

Experimental Analysis on the Role of A Large Speculator in Currency Crises*

Yasuhiro Arikawa[†], Kumi Suzuki-Löffelholz[‡] and Kenshi Taketa[§]

October 2005

Abstract

Corsetti, Dasgupta, Morris, and Shin (2004) show that the presence of the large speculator makes all other traders more aggressive in speculative attacks in the foreign exchange market. We conduct an experimental analysis designed to test their theoretical findings. The results support the theoretical predictions of Corsetti, Dasgupta, Morris, and Shin (2004). Moreover, the results suggest an asymmetric effect between regulating the size of the large speculator and de-regulating the size of the large speculator, which has not been dealt with by Corsetti, Dasgupta, Morris, and Shin (2004).

JEL classifications: F31; E58; D82; C72; C91

Keywords: Currency Crises; Global Game; Experimental Economics

*Kumi Suzuki-Löffelholz thanks financial support provided by the Waseda University 21st Century Center of Excellence program “Constructing Open Political-Economics Systems”. We thank the staff of the Bank of Japan for helpful suggestions. We also thank Yoshio Kamijo for his guidance of Z-tree. All possible remaining errors are ours. The views expressed in this paper are those of the authors and do not necessarily reflect the official views of the Bank of Japan or IMES.

[†]Graduate School of Finance, Accounting and Law, Waseda University, e-mail: arikawa@waseda.jp

[‡]Political Science and Economics, Waseda University, e-mail: suzukikumi@ruri.waseda.jp

[§]Institute for Monetary and Economic Studies, Bank of Japan, e-mail: kenshi.taketa@boj.or.jp

1 Introduction

We have witnessed many financial crises in the last fifteen years all over the world: the ERM crisis in 1992, the Mexican Peso crisis in 1994, the Asian financial crisis in 1997, the Russian crisis in 1998, the Brazilian crisis in 1999, the Argentine crisis in 2001, and so on. In these episodes, large speculators, like George Soros or Julian Robertson, have been often blamed not only for destabilizing the market unnecessarily during crises, but also for triggering these crises. This is because 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. For instance, it is well known that George Soros was dubbed “the man who broke the Bank of England” in the ERM crisis of 1992. During the Asian financial crisis of 1997, the then prime minister of Malaysia, Mahathir Mohamad, accused George Soros and others of being “the anarchists, self-serving rogues and international brigandage”.¹

Corsetti, Dasgupta, Morris, and Shin (2004) show theoretically that the presence of the large speculator does indeed make all other speculators more aggressive: relative to the case where there is no large speculator, small speculators attack the currency when fundamentals are stronger. Due to the data constraints, however, empirical research on this issue would face a severe difficulty. Their personal funds are typically registered in so-called tax havens and they do not disclose data on them since regulations in tax havens are far less stringent than in other countries.

This paper aims at filling a gap between theoretical and empirical research by using experimental analysis. A controlled environment in experimental approach allows observations to be unambiguously interpreted in relationship to the theory. This paper reports the results of experiments designed to test the predictions of Corsetti, Dasgupta, Morris, and Shin (2004). In particular, the experiment tests (A) whether the large speculator makes other small speculators more aggressive in attacking the peg, and (B) whether the large speculator is more aggressive in attacking the peg than other small speculators. Moreover,

¹Financial Times, July 25, 1997.

we test (C) whether the effect that “Soros appears” is symmetric to the effect that “Soros disappears” although Corsetti, Dasgupta, Morris, and Shin (2004) is silent on this issue. We investigate this issue here to get some possible hints to construct a dynamic theoretical model for future work. The results of experiments not only support the predictions of Corsetti, Dasgupta, Morris, and Shin (2004) but also suggest that the effect that “Soros appears” is no symmetric to the effect that “Soros disappears”. Therefore, the results may indicate a possible hint of how we could extend the model of Corsetti, Dasgupta, Morris, and Shin (2004) to explain the asymmetric effect.

This paper is organized as follows. Section 2 reviews the literature. Section 3 explains the speculative-attack model used in our preliminary experiment. Section 4 lays out the experimental design. In Section 5 we present the preliminary results and discuss issues to note when we conduct “full” experiments. Section 6 concludes the paper.

2 Literature

This paper’s interest is related to two papers: Heinemann, Nagel, and Ockenfels (2004) and Cheung and Friedman (2005). Heinemann, Nagel, and Ockenfels (2004) conduct an experiment to test the predictions of the theory of global games. Their experiment imitates the speculative-attack model by Morris and Shin (1998). They conclude that the global game solution (the so-called threshold strategy) is an important reference point and provides correct predictions for comparative statics with respect to parameters of the payoff function. Their experiment, however, is not designed to test the implications of the existence of the large speculator which is the central issue of our experiment. Cheung and Friedman (2005) deal with the issue of the large speculator in their experiments. They conclude that while the presence of a larger speculator increases the likelihood of successful attack, giving the large speculator increased size does not significantly strengthen his impact. However, notice that the increase in the likelihood due to the presence (more precisely, the appearance) of the large speculator may not be equal in magnitude to the decrease in the likelihood due to the disappearance of the large speculator in a dynamic framework. That is, it may not be the case that the effect of the appearance of the

large speculator due to de-regulation of position holdings limitation is equal to that of the disappearance of the large speculator due to regulation of position holdings limitation. We deal with this possibly asymmetric effect in our experiments while they do not. In addition, their experiment design is closer to the first generation models pioneered by Krugman (1979) and Flood and Garber (1984), rather than the global game model of Corsetti, Dasgupta, Morris, and Shin (2004), in the sense that the economic fundamentals are deteriorating in their experiments to see the timing of speculative attacks. A concern might be that the experimental design of deteriorating economic fundamentals could induce the global game solutions (threshold strategies). Morris and Shin (1998) and Corsetti, Dasgupta, Morris, and Shin (2004) show that threshold strategies are the only equilibrium strategies even in the absence of deteriorating economic fundamentals. Therefore, we need to be careful if we interpret the result of their experiments as supportive (or not supportive) to the global game solutions found by Corsetti, Dasgupta, Morris, and Shin (2004), because their experiment does not imitate the model by Corsetti, Dasgupta, Morris, and Shin (2004) very closely. In contrast, this paper conducts experiments designed to imitate the Corsetti, Dasgupta, Morris, and Shin (2004) model as closely as possible, in order to test the global game solutions.

3 The Model

In our experiment, we employ a reduced game form based on Corsetti, Dasgupta, Morris, and Shin (2004) with a finite number of speculators who decide simultaneously whether to attack the currency peg or not.

Consider an economy where the central bank pegs the exchange rate. The economy is characterized by a state of underlying economic fundamentals, Y . A high value of Y refers to good fundamentals while a low value refers to bad fundamentals. We assume that Y is randomly drawn from the interval $[\underline{Y}, \bar{Y}]$, with each realization equally likely.

Now assume that there are two kinds of speculators: a single large speculator (“Soros”) and m small speculators (m is some positive integer). Each small speculator can short-sell one unit of the domestic currency. The distinguishing feature of the large speculator is his

	Success	Failure
Attack	$D - c$	$-c$
Not Attack	0	0

Table 1: Payoff Matrix

access to a larger line of credit in the domestic currency to take a short position up to the limit of λ (≥ 1). Just for simplicity, we assume λ is an integer. We call it ‘‘Soros case’’. Later we will consider ‘‘No-Soros case’’ where there are $m + \lambda$ small speculators and there is no large speculator.

Receiving the noisy private signal about economic fundamentals, a speculator decides whether to short sell the currency, i.e., to attack the currency peg. An attack is associated with opportunity costs c . If the currency devalues, each attacking speculator earns an amount D . To make the model more interesting, we assume that a successful attack is profitable: $D - c > 0$.

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 peg as follows.

$$N = k + \lambda \cdot I[\text{Soros attacks}] \tag{1}$$

where k is the number of small speculators who attack the peg and $I[\text{Soros attacks}]$ is the indicator function which takes the value of unity if Soros attacks and zero otherwise. Therefore the possible maximum number of N is $m + \lambda$. An attack is successful if and only if a sufficient number of speculators decide to attack. The better the state of the economy, the higher the hurdle to success: the hurdle to success is modelled as a nonincreasing function of Y . Let $a(Y)$ be the size of speculative attacks that are needed to enforce a devaluation and assume $a' \leq 0$ and $a(\bar{Y}) < 0 < m + \lambda < a(\underline{Y})$. The currency peg fails if and only if

$$N \geq a(Y). \tag{2}$$

When the economic fundamentals are sufficiently strong (i.e., Y satisfies $a(Y) > m +$

λ), the currency peg is maintained irrespective of the actions of the speculators. When the economic fundamentals are sufficiently weak (i.e., Y satisfies $a(Y) \leq 0$), the peg is abandoned even in the absence of a speculative attack. The most interesting range is the intermediate case when $0 < a(Y) \leq m + \lambda$. 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). In what follows, we call it a crisis if the government abandons the peg and no crisis if the government defends the peg.

Although speculators do not observe the realization of Y , they receive informative private signals about it. When the true state is Y , a speculator i observes a signal $x_i = Y + \varepsilon_i$ that is drawn uniformly from the interval $[Y - \varepsilon, Y + \varepsilon]$ ($\varepsilon \geq 0$). Conditional on Y , 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 Soros and the small speculators is their size. In order to focus on the size effect as clearly as possible, we exclude the possibility that Soros has better information about economic fundamentals than the small speculators.

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

$$U = \text{Prob}[N \geq a(Y) | x_i] D - c$$

Here $\text{Prob}[N \geq a(Y) | x_i]$ is the probability that her attack is successful conditional on her private signal.

The timing of the game is structured as follows.

- Nature chooses the value of Y .
- Each speculator receives a *private* signal $x_i = Y + \varepsilon_i$.
- Each speculator decides whether or not to attack the currency peg.
- The central bank abandons the peg if $N \geq a(Y)$ and defends the peg otherwise.

- If the attack is successful, those who attacked get $D-c$. If the attack is not successful, their payoff is $-c$. The payoff of those who did not attack is zero.

3.1 Common Knowledge Case

Before investigating the case $\varepsilon > 0$, consider the case where there is no noise in the signal: $\varepsilon = 0$. In this case, the realization of Y is common knowledge among the speculators.

In this case there are multiple equilibria when $\lambda < a(Y) \leq m + \lambda$: the crisis is the equilibrium if all the speculators coordinate an attack, while no crisis is the equilibrium if no speculator attacks. In the multiple equilibria, there is no clear implication of the existence of Soros. To see this, suppose that there are $m + \lambda$ small speculators and there is no Soros in the market. We call it No-Soros case. Note that in this case the possible maximum number of N , which is $m + \lambda$, is the same as the one in Soros case. Notice also that there are multiple equilibria, the crisis and no crisis, in No-Soros case as in Soros case. Within multiple equilibria framework, there is no significant difference in terms of equilibrium selection between Soros-case and No-Soros-case when $\lambda < a(Y) \leq m + \lambda$: it is not very clear whether or not the existence of Soros affects equilibrium selection when $\lambda < a(Y) \leq m + \lambda$ and how. In order to consider implications of the existence of Soros, it would be useful to refine multiple equilibria to clarify how one particular equilibrium is selected over another.

3.2 Non-Common Knowledge Case

A feature already familiar from the discussion of global games in the literature is that when $\varepsilon > 0$, the realization of Y will not be common knowledge among the speculators. Applying the global game approach, Corsetti, Dasgupta, Morris, and Shin (2004) have shown that in this case there is a unique equilibrium in which the small speculators use the switching strategy around X^* while Soros use the switching strategy around X^{**} . X^* is a threshold signal such that small speculators attack if and only if they receive a signal above this threshold. X^{**} is a threshold signal such that Soros attacks if and only if he receives a signal above this threshold. Moreover, Corsetti, Dasgupta, Morris, and Shin

(2004) have shown that the presence of Soros does indeed make all other speculators more aggressive in their attacking.

A risk neutral speculator who receives the threshold signal is indifferent between attacking and not attacking provided that all other speculators attack if and only if they receive signals above their threshold signal. At state Y the probability that Soros' attack is successful is given by the probability that at least $a(Y) - \lambda$ out of m small speculators get signals above X^* and attack. This can be described by the binomial distribution. The probability that a single speculator gets a signal above X^* at state Y is $(Y - X^* + \varepsilon)/(2\varepsilon)$. Denoting the round-up of $a(Y)$ by $\hat{a}(Y)$, the expected payoff of attacking Soros with the threshold signal is

$$\begin{aligned}
& EU(X^{**}) \\
&= \frac{1}{2\varepsilon} \int_{X^{**}-\varepsilon}^{X^{**}+\varepsilon} D \cdot \text{Prob}[k \geq \hat{a}(Y) - \lambda] dY \\
&= \frac{1}{2\varepsilon} \int_{X^{**}-\varepsilon}^{X^{**}+\varepsilon} D \cdot \left(1 - \text{Prob}[k \leq \hat{a}(Y) - \lambda - 1]\right) dY \\
&= \frac{1}{2\varepsilon} \int_{X^{**}-\varepsilon}^{X^{**}+\varepsilon} D \cdot \left(1 - \sum_{k=0}^{\hat{a}(Y)-\lambda-1} \binom{m}{k} \left(\frac{Y - X^* + \varepsilon}{2\varepsilon}\right)^k \left(1 - \frac{Y - X^* + \varepsilon}{2\varepsilon}\right)^{m-k}\right) dY \\
&= \frac{1}{2\varepsilon} \int_{X^{**}-\varepsilon}^{X^{**}+\varepsilon} D \cdot \left(1 - \text{Bin}\left[\hat{a}(Y) - \lambda - 1, m, \frac{Y - X^* + \varepsilon}{2\varepsilon}\right]\right) dY, \tag{3}
\end{aligned}$$

where Bin is the cumulative binomial distribution. The equilibrium threshold signal X^{**} is defined by

$$EU(X^{**}) = c. \tag{4}$$

At state Y the probability that a small speculator's attack is successful is given by the sum of the following: (1) the probability that at least $a(Y) - \lambda - 1$ out of $m - 1$ small speculators receive private signals above X^* and Soros receive private signal above X^{**} and then they attack, and (2) the probability that at least $a(Y) - 1$ out of $m - 1$ small speculators receive private signals above X^* and attack but Soros receives private signal below X^{**} so he does not attack. Let the former be $P_1(Y)$ and the latter be $P_2(Y)$. Notice that private signals are independent across speculators (and hence between Soros

and small speculators) conditional on Y . Therefore, these two probabilities can be written as follows.

$$\begin{aligned}
P_1(Y) &= \text{Prob}[\text{Soros attacks at state } Y] \cdot \text{Prob}[k \geq \hat{a}(Y) - \lambda - 1] \\
&= \text{Prob}[x_i \geq X^{**}] \cdot \left(1 - \text{Prob}[k \leq \hat{a}(Y) - \lambda - 2]\right) \\
&= \frac{Y - X^{**} + \varepsilon}{2\varepsilon} \cdot \left(1 - \text{Bin}\left[\hat{a}(Y) - \lambda - 2, m - 1, \frac{Y - X^{**} + \varepsilon}{2\varepsilon}\right]\right) \quad (5)
\end{aligned}$$

$$\begin{aligned}
P_2(Y) &= \text{Prob}[\text{Soros does not attack at state } Y] \cdot \text{Prob}[k \geq \hat{a}(Y) - 1] \\
&= \text{Prob}[x_i < X^{**}] \cdot \left(1 - \text{Prob}[k \leq \hat{a}(Y) - 2]\right) \\
&= \left(1 - \frac{Y - X^{**} + \varepsilon}{2\varepsilon}\right) \cdot \left(1 - \text{Bin}\left[\hat{a}(Y) - 2, m - 1, \frac{Y - X^{**} + \varepsilon}{2\varepsilon}\right]\right). \quad (6)
\end{aligned}$$

The expected payoff of an attacking small speculator with the threshold signal is

$$EU(X^*) = \frac{1}{2\varepsilon} \int_{X^* - \varepsilon}^{X^* + \varepsilon} D \cdot \left(P_1(Y) + P_2(Y)\right) dY. \quad (7)$$

The equilibrium threshold signal X^* is defined by

$$EU(X^*) = c. \quad (8)$$

4 Experimental Design

Sessions were run at a PC pool in the School of Political Science and Economics at Waseda University, Tokyo on October 17 and 19, 2005. There were 70 participants. Most of the participants were economics undergraduates. The experiment was programmed and conducted with the software *z-Tree* (Fischbacher (1999)). Instructions were read aloud. Throughout the sessions participants were not allowed to communicate and could not see others' screens.

In a subsample 1, first we ran one session for No-Soros case and then proceeded to another session for Soros case. In the subsample 2, first we ran one session for Soros case

and then proceeded to another session for No-Soros case.²

In No-Soros case, there are 10 “small” subjects and no “large” subject (i.e., no Soros) in the same group. In this case, the possible maximum number of N is 10 in No-Soros case.

In Soros case, subjects are split further evenly into two groups. The session for Soros case was conducted in each group separately. Out of 5 subjects in each group, 4 subjects were “small” and 1 subject was “large” (Soros). We set $\lambda = 6$. Therefore, the possible maximum number of N in each group is again 10 ($m + \lambda = 4 + 6 = 10$ in each group) in Soros case.

Each session consisted of 10 independent rounds. In each round all subjects had to decide between alternatives A and B for 5 independent situations. In Soros case, 1 subject was randomly chosen as Soros in each round. Thus the subject who was chosen as Soros could be different across 10 rounds.

For each situation, a state Y , the same for all subjects, was randomly selected from a uniform distribution in the interval $[30, 90]$. Instead of being informed about Y , each subject received a private noisy signal, independently and randomly drawn from a uniform distribution in the interval $[Y-10, Y+10]$. These numbers were displayed with two decimal digits. We did not order the signals so as not to induce so-called threshold strategies. We did not conduct sessions with common information where subjects were informed about Y .

The payoff for alternative A was 1,000 Experimental Currency Units (ECU) with certainty. The payoff for B was 3,000 ECU, if $N \geq a(Y) = 20 - Y/4$ held, zero otherwise. 1 ECU is ¥0.01 and subjects know it. All parameters of the game and the rules were common knowledge except for drawn states Y and private signals.

Once all players had completed their decisions in one round, they saw — for each situation — the value of Y , how many people had chosen A, how many people had chosen B, payoff of A, payoff of B (which automatically showed whether action B was successful or not), and their individual payoffs. After all players had left the information screen a new round started and information of previous rounds could not be revisited. Subjects

²We investigate if there is any difference between these two subsamples in subsection 5.3.

were allowed to take notes and many of them did.

After two sessions finished, participants had to respond to eight questions about their behavior in a questionnaire and were free to give additional comments regarding the experiment. Once the questionnaire was completed, each participant was paid in private. The experiment length was about 100 minutes. The descriptive statistics about the payment to each subject is shown in Table 2.³

Table 2: Descriptive Statistics about the Payment to Each Subject

	Average(JPY)	Std.dev.	Max(JPY)	Min(JPY)
Total	1895.286	140.173	2100	1310
Oct.17th(first session)	1932	106.207	2080	1580
Oct.17th(second session)	1774	231.478	1960	1310
Oct.19th(first session)	1817.5	65.765	1900	1600
Oct.19th(second session)	1997	62.836	2100	1810

Table 3: No-Soros First

	Average(JPY)	Std.dev.	Max(JPY)	Min(JPY)
Total	1874.750	104.709	2080	1580
No-Soros Case	840	78.655	990	590
Soros-Case	1034	45.731	1110	880

Table 4: Soros First

	Average(JPY)	Std.dev.	Max(JPY)	Min(JPY)
Total	1922.667	175.065	2100	1310
Soros Case	911.667	69.881	990	680
No-Soros Case	1011	132.440	1160	630

5 Results

Our main question is whether or not speculators attack the peg (i.e., subjects choose B) more aggressively in Soros case than in No-Soros case. In order to answer this question, we

³In addition to the payment in Table 2, each participant receives ¥1000 as a fixed show-up fee.

estimate the probability with which a subject i chooses B by fitting a logistic distribution function to observed choices.⁴

$$\text{Prob}[\text{Subject } i \text{ chooses B}] = \frac{\exp(\beta_0 + \beta_1 x_i + \beta_2 I[\text{Soros case}] + \beta_3 I[\text{Large}])}{1 + \exp(\beta_0 + \beta_1 x_i + \beta_2 I[\text{Soros case}] + \beta_3 I[\text{Large}])} \quad (9)$$

where $I[\text{Soros case}]$ is a dummy variable which takes the value of unity in Soros case and zero in No-Soros case, and $I[\text{Large}]$ is a dummy variable which takes the value of unity if a subject i is chosen as Soros and zero otherwise. Theoretical predictions of the global game solutions are the following.

1. A subject is more likely to choose B when he receives a larger signal ($\beta_1 > 0$).
2. A subject is more likely to choose B in Soros case than in No-Soros case ($\beta_2 > 0$).
3. A subject is more likely to choose B when he is chosen as Soros than otherwise ($\beta_3 > 0$).

5.1 Results: All Sample

Estimation results obtained from all sample are summarized in Table 5. Three theoretical predictions of the global game solutions stated above are supported. β_0 , β_1 , β_2 and β_3 are all highly significant at the 0.1 % level. Moreover, the signs of β_1 , β_2 and β_3 are all positive as theoretical predictions.

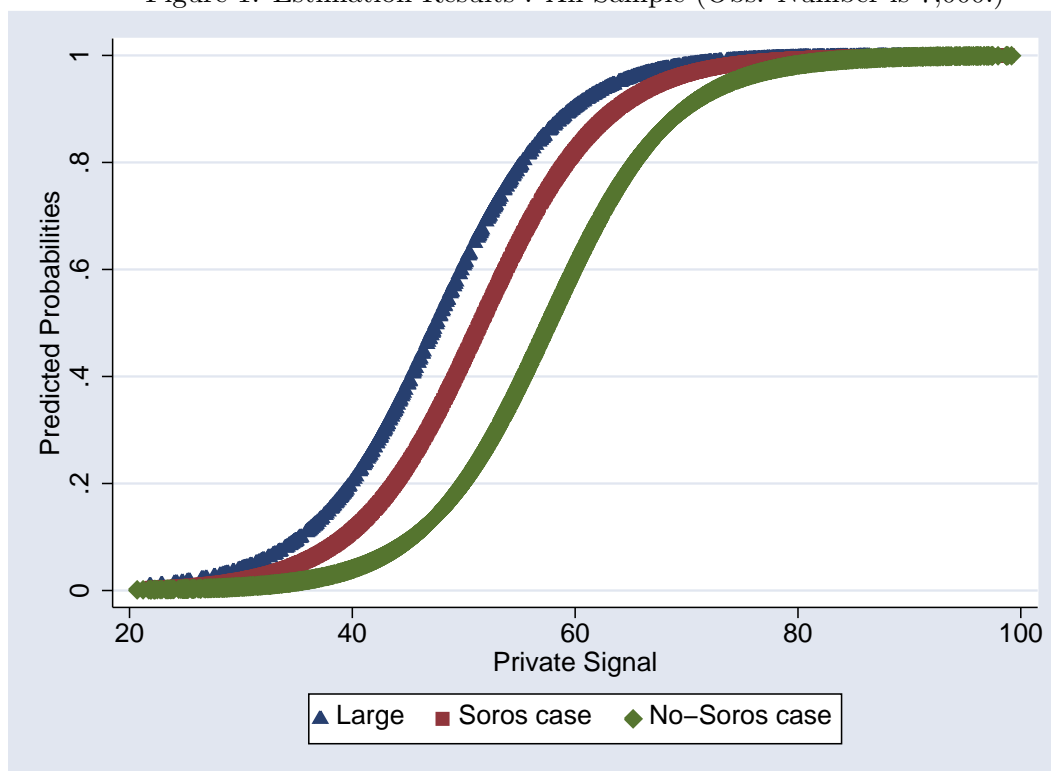
Table 5: Estimation Results: All Sample (Obs. Number is 7,000.)

Variable	Coefficient	(Std. Err.)	(P value)
Constant	-10.380	(0.252)	(0.000)
x_i	0.180	(0.004)	(0.000)
$I[\text{Soros case}]$	1.103	(0.085)	(0.000)
$I[\text{Large}]$	0.711	(0.142)	(0.000)

Predicted probabilities of choosing B are depicted in Figure 1. The curve of the predicted probabilities of choosing B when the subject is chosen as Soros in Soros case

⁴The logistic distribution is more appropriate than the normal distribution, because we observe ‘fat tails’ due to irrational behavior of a few subjects who do not play threshold strategies. Moreover, estimation results of the probit model is qualitatively similar to those of the logit model. They are available upon request.

Figure 1: Estimation Results : All Sample (Obs. Number is 7,000.)



(the curve marked with the triangle symbol “▲”) is positioned to the most left. The curve of the predicted probabilities of choosing B when the subject is *not* chosen as Soros in Soros case in the middle(the curve marked with the square symbol “■”). The curve of the predicted probabilities of choosing B in No-Soros case is positioned to the most right (the curve marked with the lozenge symbol “◆”).

5.2 Results: Subsample

The sample can be divided into two subsamples, subsample 1 and subsample 2, according to the order of the experiment of No-Soros case and that of Soros case. In the subsample 1, first we conduct the experiment of No-Soros case and then proceed to the experiment of Soros case. There are 40 subjects in the subsample 1. In the subsample 2, first we conduct the experiment of Soros case and then proceed to the experiment of No-Soros case. There are 30 subjects in the subsample 2.

It might be possible that only one of two subsamples drives the estimation results

of all sample. To investigate this issue, we estimate the equation (10) for each of these subsamples separately. In each subsample, the estimation results are qualitatively similar to those of all sample, as can be seen in Table 6, Table 7, Figure 2 and Figure 3. In each subsample, the theoretical predictions are supported as in all sample.

Table 6: Estimation Results: Subsample 1 (Obs. Number is 4,000.)

Variable	Coefficient	(Std. Err.)	(P value)
Constant	-12.416	(0.410)	(0.000)
x_i	0.214	(0.007)	(0.000)
I [Soros case]	1.728	(0.126)	(0.000)
I [Large]	0.591	(0.197)	(0.003)

Table 7: Estimation Results: Subsample 2 (Obs. Number is 3,000.)

Variable	Coefficient	(Std. Err.)	(P value)
Constant	-8.734	(0.318)	(0.000)
x_i	0.153	(0.005)	(0.000)
I [Soros case]	0.475	(0.119)	(0.000)
I [Large]	0.901	(0.210)	(0.000)

5.3 Results: All Sample Revisited

Notice that we can think of the subsample 1 as the situation where “Soros appears” due to de-regulation of position holdings limitation while the subsample 2 as the situation where “Soros disappears” due to regulation of position holdings limitation. We investigate whether or not there is any significant difference between the subsample 1 and the subsample 2.

We are interested in a possibility that the effect that “Soros appears” may not be symmetric to the effect that “Soros disappears”. In the subsample 1, we conduct the experiment of No-Soros case first and then proceed to the experiment of Soros case. In the subsample 2, we conduct the experiment of Soros case first and then proceed to the experiment of No-Soros case. If the effect that “Soros appears” (the subsample 1) is indeed symmetric to the effect that “Soros disappears” (the subsample 2), there must be no significant difference between Soros case (No-Soros case) in the subsample 1 and Soros case (No-Soros case) in the subsample 2.

Figure 2: Estimation Results : Subsample 1 (Obs. Number is 4,000.)

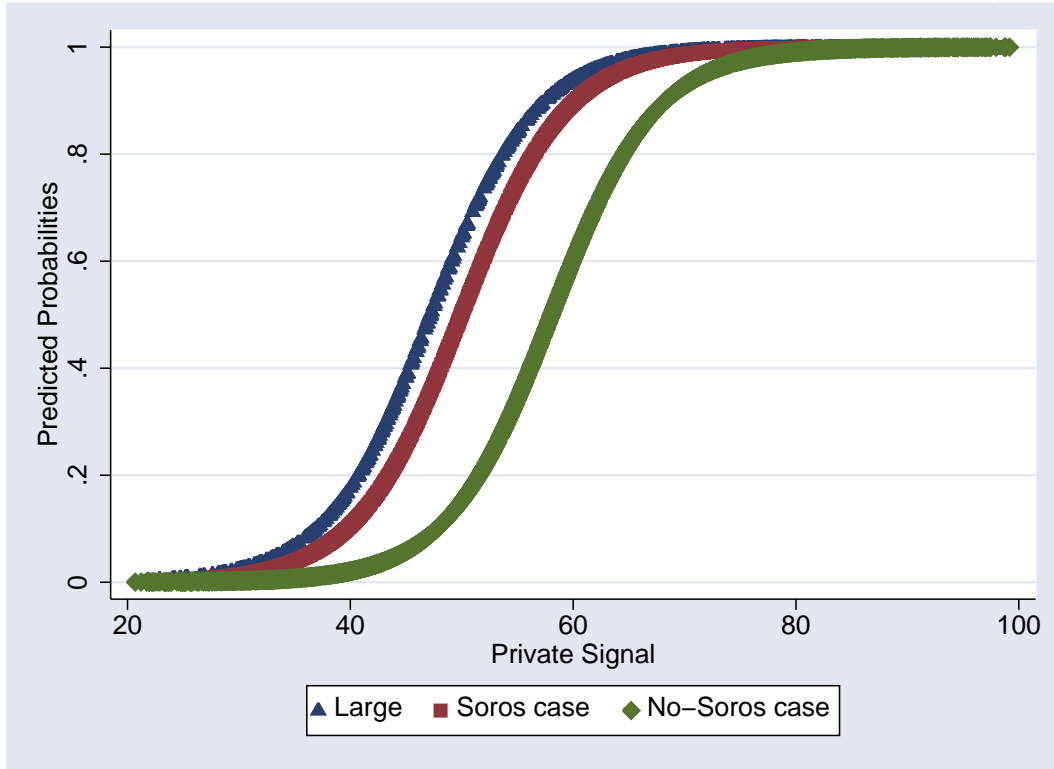
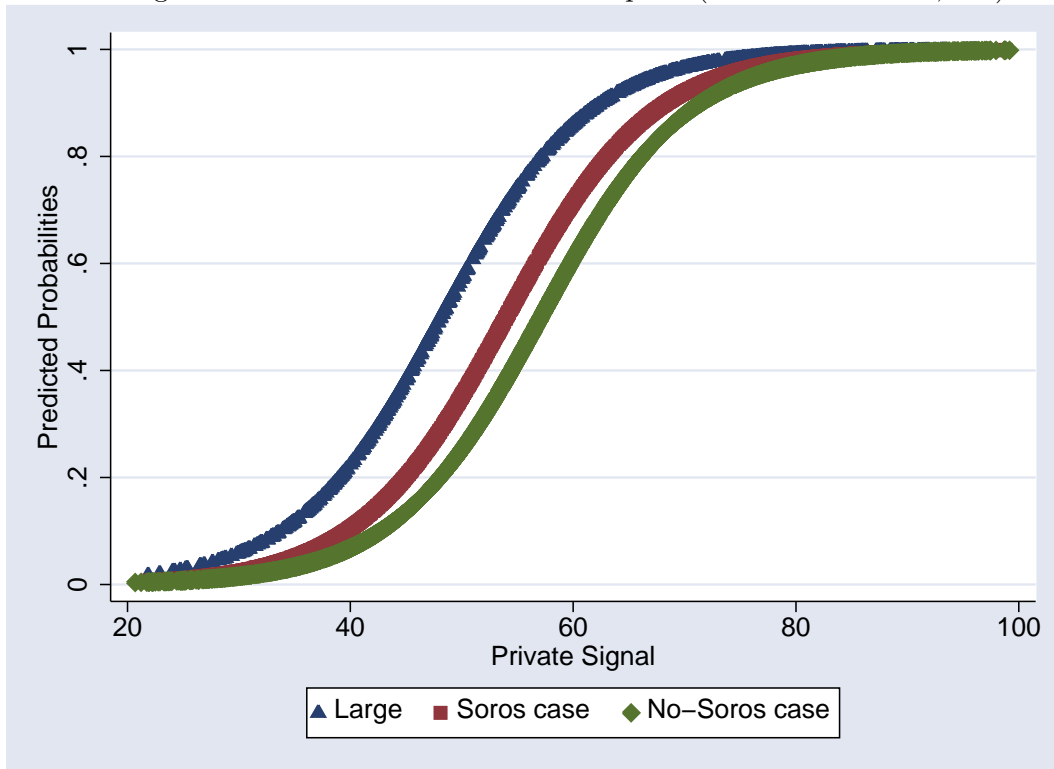


Figure 3: Estimation Results : Subsample 2 (Obs. Number is 3,000.)



Corsetti, Dasgupta, Morris, and Shin (2004) is silent on this issue. Since Corsetti, Dasgupta, Morris, and Shin (2004) considers an one-shot game of No-Soros case and an one-shot game of Soros case *independently* and then compares the resulting equilibrium of No-Soros case with that of Soros case, the order between No-Soros case and Soros case is not taken into account. Put another way, Corsetti, Dasgupta, Morris, and Shin (2004) does not deal with the implications of the existence of Soros in a dynamic framework. We investigate this issue here to get some possible hints to construct a dynamic theoretical model for future work.

To investigate this issue, we estimate the following.

$$\text{Prob}[\text{Subject } i \text{ chooses B}] = \frac{\exp(\Psi_i)}{1 + \exp(\Psi_i)} \quad (10)$$

where Ψ_i is defined as follows.

$$\begin{aligned} \Psi_i = & \beta_0 + \beta_1 x_i + \beta_{21} I[\text{Soros case}] + \beta_{22} I[\text{Soros case}] \cdot I[1] + \beta_{31} I[\text{Large}] \\ & + \beta_{32} I[\text{Large}] \cdot I[1] + \beta_4 \cdot I[1] \end{aligned} \quad (11)$$

where $I[1]$ is a dummy variable which takes the value of unity if a subject is in subsample 1 and zero otherwise. It must be the case that $\beta_{22} = \beta_{32} = \beta_4 = 0$ if there is no difference between Soros case (No-Soros case) in the subsample 1 and Soros case (No-Soros case) in the subsample 2.

The estimation results are the following. First of all, three theoretical predictions of the global game solutions stated above are supported. β_0 , β_1 , β_{21} and β_{31} are all highly significant at the 0.1 % level. Moreover, the signs of β_1 , β_{21} and β_{31} are all positive as theoretical predictions.

The null hypothesis ($\beta_{22} = \beta_{32} = \beta_4 = 0$) that there is no difference between Soros case (No-Soros case) in the subsample 1 and Soros case (No-Soros case) in the subsample 2 is rejected at 0.01 % level.

Predicted probabilities of choosing B are depicted in Figure 4. The curve of the predicted probabilities of choosing B when the subject is chosen as Soros in Soros case in

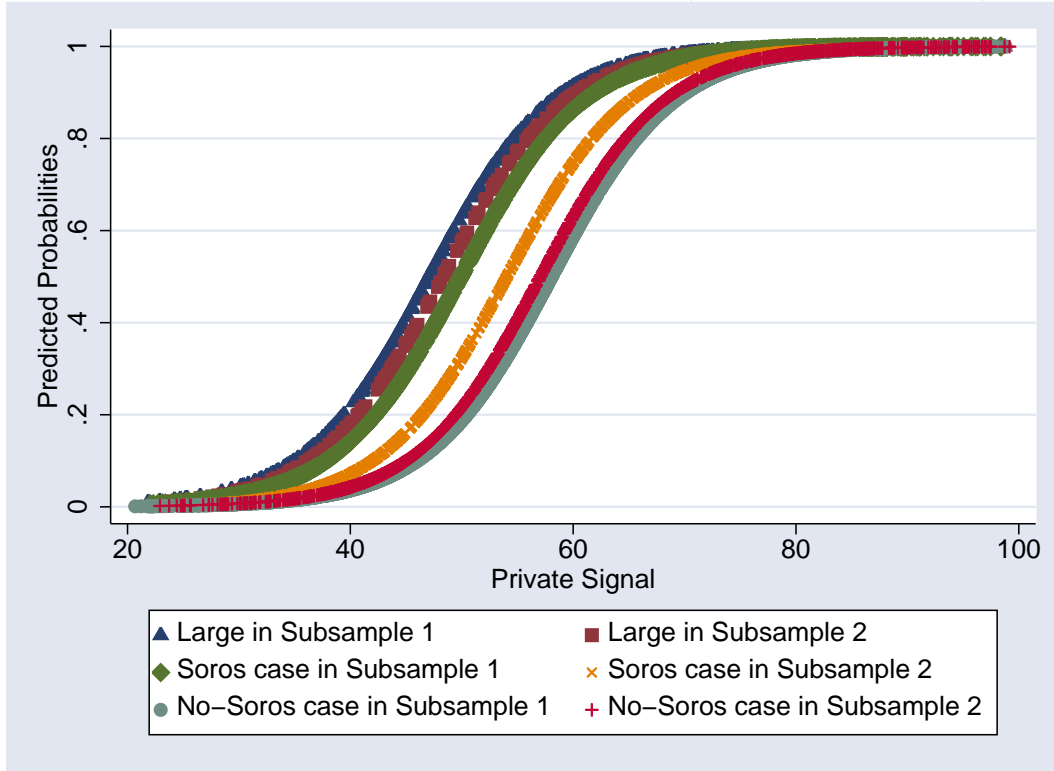
Table 8: Estimation Results: All Sample (Obs. Number is 7,000.)

Variable	Coefficient	(Std. Err.)	(P value)
Constant	-10.381	(0.259)	(0.000)
x_i	0.182	(0.004)	(0.000)
$I[\text{Soros case}]$	0.546	(0.128)	(0.000)
$I[\text{Soros case}] \cdot I[1]$	0.943	(0.168)	(0.000)
$I[\text{Large}]$	1.036	(0.226)	(0.000)
$I[\text{Large}] \cdot I[1]$	-0.516	(0.290)	(0.075)
$I[1]$	-0.186	(0.106)	(0.081)

the subsample 1 is positioned to the most left (the curve marked with the symbol “▲”). If the subject is chosen as Soros in the subsample 1, he is the most aggressive in choosing B. The curve of the predicted probabilities of choosing B when the subject is chosen as Soros in Soros case in the subsample 2 (the curve marked with the symbol “■”) is almost overlapped by the curve of the predicted probabilities of choosing B when the subject is *not* chosen as Soros in Soros case in subsample 1 (the curve marked with the symbol “◆”). These two curves are positioned to the second left. The subject chosen as Soros in the subsample 2 and the subject *not* chosen as Soros in Soros case in the subsample 1 are similarly aggressive in choosing B. The curve of the predicted probabilities of choosing B when the subject is *not* chosen as Soros in Soros case in subsample 2 is positioned in the middle (the curve marked with the symbol “×”). The curve of the predicted probabilities of choosing B when the subject in No-Soros case in subsample 2 is positioned to the second right (the curve marked with the symbol “+”). The curve of the predicted probabilities of choosing B when the subject in No-Soros case in subsample 1 is positioned to the most right (the curve marked with the symbol “●”). Thus the subject in No-Soros case in subsample 1 is the least aggressive in choosing B.

We summarize the order of aggressiveness (from the most aggressive to the least aggressive) in Table 9. Notice that the subjects in No-Soros case in subsample 1 is less aggressive in choosing B than the subjects in No-Soros case in subsample 2 while the subjects not chosen as Soros in Soros case in subsample 1 is more aggressive in choosing B than the subjects not chosen as Soros in Soros case in subsample 2. This suggests that the effect of “Soros appearance” is not symmetric to the effect of “Soros disappears”. Indeed,

Figure 4: Estimation Results: All Sample (Obs. Number is 7,000.)



subjects are significantly more aggressive in Soros case in subsample 1 than in Soros case in subsample 2: β_{22} is significantly positive.

Table 9: Aggressiveness Order

Most Aggressive	Subject chosen as Soros in subsample 1
	Subject chosen as Soros in subsample 2
	Subject <i>not</i> chosen as Soros in subsample 1
	Subject <i>not</i> chosen as Soros in subsample 2
	Subject in No-Soros case in subsample 2
Least Aggressive	Subject in No-Soros case in subsample 1

The primary question is why the subjects are significantly more aggressive in Soros case in subsample 1 than Soros case in subsample 2. One potential answer for the subsample 1's aggressiveness in Soros case is the house money effect (Thaler and J.Johnson (1990)). House money effect means prior losses can reduce risk taking behavior, while prior gain makes people more risk seeking. In our case, the income subjects get from the first session of each experiment might make subjects more risk taking. In Table 3 and 4, we can

find that the subject in subsample 1 has already get 840JPY on average at the start of the Soros case, and get 911JPY at the start of the No-Soros case in subsample 2. Then, the subjects who are given a windfall of income at the start of the second session (Soros-case in subsample 1, and No-Soros case in subsample 2) become more aggressive in choosing B.

Bringing up the house money effect as a potential explanation is natural when the decision making by the subject has the sequential nature. Supposing that players drives utilities from consumption and changes in wealth, Barberis, Huang, and Santos (2001) shows theoretically that people are less risk averse after stock prices increase and, after stock price fall, people become more risk averse. Further, Ackert, Charupat, Church, and Deaves (2003) examined the house money effect on asset pricing in a dynamic setting, using experimental methods. They show that participants are willing to pay more for the stock when a larger initial endowments. Then, our result is consistent with these literatures that the subjects with greater windfall of income are more aggressive in the decision making.

6 Conclusion and Future Research

This paper reported the results of the full experiment designed to test the predictions of Corsetti, Dasgupta, Morris, and Shin (2004). In particular, the experiment tests (A) whether the large speculator makes other small speculators more aggressive in attacking the peg, and (B) whether the large speculator is more aggressive in attacking the peg than other small speculators. The results support these theoretical predictions. Moreover, the results suggest an asymmetric effect between regulating the size of the large speculator and de-regulating the size of the large speculator, which has not been dealt with by Corsetti, Dasgupta, Morris, and Shin (2004).

References

- ACKERT, L. F., N. CHARUPAT, B. K. CHURCH, AND R. DEAVES (2003): “An Experimental Examination of the House Money Effect in a Multi-period Setting,” Working Paper Series No. 2003-13, Federal Reserve Bank of Atlanta.
- BARBERIS, N., M. HUANG, AND T. SANTOS (2001): “Prospect Theory and Asset Pricing,” *The Quarterly Journal of Economics*, 464(1), 1–54.
- CHEUNG, Y.-W., AND D. FRIEDMAN (2005): “Speculative Attacks: A Laboratory Study in Continuous Time,” mimeo.
- 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.
- FISCHBACHER, U. (1999): “z-Tree. Toolbox for Readymade Economic Experiments,” IEW Working paper 21, University of Zurich.
- FLOOD, R. P., AND P. M. GARBER (1984): “Collapsing Exchange-Rate Regimes: Some Linear Examples,” *Journal of International Economics*, 17(1-2), 1–13.
- HEINEMANN, F., R. NAGEL, 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. (1979): “A Model of Balance-of-Payments Crises,” *Journal of Money, Credit and Banking*, 11(3), 311–325.
- 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.

THALER, R., AND E. J. JOHNSON (1990): "Gambling with the House Money and Trying to Break Even: The Effects of Prior Outcomes on Risky Choice," *Managerial Science*, 36(6), 643–660.