{c}{D}) \tag{12}$$

$$\bar{x}_{A1}(\mu_1 = \mu) = \frac{1-\lambda}{2\epsilon + (1-\lambda)}\left[(4\epsilon+1)(1-\frac{c}{D}) - \frac{\mu}{D}\lambda(1-p_1) + \frac{1}{2}\frac{\lambda}{2\epsilon+(1-\lambda)}\right] + \frac{2\epsilon\lambda}{2\epsilon+(1-\lambda)} + 2\epsilon(1-\frac{c+\mu}{D}) \tag{13}$$

$$\bar{x}_{A2} = (4\epsilon+1)(1-\frac{c}{D}) - \frac{\mu}{D}\lambda(1-p_1) + \frac{1}{2}\frac{\lambda}{2\epsilon+(1-\lambda)} \tag{14}$$

C Proof of Lemma 1

This is the direct result from (10), (11), (12), (13), and (14).

D Proof of Proposition 1

A necessary and sufficient condition is that it is optimal for a speculator to attack the currency if and only if he observes a private signal lower than or equal to the switching signal, provided that everyone else follows the switching strategy. To show this, it is sufficient to show that Prob [Attack is successful| x_{Ai}] ($i = 1, 2$) is decreasing in the private signal x_{Ai} if everyone else follows the switching strategy. Because the expected payoff of attacking is increasing in Prob [Attack is successful| x_{Ai}], it is decreasing in the private signal x_{Ai} when Prob [Attack is successful| x_{Ai}] is decreasing in x_{Ai}. By construction, the switching signal makes the speculator indifferent between attacking and refraining from doing so: the expected payoff of attacking is zero when he observes the switching signal. If Prob [Attack is successful| x_{Ai}] is decreasing in x_{Ai}, the expected payoff of attacking is positive (negative) when the speculator observes the signal smaller (larger) than the switching signal. Therefore, it is optimal for the speculator to attack if and only if he observes the private signal lower than or equal to the switching signal, provided that Prob [Attack is successful| x_{Ai}] is decreasing in the private signal x_{Ai}. Prob [Attack is successful| x_{Ai}] can be written as follows.

$$
\begin{aligned}
& \text{Prob}\left[\text{Attack is successful} \mid x_{A1}\right] \\
= \; & 1 - \frac{x_{A1} - \bar{\theta}_A}{2\epsilon} \qquad (15)
\end{aligned}
$$

$$
\begin{aligned}
& \text{Prob}\left[\text{Attack is successful} \mid x_{A2}\right] \\
= \; & 1 - \frac{x_{A2} - \underline{\theta}_A}{2\epsilon} + \frac{p_1}{4\epsilon^2}\left(\bar{x}_{A1}(\mu_1 = 0)\bar{\theta}_A - \frac{(\bar{\theta}_A)^2}{2} - \bar{x}_{A1}(\mu_1 = 0)\underline{\theta}_A + \frac{(\underline{\theta}_A)^2}{2}\right) \\
& + \frac{1 - p_1}{4\epsilon^2}\left(\bar{x}_{A1}(\mu_1 = \mu)\bar{\theta}_A - \frac{(\bar{\theta}_A)^2}{2} - \bar{x}_{A1}(\mu_1 = \mu)\underline{\theta}_A + \frac{(\underline{\theta}_A)^2}{2}\right) \qquad (16)
\end{aligned}
$$

Clearly from (15) and (16), Prob [Attack is successful| x_{Ai}] is decreasing in the private signal x_{Ai}.

E Proof of Proposition 2

Taketa (2004) derives the switching values in the no-Soros case as follows. Comparing these with the switching values in the one-Soros case, Proposition 2 results after some algebra.

$$\underline{\underline{\theta}}_A = \frac{1-\lambda}{2\epsilon+(1-\lambda)}\left[2\epsilon+1-\frac{c}{D}-\frac{\mu}{D}\lambda(1-p_1)+\frac{2\epsilon c}{D}\right] \tag{17}$$

$$\begin{aligned}\bar{\bar{\theta}}_A(\mu_1=0) &= \frac{1}{p_1}\Bigg[1-\frac{c}{D}-\frac{\mu}{D}\lambda(1-p_1)-\frac{(1-p_1)(1-\lambda)}{2\epsilon+(1-\lambda)}\Bigg\{\frac{2\epsilon}{1-\lambda}+1-\frac{c}{D} \\ &\quad -\frac{\mu}{D}\lambda(1-p_1)-\frac{1}{1-\lambda}\frac{2\epsilon c}{D}-\frac{2\epsilon\lambda}{1-\lambda}\frac{\mu}{D}\Bigg\}\Bigg]\end{aligned} \tag{18}$$

$$\begin{aligned}\bar{\bar{\theta}}_A(\mu_1=\mu) &= \frac{1-\lambda}{2\epsilon+(1-\lambda)}\Bigg[\frac{2\epsilon}{1-\lambda}+1-\frac{c}{D}-\frac{\mu}{D}\lambda(1-p_1)-\frac{1}{1-\lambda}\frac{2\epsilon c}{D} \\ &\quad -\frac{2\epsilon\lambda}{1-\lambda}\frac{\mu}{D}\Bigg]\end{aligned} \tag{19}$$

$$\begin{aligned}\bar{\bar{x}}_{A1}(\mu_1=0) &= \frac{1}{p_1}\Bigg[1-\frac{c}{D}-\frac{\mu}{D}\lambda(1-p_1)-\frac{(1-p_1)(1-\lambda)}{2\epsilon+(1-\lambda)}\Bigg\{\frac{2\epsilon}{1-\lambda}+1-\frac{c}{D} \\ &\quad -\frac{\mu}{D}\lambda(1-p_1)-\frac{1}{1-\lambda}\frac{2\epsilon c}{D}-\frac{2\epsilon\lambda}{1-\lambda}\frac{\mu}{D}\Bigg\}\Bigg]+2\epsilon(1-\frac{c+\mu}{D})\end{aligned} \tag{20}$$

$$\begin{aligned}\bar{\bar{x}}_{A1}(\mu_1=\mu) &= \frac{1-\lambda}{2\epsilon+(1-\lambda)}\Bigg[\frac{2\epsilon}{1-\lambda}+1-\frac{c}{D}-\frac{\mu}{D}\lambda(1-p_1)-\frac{1}{1-\lambda}\frac{2\epsilon c}{D}-\frac{2\epsilon\lambda}{1-\lambda}\frac{\mu}{D}\Bigg] \\ &\quad +2\epsilon(1-\frac{c+\mu}{D})\end{aligned} \tag{21}$$

$$\bar{\bar{x}}_{A2} = 2\epsilon+1-\frac{c}{D}-\frac{\mu}{D}\lambda(1-p_1)+\frac{2\epsilon c}{D} \tag{22}$$

There are two caveats. First, as explained above, in the no-Soros case there are *two* counterparts to $\bar{\theta}_A$, the switching value below which the peg is abandoned when *both* groups 1 and 2 attack. Second, in the no-Soros case there is *only one* counterpart to $\underline{\theta}_A$. This is because $\underline{\theta}_A$ is defined to be the threshold level of economic fundamentals up to which attacks by group 2 *alone* are enough to cause the collapse of the peg. Thus the counterpart of $\underline{\theta}_A$ is defined as follows.

$$\begin{aligned}\underline{\underline{\theta}}_A &= (1-\lambda)\mathrm{Prob}\big[x_{A2} \leq \bar{\bar{x}}_{A2} |\ \underline{\underline{\theta}}_A\big] \\ &= (1-\lambda)\frac{\bar{\bar{x}}_{A2}-\underline{\underline{\theta}}_A}{2\epsilon}\end{aligned}$$

Clearly $\underline{\underline{\theta}}_A$ is unique as long as $\bar{\bar{x}}_{A2}$ is unique. Indeed, $\bar{\bar{x}}_{A2}$ can be shown to be unique.

F Proof of Lemma 2

For any $\theta_A \leq \underline{\theta}_A$, the currency crisis occurs in country A with probability one, regardless of Soros' type. Therefore, what occurred in country A when $\theta_A \leq \underline{\theta}_A$ provides no information on Soros' type. For any $\theta_A \geq \bar{\theta}_A$, the currency crisis will never occur in country A, regardless of Soros' type. Therefore, what occurred in country A when $\theta_A \geq \bar{\theta}_A$ provides no information on Soros' type. That is why no Bayesian updating occurs for any $\theta_A \notin [\underline{\theta}_A, \bar{\theta}_A]$.

$$\begin{aligned} p_2(\theta_A \text{ such that } \theta_A \leq \underline{\theta}_A) &= \text{Prob}\left[\mu_1 = 0 | \ \theta_A \text{ such that } \theta_A \leq \underline{\theta}_A\right] \\ &= \frac{\text{Prob}\left[\mu_1 = 0 \text{ and } \theta_A \text{ such that } \theta_A \leq \underline{\theta}_A\right]}{\text{Prob}\left[\theta_A \text{ such that } \theta_A \leq \underline{\theta}_A\right]} \\ &= \frac{q \times \text{Prob}\left[\theta_A \text{ such that } \theta_A \leq \underline{\theta}_A\right]}{\text{Prob}\left[\theta_A \text{ such that } \theta_A \leq \underline{\theta}_A\right]} \\ &= q \ = \ p_1 \end{aligned} \tag{23}$$

$$\begin{aligned} p_2(\theta_A \text{ such that } \theta_A \geq \bar{\theta}_A) &= \text{Prob}\left[\mu_1 = 0 | \ \theta_A \text{ such that } \theta_A \geq \bar{\theta}_A\right] \\ &= \frac{\text{Prob}\left[\mu_1 = 0 \text{ and } \theta_A \text{ such that } \theta_A \geq \bar{\theta}_A\right]}{\text{Prob}\left[\theta_A \text{ such that } \theta_A \geq \bar{\theta}_A\right]} \\ &= \frac{q \times \text{Prob}\left[\theta_A \text{ such that } \theta_A \geq \bar{\theta}_A\right]}{\text{Prob}\left[\theta_A \text{ such that } \theta_A \geq \bar{\theta}_A\right]} \\ &= q \ = \ p_1 \end{aligned} \tag{24}$$

(23) and (24) prove the first part of Lemma 2.

Next, suppose that the currency crisis occurred for $\theta_A \in [\underline{\theta}_A, \bar{\theta}_A]$. This means that Soros attacked country A. In turn, it implies that Soros observed a private signal lower than or equal to the switching signal.

$$
\begin{aligned}
p_2 &= \text{Prob}\left[\mu_1 = 0 | \text{ Crisis occurs for } \theta_A \in \left[\underline{\theta}_A, \bar{\theta}_A\right]\right] \\
&= \frac{\text{Prob}\left[\mu_1 = 0 \text{ and Crisis occurs for } \theta_A \in \left[\underline{\theta}_A, \bar{\theta}_A\right]\right]}{\text{Prob}\left[\text{Crisis occurs for } \theta_A \in \left[\underline{\theta}_A, \bar{\theta}_A\right]\right]} \\
&= q \times \text{Prob}\left[\theta_A \in \left[\underline{\theta}_A, \bar{\theta}_A\right] \text{ and } x_{A1} \leq \bar{x}_{A1}(\mu_1 = 0)\right] \\
&\quad \times \Big\{ q \times \text{Prob}\left[\theta_A \in \left[\underline{\theta}_A, \bar{\theta}_A\right] \text{ and } x_{A1} \leq \bar{x}_{A1}(\mu_1 = 0)\right] \\
&\quad + (1-q) \times \text{Prob}\left[\theta_A \in \left[\underline{\theta}_A, \bar{\theta}_A\right] \text{ and } x_{A1} \leq \bar{x}_{A1}(\mu_1 = \mu)\right] \Big\}^{-1}
\end{aligned}
\tag{25}
$$

The following inequality comes from $\bar{x}_{A1}(\mu_1 = 0) > \bar{x}_{A1}(\mu_1 = \mu)$.

$$
\begin{aligned}
&\text{Prob}\left[\theta_A \in \left[\underline{\theta}_A, \bar{\theta}_A\right] \text{ and } x_{A1} \leq \bar{x}_{A1}(\mu_1 = 0)\right] \\
&> \text{Prob}\left[\theta_A \in \left[\underline{\theta}_A, \bar{\theta}_A\right] \text{ and } x_{A1} \leq \bar{x}_{A1}(\mu_1 = \mu)\right]
\end{aligned}
\tag{26}
$$

(25) and (26) imply $p_2 > q = p_1$, proving the second part of Lemma 2. The third part can be proven similarly.

G Proof of Proposition 3

From Lemma 2, three possible p_2's exist depending on what has occurred in country A. For each of these three possible beliefs, Proposition 3 can be proven exactly the same as the proof of Proposition 1.

H Proof of Subgame Perfect Equilibrium

Here I prove that the sequence of Proposition 1 and Proposition 3 is indeed the subgame perfect equilibrium.

Consider first the additional benefit (period 2) and costs (period 1) that the chicken Soros must account for when deceiving. The chicken Soros has an incentive to mimic the bull Soros if and only if the benefit exceeds the cost. I show that the cost outweighs the benefit as long as ϵ is sufficiently small.

Assume that the chicken Soros succeeds in deceiving and the small speculators update their belief such that Soros is more likely to be the bull. The benefit of deceiving depends on the extent to which the small speculators become more aggressive in period 2. The larger the Bayesian updating, the larger the change in the small speculators' behavior. In other words, if the Bayesian updating is not large, the benefit is relatively small because the small speculators' behavior does not change very much. Remember that there is *no* difference in aggressiveness between the bull Soros and the chicken Soros when $\epsilon = 0$. Intuitively speaking, the aggressiveness difference is very small when ϵ is close to zero. In fact, from (12) and (13), the following can be shown.

$$\lim_{\epsilon \longrightarrow 0} (\bar{x}_{A1}(\mu_1 = \mu) - \bar{x}_{A1}(\mu_1 = 0)) = 0 \tag{27}$$

Notice that (25) and (27) imply $p_2^{\mathrm{C}} \longrightarrow q$ as $\epsilon \longrightarrow 0$. Similarly, it can be shown that $p_2^{\mathrm{NC}} \longrightarrow q$ as $\epsilon \longrightarrow 0$. Therefore, $p_2^{\mathrm{C}} - p_2^{\mathrm{NC}} \longrightarrow 0$ as $\epsilon \longrightarrow 0$. From (14), the following holds.

$$\bar{x}_{A2}(p_2 = p_2^{\mathrm{C}}) - \bar{x}_{A2}(p_2 = p_2^{\mathrm{NC}}) = \frac{\mu}{D}\lambda(p_2^{\mathrm{C}} - p_2^{\mathrm{NC}}) \tag{28}$$

Since $p_2^{\mathrm{C}} - p_2^{\mathrm{NC}} \longrightarrow 0$ as $\epsilon \longrightarrow 0$,

$$\lim_{\epsilon \longrightarrow 0} (\bar{x}_{A2}(p_2 = p_2^{\mathrm{C}}) - \bar{x}_{A2}(p_2 = p_2^{\mathrm{NC}})) = 0 \tag{29}$$

Therefore, the change in the small speculators' behavior, $\bar{x}_{A2}(p_2 = p_2^{\mathrm{C}}) - \bar{x}_{A2}(p_2 = p_2^{\mathrm{NC}})$, is arbitrarily small for sufficiently small ϵ. It means that the benefit of deceiving becomes arbitrarily small when ϵ is close to zero, because the benefit of deceiving is increasing in $\bar{x}_{A2}(p_2 = p_2^{\mathrm{C}}) - \bar{x}_{A2}(p_2 = p_2^{\mathrm{NC}})$ and is zero when $\bar{x}_{A2}(p_2 = p_2^{\mathrm{C}}) - \bar{x}_{A2}(p_2 = p_2^{\mathrm{NC}}) = 0$.

Next, consider the cost of deceiving for the chicken Soros. In order to deceive, the chicken Soros has to mimic the bull Soros in period 1. That is, the chicken Soros must use the bull Soros' switching signal $\bar{x}_{A1}(\mu_1 = 0; p_1 = q)$, instead of his own $\bar{x}_{A1}(\mu_1 = \mu; p_1 = q)$.

By definition of $\bar{x}_{A1}(\mu_1 = 0; p_1 = q)$, the following holds.

$$\text{Prob}\left[\theta_A \leq \bar{\theta}_A | \ \bar{x}_{A1}(\mu_1 = 0)\right] D - c = 0 \tag{30}$$

Thus when the chicken Soros who mimics the bull Soros observes $\bar{x}_{A1}(\mu_1 = 0; p_1 = q)$, his expected payoff is the following.

$$\text{Prob}\left[\theta_A \leq \bar{\theta}_A | \ \bar{x}_{A1}(\mu_1 = 0)\right] D - c - \mu = -\mu \tag{31}$$

The chicken Soros who mimics the bull Soros must attack whenever he observes a signal lower than or equal to $\bar{x}_{A1}(\mu_1 = 0; p_1 = q)$ to deceive the small speculators. The term $-\mu$ can be thought of as the deceiving cost. When he uses $\bar{x}_{A1}(\mu_1 = 0; p_1 = q)$, the benefit must be enough to compensate the cost $-\mu$. Remember, however, that the benefit is arbitrarily close to zero when $\epsilon \longrightarrow 0$. Therefore, given $-\mu$, one can choose a sufficiently small ϵ such that the costs outweigh the benefit. Therefore, the chicken Soros does not have any incentive to mimic the bull Soros when ϵ is sufficiently small.

Furthermore, it needs to be proven that there is no pooling equilibrium. In the pooling equilibrium, the chicken Soros and the bull Soros use the same switching signal and $p_1 = p_2 = q$. Suppose there is a pooling equilibrium where the chicken Soros and the bull Soros use the same switching signal: $\bar{x}_{A1}(\mu_1 = 0) = \bar{x}_{A1}(\mu_1 = \mu) = \bar{x}_{A1}$. Notice that the following must hold.

$$\text{Prob}\left[\theta_A \leq \bar{\theta}_A | \ \bar{x}_{A1}\right] D - c = 0 \tag{32}$$

If $\text{Prob}\left[\theta_A \leq \bar{\theta}_A | \ \bar{x}_{A1}\right] D - c > 0$, there exists a $\bar{x}^*_{A1}$ $(< \bar{x}_{A1})$ such that for any signal $x_{A1} \in [\bar{x}^*_{A1}, \ \bar{x}_{A1}]$, it is optimal for the bull Soros to attack. If $\text{Prob}\left[\theta_A \leq \bar{\theta}_A | \ \bar{x}_{A1}\right] D - c < 0$, there exists a $\bar{x}^*_{A1}$ $(> \bar{x}_{A1})$ such that for any signal $x_{A1} \in [\bar{x}_{A1}, \ \bar{x}^*_{A1}]$ it is optimal for the bull Soros to attack. This is because the bull Soros loses nothing when he reveals his type. Thus in any pooling equilibrium, (32) must hold. It means that (31) must hold in any pooling equilibrium. Using the same logic as presented above, one can show that a profitable deviation always exists as long as ϵ is sufficiently small, because the cost of using the same signal as the bull Soros (parallel to the deceiving cost above) is greater than its benefit (parallel to the benefit of deceiving above).

I Proof of Proposition 4

This is the direct result from Lemma 1, Lemma 2 and Proposition 3.

J Proof of Proposition 5

Taketa (2004) shows that previous events in country A under a certain range of economic fundamentals reveals group 1's type completely. $p_2 = 1$ if the crisis occurs in country A under the certain range of economic fundamentals, while $p_2 = 0$ if the crisis does not occur in country A under the certain range of economic fundamentals. Using this and from (18) and (19), the following results.

$$\tilde{\theta}_B^{\text{No Soros}}(Y_A = 1) = \bar{\bar{\theta}}_A(\mu_1 = 0; p_2 = 1) = 1 - \frac{c}{D} \tag{33}$$

$$\tilde{\theta}_B^{\text{No Soros}}(Y_A = 0) = \bar{\bar{\theta}}_A(\mu_1 = \mu; p_2 = 0) = 1 - \frac{c}{D} - \frac{\lambda\mu}{D} \tag{34}$$

The relative severity of contagion in the no-Soros case is therefore as follows.

$$\bar{\bar{\theta}}_A(\mu_1 = 0; p_2 = 1) - \bar{\bar{\theta}}_A(\mu_1 = \mu; p_2 = 0) = \frac{\lambda\mu}{D} \tag{35}$$

As $\epsilon \longrightarrow 0$,

$$\bar{\theta}_B(p_2) \longrightarrow 1 - \frac{c}{D} - \frac{\lambda\mu}{D}(1 - p_2) + \frac{1}{2}\frac{\lambda}{1 - \lambda} \tag{36}$$

Note that $\tilde{\theta}_B^{\text{One Soros}}(Y_A = 1) = \bar{\theta}_B(p_2 = p_2^{\text{C}})$ and $\tilde{\theta}_B^{\text{One Soros}}(Y_A = 0) = \bar{\theta}_B(p_2 = p_2^{\text{NC}})$. The relative severity of contagion in the one-Soros case in the limiting case ($\epsilon \longrightarrow 0$) is therefore as follows.

$$\bar{\theta}_B(p_2 = p_2^{\text{C}}) - \bar{\theta}_B(p_2 = p_2^{\text{NC}}) = \frac{\lambda\mu}{D}(p_2^{\text{C}} - p_2^{\text{NC}}) \tag{37}$$

Since $0 < p_2^{\mathrm{C}} - p_2^{\mathrm{NC}} < 1$, from (35) and (37)

$$\tilde{\theta}_B^{\text{No Soros}}(Y_A = 1) - \tilde{\theta}_B^{\text{No Soros}}(Y_A = 0) > \tilde{\theta}_B^{\text{One Soros}}(Y_A = 1) - \tilde{\theta}_B^{\text{One Soros}}(Y_A = 0) \qquad (38)$$

in the limiting case where $\epsilon \longrightarrow 0$. By continuity, inequality (38) holds for sufficiently small ϵ, which proves the first part of Proposition 5. From (33) and (36), it can be shown that

$$\tilde{\theta}_B^{\text{No Soros}}(Y_A = 1) - \tilde{\theta}_B^{\text{One Soros}}(Y_A = 1) > 0 \qquad (39)$$

if and only if

$$\frac{\mu}{D}(1 - p_2^{\mathrm{C}}) > \frac{1}{2}\frac{1}{1 - \lambda} \qquad (40)$$

which can hold provided that λ is not too close to one. If inequality (39) holds in the limiting case where $\epsilon \longrightarrow 0$, it also holds where ϵ is sufficiently small, which proves the second part of Proposition 5.

K Proof of Proposition 6

Suppose that $\mu_1 = 0$. Also assume that group 2 *knows* $\mu_1 = 0$ owing to financial disclosure of Soros' type. In this case, $p_1 = p_2 = 1$. Because contagion occurs if and only if $p_2 > p_1$, financial disclosure eliminates contagion. However, from Lemma 1, financial disclosure makes countries more vulnerable to crises.

L Proof of Proposition 7

This is a direct result of Proposition 5.

M The Relationship Between the Speculators Game and the Creditors Game

In the speculators' game, contagion occurs when Soros turns out to be more aggressive than expected. In the creditors' game, contagion occurs when LTCM turns out to be less aggressive than expected. Are they mutually exclusive? The answer is no. I explain here why these two games are complementary.

In the speculators' game, each speculator "has his money with him", as opposed to the creditors' game where his money is already invested. The decision for the speculator is whether to use "readily available money" for short selling. Short selling is a risky choice, and each speculator becomes more aggressive when Soros turns out to be more aggressive than expected—leading to contagion. In the creditors' game, each creditor has already invested his money in countries. The decision for the creditor is whether to pull out in order to avoid possible losses. Rolling over (i.e., refraining from pulling out money) is a risky choice, and each creditor becomes less aggressive toward rolling over when LTCM turns out to be less aggressive than expected—leading to contagion. These two games are related as follows. On the one hand, the more speculators attack a country, the more likely depreciation is in the country. When depreciation is more likely to occur in the country, creditors have a greater incentive to pull out their money. It means that as speculators become more aggressive, creditors become less so. On the other hand, when many creditors become less aggressive and pull their money out of the country, the foreign reserves of the country decrease. As discussed above, as foreign reserves shrink, the country becomes more vulnerable to crisis. As a result, speculators become more aggressive. This implies that as creditors become less aggressive, speculators become more so. In the creditors' game, contagion occurs when creditors become less aggressive. In the speculators' game, contagion occurs when speculators become more aggressive. Because speculators tend to become more aggressive when creditors become less aggressive and vice versa, these two games can interact and contagion can become more severe. In this sense, these two games are complementary. (See Figure 6.)

References

Calvo, G. A., A. Izquierdo, and E. Talvi (2003): "Sudden Stops, the Real Exchange Rate, and Fiscal Sustainability: Argentina's Lessons," NBER Working Paper 9828.

Carlson, H., and E. van Damme (1993): "Global Games and Equilibrium Selection," *Econometrica*, 61(5), 989–1018.

Corsetti, G., A. Dasgupta, S. Morris, and H. S. Shin (2004): "Does One Soros Make a Difference? A Theory of Currency Crises with Large and Small Traders," *Review of Economic Studies*, 71(1), 87–113.

Corsetti, G., P. Pesenti, and N. Roubini (2002): "The Role of Large Players in Currency Crises," in *Preventing Currency Crises in Emerging Markets*, ed. by S. Edwards, and J. A. Frankel. The University of Chicago Press.

Diamond, D. W., and P. H. Dybvig (1983): "Bank Runs, Deposit Insurance, and Liquidity," *Journal of Political Economy*, 91(3), 401–419.

Dunbar, N. (1999): *Inventing Money: The Story of Long-Term Capital Management and the Legends Behind It*. John Wiley & Sons Inc.

Forbes, K. J. (2004): "The Asian Flu and Russian Virus: The International Transmission of Crises in Firm-Level Data," *Journal of International Economics*, 63(1), 59–92.

Forbes, K. J., and R. Rigobon (2001): "Contagion in Latin America: Definitions, Measurement, and Policy Implications," *Economia*, 1(2), 1–46.

Furman, J., and J. E. Stiglitz (1998): "Economic Crises: Evidence and Insights from East Asia," *Brookings Papers on Economic Activity*, 1998(2), 1–114.

Hausmann, R., and A. Velasco (2003): "Hard Money's Soft Underbelly: Understanding the Argentine Crisis," *Brookings Trade Forum*, 2002, 59–104.

Heinemann, F., R. Hagel, and P. Ockenfels (2004): "The Theory of Global Games on Test: Experimental Analysis of Coordination Games with Public and Private Information," *Econometrica*, 72(5), 1583–1599.

KRUGMAN, P. (1998): "Soros' Plea: Stop Me!," *Fortune*, 138(10), 36–38.

——— (1999): "Balance Sheets, the Transfer Problem, and Financial Crises," in *International Finance and Financial Crises: Essays in Honor of Robert P. Flood*, ed. by P. Isard, A. Razin, and A. K. Rose. Kluwel Academic Publishers.

LOWENSTEIN, R. (2000): *When Genius Failed: The Rise and Fall of Long-Term Capital Management*. Random House.

MASSON, P. (1999a): "Contagion: Monsoonal Effects, Spillovers, and Jumps between Multiple Equilibria," in *The Asian Financial Crisis: Causes, Contagion and Consequences*, ed. by P.-R. Agénor, M. Miller, D. Vines, and A. Weber. Cambridge University Press.

——— (1999b): "Multiple Equilibria, Contagion and the Emerging Market Crises," IMF Working Paper 99/164.

OBSTFELD, M. (1996): "Models of Currency Crises with Self-Fulfilling Features," *European Economic Review Papers and Proceedings*, 40(3-5), 1037–1047.

TAKETA, K. (2004): "Contagion of Currency Crises across Unrelated Countires," IMES Discussion Paper No. 2004-E-22, Institute for Monetary and Economic Studies, Bank of Japan.

TORNELL, A. (1999): "Common Fundamentals in the Tequila and Asian Crises," NBER Working Paper 7139.

	Success	Failure
Attack	$D - t - \mu_1$	$-t - \mu_1$
Not Attack	0	0

Table 1: Payoff Matrix

Bull Soros' switching signal	$\bar{x}_{A1}(\mu_1 = 0; p_1 = q)$
Chicken Soros' switching signal	$\bar{x}_{A1}(\mu_1 = \mu; p_1 = q)$
Group 2's switching signal	$\bar{x}_{A2}(p_1 = q)$
Switching economic fundamentals	$\underline{\theta}_A(p_1 = q)$ and $\bar{\theta}_A(p_1 = q)$

Table 2: Equilibrium Strategy in Period 1

	Crisis in Country A	No Crisis in Country A
Bull Soros' switching signal	$\bar{x}_{B1}(\mu_1 = 0; p_2 = p_2^{\mathrm{C}})$	$\bar{x}_{B1}(\mu_1 = 0; p_2 = p_2^{\mathrm{NC}})$
Chicken Soros' switching signal	$\bar{x}_{B1}(\mu_1 = \mu; p_2 = p_2^{\mathrm{C}})$	$\bar{x}_{B1}(\mu_1 = \mu; p_2 = p_2^{\mathrm{NC}})$
Group 2's switching signal	$\bar{x}_{B2}(p_2 = p_2^{\mathrm{C}})$	$\bar{x}_{B2}(p_2 = p_2^{\mathrm{NC}})$
Switching economic fundamentals	$\underline{\theta}_B(p_2 = p_2^{\mathrm{C}})$ and $\bar{\theta}_B(p_2 = p_2^{\mathrm{C}})$	$\underline{\theta}_B(p_2 = p_2^{\mathrm{NC}})$ and $\bar{\theta}_B(p_2 = p_2^{\mathrm{NC}})$

Table 3: Equilibrium Strategy in Period 2 for any $\theta_A \in [\underline{\theta}_A, \bar{\theta}_A]$

Bull Soros' switching signal	$\bar{x}_{B1}(\mu_1 = 0; p_2 = q)$
Chicken Soros' switching signal	$\bar{x}_{B1}(\mu_1 = \mu; p_2 = q)$
Group 2's switching signal	$\bar{x}_{B2}(p_2 = q)$
Switching economic fundamentals	$\underline{\theta}_B(p_2 = q)$ and $\bar{\theta}_B(p_2 = q)$

Table 4: Equilibrium Strategy in Period 2 for any $\theta_A \notin [\underline{\theta}_A, \bar{\theta}_A]$

	Success	Failure
Roll Over	D	0
Do Not Roll Over	$t + \mu_1$	$t + \mu_1$

Table 5: Payoff Matrix

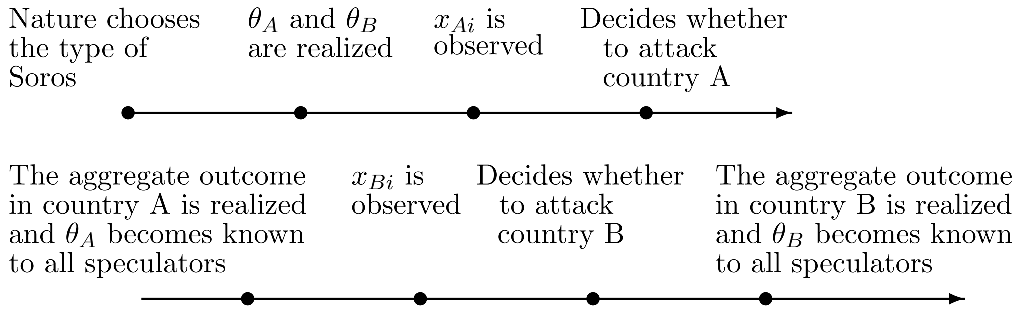

Figure 1: Timing of the Game

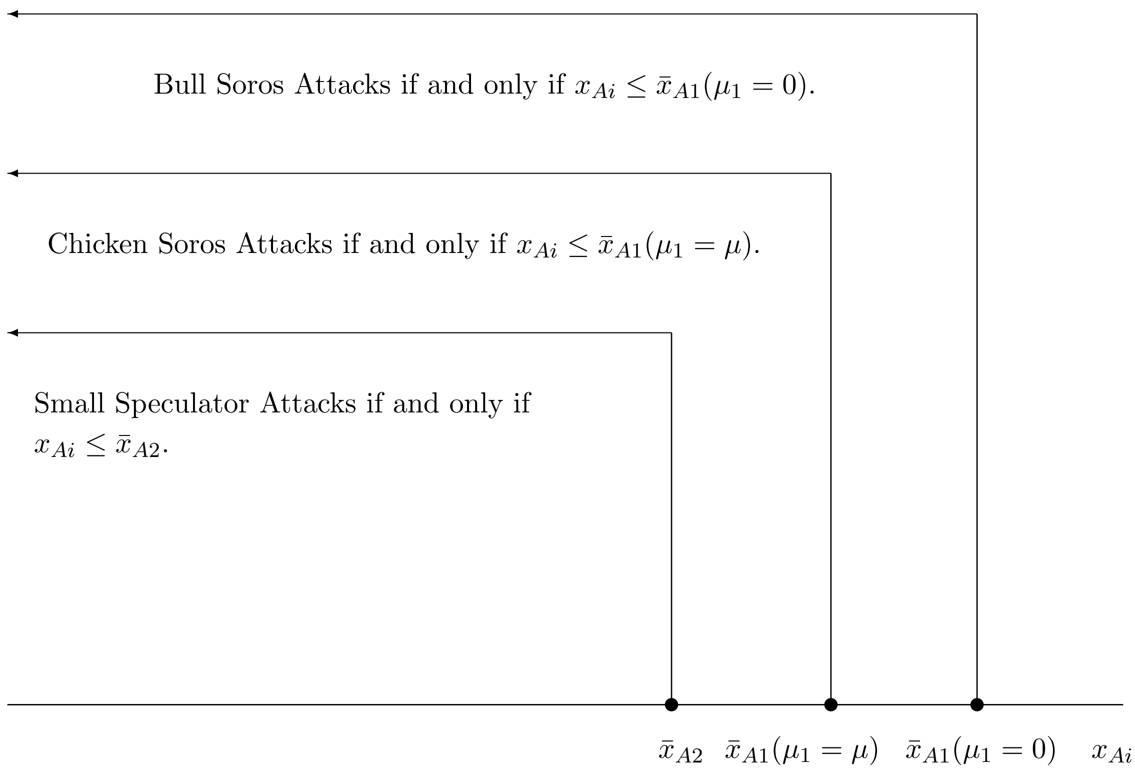

Figure 2: Switching Signals and Speculators' Decision

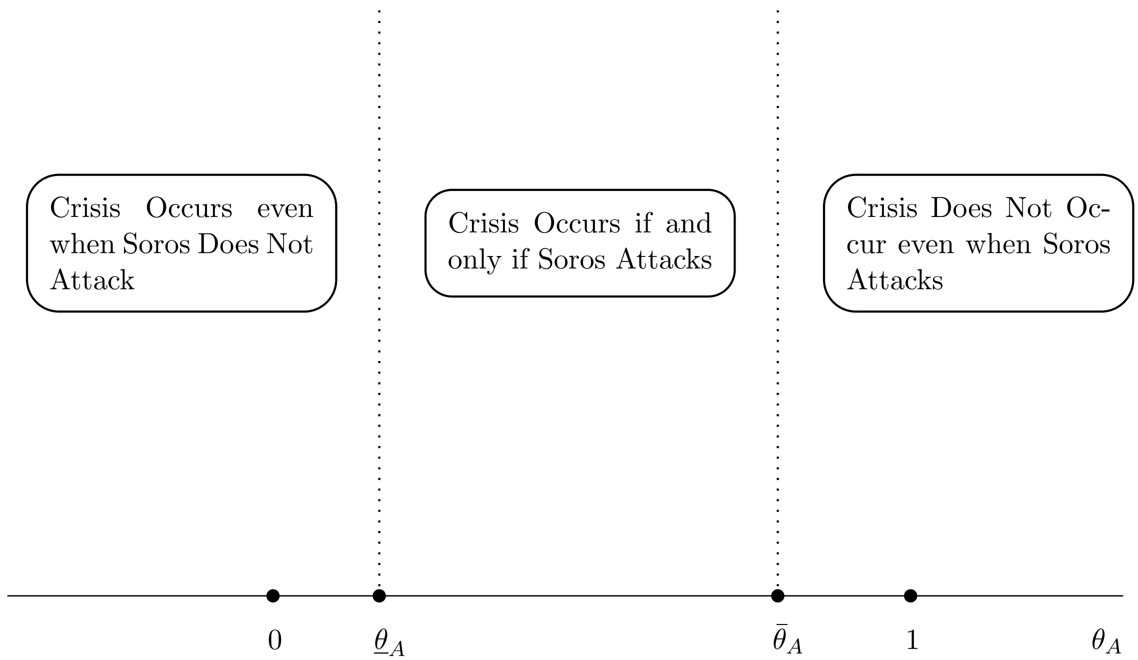

Figure 3: Soros and Switching Economic Fundamentals

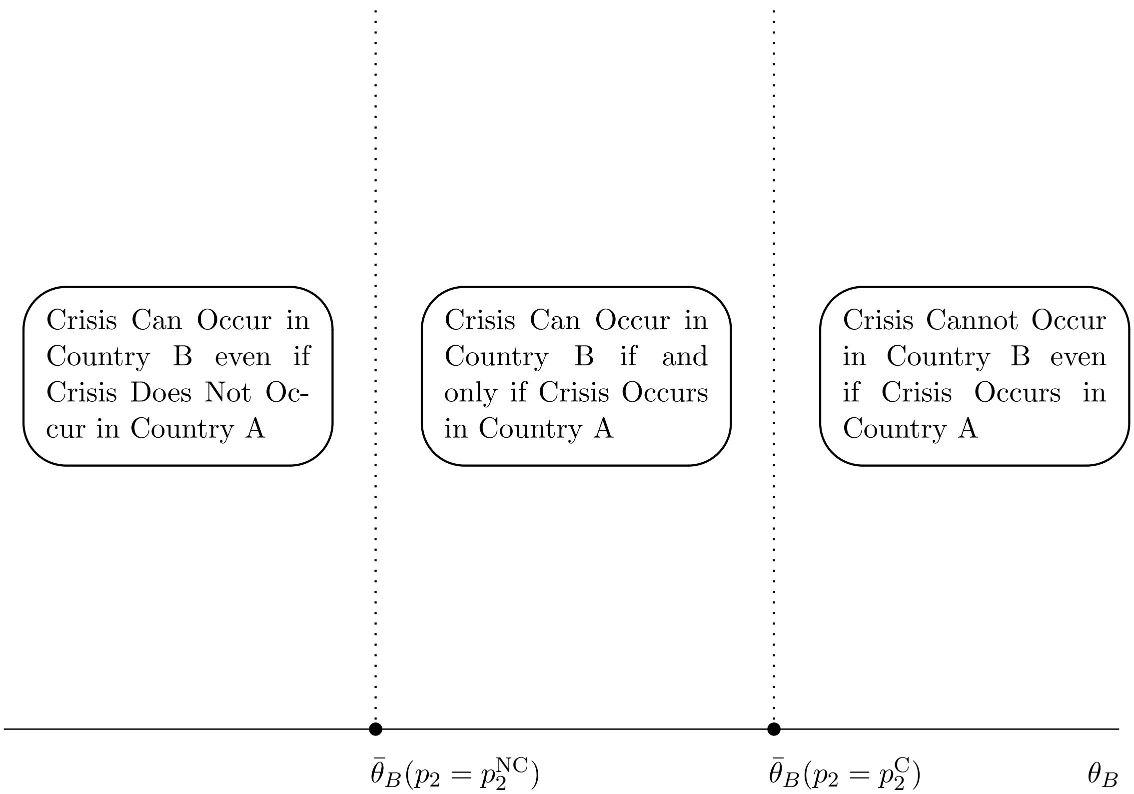

Figure 4: Contagion Can Occur when $\bar{\theta}_B(p_2 = p_2^{\mathrm{NC}}) < \theta_B < \bar{\theta}_B(p_2 = p_2^{\mathrm{C}})$

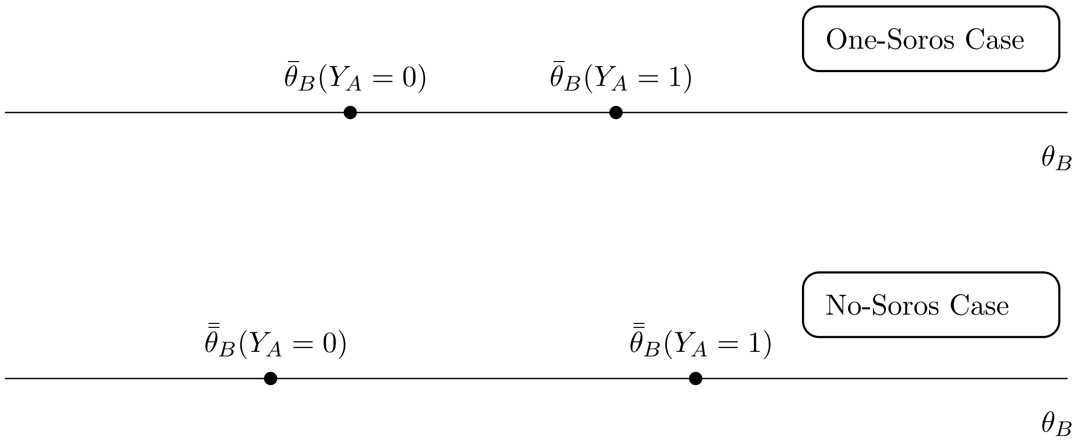

Figure 5: Severity of Contagion

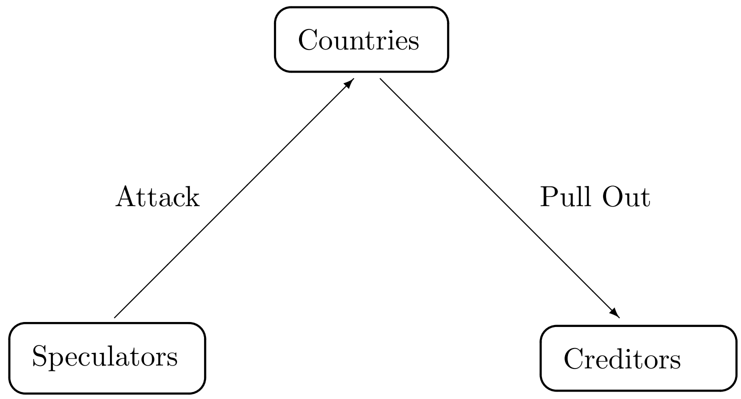

Figure 6: Complementarity between Speculators and Creditors