Performance of a reciprocity model in predicting a positive reciprocity decision

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Abstract**—**This economic experiment initiates in evaluating a model's performance in predicting a decision. The reciprocity model is measured its accuracy rate in prediction and informativeness as aspects of the model's performance. Seventy-nine undergraduate students voluntarily joined the experiment. They made decisions contingently in designed situations as the first player in a dictator game and all roles in trust-share games. The study controls effects of choice set (equal split, competitive, and different social welfare choices) and framing effect. The result shows that the model has high performance in both prediction and informative. Furthermore, it shows an existence of the loss aversion behavior, and a significant relationship between decisions in the dictator game and the trust-share games. The study suggests that the more complicated model may not be marginally useful in predicting decision in the positive reciprocity situations.

Keywords**—**Economic experiment, performance, reciprocity, trust-share game.

I. INTRODUCTION

MANY countries show their support in the tragedy of 2011-tsunami in Japan. Thailand is one of the most encouraging countries to support by founding many donation campaigns from both government and private sectors. This supporting phenomenon is very interesting because, not only is it a common act of humanity, but it shows that many Thais believe they should express their kindness to the Japanese due to the 2004-tsunami in Thailand. Japanese was among the leading countries who gave Thailand a high number of donation.

This story is a good example how people decide in exchanging favors. They are willing to return favors if they were given. In economic studies, the exchanging-favors situation is called *positive reciprocity situation* which recent studies in economic psychology have focused on [1]-[9]. They aimed to point out the important factors which affect how people make a decision, and models, both simple and complicated, were proposed [4]-[8].

This study aims to initiate the next step in evaluating a model's performance in predicting a decision. According to Samuelson [10], a good model must be simple, accurate, and informative. Therefore, among various models, this study selects the reciprocity model proposed by Dufwenberg and Kirchsteiger [8] because of its simplicity. To evaluate the model's performance, both accuracy rate in prediction and informativeness are measured at *individual level* in this study.

The study designs four *trust-share games* as positive reciprocity situations to test the model's performance. Moreover, it designs a choice set in the games to make the reciprocity as the *only* motivation to the reciprocal decision. Hence, this study can explore the model's performance with limiting factors like other scientific experiments.

In addition, the author would like to state the asymmetric decision according to the loss aversion theory. It says people use different logic in making decisions between to gain and to lose. Therefore, one out of the four trust-share games collects a decision-to-lose data by designing it as a negative payoff structure.

Furthermore, this study collects a decision in a *dictator game* (DG). It aims to state a relationship between the decision in DG and the trust-share games since the author believes that DG is related to the positive reciprocity situations. To be precise, the more the dictator gives, the more he shows his kindness. Therefore, the dictator has higher tendencies to reciprocally return favors in the positive reciprocity situations.

II. OBJECTIVES OF THE STUDY

1) To evaluate the performance of the reciprocity model proposed by Dufwenberg and Kirchsteiger [8] in positive reciprocity situations.
2) To examine an existence of the loss aversion behavior in the positive reciprocity situations.
3) To examine a relationship between the decision in DG and the decision in the trust-share games.

III. METHODOLOGY

This part has four sections. The first two sections present the trust-share games and the DG, consecutively. Then, the reciprocity model is presented in order to make a conclusion how the decision in the trust-share games is predicted. Last, the experiment protocol and measurement methods are briefly explained.

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A. The Trust-share Games

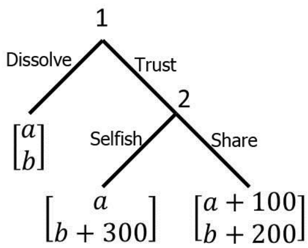

Fig. 1 Extensive form of the trust-share game in this study

TABLE I
PAYOFF STRUCTURES OF THE TRUST-SHARE GAMES IN THIS STUDY

Name	Type	a	b
Low PTS	Positive payoff	50	50
Medium PTS		100	100
High PTS		200	200
NTS	Negative payoff	-200	-600

Fig. 1 and Table 1 present the four trust-share games used as positive reciprocity situations in this study. The game is two-player-sequential situation with perfect information. The 1st player (P1) has to decide either to dissolve the situation or to trust the 2nd player (P2). If P1 dissolves, the situation is ended and both are paid as specified. But if P1 trusts P2, then P2 makes a decision whether to act selfishly by keeping additional 300 points or to act reciprocally by sharing 100 points to P1 and keeping the rest. The situations make P2 has a conflict of interests since P1's trust means he gave favors to P2 then P2 is supposed to reciprocally return, but his selfish act also gives him more payoff by not giving P1.

Three positive payoff trust-share games (PTS) and one negative (NTS) are designed. Only positive reciprocity is scoped, because, according to the Fig. 1, P1's trust gives P2 higher payoff than his dissolving, then P1's trust *clearly* gives P2 a signal of giving favors. Moreover, in order to make this study is able to explore a direct effect of the reciprocal signal, the design avoids the following;

i) Equal split choice which equally yields P1 and P2's payoffs.

ii) Competitive choice which P1 gets higher payoff than P2 in one choice while the other choice makes P2 gets higher payoff than P1.

iii) Different social welfare choice which each choice yields different amount of summed P1 and P2's payoffs.

According to recent studies [4]-[7], the choices have a significant effect on the subject's decision.

B. Dictator Game

DG is a two-person situation that only P1, called as a dictator, makes a decision but both P1 and P2 get paid. The dictator decides how many points he will keep from 200 points, and the rest will be given to P2. For example, if he keeps 150 points, then P2 gets 50 points.

The amount of points taken by the dictator is believed to imply his reciprocity in the trust-share games. For instance, a dictator who keeps 150 points is believed to act reciprocally in the trust-share games with a probability less than the one who keeps 100 points.

C. The Reciprocity Model

$$u_2\left(a_1, a_2, b_2^1, b_2^{12}, e_2^1, e_2^2, \phi_2\right) = m_2\left(a_1, a_2\right) + \phi_2 \cdot G_2\left(a_2, b_2^1, e_2^1\right) \cdot T_2\left(b_2^1, b_2^{12}, e_2^2\right). \quad (1)$$

Equation (1) is the reciprocity model proposed by Dufwenberg and Kirchsteiger [8]. It is the P2's utility function, $u_2(\cdot)$, which a_1 = P1's decision, a_2 = P2's decision, b_2^1 = P2's expectation on P1's decision, b_2^{12} = P2's expectation on P1's expectation on P2's decision, e_2^1 = P1's equitable payoff under P2's idea, e_2^2 = P2's equitable payoff under his idea, ϕ_2 = reciprocal parameter of P2, m_2 = P2's material payoff, G_2 = P2's favors given to P1, T_2 = P2's favors taken from P1.

According to the model, P2 decides his decision a_2 in order to maximize his utility level given the rest variables. Thus, the model can predict P2's decision if the rest variables are known. By using the sequential reciprocity equilibrium proposed by [8], some variables can be known as followed;

i) P2 is the last mover, thus a_1 is known.

ii) $a_1 = b_2^1$ and $a_2 = b_2^{12}$

iii) e_2^1 and e_2^2 are calculated by the model's definition.

Therefore, *the reciprocal parameter* ϕ_2 is the only unknown. Then, P2's decision will be related to the level of the parameter. According to the model, the parameter is a relative weight between P2's material payoff and the value from favors exchanging. If the parameter is zero then the model is the same as the traditional model. Hence, P2 is expected to act selfishly if the parameter is low, and vice versa.

In this study, the relationship between the P2's decision and reciprocal parameter is fixed in *all* trust-share games by the design payoff structures which calculation detail is provided in the Appendix. Then, the model can predict that each subject must decide the *same* in every trust-share game. For example, a subject who decided to act selfishly in Low PTS is predicted to act selfishly in other games, and vice versa.

D. Experiment Protocol and Analysis Methods

TABLE II

CROSS TABLE BY USING ONE TRUST-SHARE GAME AS A CONDITION, AND ANOTHER AS AN OUTCOME. A,B,C,D IS NUMBER OF SUBJECTS IN EACH GROUP.

		Outcome	
		0=Share	1=Selfish
Condition	0=Share	True Share=A	False Selfish=B
	1=Selfish	False Share=C	True Selfish=D

$$Accuracy\ rate = \frac{A+D}{A+B+C+D}. \quad (2)$$

Seventy-nine undergraduate students (64 are economic students, and 15 are not or not specified) at the Chulalongkorn University in Thailand voluntarily joined this hand-run economic experiment. Each subject decided how many points he would keep from 200 points in DG, and contingently decided as both roles in each trust-share game. The dictator game came first, and followed by the trust-share games which were shuffled. It was a double-blind experiment which staff had been trained how to conduct the experiment. The experiment uses words, in both subject's document and instructor's script, to prevent systematic framing effects, such as "situation" instead of "game", "mover" instead of "player", "decision A" instead of "trust", etc. Subjects were informed for the random matching process, and paid according to P1-P2 decision. Also, they were informed to independently decide in each situation, and did not allow to change their decisions in previous situations. The experiment was designed to pay 75 - 225 bahts/hour (with real paid at 125 bahts/hour) for a subject, which is higher than his normal income. The experiment took about 2 hours.

Subject's decisions in P2 role in the trust-share games are analyzed. The accuracy rate is measured at individual level as presented in Table II and (2). According to the table and equation, switching the situations from a condition to an outcome will give the same accuracy rate. Then, the four trust-share games can be paired up to *six pairs* of a condition and an outcome.

One trust-share game is selected as a condition, which a decision of each subject in the game implies to his decision in other trust-share games. Another trust-share game is selected as an outcome. A pair of subject's condition-outcome decisions can be categorized as presented in Table II. The accuracy rate as presented in (2) is a measurement of the percentage of correct prediction by the model which represents the model's performance in accuracy and precision.

Moreover, aggregate level decision is measured for the probability of selfish decision as a baseline probability without using the model. The baseline probability can be compared with the accuracy rate, which informs the conditional probability of subject's decision by using the model, to measure for the model's performance in informativeness. To be precise, if the accuracy rate is higher than the baseline probability then the model is informative, and vice versa.

The baseline probability between PTSs and NTS is compared to state an existence of the loss aversion behavior. If the baseline probability in PTSs is significantly different from the NTS's, then there is an evidence of the loss aversion behavior. Furthermore, the interaction effect between loss aversion and reciprocity can be stated that which one has stronger effect. For instance, if the baseline probability of selfish decision in NTS is higher than PTSs' then the loss aversion has stronger effect than the other, and vice versa.

Lastly, the relationship between the decision in DG and the trust-share games is measured by Spearman's rank correlation.

E. Assumptions and Limitations

1) This study assumed that each subject has a constant reciprocal parameter across situations.
2) Independent decision across situations is another important assumption.
3) This study only focuses on pure strategy. It is possible that the observed decision is randomly drawn from a distribution function over choices.
4) Framing-effect-free experiment can be concerned as one limitation, the result may not be consistent if the effect exists.
5) Repetition, one subject decides in many situations, is unavoidable. It is a potential cause of a systematic error.
6) Role switching is also another limitation in this study.

IV. RESULTS AND DISCUSSIONS

TABLE III

PERCENTAGE OF P2'S SELFISH DECISION AND STANDARD ERROR IN THE TRUST-SHARE GAMES.

	Percentage of P2's selfish decision	SE
LowPTS	71%	5.1%
MedPTS	73%	5.0%
HighPTS	71%	5.1%
NTS	94%	2.8%

TABLE IV

ACCURACY RATE OF A PAIR OF THE CONDITION AND OUTCOME

	Medium PTS	High PTS	NTS
Low PTS	85%	85%	75%
Medium PTS	-	82%	75%
High PTS	-	-	75%

TABLE V

SPEARMAN'S RANK CORRELATION BETWEEN THE DECISION IN DG AND OTHERS

	Low PTS	Medium PTS	High PTS	NTS
Spearman's	0.40	0.43	0.32	0.12
p-value	0.00	0.00	0.01	0.30

1) As presented in Table III, the average probability of selfish decision in PTSs is 71% - 73% (with 72% on average), and 94% in NTS. The results show us the baseline probability of observing the selfish decision in the subject group.
2) From Table IV, average accuracy rate is 82% - 85% with average at 84% among PTSs. This is the conditional probability when using one PTS as a condition and another PTS as an outcome. It implies the high performance of the model when it predicts a decision across PTSs.
3) The average accuracy rate between PTSs and NTS is 75%. This is the conditional probability when using one PTS as a condition and NTS as an outcome, or switching them. It implies that the model has lower performance when it predicts a decision between PTS and NTS, compared to the performance in prediction across PTSs
4) Using one PTS as a condition, the model can increase 12% of correct prediction of a decision in other PTSs from 72% at the baseline probability to 84% at the conditional probability. Also, using NTS as a condition, the model can increase 3% of doing so. But using PTS as a condition, the model cannot increase the percent of correct prediction from the baseline probability at 94%. It implies that the model is informative either using PTS or NTS, but it is the best to use PTS, as a condition to predict a decision in other PTSs. In addition, a model may not be needed to predict a decision in NTS because its baseline probability of selfish decision is very high at 94%. Hence, it may not efficient to use a model and a designed situation as a condition to increase marginal rate of correct prediction.
5) The baseline probability of selfish decision in NTS is 22% higher than in PTSs. It implies for an existence of the loss aversion behavior. Moreover, the increasing in the rate of selfish decision in NTS is also an evidence that the effect of the loss aversion is stronger than the reciprocity.
6) From Table V, the Spearman's rank correlation shows a significantly positive relationship, which means the more the dictator takes the lower tendency he will share, at 0.05 level of significance between the decision in DG and the decision in PTSs, but does not with the decision in NTS. It shows that the decision in DG can imply the degree of positive reciprocity. According to the model, the degree of positive reciprocity is presented by the reciprocal parameter. Hence, DG may be used as a condition to predict a decision in other positive reciprocity situations with positive payoff structure.

V. Conclusions

While previous studies aimed to explore important factors in order to understand reality and propose the mathematical models, this study initiates the next step to verify a model's validity in applicability. The study evaluates a model's performance in the aspects according to what Samuelson [10] suggested. Beside the initiation, this study also develops a new technique in designing a controlled experiment to be able to use a cross table as presented in Table II to do the analysis at individual level.

Seventy-nine undergraduate students joined this hand-run economic experiment to make decisions in the model situations. This study designs 3 PTSs and one NTS as the positive reciprocity situations to verify the performance of the reciprocity model proposed by Dufwenberg and Kirchsteiger [8]. Among various models, the Dufwenberg and Kirchsteiger's model has its strength in simplicity, which is one aspect in a good model, by just only one parameter, the reciprocal parameter, is used to capture individual relative preference between selfish and reciprocal decisions.

The result among PTSs shows that the model has high performance in accurately predicting a decision, and high performance in informativeness from marginal gain in the rate of correct prediction. It suggests that the more complicated model may not necessary to be used in order to increase the marginal gain in the rate of correct prediction but increase in marginal cost of using the model. Moreover, for the NTS, the result shows that, together with the existence of stronger effect of the loss aversion than the effect of the reciprocity, we can expect people to make a selfish decision at the very high rate without using any additional information. Hence, the result still convinces that the more complicated model may be not informative enough according to the cost of using it.

Furthermore, the study finds a significantly positive relationship between the decisions in DG and PTSs. The finding shows a possibility that the decision in DG may be used to estimate the reciprocal parameter in the model because the decision in DG provides quantitative data whereas other games like the trust-share game provide qualitative data. However, the decision in DG can also be used as a condition in developing a new reciprocity model.

For one who is interested in extending from this study, it is interesting to evaluate the model's performance in more complicated situations such as 3-choice or 3-player ones. Adding the effect of equal split, competition, or different social welfare choice, or framing effect is also a possible extension.

Appendix

The relationship between P2's decision and the reciprocal parameter: from (1), let $a_1, b_2^1 = 1$ for dissolve and $a_2, b_2^{12} = 1$ for selfish. The following equations come from the model's definition,

$$G_2 = b_2^1 a + \left(1 - b_2^1\right)\left(-100a_2 + a + 100\right) - e_2^1 . \quad (3)$$

$$T_2 = b_2^1 b + \left(1 - b_2^1\right)\left(100b_2^{12} + b + 200\right) - e_2^2 . \quad (4)$$

$$e_2^1 = 0.5\left(m_1\left(b_2^1, a_2^{\max}\right) + m_1\left(b_2^1, a_2^{\min}\right)\right). \quad (5)$$

$$e_2^1 = 0.5\left(m_2\left(b_2^{1,\max}, b_2^{12}\right) + m_2\left(b_2^{1,\min}, b_2^{12}\right)\right). \quad (6)$$

Which a, b are payoff structure as in Fig. 1, $a_2^{\max}$ is P2's decision to maximize P1's payoff given b_2^1, $a_2^{\min}$ is P2's decision to minimize P1's payoff given b_2^1, $b_2^{1,\max}$ is P2's expectation on P1's decision that maximizes P2's payoff given b_2^{12}, and $b_2^{1,\min}$ is P2's expectation on P1's decision that minimizes P2's payoff given b_2^{12}. From the designed structure, $b_2^{1,\min} = 1$ and $b_2^{1,\max} = 0$. For P2, if he has a chance to make a decision then he knows that $a_1 = b_2^1 = 0$. Thus, $a_2^{\max} = 0$ and $a_2^{\min} = 1$. Then, P2's utility function can be re-written at his decision node from (1) and (3)-(6) as,

$$u_2\left(a_2, b_2^{12}, \phi_2\right) = 100a_2 + b + 200 + \phi_2 \cdot \left(-100a_2 + 50\right) \cdot \left(50b_2^{12} + 100\right). \quad (7)$$

Which from (7), by consistent belief condition in sequential equilibrium, $b_2^{12} = a_2^*$ if a_2^* is a P2's decision in sequential equilibrium, the relationship between P2's decision and reciprocal parameter can be expressed by P2's best response function in pure strategy, BR_2,

$$BR_2 = \left\{a_2^* = 1 \middle| \phi_2 \le 1/150\right\} or \left\{a_2^* = 0 \middle| \phi_2 \ge 1/100\right\}. \quad (8)$$

Hence, the best response shows the fixed relationship between P2's decision and his reciprocal parameter for all trust-share games as specified in Fig. 1.

Q.E.D.

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