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Fairness and Bargaining Power in Threshold Public Goods Experiments

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ABSTRACT

Experiments on three two-person threshold public good provision games, namely, the simultaneous, sequential, and dictator games, are conducted to explore the motives behind giving. Players who move simultaneously are endowed with equal bargaining power, and players who move first are endowed with more bargaining power than players who move subsequently. Dictators are indubitably endowed with complete bargaining power. Since the differences between the bargaining powers of two players increase from the simultaneous to the sequential to the dictator game, comparisons among games allow us to trace whether the contribution behavior is motivated by fairness or is simply due to the strategic concern. The experimental evidence shows that the strategic concern explains the overall contribution behavior better than the motive of fairness. However, in the final round 26% of the dictators share the threshold evenly with their opponents, suggesting that some subjects do play fairly. Copyright © 2007 John Wiley & Sons, Ltd.

KEY WORDS public goods; fairness; sequential game; dictator game

INTRODUCTION

Experimental studies have consistently found evidence that is contradictory to the predictions of economic theory. A prominent example is the linear public good provision game. The dominant-strategy Nash equilibrium for this game is complete free riding, yet experimental studies often find high contributions, which sometimes amount to 40–60% of the subjects' endowments.[1] Similar contradictions are observed in the experiments of ultimatum bargaining games. The subgame perfect equilibrium suggests that the proposer will offer a minimal amount of money to the responder, and that the responder will accept this offer since it is better than nothing. However, experimental studies regularly find that the proposer often offers 30–40% of the

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[1]See for instance, Andreoni (1988), Isaac and Walker (1988), Isaac, Walker, and Thomas (1984), Marwell and Ames (1981), and the surveys by Davis and Holt (1993) and Ledyard (1995).

total amount to the responder, which is much higher than the amount the subgame perfect equilibrium predicts. Furthermore, offers of 40–50% are almost always accepted and offers below 20% are often rejected.[2]

These experimental findings suggest that if players' payoffs are confined to their own monetary rewards, then oftentimes the standard game predictions work poorly in explaining actual behavior. This gives rise to the following question: What motives make up the gap between the experimental findings and the standard game predictions? In other words, what else motivates giving other than self-interest? Among those motives that have been examined to date, fairness and strategic concerns have generated a lively discussion.

To test the fairness and strategies hypotheses, the experimental results from the ultimatum game are often compared to those from the dictator game. Forsythe, Horowitz, Savin, and Sefton (1994) initiated this design and provide prominent evidence on this issue. Forsythe et al.'s (1994) idea is that since dictators have no strategic concerns that the recipients may reject their offers, if the dictators give a substantial amount to the recipients, then they must be motivated by fairness. Hence, if fairness alone is able to explain the substantial offers by the ultimatum first movers, the distributions of offers by dictators and those by the ultimatum first movers should be the same. Otherwise, if offers by the ultimatum first movers are significantly higher than offers by dictators, then it is the strategic concern, not the fairness motive that prompts the ultimatum first movers to give. Forsythe et al.'s experimental evidence did not support the fairness hypothesis. Hoffman, McCabe, Shachat, and Smith (1994) also conducted ultimatum and dictator game experiments and found evidence supporting the strategies hypothesis, and not the fairness hypothesis.

Since in the ultimatum game a fixed amount of money is divided between two players, this game neatly provides a clear focal point for fair division: 50–50. Rabin (1993) also suggests that offering 50% of the maximum allowable offer is the equitable division. The linear public good provision game lacks such a focal point and thus whether contributions to public goods are attributable to the motive of fairness or due to strategic concerns is less readily testable. Another type of public good provision game, the threshold public goods game, however, indeed provides a nice fairness rule. In the threshold public goods game, the public good is provided only if group contributions reach a certain threshold. Hence, the division of the threshold between group members gives a simple and clear measure of fairness. However, although the threshold public good design has such a nice property, most experimental studies employing this design either aim to test whether the provision threshold can be reached or how the motives of greed and fear affect cooperation, rather than testing the fairness and strategies hypotheses.

This paper attempts to make up for this gap in the literature by conducting three two-player threshold public goods games. The three games comprise a simultaneous game, a sequential game, and a dictator game. The simultaneous game is a standard and frequently studied public good provision game and, under the threshold design, the sequential and dictator public goods games are like an ultimatum game and a standard dictator game. Since the relative strength of the bargaining powers between two players differs across the three games, the results from the three games not only provide a preliminary sketch of the contribution behavior, but comparisons between games can also help clarify the motives behind giving.

This paper aims to address the following three hypotheses:

1. *The standard game predictions*: Players behave selfishly, maximizing their own monetary payoffs. They share the threshold equally only if they move simultaneously. Otherwise, the first mover will contribute zero or a tiny amount and leave the second mover to bear all or almost the entire burden of the public good.

[2]For surveys of this vast and growing literature, one may refer to Camerer (2003), Camerer and Thaler (1995), and Güth and Tietz (1990).

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2. *The strategies hypothesis*: Players share the threshold equally only if they move simultaneously. The sequential first mover will contribute substantially more than zero, but still much less than the equal sharing level. Dictators will contribute zero or a tiny amount.
3. *The fairness hypothesis*: Players share the threshold of the public good equally in all three games.

Although the result of equal sharing from the above three hypotheses can be attributed to either the strategic or fairness considerations, or both, making comparisons between games can help elicit the motives behind giving. This is because players in the simultaneous game are endowed with equal bargaining power, while players in the other two games are not. In particular, the dictators are endowed with the whole of the bargaining power and therefore should have no strategic concerns. If the strategies hypothesis holds, then the contributions of players in the simultaneous game should be higher than the contributions by the sequential first movers, and the latter should in turn be higher than the contributions by the dictators. On the other hand, if the motive of fairness alone can explain the resulting contribution behavior, then players should behave the same in all three games.

The main findings of this paper are summarized as follows. First, the standard game predictions only work well in the simultaneous game. Second, the contributions by players in the simultaneous game are significantly higher than the contributions by the sequential first players, and the latter are in turn higher than the contributions by the dictators, suggesting that the strategic concern explains the overall contribution behavior better than the motive of fairness. Third, 29% of the dictators share at least half of the threshold with their recipients in the final round of the game. This observation indicates that some players do play fairly even though they possess all of the bargaining power.

The remainder of this paper is organized as follows. The following section gives a brief review of the related experimental literature. While Section *Game Description* provides a simple model of the threshold public goods game and *Method* Section presents the experimental design. This is followed by *Results* Section. The implications and limitations of the results are discussed in the last section.

RELATED EXPERIMENTAL LITERATURE

A 'divide-the-dollar' game is a game in which a fixed amount of money is divided between two players. Because of its simplicity and fundamentality, the ultimatum game has been a frequently studied 'divide-the-dollar' game. The ultimatum game is important because it not only serves as the basis for studying more complicated bargaining games, but also comparing the ultimatum game with other games can also help elicit the possible factors that give rise to the disparity between the equilibrium predictions and actual behavior. For instance, as discussed previously, Forsythe et al. (1994) and Hoffman et al. (1994) compared the experimental results from the ultimatum game with those from the dictator game to clarify whether fairness can explain the deviation of the subgame perfect equilibrium in the ultimatum game. Furthermore, Nelson (2002) conducted a truncated ultimatum game experiment in which the first mover's maximum offer is limited to 20% of the money to be divided. He found that almost all of the maximum possible offers are accepted by the second movers, but that the amount offered is often rejected in the standard ultimatum game, suggesting that the intention to play fairly matters, even though the outcome looks unfair. Prasnikar and Roth (1992) compared the experimental results from the ultimatum game with those from the best-shot game. In the best-shot game, both players obtain payoffs equal to the maximum of the two players' giving. They found that in the ultimatum game first movers generally offer around 40% of the pie in all the 10 trials, but in the best-shot game the first movers' offers consistently converge to zero, indicating that the fairness consideration cannot be applied if there is no opportunity to play fairly.

Because of the provision threshold, the three public goods games (simultaneous, sequential, and dictator) examined in this study are variations of the 'divide-the-dollar' game, and in particular, the game with

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sequential movement is like an ultimatum game. The major difference between the threshold public goods game and other 'divide-the-dollar' games is that in the former the players share a fixed amount of cost, while in the latter a fixed amount of money is divided between the players.

The models of threshold public goods games have been developed by Bagnoli and Lipman (1989) and Palfrey and Rosenthal (1984). Besides examining whether the threshold can be successfully reached (e.g., Aquino, Steisel, & Kay, 1992; Bagnoli & McKee, 1991; Cadsby & Maynes, 1999; Isaac, Schmidtz, & Walker, 1989; Marks & Croson, 1998; Rutte, Wilke, & Messick, 1987; Sonnemans, Schram, & Offerman, 1998; van de Kragt, Orbell, & Dawes, 1983; van Dijk & Wilke, 1995), a number of studies in this literature focus on the motives of greed and fear in cooperation. In the climate with a threshold, greed is present if a person expects that enough contributions will be made by other members and therefore he can free ride by contributing nothing or only a small amount. If instead a person expects that insufficient total contributions will be made even if his own contribution is included, then he may back out because of fear.

Comparisons between the no-greed, no-fear, and the greed-and-fear conditions help determine whether greed or fear is the more important reason giving rise to non-cooperation. The no-greed condition can be manipulated by imposing an enforced contribution on those who contribute zero or smaller amounts than others when group contributions turn out to reach the threshold. The no-fear condition can be established by refunding one's contribution if group contributions eventually fail to meet the threshold. If contributions are significantly higher in the no-greed (no-fear) condition than in the greed-and-fear condition, then greed (fear) is a reason for non-cooperation. Comparing the results based on the no-greed condition with those based on the no-fear condition can also help determine which motive is more important for non-cooperation.

Conclusions from the experimental studies on greed and fear are generally inconsistent. Ahn, Ostrom, Schmidt, Shupp, and Walker (2001), Dawes, Simmons, and van de Kragt (1986), Poppe and Utens (1986), and Rapoport and Eshed-Levy (1989) found that greed is more important than fear in non-cooperation. On the other hand, Liebrand, Wilke, Vogel, and Wolters (1986) and Bruins, Liebrand, and Wilke (1989) concluded that fear and greed are equally important. Poppe and Zwikker (1996) employed various threshold levels and showed that whether it is the level of greed or fear that is higher depends on the levels of the threshold.

From the results of the above-mentioned studies, a number of papers suggest that removing greed can induce more cooperation. However, some questions remain unanswered. If greed is not removed, will players necessarily behave selfishly? Furthermore, if some of them do cooperate when greed is retained, what is the motive driving them to do so? Is it because of fairness or due to the strategic concern? In view of the similarity between the threshold public goods game and other 'divide-the-dollar' games, the fairness and strategies hypotheses can indeed be tested in the threshold public goods game, and this is the main purpose of this study.

It is worth noticing that Andreoni, Brown, and Vesterlund (2002) also examined the fairness issue in three two-player public goods games. There are two major differences in the experimental designs between their paper and this one. First, the three games examined in their paper are the simultaneous, sequential, and best-shot games. In this paper, the first two games are also examined, but the third game is a dictator game. Second, they did not impose a threshold in all three games. They designed the payoff schemes in such a way that in all three games only one person contributes in the Nash equilibrium and found evidence that was contradictory: except for the best-shot game, the experimental results from the other two games differ from the Nash equilibrium predictions. Since in the best-shot game there is no way of behaving fairly, they therefore concluded that, besides having the intention to play fairly, having the opportunity to play fairly also matters.

While a major issue in Andreoni et al.'s (2002) paper is to examine whether there will be a fair outcome when there is no opportunity provided to behave fairly, the opportunity to be fair exists in all three games in this paper. The main purpose of this paper is to explore whether players will behave fairly and to determine the motives behind giving. Due to the differences in the experimental designs and the main foci, the study by Andreoni et al. and this paper are complementary.

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GAME DESCRIPTION

The game

This paper explores the effects of fairness and strategies on the provision of public goods in three two-player threshold public goods games. The three games have similar equilibrium levels of total contributions, but different equilibrium levels of individual contributions. The first game is the simultaneous game in which two players make their contributions simultaneously. The second game is the sequential game. In this game player one makes his contribution first, and then player two makes his own contribution after observing player one's decision. The last game is the dictator game, in which player one (the dictator hereafter) determines not only his own contribution, but also how much player two (the recipient hereafter) contributes.

Each player is endowed with an exogenous income w and allocates w between private good consumption (x_i) and a contribution to the public good (g_i). Hence, each player faces a budget constraint $x_i + g_i = w$. If group contributions reach a certain threshold T, then the public good consumption G is equal to T; otherwise G is zero. The condition $T = w$ is set in the experiments. That is, the public good can be provided by one player alone.

As Section *Related Experimental Literature* mentions, the motives of both greed and fear can induce non-cooperative behavior in the threshold public good provision game. Hence, either greed or fear needs to be removed, since we will otherwise be unable to tell whether the players' behavior in terms of contributing is attributable to less greed (or more altruistic concern) or arises simply because of less fear.

Since the main purpose of this paper is to explore whether players will behave fairly when they have the incentive to free ride, greed cannot be removed. Furthermore, if greed is removed by enforced contributions, then players will have the same bargaining power regardless of the order of movement, and it will be rather strange if the dictator has to contribute the same amount as he determined for the recipient. One last reason for removing fear is that dictators should have no fear in making decisions. Retaining fear will mean that the results from different games will be incomparable.

Hence, a refund is employed to eliminate the motive of fear, but no enforced contribution is imposed so that the motive of greed is retained. Given the refund's design, the player's payoff function can be written as $u_i = x_i + \mathrm{G} + r_i$, where r_i is the refund. If $g_1 + g_2 \geq T$, then $G = T$, $r_i = 0$, and $u_i = w - g_i + G$; otherwise $G = 0$, $r_i = g_i$, and $u_i = w$.

Equilibrium analysis

Consider first the simultaneous game. In this game, the best response to $g_{-i} = 0$ is $g_i = 0$ or $g_i = w$ for $i = 1, 2$. Therefore, we first have two Nash equilibria. In one equilibrium, both players adopt a complete free-riding strategy and, in the other, one player contributes nothing and the other player contributes w. In addition to the two equilibria, any pairs of contributions such that $g_1 + g_2 = T$ are clearly also Nash equilibria.

Next, in the sequential game, player one makes his contribution first. After observing player one's decision, player two makes his contribution. Since player two gets to know what player one has chosen before player two makes his decision, player one can look ahead to see how player two will respond to his choice. Solving this game backwards yields two subgame perfect Nash equilibria. First, consider the situation where player one contributes nothing in the first stage. In this case player two is indifferent between contributing w and zero, since both will earn player two the same payoff w. If player two accepts player one's contribution and responds by contributing w, then the subgame perfect Nash equilibrium is $(g_1, g_2) = (0, w)$. If player two rejects player one's contribution by also contributing zero, then it is better for player one to contribute zero plus a minimum increment, say, NT\$1, in the experiments, and player two will accept. Hence, there is another subgame perfect Nash equilibrium, namely, player one contributes NT\$1 and leaves player two to make up the threshold by giving w–NT\$1.

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Finally, since in the dictator game the dictator makes decisions for both players, the best strategy for the dictator is to give nothing and to make the recipient contribute his entire *w*. Notice that, in all three games, Pareto efficiency is achieved as long as group contributions exactly match the threshold.

METHOD

Participants

Forty subjects were employed for each game, but for the reasons described in the procedure below, in the end 38 valid observations were included in the dictator game. The subjects were recruited from economics courses at National Chengchi University and National Taiwan University in Taiwan. None of them had ever participated in any public goods experiments. The simultaneous and dictator games lasted about 50 minutes each. The sequential game was more time consuming, taking about 80 minutes. The average earnings were NT$284 for the simultaneous game, NT$295 for player one and NT$249 for player two in the sequential game, and NT$369 for the dictator in the dictator game, with an average of NT$307 for all participants. The average earnings for the hypothetical recipients in the dictator game were NT$229.[3]

Procedure

In each game, subjects were randomly and anonymously assigned to groups of two and played the game for 10 rounds. The two players in the group were called A and B, and corresponded, respectively, to player one and player two in the model. Both As and Bs were informed that they would be randomly re-matched with a new partner when a new round started, and no one would be paired with the same partner more than once.

In the simultaneous and sequential games, 20 subjects were assigned to be A players and the other 20 subjects were assigned to be B players. The As and Bs were placed in separate rooms and their identities remained unchanged for all 10 rounds.

In the dictator game, 40 subjects were also divided evenly between two separate rooms. Since recipients in the dictator game only passively accept the decisions determined by dictators, to avoid resentment or any other emotional problems, all 40 subjects were assigned to be A (the dictator), but they were informed that subjects in the other room were Bs (recipients).[4] To avoid the experimenter observation effect, dictators were required to write down their decisions and calculate the payoffs for both players on two copies of the decision form.[5] They retained one copy for record-keeping purposes and turned in the other copy to assistants, with the front side face down so that no one else in the room (including the experimenter) could observe their decisions. They were informed that the other copies would be handed over to the recipients in the other room, but they were unaware that the recipients were actually absent. Since subject 29 continuously entered the

[3]When these experiments were conducted, the exchange rate between the NT (New Taiwan) dollar and the US dollar was about 32:1. The part-time hourly wage rate for an undergraduate student in Taiwan is about NT$120. All the resulting data can be found on the website: http://pf.nccu.edu.tw/Faculty/Hsu/research/dataFairnessLT.pdf

[4]Here all subjects were assigned the role of dictators due to the following considerations: First, since only dictators make decisions, this design has no effect on dictators' incentives. Second, recipients might have felt upset since they could not make any decisions but only passively accepted a very small amount of money determined by the dictators in all 10 rounds. This design can help prevent any emotional problems during and after the experiment. Third, as was pointed out by Frohlich, Oppenheimer, and Moore (2001), a problem with the dictator game experiments is that the dictators may doubt the existence of the 'real' recipients in the other room. Hence, if the dictators had doubted the existence of the recipients, they would have doubted anyway, even if there were real recipients. Notice that Frohlich et al. (2001) also pointed out that this doubt may result in more selfish behavior. Allowing dictators and recipients to meet is a possible way of avoiding this doubt, but then this design may give rise to a flaw in that the dictators' incentives may be affected.

[5]If dictators' decisions were observed by other people (especially the experimenter), then to prevent them from having an opinion that dictators were parsimonious, dictators might have offered the recipients more than what they were actually willing to offer. Hoffman et al. (1994) found evidence in support of the experimenter observation effect, but Bolton, Katok, and Zwick (1998) did not.

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wrong payoffs in every round except for the first round, and subject 38 wrote nothing on the decision form in the fourth round, eventually 38 valid observations remained.

Subjects were given written instructions in Chinese.[6] The experimenter read the instructions aloud and answered any questions raised by the subjects. Before playing the games, the experimenter held a quiz, asking subjects to calculate the payoffs in three specific examples.

In the simultaneous game, subjects were each endowed with NT$20 per round and were instructed to invest the endowment between object X (the private good) and object Y (the public good) simultaneously. Each NT$1 invested in X would yield the subject a return of NT$1, while the return from Y depended on whether the threshold was reached or not. If group investment in Y reached the threshold NT$20, then *each* member would earn NT$20 from Y. If group investment in Y fell short of NT$20, then the amount of money originally invested in Y would be returned to the subject's own account and would then be automatically re-invested in X instead. The same procedures were run in the sequential and dictator games, except that in the sequential game player one and player two made decisions sequentially, and in the dictator game the dictator made decisions for both players.

RESULTS

Testing the standard game predictions

Figure 1 reports the average contributions across rounds by players in various roles. From directly observing Figure 1, it seems that there is no decay in any of the games. The no-decay result in the simultaneous game can be attributed to the threshold and refund designs, and can also be observed in previous experimental studies employing similar designs (Bagnoli & McKee, 1991; Cadsby & Maynes, 1999). Furthermore, except for the contributions of the sequential second players, the contributions of all those in other roles are quite smooth over 10 rounds. The smoothest contributions are those of players in the simultaneous game, who contribute on average half of the threshold in almost every round.

Let us start by looking at how good the Nash equilibria are at making predictions in the simultaneous game. The data show that no one gave NT$0 in any round of the game. As a result, the complete free-riding

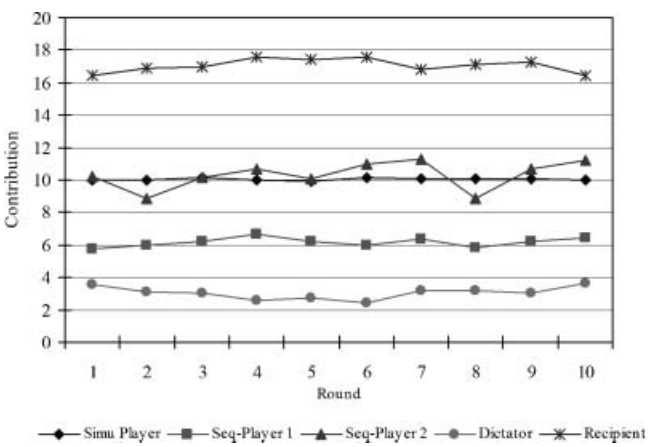

Figure 1. Average contributions by round

[6]The translations of the Subjects' Instructions are available from the author upon request.

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Nash equilibrium never shows up. However, the threshold Nash equilibria do occur frequently. Figure 2a depicts the proportion of groups that provide the public good successfully for all 10 rounds in the simultaneous game. In the first round, 50% of the groups attain the threshold Nash equilibrium and another 25% of the groups over-contribute, with a total of 75% providing the public good successfully. Successful provision generally increases over rounds and in the final round 95% of the groups reach the threshold and only two of these (10%) over-contribute.

Next, let us proceed to the sequential game. The subgame perfect Nash equilibria for this game are that player one gives NT$0 or NT$1, and player two fills up the threshold by giving the rest. This game prediction cannot be confirmed by the data. Looking at Figure 1 again, those in the player one role give an average of

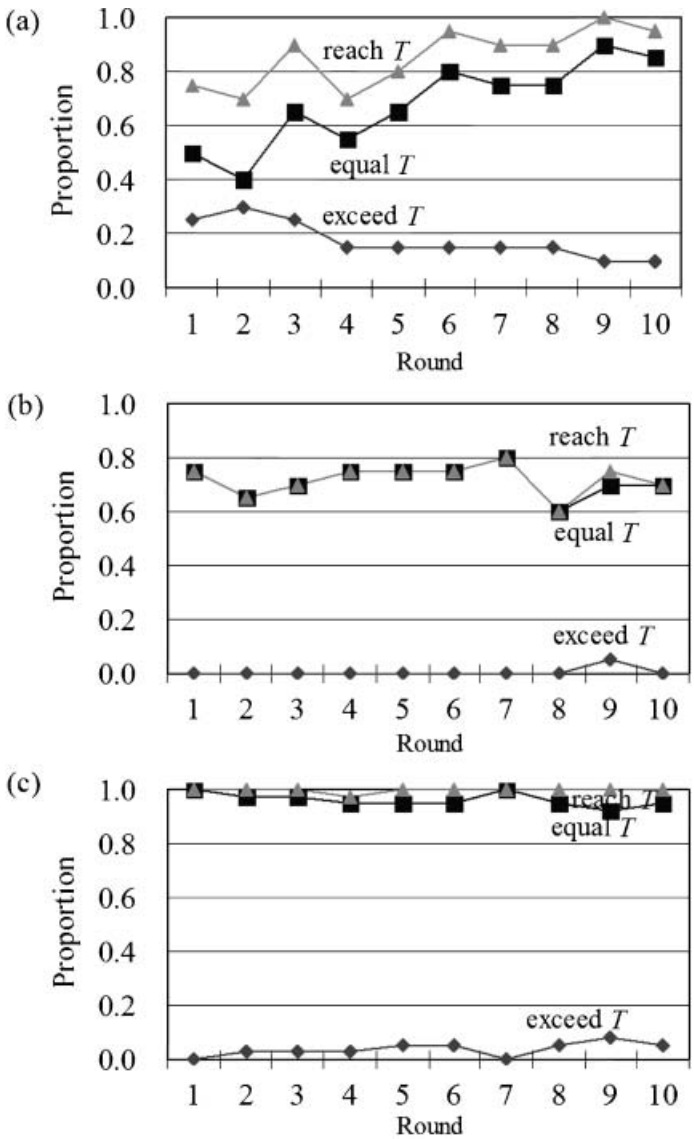

Figure 2. The proportion of groups providing public goods successfully. (a) Simultaneous game (b) Sequential game (c) Dictator game

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about NT$6 (of NT$20) in most rounds, resulting in an average of 31% of their endowments over 10 rounds. The average contributions of the second players, on the other hand, fluctuate over a wider range, with an average contribution of 52% of their endowments over 10 rounds. These magnitudes deviate from what the subgame perfect Nash equilibria predict.

Besides the subgame perfect Nash equilibria, we can also look at how often the threshold is reached in the sequential game. A direct comparison between Figure 2a and 2b shows that while redundant contributions are rarely observed in the sequential game, fewer successful provisions are also involved in the sequential game than in the simultaneous game. Specifically, successful provision of public goods starts in 75% of the groups and ends up with 70% in round 10, with an average of 72% over all 10 rounds. Only one group in round 9 over-contributes.

Finally, the standard game prediction in the dictator game is that the dictator will give nothing and will thus leave the recipient to give his (her) entire endowment. Again, the data conform slightly to this game prediction. As Figure 1 shows, the dictators require the recipients to give on average 85% of their endowments over 10 rounds, while dictators give on average 15% of their endowments, which is much higher than zero. Figure 2c shows further that 1 of 38 groups in the fourth round fails to provide the public good and over-contributions are found in one or two groups in 8 of the 10 rounds. On average, the public good fails to be provided efficiently about 4% of the time. All the observations deviate from the selfish equilibrium. Hence, the first main result of this paper is that, except for the simultaneous game, the standard game predictions perform poorly in the other two games.

Testing the strategies and fairness hypotheses

Aggregate behavior

Examinations of the strategies and fairness hypotheses can be best started by comparing the contributions by players in various roles. Figure 1 depicts this information. It is observed that the contributions that the dictators determined for the recipients are substantially higher than the contributions of players in all other roles. By contrast, the dictators make the smallest contributions. The contributions by the sequential first players are higher than the contributions by the dictators, but are lower than the contributions by the sequential second players and the simultaneous players. The contributions made by those in the latter two roles are about half of the endowment, with the contributions by the sequential second players being slightly higher than the contributions by the simultaneous players in most rounds.

The two-sided Mann–Whitney U-tests confirm the above observations.[7] Apart from the differences between the contributions by the simultaneous players and the contributions by the sequential second players in the first five rounds being insignificant ($p = 0.567$), the observations above are all confirmed ($p \leq 0.020$), regardless of whether one looks at the first round, the first five rounds, the last five rounds, the final round, or the entire set of repetitions.

Figure 1 indicates that the average contributions by the simultaneous players coincide with the absolutely fair contribution in almost every round, but this phenomenon cannot be observed for the sequential first players and dictators. This leads us to ask whether the first movers in each game act fairly. After performing a one-sample sign test, the statistical results show that the median contribution by the simultaneous players does not differ significantly from NT$10 ($p \geq 0.541$), but the median contributions by the sequential first movers and dictators are significantly lower than NT$10 ($p = 0.000$), regardless of whether one looks at the first round, the first five rounds, the last five rounds, the final round, or the entire 10 rounds.

[7]This test and others are performed using the individual subjects' choices as observations. When looking at a subject's choices over several rounds, the average of these choices is used as the observation. Since subjects' decisions in later rounds may be affected by both their and their opponents' decisions in previous rounds, except for the first-round observations, the observations of all other rounds may not be independent.

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The results above indicate that there are more sequential first movers and dictators acting unfairly than acting fairly. Hence, the fairness hypothesis seems to fail. Furthermore, since the contributions made by the simultaneous players are significantly higher than the contributions by the sequential first players and the latter are in turn higher than the contributions by the dictators, this finding indicates that the concern over strategies explains the overall contribution behavior better than the fairness motive. The following subsection will explore the fairness and strategies hypotheses in greater depth by looking at the dynamics of the games and individual players' behavior. A more thorough discussion of the fairness and strategies hypotheses will be provided in the next section.

Dynamic analysis and individual players' behavior

Let us look first at Figures 3 and 4 which illustrate the frequency of outcomes in the first and final rounds of play. Figures 3a and 4a show that in the simultaneous game the equal-sharing contribution (i.e., NT$10) occurs in a dominant amount of time. In round 1, 67.5% of the subjects share the threshold evenly with their opponents, and 85.2% of them are involved in a successful provision of public goods. By the end of the game, an overwhelming 92.5% of subjects adopt this strategy and 97.3% of them are successful.

Apparently, those subjects whose contributions deviate from the equal-sharing level are punished by either wasting their contributions or failing to provide the public good. This raises the questions of how persistent the subjects' choices are and how they react after they find out that they are not on the right track. Table 1 summarizes the frequencies of subjects' choices using NT$10 as the cutoff point. It can be seen that 36 of the 40 subjects (90%) give NT$10 in more than 5 rounds, and even 13 of the subjects (32.5%) do so throughout the whole game. Besides the extremely high frequencies of giving NT$10, Table 2 shows a further tendency toward this: in round 1 through round 9, subjects give more than NT$10 only 41 times. Among the 41 observations, 8 of them maintain the same amount of contributions in the following round, 31 adjust their behavior inversely, and only 2 give even more. An inverse relationship is also found in the situation where subjects realize that they give too little. By applying the Chi-square test for the null hypothesis that the three reactions (no change, increase, decrease) are equally likely, the null hypothesis for each situation can be rejected at the 1% significance level. By considering only the reactions *increase* and *decrease* and applying the binominal test, the null hypothesis that the two reactions are equally likely is also rejected in situations 2 and 3 at the 1% significance level. This result suggests that subjects do return to the right track after they find out that they gave either too much or too little.

Choices in the sequential game are more diverse as compared with those in the simultaneous game, and as Figure 4b shows, no convergence is observed in the final round of play. To look more closely at the individual subjects' choices, Table 3 provides the frequencies of the various levels of g_1 and the number of times the g_1 are accepted by the second players across rounds. Table 3 is read as follows. In round 1, four first players contribute NT$1 and two of the four cases are successfully matched by the second players. It can be seen that contributions by the first players below NT$4 are rare and that most occur in the early rounds of the game. Except for two cases in round 1, none of them are accepted by the second players. Furthermore, although contributions of NT$8 or above guarantee a successful provision at least 90% of the time, the mode of g_1 is NT$5. This suggests that the contribution ratio $g_1/g_2 = 5/15$ or 1/3 seems to be considered 'fair' by players in both roles, although some second players punish the first players whose contributions meet or exceed this ratio.

Reciprocity plays an important role when the second players decide to accept or reject the first players' contributions. The correlation results presented in the last row of Table 3 show that the Pearson correlation coefficients for the correlations of g_1 and the frequencies that g_1 are accepted by player two are all positive and, except in round 1, are all statistically significant at the $p < 0.05$ level. This indicates that the probability of successful provision increases with g_1. Notice that because of the refund, any amounts of g_2 deliver the same punishing effect on the first player as long as the public good eventually fails to be provided. The

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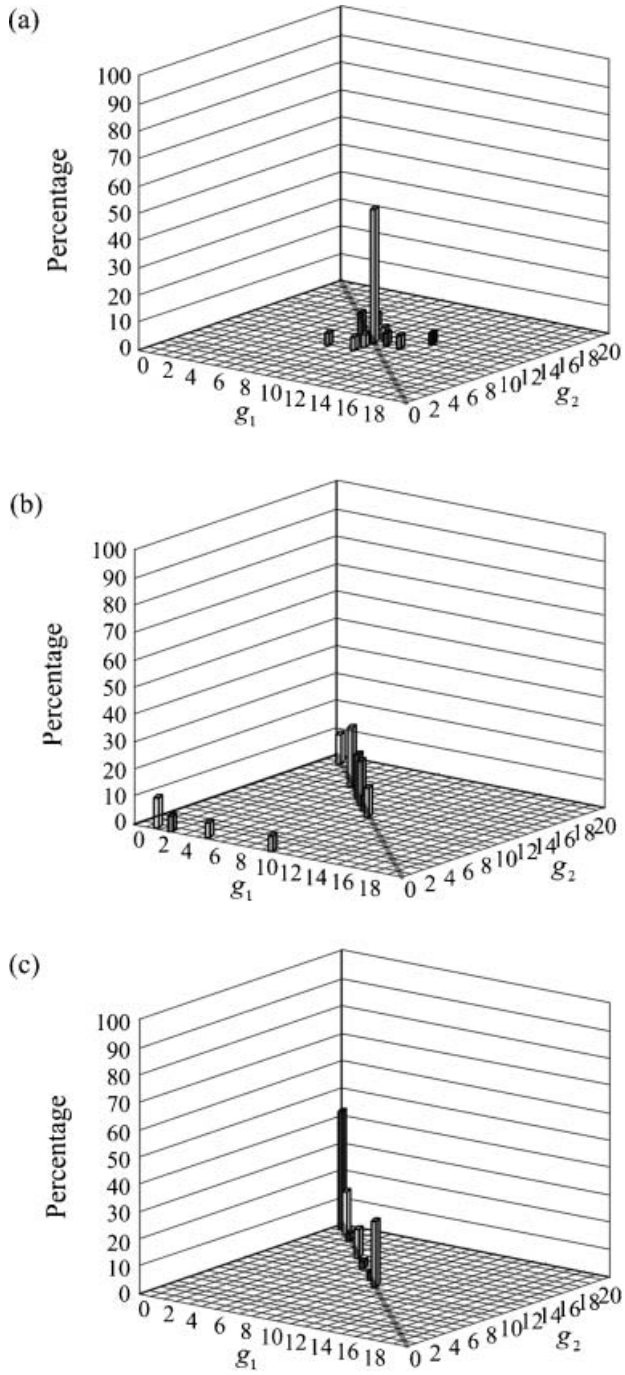

Figure 3. The percentage of outcomes in the first round. (a) Simultaneous game (b) Sequential game (c) Dictator game

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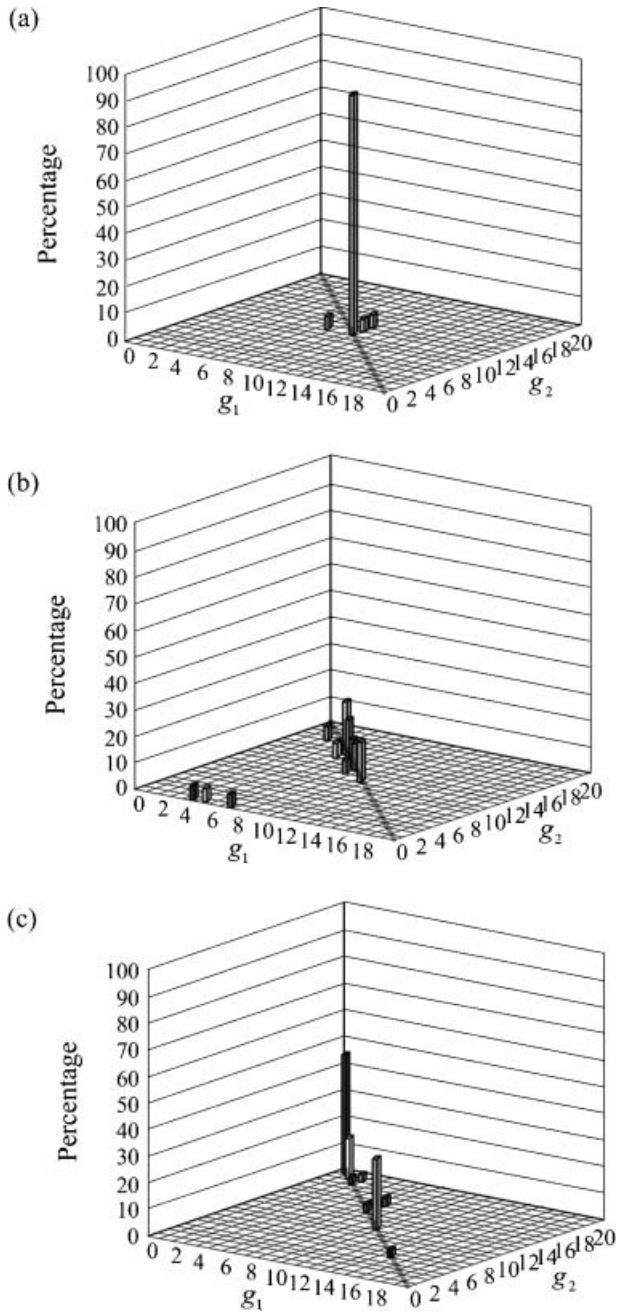

Figure 4. The percentage of outcomes in the final round. (a) Simultaneous game (b) Sequential game (c) Dictator game

punishment cost for the second player is g_1, since g_1 represents his (her) net benefit from the public good if the public good were provided. Therefore, the results from Table 3 also indicate that the second players are less willing to punish the first players when their punishment costs increase.

Table 4 reports the information associated with the effectiveness of the punishments. It shows that from round 1 through round 9, the first players' contributions are rejected by the second players 50 times. Among

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Table 1. The frequencies of subjects' choices in the simultaneous game

Total number of subjects contributing	
Total no. of subjects	40
Give less than NT$10 in more than 5 but less than 10 rounds	1
Give NT$10 in 5 rounds	1
Give NT$10 in more than 5 rounds but less than 10 rounds	23
Give NT$10 in all 10 rounds	13
Give more than NT$10 in more than 5 but less than 10 rounds	2

Table 2. In the simultaneous game, the number of times that a subject gives equal to, more than, or less than NT$10, and subjects' reactions in the following round

Situation	Own contribution	No. of observations	No change	Increase	Decrease
1	= NT$10	283	255	13	15
2	> NT$10	41	8	2	31
3	< NT$10	36	4	30	2

Table 3. The frequencies of various levels of g_1 and the number of times the g_1 are successfully matched by g_2 in the sequential game

g_1	Round 1	Rounds 1–5	Rounds 6–10	Rounds 1–10	Round 10
NT$1	2/4	2/8	0/1	2/9	0/0
NT$2	0/1	0/1	0/1	0/2	0/1
NT$3	0/0	0/6	0/2	0/8	0/0
NT$4	0/0	2/3	3/7	5/10	0/1
NT$5	4/5	18/25	23/34	41/59	4/6
NT$6	0/0	6/8	12/14	18/22	3/3
NT$7	3/3	15/18	14/20	29/38	2/3
NT$8	3/3	14/14	10/11	24/25	2/3
NT$9	1/1	5/6	4/4	9/10	0/0
NT$10	2/3	8/9	4/4	12/13	3/3
NT$11	0/0	2/2	1/1	3/3	0/0
NT$12	0/0	0/0	1/1	1/1	0/0
Total	15/20	72/100	72/100	144/200	14/20
Pearson correlation coefficient	0.703 (0.078)	0.857 (0.001)	0.918 (0.000)	0.892 (0.000)	0.804 (0.029)

Note: None of the first players gives $0 in any round. The p values of the Pearson correlation coefficient are in parentheses.

Table 4. The number of times that the g_1 in the sequential game are accepted or rejected by the second players and the first players' reactions in the following round

Situation	g_1	No. of observations	No change	Increase	Decrease
1	Accepted	130	51	14	65
2	Rejected	50	14	33	3

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Table 5. The frequencies of various amounts of contributions by dictators

Total number of subjects contributing	
Total no. of subjects	38
Give $0 in all 10 rounds	11
Give $0 in more than 5 rounds but less than 10 rounds	6
Give $10 in all 10 rounds	2
Give $10 in more than 5 rounds but less than 10 rounds	2

the 50 rejections, 14 of them do not change their contributions in the following round, 33 increase their contributions, and only 3 reduce their contributions. By again applying the Chi-square test for the null hypothesis that the three reactions (no change, increase, decrease) are equally likely, we can reject the null hypothesis for each situation at the 1% significance level. By considering only the reactions *increase* and *decrease* and applying the binominal test, the null hypothesis that the two reactions are equally likely is also rejected in each situation at the 1% significance level, indicating that the second player's punishment in relation to the first player's decision is effective in the next round.

In contrast to the nearly consistent decisions made by the simultaneous players and the rather diversified choices adopted by the sequential first players, Figures 3c and 4c show that there are two strategies most commonly selected by the dictators at both the beginning and the end of the game: one being equal-sharing and the other complete free-riding. Looking at the data from all 10 rounds, it is observed that except for the first and final rounds in which 9 and 10 dictators, respectively, behave completely fairly, fair contributions are rarely observed. By contrast, it is always the case that about half of the dictators behave completely selfishly in each round. Table 5 reports further that the completely selfish dictators are by and large the same ones: 17 dictators (44.7%) give nothing more than half of the time. By contrast, there are only four dictators (10.5%) who give NT$10 in more than 5 rounds. Six dictators give NT$10 in both the first and final rounds: besides dictators 35 and 39 who contribute NT$10 across all 10 rounds, the other 4 dictators are dictators 11, 25, 28, and 36.

Besides the two main categories above, the two cases exhibiting over-contributions in Figure 4c are also worth noting. One of the two choices is made by dictator 15, who also over-contributes in six other rounds, and the other is made by dictator 27, who made one other such choice in round 9. Besides these cases, dictator 10 over-contributes four times and dictator 17 once, for a total of 14 cases of over-contributions.[8] Of the 14 cases, the dictators require the recipients to give at least NT$15 in 13 cases and even at least NT$19 in 7 cases. Some speculations regarding this kind of behavior are as follows. First, these dictators have preferences for control or distributing, and do not care about the waste. Second, they over-contribute simply to make themselves feel less stingy. Third, they may perceive that the stakes are too low for them to care enough about how much they would earn from the experiment.[9]

DISCUSSION

This section starts by exploring whether fairness alone can explain the resulting contribution behavior. According to Forsythe et al. (1994), if non-trivial offers are due solely to the proposers' concern for fairness, then the distributions of offers will be the same in both the ultimatum and dictator games. Alternatively, if the

[8]Dictator 10 also under-contributes in round 4.

[9]I thank a referee for providing me with the explanation of preferences for control. For studies on the stake effect, one may refer to Smith & Walker (1993a, 1993b).

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distributions differ, then other factors must come into play. It can be seen from Figure 4 that the final-round plays in the simultaneous game are centered at half of the threshold. As we move to the sequential game, a more scattered distribution of choices by the first players is observed, and as we move further to the dictator game, the distribution of choices by dictators becomes bimodal, with two peaks occurring at (NT$0, NT$20) and (NT$10, NT$10). The distributions of choices are distinct across games.

In the simultaneous game the two players are endowed with equal bargaining power, so that playing fairly turns out to be the only choice, and learning or experience will only enhance the fair outcome. However, if players are inherently unequal, then those who are endowed with more bargaining power can choose to play fairly or not to, and can decide to what extent they will be fair. If a player is motivated by fairness, then he should make no difference in contributions between games. By contrast, a player motivated by self-interest may behave fairly because of the strategic concern, but he will behave rather selfishly if he has the priority of moving first or if he becomes a dictator. Since contributions by the first movers decrease from the simultaneous to the sequential to the dictator game, the strategic concern explains the overall contribution behavior better than the motive of fairness. That is, more subjects are motivated by self-interest than by fairness.

Bolton and Ockenfels (2000) noted that in Forsythe et al.'s (1994) ultimatum experiments none of the proposers give $0 or $1, and as many as 71% of the offers are $5 (out of $10). Moreover, although 21% of the proposers give $0 in the dictator game, 21% of the proposers offer $5. Bolton and Ockenfels therefore claimed that since proposers *do* give money in the dictator game, they seem to care about equity. However, it should be the responders' concerns for equity that impel proposers to give in the ultimatum game. In other words, there exists an interaction between equity and strategic considerations.

The experimental evidence in this paper exhibits similar results. In the final round of the sequential game, none of the first players give NT$0 or NT$1 and three first players (15%) share the threshold evenly with the sequential second players. In the final round of the dictator game, 23 dictators (60.5%) give either NT$0 or NT$1, but 10 dictators (26.3%) give NT$10 and even one dictator gives NT$15. Although the fraction of 'fair' first movers is smaller in the sequential game than in the dictator game, the difference is insignificant (binomial tests, $z = -1.28$, $p = 0.199$). However, it should be noted that in the sequential game it is the interaction of fairness and punishment by the second player driving the first player to play fairly, but in the dictator game the dictator acts spontaneously in a rather altruistic manner.

Although the players who behave fairly may not be solely motivated by fairness, those players whose behavior looks unfair are surely not fair players. Since almost all simultaneous players behave fairly in the final round and dictators have no concern over strategies, the proportion of players playing strategically can be best inferred from the sequential game. Looking at the observations from all 10 rounds in Table 3, on average 91.5% of the sequential first players give less than NT$10. If the sequential first players who give only NT$1 or NT$2 are considered to be having pity on the sequential second players and therefore are regarded as purely selfish or game-theoretic players, then the remaining 86.5% of the sequential first players can be categorized as strategically oriented. If looking at the final round only, then this proportion drops slightly to 80%. Hence, we may conclude that at least 80% of the sequential first players play strategically.

As for the proportion of players who are entirely fairness-minded, this can be best deduced from the dictator game. As Table 5 shows, four dictators (10.5%) share the threshold evenly with their opponents more than half of the time, including the two dictators who always play fairly throughout the whole game. Hence, we may conclude that about 10% of the dictators are purely or close to purely fairness-minded.

Finally, as noted by Nelson (2002, p. 425), fairness-based models will become overwhelmingly complicated when extended to games with more than two players. Some of the results of this paper, especially those from the sequential game, are also confined to the two-player case and may not be generalized to games beyond two players. It may be conceivable to infer that the three (or more) players in the simultaneous experiment will eventually find equal sharing not only their focal point but also consistent with their equal bargaining powers. It is also plausible to predict that a dictator motivated by fairness will share the burden

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with the other two players and a selfish dictator will retain most of his income. However, it is hard to predict how the dictator divides the burden between two or more recipients, since the dictator may not treat the recipients in the same way, although they are endowed with the same (i.e., zero) bargaining power. The most complicated game is the sequential game, since in this game each player needs to contemplate how other players will respond or how they will react to other players' actions or both. Hence, it is hard to predict anything without a specific experimental examination.

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