Mate Choice Mechanism for Solving a Quasi-Dilemma

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Abstract

Saijo, Okano, and Yamakawa (2014) showed that the mate choice mechanism for a symmetric prisoner’s dilemma (PD) game implements cooperation in backward elimination of weakly dominated strategies (BEWDS), and it attained almost full cooperation in their experiment. First, this study shows that the mechanism works well in the class of quasi-dilemma (QD) games such as asymmetric PD games and coordination games. Second, the class of BEWDS-implementable games is exactly the same as the class of QD games. Third, the mechanism cannot implement cooperation in a subgame perfect equilibrium. Finally, we confirm that the mate choice mechanism works well experimentally for an asymmetric PD game.

1. Introduction

This study is part of our endeavor to find one of the simplest possible mechanisms to solve social dilemmas, including the prisoner’s dilemma (PD), public good provision, and coordination, both experimentally and theoretically.1 Experimentally, we aim to design mechanisms that can attain a Pareto efficient outcome in a few rounds,2 because we cannot repeat the same mechanism many times in real-life settings. Theoretically, we seek natural behaviors among subjects in experiments rather than stick to Nash or Nash-type equilibrium.

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1 See, for example, Huang, Masuda, and Saijo (2014), Masuda, Okano, and Saijo (2014), and Saijo, Okano, and Yamakawa (2014). Masuda et al. (2014) constructed a mechanism that implements a Pareto efficient allocation in a public good economy when the number of players is two and their preferences are linear, and then, they conducted experiments in which the rate of contribution is 94.9%. The mechanism, called the minimum approval mechanism, is a version of the mate choice mechanism. Huang et al. (2014) constructed a mechanism that implements cooperation when the number of players is at least two. They conducted experiments in which the rate of cooperation is more than 90% after period 4 with three players. The mechanism is called the simplified approval mechanism, and it is also based upon the mate choice mechanism.

2 Chen (2005), for example, found that the stability property of mechanisms depends on their supermodularity. Supermodular mechanisms may require many periods to converge to a desired outcome. The goal of the endeavor is not to find such mechanisms but to find mechanisms that can attain a desired outcome in a few periods.
concepts. In addition, we do not use punishment or reward to balance the budget in the mechanism design.

The study by Saijo, Okano, and Yamakawa (2014) is one of the first attempts to design such a mechanism for the PD. They proposed the mate choice mechanism after a symmetric PD game. After observing the choice of cooperation (C) or defection (D) in the PD game, each player approves or disapproves the other’s choice: if both approve it, the outcome is what they chose in the PD game, and if at least one player disapproves the other choice, the outcome is that when both defect, which is called the mate choice (MC) mechanism. Because the MC mechanism does not have devices such as punishment or reward, it is budget balanced.

Experimentally, they observed that the cooperation rate, that is, the ratio of subjects who chose cooperation, with the mechanism was 95.0% in round 1 and 96.9% through 19 rounds, when each subject was never matched with the same subject again in all rounds. The (C,C) share, that is, the ratio of pairs in which both chose C, was 90.0% in round 1 and 94.0% through 19 rounds. They also found that subjects’ behavior was consistent with backward elimination of weakly dominated strategies (BEWDS) rather than Nash equilibrium (NE) or subgame perfect equilibrium (SPE) behavior. BEWDS is a procedure to eliminate weakly dominated strategies in each subgame backwardly. We also call the strategies that survive through the procedure BEWDS strategies. Theoretically, the MC mechanism implements cooperation in BEWDS for symmetric PD games.

Our paper expands the domain of this mechanism from symmetric PD games to asymmetric games that are not necessarily PD games. We find that the MC mechanism implements cooperation in BEWDS for the class of quasi-dilemma (QD) games, which contains coordination games, including the stag hunt game and PD games. Furthermore, under several mild conditions, we show that the class of games implementing cooperation in BEWDS is exactly the same as the class of QD games. On the other hand, the MC mechanism cannot implement cooperation in SPE.

In order to test the performance of the MC mechanism in an asymmetric environment,

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3 According to Guala (2013), strong reciprocity, in which a player punishes other players using the player’s own resource, is rare in human history.
4 This is called complete stranger matching, and only a few experiments employ this matching. Saijo et al. (2014) chose this matching since it is the least favorable design for cooperation with respect to matching.
5 The MC mechanism uses unanimity. Banks, Plott, and Porter (1988) introduced a voting stage after a public good provision stage and observed that unanimity reduced efficiency. Researchers stopped pursuing this avenue after Banks et al. (1988) presented their findings. Furthermore, Masuda et al. (2014) found that the MC mechanism cannot implement a Pareto-efficient allocation in BEWDS for an economy with a public good.
we choose an asymmetric PD game in which cooperation cannot be attained by the compensation mechanism in SPE that is proposed by Charness, Fréchette, and Qin (2007). The compensation mechanism asks players to transfer money to the other player in the first stage, and then, they both play a PD game. The monetary transfer must be done when the other player chooses cooperation in the PD stage. The compensation mechanism does not cover all PD games although the mate choice mechanism covers all PD games, and moreover, it covers non-PD games. That is, there is a class of PD games in which the compensation mechanism cannot implement cooperation in SPE.

Experimentally, we observed that the cooperation rate with the mechanism is 76.7% in round 1, 86.7% in round 2, 93.3% in round 3, and 96.7% through 19 rounds. The (C,C) share is 56.7% in round 1, 73.3% in round 2, 86.7% in round 3, and 93.5% through 19 rounds. That is, the MC mechanism works reasonably well although it took a few rounds to achieve high (C,C) shares in an asymmetric PD game with the MC mechanism.

Section 2 describes the MC mechanism applied to QD games. Section 3 proves that BEWDS implementable games are QD games and shows that the MC mechanism cannot implement cooperation in SPE. Section 4 presents the experimental design, and section 5, the results. Section 6 provides suggestions for further research.

2. The mate choice mechanism and quasi-dilemma games

Consider a 2 x 2 game that has two strategies: cooperation (C) and defection (D).

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   C        D
C | (a,v) = V | (b,w) = W |
D | (c,x) = X | (d,z) = Z |
```

Figure 1. A QD game.

Define function \( p \) as follows: \( p(C,C) = (a,v) = V, p(D,C) = (c,x) = X, p(C,D) = (b,w) = W, \) and \( p(D,D) = (d,z) = Z. \) If \( p \) satisfies \( V > Z (a > d \) and \( v > z), X \n Z (d > c \) or \( z > x), \) and \( W \n Z (d > b \) or \( z > w), \) then \( p \) is a QD game, and if \( p \) satisfies \( V > Z, (c,d) > (a,b) \) and \( (w,z) > (v,x), \) then \( p \) is a PD game.\(^6\) Coordination games, including the stag hunt game, are QD games.

\(^6\) “\( > \)” shows that each element of the left-hand-side vector is “strictly greater than” each element of the right-hand-side vector, and “\( \n \)” shows that each element of the left-hand-side vector is “greater than or equal to” each element of the right-hand-side vector.
**Property 1.** A prisoner’s dilemma game is a quasi-dilemma game.

*Proof.* Let $p$ be a PD game. Suppose that $(a,v) > (d,z)$, $(c,d) > (a,b)$, and $(w,z) > (v,x)$. Given $V = (a,v)$ and $Z = (d,z)$, let $X = (c,x)$ and $W = (b,w)$ satisfy the conditions. Then, $c > a$, $z > x$, $d > b$, and $w > v$. This implies that $z > x$ and $d > b$, showing that $(d > c$ or $z > x$) and $(d > b$ or $z > w$). That is, $X \not\preceq Z$ and $W \not\preceq Z$. □

Figure 2. Possible locations of $X$ and $W$ in QD and PD games.

Figure 2 shows the possible locations of $X$ and $W$ in QD and PD games. The region for QD games is the dark $L$-shaped area (i.e., R1, R2, R3, R4, and R5), and the regions for PD games are R1 for $W$ and R5 for $X$. Line $\ell - \ell'$ shows that the sum of benefits of both players is equal to $a + v$. If $V$ must be Pareto efficient, $X$ and $W$ must be located under $\ell - \ell'$. We do not impose this condition hereafter.

Let us define the MC mechanism. Players first choose either $C$ or $D$ in Figure 1. After this stage, each subject can approve ($y$) or disapprove ($n$), the other player’s choice in the second stage. If both approve the other player’s choice, the outcome is what they choose, and if either one disapproves the other player’s choice, the outcome is that both defect. Let $M_i, m_i,$ and $u_i$ be player $i$'s choice between $C$ and $D$, $i$'s choice between $y$ and $n$, and $i$'s payoff, respectively. Then, the MC mechanism is defined by the following rule: if $m_1 = m_2 = y$, then $(u_1, u_2) = p(M_1, M_2)$; otherwise, $(u_1, u_2) = p(D, D)$. In general, we call the two-stage game without rule specification an approval mechanism.
Saijo et al. (2014) prepared five possible behavioral principles in their experiments for the MC mechanism: the NE, the SPE, evolutionarily stable strategies (ESS), neutrally stable strategies (NSS), and BEWDS. Of the five behavioral principles, the data of their experiments are most compatible with BEWDS.

Since we focus upon SPE and BEWDS, let us define them. As we show later, since there is no need to consider mixed strategies in our framework, a profile of strategies indicates an assignment of a pure strategy for each information set. A profile of strategies is a SPE if the restriction of the profile at each subgame is a Nash equilibrium. Let us fix a subgame, and we say that a strategy at an information set in the game survives the elimination of weakly dominated strategies if the strategy is not weakly dominated by any other strategies in the set.\(^7\) A profile of strategies is a BEWDS if the restriction of the profile at each subgame survives the elimination of weakly dominated strategies. A mechanism implements cooperation in SPE (or BEWDS) if all players choose cooperation in the first stage under SPE (or BEWDS). Next, we show that the MC mechanism with a QD game implements cooperation under BEWDS.

**Property 2.** The mate choice mechanism with a QD game implements the cooperative outcome under BEWDS.

*Proof and Interpretation.* The MC mechanism with a QD game has four subgames in Figure 3. Because of the definition of the MC mechanism, we have \((u_1, u_2) = (d, z)\) at \((y,n)\), \((n,y)\), and \((n,n)\) for each subgame. This was termed the MC flat by Saijo et al. (2014), because the three cells other than \((y,y)\) have the same payoff vector.

Consider subgame CC where both choose C. Player 1 must compare \((a,d)\) and \((d,d)\). Because \(a > d\), player 1 chooses \(y\) based upon the elimination of weakly dominated strategies. However, player 1 does not necessarily compare two vectors because of the MC flat. Player 1 should compare \(a\) and \(d\) to understand this domination.

Although player 1 can choose either \(y\) or \(n\) based only on the elimination of weakly dominated strategies, player 1 must also consider player 2’s choice. Player 1 compares \(v\) and \(z\), and hence, player 1 understands that player 2 chooses \(y\). Thus, player 1 understands that the choice at \((C,C)\) is \((y,y)\), which is shown by the bold square in Figure 3 for subgame CC.

Therefore, player 1 can fill the \((C,C)\) part of the reduced normal form game with \((a,v)\), which is

\(^7\) Let \(X\) and \(Y\) be strategies of a player, and let \((a,b)\) and \((c,d)\) be payoff vectors when the player chooses \(X\) and \(Y\), respectively. \(X\) weakly dominates \(Y\) if and only if \(a \geq c\), \(b \geq d\), and there is at least one strict inequality. Notice that no strategies could survive if we use strong domination with strict inequality of each element.
located above the four subgames in Figure 3.

Consider subgame $DC$. Because $X \geq Z$, $d > c$ or $z > x$. Suppose that $z > x$. Then, player 2 chooses $n$ and understands that the outcome is $(d, z)$ regardless of the choice of player 1 in this subgame. However, as a thought experiment, player 1 must consider player 2’s choice if it were $c > d$. That is, although player 1 would choose $y$, player 1 could not identify which of $(c, x)$ and $(d, z)$ would be realized without knowing player 2’s choice. Suppose $d > c$. Player 1 chooses $n$ and understands that the outcome is $(d, z)$ without considering player 2’s choice.

Repeating the same procedure at each of the subgames $CD$ and $DD$, player 1 can construct the reduced normal form game above the four subgames in Figure 3. Because the game also has the $MC$ flat and $a > d$, player 1 chooses $C$.

If player 1 understands that player 2’s position is the same as that of player 1 using the same procedure, player 1 is convinced that player 2 also chooses $(C, y)$. If so, the equilibrium path under BEWDS is $((C, C), (y, y))$. Thus, we simply write $(C, C, y, y)$ hereafter.

![Figure 3. Construction of the reduced normal form game.](image)

Although this proof is mathematically almost the same as that of Saijo et al. (2014), there are several differences between the two because of possible asymmetry. First, because they used the symmetric payoff table, $d = z$, all components of the three cells have the same number. In this sense, these three cells have the completely flat property. Therefore, the change from $d = z$ to $d \neq z$ might increase the player’s burden to understand the game. Second, $(a, d)$ is different from $(v, z)$, although $(a, d) = (v, z)$ in Saijo et al. (2014). This change also increases the players’ burden. The same argument can be applied to all subgames. Third, players who understand the strategic implication of vectors $V$, $W$, $X$, and $Z$ in the symmetric case might not
be able to understand it in the asymmetric case under BEWDS. Finally, even though players may understand these points, the difference between $a$ and $v$ may evoke an “equity” module in their brains, which could trigger “non-rational” motivation.

An important property of the MC mechanism is that it is onto: the set of possible outcomes of a QD game is equal to those of the MC mechanism. The former is $\{V,W,X,Z\}$, and the latter must be the same. For example, although player 1 does not want to choose $y$ at $(C,D)$, $W$ is the outcome if both choose $y$. This condition excludes any payoff flow from or to the game. In other words, no outside penalty or reward is given in order to maintain a balanced budget.8

3. Backward elimination of weakly dominated strategies implementable games are quasi-dilemma games

We consider the tightness of the parameter space of QD games and the implementable parameter space of BEWDS. If the latter is larger, the idea of BEWDS implementation can be applied to many other 2 x 2 games. However, we show that these two spaces are identical under several assumptions.9

First, the approval mechanism satisfies forthrightness: If both choose $y$ in the second stage after the choice of a strategy pair in the first stage, the outcome must be that strategy pair.10 That is, the outcome must be what they choose whenever both choose $y$. Second, the approval mechanism has a flat: the outcome of the second stage, except for $(y,y)$, and that of the reduced game, except for $(C,C)$, are the same. Thus, we have the following property.

**Property 3.** Suppose that $V > Z$ and that an approval mechanism satisfies forthrightness with the flat, $Z$. Then, the class of games implementing cooperation in BEWDS is exactly the same as that of QD games.

**Proof:** Consider any approval mechanism implementing outcome $V$ in BEWDS. Because forthrightness is satisfied, if both choose $y$, the outcomes of subgames CC, CD, DC, and DD must be $V, W, X, \text{ and } Z$, respectively. Because $Z$ is the flat and the mechanism implements

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8 The money-back-guarantee mechanism introduced by Dawes, Orbell, Simmons, and van de Kragt (1986) and Isaac, Schmidt, and Walker (1989) is not onto. Let $C$ be a fixed amount of contribution for public good provision, and let $D$ be no contribution. The money-back-guarantee mechanism returns the contribution to a player if both do not contribute, and hence, $X$ and $W$ cannot be the outcomes of the mechanism. If player 1 is a utilitarian, and hence prefers $X$ to $Z$, the MC mechanism can choose $X$ unlike the money-back-guarantee mechanism.

9 These assumptions are essentially the same as those introduced by Saijo et al. (2014).

10 Saijo, Tatamitani, and Yamato (1996) introduced forthrightness in the natural mechanism design.
cooperation, the outcome should be $Z$ in subgames $CD$ and $DC$. That is, $(d > b$ or $z > w)$ and $(d > c$ or $z > x)$ for subgames $CD$ and $DC$, respectively. Because $(d > b$ or $z > w) = (d \leq b$ and $z \leq w) = (W \geq Z)$, $(d > b$ or $z > w)$ is equivalent to $W \not\geq Z$. Similarly, we obtain $X \not\geq Z$. That is, the class of games implementing cooperation in BEWDS is exactly the same as the class of QD games.

Let us now consider the SPEs of QD games. Since the Nash equilibrium outcomes are $(a,v)$ and $(d,z)$ at subgame CC and $(d,z)$ at subgames DC, CD, and DD, two cases exist in the reduced normal form games shown in Figure 4. That is, because all combinations, $(C,C)$, $(D,C)$, $(C,D)$, and $(D,D)$, are Nash equilibria of the games, they are also the outcomes of SPEs. Therefore, the MC mechanism cannot implement cooperation in SPE.

<table>
<thead>
<tr>
<th>Player 1</th>
<th>Player 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C$</td>
<td>$a,v$</td>
</tr>
<tr>
<td>$D$</td>
<td>$d,z$</td>
</tr>
</tbody>
</table>

(i) $(y,y)$ in subgame CC

<table>
<thead>
<tr>
<th>Player 1</th>
<th>Player 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C$</td>
<td>$d,z$</td>
</tr>
<tr>
<td>$D$</td>
<td>$d,z$</td>
</tr>
</tbody>
</table>

(ii) $(n,n)$ in subgame CC

Bold italic cells indicate Nash Equilibria in the reduced normal form games.

Figure 4. Two reduced normal form games.

As the above discussion shows, multiple Nash equilibria in a subgame generate multiple SPEs due to the MC flat. Furthermore, players in SPE must consider how the other player behaves in each subgame. In this sense, SPE might place a heavy information burden on players. On the other hand, players in BEWDS do not need information about how the other player behaves since they care about the comparison of their own strategies in each subgame as far as the BEWDS strategy is unique. However, this fact does not necessarily support BEWDS in general since the facts are specific to the MC mechanism. The next two sections describe the experiment and its results.

4. Experimental design

Our experimental focus is payoff asymmetry of the PD game. We conducted experiments of an asymmetric PD game with the MC mechanism (AsymPDMC). For comparison with the data of the AsymPDMC, we borrowed the data regarding a symmetric PD game with the MC mechanism (SymPDMC) and a symmetric PD game without the MC...
mechanism (SymPD) from Saijo et al. (2014).

We chose an asymmetric payoff table in which cooperation cannot be implemented by the compensation mechanism in SPE, but it can be implemented by the MC mechanism in BEWDS. The compensation mechanism also has two stages. It asks players to transfer money to the other player in the first stage, and then, both play a PD game. The monetary transfer must be done when the other player chooses cooperation in the PD stage. Varian (1994) designed the compensation mechanism in a general setting, and then, Andreoni and Varian (1999) and Charness et al. (2007) conducted the experiments using the PD games. As Charness et al. (2007) showed, the compensation mechanism does not cover the entire class of PD games. In this sense, we chose one of the least favorable matrices to achieve cooperation in our experimental design. Figure 5 shows the symmetric and asymmetric payoff matrices. The symmetric payoff table comes from Saijo et al. (2014) and the asymmetric payoff matrix comes from Charness et al. (2007). The average cooperation rates in Charness et al. (2007) are 43-68% with the compensation mechanism.

<table>
<thead>
<tr>
<th>Player 1</th>
<th>Player 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C</td>
</tr>
<tr>
<td>C</td>
<td>14,14</td>
</tr>
<tr>
<td>D</td>
<td>17,7</td>
</tr>
</tbody>
</table>

(i) Symmetric payoff matrix

<table>
<thead>
<tr>
<th>Player 1</th>
<th>Player 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C</td>
</tr>
<tr>
<td>C</td>
<td>44,36</td>
</tr>
<tr>
<td>D</td>
<td>52,0</td>
</tr>
</tbody>
</table>

(ii) Asymmetric payoff matrix

Figure 5. Symmetric and asymmetric payoff matrices.

All the above-mentioned experiments were carried out in Osaka University during the period from November 2009 to December 2011. The AsymPDMC and SymPDMC experiments each had three sessions, and the SymPD experiment had one session. Twenty subjects participated in each session and no subject attended more than one session. We recruited these 140 undergraduate subjects with different majors through campus-wide advertisements. They were told that there would be an opportunity to earn money in a research experiment.

At the beginning of the experiment, each subject had a set of printed instructions and a record sheet. Instructions were read aloud by an experimenter. After that, subjects were

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11 In the experiment, we used payoff numbers that are 100 times the numbers in Figure 5 due to the exchange rate.
given five minutes to ask private questions. Communication among subjects was prohibited, and we declared that the experiment would be stopped if it was observed. This never happened. There was no practice period. We used the z-Tree software (Fischbacher, 2007) for the experiment.

The experimental procedure was as follows. We formulated 10 pairs out of the 20 subjects seated at computer terminals in each session. These pairings were anonymous and determined in advance in order not to pair the same two subjects more than once. Since most previous studies, such as Andreoni and Varian (1999) and Charness et al. (2007), have employed random matching among four to eight subjects (two to four groups), such repetition necessarily entails pairings of the same two subjects. Therefore, compared with previous experiments, this “complete” strangers design might reduce the possibility of cooperation among subjects. Each subject received an instruction sheet and a record sheet.

Let us explain the PDMC experiment. When the period started, each subject selected either A (defection) or B (cooperation) in the choice (or PD) stage and then inputted the choice into a computer and also noted it on the record sheet. After that, each subject explained the reason behind this choice in a small box on the record sheet. The next step was the decision (or approval) stage. Based on the knowledge of the other subject’s choice, each subject chose to either “accept” or “reject” it and then inputted the decision into a computer, noted it on the record sheet, and explained his or her reasoning as before. Once subjects had finished the task, each could see “your decision,” “the other’s decision,” “your choice,” “the other’s choice,” “your points,” and “the other’s points” on the computer screen. However, neither the choices nor the decisions in pairs other than “your” own were shown on the computer screen. This ended one period. The experiment without the approval stage became the PD experiment. After finishing all 19 periods, every subject filled in questionnaire sheets.

Each session lasted approximately 90 minutes including the time spent on answering the post-experiment questionnaires and payment. Subjects earned, on average, 5233 JPY (about 43.61 USD, using 1 USD=120JPY), 4873 JPY (about 40.61 USD), and 3920 JPY (about 32.67USD) in AsymPDMC, SymPDMC, and SymPD sessions, respectively.

5. Experimental results

Figure 6 shows the time path of cooperation rates over the 19 periods. The

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12 Charness et al. (2007) divided 16 subjects in one session into four separate groups, with four subjects in each group interacting only with each other over the course of the session.

13 An exception is Cooper, DeJong, Forsythe, and Ross (1996), who employed complete stranger matching.
cooperation rate in each period is defined as the ratio of number of subjects choosing C to the total number of subjects. As shown, the cooperation rate of PD started at 15% in the first three periods, and then ranged between 5% and 10% in the next 16 periods. In contrast, the cooperation rate of SymPDMC was always above 90% in each period, while that of AsymPDMC started at about 76.7% in the first period, rose to 86.7% in the second period, and then stayed above 90% in the remaining 17 periods.

The large gap in cooperation rates between PD and PDMC (either symmetric or asymmetric) was statistically supported by the proportion test. All the p values for comparing the cooperation rate of AsymPDMC or SymPDMC with that of PD are smaller than 0.001 in each period, which suggests that introducing the second stage after the PD game dramatically increases the cooperation rate in both symmetric and asymmetric PD games.

For the comparison of AsymPDMC with SymPDMC, we ran the proportion test by using both the data of each period and the data pooled over all periods. The two-tailed p values are reported in Table 1 (see the fourth column from the left). Generally, there is no significant difference in the cooperation rates between an asymmetric PD and a symmetric PD games when the data were pooled over all periods (p = 0.7212). In the first two periods, the cooperation rate is significantly lower under the asymmetric environment. Thereafter, the cooperation rate in the asymmetric mate choice mechanism no longer remains statistically significantly lower than its symmetric counterpart. In fact, a significantly higher cooperation rate in AsymPDMC is even observed in 3 periods (i.e., periods 7, 14, and 15) out of the remaining 17 periods.

With regard to the share of the (C,C) combination, Figure 7 shows its time path over the 19 periods. Applying the proportion test, we found that the (C,C) share is significantly higher in either AsymPDMC or SymPDMC than in PD in each period (all p values < 0.001). Additionally, as indicated in the last column of Table 1, there is no significant difference in the share of the (C,C) combination between AsymPDMC and SymPDMC (p = 0.6031) when the data were pooled over all periods. However, if we look at the p values by period, we find that the (C,C) share is significantly lower in the asymmetric environment than in the symmetric environment in the first four periods. Thereafter, similar to the case of the cooperation rate, the share of AsymPDMC is once again always statistically higher than or equal to its symmetric counterpart.
Figure 6. Cooperation rates by periods.

Figure 7. Share of (C,C) by periods.
Table 1. Proportion test results for AsymPDMC vs. SymPDMC.

<table>
<thead>
<tr>
<th>Period</th>
<th>Cooperation rate</th>
<th>Share of (C,C)</th>
<th>p value</th>
<th>Cooperation rate</th>
<th>Share of (C,C)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AsymPDMC</td>
<td>SymPDMC</td>
<td></td>
<td>AsymPDMC</td>
<td>SymPDMC</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>76.7%</td>
<td>95.0%</td>
<td>0.0040</td>
<td>56.7%</td>
<td>90.0%</td>
<td>0.0000</td>
</tr>
<tr>
<td>2</td>
<td>86.7%</td>
<td>96.7%</td>
<td>0.0475</td>
<td>73.3%</td>
<td>93.3%</td>
<td>0.0033</td>
</tr>
<tr>
<td>3</td>
<td>93.3%</td>
<td>98.3%</td>
<td>0.1705</td>
<td>86.7%</td>
<td>96.7%</td>
<td>0.0475</td>
</tr>
<tr>
<td>4</td>
<td>93.3%</td>
<td>98.3%</td>
<td>0.1705</td>
<td>86.7%</td>
<td>96.7%</td>
<td>0.0475</td>
</tr>
<tr>
<td>5</td>
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<td>1.0000</td>
</tr>
<tr>
<td>6</td>
<td>98.3%</td>
<td>95.0%</td>
<td>0.3091</td>
<td>96.7%</td>
<td>90.0%</td>
<td>0.1432</td>
</tr>
<tr>
<td>7</td>
<td>100.0%</td>
<td>95.0%</td>
<td>0.0794</td>
<td>100.0%</td>
<td>90.0%</td>
<td>0.0120</td>
</tr>
<tr>
<td>8</td>
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<td>98.3%</td>
<td>1.0000</td>
<td>96.7%</td>
<td>96.7%</td>
<td>1.0000</td>
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Notes: The reported p values are based on the two-tailed proportion test.

6. Concluding remarks

We showed that the MC mechanism implements cooperation in BEWDS for QD games and that BEWDS-implementable games are QD games. QD games include not only PD games but also coordination games. Furthermore, the mechanism cannot implement cooperation in SPE.

The MC mechanism is essentially a unanimous voting rule between two players, and it can be interpreted as a “minimum” communication device to achieve cooperation. In the first stage, each player reveals the choice of C or D. Then knowing the other’s choice, each chooses y
or $n$. If both choose $y$, the outcome is what they choose in the first stage; otherwise, the outcome is $(D,D)$. This mechanism implicitly presupposes that the status quo is $(D,D)$ and disagreement results in the status quo. This procedure can be a natural way to avoid conflict, such as PD, or a coordination situation in daily life. Using functional near-infrared spectroscopy (fNIRS), Nagatsuka, Shinagawa, Okano, Kitamura, and Saijo (2013) found that compared with the PD game, subjects made their choices with less stress using only the MC mechanism. We also found that except for first few periods, the MC mechanism works well under an asymmetric environment.

Masuda, Okano, and Saijo (2014) expanded the idea of the MC mechanism to public good provision and showed that the minimum approval mechanism implements an efficient allocation in BEWDS theoretically and experimentally. Furthermore, Huang, Masuda, Okano, and Saijo (2014) designed a simplified approval mechanism in the spirit of the MC mechanism in a social dilemma and showed theoretically and experimentally that it implements cooperation in BEWDS when there are at least two players. However, designing a reasonable approval mechanism to implement cooperation in multiple choices and players is an open question.

References


