Discussion Paper Series

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Kobe University

DP2017-03

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March 8, 2017

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Equilibrium Selection in Monetary Search Models: An Experimental Approach*

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March 6, 2017

Abstract

It is known that there exists a multiplicity (indeterminacy) of stationary equilibria in search models with divisible money. This paper investigate whether some specific stationary equilibrium is selected through economic experiments. We observe that in some treatments there is a tendency to converge to the most efficient equilibrium. However, as a whole, there remains some degree of indeterminacy.

Keywords: Real Indeterminacy, Random Matching, Money, Experiment, Equilibrium Selection.

JEL Classification Number: C91, C92, D51, D83, E40

1 Introduction

The real indeterminacy of stationary equilibria has been found in both specific and general search models with divisible money.[1] In these models, there exists a continuum of stationary equilibria

*We thank John Duffy, Hirokazu Ishise and Masahiko Shibamoto for helpful comments. This research is financially supported by the Nomura Foundation for Social Science, a grant-in-aid from Zengin Foundation for Studies on Economics and Finance, Grant-in-Aid for Scientific Research (B) from JSPS (16H03596) and Grant-in-Aid for Scientific Research (C) from JSPS (24530207 for the second author, 26380242 for the third author, and 26380252 for the last author). Of course, any remaining errors are our own.

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[1] Green and Zhou [9, 10], Kamiya and Shimizu [14], Matsui and Shimizu [16], Zhou [19] for specific models, and Kamiya and Shimizu [12] for a general model.

and, money holdings distributions and equilibrium prices are different across stationary equilibria. The purpose of this paper is to investigate whether some specific stationary equilibrium is selected through economic experiments.

Our baseline model is a variant of Zhou [19]' model. Agents are randomly matched pair-wise and each matched pair trade indivisible goods. In each matched pair, the roles of buyer and seller are randomly assigned. A bargaining over a price proceeds by seller's take-it-or-leave-it-offer. We focus on the stationary equilibria in which every good is traded with a common price, say p, and the support of stationary money holdings distribution is $\{0, p\}$. Such an equilibrium is called a single price equilibrium (SPE). In Section 2, it is shown that there is a region of parameters in which there exists a multiple SPEs.

We conduct the experiments using the above model. In order to investigate equilibrium selection, we focus on the convergence of sellers' offer price. We observe that in some treatments there is a tendency to converge to the most efficient equilibrium. However, as a whole, there remains some degree of indeterminacy. We also observe systematic deviations from typical SPEs. First, many subjects avoid spending all their money holdings and keep a certain amount of money. Second, some subjects become inactive as the session lasts longer.

There are a few theoretical papers concerning equilibrium selection. Matsui and Shimizu [16] introduces marketplaces to a monetary search model and adopts the concept of the evolutionary stability. They demonstrate that, while there exists a continuum of stationary equilibria, efficient stationary equilibria only survive against the evolutionary pressure. Kamiya and Shimizu [13] introduce a kind of redistribution policy and show that such a policy makes stationary equilibria locally determinate and enables the government to induce a desirable equilibrium. Lagos and Wright [15] introduce the Walrasian markets in addition to the search markets. They demonstrate that the trading opportunities in Walrasian markets make an equilibrium money holdings distribution degenerate and it leads to the uniqueness of stationary equilibrium.

There is only a few literature on experiments using monetary search models. Duffy and Ochs [5, 6] study Kiyotaki and Wright model with either commodity or indivisible fiat money. Duffy and Puzzello [7] investigate an equilibrium selection problem in an economy with divisible fiat money. Their model is a variant of Lagos and Wright [15]'s model and there is a unique stationary monetary equilibrium and multiple non-monetary gift-exchange equilibria. Their concern is whether subjects choose an efficient non-monetary gift-exchange equilibrium. It is worthwhile noting that our concern is the selection from multiple monetary equilibria. In the modern market economy, only monetary equilibria are observed and our question seems to be more important.

This paper investigates an equilibrium selection problem in a dynamic situation. In experimental economics, while there is a vast literature on exmeriments of equilibrium selection on static games,[2] equilibrium selection on dynamic games has attracted less attention. One exeption is research in infinitely repeated prisoner's dilemma. According to the survey by Dal Bó and Fréchette [3], the problem can be decomposed into the following two topics: (i) the determinants of emergence of a specific equilibrium path, (ii) identification of strategies adopted by subjects to attain that equilibrium path. If we look at the current paper from these viewpoints, contributions of this study are as follows. On the determinants of emergence of a specific equilibrium path, we found that the subjects play some stationary equilibria more in the case of higher utility treatment, but they play the effcient outcome more in the lower utility treatment among the converged paths. These findings imply that utility level may affect both the convergence and the emergence of a stationary equilibrium. With respect to the second point, we adopt a different approach from the one adopted in the experimental studies of infinitely repeated prisoner's dilemma. Because the subjects can offer prices from positive real numbers in our experiment, we can not estimate the strategies through the method such as Strategy Frequency Estimation Method (SFEM) by Dal Bó and Fréchette [2]. Instead, we estimate the price offer strategies by checking the convergence of price offers in each group through the Dickey-Fuller test.

The plan of this paper is as follows. In Section 2, we present a variant of Zhou [19]'s money search model that is used in the experiment. In Section 3, we reports the experimental design including our parameterization and the findings of the experiment. Section 4 concludes the paper.

[2]For example, McKelvey and Palfrey [17] suggest the limiting logit equilibrium; Anderson et al. [1] study the relationship between stochastic potential and logit equlibrium; Schmidt et al. [18] study the influence of risk dominance in coordination games; Cachon and Camerer [4] study the effect of loss avoidance.

2 Theory

2.1 Environment

We consider a variant of Zhou [19]'s money search model with I agents, where I is a finite positive integer larger than one. Time is discrete and horizon is infinite, denoted by $t = 1, 2, \ldots$. There are money and I types of goods. Agent i can produce one unit of type i good in each period, and she cannot consume type i good by herself but can consume type-j good, where $j \neq i$. Goods are indivisible and perishable. Money is perfectly divisible and durable. The total supply of money is $M > 0$. Each agent can hold any nonnegative amount of money.

The timeline in each period is as follows. In the beginning of each period agents observe the current economy-wide money holdings distribution. Then bilateral random matchings take place. In each matching, each agent cannot observe the partner's money holding, and one agent becomes a seller with probability $\frac{1}{2}$ and the other becomes a buyer. Then, a bargaining over a price proceeds by seller's take-it-leave-it-offer. That is, the seller post a price $p \geq 0$ and if the buyer accepts, then the trade occur, i.e., he pays p and consumes one unit of good, and otherwise there is no trade. Finally, the matching resolves and the economy ends with probability $1 - \delta$ and it goes to the next period with probability δ.

u is the utility of one unit of good and c is the cost of producing one unit of goos. We assume $u > c > 0$. Although agents do not discount future payoffs, δ plays a role of discount factor.

2.2 Single Price Equilibrium

As in Zhou [19], we focus on a special class of stationary equilibria called single price equilibria, where some agents have $p \geq 0$ amount of money and the other agents do not have money, and the equilibrium price of goods is p.[3]

Definition 1 *A single price equilibrium (SPE)* is a pair of price and the number of agents who do not have money, denoted by (p, I_0), satisfying

1. $(I_0/I, I_1/I)$, where $I_1 = I - I_0$, is a stationary money holdings distribution,

[3] In Zhou's original model, where there are infinite number of agents, there exist other types of single price equilibria in which equilibrium money holdings distribution is on $\{0, p, 2p, \ldots, Np\}$. Note that, in the case of finite number of agents, it can be shown that a money holding distribution with $N \geq 2$ cannot be stationary.

2. p satisfies $M/p = I_1$,

3. a seller offers p if her current money holding η is less than p,

4. a seller offers a price which is never accepted, e.g., $2p$, if her current money holding η is larger than or equal to p, and

5. a buyer accept p whenever she holds $\eta \geq p$.

Note that the money holdings distribution is clearly stationary if all agents play the equilibrium strategy defined above. Next, we define the value function as follows:

$$V(np) = \begin{cases} \frac{H_1}{2}\left\{-c + \delta V(p)\right\} + \left(1 - \frac{H_1}{2}\right)\delta V(0) & \text{if } n = 0, \\ \frac{H_0}{2}\left\{u + \delta V((n-1)p)\right\} + \left(1 - \frac{H_0}{2}\right)\delta V(np) & \text{if } n \geq 1, \end{cases}$$

where $H_n = \frac{I_n}{I-1}$. Solving this, we obtain

$$V(np) = \frac{H_0}{2(1-\delta)}u - \left\{\frac{\delta H_0}{2(1-\delta) + \delta H_0}\right\}^n \left\{\frac{2(1-\delta) + \delta H_0}{2(1-\delta)\left(2 - \delta(2 - H_0 - H_1)\right)}\right\}(H_0 u + H_1 c).$$

We first consider the conditions 3 and 4 in the above definition on the equilibrium path, i.e., the case of agents with money holdings zero and p. The condition 3 in the above definition is expressed as

$$-c + \delta V(p) \geq \delta V(0).$$

This means that an agent without money chooses to sell her production good with the price p instead of offering the price which cannot be accepted by any buyer. This is equivalent to

$$\frac{u}{c} \geq \frac{2(1-\delta) + \delta H_0}{\delta H_0}. \tag{1}$$

The condition 4 in the above definition is expressed as

$$\delta V(p) \geq -c + \delta V(2p).$$

This means that an agent with p amount of money chooses to offer a price which cannot be accepted by any agents. This is equivalent to

$$\frac{u}{c} \leq \frac{\left(2(1-\delta) + \delta H_0\right)\left(2(1-\delta) + \delta(H_0 + H_1)\right) - \delta^2 H_0 H_1}{\delta^2 (H_0)^2}. \tag{2}$$

We can show that these conditions are sufficient. That is, the condition 3 and 4 follow from (1) and (2), and the condition 5 in the above definition can be easily shown.

2.3 SPE with residuals

Besides SPEs defined in the previous subsection, there may exist a variant of SPEs in which some agents hold small amounts of money with no values on the equilibrium path. We call such small fractions *residuals*. To be more precise, we define a vector of residuals $(r_1, \ldots, r_I)$ as follows. When agent i holds $p + r_i$ amount of money, she is a potential buyer, and when she only holds r_i amount of money, she is a potential seller. Condition 2 in the definition of SPE is replaced by

$$pI_1 + \sum_{i=1}^{I} r_i = M.$$

Since r_i has no value on the equilibrium path, $\max\{r_1, \ldots, r_I\} < p$ must be satisfied. If we require that money holdings distribution including residuals is time-invariant, $r_1 = \cdots = r_I$ must be satisfied. Indeed, suppose consumer 1 is a seller with money holding r_1 and consumer 2 is a buyer with money holding $p + r_2$, where $r_1 \neq r_2$, then the money holdings after a trade are $p + r_1$ and r_2 and clearly $(r_1, p + r_2) \neq (r_2, p + r_1)$. Since the residuals have no value, it might be better to define stationary money holdings distributions without using residuals.

3 Experiment

3.1 Experimental Design

The experiments were conducted at Kansai University on January, February, and December in 2015 and June and July in 2016. 492 subjects in total voluntarily participated at The Center for Experimental Economics, Kansai University. The subjects were all undergraduate students at Kansai University with no prior experience of the game we conducted.

We considered the case $I = 6$. In each session, 24 or 18 subjects were randomly divided into 4 or 3 groups consisting of 6 members and interacted through z-Tree software (Fichbacher [8].) In the beginning of each session, subjects were given written instructions on the game they were about to play.[4] After the written instructions were read aloud, subjects had to correctly answer a number of questions about the rule of the game.

[4]Instructions are given in Appendix.

Each session consisted of several *sequences*. A sequence consisted of an indefinite number of periods of a stage game. In each stage game, members of each group were randomly matched in pairs. Each pair bargained over a price according to the process we described in Section 2. At the end of each stage game, the sequence continued with probability δ. If a sequence ended and one hour had not passed after the instruction, the current group were resolved and new groups consisting of 6 subjects were randomly formed.

We choose the following parameter values:

- $\delta = 0.9$,
- $c = 10$, and
- $M = 600$.

We conducted the experiments with two different values of u: $u = 14$ and $u = 20$. In the case of $u = 14$, by (1) and (2), it is verified that there exist the following 3 types of single price equilibria:

- The price is 200, and 3 agents hold 200 units of money and the other agents hold no money in a stationary money holdings distribution,
- The price is 300, and 2 agents hold 300 units of money and the other agents hold no money in a stationary money holdings distribution, and
- The price is 600 and 1 agent holds 600 units of money, and the other agents hold no money in a stationary money holdings distribution.

On the other hand, in the case of $u = 20$, by (1) and (2), it is verified that there exist the following 2 types of single price equilibria:

- The price is 150, and 4 agents hold 150 units of money and the other agents hold no money in a stationary money holdings distribution, and
- The price is 200, and 3 agents hold 200 units of money and the other agents hold no money in a stationary money holdings distribution.

Note that the SPE with $p = 200$ is the most efficient in both cases.

We conducted experiments with different initial money holdings and the information which subjects obtain. As for initial money holdings, there are four cases:

- **dis300**: 2 agents hold 300 units of money and the other agents have no money,
- **dis200**: 3 agents hold 200 units of money and the other agents have no money,
- **dis150**: 4 agents hold 150 units of money and the other agents have no money, and
- **dis100**: all agents hold 100 unit money.

Note that the last initial money holdings do not constitute SPE in both cases.

As for the information structure, there are two cases:

- **ShowPrice**=0: each subject was only informed of her current money holding and the current money holdings distribution of the group they belong to, and
- **ShowPrice**=1: in addition to the information in **ShowPrice**=0, each subject was informed of the prices of the group with which trades were successfully made.

Each subject was initially endowed with 300 points as a show-up fee. Her/His total points consisted of initial 300 points plus the cumulative points he acquired in all the sequences. Total points were converted into cash at the end of the session at the exchange rate of 1 point = 10JPY.

3.2 Experimental Results

Below, we report the results from 21 sessions. We conducted 9 sessions with **ShowPrice**=0 and 12 sessions with **ShowPrice**=1. A summary of experimental sessions is given in Table 1.

3.2.1 Gift Giving

In an economy with a finite number of agents, gift giving equilibria can occur. That is, it is easy to see that the following strategy can be a stationary equilibrium if δ is sufficiently close to one: for all period t

in each meeting, (i) each seller offers $p = 0$ and (ii) each buyer accepts $p = 0$ if he did not observe a price offer $p \neq 0$ or a rejection of $p = 0$ in periods, $s = 1, \ldots, t-1$, and reject any offer otherwise.

Table 2 reports the frequencies of offer prices. The percentage of $p = 0$ is below 1% and thus we can conclude that gift giving equilibria rarely occurs.

Result 1 Gift giving equilibria rarely occurs.

3.2.2 Convergence of Offer Prices

Next, we investigate the convergence of offer prices. First, there are two types of offer prices: a 'no-sale offer' and a 'serious offer'. The former is a price which is too high and no potential buyer can afford to buy the good, and the latter is a price which is not too high and some potential buyer can afford to buy the good. Since, in the definition equilibrium (p, I_0), p is a serious offer, then we focus on the convergence of serious offer prices.

We focus on the samples whose length of sequences are longer than or equal to 21, since if the length is short, then a price data is less likely to converge. Moreover, we use price data from period 6, since in the beginning of the experiments subjects are not get used to the game. In the present paper, we adopt Dicky-Fuller test for testing convergence of offer prices. More precisely, we estimate the following equation:

$$p_t - p_{t-1} = \alpha + \beta p_{t-1} + \varepsilon_t,$$

where p_t is the mean of serious offer prices at period t and ε_t is an error term, and test the null hypothesis $H_0 : \beta = 0$. If ε_t is i.i.d. with mean zero, denoted by ε, then the process is

$$p_t = (1 + \beta)p_{t-1} + \alpha + \varepsilon.$$

Thus

$$p_t = (1 + \beta)^{t-1} p_1 - \frac{1 - (1 + \beta)^{t-1}}{\beta}\alpha - \frac{1 - (1 + \beta)^{t-1}}{\beta}\varepsilon$$

holds. Therefore, if $\beta < 0$, then price process converges to a stationary process with mean $-\frac{\alpha}{\beta}$. If the hypothesis is rejected for a given significance level, then $\beta < 0$. The reason is that $\beta > 0$

implies divergence of p_t and it contradicts the fact that p_t is less than or equal to the total money holding M. We consider a group as a non-convergent one if the null hypothesis is not rejected with significance level of 90 %, otherwise as a convergent one.

As for the convergent groups, we define a variable **LimitPrice** as the estimated value of $-\frac{\alpha}{\beta}$. It can be considered as the estimated limit point of serious offer price dynamics. **LB** is the lower bound of confidence interval of $-\frac{\alpha}{\beta}$.[5] If a subject holds $\eta <$ **LB**, we consider that η cannot be used in trades, since offer prices are likely to be more than **LB**. **Rich** is the average number of subjects whose money holdings are above **LB** within the last 5 periods of the sequence. We consider this as the number of hypothetical buyers. **Residual** is defined as follows:

$$\textbf{Residual} := \frac{M - \textbf{LimitPrice} \times \textbf{Rich}}{6}.$$

It is a hypothetical average amount of money not used in trades. Note that we use **LimitPrice** instead of **LB**. We can define **Residual** using **LB**. We call the groups inconsistent, if their **Residual** is larger than or equal to their **LimitPrice**. This is because **Residual** clearly has a positive value and it contradicts the definition of SPE. We call the other groups consistent.

We classify the groups using **Rich** as follows. A group is called **Class-N** if the closest integer of **Rich** is N. For example, if **Rich**$= 1.8$, then the group is **Class-2**.

Figures 1 and 2 illustrate typical paths of p_t and **LimitPrice**s in convergent and non-convergent groups.

Our first observation is on the residuals.

Result 2 All convergent and consistent groups have a significant amount of residuals.

Table 3 shows the basic statistics of **Residulal**. The mean of **Residual** is about 50 and the minimum is above 15. Recall that the total amount of money is 600.

We first investigate whether subjects intentionally hold residuals. Figure 3 illustrates buyer's response to acceptable offer. In the left panel, the horizontal axis is the remaining amount of money after buying goods. In the right panel, the horizontal axis is the proportion of remaining amount of money to the money holdings before buying goods. Both panels indicate that the more

[5] If the null hypothesis $\beta = 0$ is rejected, then $\{p_t\}$ is a stationary AR process. Thus in the case of convergent groups the confidence interval of $-\frac{\alpha}{\beta}$ can be calculated using a standard technique.

money remains, the more likely the buyers accept. Which is the buyers' concern, the remaining amount or proportion? We used the random effects, probit estimation of buyer's acceptance. (See Table 4.) We used the remaining amount and the remaining proportion as explanatory valuables, and the remaining proportion is significant and positive, while the remaining amount is not significant. Therefore, we conclude that buyers intentionally hold residuals and only care the remaining proportions.

Next, we investigate the impacts of period and risk aversion on the acceptance of offer. In the random effects, probit estimation, we used variables **Period** and **Holt-Laury Score**. The former is defined as period number not in a sequence but in a session. The latter measures a degree of subject's risk aversion, proposed by Holt and Laury [11]. Table 4 shows that both **Period** and **Holt-Laury Score** are significant, and the former is positive and the later is negative.

Result 3 **Period** and **Holt-Laury Score** are significant, and the former is positive and the later is negative.

Next, we present some results on the convergence of offer prices. Figure 4 shows the bar graphs of the frequency of each category of the groups in the case of $u = 14$. 11 groups belong to non-convergence category. All groups are consistent with some SPE. That is, in the case of $u = 14$, the number of agents who has money is 1, 2, or 3 in stationary equilibria, and all groups are **Class-1**, **Class-2**, or **Class-3**. Moreover, **Class-3** is most frequently observed and it corresponds to the most efficient SPE. Therefore, we conclude that in the case of $u = 14$, the offer price is most likely converge to the most efficient stationary equilibrium.

Result 4 In the case of $u = 14$, the offer price is most likely to converge to the most efficient stationary equilibrium.

Figure 5 is the case of $u = 20$. A red bar means that a group is consistent with some SPE, while a blue bar means that it is not consistent with any SPE. Comparing those graphs with the case of $u = 14$, we can find the following two features. The first finding is that the frequency of non-convergent groups is very low. The second finding is that, in many convergent groups, there are fewer buyers than the theory predicts.

Result 5 The frequency of non-convergent groups is much less in the case of $u = 20$ than in the case of $u = 14$.

Result 6 In the case of $u = 20$, the number of hypothetical buyers (**Rich**) is less than that in SPEs.

As for Result 5, a possible reason is that a higher utility leads to a higher acceptance rate, and thus offer prices converge in relatively early stage. That is, frequent trade lead to spread of information on subjects' strategy, and thus they can coordinate on a SPE in a relatively early stage. Indeed, we can observe that buyers' acceptance rate is higher in the case of $u = 20$ than that of $u = 14$. (See Table 5.) We also conducted Wilcoxon-Mann-Whitney test on the null hypothesis H_0: the acceptance rates are equal. The hypothesis was rejected with significance level 99 %.

As for Result 6, a possible reason is due to the existence of inactive sellers. That is, some subjects refuse trades, i.e., offer a very high price, even when they only hold a small amount of money. If we exclude these subjects, then the number of hypothetical buyers is fewer and is consistent with some SPE. To see this, we define the variable **InactiveSellerRate**: the rate of no-sale offers among all offers when sellers' current money holdings are less than **LB** within the last 10 periods of the sequence. We have 7 samples in which the number of buyers are fewer than that of any SPE. Among such samples, **InactiveSellerRates** are above 0.4 in 5 samples. This seems to be an evidence that a certain number of subjects are inactive.[6]

To investigate the determinants of inactive sellers, we conducted random effects, probit estimation of no-sale offer. (See Table 6.) We focused on the sellers whose money holdings are the least within the groups they are belonging to. This is because such sellers must make serious offers in any monetary equilibrium. The results are (i) **Period** has a significant positive effect, (ii) **Money Holding** has a significant positive efffect, and (iii) **AcquiredPoints** and **Holt-Laury Score** have no significant effects. This means some subjects become inactive as a session lasts longer.

[6]Theoretically, there is also a possibility that subjects play mixed strategy equilibrium with mixing no-sale offer and serious offer.

4 Conclusion

In this paper, we present a monetary search model with multiple single price stationary equilibria (SPE). We observe that in some treatments there is a tendency to converge to the most efficient equilibrium, however, as a whole, there remains some degree of indeterminacy. We also observe deviations from typical SPEs. First, many subjects avoid spending all of their money holdings and keep some small amount of money. Second, some subjects become inactive as the session lasts longer.

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Appendix: Sample Instructions

The instructions are originally written in Japanese. Here, we provide a translated sample copy of the experimental instructions used in our treatment "dis200 & u=20 & ShowPrice=1."[7] The instructions for the other treatments were adapted accordingly. The screen shots of the program are illustrated in Figures 6-10.

Instructions

This experiment is one concerning economic decision-making. If you are able to understand these instructions well, and carry out appropriate decision-making, you can earn a reasonable amount of money. Points that are acquired during the course of this experiment will be converted into monetary funds and paid out in cash once the experiment is over. At the start of the experiment, you will be given 300 points, which fluctuate in accordance with your decision-making thereafter. In this experiment, 1 point will be converted to 10 yen.

1. In this experiment, you will engage in multiple instances of decision-making. You are to randomly gather with other subjects into one group consisting of six people, and carry out decision-making multiple times. This period in which you create a group with the same six people will be called a "cycle."

2. The length of the cycle will be randomly determined. After each decision-making instance, there is a 90% probability of continuing this cycle. In other words, there is a 10% probability that the cycle will end.

3. Once the cycle ends, six new people will form one group at random, and a new cycle will begin.

4. During each cycle, six people will form one group and engage in decision-making. These six people will not change (groups) until one cycle is over.

[7] In the main part of this paper, we use the term "sequence" to refer a sequence of the stage games until the period when a play are randomly terminated. However, we used the term "cycle" to refer the same object in our instruction. This is because the term "cycle" is more fitted to this context in Japanese.

5. In this experiment, apart from points, a substitute currency will be used. At the start of each cycle, three members from each group will be assigned 0 units of substitute currency, while the remaining three members will be assigned 200 units of substitute currency at random.

Figure 11 shows the summary of the aforementioned flow.

Each period will proceed according the following format.

1. In each period, among the six people who created the same group at the beginning of the cycle, you will randomly form a group of two with subjects other than you and engage in decision-making.

2. Although you are allowed to know the distribution of the substitute currencies among the six members of your group, you will not be able to know the amount held by the paired opponent.

3. One of the people in the pair will be assigned the role of a "buyer," while the other will be assigned the role of a "seller" at random.

4. The seller will always have the opportunity to sell one unit worth of goods to the buyer. When doing so, the seller will present the amount of substitute currency requested to the buyer in exchange for the goods.

5. Upon looking at the amount of substitute currency that has been requested, the buyer decides whether to "make a deal" or "do not make a deal." However, when the amount of substitute currency requested by the seller is more than the amount held by the buyer, "do not make a deal" is automatically selected.

6. If the buyer chooses "make a deal" and a deal is established, the buyer acquires 20 points; at the same time, the buyer loses the requested amount of substitute currency. On the

other hand, when a deal is established, the seller loses 10 points as the cost of producing the goods; at the same time, the seller acquires the substitute currency that was requested.

7. If the buyer does not make a trade, both the buyer and seller will earn 0 points. In other words, there will be no increase or decrease in terms of points. Furthermore, there will be no increase or decrease in terms of substitute currency.

8. Here, it is worth noting that the buyer will lose the requested amount of substitute currency instead of being able to earn points by trading and acquiring the goods, and the seller will lose points as the deal is made and the goods are handed over to the buyer. In particular, points are not acquired from the holding of substitute currency.

9. The following three pieces of information about the group will be displayed at the end of each period. (1) Success or failure in regard to making a deal among the three pairs in the group, (2) the amount of substitute currency requested by the seller for groups in which deals are made, (3) distribution of the substitute currency held by the six members of the same group after these deals have been made.

Figure 12 shows the summary of the aforementioned flow.

Notes:

(1) At the beginning of the cycle, assignment of the substitute currency is determined randomly, regardless of the amount of substitute currency held in the prior cycle. In other words, at the end of the cycle, all substitute money held will be set to zero, and will be newly assigned randomly at the start of the next cycle.

(2) The experiment will end at the end of the first cycle after one hour has passed since the start of the experiment.

Session No., Treatment	Subjects	Total Periods	Sequences	Ave. Duration
1: u=14, dis200, ShowPrice=0	6 × 4	44	2	22
2: u=14, dis200, ShowPrice=0	6 × 4	76	4	19
3: u=14, dis100, ShowPrice=0	6 × 4	45	9	5
4: u=14, dis100, ShowPrice=0	6 × 4	48	8	6
5: u=14, dis300, ShowPrice=0	6 × 4	50	10	5
6: u=14, dis300, ShowPrice=0	6 × 4	55	7	7.9
7: u=14, dis100, ShowPrice=0	6 × 4	55	8	6.9
8: u=14, dis200, ShowPrice=0	6 × 4	53	7	7.6
9: u=14, dis300, ShowPrice=0	6 × 4	55	2	27.5
10: u=14, dis200, ShowPrice=1	6 × 4	49	7	7
11: u=14, dis300, ShowPrice=1	6 × 4	55	10	5.5
12: u=14, dis300, ShowPrice=1	6 × 4	54	7	7.7
13: u=14, dis100, ShowPrice=1	6 × 4	53	4	13.25
14: u=14, dis100, ShowPrice=1	6 × 4	57	6	9.5
15: u=14, dis200, ShowPrice=1	6 × 4	49	6	8.2
16: u=20, dis200, ShowPrice=1	6 × 3	44	4	11
17: u=20, dis200, ShowPrice=1	6 × 4	64	8	8
18: u=20, dis100, ShowPrice=1	6 × 3	46	2	23
19: u=20, dis100, ShowPrice=1	6 × 4	48	4	12
20: u=20, dis150, ShowPrice=1	6 × 4	48	6	8
21: u=20, dis150, ShowPrice=1	6 × 4	66	7	9.4

Table 1: Summary of Experimental Sessions

Offer Price	Frequency	Percent
$p = 0$	72	0.55
$0 < p < 100$	3,285	25.21
$100 \leq p < 200$	3,481	26.71
$200 \leq p < 300$	2,865	21.98
$300 \leq p < 400$	1,755	13.47
$p \geq 400$	1,574	12.08

Table 2: Frequency of Offer Prices

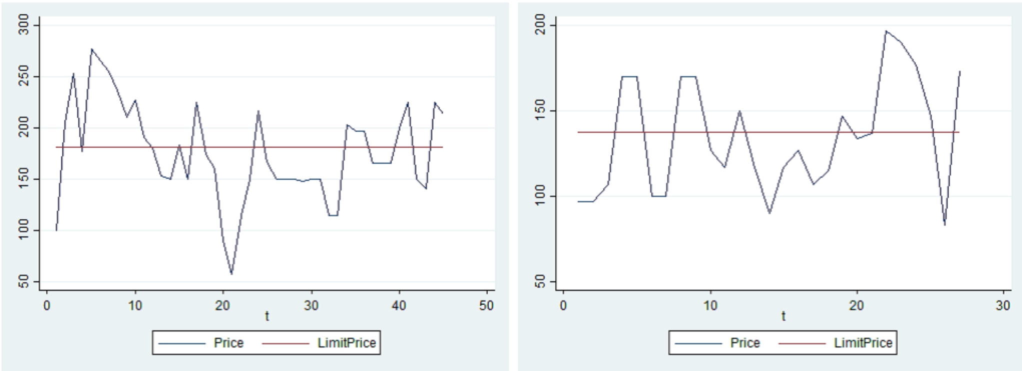

Figure 1: Price Paths and Limit Price of Convergent Group

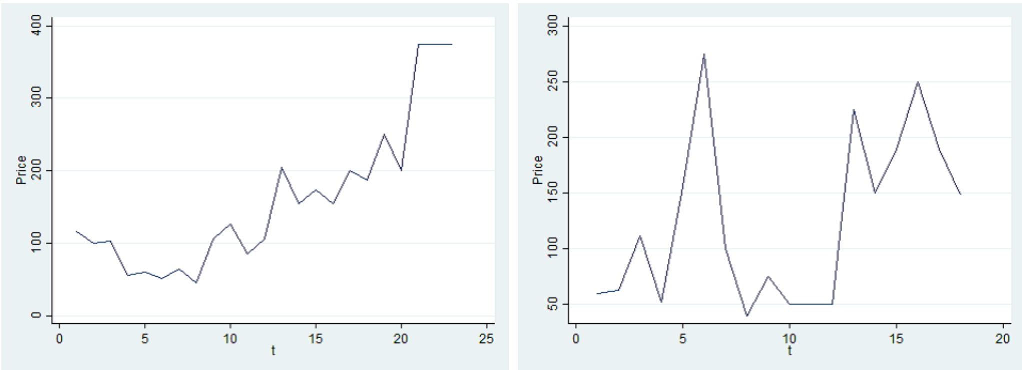

Figure 2: Price Paths of Non-Convergent Group

	Residual
Mean	46.86
Min	15.57
Max	77.15

Table 3: Statistics of Residuals

Figure 3: Buyers' Response to Acceptable Offer

	(1)	(2)	(3)	(4)
Period	0.0398***	0.0365***	0.0385***	0.0354***
	(0.00242)	(0.00228)	(0.00310)	(0.00295)
Offer Price	-0.0155***		-0.0155***	
	(0.000668)		(0.000867)	
Money Holding	0.00776***		0.00806***	
	(0.000544)		(0.000704)	
Remaining Amount		-0.00120		-0.000451
		(0.000813)		(0.00106)
Remaining Proportion		3.076***		2.837***
		(0.197)		(0.251)
Holt-Laury Score			-0.0598*	-0.0685**
			(0.0336)	(0.0343)
Constant	0.487***	-0.820***	0.737***	-0.415*
	(0.0802)	(0.0825)	(0.239)	(0.248)
Observations	4,349	4,322	2,523	2,511

Standard errors in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 4: Random Effects, Probit Analysis on Buyers' Acceptance

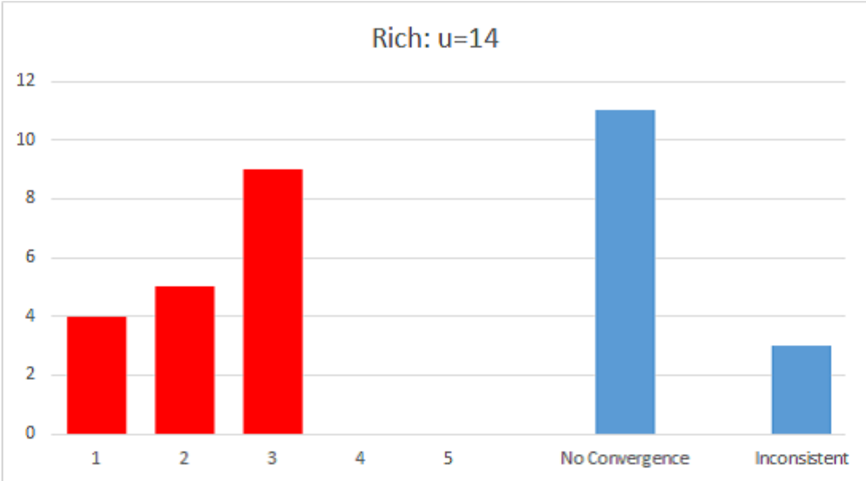

Figure 4: Number of Hypothetical Buyers: $u = 14$

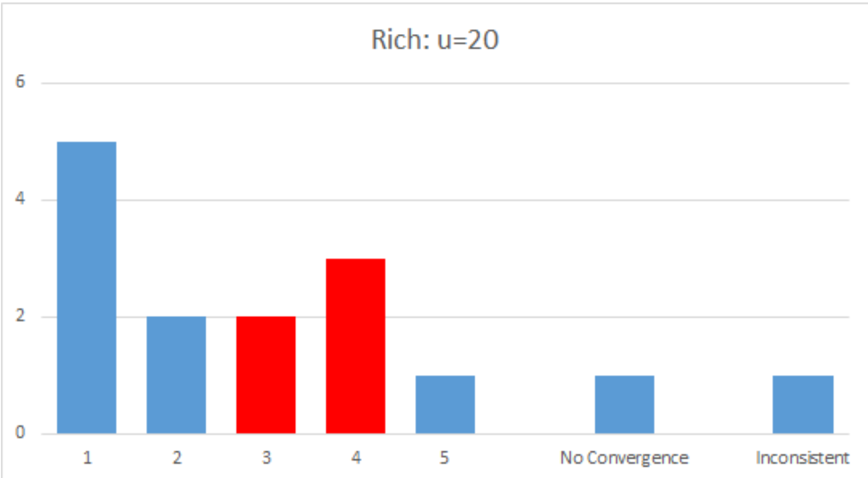

Figure 5: Number of Hypothetical Buyers: $u = 20$

	Acceptance Rate
u=14	0.34
u=20	0.41

Table 5: Higher Buyer's Acceptance Rate in $u = 20$

	(1)	(2)	(3)	(4)
Period	0.0470***	0.0480***	0.0494***	0.0583***
	(0.00268)	(0.00574)	(0.00376)	(0.00846)
AcquiredPoints		0.00144		-0.00158
		(0.00355)		(0.00458)
Money Holding		0.0303***		0.0316**
		(0.0100)		(0.0136)
Holt-Loury score			0.00458	-0.104
			(0.103)	(0.153)
Constant	-3.441***	-3.690***	-3.983***	-2.610
	(0.182)	(1.146)	(0.728)	(1.898)
Observations	4,073	1,386	2,102	691
Standard errors in parentheses				
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$				

Table 6: Random Effects, Probit Analysis on Seller's No-Sale Offer

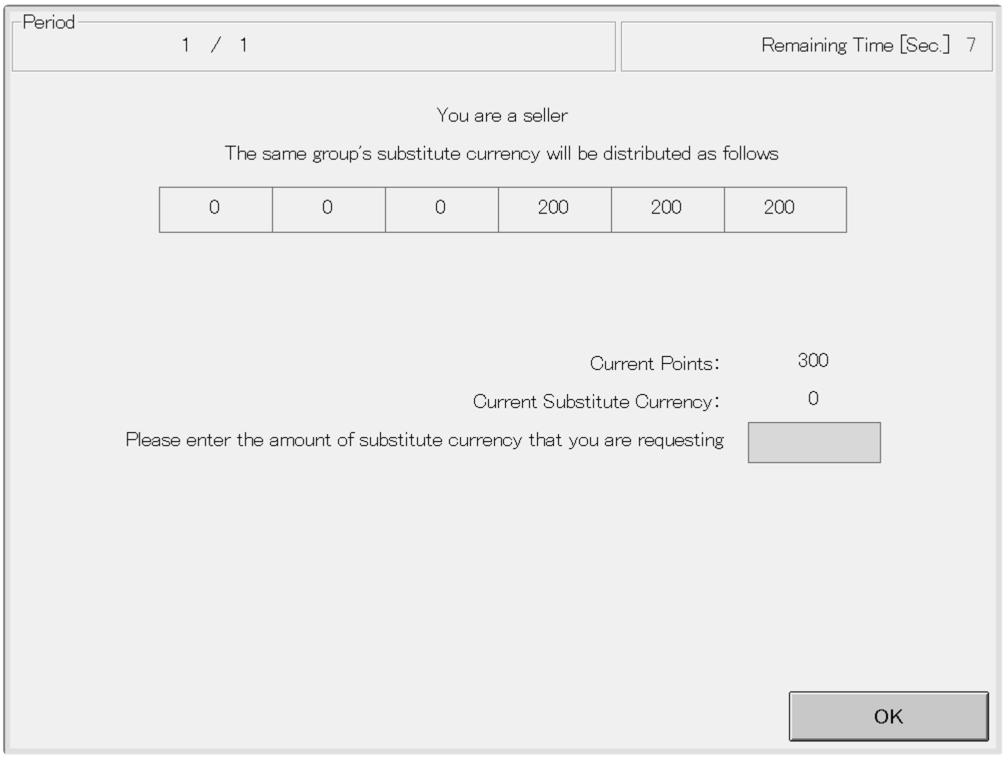

Figure 6: Seller's Decisions Screen

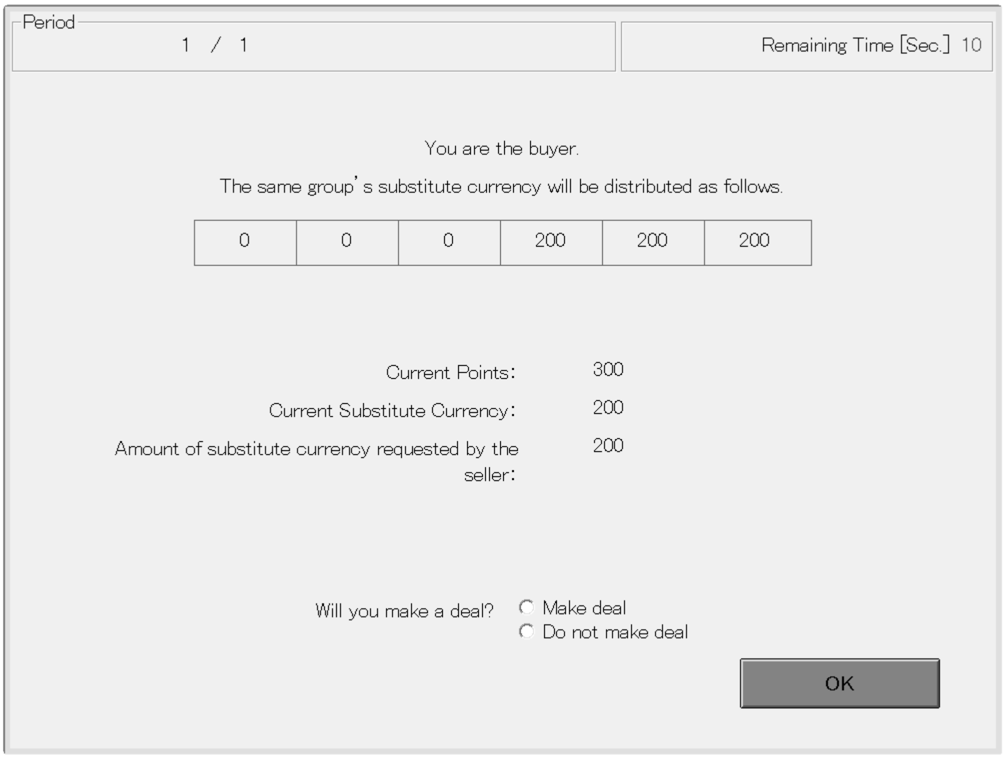

Figure 7: Buyer's Decisions Screen: Acceptable Offer

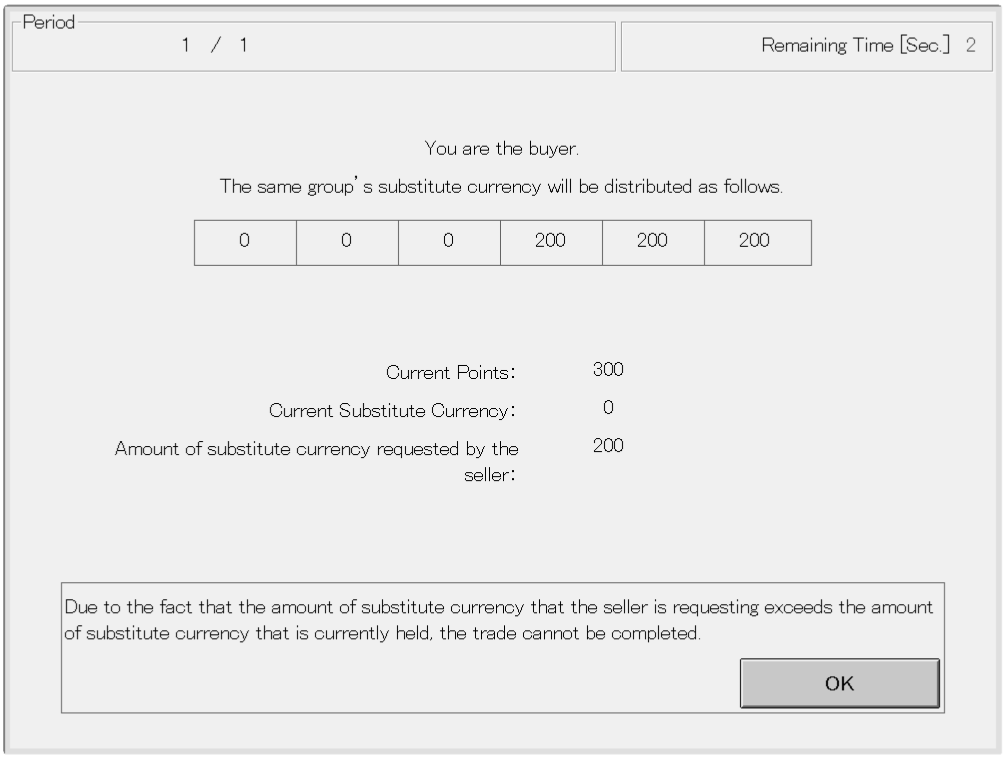

Figure 8: Buyer's Decisions Screen: Non-Acceptable Offer

Figure 9: Transaction Result Screen: ShowPrice=0

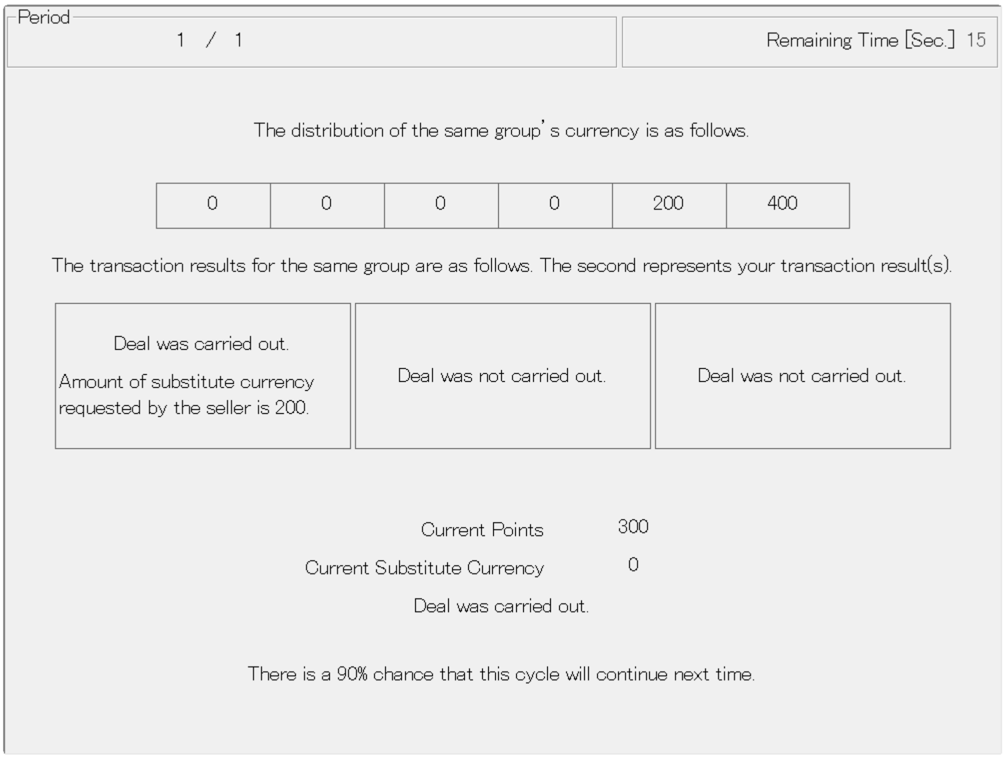

Figure 10: Transaction Result Screen: ShowPrice=1

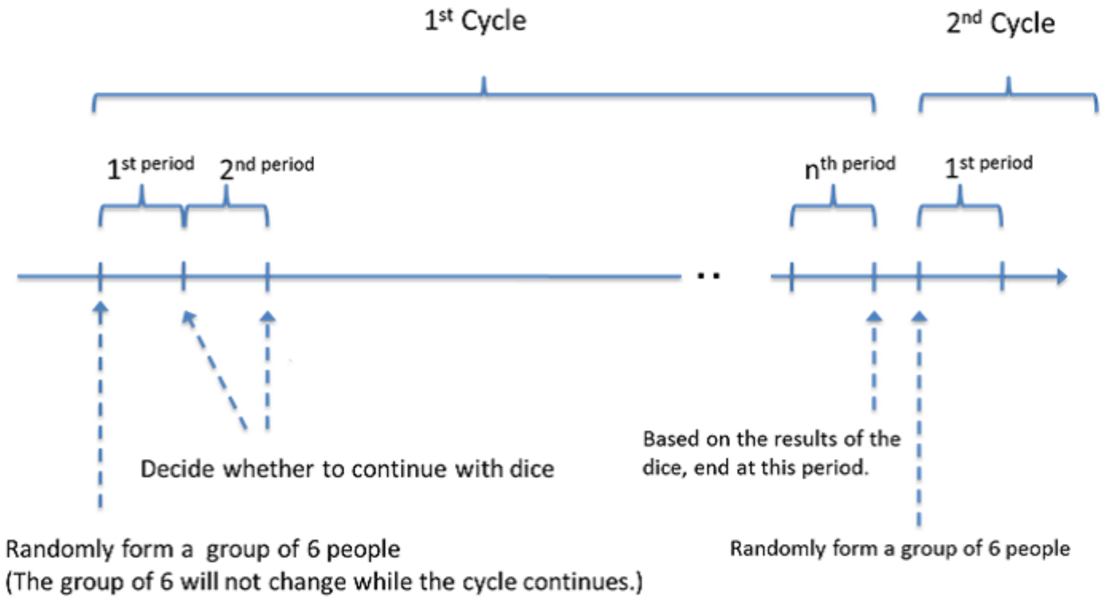

Figure 11: Relationship Between Each Period and Cycle

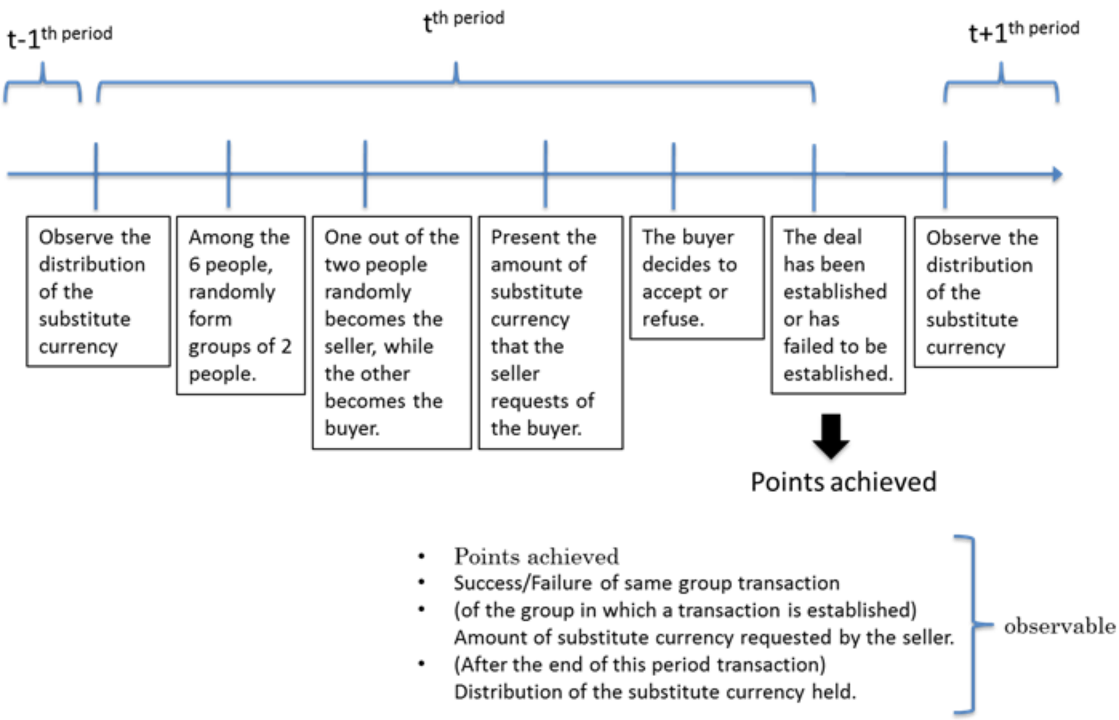

Figure 12: Decision-Making Flow for Each Period