IMES DISCUSSION PAPER SERIES

Contagion of Currency Crises across Unrelated Countries

Kenshi Taketa

Discussion Paper No. 2004-E-22

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-22
December 2004

Contagion of Currency Crises across Unrelated Countries

Kenshi Taketa*

Abstract

This paper shows that a currency crisis can spread from one country to another even when these countries are unrelated in terms of economic fundamentals. The propagation mechanism lies in each speculator's private information about his/her own type and learning behavior about other speculators' types. Since the payoff of each speculator depends on the behavior of other speculators as determined by their types, each speculator's behavior depends on his/her belief about other speculators' types. If a crisis in one country reveals the speculator types, it leads to a revision of each speculator's beliefs about other speculators' types and therefore a change in his/her optimal behavior, which in turn can cause a crisis even in another unrelated country. This paper also shows that the better the economic fundamentals in the country where the crisis originates, the more contagious the original crisis can be.

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 2 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.

1 Introduction

This paper provides a model to show that a currency crisis can spread even across unrelated countries. Moreover, it is shown that a crisis in a country with good economic fundamentals can become more contagious than one in a country with bad economic fundamentals. Thus, in order for policy makers to determine which countries may set off a currency crisis contagion and how severely this may affects other countries, it may not be sufficient to monitor only countries with poor economic fundamentals where a crisis seems likely to occur. This is because if the crisis occurs in a country with good economic fundamentals, where crises used to be less likely, it can become more contagious.

This paper focuses on one propagation mechanism: each speculator's private information about his/her type, and his/her learning behavior with regard to other speculators' types. Since the payoff of each speculator depends on other speculators' behavior determined by their types, the optimal behavior of each speculator depends on his/her beliefs about other speculators' types. If a crisis in one country reveals other speculators' types, it will lead each speculator to update his/her beliefs and thereby change his/her optimal behavior, which in turn can lead to a crisis in another unrelated country. This propagation mechanism has an important policy implication for country surveillance to assess the likelihood and severity of contagion. On the one hand, if the economic fundamentals are quite bad in one country, the crisis will certainly occur there regardless of the type of speculators. Therefore, the crisis does not reveal the type. On the other hand, if the crisis occurs in a country whose economic fundamentals are considered to be good, it reveals the type of speculators. This is because the crisis would occur in this case if and only if speculators are of a certain type. Therefore, the crisis makes speculators revise their beliefs about others' types and thereby change their own behavior, which can cause a crisis in other countries. This means that the better the economic fundamentals in the country where the crisis originates, the more contagious the original crisis can be.

This paper is not the first to consider why an initial country-specific shock can be transmitted to other countries.[1] Several possible contagion channels have been analyzed

[1] For surveys of the literature, see Forbes and Rigobon (2001) and Forbes (2004).

so far. For instance, the crisis could spread through capital and/or trade linkage.[2] In this literature, the worse the economic fundamentals in the country where the crisis originates, the larger the negative impact that would spread through these linkages. The larger the negative impact, the more severely other countries would be affected. Thus the worse the economic fundamentals in the originating crisis country, the more contagious the originating crisis. In contrast, this paper shows that the opposite can be true. This paper implies that even if a crisis in a country with very poor economic fundamentals does not cause severe contagion (e.g., the Argentine financial crisis in 2002), it does not necessarily mean that a possible future crisis in another country with better economic fundamentals would never cause contagion.

Besides capital and/or trade linkage, several authors argue that contagion across seemingly unrelated countries might be explained as jumps between multiple equilibria: a crisis in one country might work as a sunspot that leads to a self-fulfilling crisis in another unrelated country.[3] 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, this paper uses the global game approach proposed 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, this paper provides a new explanation for contagion.

In the theoretical literature of currency crises, the closest papers to this one are Morris and Shin (1998) and Metz (2002). They show how to derive the unique equilibrium in the models of currency crises where there are multiple equilibria, using the global game approach. However, these papers are not concerned with the problem of contagion, whereas the issue of contagion is central to this one. This paper is organized as follows. In Section 2, the model is described. Section 3 concludes. Proofs are presented in the Appendix.

[2]For contagion due to capital linkage such as interbank market and/or portfolio rebalancing by international investors, see Allen and Gale (2000), Dasgupta (2004), Calvo (1999) and Calvo and Mendoza (2000). For contagion due to trade linkage, see Gerlach and Smets (1995) and Corsetti, Pesenti, Roubini, and Tille (2000).

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

2 The Model

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 the state of its 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 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.

There are two groups of speculators: group 1 and group 2. Both groups consist of a continuum of small speculators, so that each individual speculator's stake is negligible as a proportion of the whole. I index the set of speculators by the unit interval $[0, 1]$. They consists of offshore funds registered in so-called tax havens, and therefore regulation of them is less stringent than in industrialized countries. Since information about such offshore funds is not typically open to the public, it is hard to figure out how much risk they can take in attacking the peg.[4] Therefore, some uncertainty exists about their attitude toward risk. Thus, group 1's "type" is their private information. There are two possible types of group 1 with respect to aggressiveness: one type is the "bull" with probability q while another type is the "chicken" with probability $1 - q$. That is, all the speculators in group 1 are bulls (chickens) with probability q $(1 - q)$. Just for simplicity, group 2's type is always the bull and is public information. The size of group 1 is λ while that of group 2 is $1 - \lambda$, where $0 \leq \lambda \leq 1$.

Receiving a private signal (perhaps ambiguous due to "noise") about economic fundamentals, a speculator decides whether to short-sell the currency; i.e., to attack the currency peg. I envisage the short-selling as consisting of borrowing domestic currency and selling it for dollars. If the attack is successful (i.e., the peg is abandoned), the speculator gets a fixed payoff D (> 0). Attacking the currency, however, also leads to 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/she is not exposed to any cost, but does not gain anything either (see Table 1). μ_1 captures a difference of

[4] For a general overview of recent developments in the hedge fund industry, see Financial Stability Forum (2002).

the cost between the bull and the chicken: $\mu_1 = 0$ for the bull and $\mu_1 = \mu > 0$ for the chicken. To make the model 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 number of speculators attacking the currency in the foreign exchange market. If the number of speculators attacking the currency peg of country j is denoted by l_j, the currency peg fails if and only if

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

Therefore, 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 interesting range is the intermediate case when $0 < \theta_j \leq 1$. Here, the government is forced to abandon the peg if a sufficiently large proportion of speculators attacks the currency, whereas the peg will be kept if a sufficiently large proportion of speculators chooses not to attack. This tripartite classification of fundamentals follows Obstfeld (1996). In what follows, 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 stating that the government defends the currency peg if and only if the cost of this action is not too high. This cost increases with l_j and decreases with 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 defense increases with l_j. However, if the economic fundamentals are good, the government may have plenty of foreign reserves to defend the peg so that it may not have to raise the interest rates so sharply. This means that the negative effect of defending the peg on the country will be relatively mild. Therefore, the cost of defense decreases with 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 θ_j directly, they receive informative private signals about it. When the true state is θ_j, a speculator i observes a signal $x_{ji} = \theta_j + \epsilon_{ji}$, which is drawn uniformly from the interval $[\theta_j - \epsilon, \theta_j + \epsilon]$, for some small positive ϵ. Conditional on θ_j, the signals are independently and identically distributed (i.i.d.) across individuals.

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

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

Here, $\text{Prob}\,[l_j \geq \theta_j |\, x_{ji}]$ is the probability that his/her attack is successful conditional on his/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 the type of group 1. Group 1 is chosen to be the bull with probability q or the chicken with probability $1 - q$ $(0 < q < 1)$. The value of θ_j is known to the government of country j. Group 1 's type is known to every speculator in group 1, but it 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 individually.
  - The government of country A abandons the peg if $l_A - \theta_A \geq 0$ and defends the peg otherwise.
  - Both the aggregate outcome in country A and the value of θ_A are known to every speculator. 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 individually.
  - The government of country B abandons the peg if $l_B - \theta_B \geq 0$ and defends the peg otherwise.
  - Both the aggregate outcome in country B and the value of θ_B are known to every speculator. 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).

2.1 Equilibrium

A fact already familiar from the discussion of global games in the literature is that even if ϵ becomes very small, 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.[5] The equilibrium strategy consists of the following values conditional on group 1's type and the information structure: a unique value of the switching economic fundamentals $\tilde{\theta}_j$ up to which the government always abandons the peg, and a unique value of the switching private signal conditional on the type of speculators $\tilde{x}_{ji}(\mu_1)$, such that every speculator who receives a signal lower than $\tilde{x}_{ji}(\mu_1)$ attacks the peg.

In order to explain intuitively how and why the crisis in country A triggers the crisis in country B, I shall first explain what happens in country A and then what happens in country B. In what follows, 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 events that is explained in Subsections 2.1.1 and 2.1.2 is indeed the subgame

[5] 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.

perfect equilibrium. Of course, I can explain the game in the usual way by backward induction, proceeding from what happens in country B to what happens in country A. Rather than giving such an explanation in the main text, I give the proof by backward induction in the appendix.

2.1.1 Equilibrium in Country A

The equilibrium values $\tilde{\theta}_j$ and $\tilde{x}_{ji}(\mu_1)$ belong to two situations of indifference: for $\theta_j = \tilde{\theta}_j$ the government is indifferent between defending the peg and abandoning it, whereas speculators with μ_1 receiving a private signal $\tilde{x}_{ji}(\mu_1)$ are indifferent between attacking the peg and refraining from doing so. I consider the symmetric switching strategy equilibrium in which every speculator of the same type uses the same switching value: $\tilde{x}_{ji}(\mu_1) = \tilde{x}_j(\mu_1)$. Thus in what follows, I omit the subscript i.

After receiving a private signal, each speculator has to decide whether to attack the peg, which leads to costs of $c + \mu_1$ and an uncertain payoff of D, or not to attack the peg, which is associated with a certain net profit of zero. The switching signal, $\tilde{x}_A(\mu_1)$, makes each speculator of type μ_1 indifferent between these two choices. For indifference, it is thus required that:

$$\text{Prob}\left[\text{Attack is successful} \mid \tilde{x}_A(\mu_1)\right] D - c - \mu_1 = 0. \tag{2}$$

The government will abandon the peg if θ_A is smaller than or equal to $\tilde{\theta}_A$, so that the probability of a successful attack equals the probability that the realized value of θ_A is smaller than or equal to $\tilde{\theta}_A$, given $\tilde{x}_A(\mu_1)$. As will be shown, $\tilde{\theta}_A$ takes different values depending on whether speculators in group 1 are of the bull or chicken type. Therefore, I denote $\tilde{\theta}_A(\mu_1) \equiv \tilde{\theta}_A^*$ if speculators in group 1 are bulls (i.e., $\mu_1 = 0$) and $\tilde{\theta}_A(\mu_1) \equiv \tilde{\theta}_A^{**}$ if speculators in group 1 are chickens (i.e., $\mu_1 = \mu$).

First, consider the behavior of speculators in group 1. They know their own type and the type of speculators in group 2, so that they know which value of $\tilde{\theta}_A(\mu_1)$, $\tilde{\theta}_A^*$ or $\tilde{\theta}_A^{**}$, would appear in the equilibrium. Noting $x_A = \theta_A + \epsilon_A$ and $\epsilon_A \sim U[-\epsilon, \epsilon]$, (2) can be rewritten as follows.

$$\begin{aligned}
c+\mu_1 &= \text{Prob}\left[\text{Attack is successful} \mid \tilde{x}_{A1}(\mu_1), \tilde{\theta}_A(\mu_1)\right] D \\
&= \text{Prob}\left[\theta_A \leq \tilde{\theta}_A(\mu_1) \mid \tilde{x}_{A1}(\mu_1), \tilde{\theta}_A(\mu_1)\right] D \\
&= \text{Prob}\left[\tilde{x}_{A1}(\mu_1) - \epsilon_A \leq \tilde{\theta}_A(\mu_1) \mid \tilde{x}_{A1}(\mu_1), \tilde{\theta}_A(\mu_1)\right] D \\
&= \left\{1 - \text{Prob}\left[\epsilon_A \leq \tilde{x}_{A1}(\mu_1) - \tilde{\theta}_A(\mu_1) \mid \tilde{x}_{A1}(\mu_1), \tilde{\theta}_A(\mu_1)\right]\right\} D \\
&= \left\{1 - \frac{\tilde{x}_{A1}(\mu_1) - \tilde{\theta}_A(\mu_1)}{2\epsilon}\right\} D \qquad (3)
\end{aligned}$$

Here, the subscript of $\tilde{x}_{A1}$ stands for country A and group 1. From (3), the switching signals $\tilde{x}^*_{A1} \equiv \tilde{x}_{A1}(\mu_1 = 0)$ and $\tilde{x}^{**}_{A1} \equiv \tilde{x}_{A1}(\mu_1 = \mu)$ have to satisfy the following.

$$\frac{\tilde{x}^*_{A1} - \tilde{\theta}^*_A}{2\epsilon} = \frac{\tilde{x}_{A1}(\mu_1 = 0) - \tilde{\theta}_A(\mu_1 = 0)}{2\epsilon} = 1 - \frac{c}{D} \qquad (4)$$

$$\frac{\tilde{x}^{**}_{A1} - \tilde{\theta}^{**}_A}{2\epsilon} = \frac{\tilde{x}_{A1}(\mu_1 = \mu) - \tilde{\theta}_A(\mu_1 = \mu)}{2\epsilon} = 1 - \frac{c+\mu}{D} \qquad (5)$$

Second, consider the behavior of speculators in group 2. They know their own type, but they do not know the type of speculators in group 1. Hence, they do not know which value of $\tilde{\theta}_A(\mu_1)$ would appear in the equilibrium. Let q be their belief that speculators in group 1 are bulls. (2) can be rewritten as follows.

$$\begin{aligned}
c &= \text{Prob}\left[\text{Attack is successful} \mid \tilde{x}_{A2}\right] D \\
&= \text{Prob}\left[\text{Attack is successful when } \mu_1 = 0 \mid \tilde{x}_{A2}\right] D \\
&\quad + \text{Prob}\left[\text{Attack is successful when } \mu_1 = \mu \mid \tilde{x}_{A2}\right] D \\
&= q \times \text{Prob}\left[\theta_A \leq \tilde{\theta}^*_A \mid \tilde{x}_{A2}\right] D + (1-q) \times \text{Prob}\left[\theta_A \leq \tilde{\theta}^{**}_A \mid \tilde{x}_{A2}\right] D \\
&= q \times \left\{1 - \frac{\tilde{x}_{A2} - \tilde{\theta}^*_A}{2\epsilon}\right\} D + (1-q) \times \left\{1 - \frac{\tilde{x}_{A2} - \tilde{\theta}^{**}_A}{2\epsilon}\right\} D \qquad (6)
\end{aligned}$$

Therefore, conditional on q , $\tilde{x}_{A2}$ has to satisfy the following.

$$\frac{\tilde{x}_{A2} - q\,\tilde{\theta}^*_A - (1-q)\tilde{\theta}^{**}_A}{2\epsilon} = 1 - \frac{c}{D} \qquad (7)$$

Third, consider the behavior of the government. The government is indifferent between defending the currency peg and abandoning it, if the proportion of speculators attacking the peg $l_A = \theta_A$. The proportion of attacking speculators in group j is equal to the proportion of speculators who get a private signal smaller than or equal to $\tilde{x}_{Aj}(\mu_1)$ ($j = 1, 2$). Since the noise term ϵ_A is i.i.d., this proportion is equal to the probability that any particular speculator in group j receives a signal below the switching signal. Thus, the proportion of attacking speculators conditional on θ_A is the following.

$$\begin{aligned} l_A(\theta_A) &= \lambda \text{Prob}\left[x_{A1} \leq \tilde{x}_{A1}(\mu_1) \mid \theta_A\right] + (1-\lambda)\text{Prob}\left[x_{A2} \leq \tilde{x}_{A2} \mid \theta_A\right] \\ &= \lambda \text{Prob}\left[\theta_A - \epsilon_A \leq \tilde{x}_{A1}(\mu_1) \mid \theta_A\right] + (1-\lambda)\text{Prob}\left[\theta_A - \epsilon_A \leq \tilde{x}_{A2} \mid \theta_A\right] \\ &= \lambda \frac{\tilde{x}_{A1}(\mu_1) - \theta_A}{2\epsilon} + (1-\lambda)\frac{\tilde{x}_{A2} - \theta_A}{2\epsilon} \qquad (8) \end{aligned}$$

In the right-hand side of the first line, the first term is the proportion of attacking speculators in group 1, while the second term is the proportion of attacking speculators in group 2. From (8) and the definition of $\tilde{\theta}_A(\mu_1)$, the following holds.

$$\tilde{\theta}_A(\mu_1) = l_A\left(\tilde{\theta}_A(\mu_1)\right) = \lambda \frac{\tilde{x}_{A1}(\mu_1) - \tilde{\theta}_A(\mu_1)}{2\epsilon} + (1-\lambda)\frac{\tilde{x}_{A2} - \tilde{\theta}_A(\mu_1)}{2\epsilon}$$

Therefore, $\tilde{\theta}_A^*$ and $\tilde{\theta}_A^{**}$ can be described as follows.

$$\begin{aligned} \tilde{\theta}_A^* &\equiv \tilde{\theta}_A(\mu_1 = 0) = \lambda \frac{\tilde{x}_{A1}^* - \tilde{\theta}_A^*}{2\epsilon} + (1-\lambda)\frac{\tilde{x}_{A2} - \tilde{\theta}_A^*}{2\epsilon} \qquad (9) \\ \tilde{\theta}_A^{**} &\equiv \tilde{\theta}_A(\mu_1 = \mu) = \lambda \frac{\tilde{x}_{A1}^{**} - \tilde{\theta}_A^{**}}{2\epsilon} + (1-\lambda)\frac{\tilde{x}_{A2} - \tilde{\theta}_A^{**}}{2\epsilon} \qquad (10) \end{aligned}$$

There are five equations, (4), (5), (7), (9), and (10), and there are five unknowns, $\tilde{x}_{A1}^*$, $\tilde{x}_{A1}^{**}$, $\tilde{x}_{A2}$, $\tilde{\theta}_A^*$ and $\tilde{\theta}_A^{**}$. One can explicitly solve these five equations for five unknowns.[6] It can be shown that these five solutions characterize the switching strategy equilibrium.[7] (See Table 2, Figure 2 and Figure 3.)

Proposition 1 *Conditional on the type of speculators in group 1, the unique switching*

[6]See the appendix for explicit solutions.
[7]See the appendix for proof.

strategy equilibrium in country A consists of the switching private signal and the switching economic fundamentals.

2.1.2 Equilibrium in Country B

In period 2, every speculator observes not only what has happened in country A, but also the exact value of θ_A. These observations can convey information about the type of speculators in group 1 because different types use different switching signals, resulting in different outcomes in country A under certain conditions.

There are two possible cases of θ_A that are critical to the information structure in period 2. First, select any $\theta_A \notin [\tilde{\theta}_A^{**}, \tilde{\theta}_A^{*}]$. For any $\theta_A \leq \tilde{\theta}_A^{**}$, the crisis will certainly occur in country A, regardless of the type of speculators in group 1. For any $\theta_A \geq \tilde{\theta}_A^{*}$, the crisis will never occur in country A regardless of the type of speculators in group 1. Therefore, the type of speculators in group 1 will never be revealed for any $\theta_A \notin [\tilde{\theta}_A^{**}, \tilde{\theta}_A^{*}]$. This means that there is no essential change in the information structure in period 2. Second, select any $\theta_A \in [\tilde{\theta}_A^{**}, \tilde{\theta}_A^{*}]$. Conditional on such θ_A, the crisis occurs in country A if and only if speculators in group 1 are bulls. Observing the crisis in country A for such θ_A, speculators in group 2 learn that speculators in group 1 are bulls. Thus, speculators in group 2 update their beliefs about the type of group 1 and thereby they change the optimal behavior in country B. Therefore, even though economic fundamentals are totally unrelated across country A and country B, what has happened in country A affects the optimal behavior of speculators in country B, which in turn affects what would happen in country B. This is the key to explaining contagion across unrelated countries.

Now I can derive the switching strategy equilibrium in country B, which is conditional on both what has happened in country A and the value of θ_A. For any $\theta_A \notin [\tilde{\theta}_A^{**}, \tilde{\theta}_A^{*}]$, there is no essential change in the information structure so that the switching strategy equilibrium in country B is exactly same as the one in country A in Proposition 1. For any $\theta_A \in [\tilde{\theta}_A^{**}, \tilde{\theta}_A^{*}]$, there are two possible cases. One is that the crisis has occurred in country A while another is that the crisis has not occurred in country A. In the former case, speculators in group 2 learn that speculators in group 1 are of the bull type. Let us call this Case 1. In the latter case, speculators in group 2 learn that speculators in group 1 are chickens. Let us call this Case 2. I analyze the switching strategy equilibrium in country B in each case.

In Case 1, every speculator is a bull and this fact is common knowledge. This means that every speculator is identical so that all the speculators will use the same switching signal, x_B^*. Thus, the proportion of attacking speculators conditional on θ_B is as follows.

$$\begin{aligned} l_B(\theta_B) &= \text{Prob}\left[x_B \leq x_B^* \middle| \, \theta_B\right] \\ &= \text{Prob}\left[\theta_B + \epsilon_B \leq x_B^* \middle| \, \theta_B\right] \\ &= \frac{x_B^* - \theta_B}{2\epsilon} \end{aligned} \tag{11}$$

Since the government is indifferent between defending the peg and abandoning it when $\theta_B^* = l_B$, (11) implies that the switching value of economic fundamentals θ_B^* satisfies the following.

$$\theta_B^* = l_B(\theta_B = \theta_B^*) = \frac{x_B^* - \theta_B^*}{2\epsilon} \tag{12}$$

Observing the switching private signal x_B^*, the expected utility of attacking the currency peg must be zero.

$$\begin{aligned} c &= \text{Prob}\left[\text{Attack is successful} \mid x_B^*\right] D \\ &= \text{Prob}\left[\theta_B \leq \theta_B^* \middle| \, x_B^*\right] D \\ &= \text{Prob}\left[x_B^* - \epsilon_B \leq \theta_B^* \middle| \, x_B^*\right] D \\ &= \left(1 - \frac{x_B^* - \theta_B^*}{2\epsilon}\right) D \end{aligned} \tag{13}$$

From (12) and (13), x_B^* and θ_B^* can be derived as follows.

$$\theta_B^* = 1 - \frac{c}{D} \tag{14}$$

$$x_B^* = (2\epsilon + 1)\left(1 - \frac{c}{D}\right) \tag{15}$$

It can be shown that (14) and (15) comprise the switching strategy equilibrium of Case 1 as in Proposition 1.

In Case 2, it is common knowledge that speculators in group 1 are the chicken type and speculators in group 2 are the bull type. I denote the switching signal of a speculator in group 1 by x_{B1}^{**}, that of a speculator in group 2 by x_{B2}^{**}, respectively. The proportion of attacking speculators conditional on θ_B is as follows:

$$\begin{aligned} l_B(\theta_B) &= \lambda \text{Prob}\left[x_{B1} \leq x_{B1}^{**} | \, \theta_B\right] + (1-\lambda)\text{Prob}\left[x_{B2} \leq x_{B2}^{**} | \, \theta_B\right] \\ &= \lambda \text{Prob}\left[\theta_B + \epsilon_B \leq x_{B1}^{**} | \, \theta_B\right] + (1-\lambda)\text{Prob}\left[\theta_B + \epsilon_B \leq x_{B2}^{**} | \, \theta_B\right] \\ &= \lambda \frac{x_{B1}^{**} - \theta_B}{2\epsilon} + (1-\lambda)\frac{x_{B2}^{**} - \theta_B}{2\epsilon} \end{aligned} \tag{16}$$

Since the government is indifferent between defending the peg and abandoning it when $\theta_B^{**} = l_B$, (16) implies that the switching value of economic fundamentals θ_B^{**} satisfies the following:

$$\theta_B^{**} = l_B\left(\theta_B = \theta_B^{**}\right) = \frac{1}{2}\frac{x_{B1}^{**} - \theta_B^{**}}{2\epsilon} + \frac{1}{2}\frac{x_{B2}^{**} - \theta_B^{**}}{2\epsilon}. \tag{17}$$

Observing the switching private signal x_{B1}^{**}, the expected utility of attacking the currency peg for the chicken speculator must be zero.

$$\begin{aligned} c + \mu &= \text{Prob}\left[\text{Attack is successful} \mid x_{B1}^{**}\right] D \\ &= \text{Prob}\left[\theta_B \leq \theta_B^{**} | \, x_{B1}^{**}\right] D \\ &= \text{Prob}\left[x_{B1}^{**} - \epsilon_B \leq \theta_B^{**} | \, x_{B1}^{**}\right] D \\ &= \left(1 - \frac{x_{B1}^{**} - \theta_B^{**}}{2\epsilon}\right) D \end{aligned} \tag{18}$$

Similarly, observing the switching private signal x_{B2}^{**}, the expected utility of attacking the currency peg for the bull speculator must be zero. Since the type of speculators in group 1 is common knowledge, speculators in group 2 do not need to take an expectation of over θ_B^{*} and θ_B^{**} in their expected utility. They actually know that θ_B^{**} would arise as the value of switching economic fundamentals. Thus, the expected utility conditional on x_{B2}^{**} can be written as follows.

$$
\begin{aligned}
c &= \text{Prob}\,[\text{Attack is successful} \mid x_{B2}^{**}]\, D \\
&= \text{Prob}\,[\theta_B \leq \theta_B^{**} \mid x_{B2}^{**}]\, D \\
&= \left(1 - \frac{x_{B2}^{**} - \theta_B^{**}}{2\epsilon}\right) D \qquad (19)
\end{aligned}
$$

From (17), (18) and (19), x_{B1}^{**}, x_{B2}^{**} and θ_B^{**} can be derived as follows.

$$
\begin{aligned}
\theta_B^{**} &= 1 - \frac{c}{D} - \frac{\lambda\mu}{D} \qquad (20) \\
x_{B1}^{**} &= (2\epsilon + 1)\left(1 - \frac{c}{D}\right) - (2\epsilon + \lambda)\,\frac{\mu}{D} \qquad (21) \\
x_{B2}^{**} &= (2\epsilon + 1)\left(1 - \frac{c}{D}\right) - \frac{\lambda\mu}{D} \qquad (22)
\end{aligned}
$$

It can be shown that (20), (21) and (22) comprise the switching strategy equilibrium of Case 2 as in Proposition 1. Proposition 2 summarizes the above argument.[8] (See Table 3 and 4.)

Proposition 2 *Conditional on θ_A and what has happened in country A, the unique switching strategy equilibrium in country B consists of the switching private signals and the switching economic fundamentals.*

Now, I have shown the existence of contagion. (See Figure 4.)

Proposition 3 *Contagion can occur across unrelated countries: $\theta_B^{**} < \theta_B^{*}$.*

Proposition 3 distinguishes contagion of crises from a coincidence of crises. To see this, first pick any θ_B such that $\theta_B^{**} < \theta_B < \theta_B^{*}$. Given such θ_B, the crisis occurs in country B if and only if the crisis occurs in country A. This is contagion. Next, select any θ_B such that θ_B^{**}. In this case, the crisis occurs in country B regardless of the occurrence of the crisis in country A. Therefore, it is just a coincidence in the latter case if the crisis occurs in both countries.

[8]See the appendix for proof that the sequence of Proposition 1 and Proposition 2 is the subgame perfect equilibrium.

Between the literature and this new channel, there is a key difference of the implication as to what kind of crisis is contagious.

Proposition 4 *Crisis in country A with better economic fundamentals is more contagious than in one with worse economic fundamentals.*

See Figure 5. For any $\theta'_A \leq \tilde{\theta}^{**}_A$, the peg would be abandoned in country A regardless of the type of group 1. Thus, the crisis would not reveal the type, which would not cause contagion. However, for any $\theta''_A \in [\tilde{\theta}^{**}_A, \tilde{\theta}^{*}_A]$, the crisis would occur in country A if and only if speculators in group 1 are bulls. Thus, whether or not the crisis has occurred in country A reveals the type of group 1, which is the source of contagion. Intuitively speaking, for any $\theta'_A \leq \tilde{\theta}^{**}_A$, the economic fundamentals in country A are so bad that no speculator would be surprised at the crisis, which means that no speculator would change his/her behavior. However, for any $\theta''_A \in [\tilde{\theta}^{**}_A, \tilde{\theta}^{*}_A]$, the economic fundamentals in country A are not so bad, in that the crisis would not have occurred if speculators in group 1 had been chickens. Thus, the crisis would surprise speculators in group 2 in this case, which would make them change their behavior so as to cause contagion.

The common implication in the literature is the following. The worse the economic fundamentals in the originating crisis country, the larger the negative impact of the originating crisis. The larger the negative impact, the more severely countries would be affected through trade and/or capital linkage. However, Proposition 4 shows that the opposite can be true. If the crisis occurs where economic fundamentals are considered to be good, it will lead to a big surprise and hence the crisis can become more contagious than otherwise.

In order to explain the contagion channel as clearly as possible, I construct a two-country model where a crisis (i.e., successful speculative attacks) can spread from one country to another. Here I discuss three further things that the model can show.

First, the model can describe contagion in a broader way such that failed as well as successful speculative attacks spread across countries. If the speculators in group 2 directly observe the speculative pressure itself (l_A) rather than just whether or not the crisis occurs in country A, they can update their belief about the type of speculators in group 1 even by observing the failed speculative attack to country A, which can cause contagion.

Second, the model can show that the potential victims of crisis are not necessarily those who peg the currency. Even countries with floating systems can face some selling pressure when their currencies appear to be over-valued, which could result in contagious selling pressure to other countries.

Third, the propagation mechanism in this paper can work with other mechanisms. For instance, it can work with a common lender. See the appendix for detail.

3 Conclusion and Future Research

This paper presents a model showing a new contagion channel that can work across unrelated countries. Moreover, the model shows that the better the economic fundamentals in the originating crisis country, the more contagious the originating crisis. Here I discuss possible extensions of the model for future research.

The model can be extended to an N-country model (N $\geq$ 3). Which country would suffer from contagion in the N-country model? *Other things being equal*, the worse the economic fundamentals of a country, the more likely it is that the country will suffer from contagion. However, in reality, the economic fundamentals are not the only factor explaining why some countries are severely affected during financial crises while others are left unscathed. In the two-country model, for simplicity, I assume that two countries are identical *ex ante* and can be different *ex post* only in terms of the economic fundamentals. However, the model can be modified such that countries can be different in terms of other aspects. For instance, suppose the economic fundamentals happen to be the same across countries, but severe capital control is imposed in one country while no control is imposed in the other. In this case, the latter is more likely to suffer from contagion, and more severely, than the former. Indeed, Kaminsky, Lyons, and Schmukler (2000) argue that liquidity of financial markets could also be an important factor in explaining why some countries suffer from contagion. This is because investors may prefer to sell in liquid markets (e.g., less restricted and less thin markets) rather than illiquid markets when they close their positions. Relating to this point, Committe on the Global Financial System (1999) argues that a hedging strategy, called proxy hedging, could be one of the contributing factors for contagion. This strategy leads traders to use major national markets to offset positions in thin markets that might be difficult to liquidate quickly. An example could be the fall in asset prices in Australia and Hong Kong at the time that the Asian crisis broke in 1997. It will be useful to consider proxy hedging for a fuller understanding of contagion.

The model can also be extended to consider the role of a single large speculator who can affect the whole market to some degree. In this paper, none of the speculators can affect the market as a whole by him/herself. However, recent currency crises episodes suggest that large traders like George Soros can exercise a disproportionate influence on the likelihood and severity of a financial crisis by fomenting and orchestrating attacks against weakened currency pegs. Corsetti, Dasgupta, Morris, and Shin (2004) argue that the presence of the large speculator does make all other traders more aggressive in their selling, but they do not consider the implication of the presence of the large speculator for contagion. The implication for contagion is not so obvious. On the one hand, the crisis may be more contagious in the presence of the large speculator simply because the large speculator has greater market power in attacking the peg of *country B*. On the other hand, the crisis may be less contagious because the type revealing effect, which is critical to the contagion channel in this paper, may become small if all other traders become more aggressive in attacking the peg of *country A*. I will be addressing this issue in another paper.[9]

[9]See Taketa (2004).

A Solutions for Switching Values

$$\begin{aligned}
\tilde{\theta}_A^* &= \frac{1}{q}\Big[1-\frac{c}{D}-\frac{\mu}{D}\lambda(1-q)-\frac{(1-q)(1-\lambda)}{2\epsilon+(1-\lambda)}\Big\{\frac{2\epsilon}{1-\lambda}+1-\frac{c}{D} \\
&\qquad -\frac{\mu}{D}\lambda(1-q)-\frac{1}{1-\lambda}\frac{2\epsilon c}{D}-\frac{2\epsilon\lambda}{1-\lambda}\frac{\mu}{D}\Big\}\Big] \qquad (23)\\
\tilde{\theta}_A^{**} &= \frac{1-\lambda}{2\epsilon+(1-\lambda)}\Big[\frac{2\epsilon}{1-\lambda}+1-\frac{c}{D}-\frac{\mu}{D}\lambda(1-q)-\frac{1}{1-\lambda}\frac{2\epsilon c}{D} \\
&\qquad -\frac{2\epsilon\lambda}{1-\lambda}\frac{\mu}{D}\Big] \qquad (24)\\
\tilde{x}_{A1}^* &= \frac{1}{q}\Big[1-\frac{c}{D}-\frac{\mu}{D}\lambda(1-q)-\frac{(1-q)(1-\lambda)}{2\epsilon+(1-\lambda)}\Big\{\frac{2\epsilon}{1-\lambda}+1-\frac{c}{D} \\
&\qquad -\frac{\mu}{D}\lambda(1-q)-\frac{1}{1-\lambda}\frac{2\epsilon c}{D}-\frac{2\epsilon\lambda}{1-\lambda}\frac{\mu}{D}\Big\}\Big]+2\epsilon(1-\frac{c+\mu}{D}) \qquad (25)\\
\tilde{x}_{A1}^{**} &= \frac{1-\lambda}{2\epsilon+(1-\lambda)}\Big[\frac{2\epsilon}{1-\lambda}+1-\frac{c}{D}-\frac{\mu}{D}\lambda(1-q)-\frac{1}{1-\lambda}\frac{2\epsilon c}{D}-\frac{2\epsilon\lambda}{1-\lambda}\frac{\mu}{D}\Big] \\
&\qquad +2\epsilon(1-\frac{c+\mu}{D}) \qquad (26)\\
\tilde{x}_{A2} &= 2\epsilon+1-\frac{c}{D}-\frac{\mu}{D}\lambda(1-q)-\frac{2\epsilon c}{D} \qquad (27)
\end{aligned}$$

B Proof of Proposition 1

By construction, the switching private signals make each speculator in each group indifferent between attacking the currency peg and refraining from doing so, respectively, conditional on $\tilde{\theta}_A^*$ and $\tilde{\theta}_A^{**}$. To show that these values indeed consist of the switching strategy equilibrium, it needs to be verified that every speculator in each group strictly prefers to attack (refrains from attacking) the currency peg given any private signal less than (greater than) the switching private signals conditional on $\tilde{\theta}_A^*$ and $\tilde{\theta}_A^{**}$. In order to verify this, it is sufficient to check whether an individual speculator in each group finds it optimal to follow the switching strategy provided that every other speculator follows the switching strategy. Therefore, suppose that every other speculator follows the switching strategy. Then, an individual speculator in each group takes $\tilde{\theta}_A^*$ and $\tilde{\theta}_A^{**}$ as given. From (3) and (6), the expected utility of attacking the currency peg is *strictly decreasing* in the private signal given $\tilde{\theta}_A^*$ and $\tilde{\theta}_A^{**}$. This is because the probability that an attack is successful decreases strictly with the private signal given $\tilde{\theta}_A^*$ and $\tilde{\theta}_A^{**}$.[10] Therefore, for any private signal less than (greater than) the switching signal, the expected utility of attacking the currency peg is strictly greater than (smaller than) that of refraining from doing so. Thus, it is optimal for any speculator to follow the switching strategy provided that everyone else follows the switching strategy. Moreover, it can be shown that $\tilde{\theta}_A^* > \tilde{\theta}_A^{**}$. Intuitively speaking, the bull speculators are more likely to attack for any given economic fundamentals, which implies that the currency peg is more likely to be abandoned if the speculators in group 1 are bulls. That is why $\tilde{\theta}_A^* > \tilde{\theta}_A^{**}$.

C Proof of Subgame Perfect Equilibrium

Here I prove that the sequence of Proposition 1 and Proposition 2 is the subgame perfect equilibrium.

Notice that if speculators in group 2 believe that speculators in group 1 are bulls, it is more likely that the currency peg will be abandoned. Therefore the chicken speculators *may* have an incentive to make speculators in group 2 believe that group 1 are bulls. In order for the chicken speculators to deceive, they need to behave in country A as if they are bulls by using the switching private signal of the bull speculators, $\tilde{x}_{A1}^*$. In that case, the switching economic fundamentals in country A would be $\tilde{\theta}_A^*$ as long as all the chicken speculators use $\tilde{x}_{A1}^*$. Then, for $\theta_A \leq \tilde{\theta}_A^*$, the currency crisis would occur in country A. Therefore, the expected utility of the *deceiving* chicken speculator conditional on $\tilde{x}_{A1}^*$ is as follows.

$$
\begin{aligned}
& \text{Prob}\left[\text{Attack is successful} \mid \tilde{x}_A^*\right] D - c - \mu \\
= \;& \left\{1 - \frac{\tilde{x}_A^* - \tilde{\theta}_A^*}{2\epsilon}\right\} D - c - \mu \\
= \;& -\mu \qquad (28)
\end{aligned}
$$

The second equality is because $\tilde{x}_A^*$ makes the bull speculator indifferent between attacking

[10] The greater the private signal, the more likely that everyone else receives the greater signal also. This means that the proportion of attacking speculators is likely to be small because everyone else is more likely to refrain from attacking the peg, so the probability that an attack will be successful becomes smaller.

the peg and refraining from doing so; i.e., $1 - c/D - (\tilde{x}_A^* - \tilde{\theta}_A^*)/2\epsilon = 0$. Thus μ can be thought of as the cost of deceiving. Next, suppose that the chicken speculators succeed in deceiving group 2 by using $\tilde{x}_{A1}^*$ as their switching private signal: it becomes more likely for the currency peg in country B to be abandoned since speculators in group 2 believe speculators in group 1 are bulls. This means that the expected utility in period 2 would increase. As long as the increase in the expected utility in period 2 is greater than or equal to the cost μ, deceiving seems to be the equilibrium, but actually it cannot be the equilibrium. To see this, suppose that the increase in the expected utility in period 2 is greater than the cost μ. In this case, a chicken speculator has an incentive to *refrain from* attacking the peg in period A when he/she observes $\tilde{x}_A^*$, provided that every other chicken speculator uses $\tilde{x}_A^*$ as the switching private signal. This is because they can save the cost μ by refraining from attacking, *without changing the switching economic fundamentals in country A*.[11] Even if they do not pay the cost of deceiving, they can enjoy the increase in the expected utility in period 2 because of other chicken speculators' deceiving behavior. Put another way, they can *free-ride* on other chicken speculators' deceiving behavior. This in turn implies that no chicken speculator has an incentive to pay the cost. Therefore, deceiving cannot be the equilibrium. In other words, there is no switching private signal other than those in Proposition 1 and Proposition 2 in the *two-stage* game.

D A Rollover Game

The contagion channel in this paper can work with other channels at the same time. Here I show it can work with the common lender. In particular, I show that the model in this paper can describe a rollover game among common lenders.

Just rename speculators in the model as foreign creditors. Foreign creditors have invested in both country A and country B. They have financed a project in each country. Therefore, they are the common lenders. Observing a private signal, a creditor decides whether to roll over a loan or not. If (s)he decides not to roll over and asks to liquidate, the payoff is $c + \mu_1$ for certain. Not to roll over is a safe choice, which corresponds

[11] No individual speculator can affect the switching economic fundamentals by him/herself alone.

to refraining from attacking the peg in the model. If he/she decides to roll over, the payoff depends on two factors: the economic fundamentals θ_j and the degree of disruption caused to the project by the early liquidation by other creditors. The latter is measured by the proportion of creditors who do not roll over, l_j. The project yields the payoff D (i.e., rollover is successful) if $\theta_j \geq l_j$ and zero (i.e., rollover fails) if $\theta_j < l_j$. That is, if a sufficient proportion of creditors refuses to roll over relative to the economic fundamentals ($\theta_j < l_j$), the project is liquidated entirely and yields nothing.[12] Rolling over is a risky choice in that the payoff is uncertain, which corresponds 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 exists. If creditors in group 1 are the *chickens* and $\theta_A \in [\tilde{\theta}_A^{**}, \tilde{\theta}_A^{*}]$, a sufficient proportion of creditors refuses to roll over so that the project dies in country A (i.e., the financial crisis in country A). Observing that, creditors in group 2 learn the type of creditors in group 1 and thereby change the switching signal for country B, resulting in contagion from country A to country B.

In terms of deriving the equilibrium, the speculators' game and the creditors' game are exactly the same. A difference is that the bull speculators play a central role in contagion in the speculators' game, while the chicken creditors play a central role in contagion in the creditors' game.

[12] This formulation is similar to Diamond and Dybvig (1983).

References

Allen, F., and D. Gale (2000): "Financial Contagion," *Journal of Political Economy*, 108(1), 1–33.

Calvo, G. A. (1999): "Contagion in Emerging Markets: When Wall Street is a Carrier," unpublished manuscript.

Calvo, G. A., and E. G. Mendoza (2000): "Rational Contagion and the Globalization of Securites Markets," *Journal of International Economics*, 51(1), 79–113.

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

Committe on the Global Financial System (1999): "A Review of Financial Market Events in Autumn 1998," CGFS Publications No. 12, Bank of International Settlements.

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, N. Roubini, and C. Tille (2000): "Competitive Devaluations: Toward A Welfare-based Approach," *Journal of International Economics*, 51(1), 1211–1236.

Dasgupta, A. (2004): "Financial Contagion thourgh Capital Connections: A Model of the Origin and Spread of Bank Panics," *Journal of the European Economic Association*, 2(6), forthcoming.

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

Financial Stability Forum (2002): "The FSF Recommendations and Concerns Raised By Highly Leveraged Institutions (HLIs): An Assessment," 11 March 2002.

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): "Measuring Contagion: Conceptual and Empirical Issues," in *International Financial Contagion*, ed. by S. Claessens, and K. J. Forbes. Kluwer Academic Publishers.

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

Gerlach, S., and F. Smets (1995): "Contagious Speculative Attacks," *European Journal of Political Economy*, 11(1), 45–63.

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.

Kaminsky, G. L., R. Lyons, and S. Schmukler (2000): "Economic Fragility, Liquidity, and Risk: The Behavior of Mutual Funds during Crises," unpublished manuscript.

Krugman, P. (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.

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.

Metz, C. E. (2002): "Private and Public Information in Self-Fulfilling Currency Crises," *Journal of Economics*, 76(1), 65–85.

Morris, S., and H. S. Shin (1998): "Unique Equilibrium in a Model of Self-Fulfilling Currency Attacks," *American Economic Review*, 88(3), 587–597.

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): "A Large Speculator in Contagious Currency Crises: A Single "George Soros" Makes Countries More Vulnerable to Crises, but Mitigates Contagion," IMES Discussion Paper No. 2004-E-23, 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	$D - c - \mu_1$	$-c - \mu_1$
Not Attack	0	0

Table 1: Payoff Matrix

	$\mu_1 = 0$	$\mu_1 = \mu$
Group 1's switching signal	$\tilde{x}^*_{A1}$	$\tilde{x}^{**}_{A1}$
Group 2's switching signal	$\tilde{x}_{A2}$	$\tilde{x}_{A2}$
Switching economic fundamentals	$\tilde{\theta}^*_A$	$\tilde{\theta}^{**}_A$

Table 2: Equilibrium Strategy in Period 1

	$\mu_1 = 0$	$\mu_1 = \mu$
Group 1's switching signal	$\tilde{x}^*_{B1}$ $(= \tilde{x}^*_{A1})$	$\tilde{x}^{**}_{B1}$ $(= \tilde{x}^{**}_{A1})$
Group 2's switching signal	$\tilde{x}_{B2}$ $(= \tilde{x}_{A2})$	$\tilde{x}_{B2}$ $(= \tilde{x}_{A2})$
Switching economic fundamentals	$\tilde{\theta}^*_B$ $(= \tilde{\theta}^*_A)$	$\tilde{\theta}^{**}_B$ $(= \tilde{\theta}^{**}_A)$

Table 3: Equilibrium Strategy in Period 2 for any $\theta_A \notin [\tilde{\theta}^{**}_A, \tilde{\theta}^*_A]$

	Crisis in Country A[13]	No Crisis in Country A[14]
Group 1's switching signal	x_B^*	x_{B1}^{**}
Group 2's switching signal	x_B^*	x_{B2}^{**}
Switching economic fundamentals	θ_B^*	θ_B^{**}

Table 4: Equilibrium Strategy in Period 2 for any $\theta_A \in [\tilde{\theta}_A^{**}, \tilde{\theta}_A^*]$

[14]Crisis occurs in country A for any $\theta_A \in [\tilde{\theta}_A^{**}, \tilde{\theta}_A^*]$ if and only if group 1 are bulls ($\mu_1 = 0$).
[14]No crisis occurs in country A for any $\theta_A \in [\tilde{\theta}_A^{**}, \tilde{\theta}_A^*]$ if and only if group 1 are chickens ($\mu_1 = \mu$).

	Success	Failure
Roll Over	D	0
Not Roll Over	$c + \mu_1$	$c + \mu_1$

Table 5: Payoff Matrix

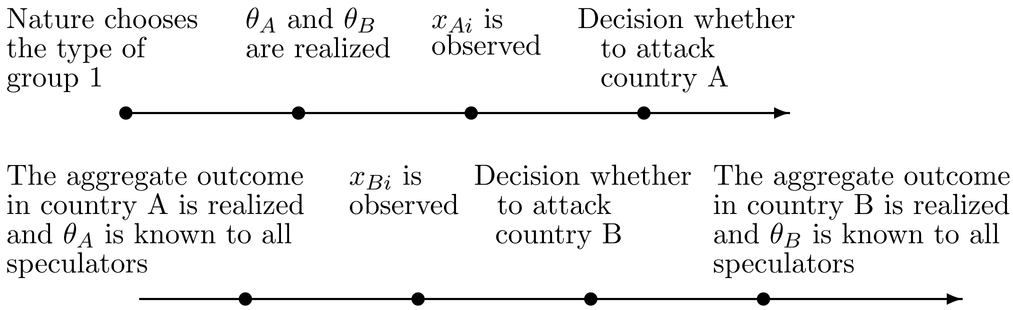

Figure 1: Timing of the Game

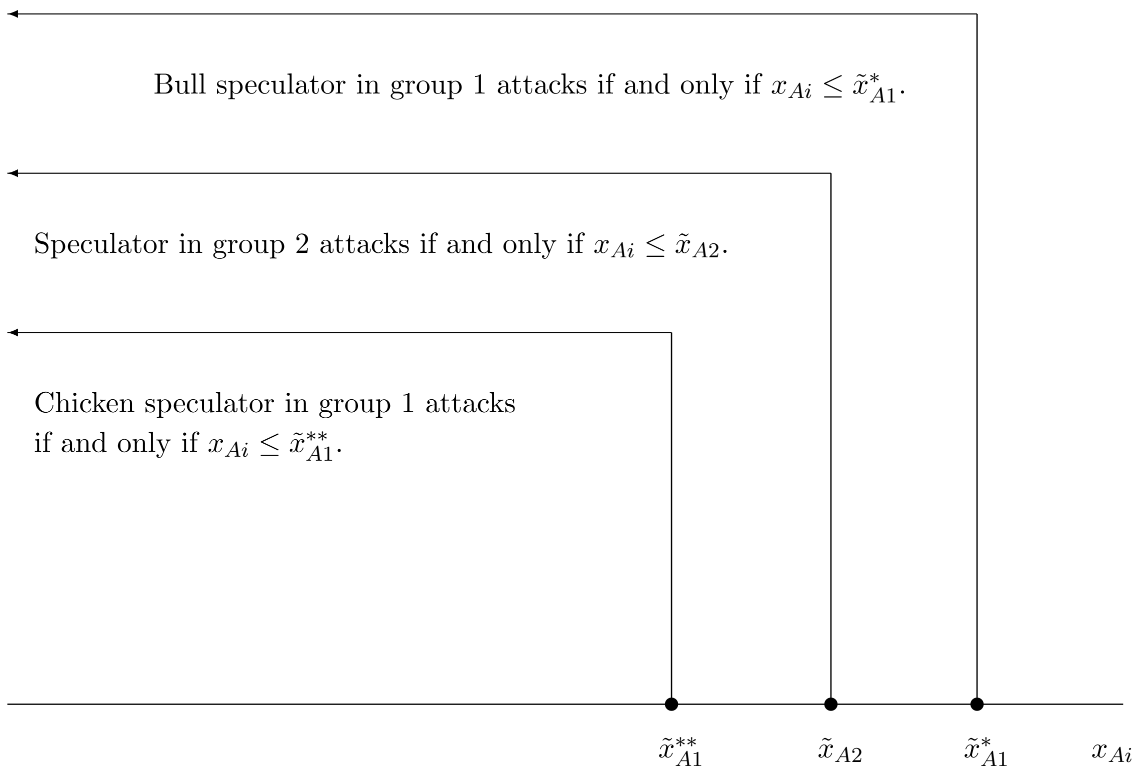

Figure 2: Switching Signals and Speculators' Decision

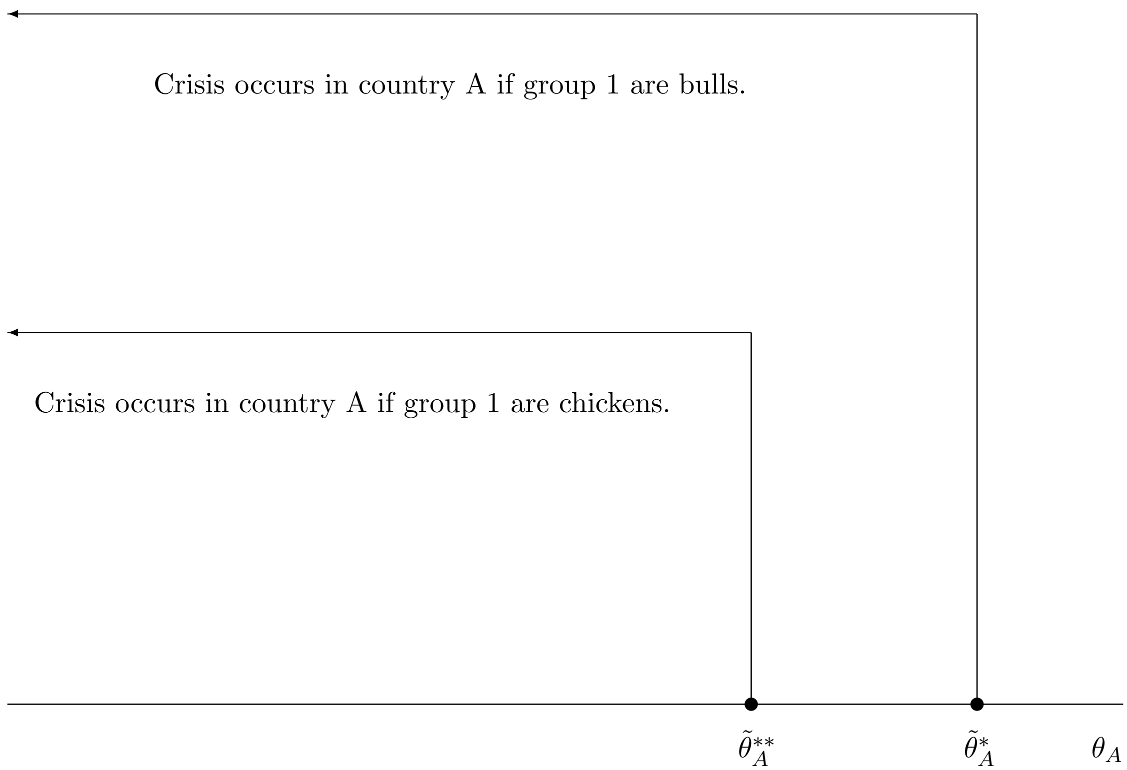

Figure 3: Switching Economic Fundamentals in Country A and Group 1's Type

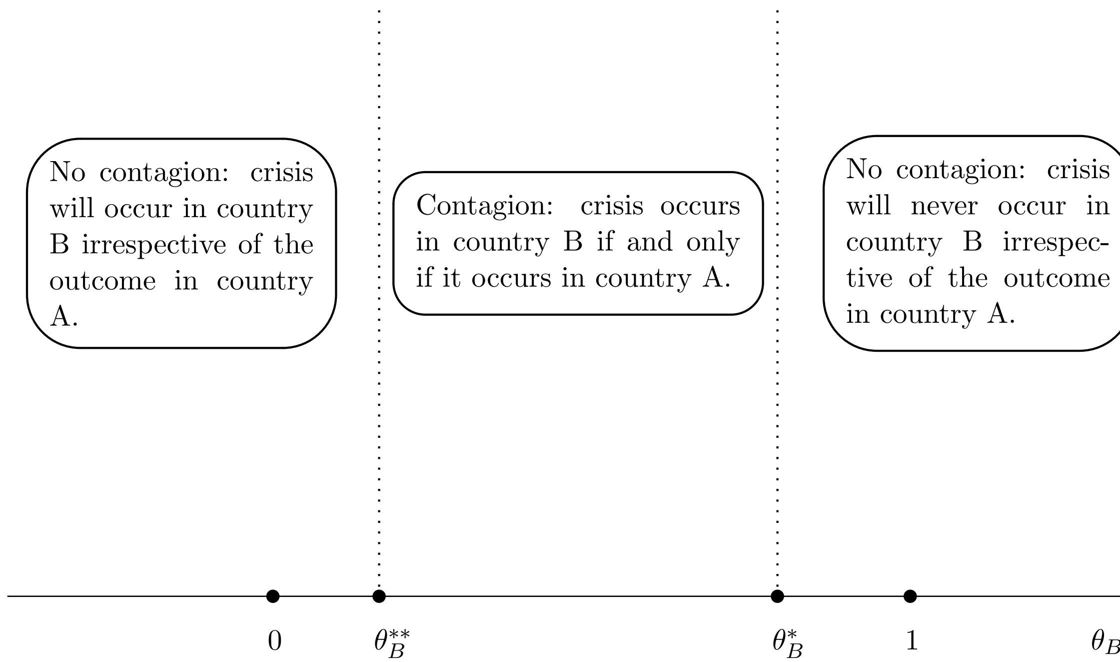

Figure 4: Contagion of Currency Crises

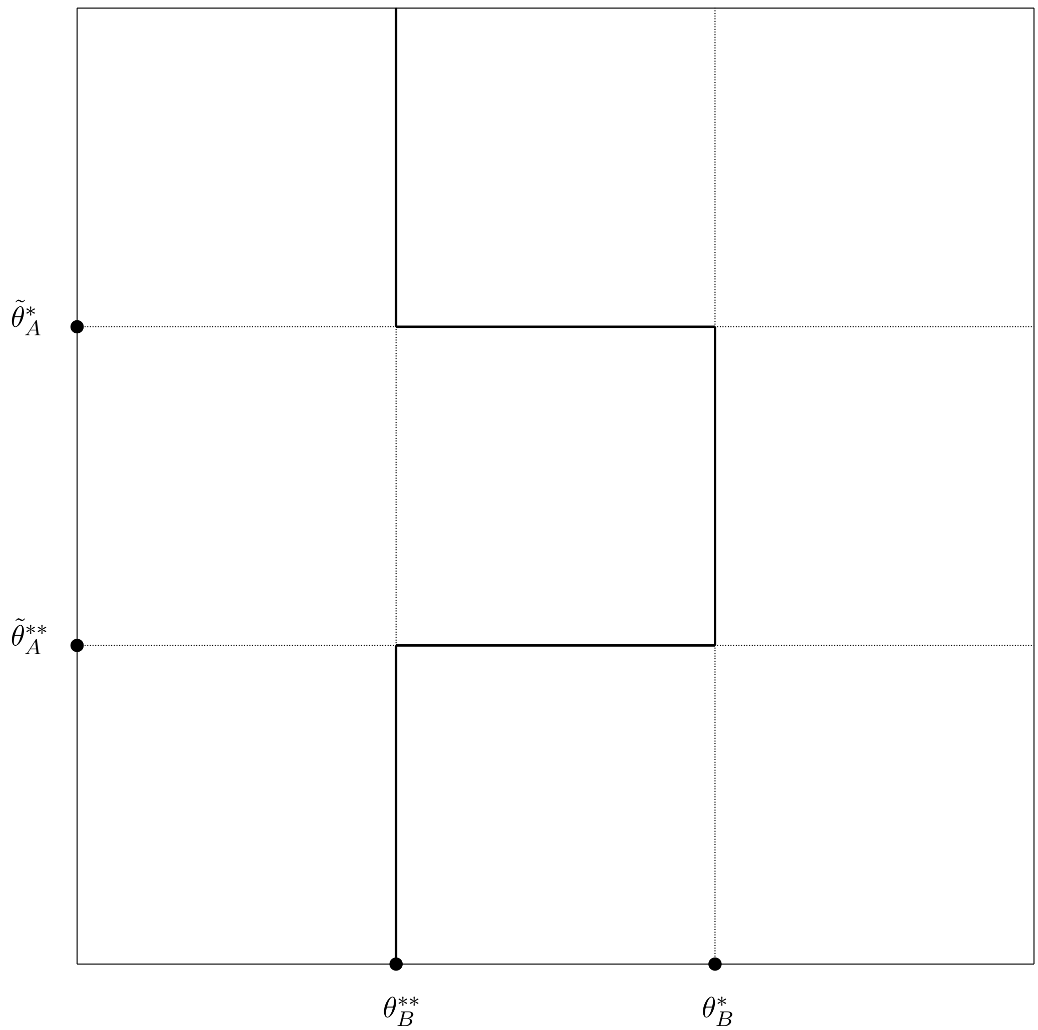

Figure 5: Switching Economic Fundamentals when Group 1 Speculators are the Bull Type