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by

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Income Interdependence and Informal Risk Sharing: The Effects of Future Interactions and Directed Altruism

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Abstract[1]

We propose a framework to analyze the effects of income correlation between two players on risk sharing without commitment. In theory, the likelihood that a risk-sharing agreement is self-enforcing decreases with income correlation. We tested this prediction in the laboratory with negative, zero, and positive correlation coefficients and observed the largest average transfer in the positive-correlation treatment. This surprising result suggests that experiencing the same state of income could create a social bond and induce altruism between the two players. Therefore, informal risk sharing can be successful in a group with social identity despite high income interdependence.

Keywords: risk sharing, income correlation, infinite horizon games, income smoothing, altruism, economic experiments

JEL Codes: D81, C91, C73, O17

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1 Introduction

When faced with income fluctuation, an individual may smooth her consumption and protect herself from bad times by buying insurance. However, in a society where market insurance is not available, an informal risk-sharing arrangement is a crucial mechanism to alleviate the impact of income fluctuation. Under such an arrangement, individuals facing adverse shocks may receive financial help in cash, in-kind transfers, or loans from those in better circumstances. While many researchers use existing survey data from various countries to analyze risk sharing between individuals or households,[2] some design an experiment to investigate risk sharing in a controlled environment in the laboratory (e.g., Charness and Genicot, 2009) or in the field (e.g., Barr and Genicot, 2008). In this paper, we propose a simple model that allows us to theoretically derive the relationship between income correlation of two individuals and their decisions to sustain a risk-sharing arrangement without an enforceable contract, and empirically test such a relationship in the laboratory.

We adopt a two-player symmetric game played in multiple periods with stochastic endings. In each period, each player has a probability of receiving extra income. After observing the outcome, each player may make a transfer to their counterpart. In theory, the risk sharing between two individuals is at a maximum when their incomes are perfectly and negatively correlated. This is because when one person suffers from a low income, the other person is in the best position to offer financial help. While making a transfer to the low-income counterpart, the high-income person is aware of the highest possibility of future interactions that the counterpart will reciprocate in periods when their positions are reversed. As the income correlation increases, such an interaction in the future becomes less likely, and the expected benefit from risk sharing decreases for both individuals. In the extreme case where individuals have a perfectly positive correlation of income, they will always have the same income and therefore would not gain by engaging in risk sharing. Our theoretical model formally shows a negative relationship between the income correlation and the maximum transfer amount between two players without an explicit risk-sharing contract.

Even though informal risk sharing has been extensively investigated using actual data from various countries and experimental data from the lab and the field, the direct effect of income

[2] For example, see empirical analyses using data from India (Townsend, 1994; Ligon et al., 2002), Nigeria (Udry, 1994), the Philippines (Fafchamps & Lund, 2003), Kenya (Jack & Suri, 2014) and China (Wu & Zhao, 2020).

interdependence has not been formally analyzed in the literature.[3] Such an analysis is important for two reasons. First, a group of individuals who participate in informal risk sharing may be neighbors who are likely to have similar jobs or suffer the same natural disaster, so they are subject to the same shock to their incomes. Thus, the income correlation between individuals in a risk sharing group is expected to be positive. Second, income risk in the real world is due to various sources, such as employment, agricultural returns, and natural catastrophes, so the income correlation between individuals differs across risk-sharing groups.

Our study is the first to experimentally investigate the relationship between income correlation and informal risk sharing. The experimental design is based on Charness and Genicot's (2009) experiment on informal risk sharing in an infinite horizon. In their study, two participants are matched in multiple periods with stochastic endings. In each period, only one of the two participants randomly receives an additional income so the correlation coefficient between the two participants' incomes is -1. After observing who receives the extra income, each participant can make a voluntary transfer to the other. The results support risk-sharing behavior: those who receive the extra income transfer more than their counterparts do, and more risk-averse individuals transfer more. Since these findings are based on the assumption of perfectly negative correlation, they are not applicable to risk-sharing arrangements in the real world, where income correlation is nonnegative. Thus, we use Charness and Genicot's setting as our baseline and test whether risk sharing still prevails in treatments with zero and positive correlations.

We conduct the experiment with three treatments using three correlation coefficients: -1, 0, and $1/3$. Our results suggest there is evidence of risk sharing, since subjects transfer more when they receive the extra income and their counterparts do not. In addition, we also observe more engagement in risk sharing among males and more risk-averse subjects. These results are in line with the findings of Charness and Genicot (2009). In the survey, we also pose Cognitive Reflection Test (CRT) questions (Frederick, 2005). Subjects who answer more of these questions correctly (compared to those who answer fewer questions correctly) transfer more when they earn more income than their counterparts do and less in the other

[3] Both Coate and Ravallion (1993) and Foster and Rosenzweig (2001) point out that income correlation plays an important role in informal risk sharing. However, they only discuss the effects of income correlation on transfer amount by providing numerical examples.

outcomes. These results suggest subjects may require deliberation in order to understand and engage in informal risk sharing.

Comparing across treatments, our theory predicts the highest transfers in the treatment with a correlation of -1 because of its highest expected reciprocity, followed by treatments with correlations of 0 and $1/3$, respectively. However, in the outcome in which subjects receive the extra income while their counterparts do not, we observe the highest transfers in the treatment with a correlation of $1/3$. Our results suggest that informal risk sharing can be more successful among community members with positive income correlation. To explain the inconsistency between the theory and the experimental results, we propose a model that includes altruism in addition to expected reciprocity. In the positive-correlation treatment, the two players share the same state of nature (high income or low income) more than half the time. This experience of sticking together through thick and thin could create a social identity which in turn induces directed altruism. As a result, individuals in the treatment with a correlation of $1/3$ engage more in informal risk-sharing arrangements than predicted by the theory.

This paper makes the following contributions to the literature. First, we are the first to investigate the relationship between income correlation and risk sharing theoretically and in a lab experiment. Second, we incorporate the role of directed altruism induced by social identity in addition to the expected reciprocity in the risk-sharing decisions to explain why subjects in the treatment with low expected reciprocity transfer the most. Third, we replicate the findings of Charness and Genicot (2009) in the determinants of transfers, especially finding that males and more risk-averse subjects transfer more. In addition, we observe more engagement in risk sharing among subjects who answer more CRT questions correctly, which suggests that risk sharing may require deliberative thinking.

The role of directed altruism on risk sharing found in our study is consistent with findings from the following experimental studies in the field. In the absence of contract enforcement, comembership in community-based organizations (Barr et al., 2012), friendship and kinship (Attanasio et al., 2012), and social closeness (Chandrasekhar et al., 2018) all support risk sharing. Islam et al. (2020), find that subjects from the same natural disaster affected villages in Bangladesh (i.e., those who experienced similar income shocks) are more likely to cooperate in risk sharing. Our experimental results reaffirm that experiencing similar income shocks can induce altruism even when subjects are not identifiable.

The remainder of the paper is structured as follows. Section 2 describes our theoretical model of informal risk sharing. Section 3 explains the experimental design and procedures, and Section 4 analyzes the experimental results. Section 5 discusses an augmented model that uses directed altruism to explain our findings from the experiment, and Section 6 concludes.

2 Theoretical Model

Consider an infinitely repeated game with two risk-averse players indexed by $i = 1, 2$. Suppose that both players derive utility from their own wealth and aim to maximize their own expected utility. In each period, each player is given an initial income of L and a possibility of receiving extra income. We use a random variable $Y_{i,t}$ to represent player i's extra income in period t, which is either y or 0 with equal marginal probabilities, i.e., $Prob(Y_{i,t} = y) = Prob(Y_{i,t} = 0) = \frac{1}{2}$. Specifically, for any $m \geq 1$, we assume that the underlying joint probability density function for $Y_{1,t}$ and $Y_{2,t}$ is given by

$$f(y_{1,t}, y_{2,t}) = \begin{cases} \frac{m-1}{2m} & if \quad y_{1,t} = y_{2,t} = y, or\ y_{1,t} = y_{2,t} = 0, \\ \frac{1}{2m} & if \quad y_{1,t} = y\ \&\ y_{2,t} = 0, or\ y_{1,t} = 0\ \&\ y_{2,t} = y, \\ 0 & otherwise. \end{cases} \tag{1}$$

It follows that the correlation coefficient between $Y_{1,t}$ and $Y_{2,t}$ is

$$Corr(Y_{1,t}, Y_{2,t}) = \frac{m-2}{m}. \tag{2}$$

For the three treatments in our experiment, we let $m = 1, 2,$ and 3, so the correlation coefficients between $Y_{1,t}$ and $Y_{2,t}$ are -1, 0, and 1/3, respectively. Let player i's final wealth in period t be $w_{i,t}$ and the corresponding utility be $u(w_{i,t})$. We assume that u is a strictly increasing and strictly concave function.

Consider an informal agreement between the two players where player i transfers $x > 0$ to player $-i$ if and only if $y_{i,t} = y$ and $y_{-i,t} = 0$. Let V_{t+1}^{aut} and V_{t+1}^{rsa} denote the sum of all future utilities beginning in period $t + 1$, discounted to period t with a per-period discount factor $\delta \in (0,1)$, under autarky and the risk-sharing agreement, respectively. Such an informal agreement is self-enforcing if

$$u(H - x) + V_{t+1}^{rsa} \geq u(H) + V_{t+1}^{aut}, \tag{3}$$

where $H = L + y$. This condition, called an implementability constraint in Coate and Ravallion (1993) or a sustainability constraint in Ligon et al. (2002), can be written as

$$V_{t+1}^{rsa} - V_{t+1}^{aut} \geq \Delta^H(x), \tag{4}$$

where $\Delta^H(x) \equiv u(H) - u(H - x) > 0$. We find that

$$V_{t+1}^{rsa} = \left(\frac{\delta}{1-\delta}\right)\left[\frac{(m-1)}{2m}u(H) + \frac{1}{2m}u(H-x) + \frac{1}{2m}u(L+x) + \frac{(m-1)}{2m}u(L)\right] \tag{5}$$

and

$$V_{t+1}^{aut} = \left(\frac{\delta}{1-\delta}\right)\left[\frac{1}{2}u(H) + \frac{1}{2}u(L)\right]. \tag{6}$$

Thus,

$$V_{t+1}^{rsa} - V_{t+1}^{aut} = \left(\frac{\delta}{1-\delta}\right)\left[\frac{1}{2m}\Delta^L(x) - \frac{1}{2m}\Delta^H(x)\right], \tag{7}$$

where $\Delta^L(x) \equiv u(L + x) - u(L) > 0$. We find that the constraint $V_{t+1}^{rsa} - V_{t+1}^{aut} \geq \Delta^H(x)$ is satisfied if and only if

$$\frac{\Delta^L(x) - \Delta^H(x)}{\Delta^H(x)} \geq \frac{2m(1-\delta)}{\delta} \tag{8}$$

or, equivalently,

$$\delta \geq \frac{2m\Delta^H(x)}{(2m-1)\Delta^H(x) + \Delta^L(x)} \equiv \bar{\delta}(x, m). \tag{9}$$

We find that $\bar{\delta}(x, m) < 1$ for any strictly concave $u(w)$, and $\bar{\delta}(x, m)$ is increasing in m.

We consider two cases, CARA and CRRA, i.e.,

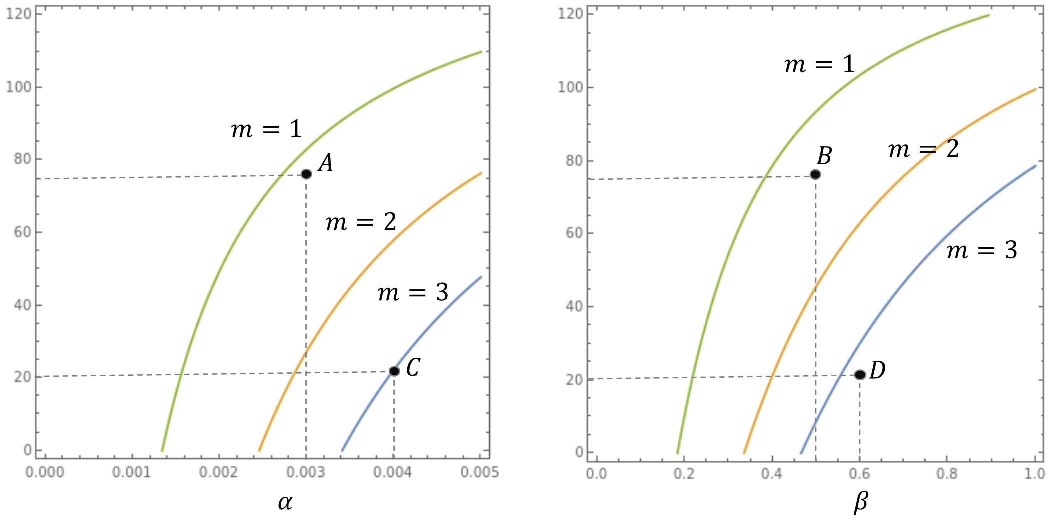
$$u(w) = -e^{-\alpha w}, \tag{10}$$

where $\alpha > 0$, and

$$u(w) = w^{1-\beta}, \tag{11}$$

where $\beta \in (0,1)$, and derive the maximum value of transfer from a high-income player to a low-income player that satisfies the constraint, given $\delta = 0.9$ for each preference parameter α and β in Figure 1. In our experiment where we let $y = 150$, the transfer of 75 is first best (Kocherlakota, 1996) and can be achieved for a small value of m when δ and α and β are large enough. Figure 1 suggests that, given $\delta = 0.9$ and a CARA player with $\alpha = 0.003$ or a

CRRA player with $\beta = 0.5$, this first-best allocation can be achieved under treatment $m = 1$, but not under treatment $m = 2$ or $m = 3$ (See points A and B). For example, a transfer of 20 is self-enforcing under all three treatments for a CARA player with $\alpha > 0.004$ or a CRRA player with $\beta > 0.6$ (See points C and D).



(a) CARA (b) CRRA

Figure 1. Maximum sustainable transfer in equilibrium, given $\boldsymbol{\delta = 0.9}$.

3 Design, Hypotheses, and Procedures

3.1 Experimental Design

We conduct an experiment of the two-player informal risk-sharing game in an infinite-horizon setting as in Charness and Genicot (2009). Each subject will play the game for a number of periods grouped into segments. In each segment, each subject will be randomly matched with another subject. The matched subjects will remain the same for the entire segment. Each segment consists of an uncertain number of periods. After each period, there is a 90% chance that another period follows and a 10% chance that a segment ends immediately. When the segment ends, all subjects will be randomly rematched with different subjects for the next segment. These probabilities imply that the discount factor per period, δ, is 0.9.

The game in each period consists of two stages. In stage 1, each player receives an initial income of 75 units and a possibility to receive an extra income of 150 units. The probability of receiving the extra income is 50% for each player, but the correlations of receiving the extra income are different across the two players.

The experiment consists of three treatments whose correlations of receiving the extra income are different. We use the correlation coefficients of -1, 0, and 1/3 in treatments $m = 1$, 2, and 3, respectively.[4] At the beginning of stage 2, each player will be notified whether each player received the extra income of 150 units during stage 1. Then, each player privately and simultaneously chooses the amount of transfer to the paired subject. Note that we allow subjects to make transfers in any situation to avoid a bias in favor of risk-sharing behavior and prevent subjects from inferring the objective of the experiment. The amounts transferred are revealed to all players at the end of stage 2.

In stage 1, one player from each pair will be randomly selected as a red player, while the other player is a blue player. To determine whether each player receives the extra income, we explain to the subjects that the system will randomly select a ball from a box. In treatment m = 1, there are 60 balls in the box; 30 are red, and 30 are blue. If the ball selected is red, only the red player will receive the extra income. If the ball selected is blue, only the blue player will receive the extra income. In treatment m = 2, there are two boxes, one for each player. For the red player's box, there are 60 balls; 30 are red, and 30 are white. The red player receives the extra income only if the ball selected is red. For the blue player's box, there are 60 balls; 30 are blue, and 30 are white. The blue player receives the extra income only if the ball selected is blue. In treatment m = 3, there is only one box with 60 balls; 10 are red, 10 are blue, 20 are gray, and 20 are white. The red player receives the extra income only if the ball selected is red or gray while the blue player receives the extra income only if the ball selected is blue or gray. No one receives the extra income if the ball selected is white.

Table 1. Probability of each outcome in each treatment

Treatment		Probability of extra income given to			
m	**Correlation**	**Both**	**Self**	**Counterpart**	**None**
1	-1	0	1/2	1/2	0
2	0	1/4	1/4	1/4	1/4
3	1/3	1/3	1/6	1/6	1/3

Even though each subject has a 50% chance of receiving the extra income in all treatments, there are only two possible outcomes in treatment m = 1 (i.e., only the red player and only the blue player receive the extra income) while in the other two treatments, there are two more possible outcomes (i.e., no player and both players receive the extra income). That is, the incomes realized in treatment m = 1 are always different, but they can be the same in the

[4] The correlation coefficient given m is $\frac{m-2}{m}$ as derived in Section 2.

other two treatments. The probability of each outcome in each treatment is shown in Table 1. In treatment *m* = 2, the probability of each outcome is 1/4; however, in treatment *m* = 3, the probability that no player or both players receive the extra income is 1/3 each, while the probability that only the red player or only the blue player receives the extra income is lower, at 1/6 each.

3.2 Experimental Procedures

We conducted a laboratory experiment at The Interactive Decision Experiment (TIDE) lab at the University of Alabama using the z-Tree program (Fischbacher, 2007). All subjects were undergraduate students at the University of Alabama. Each subject participated in only one session. For each treatment, we conducted five 12-subject experimental sessions. In each session, we grouped subjects into two cohorts of six subjects each. Therefore, we had 10 cohorts, with a total of 60 subjects in each treatment.

The setting of each cohort was identical. More precisely, the number of segments, the number of periods in each segment, and the matching in each segment were the same across all cohorts of all three treatments. The only variable that differed among treatments was the outcome of the game (who received the extra income) in each period since the probability of each outcome were not the same across treatments. However, the outcome of each period in the same treatment is the same across all cohorts.

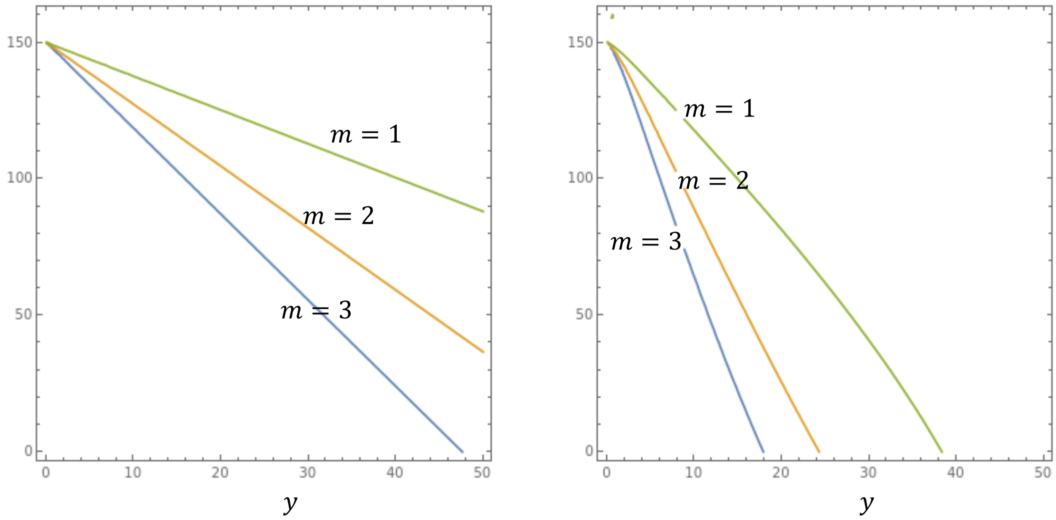
Before the main experiment on risk-sharing behaviors, we collected information about risk-preference using a setting similar to that of Gneezy and Potters (1997). In this game, a subject earns 50 points and chooses the portion of this amount (between 0 and 50 points, inclusive) to invest in a risky option. The risky option has a 50% probability that the investment will fail. If the investment fails, the subject loses the amount invested. If the investment succeeds, the subject receives 2.5 times the amount invested. Every subject receives this additional earning with a conversion rate of 15 units to one cash dollar. Each subject learns the outcome of this game only after the completion of the main experiment. We calculate each risk-preference parameter for CARA and CRRA functional forms as follows. Let y be the amount of a risky investment chosen by a subject. Then,

$$\alpha = \frac{\ln 1.5}{2.5y} \tag{12}$$

for a CARA player and

$$\beta = \frac{\ln 1.5}{\ln\left(\frac{50+1.5y}{50-y}\right)} \tag{13}$$

for a CRRA player. Both α and β are decreasing in y. A larger value of y, therefore, implies that the player is less risk averse. Specifically, they are less absolutely risk averse for the CARA function and less relatively risk averse for the CRRA function.



(a) CARA (b) CRRA

Figure 2. Maximum sustainable transfer in equilibrium implied by the risky investment amount in experiment (y), given $\delta = 0.9$.

At the beginning of the main experiment, the experimenter read the instructions aloud to the subjects, who were then asked to complete a short quiz to ensure that they understood the instructions; see Appendix B for the instructions. The subjects were allowed to ask questions about the instructions. After all questions were answered, the experiment started.

After the main experiment, each subject completed a survey, which included questions about the game, descriptive characteristics, and a Cognitive Reflection Test (similar to Frederick, 2005); see Appendix C for the survey questions. After that, each subject privately received cash compensation. To calculate the compensation, one of the periods was randomly selected, with a conversion rate of 15 units to one cash dollar. In addition, every subject earned a show-up fee of \$7.50 and the payment from the risk experiment. Each session lasted approximately 70 minutes. On average, subjects earned approximately \$22.

4 Results

4.1 Basic Results

We commence by analyzing the average transfers, as reported in Table 2. On average, subjects in treatments m = 1, 2, and 3 transfer 19.09, 7.18, and 13.18 units, respectively. However, the transfer amount depends on who receives the extra income.

Table 2. Average transfers

Treatment (Correlation)	**Average transfer when extra income is given to**				
	Both	**Self**	**Counterpart**	**Neither**	**All cases**
m = 1	N/A	31.00	7.17	N/A	19.09
(-1)		(37.50)	(13.20)		(30.53)
		[3,210]	[3,210]		[6,420]
m = 2	6.34	18.71	1.92	2.04	7.18
(0)	(19.51)	(27.51)	(5.69)	(5.48)	(18.53)
	[1,642]	[1,566]	[1,566]	[1,646]	[6,420]
m = 3	15.82	34.37	4.83	4.57	13.26
(1/3)	(32.17)	(33.68)	(10.94)	(11.33)	(26.62)
	[2,176]	[1,042]	[1,042]	[2,160]	[6,420]

Notes: 1. Standard deviations are shown in parentheses.
2. Numbers of observations are shown in brackets.
3. The number of subjects is 60 in each treatment.

In treatment m = 1, there are only two possible outcomes: one or the other player receives the extra income. The result shows that, on average, a subject transfers more when she receives the extra income than otherwise (31.00 and 7.17 units, respectively). This result supports the risk-sharing hypothesis; subjects who receive the extra income transfer funds to the other who does not, in order to smooth their income in each period. In the other two treatments, subjects also transfer more when they receive extra income. In these treatments, there are two other possible outcomes, one in which both players receive extra income and the other in which no player receives it. If a subject receives the extra income, she transfers less when the counterpart also receives it than when the counterpart does not (6.34 vs. 18.71 in treatment m = 2, and 15.82 vs. 34.37 in treatment m = 3). These results further support the risk-sharing hypothesis, since subjects give more when the counterpart earns less. However, when subjects do not receive extra income, the difference in their transfers, when the counterpart receives and does not receive extra income, is small and not statistically significant.

Next, we compare the amount of risk sharing among treatments. When a subject receives the extra income and the counterpart does not, the theory predicts a negative relationship between the correlation of income and the amount of the transfer. That is, we should observe the highest transfer in treatment $m = 1$, followed by $m = 2$, and the lowest in treatment $m = 3$. In contrast to this prediction, in our experiment, we observe the highest transfer in treatment $m = 3$.

Table 3 shows the percentages of zero transfers in each treatment and each outcome. When we consider all outcomes, we observe zero transfers approximately 44%, 67%, and 56% of the time in treatments $m = 1$, 2, and 3, respectively. In all treatments, when a subject does not receive the extra income, she chooses not to transfer to the counterpart more often than when she does receive the extra income. In addition, when receiving the extra income, a subject chooses not to transfer to the counterpart more often if the counterpart also receives the extra income than otherwise (only applicable for treatments $m = 2$ and $m = 3$). These results support the risk-sharing hypothesis, since a subject is more likely to transfer funds when she earns more than the counterpart.

Table 3. Proportions of zero transfers

Treatment (Correlation)	**Proportion of zero transfers when extra income is given to**				
	Both	**Self**	**Counterpart**	**Neither**	**All cases**
$m = 1$ (-1)	N/A	31.81% [3,210]	56.95% [3,210]	N/A	44.38% [6,420]
$m = 2$ (0)	68.76% [1,642]	42.21% [1,566]	78.35% [1,566]	78.13% [1,646]	67.02% [6,420]
$m = 3$ (1/3)	54.96% [2,176]	21.40% [1,042]	66.41% [1,042]	69.17% [2,160]	56.15% [6,420]

Notes: 1. Numbers of observations are shown in brackets.
2. The number of subjects is 60 in each treatment.

Comparing treatments, when a subject is the only one who receives the extra income, our theoretical model predicts that a subject in treatment $m = 1$ will be the least likely to make a zero transfer, followed by treatments $m = 2$ and $m = 3$, respectively. However, we observe the lowest percentage of zero transfer in treatment $m = 3$ (21.40%), followed by treatments $m = 1$ (31.81%) and $m = 2$ (42.21%), respectively. This result, together with the result from Table 2 that subjects in treatment $m = 3$ transfer the largest amount when being the only player who receives the extra income, suggests that the theory may fail to capture the fact that subjects are more willing to share when they have experienced income fluctuation together.

4.2 Behavior as the Only Player Who Receives Extra Income

Figure 3 shows the distribution of the transfer when a subject is the only one who receives the extra income, using cumulative distribution functions (CDFs) for each treatment. A CDF determines the probability that a data value is less than a certain value. At 50% (or a median), the values in treatments *m* = 1, 2, and 3 are approximately 15, 5, and 23, respectively; this means that 50% of the transfers for each treatment are lower than these respective values. Figure 3 indicates that subjects in treatment *m* = 2 transfer the least. The transfers in the other two treatments are more similar, but there are more low transfers in treatment *m* = 1 than in *m* = 3; this is probably the main source of difference between these two treatments: we observe the average transfers to be higher in treatment *m* = 3.

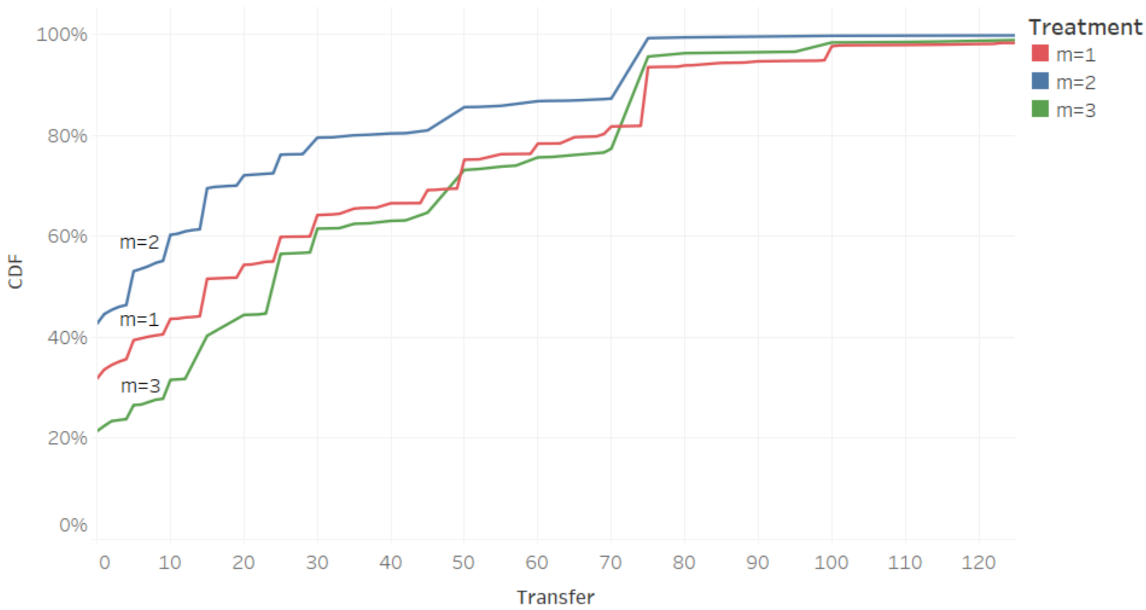


Figure 3. Distribution of transfer amounts from a player who is the only one receiving extra income.

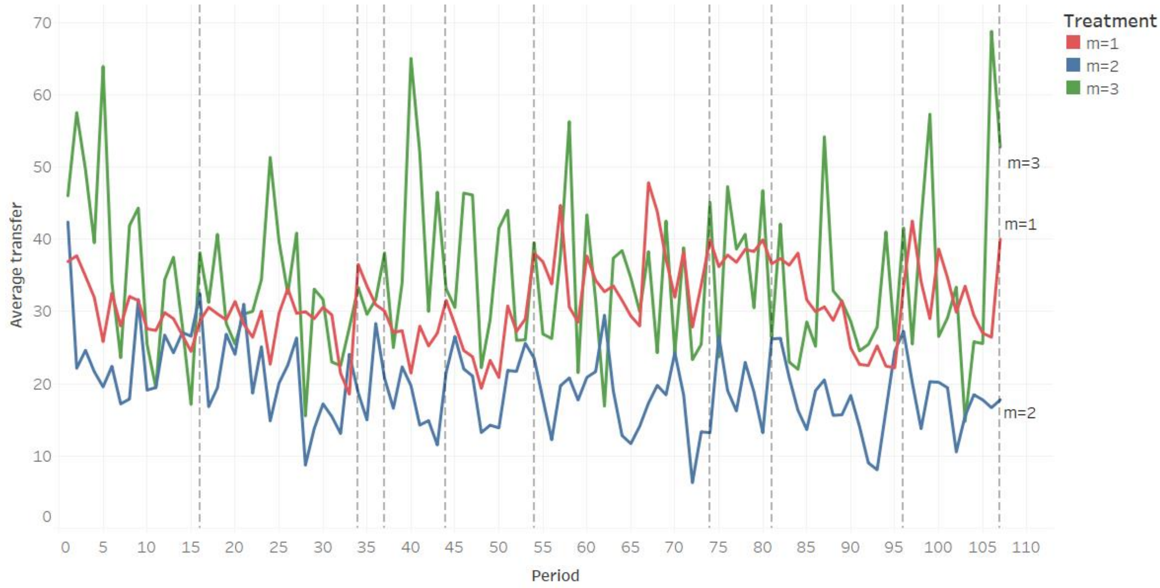


Figure 4. Average transfer by period from a player who is the only one receiving extra income.

Figure 4 shows the average transfers, by period, when a subject is the only one who receives the extra income for each treatment. We use a broken line to separate each segment (a new match). We can observe that in most periods, subjects in treatment m = 3 transfer the highest amount, followed by treatment m = 1, and subjects in treatment m = 2 transfer the least in most periods. Comparing each segment of the same treatment, the trend may not be strong, but Figure 3 suggests a downward trend in average transfers.[5] We will use a regression analysis to confirm this finding in the following subsection.

4.3 Regression Analysis

We now proceed to analyze the determinants of the transfer amounts. Following Charness and Genicot (2009), and given the censored nature of the transfers, we use random-effects Tobit regressions (in addition to standard and clustered Tobit regressions) to account for unobserved individual characteristics and multiple observations for each subject.

Table 4 presents the results of three different regressions using transfers in all cases as independent variables. Table 5 reports the same three regressions, using only transfers made by a subject who receives the extra income while the counterpart does not, as independent

[5] Subjects may believe that there are fewer periods left to play, when playing longer. Given this belief, the benefits of sharing are lower and thus would result in a decrease in the transfer amount.

variables.[6] We present seven results from these two tables. First, our regressions are robust with different regressions. The random-effects Tobit regressions provide slightly different results from the other two regressions in that some of the subjects' characteristics become statistically insignificant.

Table 4. Determinants of transfer in all cases

	(1) Standard	**(2) Clustered**	**(3) RE**
m = 1	20.12***	20.12***	21.03***
	(0.892)	(0.940)	(4.485)
m = 3	8.581***	8.581***	12.61***
	(0.896)	(0.913)	(4.490)
Invest	-0.173***	-0.173***	-0.254
	(0.0308)	(0.0329)	(0.157)
Male	0.0622	0.0622	-0.567
	(0.763)	(0.770)	(3.995)
Correct CRT	-2.774***	-2.774***	-2.979**
	(0.251)	(0.256)	(1.292)
Other's 1^{st} transfer	1.665***	1.665***	0.943***
	(0.0627)	(0.0850)	(0.0624)
Other's 1^{st} transfer | h	-1.167***	-1.167***	-0.615***
	(0.0613)	(0.0823)	(0.0605)
Segment period	-0.669***	-0.669***	-0.688***
	(0.0713)	(0.0721)	(0.0665)
Constant	-19.79***	-19.79***	-15.00***
	(1.182)	(1.229)	(5.245)

Notes: 1. ∗, ∗∗, and ∗∗∗ indicate significance at the 10%, 5%, and 1% levels, respectively.
2. Standard errors clustered by subject are shown in parentheses.
3. *m* = 2 is the base category.
4. The number of observations is 19,260, and the number of subjects is 180.

Second, given all outcomes, subjects in treatment *m* = 1 transfer the most, followed by subjects in treatments *m* = 3 and *m* = 2, respectively. However, when we consider only the outcome in which a subject is the only player who receives the extra income, we observe higher transfers in treatment *m* = 3. These results confirm the findings in Tables 2 and 3, which suggest that subjects are more willing to help each other when face income fluctuation together.

Third, subjects who are more risk averse transfer more; this result confirms our theoretical prediction. The coefficients on "Invest" (the amount invested in the risky investment) are negative in all specifications and statistically significant in specifications (1), (2), (4), and (5).

[6] The results of using transfers given three other outcomes as independent variables are reported in Appendix A.

Subjects who invest more in the risky investment are less risk averse and transfer less, as predicted by the model.

Table 5. Determinants of transfer from a player who is the only one receiving extra income

	(4) Standard	(5) Clustered	(6) RE
m = 1	7.610***	7.610***	10.68*
	(1.347)	(1.491)	(5.485)
m = 3	17.98***	17.98***	22.60***
	(1.670)	(1.678)	(5.548)
Invest	-0.262***	-0.262***	-0.163
	(0.0472)	(0.0510)	(0.193)
Male	4.436***	4.436***	3.154
	(1.205)	(1.222)	(4.915)
Correct CRT	0.716*	0.716*	0.993
	(0.391)	(0.397)	(1.588)
Other's 1^{st} transfer	1.833***	1.833***	1.053***
	(0.148)	(0.197)	(0.124)
Other's 1^{st} transfer | h	-1.150***	-1.150***	-0.640***
	(0.147)	(0.194)	(0.122)
Segment period	-0.662***	-0.662***	-0.665***
	(0.111)	(0.113)	(0.0898)
Constant	-2.011	-2.011	0.447
	(1.863)	(1.841)	(6.447)

Notes: 1. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.
2. Standard errors clustered by subject are shown in parentheses.
3. *m* = 2 is the base category.
4. The number of observations is 5,818, and the number of subjects is 180.

Fourth, when they are the only player who receives the extra income, males transfer more than females. Specifications (4) and (5) in Table 5 show that males transfer 4.4 units more than females when they are the only players who receives the extra income, and the difference is statistically significant. However, when we consider all outcomes, as in Table 4, the difference is not statistically significant. These results are consistent with the findings by Charness and Genicot (2009) that males engage more in risk sharing than females do.

Fifth, subjects who answer more CRT questions correctly transfer less when considering all outcomes but transfer more when they are the only players who receive the extra income. CRT consists of five questions with apparently easy, but incorrect, answers. Answering correctly requires more deliberative thinking; see Part 2 of Appendix C for the questions. Frederick (2005) proposed the test to measure an individual's propensity to use System 1 ("quick") or System 2 ("deliberative") thinking; see Kahneman (2011) and Stanovich and West (2000) for more details on this dual-system theory. The results show that subjects who are more deliberative thinkers are more consistent with the theory; they transfer more funds when they earn more income than their counterparts do. These results suggest that informal risk sharing may require deliberation in order to understand and engage in it.

Sixth, subjects transfer more when their counterparts also transfer more, which suggests that risk sharing requires reciprocity. The coefficients on "Other's 1st transfer" (the counterpart's transfer in the first period of the segment) are significantly positive in all specifications. Since risk sharing requires a reciprocal response, subjects respond positively to their counterparts' transfers as predicted by the theory. Interestingly, the coefficients in most specifications are greater than 1, which indicates that when their counterparts transfer one unit more, subjects increase the transfers by more than one unit. The coefficients on "Other's 1st transfer | h" (the dummy whether the counterpart receives the extra income in the first period of the segment) are significantly negative in all specifications. This indicates that subjects expect more transfers from their counterparts if the subjects receive the extra income than otherwise.

Seventh, subjects transfer less over time. We observe significantly negative coefficients on "Segment period" in all specifications. This could be because subjects believe that there are fewer periods left to play in later periods of each segment. Given this belief, the benefits of sharing are lower and thus would result in a decrease in the transfer amount.

Table 6. Determinants of first-period transfer from a player who is the only one receiving extra income

	(7) Standard	(8) Clustered	(9) RE
m = 1	19.77***	19.77***	18.93***
	(2.769)	(2.885)	(6.118)
m = 3	25.50***	25.50***	26.40***
	(2.915)	(2.775)	(6.160)
Invest	0.0106	0.0106	0.0199
	(0.0994)	(0.107)	(0.215)
Male	3.608	3.608	3.277
	(2.514)	(2.555)	(5.470)
Correct CRT	1.212	1.212	0.973
	(0.815)	(0.820)	(1.769)
Constant	5.365	5.365*	5.331
	(3.304)	(3.128)	(7.139)

Notes: 1. $*$, $**$, and $***$ indicate significance at the 10%, 5%, and 1% levels, respectively.
2. Standard errors clustered by subject are shown in parentheses.
3. m = 2 is the base category.
4. The number of observations is 1,526, and the number of subjects is 180.

Table 6 presents the same three regressions using the same independent variables as Table 5 (transfers made by a subject who receives the extra income while the counterpart does not) but only with the first period of such an outcome in each segment. Specifications (7), (8), and (9) confirm the treatment effects that subjects in treatment m = 3 transfer the most, followed by subjects in treatments m = 1 and m = 2, respectively. However, all other coefficients are not statistically significant; this could be because the number of observations from the first period alone is small.

5 Altruistic Behavior

Our experimental results show that subjects engage more in risk sharing in the treatment with a positive correlation than predicted by the theory. We hypothesize that when subjects develop social ties from facing the same income fluctuation together, they are willing to share more, even though they have a low possibility of future interactions.[7] This section incorporates altruism in the model to explain the experimental results. In the model, suppose that both players are altruistic. Player i's utility in period t is

$$v\left(w_{i,t}, w_{-i,t}\right) = u\left(w_{i,t}\right) + \gamma u\left(w_{-i,t}\right), \tag{14}$$

where $\gamma \in [0,1)$. This functional form is used in the context of risk sharing in Foster and Rosenzweig (2001), Lin et al. (2014), and Bourlès et al. (2017). It follows that

$$V_{t+1}^{rsa} = \left(\frac{\delta}{1-\delta}\right)\left[\frac{(m-1)}{2m}v(H,H) + \frac{1}{2m}v(H-x, L+x) + \frac{1}{2m}u(L+x, H-L) + \frac{(m-1)}{2m}u(L,L)\right] \tag{15}$$

and

$$V_{t+1}^{aut} = \left(\frac{\delta}{1-\delta}\right)\left[\frac{(m-1)}{2m}v(H,H) + \frac{1}{2m}v(H,L) + \frac{1}{2m}v(L,H) + \frac{(m-1)}{2m}v(L,L)\right]. \tag{16}$$

We find that

$$v(H-x, L+x) + V_{t+1}^{rsa} \geq v(H,L) + V_{t+1}^{aut} \tag{17}$$

if and only if

$$\frac{\Delta^L(x) - \Delta^H(x)}{\Delta^H(x) - \gamma\Delta^L(x)} \geq \frac{2m(1-\delta)}{\delta(1+\gamma)} \tag{18}$$

[7] There are studies that show a relationship between social identity and reciprocity. See, for example, Buchan et al. (2002) and Tanis and Postmes (2005).

or, equivalently,

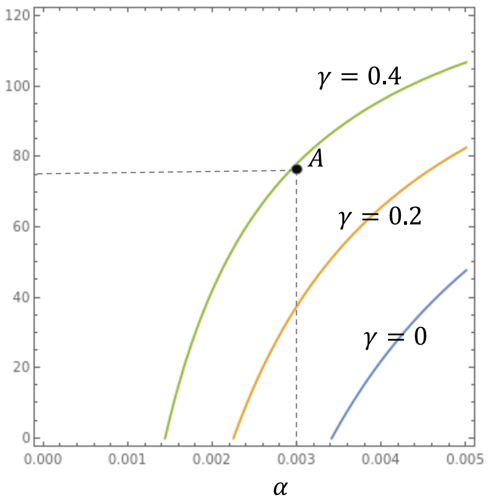
$$\delta \geq \frac{2m[\Delta^H(x)-\gamma\Delta^L(x)]}{(2m-1)[\Delta^H(x)-\gamma\Delta^L(x)]+[\Delta^L(x)-\gamma\Delta^H(x)]} \equiv \hat{\delta}(x,m,\gamma). \quad (19)$$

To guarantee the possibility that the constraint is satisfied, we assume that γ is not too large, i.e.,

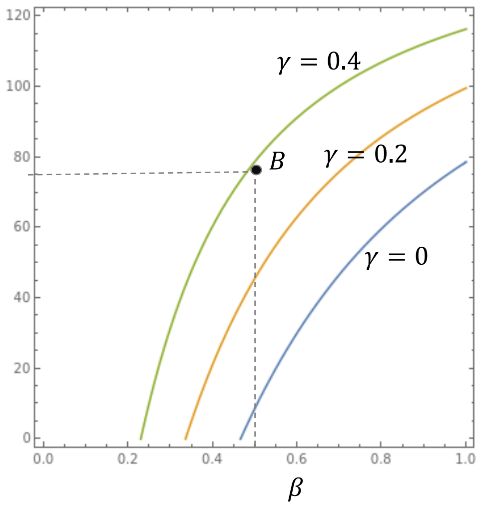
$$\gamma < \frac{\Delta^H(x)}{\Delta^L(x)}. \quad (20)$$

This condition is also assumed in Lin et al. (2014). We find that $\bar{\delta}(x,m) = \hat{\delta}(x,m,\gamma)$ given $\gamma = 0$, $\hat{\delta}(x,m,\gamma) < 1$ for any strictly concave $u(w)$, and $\hat{\delta}(x,m,\gamma)$ is increasing in m and decreasing in γ.

We believe that social ties exist in treatment $m = 3$, because the probability that both players receive the same amount of extra income is 2/3. The fact that they went through thick and thin together more than half the time would create a sense of comradery between them and, as a result, encourage altruistic behavior in the game. In Figure 5, we plot the maximum sustainable transfer for CARA and CRRA players, given $\delta = 0.9$, with the altruistic parameter $\gamma = 0.2$ and 0.4 contrasting the case where players are selfish (i.e., $\gamma = 0$). We find that, given $\gamma = 0.4$, the first-best allocation with a transfer of 75 from a high-income player to a low-income player can be achieved for a CARA player with $\alpha = 0.003$ or a CRRA player with $\beta = 0.5$, but not for their selfish counterpart (See points *A* and *B*).



(a) CARA



(b) CRRA

Figure 5. Maximum sustainable transfer in equilibrium, given $m = 3$ and $\delta = 0.9$.

6 Discussion and Concluding Remarks

In an infinitely repeated game setting, we show theoretical results and experimental evidence that support risk sharing without commitment. Subjects in the laboratory transfer more often and with a larger amount when they receive extra income and their counterparts do not. These positive transfers from the one with more income to the other with less income help smooth both players' payoffs over time. As predicted by the theory, we find that more risk-averse subjects engage more in risk sharing by transferring more funds to their counterparts than those who are less risk averse do. We also observe reciprocity between subjects; subjects transfer more funds after their counterparts made a larger transfer to them. In line with Charness and Genicot (2009), we observe more transfers by males than females. We also find that risk sharing requires deliberative thinking, since subjects who answer more CRT questions correctly engage more in risk sharing.

The main goal of our theoretical model and experimental design is to investigate the effects of income correlation on the possibility and amount of risk sharing. Since the benefit of risk sharing arises when a high-income player makes a transfer to a low-income player, they will be less likely to participate in risk sharing if the probability that both players receive the same amount of income in each period is high. Thus, in theory, we expect a negative relationship between the correlation of incomes and the possibility (as well as the amount) of risk sharing. We test this prediction using a laboratory experiment with three treatments: negative, zero, and positive correlations.

In contrast to the theory, which predicts the lowest level of risk sharing in the treatment with a positive correlation, we observe that subjects in that treatment transfer the most often and with the highest amount. To explain this result, we include directed altruism as a determinant of risk sharing in the theoretical model. We hypothesize that this directed altruism is high among subjects who face similar income shocks, stick together through thick and thin; and eventually create a common social identity.

Our study provides evidence that income correlation plays an important role in informal risk sharing. The results suggest that informal risk sharing can be successful among a group of individuals who face similar shocks because of directed altruism induced by their social identity, despite a low probability of future interactions that allow reciprocity. Future studies could directly investigate the relationship between other sources of social identity and risk sharing. Others may evaluate the crowding-out effect of formal insurance on informal risk sharing (see Lin et al., 2014, and Lin et al., 2020) under different correlation coefficients.

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Appendix A: Additional Tables

Table A1. Determinants of transfers when the counterpart is the only player who receives extra income

	(1) Standard	(2) Clustered	(3) RE
m = 1	12.68***	12.68***	12.79***
	(0.913)	(0.947)	(3.503)
m = 3	5.747***	5.747***	7.667**
	(1.127)	(1.131)	(3.559)
Invest	-0.120***	-0.120***	-0.279**
	(0.0302)	(0.0317)	(0.124)
Male	0.520	0.520	-1.013
	(0.750)	(0.771)	(3.107)
Correct CRT	-2.886***	-2.886***	-2.905***
	(0.255)	(0.261)	(1.009)
Other's 1^{st} transfer	0.962***	0.962***	0.546***
	(0.0881)	(0.124)	(0.0760)
Other's 1^{st} transfer | h	-0.752***	-0.752***	-0.416***
	(0.0870)	(0.122)	(0.0747)
Segment period	-0.280***	-0.280***	-0.325***
	(0.0708)	(0.0703)	(0.0599)
Constant	-13.81***	-13.81***	-9.089**
	(1.232)	(1.268)	(4.113)

Notes: 1. ∗, ∗∗, and ∗∗∗ indicate significance at the 10%, 5%, and 1% levels, respectively.
2. Standard errors clustered by subject are shown in parentheses.
3. m=2 is the base category.
4. The number of observations is 5,818, and the number of subjects is 180.

Table A2. Determinants of transfers when both players receive extra income

	(1) Standard	(2) Clustered	(3) RE
m = 3	13.41***	13.41***	16.45***
	(1.825)	(1.882)	(6.126)
Invest	-0.145*	-0.145*	-0.218
	(0.0812)	(0.0836)	(0.268)
Male	-5.544***	-5.544***	-3.484
	(1.889)	(1.883)	(6.630)
Correct CRT	-6.632***	-6.632***	-6.376***
	(0.624)	(0.609)	(2.127)
Other's 1^{st} transfer	1.850***	1.850***	1.165***
	(0.110)	(0.179)	(0.102)
Other's 1^{st} transfer | h	-1.230***	-1.230***	-0.801***
	(0.106)	(0.169)	(0.0958)
Segment period	-0.945***	-0.945***	-0.900***
	(0.178)	(0.184)	(0.149)
Constant	-17.70***	-17.70***	-14.11*
	(2.909)	(3.043)	(8.506)

Notes: 1. ∗, ∗∗, and ∗∗∗ indicate significance at the 10%, 5%, and 1% levels, respectively.
2. Standard errors clustered by subject are shown in parentheses.
3. m=2 is the base category.
4. The number of observations is 3,818, and the number of subjects is 120.

Table A3. Determinants of transfers when no player receives extra income

	(1) Standard	(2) Clustered	(3) RE
m=3	4.354***	4.354***	6.086**
	(0.911)	(0.929)	(2.882)
Invest	-0.0136	-0.0136	-0.167
	(0.0406)	(0.0389)	(0.127)
Male	-1.972**	-1.972**	-1.943
	(0.955)	(0.968)	(3.108)
Correct CRT	-2.654***	-2.654***	-2.569**
	(0.315)	(0.326)	(1.001)
Other's 1st transfer	1.180***	1.180***	0.772***
	(0.0580)	(0.0711)	(0.0550)
Other's 1st transfer | h	-0.996***	-0.996***	-0.618***
	(0.0550)	(0.0664)	(0.0507)
Segment period	-0.264***	-0.264***	-0.339***
	(0.0894)	(0.0892)	(0.0799)
Constant	-15.38***	-15.38***	-12.05***
	(1.497)	(1.717)	(4.030)

Notes: 1. $*$, $**$, and $***$ indicate significance at the 10%, 5%, and 1% levels, respectively.
2. Standard errors clustered by subject are shown in parentheses.
3. m = 2 is the base category.
4. The number of observations is 3,806, and the number of subjects is 180.

Appendix B: Instructions

Welcome to our experiment. For showing up on time, we will pay you a $7.50 show-up fee. There will be two parts to the experiment. Today's session will take no more than 75 minutes.

Experiment 1

In this experiment, you will receive 50 points. You will be asked to choose a portion of this amount (between 0 points and 50 points, inclusive) that you wish to invest in a risky option. The rest of the points (those you don't invest) will be kept in your balance.

<u>The risky investment</u>: There is a 50% probability that the investment will fail. If the investment fails, you lose the amount you invested. If the investment succeeds, you receive 2.5 times the amount invested.

<u>How do we determine whether the risky investment succeeds</u>? You are asked to choose **Heads** or **Tails**. After all the experiments, the experimenter will flip a coin. Your investment succeeds if the outcome of the coin flip matches your choice.

You will receive additional earnings with a conversion rate of 15 experimental units to one cash dollar. You will learn the outcome of this experiment only after you complete both parts of experiments.

You can enter the amount of points you want to invest; the program will calculate your potential earnings in the two scenarios: when the investment fails and when the investment succeeds.

Experiment 2

The body of this experiment is comprised of a number of <u>segments</u>. In each of these segments, each participant will be randomly matched with one other person and randomly assigned a color, either red or blue. The person you are matched with is called your counterpart. The color assigned to you will be different from the color assigned to your counterpart.

Each segment is comprised of an uncertain number of <u>periods</u>. The number of periods in a segment is determined as follows:

- After each period, the computer will randomly select a number from 1, 2, …, 10 for the entire session, to see whether another period will follow.
- If the selected number is from 1, 2, …, 9, the next period will follow. If the selected number is 10, the segment will end.
- There is a 90% chance that another period follows, and a 10% chance that the segment ends immediately. With this continuation probability, the expected number of subsequent periods in a segment, at any point in time, is 9.
- When the segment ends, all participants will be randomly rematched with different participants for the next segment. The color assigned to you in the next segment may or may not be different from that in the current segment.

There are two <u>stages</u> to each period.

In stage 1, you and your counterpart each will receive an initial income of 75 units and a possibility to receive an extra income of 150 units. Whether you or your counterpart will receive the extra income is determined as follows:

[Only in Treatment m = 1]

- There are 60 balls in a box; 30 are red and 30 are blue.
- After all participants click the "Begin" button, the computer will randomly select a ball, and the color of the selected ball for the period will be revealed to all participants.
- If the ball selected is red, only the red player will receive the extra income.
- If the ball selected is blue, only the blue player will receive the extra income.

[Only in Treatment m = 2]

- There is a box for each player, with 60 balls in each of them.
- In the Red player's box, there are 30 red and 30 white balls.
- In the Blue player's box, there are 30 blue and 30 white balls.
- After all participants click the "Begin" button, the computer will randomly select a ball from each box, and the color of the selected balls for the period will be revealed to all participants.
- If the selected ball from the Red player's box is red, the Red player will receive the extra income. If the selected ball is white, the Red player will not receive the extra income.
- If the selected ball from the Blue player's box is blue, the Blue player will receive the extra income. If the selected ball is white, the Blue player will not receive the extra income.

[Only in Treatment m = 3]

- There are 60 balls in a box; 10 are red, 10 are blue, 20 are gray, and 20 are white.
- After all participants click the “Begin” button, the computer will randomly select a ball, and the color of the selected ball for the period will be revealed to all participants.
- If the selected ball is red, only the red player will receive the extra income.
- If the selected ball is blue, only the blue player will receive the extra income.
- If the selected ball is gray, both players will receive the extra income.
- If the selected ball is white, neither player will receive the extra income.

In stage 2, you and your counterpart each will be notified whether you received the extra income of 150 units in stage 1. Now, you and your counterpart simultaneously decide on transfers to the other person. You will know the amount that your counterpart transfers to you after you have chosen the amount of your transfer to him or her. The history of incomes and transfers in each period will be available on your screen.

The amount that you can transfer to your counterpart is any value from 0 to the total income that you received in stage 1, i.e., 225 units if you received the extra income, and 75 units if you did not. Type in the transfer amount and click the “Continue” button. The net income for the period will be revealed after both you and your counterpart have clicked the “Continue” button. Suppose you transfer X units to your counterpart, while he or she transfers Y units to you. Then, your net income for this period is 225 – X + Y units if you received the extra income, and 75 – X + Y units if you did not.

At the end of the experiment, only one period will be chosen at random for payment. Even though you will be involved in many periods, we wish to make it clear that only one of these periods will be chosen at random for conversion to real dollars, at the rate of 15 experimental units to one cash dollar.

At the end of the experiment, the $7.50 show-up fee, the earnings from each part of the experiment, and the total amount of your earnings will appear on your screen. We will distribute receipts forms for participants to sign. We will pay you individually and privately.

Appendix C: Survey Questions

Part 1

1. How often did you make a transfer to your counterpart?

   - Always
   - More than half of the time
   - Less than half of the time
   - Never - skip questions 2 - 3 and answer only question 4.

2. Please rank the following information, from most important (1) to least important (6), about your decision whether or not to make a transfer in a given period.

	(1)	(2)	(3)	(4)	(5)	(6)
Whether or not you received the extra earning in that period						
Whether or not your counterpart received the extra earning in that period						
History of your extra earnings						
History of your counterpart's extra earnings						
History of your transfers						
History of your counterpart's transfers						

3. Any other information (in addition to the above) that you used when you decided whether or not to make a transfer? ____

4. If you answered "Never" in question 1, please explain why you did not make any transfers in the experiment. Otherwise, skip this question and click the "Next" button.

____

Part 2

1. A bat and a ball cost $1.10 in total. The bat costs a dollar more than the ball. How much does the ball cost? ________ cents.
2. If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets? _________ minutes.
3. In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake? ______ days.
4. If John can drink one barrel of water in 6 days, and Mary can drink one barrel of water in 12 days, how long would it take them to drink one barrel of water together? ______ days.
5. Jerry received both the 15th highest and the 15th lowest mark in the class. How many students are in the class? ______ students.

Part 3

1. Gender
   - ○ Male
   - ○ Female
2. Age ______
3. Classification
   - ○ Freshman (0-30 hours)
   - ○ Sophomore (31-60 hours)
   - ○ Junior (61-90 hours)
   - ○ Senior (91+ hours)
4. Major(s) ______