Supplementary Materials for webpage

APPENDIX A

INSTRUCTIONS

Thank you for participating in our experiment. You will receive $5 for showing up on time, plus you will receive your earnings from the choices made in the session.

There will be 25 periods. In each period, each person will be matched with one other person. The person with whom you are matched will be randomly re-drawn after every period. You are paired anonymously, which means that you will never learn the identity of the other person in any of the periods.

One person will have the role of ROW and the other person will have the role of COLUMN. Your role will also be randomly re-drawn in each period, so that sometimes you will have the role ROW and sometimes you will have the role of COLUMN.

Here is the basic game:

		COLUMN	
		Left	Right
ROW	Up	40, 52	8, 60
	Down	52, 8	28, 24

The ROW and COLUMN players make choices simultaneously. The ROW player chooses Up or Down; the COLUMN player chooses Left or Right.

The **1st number in each cell** refers to the **payoff** (in cents) **for the** ROW **player**, while the **2nd number in each cell** refers to the **payoff** (in cents) **for** the COLUMN **player**. Thus, for example, if ROW chooses Up and COLUMN chooses Left, the ROW player would receive 40 and the COLUMN player would receive 52.

However, before these game choices are made, ROW may choose a binding amount to be paid (*transferred*) by him or her to COLUMN if and only if COLUMN chooses Left. COLUMN (at the same time) may offer a binding amount to be transferred to ROW if and only if ROW chooses Up. These amounts must be non-negative integers.

The amounts that you each choose will be communicated to each of you **prior** to your choices in the game above. You will then make your game choice (Up or Down if you are ROW, or Left or Right if you are COLUMN). You will then learn your payoff for the period, from which you can infer the game choice made by the person with whom you are paired.

This completes one period of play. We'll do 25 periods and pay people individually and privately.

FURTHER EXPLANATION

Offers to pay money contingent on the other person choosing Up (or Left, if the other person is a COLUMN player) have the effect of changing the payoff matrix. Note that whatever amount you state will be transferred to the other person if he or she plays Up as a ROW player or Left as a COLUMN player; **this money will be transferred regardless of your game choice.**

Suppose, for example, that ROW offers to pay \$$x$ to COLUMN if COLUMN plays Left and COLUMN offers (independently and simultaneously) to pay \$$y$ to ROW if ROW plays Up. Then the payoff matrix becomes:

		COLUMN Left	COLUMN Right
ROW	Up	$40 + y - x$, $52 + x - y$	$8 + y$, $60 - y$
	Down	$52 - x$, $8 + x$	28, 24

We explain the 4 possible outcomes below. Remember, the values of x and y are always determined by the ROW and COLUMN players, respectively, before making game choices.

1) If ROW chooses Up and COLUMN chooses Left, then ROW must pay x units to COLUMN and COLUMN must pay y units to ROW. Thus, ROW would receive $40 + y - x$ and COLUMN would receive $52 + x - y$.

2) If ROW chooses Up and COLUMN chooses Right, then COLUMN must pay y units to ROW, but ROW pays nothing to COLUMN (because COLUMN did not choose Left). Thus, ROW would receive $8 + y$ and COLUMN would receive $60 - y$.

3) If ROW chooses Down and COLUMN chooses Left, then ROW must pay x units to ROW, but COLUMN pays nothing to ROW (because ROW did not choose Up). Thus, ROW would receive $52 - x$ and COLUMN would receive $8 + x$.

4) If ROW chooses Down and COLUMN chooses Right, then neither player pays the other anything. Thus, ROW would receive 28 and COLUMN would receive 24.

We don't wish to illustrate this with an example with realistic numbers, as this could bias your behavior. However, we can use an example where $x = 999$ and $y = 1000$. (We don't expect anyone to choose these values for x and y.) In this case, the payoff matrix becomes:

		COLUMN Left	COLUMN Right
ROW	Up	41, 51	1008, -940
	Down	-947, 1007	28, 24

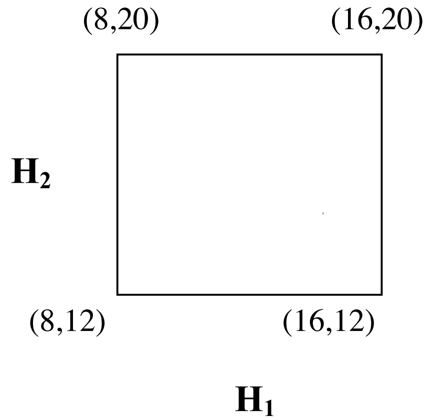
We encourage people to work out scenarios on paper, drawing a game matrix for each possibility.

Are there any questions? Please feel free to ask, by raising your hand.

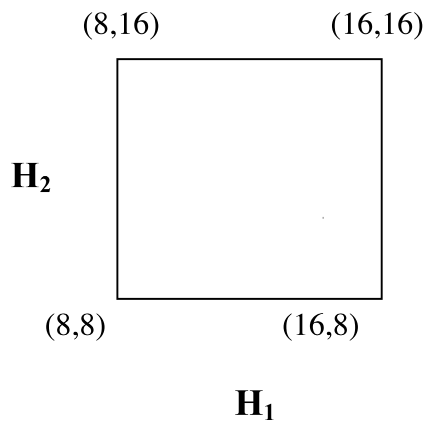
APPENDIX B

Transfer-pair regions consistent with (C,C) being a subgame-perfect action pair

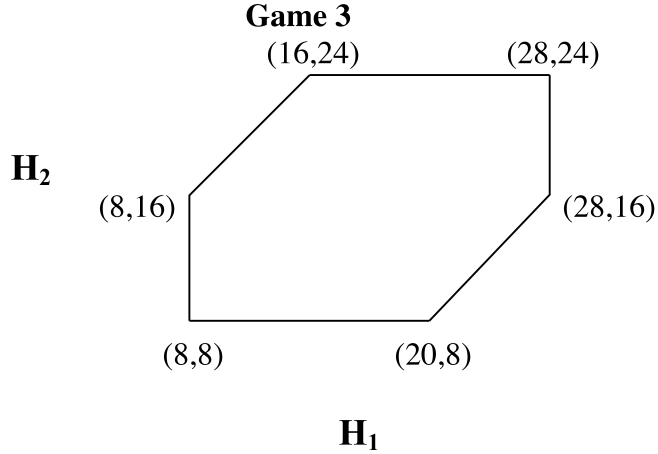
Game 1



Game 2



Game 3



APPENDIX C

Determinants of cooperation
Random-effects probit estimates in NE region

	Game 1: Row	Game 1: Column	Game 2: Row	Game 2: Column	Game 3: Row	Game 3: Column
Would Pay	-0.03	-0.013	0.056	-0.011	-0.013	0.029
	(0.019)	(0.049)	(0.056)	(0.036)	(0.029)	(0.026)
Would Receive	0.102*	0.151***	0.113**	0.012	0.172***	0.076***
	(0.054)	(0.055)	(0.050)	(0.051)	(0.033)	(0.022)
NE Border	-0.562	-1.359***	-0.990***	-1.087***	-0.067	-0.45
	(0.371)	(0.386)	(0.344)	(0.326)	(0.280)	(0.288)
Equal Transfers	0.935*	0.054	0.432	-0.435	0.711**	0.522*
	(0.535)	(0.556)	(0.362)	(0.486)	(0.315)	(0.301)
Final Payments are Closer	-0.262	-0.368	1.129***	-1.060**	0.425*	0.725***
	(0.353)	(0.372)	(0.393)	(0.438)	(0.249)	(0.247)
Constant	-0.185	-0.349	-1.702*	2.055**	-2.085***	-1.671***
	(0.939)	(1.304)	(0.946)	(0.986)	(0.636)	(0.578)
Observations	228	228	298	298	294	294
Number of Subjects	31	32	31	32	32	32

Standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%

APPENDIX D

Determinants of mutual cooperation
Random-effects probit with one way subject error terms
and marginal-effects estimates in SPE region

	Game 1	Game 2	Game 3	All Games	All Games: Marginal
NE Border	-2.138***	-1.275***	-0.113	-0.936***	-0.321***
	(0.460)	(0.328)	(0.286)	(0.183)	(0.053)
Sum of Transfers	0.035	0.035	0.076***	0.057***	0.022***
	(0.045)	(0.050)	(0.024)	(0.018)	(0.007)
Equal Transfers	0.875	0.183	0.512*	0.487**	0.191**
	(0.561)	(0.363)	(0.281)	(0.199)	(0.078)
Final Payments are Closer	-0.179	0.357	0.468**	0.340**	0.129**
	(0.411)	(0.297)	(0.219)	(0.157)	(0.058)
Game 1				0.608***	0.237***
				(0.214)	(0.082)
Game 2				1.008***	0.385***
				(0.212)	(0.075)
Constant	-0.401	-0.535	-2.858***	-2.146***	
	(1.387)	(1.198)	(0.721)	(0.543)	
Observations	169	197	266	632	632
Number of Groups	28	28	32	88	88

Standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%

APPENDIX E

This appendix presents the two-player versions of two recent social-preference models, and considers how such preferences affect the possibility and likelihood of (mutual) cooperation in relation to characteristics of qualifying transfer pairs. In what follows below, by *more egalitarian transfers* we mean those transfers that bring players' material payoffs from mutual cooperation closer to each other. When transfers make the material payoffs from mutual cooperation identical, we simply call them *egalitarian transfers*.

Fehr and Schmidt (1999)

Denote by π_i player *i*'s material payoff. Fehr and Schmidt (1999) introduces the following utility function (in the two-player case):

$$V_i(\pi_i, \pi_j) = \pi_i - \alpha_i \max\{\pi_j - \pi_i, 0\} - \beta_i \max\{\pi_i - \pi_j, 0\}, \quad (1)$$

where $\beta_i \leq \alpha_i$, $0 \leq \beta_i < 1$. We define a *Social Welfare Equilibrum* (SWE) of a game with material payoffs as a Nash equilibrium of the game with material payoffs replaced with payoff functions V_i as in (1).

We demonstrate that for all three games, (i) unless the transfers are egalitarian, the player with a smaller material payoff from (C, C) sometimes has incentives to deviate from C to D; and (ii) mutual defection (D, D) is always a SWE in the second stage.

Game 1

In game 1, egalitarian transfer pairs are characterized by the equality of $y - x = 6$. The defector's material payoff is always bigger than the cooperator's material payoffs with any transfer pair in the SPE region. That is, $52 - x > 8 + x$ *and* $60 - y > 8 + y$ for all transfer pairs (x, y) in the SPE region. Hence, by (1)

$$V_1(D,C) = (52 - x) - \beta_1(44 - 2x). \quad (2)$$
$$V_2(C,D) = (60 - y) - \beta_2(52 - 2y). \quad (3)$$

Transfers with $y - x \geq 6$.

In this case, player 1's material payoff from (C, C) is no less than that of player 2. By (1),

$$V_1(C,C) = 40 + y - x - \beta_1[2(y - x) - 12] = 40 + (1 - 2\beta_1)(y - x) + 12\beta_1. \quad (4)$$
$$V_2(C,C) = 52 + x - y - \alpha_2[2(y - x) - 12] = 52 - (1 + 2\alpha_2)(y - x) + 12\alpha_1. \quad (5)$$

By (2) and (4),

$$V_1(C,C) \geq V_1(D,C) \textit{ if and only if } (y - 12) + (56 - 2y)\beta_1 \geq 0.$$

Since $12 \le y \le 20$ for any transfer pairs (x, y) in the SPE region, the above necessary and sufficient condition always holds in the SPE region. On the other hand, by (3) and (5),

$$V_2(C,C) \ge V_2(C,D) \text{ if and only if } (x - 8) + \alpha_2[12 + 2(x - y)] + \beta_2(52 - 2y) \ge 0.$$

Notice the second term on the left-hand-side of the second inequality is negative when $y - x > 6$. Hence, since $y - x \ge 6$, whether the necessary and sufficient condition holds depends on the sizes of α_2, β_2. Player 2 may thus have incentives to deviate from C to D unless the transfers are egalitarian, i.e. when $y - x = 6$.

Transfers with $y - x \le 6$.

In this case, player 1's material payoff from (C, C) is no bigger than that of player 2. By (1),

$$V_1(C,C) = 40 + y - x - \alpha_1[12 + 2(x - y)] = 40 + (1 + 2\alpha_1)(y - x) - 12\alpha_1. \qquad (6)$$

$$V_2(C,C) = 52 + x - y - \beta_2[12 + 2(x - y)] = 52 + (2\beta_2 - 1)(y - x) - 12\beta_2. \qquad (7)$$

By (2) and (7),

$$V_2(C,C) \ge V_2(C,D) \text{ if and only if } (x - 8) + \beta_2(40 - 2x) \ge 0.$$

Since $8 \le x \le 16$ and $12 \le y \le 20$ for any transfer pairs in the SPE region, it follows that the above necessary and sufficient condition always holds for transfer pairs in the SPE region. On the other hand, by (2) and (6),

$$V_1(C,C) \ge V_1(D,C) \text{ if and only if } (y - 12) - \alpha_1[12 + 2(x - y)] + \beta_1(44 - 2x) \ge 0.$$

The second term one the left-hand-side of the above inequality is negative when $y - x < 6$. Since $y - x \le 6$, it follows that whether the necessary and sufficient condition holds depends on the sizes of α_1, β_1. Player 1 may therefore have incentives to deviate from C to D unless transfers are egalitarian.

Game 2

In Game 2, egalitarian transfer pairs are characterized by the equality of $y - x = 10$. It turns out that no transfer pairs in the SPE region satisfies this condition. The defector's material payoff is always bigger than the cooperator's material payoff with any transfer pair in the SPE region. That is, $40 - x \ge 8 + x$ and $4 + y < 60 - y$ for any transfer pair (x, y) in the SPE region. Hence, by (1),

$$V_1(D,C) = 40 - x - \beta_1(32 - 2x). \qquad (8)$$

$$V_2(C,D) = 60 - y - \beta_2(56 - 2y). \qquad (9)$$

Notice that in Game 2**,** $y - x \ge 10$ is not possible because $y_{max} - x_{min} = 8$. Hence, we have $y - x < 10$ for all transfer pairs (x, y) in the SPE region. That is, player 1's material payoff from (C, C) is always less than that of player 2 over the SPE region. By (1),

$$V_1(C,C) = 32 + y - x - \alpha_1[(20 + 2(x - y)] = 32 + (1 + 2\alpha_1)(y - x) - 20\alpha_1. \qquad (10)$$

$$V_2(C,C) = 52 + x - y - \beta_2[20 + 2(x - y)] = 52 + (2\beta_2 - 1)(y - x) - 20\beta_2. \qquad (11)$$

By (9) and (11),

$$V_2(C,C) \ge V_2(C,D) \text{ if and only if } (x - 8) + \beta_2(36 - 2x) \ge 0.$$

Since $8 \le x \le 16$ for any transfer pair (x, y) in the SPE region, the above necessary and sufficient condition always holds. On the other hand, by (8) and (10),

$$V_1(C,C) \ge V_1(D,C) \text{ if and only if } (y-8) - \alpha_1[(20+2(x-y)] + \beta_1(32-2x) \ge 0.$$

Since $y - x < 10$, it follows that the second term on the left-hand-side of the second inequality is always negative. Thus, for any α_1, β_1 satisfying the stated conditions, there always exist transfer pairs within the SPE region that would make the second inequality unsatisfied. Hence, for any α_1, β_1 satisfying the stated conditions, there ways exist transfer pairs that would eliminate (C, C) as a SWE.

Game 3

In game 3, egalitarian transfers are characterized by the condition $y - x = -4$. However, in this game the defector's payoff is not always bigger than that of the cooperator.

Transfers with $y - x \ge -4$.

In this case, player 1's material payoff from (C,C) is no less than that of player 2. By (1),

$$V_1(C,C) = 44 + y - x - \beta_1[8+2(y-x)] = 44 + (1-2\beta_1)(y-x) - 8\beta_1. \qquad (12)$$

$$V_2(C,C) = 36 + x - y - \alpha_2[8+2(y-x)] = 36 - (1+2\alpha_2)(y-x) - 8\alpha_2. \qquad (13)$$

Case 1: $8 \le x \le 26,\ 8 \le y \le 18$.

In this case, the defector's material payoff is no less than that of the cooperator at either (D, C) or (C, D). Thus, by (1),

$$V_1(D,C) = 52 - x - \beta_1(52-2x). \qquad (14)$$

$$V_2(C,D) = 44 - y - \beta_2(36-2y). \qquad (15)$$

By (12) and (14),

$$V_1(C,C) \ge V_1(D,C) \text{ if and only if } (y-8) + \beta_1(44-2y) \ge 0. \qquad (16)$$

Since $8 \le y \le 18$, the necessary and sufficient condition clearly holds. Hence, $V_1(C,C) \ge V_1(D,C)$. By (13) and (15),

$$V_2(C,C) \ge V_2(C,D)) \text{ if and only if } (x-8) - \alpha_2[8+2(y-x)] + \beta_2(36-2y) \ge 0.$$

In the range of $8 \le x \le 26,\ 8 \le y \le 18$, and $y - x \ge -4$, there are transfer pairs for given α_2, β_2 such that the above necessary and sufficient condition does not satisfy. With these transfer pairs, (C, C) will be eliminated as a SWE.

Case 2: $26 \le x \le 28,\ 8 \le y \le 18$.

In this case, $y - x \le -8$. Thus, the range with $26 \le x \le 28,\ 8 \le y \le 18$, and $y - x \ge -4$ is empty.

Case 3: $8 \le x \le 26,\ 18 \le y \le 24$.

In this case, the defector's material payoff at (D, C) is larger than that of the cooperator wile the opposite holds at (C, D). Thus, $V_1(D,C)$ is as in (14). By (16), $V_1(C,C) \geq V_1(D,C)$ if and only if $(y - 8) + \square_1(44 - 2y) \geq 0$. Since $\square_1 < 1$, the preceding necessary and sufficient condition clearly holds. On the other hand, by (1)

$$V_2(C,D) = 44 - y - \square_2(2y - 36). \qquad (17)$$

Thus, by (13) and (17),

$$V_2(C,C) \geq V_2(C,D) \textit{ if and only if } (x - 8) + \square_2(2x - 44) \geq 0. \qquad (18)$$

Since $8 \square x \square 26$, the above necessary and sufficient condition does not always hold. Thus, there are transfer pairs with which (C, C) is eliminated as a SWE.

Case 4: $26 \square x \square 28, 18 \square y \square 24$.

In this case, the defector's material payoff is always less than that of the cooperator's. It follows that

$$V_1(D,C) = 52 - x - \square_1(2x - 52) \qquad (19)$$

while $V_2(C,D)$ is as in (17). By (12) and (19),

$$V_1(C,C) \geq V_1(D,C) \textit{ if and only if } (y - 8) + \square_1(2x - 52) - \square_1[8 + 2(y - x)] \geq 0.$$

Notice in this case, $y \geq 22$ in order for $y - x \geq -4$. Consequently, $8 + 2(y - x) \square 4$ which implies $-\square_1[8 + 2(y - x)] \geq -4\square_1$. Since $\square_1 < 1$ and $y - 8 \geq 14$, the above necessary and sufficient condition is satisfied. On the other hand, by (18), $V_2(C,C) \geq V_2(C,D)$ if and only if $(x - 8) + \square_2(2x - 44) \geq 0$. This condition is clearly satisfied in the range of $26 \square x \square 28$.

A parallel analysis can be established for Transfers with $y - x \square -4$ in the SPE region of Game 3. It can also be verified that for all three games, (D, D) will always be a SWE with transfers in the SPE regions.

An example

Consider Game 2:

Game 2

Player 2

Player 1		C	D
	C	32, 52	4, 60
	D	40, 8	20, 24

Suppose $(H_1, H_2) = (15, 9)$. Then the transformed game is:

Game 2 transformed by (15, 9)

Player 2

Player 1		C	D
	C	26, 58	13, 51
	D	25, 23	20, 24

Suppose the players have Fehr-Schmidt preferences. The utility from each outcome is:

Game 2 transformed by (15, 9), F-S utility

Player 2

Player 1		C	D
	C	26-32□, 58-32□	13-38□, 51-38□
	D	25-2□, 23-2□	20-4□, 24-4□

If Player 2 chooses C, Player 1's best response depends on the values of □ and □. If 25-2□ > 26-32□, or 32□-2□ > 1, then D is the best response. Since □ cannot exceed □, if 30□ > 1, (C,C) is not an equilibrium.

If Player 1 chooses C, then if 51-38□ > 58-32□, or -6□ > 7, then D is Player 2's best response. But since □ > 0, this cannot occur, so C is Player 2's best response to C by Player 1.

Now suppose instead that $(H_1, H_2) = (9, 15)$ and that players have F-S preferences. The utility from each outcome is:

Game 2 transformed by (9, 15), F-S utility

Player 2

Player 1		C	D
	C	38-8□, 46-8□	19-26□, 45-26□
	D	31-14□, 17-14□	20-4□, 24-4□

If Player 2 chooses C, Player 1's best response depends on the values of □ and □. If 31-14□ > 38-8□, or 8□-14□ > 7, then D is the best response. Even if □ = 0 (the minimum value), we must have 8□ > 7 for D to be a best response, so that □ must be at least 7/8.

If Player 1 chooses C, then if 45-26□ > 46-8□, or -18□ > 1, then D is the best response. But since □ > 0, this cannot occur, so C is Player 2's best response to C by Player 1.

Overall, in this example, the more egalitarian transfers make cooperation for Player 1 a best response for a broader range of values, while not affecting the range for Player 2

Thus, (C,C) is an equilibrium for a broader range of values when transfers bring the mutual-cooperation payoffs closer together than further apart.

Charness and Rabin (2002)

Charness and Rabin (2002) introduces a $(\square,\square)\square$ utility function for each player:

$$V_i(\square_i,\square_j) = \square_i + \square(1\square\square)\square_j,\ if\ \square_i\ \square\ \square_j;\ V_i(\square_i,\square_j) = (1\square\square\square)\square_i + \square\square_j\ if\ \square_i \geq \square_j, \qquad (1)$$

where $\square, \square\square$ [0, 1] and $\square_i$ and $\square_j$ are the material payoffs of payers *i* and *j*. Note that this is the reciprocity-free version of the full model. They define a *Social Welfare Equilibrium* (SWE) of a game with material payoffs as a Nash equilibrium of the game with material payoffs replaced with $(\square,\square)\square$ social welfare payoffs.

We now demonstrate the following properties for the three games in the paper. (A) Mutual cooperation is more *socially rewarding* (both players benefit) the more egalitarian the transfers are when $\square(1+\square) > 1$; the player receiving the lower material payoff from mutual cooperation prefers more egalitarian transfers to less egalitarian transfers while the other player holds opposite preferences when $\square(1+\square) < 1$. (B) Mutual cooperation is always a SWE in the second stage for all transfer pairs within the SPE regions. (C) Mutual defection is eliminated as a SWE in the second stage for a range of transfer pairs in the SPE regions of Game 1 and Game 2, but mutual defection is always a SWE in the second stage for all transfers in the SPE region of Game 3.

Game 1

In game 1, egalitarian transfer pairs are characterized by the equality of $y \square x = 6$. Furthermore, the defector's material payoff is always bigger than the cooperator's material payoffs with any transfer pair in the SPE region. That is, $52 \square x > 8 + x\ and\ 60 \square y > 8 + y$ for all transfer pairs (x, y) in the SPE region. By (1)

$$V_1(D,C) = (1\square\square\square)(52\square x) + \square(8+x) = [\square(1+\square)\square 1]x + 52(1\square\square\square) + 8\square. \qquad (2)$$

$$V_2(C,D) = (1\square\square\square)(60\square y) + \square(8+y) = [\square(1+\square)\square 1]y + 60(1\square\square\square) + 8\square. \qquad (3)$$

Transfers with $y \square x \geq 6$.

In this case, player 1's material payoff from (C, C) is no less than that of player 2. By (1),

$$V_1(C,C) = [1\square\square(1+\square)](y\square x) + 44(1\square\square\square) + 52\square. \qquad (4)$$

$$V_2(C,C) = \square[1 - \square(1 - \square)](y - x) + 44\square(1 - \square) + 52. \qquad (5)$$

With $y - x \geq 6$, (4) and (5) imply that as transfers become more egalitarian, both players' C-R payoff functions increase in the difference $y - x$ when $\square(1+\square) > 1$; $V_1(C,C)$ decreases while $V_2(C,C)$ increases in $y - x$ when $\square(1+\square) < 1$. This shows that mutual cooperation is more socially rewarding the more egalitarian the transfers are when $\square(1+\square) > 1$; the player receiving the lower material payoff from mutual cooperation prefers more egalitarian transfers to less egalitarian transfers while the other player holds opposite preferences when $\square(1+\square) < 1$.

By (2) and (4),

$$V_1(C,C) \geq V_1(D,C) \textit{ if and only if } 36\square \geq [\square(1+\square) - 1](y - 8).$$

Since $[\square(1+\square) - 1](y - 8) \leq \square\square(y - 8)$ and $12 \leq y \leq 20$ for any transfer pairs (x, y) in the SPE region, $[\square(+\square) - 1](y - 8) \leq 12\square\square$. It follows that the above necessary and sufficient condition always holds in the SPE region for any $\square, \square \in [0, 1]$.

Similarly, by (3) and (5),

$$V_2(C,C) \geq V_2(C,D) \textit{ if and only if } (x - 8) + \square(36 - x) \geq \square\square(y - 8) + \square\square(y - x - 8).$$

Since $8 \leq x \leq 16$ and $12 \leq y \leq 20$ for any transfer pairs (x, y) in the SPE region, it follows that $y - 8 \leq 12$ and $y - x - 8 \leq 4$. Consequently, $\square\square(y - 8) + \square\square(y - x - 8) \leq 16\square\square$. Since $\square \leq 1$, the above necessary and sufficient condition always holds in the SPE region. This shows that (C, C) is always a SWE. A parallel analysis can be made for transfers satisfying $y - x \leq 6$.

Game 2

In Game 2, egalitarian transfer pairs are characterized by the equality of $y - x = 10$. It turns out no transfer pairs in the SPE region satisfies this condition. Furthermore, the defector's payoff is always bigger than the cooperator's material payoff with any transfer pair in the SPE region. That is, $40 - x \geq 8 + x$ and $4 + y < 60 - y$ for any transfer pair in the SPE region. Hence, by (1),

$$V_1(D,C) = [\square(1+\square) - 1]x + 40(1 - \square\square) + 8\square. \qquad (8)$$

$$V_2(C,D) = [\square(1+\square) - 1]y + 60(1 - \square\square) + 4\square. \qquad (9)$$

$y - x \geq 10$ is not possible because $y_{\max} - x_{\min} = 8$.

Transfers with $y - x < 10$.

In this case, player 1's material payoff is less than that of player 2. By (1),

$$V_1(C,C) = [1 - \square(1 - \square)](y - x) + 52\square(1 - \square) + 32. \qquad (10)$$

$$V_2(C,C) = \square[1 - \square(1+\square)](y - x) + 52(1 - \square\square) + 32\square. \qquad (11)$$

By (10) and (11), $y - x < 10$ implies that as transfers become more egalitarian, both players' C-R payoff functions increase in the difference $y - x$ when $\square(1+\square) > 1$;

$V_1(C,C)$ increases while $V_2(C,C)$ decreases in $y \square x$ when $\square(1+\square) < 1$. This shows that mutual cooperation is more *socially rewarding* the more egalitarian the transfers are when $\square(1+\square) > 1$; the player receiving the lower material payoff from mutual cooperation prefers more egalitarian transfers to less egalitarian transfers while the more materially paid player hold opposite preferences when $\square(1+\square) < 1$.

By (8) and (10),

$$V_1(C,C) \geq V_1(D,C) \textit{ if and only if } \square(16 \square \square x) + \square[(16 \square y) + \square(y \square x)] \geq 0.$$

Since $8 \square x \square 16$ and $8 \square y \square 16$ for any transfer pair (x, y) in the SPE region, the necessary and sufficient condition always holds. Similarly, by (9) and (11),

$$V_2(C,C) \geq V_2(C,D) \textit{ if and only if } 28\square \geq \square x + (\square\square \square 1)(x \square 8).$$

Since $8 \square x \square 16$ and $\square\square \square 1$ for any transfer pairs (x, y) in the SPE region, the necessary and sufficient condition always holds. This shows that (C, C) is always a SWE.

Game 3

In Game 3, egalitarian transfers are characterized by the condition $y \square x = \square 4$. However, in this game whether the defector's payoff is bigger than that of the cooperator depends on the transfers.

Transfers with $y \square x \geq \square 4$.

In this case, player 1's material payoff from (C,C) is no less than that of player 2. By (1),

$$V_1(C,C) = [1 \square \square(1+\square)](y \square x) + 44(1 \square \square\square) + 36\square. \qquad (12)$$

$$V_2(C,C) = \square[1 \square \square(1 \square \square)](y \square x) + 44\square(1 \square \square) + 36. \qquad (13)$$

From (12) and (13), $y \square x \geq \square 4$ implies that as transfers become more egalitarian, Both players' C-R payoff functions increase in $y \square x$ when $\square(1+\square) > 1$; $V_1(C,C)$ decreases while $V_2(C,C)$ increases in $y \square x$ when $\square(1+\square) < 1$. This shows that mutual cooperation is more *socially rewarding* the more egalitarian the transfers are when $\square(1+\square) > 1$; the less materially paid player from mutual cooperation prefers more egalitarian transfers to less egalitarian transfers while the more materially paid player hold opposite preferences when $\square(1+\square) < 1$.

Case 1: $8 \square x \square 26, 8 \square y \square 18$.

In this case, the defector's payoff is no less than that of the cooperator at either (D, C) or (C, D). Thus, by (1),

$$V_1(D,C) = [\square(1+\square) \square 1]x + 52(1 \square \square\square). \qquad (14)$$

$$V_2(C,D) = [\square(1+\square) \square 1]y + 44(1 \square \square\square) + 8\square. \qquad (15)$$

By (12) and (14),

$$V_1(C,C) \geq V_1(D,C) \textit{ if and only if } 36\square \geq \square y + (\square\square \square 1)(y \square 8).$$

Since $8 \square y \square 18$ and since $\square\square \square 1$, the necessary and sufficient condition clearly holds. Hence, $V_1(C,C) \geq V_1(D,C)$. By (13) and (15),

$$V_2(C,C) \geq V_2(C,D)) \textit{ if and only if } [1 \square \square(1 \square \square)](x \square 8) + \square(36 \square 2\square y) + 28\square(1 \square \square) \geq 0.$$

Since $8 \square x \square 26, 8 \square y \square 18$ and since $\square, \square \square [0,1]$, the necessary and sufficient condition holds. Hence, $V_2(C,C) \geq V_2(C,D)$.

Case 2: $26 \square x \square 28, 8 \square y \square 18.$

In this case, $y \square x \square \square 8$. The range with $26 \square x \square 28, 8 \square y \square 18,$ and $y \square x \geq \square 4$ is thus empty.

Case 3: $8 \square x \square 26, 18 \square y \square 24.$

In this case, the defector's material payoff at (D, C) is larger than that of the cooperator while the opposite holds at (C, D). Thus, $V_1(D,C)$ is as in (14).
Hence, $V_1(C,C) \geq V_1(D,C)$ as shown in case 1. By (1),

$$V_2(C,D) = [\square(1 \square \square) \square 1]y + 8\square(1 \square \square) + 44. \qquad (16)$$

Thus, by (13) and (16),

$$V_2(C,C) \geq V_2(C,D) \textit{ if and only if } (x \square 8) + \square(1 \square \square)(36 \square x) \geq 0.$$

Since $8 \square x \square 26$, the second inequality holds. Hence, $V_2(C,C) \geq V_2(C,D)$.

Case 4: $26 \square x \square 28, 18 \square y \square 24$**.**

In this case, the defector's material payoff is always less than that of the cooperator's. It follows that

$$V_1(D,C) = 52 \square x + \square(1 \square \square)x. \qquad (17)$$

By (12) and (17),

$$V_1(C,C) \geq V_1(D,C) \textit{ if and only if } \square\square(x \square y) + \square\square(x \square 44) + (y \square 8) + (36 \square y)\square \geq 0.$$

Since $26 \square x \square 28, 18 \square y \square 24$, and $y \square x \geq \square 4$**,** we have $y \geq 22$. Hence,

$$\square\square(x \square y) + \square\square(x \square 44) + y \square 8 + (36 \square y)\square \geq 2\square\square \square 18\square\square + 14 + 12\square > 0.$$

Consequently, $V_1(C,C) \geq V_1(D,C)$. On the other hand, $V_2(C,D)$ is as in (16). Hence, $V_2(C,C) \geq V_2(C,D)$ as shown in Case 3.

In summary**,** we have shown that $V_1(C,C) \geq V_1(D,C)$ and $V_2(C,C) \geq V_2(C,D)$ for all transfer pairs in the SPE region with $y \square x \geq \square 4$**.** Hence, (C, C) is always a SWE for transfer pairs in the SPE region satisfying $y \square x \geq \square 4$**.** A parallel analysis can be made for transfer pairs in the SPE region satisfying $y \square x \square \square 4$.

Elimination of (D, D) as a Social Welfare Equilibrium

We show that mutual defection does not survive social considerations as modeled in Charness and Rabin (2002) over a large range of transfer pairs in the SPE regions in Games 1 and 2; it survives in Game 3 over the entire region of transfer pairs.

Game 1

Notice in this game

$$V_1(C,D) = 8 + y + \square(1 - \square)(60 - y) \qquad (18)$$

$$V_1(D,D) = 28(1 - \square\square) + 24\square. \qquad (19)$$

By (18) and (19),

$$V_1(C,D) > V_1(D,D) \text{ if and only if } y > 16 - \frac{20\square(1-\square)}{1-\square(1-\square)}.$$

Since (x, y) is in the SPE region if and only $8 \le x \le 16$ and $12 \le y \le 20$, there exist many transfer pairs that make $V_1(C,D) > V_1(D,D)$. With these transfer pairs, (D, D) cannot be a SWE.

Game 2

In this game,

$$V_1(C,D) = 4 + y + \square(1 - \square)(60 - y). \qquad (20)$$

$$V_1(D,D) = 20 + 24\square(1 - \square). \qquad (21)$$

Together, (20) and (21) imply

$$V_1(C,D) > V_1(D,D) \text{ if and only if } y > 16 - \frac{20\square(1-\square)}{1-\square(1-\square)}.$$

Since (x, y) is in the SPE region if and only if $8 \le x \le 16$ and $8 \le y \le 16$, there exist many transfer pairs that make $V_1(C,D) > V_1(D,D)$. With these transfer pairs, (D, D) cannot be a SWE.

Game 3

Notice first in this game

$$V_1(D,D) = 32(1 - \square\square) + 28\square. \qquad (22)$$

$$V_2(D,D) = 28 + 32\square(1 - \square). \qquad (23)$$

We partition the SPE region into four different parts, depending on the comparison of a defector's material payoff with that of the defector.

Case 1: $8 \le x \le 26,\ 8 \le y \le 18$.

In this case,

$$V_1(C,D) = 8 + y + \square(1 - \square)(44 - y). \qquad (24)$$

$$V_2(D,C) = x + \square(1 - \square)(52 - x). \qquad (25)$$

By (22) and (24),

$$V_1(C,D) \square V_1(D,D) \text{ if and only if } \square(1\square\square)(12\square y)\square 24\square y\square 4\square.$$

Since $24\square y\square 4\square\square 20\square y$ and since $\square(1\square\square)\square 1$, the necessary and sufficient condition holds. By (23) and (25),

$$V_2(D,C))\square V_2(D,D) \text{ if and only if } \square(1\square\square)(20\square x)\square 28\square x.$$

Since $\square(1\square\square)\square 1$, the necessary and sufficient condition holds.

Case 2: $26\square x\square 28, 8\square y\square 18.$

In this case, $V_1(C,D)$ is as in (24). Hence, $V_1(C,D)\square V_1(D,D)$ as shown in Case 1. For player 2,

$$V_2(D,C) = (1\square\square\square)x + \square(52\square x). \qquad (26)$$

Together, (23) and (26) imply

$$V_2(D,C))\square V_2(D,D) \text{ if and only if } \square(52\square 2x)\square[1+\square(1\square\square)](28\square x)+4\square(1\square\square).$$

Since $26\square x\square 28$**,** the necessary and sufficient condition holds.

Case 3: $8\square x\square 26, 18\square y\square 24.$

In this case, $V_2(D,C)$ is as in (25). Hence, $V_2(D,C)\square V_2(D,D)$ as shown in Case 1. For player 1,

$$V_1(C,D) = (1\square\square\square)(8+y)+\square(44\square y). \qquad (27)$$

By (22) and (27),

$$V_1(C,D)\square V_1(D,D) \text{ if and only if } \square(16\square y)\square(1\square\square\square)(24\square y).$$

Since $18\square y\square 24$, the necessary and sufficient condition holds.

Case 4: $26\square x\square 28, 18\square y\square 24$**.**

In this case, $V_1(C,D)$ is as in (27) and $V_2(D,C)$ is as in (26).
Hence, $V_1(C,D)\square V_1(D,D)$ as shown in Case 3 and $V_2(D,C)\square V_2(D,D)$ as shown in Case 2.

In summary**,** we have shown that (D, D) is always a SWE for all transfer pairs in the SPE region of Game 3.

An example

Consider Game 2:

Game 2

Player 2

	C	D

Player 1	C	32, 52	4, 60
	D	40, 8	20, 24

Suppose $(H_1, H_2) = (15, 9)$. Then the transformed game is:

Game 2 transformed by (15, 9)

		Player 2	
		C	D
Player 1	C	26, 58	13, 51
	D	25, 23	20, 24

Suppose the players have Charness-Rabin distributional preferences. The utility from each outcome is:

Game 2 transformed by (15, 9), C-R utility

		Player 2	
		C	D
Player 1	C	26+58□(1-□), 58(1- □□)+ 26□	13+51□(1-□), 51(1- □□)+ 13□
	D	25(1- □□)+ 23□, 23+25□(1-□)	20+24□(1-□), 24(1- □□)+ 20□

If Player 2 chooses C and if 25(1- □□) + 23□ > 26 + 58□(1-□), or 25 – 25□□ + 23□ > 26 + 58□- 58□□, or 33□□ - 35□ > 1, then Player 1's best response is D. But since □ cannot exceed 1, this condition cannot hold, so C is always Player 1's best response to C from Player 2.

If Player 1 chooses C, Player 2's best response is D if 51(1- □□)+ 13□ > 58(1- □□)+ 26□, or 51 - 51□□ + 13□ > 58 - 58□□ + 26□, or 7□□ - 13□ > 7. But since □ and □ cannot exceed 1, 7□□ cannot exceed 7, and since □ is non-negative, 7□□ - 13□ cannot exceed 7. Thus, this condition can't hold, so that C is always Player 2's best response to C from Player 1.

Now suppose instead that $(H_1, H_2) = (9, 15)$ and that players have C-R preferences. The utility from each outcome is:

Game 2 transformed by (9, 15), C-R utility

Player 2

		C	D
Player 1	C	38+46□(1-□), 46(1- □□)+ 38□	19+45□(1-□), 45(1- □□)+ 19□
	D	31(1- □□)+ 17□, 17+31□(1-□)	20+24□(1-□), 24(1- □□)+ 20□

If Player 2 chooses C and if 31(1- □□) + 17□ > 38 + 46□(1-□), or □(15□ - 29) > 7, then Player 1's best response is D. But since □ cannot exceed 1, this condition cannot hold, so C is always Player 1's best response to C from Player 2.

If Player 1 chooses C and if 45(1- □□) + 19□ > 46(1- □□) + 38□, or 0 > (1 - □□) + 19□, then Player 1's best response is D. But since □ and □ cannot exceed 1, (1 - □□) cannot be negative, and since □ is non-negative, (1 - □□) + 19□ must be positive. Thus, this condition can't hold, so that C is always Player 2's best response to C from Player 1.

In these examples, (C,C) is an equilibrium for all permitted values of □ and □ when the transfers are in the qualifying range.