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Causes and Effects of Wealth Inequality : visibility leads to a tradeoff between social mobility and wealth satisfaction

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Abstract

Although the disparity of wealth is one of the most important topics in the modern world, our literature review shows little empirical or theoretical study examining its cause at the micro level. In the present study, by designing an economic experiment based on the investment (private goods provision) game, we focus on the effect of various economic information on the wealth accumulation by manipulating its visibility. Our main findings follow: first, when participants' wealth distribution is visible, and the endowment of investment is carried over, people, especially the disadvantaged, are more likely to invest; second, the active investment enables people to move frequently in the economic hierarchy of the group; and finally, people are less satisfied with their final results or wealth when the wealth distribution is visible. It may follow that an important *tradeoff* between social mobility and wealth satisfaction is caused by the information visibility: the more transparent the people's economic performance, the more active the investment; the more fluidly people move in social layers, the less satisfied they are with their economic position.

JEL codes: C72, C91, C92, M54

Keywords: Disparity, Wealth, Investment game, Experiment, Information.

Declarations

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Code availability: All syntax of R (version 3.6.1) used in this study are included in the Supplementary Information files.

Authors' contributions: K.S., Y.K., H.O., & A.G designed the research and performed the experiment. K.S. and Y.K. wrote the paper, K.S. and H.O. analyzed the data, Y.K. was in charge of the theoretical part, and A.G implemented the experiment using oTree. All authors interpreted the results and reviewed the manuscript.

1. Introduction

Although the number of people living below the lowest poverty line (US$1.90 a day) has declined globally over the last few decades, income and wealth disparity between and within countries is widening (World Bank Report 2015; World Disparity Report 2019). In cross-sectional analyses, the disparity is significantly correlated with infant mortality (positively), murder rate (positively), life expectancy (negatively), and there is some evidence that this relationship is causal (Wilkinson and Pickett 2006). It is not hard to imagine that the disparity has a great impact on economy; on the one hand, if the disparity arises from the protection of vested interests, people will lose incentive to engage in sound economic activity, and excessive disparity will lead to social instability; on the other hand, if people's productivity is not reflected in the difference in revenue, people will lose incentive for efficient economic activities. Because income or wealth disparity affect individuals multidimensionally in health, economic, political, and social spheres, numerous attempts have been made by scholars in various disciplines to examine the effects on the *individual*. Surprisingly, few studies have so far been made to investigate its cause from the *micro* (*individual*) level.

Wealth or income disparity have been traditionally studied in regard to their distribution in the growth and business cycle theory of macroeconomics, but the disparity has been determined among *aggregated* macroeconomic players, such as firms, households, and governments. Over the last 40 years, macroeconomists have developed their novel tools and methodology by constructing the micro-foundations of the models: particularly, in models based on "representative individuals," in which their rational expectations are taken very seriously, and these models are dynamic (in either a backward- or forward-looking sense). A micro-foundation of macroeconomics could open a field of experimental macroeconomics, and surveys of experimental macroeconomics are found in Duffy (2005). Because the macroeconomic model is based on “representative individuals,” each sector–household, firm, and government—is assumed to comprise only one player. Hence, it is difficult to clarify how the wealth disparity is born by the interaction among individual economic players.

In regard to microeconomics and game theory, there are also very few theoretical models that focus on dynamics of income or wealth disparity—its occurrence, expansion, and contraction—possibly because in microeconomics disparity is always only a reflection of different marginal productivities of economic players and the accumulation path is not the main target of analysis. In general, there is a dearth of research or experiment on the disparity of wealth; the only exception is the experimental research based on the public goods provision game. For instance, Nax et al. (2018) showed that the so-called tradeoff between efficiency and equality did not occur as predicted by microeconomics: if a “contribution-based competitive grouping” works precisely, it increases both efficiency and equality. Nishi et al. (2015) demonstrated that disparity increases more greatly when the disparity of initial resource allocation is known among players than when it is not.

Both Nax et al. (2018) and Nishi et al. (2015) provide interesting insights concerning wealth disparity; however, in their experiments, the disparity only arises from differences in players’ contributions to public goods. Of course, since wealth consists of public and private goods, it is necessary to also consider a mechanism of private goods accumulation and its impact on the disparity when analyzing the dynamics of wealth disparity. This is why we chose the investment (i.e., private goods provision) game instead of a public goods game as the theoretical base of our experiment. The investment game (Hamada 2003 2004) shows how the wealth distribution, produced by individual investment choice in an iterated game, changes according to "with or without" cumulative wealth (for detail see Section 2). Our study and those mentioned above are expected to produce complementary knowledge such that they can significantly contribute to disparity research[1].

To examine the mechanism of private goods accumulation, we particularly manipulate visibility of participants' wealth information in this study. Development of the internet can greatly facilitate knowledge of others' economic performance and financial results in real life; however, standard economic theory, based on rational *homo-economicus*, is not interested in the influence of the mere information concerning others' wealth on economic behavior. This is because the economic player is assumed to maximize their *own* utility and to *be indifferent* to others' welfare. Hence, sizable experimental and survey research has been conducted to cover the theoretical deficit and this has suggested that the information of neighbors' benefits or expenditures could affect our economic behavior (Andreoni and Petrie 2004; Haruvy et al. 2017; Heffetz 2012; Nishi et al. 2015).

In our experiment, we manipulate graphically the visibility of participants' wealth distribution because not only in daily life, but also in the previous research, we can easily find examples in which

[1] Because the investment game is theoretically very simple, we can shed light on the cause and effect of dynamism of wealth/income disparity at the micro-level.

our economic behavior is affected by our relative position in an economic hierarchy[2]. When the participants' wealth distribution is visible, they can identify not only their wealth ranking in the group (*relative* index regarding their economic position), but also the quantitative difference in wealth between the wealthiest and their own, and that between the wealthiest and the most disadvantaged. Because the last two differences are *absolute* indexes regarding the individual's economic position in the group, it will be meaningful to determine if the relative and/or absolute indexes can influence their investment[3]. In addition, we have good reason to expect that the difference in wealth between the richest and their own can affect the individual's investment behavior; the importance of "imitation," long recognized by social scientists and psychologists—for an early example, see Miller and Dollard (1941)—has been recently discussed in economics. The basic idea is that individuals who are in repeated choice problems will imitate others who obtain high payoffs; this idea has been verified by some experimental data, despite only few experiments on imitation (for a meta-analysis of experimental results on imitation, see Apesteguia et al. 2007). Alos-Ferrer and Ania (2005) theoretically showed that imitation learning as a social learning can converge to an evolutionarily stable strategy over a finite population.

Our review of the literature showed that previous research principally concerns the effect of information on the contribution to public goods or consumption behavior (e.g. Heffetz 2012; Nax et al. 2018; Nishi et al. 2015) but not on investment of private goods. Our interest is to investigate how the

[2] Holmen and Kirchler (2014) show that economic rank can influence portfolio choice in laboratory experiments, using an employer–employee data set of full-time male prime-age workers in western Germany for the years 1996–2005. Pfeifer and Schneck (2012) find that workers with higher relative wage positions within their firms are more likely to quit their jobs than those with lower relative wage positions.

[3] Put intuitively, if the participant's rank was 3rd in the group, the relative rank could have a different meaning according to the distance from the 1st ranked participant and the variance of wealth in their group.

visibility of the information influences the dynamics of wealth disparity: can it enlarge the disparity and mobilize people's economic position? In this respect also, our study can provide complementary knowledge.

The remainder of the paper is organized as follows. Section 2 introduces the investment games and the experimental details. Section 3 explains the experimental design and procedure. Section 4 is the results of data analysis and findings. Finally, in Section 5, we present our conclusion. In the online supplements to this paper, we report the data and the syntax of statistical analysis used in this study.

2. Investment game and wealth disparity

In this section, we explain a simple version of the investment game developed by Hamada (2003). In this game, there are n individuals and we denote the set of individuals by $N = \{1,2,\dots,n\}$. For each $i \in N$, the wealth of individual i is denoted by W_i. From this wealth, individual i obtains B_i as interest (or an endowment of this game) and then can invest it in a risky project. The investment decision is a binary choice problem in which s/he can invest B_i $(0 < B_i < W_i)$ in the risky project or not. If the project succeeds, s/he obtains rB_i, $(r > 1)$, where r is the return rate of the project and is common to all investors. If the project fails, s/he receives nothing and loses B_i.

The investment decision of n individuals is competitive in the sense that the number of persons with success is determined by some exogenous variable, denoted by n_1 $(0 < n_1 < n)$. So, if the number of investments is greater than this limit, a random device determines successful investments.

Let P denote the set of individuals who choose the investment. If $|P|$ is greater than n_1, n_1 individuals are randomly selected from P as successful people, and the other $|P| - n_1$ individuals' investments fail. In contrast, if $|P|$ is less than or equal to n_1, all investments succeed. Thus, their payoff of this one-shot investment game is described as follows:

$$\begin{cases} W_i + B_i & \text{if } i \text{ chooses not to invest,} \\ W_i + rB_i & \text{if } i \text{ chooses to invest and succeeds, and} \\ W_i & \text{if } i \text{ chooses to invest and fails.} \end{cases}$$

If we assume the risk-neutral player, their ex-ante expected payoff is

$$\begin{cases} W_i + B_i & \text{if } i \text{ chooses not to invest,} \\ W_i + rB_i \dfrac{n_1}{|P|} & \text{if } i \text{ chooses to invest and } |P| > n_1 \text{, and} \\ W_i + rB_i & \text{if } i \text{ chooses to invest and } |P| \leqq n_1. \end{cases}$$

Apparently, this is a kind of coordination game known as a "battle of sexes" game, wherein there are multiple asymmetric pure strategy equilibria. A pure strategy equilibrium of the investment game is calculated as follows. For a risk-neutral individual, the investment is attractive if and only if $rB_i(n_1/|P|) > B_i$. Let n_2 be defined by the maximal number satisfying $rB_i(n_1/n_2) \geqq B_i$, and equivalently $n_2 = rn_1$. Then, any combination of decisions is a pure strategy equilibrium if and only if $[n_2]$ individuals choose to invest and the others choose not to. Therefore, asymmetric pure strategy equilibria of the investment game are such that some invest and the others do not, meaning that there is no loss from the coordination failure. However, attaining such a perfectly coordinated pure strategy equilibrium is extremely difficult without any communication (Cooper et al. 1989). Thus, investigating the mixed strategy equilibrium is more fruitful.

Let p_i denote the probability of individual i choosing an investment, and the mixed strategy profile is the profiles of such probabilities of n individuals. Here, we consider a symmetric mixed strategy equilibrium wherein every i follows the same mixed strategy p. Let $F(n,k)$ denote the probability such that in the mixed strategy profile $(p,p,\ldots,p)$, the number of players choosing investment is k. Mathematically, $F(n,k) = \binom{n}{k} p^k (1-p)^{n-k}$. We obtain the following proposition.

Proposition 1. Suppose that p with $0 < p < 1$ satisfies the following condition

$$\sum_{k=0}^{n_1-1} F(n-1,k) + \sum_{k=n_1}^{n-1} F(n-1,k)\frac{n_1}{k+1} = \frac{1}{r}$$

Then, mixed strategy profile $(p,p,\ldots,p)$ is an equilibrium of an investment game.

[Proof] Since at the mixed strategy equilibrium with $0 < p < 1$ (i.e., both to invest and not to invest support the mixed strategy), for each individual, the expected payoff when s/he chooses the investment should equal that when s/he chooses not to invest. The expected payoff of the former is

$$W_i + rB_i\left(\sum_{k=0}^{n_1-1} F(n-1,k) + \sum_{k=n_1}^{n-1} F(n-1,k)\frac{n_1}{k+1}\right)$$

and that of the latter is $W_i + B_i$. Equalizing these two, we obtain the condition in this proposition. [QED]

The relationship of the equilibrium investment probability p^* to exogenous variables like r and n_1 is shown in Fig. 1A and B; p^* is an increasing function only to the point where $rn_1 = n$. Once reaching $rn_1 > n$, players will most assuredly decide on investing due to the favorable condition characterized by $p^* = 1$.

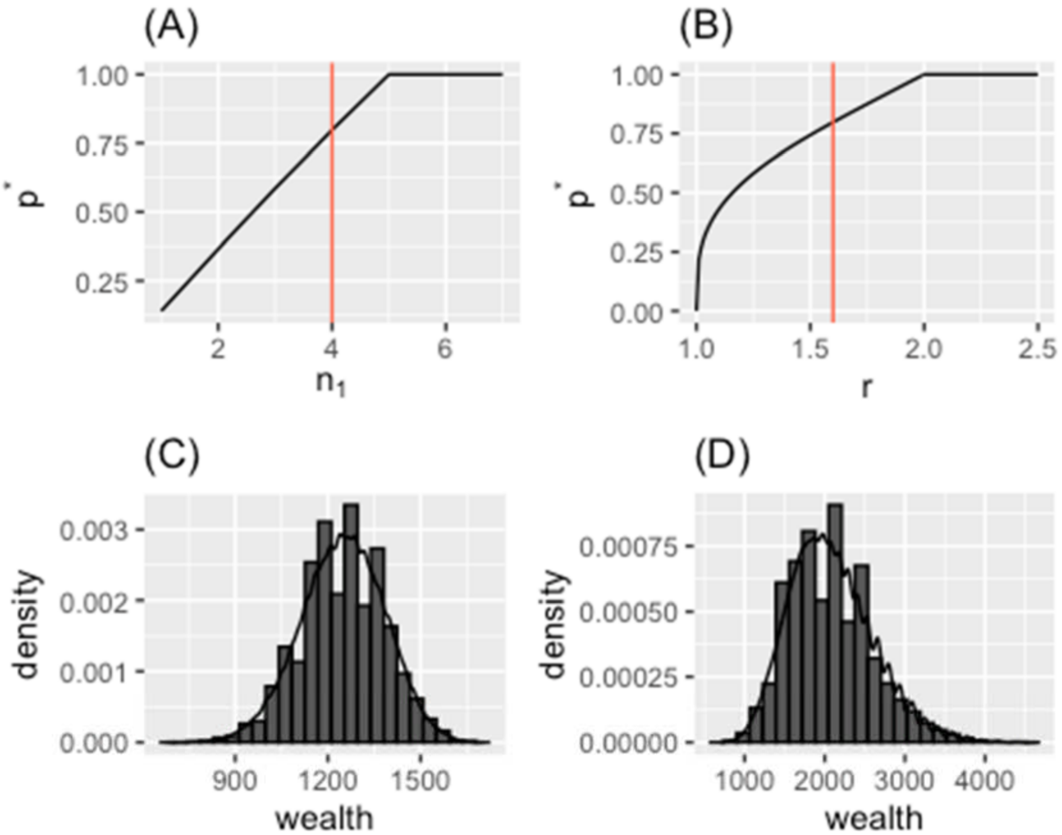


Fig. 1 How the equilibrium investment probability is related to the (A) upper limit of success ($n = 8$ and $r = 1.6$) and (B) return rate ($n = 8$ and $n_1 = 4$). The vertical red lines correspond to the experimental condition (see Section 3), implying that $p^* = 0.798$. (C) and (D) represent the simulated wealth distribution over the population after the repeated investment game when players follow the mixed strategy equilibrium under the parameters used in our experiment ($n = 8$, $n_1 = 4$, $r = 1.6$, initial wealth $= 500$, and 15 repetitions), when the (C) bet is constant across repetitions and (D) bet is proportional to the wealth level at that time. The number of instances in the simulation is 10000

An important implication of the equilibrium condition is that p^* is not affected by the endowment of investment (B_i) and wealth level (W_i), indicating that the change of these state variables does not change their behavior. This property is critically important when we consider the repeated investment game and its equilibrium. Because of this independence from the state variables, even when these state variables are changed through repetition of the investment game, their equilibrium behavior is theoretically unchanged.

We now consider the repeated investment game wherein the wealth is accumulated after the investment game. Let $W_{i,t}$ denote the wealth of individual i at the beginning of period t. The stage game during period t is an investment game for n individuals wherein r and n_1 are constant across periods but $B_{i,t}$, the bet amount of individual i at period t can be contingent on the sequence of the past wealth levels of this individual.

We consider two different situations in how $B_{i,t}$ is determined. In a fixed endowment situation, $B_{i,t}$ is constant across periods even though $W_{i,t}$ is accumulated over time. In contrast, in a carry-over endowment situation, $B_{i,t}$ is proportional to $W_{i,t}$ of this period.

Equilibrium strategy of a finitely repeated investment game with fixed endowment is simple because the game of each period (the game stage) is identical across periods and playing stage equilibrium for all periods constitutes the equilibrium of the finitely repeated game. In contrast, calculating the equilibrium of a finitely repeated investment game with carry-over endowment appears complicated because the game stages evolve across periods, depending on the results of the previous stages. However, fortunately, playing stage equilibrium for all periods constitutes the equilibrium in this case. Thus, we obtain the following proposition. Proofs are found in the Appendix A.

Proposition 2. In a finitely repeated investment game with fixed endowment, wherein r and n_1 are constant across periods, following p^* specified in Proposition 1 at each period constitutes the equilibrium strategy of this repeated game. This is true in a finitely repeated investment game with carry-over endowment.

The wealth distribution after repetition of the investment game, given the equilibrium investment probability, is shown in Fig. 1C and D. The histogram of wealth when the endowment of investment remains constant across periods, corresponding to a repeated investment game with a fixed endowment (the FxLim and FxPl conditions are explained in the Section 3) is shown in Fig. 1C.

Theoretically, the wealth distribution approaches a normal distribution when the endowment of investment is fixed across periods. However, it is natural to assume that wealth accumulation affects a bet in the investment game. The histogram of wealth when the endowment of investment increases proportional to the wealth level, corresponding to a repeated investment game with a carry-over endowment (and CoLim and CoPl conditions explained in the Section 3) is shown in Fig. 1D. It is theoretically shown that the wealth distribution approaches a log-normal distribution (Hamada 2004), which is empirically known to be similar to wealth distribution in the real world (Gibrat’s law). Thus, whether the endowment of investment is constant across periods or proportional to wealth is critical in considering wealth disparity, and is one of the manipulations of our experiment.

3. Experimental design and procedure

In this section, we describe the experimental procedure and its design.

3.1. Methods

Our experiment was conducted in accordance with approved guidelines by the Waseda University Ethical Review Board in June and November 2019. Written informed consent was obtained from all participants prior to beginning the experiment. Data were analyzed while ensuring anonymity of the participants.

3.2. Treatments

We conducted four treatments based on the investment game with eight participants by manipulating information visibility and the endowment of investment (Table 1). In every treatment, at each period, participants obtain the interest of their wealth as endowment for the investment, and decide to invest the interest or not. If they succeed, the profit from the investment is *successively* added to their wealth; if they fail, only the invested endowment (the interest) is lost, but the wealth is kept. But treatments with "carried-over endowment" (CoLim and CoPl in Table 1) and treatments with "fixed endowment" (FxLim and FxPl in Table 1) differ regarding the following point: in treatments with "carried-over endowment," they can invest a fixed proportion of the *accumulated* wealth; and in treatments with "fixed endowment," they can invest a fixed proportion of the *initial* wealth.

Regarding information, in treatments with "limited information," (FxLim and CoLim in Table 1) the participants can only know in words their own investment success/failure and the number of investors for the current period and accumulated wealth up to the current period . In treatments with "plenty of information" (FxPl and CoPl in Table 1), in addition to the information mentioned above, they can see the wealth distribution of their group in a graph, in which the vertical axis indicates the number of people, and the horizontal axis represents their accumulated wealth up to the current period. The graph also shows various information about wealth, for example, their own rank in the group, disparity of wealth in the group, and wealth of every participant. For pictures of the information screen in the experiment, please see Appendix B. In every treatment, there were 15 repetitions of the investment game.

Table 1 Names of treatments and experimental settings

Names of treatments	Investment fund	Information about wealth	Number of subjects

FxLim	Fixed	Limited information	40 (5 groups)
FxPl	Fixed	Plenty of information	32 (4 groups)
CoLim	Carried over	Limited information	32 (4 groups)
CoPl	Carried over	Plenty of information	48 (6 groups)

Note: $n = 8$, $n_1 = 4$, $r = 1.6$, and 15 repetitions. Theoretical prediction is $p^* = .798$. Please also refer to Fig. 1 for the theoretical wealth distributions after the game.

3.3. Participants

In total, 152 university students participated in this experiment: 40 (five groups) participated in the FxLim condition, 32 (four groups) in FxPl, 32 (four groups) in CoLim, and 48 (six groups) in CoPl. Participants were recruited via a university portal website, and monetary reward was emphasized during recruitment.

3.4. Procedure

In all conditions, participants were assigned to laboratory booths to ensure their anonymous and independent decisions. Eight people respectively participated in each session of the experiment of FxLim, FxPl, CoLim, and CoPl. After reading explanations on a computer screen constructed using oTree (Chen et al. 2016), participants completed confirmation tests concerning their understanding of the experiment's details. Neutral words were selected for explanation. After confirming that all participants understood the experimental details, we ran one trial period and then participants started the real session. Details of the experimental transactions follow.

In every treatment, participants were given the same initial wealth (500 points) and, for the first period, they decided whether or not to invest 10% of the wealth (50 points); the 50 points can be considered interest from the initial wealth of 500. If they succeeded, they received 1.6 times the invested amount (1.6 × 50 = 80 points), otherwise they lost the invested amount. When the number of investors was four or less, every investor succeeded. If the number of investors exceeded four, four winners were randomly determined among them.

For each of periods 2–15, in CoLim and CoPl, treatments with "carried-over endowment," they could decide to invest 10% of the *accumulated* wealth or not (binary choice); and in FxLim and FxPl, treatments with "fixed endowment," they could *always* decide to invest 10% of the initial wealth or not, 500 × 0.1 = 50 points (binary choice). For example, in CoLim and CoPl, if the investment failed in period 4, the endowment invested in this period was lost; however, for the next period, participants could restart and decide whether to invest or not 10% of the wealth accumulated up to period 3; in FxLim and FxPl, they would decide whether to invest or not 50 points at the next period. It is worth pointing out again that the equilibrium investment probability is affected neither by the endowment of investment nor wealth level; the equilibrium remains identical among four conditions: FxLim, FxPl, CoLim, and CoPl. After the investment game experiment, all participants were asked about their satisfaction with the final result (see Section 4.3 for detail).

Each session took an average of approximately 60 minutes. The total attained points were converted to money using the fixed rate. In addition, a 800-yen show-up fee was given to participants who completed the experiment. Average remuneration was around 2000 yen (100 yen is approximately 1 US dollar).

4. Results and findings

In this section, using results of statistical analysis, we claim that people are more likely to invest in CoPl than in the other three treatments. Therefore, people can change their rank more fluidly in CoPl than in CoLim, and plenty of information can reduce people's satisfaction with their final wealth.

4.1. Performance of the four treatments

As the theory predicted, the distribution of accumulated wealth has longer right tails and higher variances in CoLim and CoPl than in FxLim and FxPl (Fig. 2). The Gini indexes are also higher in CoLim and CoPl than in FxLim and FxPl. Additionally, mean and the variance of wealth increase more rapidly with time in CoLim and CoPl than in FxLim and FxPl (Fig. 3-1 and 3-2). Both CoLim and CoPl show similar trends of wealth accumulation and variance (Fig. 3-1 and 3-2).

The results shown in Fig. 3-1 and 3-2 can be naturally expected by the structure of the investment game; Fig. 4, however, suggests an interesting phenomenon that we cannot theoretically derive. In the CoPl, participants may show different investment behavior in comparison with the three other conditions; the investment seems to be holding up throughout the 15 periods compared to the other groups[4]. From Table 2, we can infer that the difference in investment behavior may be mainly because, in CoPl, low ranked people invest more actively in the next period than the other three conditions. Actually, chi-square analysis with Bonferroni correction shows that although investment behavior is significantly more frequent in CoPl than in the FxLim, FxPl, and CoLim (*p*-values of .006, .09, and <.0001, respectively), middle and high ranked people's behavior is not significantly different across all treatments (p >.10). In the next section, we analyze individual-level data to precisely examine factors that can motivate people's investment.

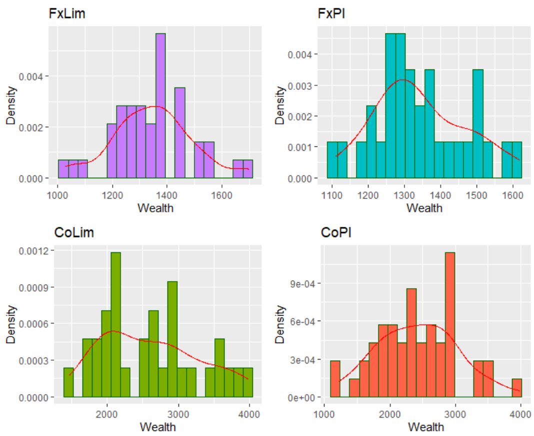
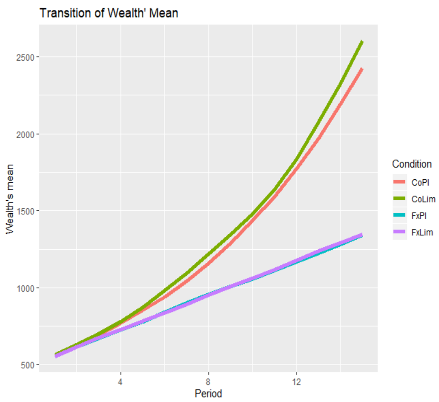


Fig. 2 Distribution of accumulated wealth

Note: Gini Index for FxLim = 0.05893354, FxPl = 0.05279119, CoLim = 0.145123, and CoPl = 0.1416309

[4] The high level of investment in CoPl, compared to the other three conditions, is not a coincidence. Statistical analysis shows that the interaction of plenty of information and the accumulated amount of investment has a significant positive effect on investment behavior. See Appendix C.



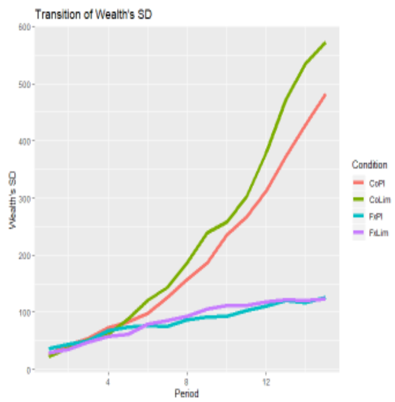


Fig. 3-1 Transition of wealth (mean) **Fig. 3-2** Transition of wealth (standard variance)

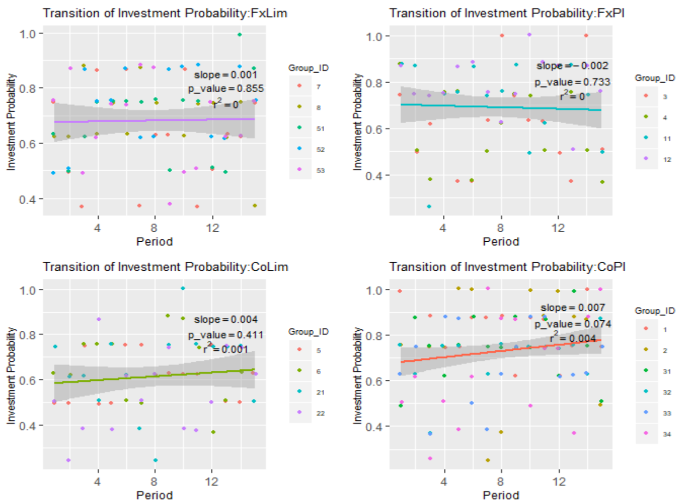


Fig. 4 Transition of investment probability

Table 2 Frequency of investment by rank in the previous period for the four conditions

FxLim				
Rank in the previous period	Investment in the next period	No investment in the next period	Sum	Investment Rate
H	44	161	205	0.79
M	49	104	153	0.68
L	84	118	202	0.58
ALL	177	383	560	0.68

FxPl				
Rank in the previous period	Investment in the next period	No investment in the next period	Sum	Investment Rate
H	46	121	167	0.72
M	35	87	122	0.71
L	63	96	159	0.60
ALL	144	304	448	0.68

CoLim				
Rank in the previous period	Investment in the next period	No investment in the next period	Sum	Investment Rate
H	41	120	161	0.75
M	38	85	123	0.69
L	93	71	164	0.43
ALL	**172**	**276**	**448**	**0.62**

CoLim				
Rank in the previous period	Investment in the next period	No investment in the next period	Sum	Investment Rate
H	68	188	256	0.73
M	43	123	166	0.74
L	69	181	250	0.72
ALL	**180**	**492**	**672**	**0.73**

Note: high rank (H), $6 \leq$ rank ≤ 8; middle rank (M), $3 <$ rank < 6; low rank (L), $1 \leq$ rank ≤ 3.

4.2. Determinants of investment

Provided that low ranked people invest more actively in the CoPl than the other three conditions, it is reasonable to examine how the interaction of information condition and accumulation type of wealth can affect the investment behavior. In the condition of plenty of information, we particularly pay attention to information that is becoming more *salient* for investors as wealth is accumulating, because investment is activated only in the CoPl. We include in our econometric model the following three main explanatory variables: the rank for the eight participants in the previous period (lowest in rank 1 and highest for rank 8) (hereafter Pre_rank), the wealth difference between the richest and each individual in the previous period (hereafter Pre_Dif_Max_Own), and the wealth difference between the richest and poorest in the previous period (hereafter Pre_Dif_Max_Min).

Individual data over 15 periods are nested in group. Thus, the individual variation is relative not only to condition differences but also to differences among groups and individuals. To investigate the determinants of investment by using repeatedly measured data (over 15 periods), we constructed various multilevel logit-regression models, which consider random intercepts for each group and individual when the coefficients are estimated.

We predict that these variables (Pre_rank, Pre_Dif_Max_Own, and Pre_Dif_Max_Min) are significant only in CoPl. In FxLim, the wealth disparity is relatively small and furthermore participants cannot know information about the disparity; in FxPl, participants can obtain information about the disparity, but because the interest is fixed, Pre-rank, Pre_Dif_Max_Own, and Pre_Dif_Max_Min are not sufficiently salient; and in CoLim, although the wealth disparity increases as time passes, participants cannot know this information. Results of multilevel regression models support our prediction (Table 3): *only* in CoPl, when the wealth gap between the top and the bottom is widened (the coefficient of Pre-Dif_Max_Min is positive) and the relative and absolute differences of the individual's position from the top are simultaneously widened (the interaction of Pre-rank and Pre-Dif_Max_Own is negative), they are more likely to invest[5].

Table 3 Determinants of investment in four treatments

[5] Because the prediction depends on our assumption that the three main explanatory variables (Pre_rank, Pre_Dif_Max_Own, and Pre_Dif_Max_Min) are getting more salient for the participants as the inequality of wealth becomes greater, we analyzed the CoPl data by separating the 15 periods into the first and second halves to check the robustness of the assumption. Our prediction is that the effects of these three variables are weakened or not significant in the first half, but are effective in the second half, because the wealth disparity accelerates after the middle of the 15 periods, and thus may be getting more salient. The result supports the assumption (see Appendix E).

		FxLim			FxPl			CoLim			CoPl	
Dependent Variable	**Investment_Dummy**			**Investment_Dummy**			**Investment_Dummy**			**Investment_Dummy**		
Predictors	*Estimates*	*Std. Error*	*p*	*Estimates*	*Std. Error*	*p*	*Estimates*	*Std. Error*	*p*	*Estimates*	*Std. Error*	*p*
(Intercept)	1.3317	.9617	.1660	.4886	1.1051	.6580	-1.0888	.9339	.2440	-1.3015	.6905	.0590
Gender	-.4794	.2154	**.0260**	-.5835	.2469	**.0180**	.0675	.2934	.8180	-.3133	.2457	.2020
Risk_seekingness	.0030	.0045	.4990	.0147	.0060	**.0150**	.0164	.0071	**.0210**	.0134	.0065	**.0390**
Period	-.0857	.0768	.2640	-.0187	.0779	.8100	-.1373	.0971	.1570	-.0543	.0772	.4820
Pre_earned	-.0048	.0039	.2090	-.0079	.0042	.0570	-.0007	.0022	.7370	.0005	.0017	.7700
Pre_investment_rate	-.3294	.6636	.6200	-.3517	.6186	.5700	.6058	.7369	.4110	.4744	.5551	.3930
Pre_Success_num	.1836	.1050	.0800	.1431	.1219	.2410	.4217	.1595	**.0080**	.2329	.1543	.1310
Pre_Participation_rate	1.0902	.4877	**.0250**	.9824	.6144	.1100	1.0630	.6899	.1230	1.4896	.5210	**.0040**
Pre_rank	-.1131	.1134	.3180	-.0122	.1394	.9300	-.0316	.1049	.7630	.1086	.0753	.1490
Pre_Dif_Max_Own	-.0058	.0034	.0950	.0010	.0050	.8430	-.0009	.0013	.5050	.0052	.0015	**<.001**
Pre_Dif_Max_Min	-.0012	.0027	.6410	-.0010	.0037	.7890	-.0009	.0009	.3530	-.0020	.0007	**.0070**
Pre_rank * Pre_Dif_Max_Own	.0001	.0005	.7990	-.0003	.0007	.6400	.0001	.0002	.5170	-.0007	.0002	**<.001**
Pre_rank * Pre_Dif_Max_Min	.0009	.0005	.0960	.0000	.0006	.9450	.0002	.0001	.2640	.0002	.0001	.0640
Random Effects												
Individual	Yes			Yes			Yes			Yes		
Group	Yes			Yes			Yes			Yes		
Observations	560.0000			448.0000			448.0000			672.0000		
R^2	.1640			.1470			.3100			.1480		
AIC	663.8990			545.2150			510.2290			736.1450		
Note: Multicoliniality does not occur among explanatry variables.												

Note: Multicollinearity does not occur among explanatory variables. Gender (dummy), if participant is male, takes 1, otherwise 0. Risk_seekingness (numeric) is measured by the number of boxes that a participant collects in "Bullet" question (for detail, see Appendix D). Period (numeric), the first period is omitted because we use several variables of the previous period. Pre_earned (numeric) is the points that participants earned in the previous period. Pre_investment_rate (numeric) is the proportion of participants who invested among eight members in the previous period. Pre_Success_num (numeric) is the number of successful investments by the previous period. Pre_Participation_rate (numeric) is the frequency of investment by the previous period.

4.3. Social mobility and information

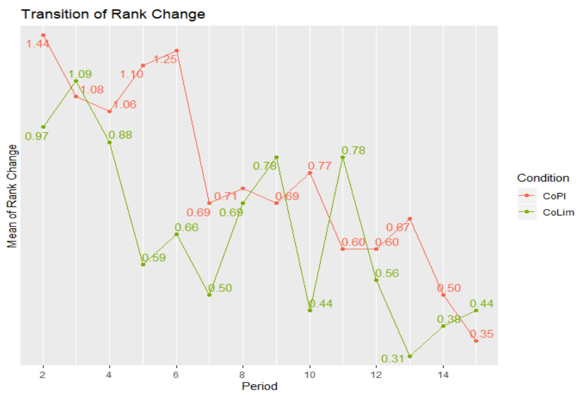
In this section, we focus on an important effect caused by the different investment behaviors of people—social mobility. The statistical analysis in the previous section suggests that during the wealth accumulation process, investment behavior differs between CoLim and CoPl; low ranked people in CoPl invest more actively that in CoLim. Hence, we expect that the rank of CoPl participants may change more frequently than for CoLim—i.e., CoPl society is more fluid than CoLim society. To examine the social mobility, we feature CoLim and CoPl, because in both treatments as well as in real society, participants can invest their accumulated profit—comparing these two treatments can give interesting insight concerning mobility in society[6].

In this analysis, we measure social mobility as a sum of the absolute difference of a participant's rank in the present period and that in the next period—i.e., rank change. If rank is 2nd in the present period and falls to 6th in the next period, the rank change is 4. If rank is 6th in the present period and rises to 3rd in the next, the rank change is 3. If the rank remains invariant, then the rank change is zero. Assuming that these three cases are concurrent in a group, then the social mobility is 7 = 3 + 4 (in Fig. 5, we take the mean of the sum: i.e., the sum divided by 8, which is the number of members in the group). A standard definition of social mobility is "movement of individuals, families, or groups through a system of social stratification" (*Encyclopaedia Britannica*), we should point out that our measure focuses only on the economic aspect.

Although people in CoPl move more actively than in CoLim for almost all of the periods (Fig. 5), the rank change becomes more difficult as time progresses because, in both treatments, the wealth disparity becomes structurally enlarged by the re-investment of accumulated profit. The t-tests reveal that in both treatments, the rank change is significantly different in the first half and the entire period (both $p < .01$), but not significantly different in the latter half ($p = .29$) (regarding the difference in each period, see the note of Fig. 5). Using Fig. 6, we can verify that in CoPl people are more likely to change rank than in CoLim. For example, nobody rises from the low to the high class or falls from the high to

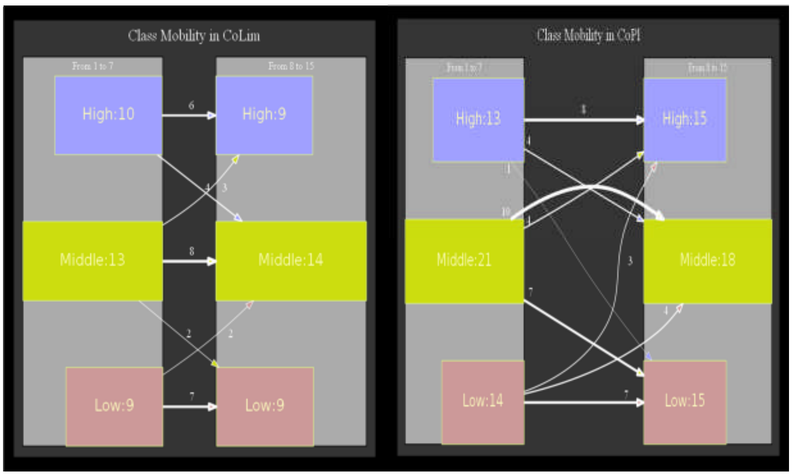
[6] Appendix F shows that the information condition does not consistently differentiate the social mobility of FxLm and FxPl.

the low class in CoLim (0 of 10 and 0 of 9, respectively) but correspondingly 3 of 14 and 1 of 13 do in CoPl. As a result, we may conclude that CoPl is more fluid than CoLim in terms of rank change.



Note: t-test shows that at periods 2, 4, 5, 10, and 13 the mean rank change of CoPl is significantly larger than that of CoLim at $p < .05$.

Fig. 5 Transition of rank change in CoLim and CoPl



Note: high rank, 6 ≤ mean rank ≤ 8; middle rank, 3 < mean rank < 6; low rank 1 ≤ mean rank ≤ 3. Each mean rank is calculated either for periods 1–7 or 8–15.

Fig. 6 Class mobility in CoLim and CoPl

4.3. Satisfaction with final wealth

The influence of comparisons with others on individual life satisfaction has long been studied, and verified especially in psychology and public health. Typically, comparison with those who are worse-off has a positive effect, and with those better off has a negative effect (e.g., Clark and Oswald 1996; Gordon et al. 2008: Walasek and Brown 2016). Based on these studies, it is worth examining whether the information condition affects participant satisfaction; in our experimental setting, participants can compare their final result to the others for CoPl and FxPl, but not for FxLim and CoLim. To examine the effect, we prepared a question asking the participants' satisfaction about their final results: "to what extent are you satisfied with your final result?" and their answers range from 1 (*not at all satisfied*) to 8 (*completely satisfied*).

The individual means of satisfaction concerning their final results according to their final rank are shown in Fig. 7. For FxLim vs FxPl, and CoLim vs CoPl (the carry-over condition is controlled), people seem more satisfied in the treatment without information than those with information. Multilevel regression analysis (Table 4) suggests that this finding is not a coincidence but that, with plenty of information, the final rank may play an important role in the effect: the final rank and its interaction with the plenty of information have negative coefficients (p = .079 and .053, respectively). Interestingly, the effect of value of final wealth itself is not significant.

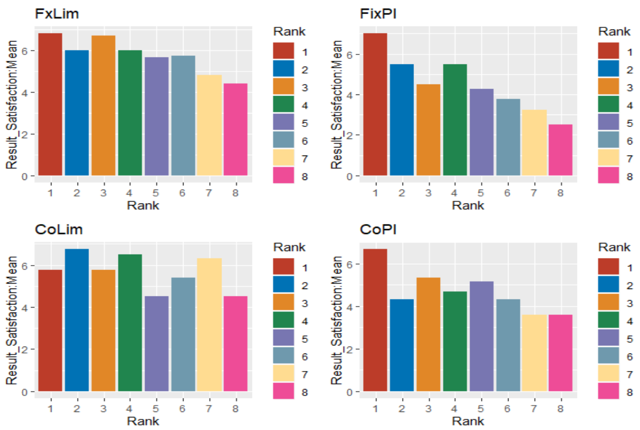


Fig. 7 Individual means of satisfaction concerning the final result

Table 4 Determinants of satisfaction concerning the final result

Dependent Variable	**Result satisfaction**		
Predictors	*Estimates*	*Std. Error*	*p*
(Intercept)	7.22	.96	**<.001**
Gender	-.24	.25	.328
Risk_seekingness	.00	.01	.886
Final Wealth	.00	.00	.584
Success_num	.20	.21	.351
Num of Inv	-.12	.14	.388
Final rank	-.23	.13	.079
PL_dummy	-.39	.58	.502
CO_dummy	-.22	1.52	.887
Final rank* PL_dummy	-.20	.10	**.053**
Final rank* CO_dummy	.11	.16	.475
PL_dummy * CO_dummy	.43	.49	.384
Random Effects			
Group	Yes		
Observations	152		
R^2	.335		
AIC	584.675		
Note: Multicoliniality does not occur among explanatry variables.			

Note: Multicollinearity does not occur among explanatory variables. Gender (dummy), if participant is male, it takes 1, otherwise 0. Risk_seekingness (numeric) is measured by the number of boxes that the participant collects in "Bullet" question (for detail, see Appendix D). Final Wealth (numeric) is the total wealth that the participant obtained. Success_num (numeric) is the total number of a participant's successful investments. Num of Inv (numeric) is the total number of a participant's investments. PL_dummy (dummy), if there is a plenty of information, it takes 1, otherwise 0. CO_dummy (dummy), if the wealth is carried over, it takes 1, otherwise 0.

In the experiment conducted in November 2019, in addition to the previous question about the final result, we prepared a question asking for the participants' satisfaction about their final wealth: "to what extent are you satisfied with your final wealth?" and their answers are spread from 1 (*not at all* *satisfied*) to 8 (*completely satisfied*). We were concerned that the term "final result" might remind the participants of something other than "final wealth." However, multilevel regression analysis of the "final wealth" also shows that the interaction of final rank and rich information negatively affects participants' satisfaction (Table 5).

Table 5 Determinants of satisfaction with final wealth

Dependent Variable	**Wealth satisfaction**		
Predictors	*Estimates*	*Std. Error*	*p*
(Intercept)	5.14	1.93	**.008**
Gender	-.54	.37	.141
Risk_seekingness	-.01	.01	.535
Final Wealth	.00	.00	.809
Success_num	.33	.47	.484
Num of Inv	-.26	.31	.393
Final rank	-.03	.23	.905
PL_dummy	1.07	.89	.233
CO_dummy	-1.39	4.16	.738
Final rank* PL_dummy	-.42	.15	**.006**
Final rank* CO_dummy	.12	.37	.742
PL_dummy * CO_dummy	.14	.89	.873
Random Effects			
Group	Yes		
Observations	88		
R^2	.465		
AIC	362.712		
Note: Multicoliniality does not occur among explanatry variables.			

Note: Multicollinearity does not occur among explanatory variables. Gender (dummy), if participant is male, it takes 1, otherwise 0. Risk_seekingness (numeric) is measured by the number of boxes that a participant collects in "Bullet" question (for detail, see Appendix D). Final Wealth (numeric) is the total wealth that a participant obtained. Success_num (numeric) is the total number of a participant's successful investments. Num of Inv (numeric) is the total number of a participant's investments. PL_dummy (dummy), if there is a plenty of information, takes 1, otherwise 0. CO_dummy (dummy), if the wealth is carried over, it takes 1, otherwise 0.

5. Conclusion and discussion

Although the disparity of wealth is one of the most important topics in the modern world, our review of the literature showed little empirical or theoretical study examining its cause at the micro level. Since the disparity of wealth has arisen by a dynamic interaction among economic players whose behavior cannot totally be covered by economic theory based on rationality, we have good reason to use an experimental approach to investigate the phenomenon. We will be very pleased if we can shed the first experimental light on this topic.

We focused on the effect of various information about participants' own and others' wealth on their investment decision making. Our main findings follow: first, for the CoPl condition, where participants can obtain plenty of information about the wealth/investment, and the endowment of investment is carried over, people, especially if low ranked, are more likely to invest than in the other three conditions. We interpret that in the CoPl, where the difference between the low and high ranked people is more salient, they imitate others who obtain higher payoffs to be better off in terms of profit. This interpretation relies on research about imitation or social learning[7].

Second, active investment in the CoPl condition enables people to move frequently in the

[7] Because "spite," which directly imposes harm on another and provides no immediate benefit to the spiteful actor, is not rare in public goods game experiments, spite is another interpretation (e.g., Cason et al. (2002)): low ranked participants may invest to decrease the success probability of better-off participants. If the spiteful behavior made people's investment active and thus a society more fluid, it suggests a counter-intuitive role of spite in human society.

economic hierarchy of the group. Last, people are less satisfied with their final results or wealth when they have plenty of information. Nax et al. (2018) and Nishi et al. (2015) suggest a negative effect of information about wealth or economic performance on the public goods provision; however, our study suggests its ambivalent effect: plenty of information can activate people's investment (private goods provision) decision, thus making a society more fluid, but reducing their satisfaction with their wealth. Although we cannot overlook the difference in the experimental settings among ours and these two previous studies, we may claim that the information can play a different role in public and private goods provision.

In our society where economic disparity is non-negligible, it has become easier to know people's economic status and performance with the global development of the internet. When the economic disparity is visible, *The Inner Level* (Wilkinson and Pickett 2019), with a deep well of data and analysis, warns that in unequal societies, people are more likely to suffer psychological stress and unhappiness; for example, low social status is intimately associated with elevated levels of depression. Since CoPl treatment is implemented with cumulative endowment of wealth and rich information concerning the wealth, it may be no exaggeration to derive from our three main findings mentioned above an important *tradeoff* between social mobility and wealth satisfaction caused by information visibility: the more transparent the people's economic performance, the more active the investment; and the more fluidly people move in social layers, the less satisfied they are with their economic position.

We suggest, however, that there are limitations to our study and we propose future research directions. First, although the wealth disparity is at least partially due to the fact that people's ability is unequally distributed, in our experiment the disparity is only produced by participants' investment decisions. In order to conduct an experiment that can include the influence of people's ability on the wealth disparity, it is worth considering an implementation of "real effort" treatment in the experiment.

Funding

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References

Alos-Ferrer, C., & Ania, A. B. (2005). The evolutionary stability of perfectly competitive behavior. *Economic Theory*, *26*(3), 497-516

Andreoni, J., & Petrie, R., 2004. Public goods experiments without confidentiality: a glimpse into fund-raising. J. Public Econ.88 (7), 1605–1623.

Apesteguia, Jose., Steffen Huck, and Jörg Oechssler,, F. Vega-Redondo, The evolution of Walrasian behavior, Econometrica 65 (1997) 375–384.

Cason T, Saijo T, Yamato T (2002) Voluntary participation and spite in public good provision experiments: an international comparison. Experimental Economics 5: 133–153.

Christian Pfeifer and Stefan Schneck (2012), Relative Wage Positions and Quit Behavior:

New Evidence from Linked Employer-Employee Data, *Industrial and Labor Relations Review*, Vol. 65, No.

1 (January 2012).

Clark, A. E. & Oswald, A. J. 1996.Satisfaction and comparison income. J. Public Econ. 61,359–381.

Cooper, R., DeJong, D. V., Forsythe, R., & Ross, T. W. (1989). Communication in the battle of the sexes game: some experimental results. The RAND Journal of Economics, 568-587.

Daniel L.Chen, MartinSchonger and ChrisWickens, (2016), oTree—An open-source platform for laboratory, online, and field experiments, Journal of Behavioral and Experimental Finance,Volume 9, March 2016, Pages 88-97.

Ernan Haruvy, Sherry XinLi, Kevin McCabe, Peter Twieg, 2017,Communication and visibility in public goods provision, Games and Economic Behavior, 105 (2017) 276–296.

Gordon D. A. Brown,* Jonathan Gardner, Andrew J. Oswald, and Jing Qian, Does Wage Rank Affect Employees' Well-being? Industrial Relations, Vol. 47, No. 3 (July 2008).

Hamada, H. (2003). A generative model of income distribution: Formalization with iterated investment game. Mathematical Sociology, 27(4), 279-299.

Hamada, H. (2004). A generative model of income distribution 2: Inequality of the iterated investment game. Mathematical Sociology, 28(1), 1-24.

Holzmeister Felix and Armin Pfurtscheller, oTree: The "bomb" risk elicitation task, Journal of Behavioral and Experimental Finance, June 2016 Vol.10, 105-108.

John Duffy, 2005, Macroeconomics: A Survey of Laboratory Research, Handbook of Experimental Economics Vol. 2, edited by John H. Kagel and Alvin E. Roth,, Princeton University Press.

Lukasz Walasek and Gordon D. A. Brown,2016, Income Disparity, Income, and Internet Searches for Status Goods: A Cross-National Study of the Association Between Disparity and Well-Being, Soc Indic Res (2016) 129:1001–1014 DOI 10.1007/s11205-015-1158-4

Miller, N. E., & Dollard, J. (1941). *Social learning and imitation.* Yale University Press.

Nax, Heinrich H.; Balietti, Stefano; Murphy, Ryan O.; Helbing, Dirk, 2018, Adding noise to the institution: An experimental welfare investigation of the contribution-based grouping mechanism, Social Choice and Welfare 50(2).

Nishi A., Hirokazu Shirado, David G. Rand & Nicholas A. Christakis, 2015, Disparity and visibility of wealth in experimental social networks, Nature Oct 15;526(7573):426-9.doi: 10.1038

Ori Heffetz, 2012, Who sees what? Demographics and the visibility of consumer expenditures, Journal of Economic Psychology, 33 (2012) 801–818.

Paolo Crosetto and Antonio Filippin, The "bomb" risk elicitation task, Journal of Risk and Uncertainty, August 2013, Vol. 47, No. 1 (August 2013), pp. 31-65.

Wilkinson and Pickett, 2006, Income disparity and population health: Correlation and causality Social Science & Medicine,Volume 66, Issue 7, April 2008, Pages 1614-1626.

Appendix A: Proof of the proposition

1. Setup

Let r_1 be an interest rate of the wealth and r_2 be the return rate of a project when it succeeds (we use notation r in the main text). Let n_1, n be a given. Let $s = \frac{n_1}{n}$. A T period repeated investment game is a repetition of the investment game having the following structure.

At the beginning of each period t, the wager vector $B^t = (B_1^t, \ldots, B_n^t)$ is determined. B_i^t is equal to $r_1 W_i^t$, where W_i^t is the welth level at the beginning of period t and r_1 is an interest rate satisfying $0 < r_1 < 1$. Taking this wager vector as an endowment, they play an investment game as a stage game of this super-game for each period. The payoff from the stage game in period t is determined in the same way as the payoff in the one-shot investment game with the wager vector $B^t = (B_1^t, \ldots, B_n^t)$ (only the incremental gain on wealth is considered as payoff). The payoff of the T period repeated investment game is the sum of the payoffs of investment games from periods 1 to T (which is equal to the final wealth minus wealth at the start of the first period). The wealth increases across periods as the following way.

$$W_i^{t+1} = W_i^t + i\text{'s payoff in the } t \text{ th investment game}$$

Given r_1, r_2, n_1, n, the repeated investment game is defined only by the first period's wager vector B^1 and the number of repetitions T because the inital wealth are computable from the wager vector).

Consider the subgame of the T period repeated investment game startig from t-th stage game with wager vector $B^t = (B_1^t, .., B_n^t)$. Since the payoff of the repeated investment game is defined by sum of the payoffs from each stage games, to calculate the subgame perfect equilibrium, it is possible to ignore the payoff before t period and thus we consider the payoffs obtained from period t and later periods. Assuming that the equilibrium of any subgame starting at $t + 1$ is known, the payoff earned after the $t + 1$ period can be replaced by (expected) payoff in equilibrium of these subgames. Therefore, the total payoff obtained by the action at period t and later periods is given by

$$\text{the payoff in the } t \text{ th stage game} + \text{ the equilibrium payoff obtained in the subsequent subgame}$$

A one-shot game defined in this way is called a contraction game of period t.

If we can derive the equilibrium of this contraction game, we combine it with the equilibrium of any subgame starting at $t + 1$ already known, which is the equilibrium of the subgame starting at period t.

2. Proof of Main Theorem

We first summarize some facts that are useful to show our main theorem.

Fact 1. Consider the stage game of period t with wager vector $B^t = (B_1^t, \ldots, B_n^t)$. Then, for any $i \in N$, i's payoff from this stage game and the wager B_i^{t+1} in the next period are determined as follows. If s/he invests and the investment succeeds, the payoff of this period is $r_2 B_i^t$ and $B_i^{t+1} =$

$(1 + r_1 r_2)B_i^t$. If s/he invests and the investment fails, the payoff of this period is 0 and $B_i^{t+1} = B_i^t$, and if s/he doesn't invest, the payoff of this period is B_i^t and $B_i^{t+1} = (1 + r_1)B_i^t$.

Proof of Fact 1.

It is obvious about the payoff from the rule of the one-shot investment game.

Since the wager is B_i^t, the weath level at the begginig of period t is $\frac{B_i^t}{r_1}$. When i invests at period t and the investment succeeds, the wealth level of the next period becomes $\frac{B_i^t}{r_1} + r_2 B_i^t$ and thus, the wager of the next period is $B_i^t + r_1 r_2 B_i^t$. When i invests at period t and the investment fails, the wealth level of the next period becomes $\frac{B_i^t}{r_1}$ and thus, the wager of the next period is B_i^t. Finally, when i doesn't invest in period t, the wealth level of the next period becomes $\frac{B_i^t}{r_1} + B_i^t$ and thus, the wager of the next period is $B_i^t + r_1 B_i^t$. **[End of Proof]**

Fact 2. Suppose that $\sigma = (\sigma_i)_{i \in N}$ is a mixed strategy NE for a normal form game and i's pure strategies s_i and $'s_i$ are support of i's mixed strategy σ. Then, the two pure strategies give the same expected payoff against others mixed strategy profile $\sigma_{-i} = (\sigma_j)_{j \neq i}$.

Let $i \in N$. Suppose that players other than i follows mixed strategy p in an investmet game. Then, the probability of success of i's investment is given by

$$g(p) = \sum_{k=0}^{n_1-1} {}_nC_k p^k(1-p)^{n-k} + \sum_{k=n_1}^{n-1} {}_nC_k p^k(1-p)^{n-k}\frac{n_1}{k+1}.$$

Fact 3. Let $p^* \in (0,1)$ be the value satisfying $g(p^*) = \frac{1}{r_2}$. Since $g(.)$ is a continuous function satisfying $g(0) = 1$ and $g(1) = \frac{n_1}{n} = s$, the existence of p^* is guaranteed by the intermediate value theorem when $s < \frac{1}{r_2} < 1$.

Theorem. Suppose $sr_2 < 1$. The strategy profile such that they play $(p^*, \ldots, p^*)$ in every stage game constitutes the subgame perfect equilibrium of the T period repeated investment game.

Proof of Theorem.

We prove the theorem by simultaneously showing the following lemmas.

Lemma 1. In a contraction game in period t, $(p^*, \ldots, p^*)$ is a mixed strategy NE.

Lemma 2. Consider a contraction game in period t with wager vector $(B_1^t, \ldots, B_n^t)$, the expected payoff of player i in the equilibrium specified in Lemma 1 is $a(t)B_i^t$, where $a(t)$ is some real number independently determined from the identity of i and the wager B_i^t.

We show Lemma 1 and 2 by induction.

From Proposition 1 in the main text, $(p^*, \ldots, p^*)$ is a mixed-strategy NE of the investment game in period T with wager vector $(B_1^T, \ldots, B_n^T)$. Also, the expected payoff of i is B_i^T from $p^* \in (0,1)$ and Fact 2. Thus, it holds as $a(T) = 1$.

We assume that for subgame starting from $t+1$ and later periods, Lemmas 1 and 2 hold. And, we will show that statements of the two lemmas holds even for the t-th period.

First, we show that $(p^*,\ldots,p^*)$ is a mixed strategy NE of the contraction game of period t.

Let $i \in N$. Suppose that $n-1$ players other than i follows p^*.

From Fact 1 and the induction assumptions, the expected payoff of i in period t-th contraction game when i chooses an investment is

$$g(p^*)\left(r_2 B_i^t + a(t+1)(1+r_1 r_2)B_i^t\right) + (1-g(p^*))\left(0 + a(t+1)B_i^t\right)$$

$$= g(p^*)(r_2 + r_1 r_2 a(t+1))B_i^t + a(t+1)B_i^t$$

Since $g(p^*) = \frac{1}{r_2}$ by the definition of p^*, it is reduced to

$$= (1 + (1+r_1)a(t+1))B_i^t$$

In contrast, from Fact 1 and the induction assumptions, the expected payoff when i doesn't invest is

$$B_i^t + a(t+1)(1+r_1)B_i^t = (1 + (1+r_1)a(t+1))B_i^t$$

Thus, when $n-1$ players other than i follows p^*, i's expected payoff when i invests is equal to the one when i doesn't invest.

Therefore, p^* of i becomes the best reply to $(p^*)_{j\neq i}$.

This holds for any $i \in N$, and thus, $(p^*,\ldots,p^*)$ is a mixed strategy NE of the contraction game. Thus, statement of Lemma 1 holds for t-th period investmetn game.

At the equilibrium mentioned above, the i's expected payoff of the contraction game is equal to the expected payoff when i doesn't invest from Facts 1 and the induction assumptions. Thus, it is

$$(1 + (1 + r_1)a(t + 1))B_i^t$$

Therefore, the statement of Lemma 2 holds for t-th period investmetn game by letting

$$a(t) = 1 + (1 + r_1)a(t + 1).$$

Thus, Lemma 1 and 2 holds true and thus, we prove the theorem. **[End of Proof]**

3. Example

As a corollary of the theorem, it is possible to calculate the expected payoff at the subgame perfect equilibrium of the T period repeated investment game. The following corollary show what $a(t)$ in Lemma 2 is.

Corollary. Suppose that $sr_2 < 1$. Then, we have

$$a(T) = 1,$$

$$a(t) = \frac{(1 + r_1)^{T-t+1} - 1}{r_1} \quad \forall t = T - 1, T - 2, \ldots, 1$$

Proof. From the proof of the theorem, the following holds true.

$$a(T) = 1, \quad a(t) = 1 + (1 + r_1)a(t + 1)\ \forall t = 1, 2, \ldots, T - 1.$$

Thus, solving the recurrence equation, we have the formula in this corollary. **[End of Proof]**

From this corollary, we can calculate $a(T)$ for our experimental condition as Figure S1.

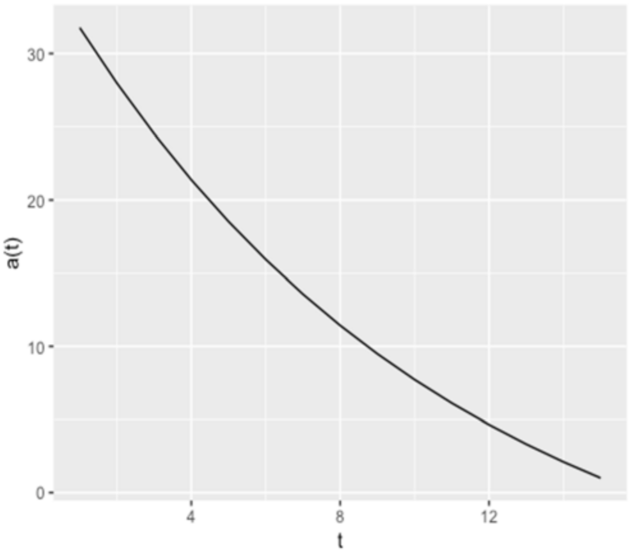
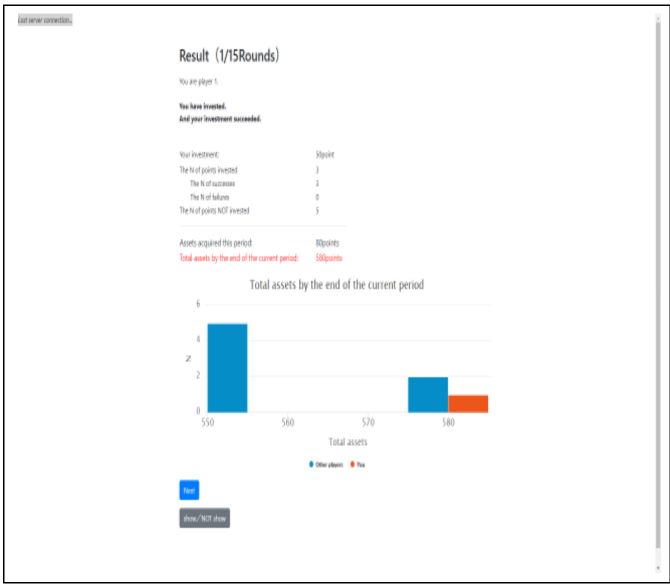
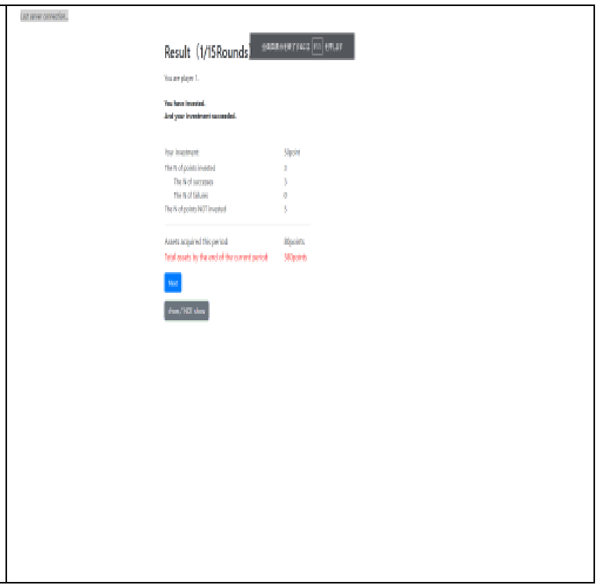


Figure S1. The values of a(t) under the experimental parameters

Appendix B: Pictures of the information screen for CoPl and CoLim

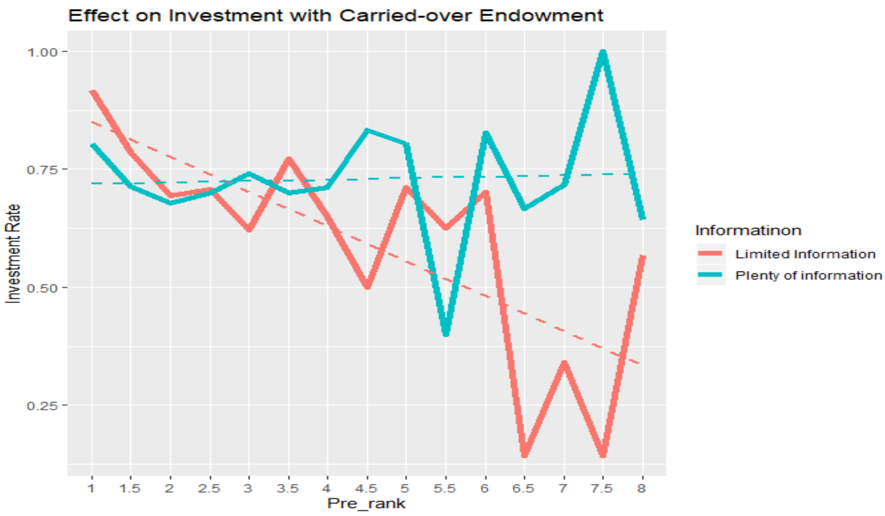




CoPl

CoLim

Appendix C: Interaction of plenty of information and the accumulated amount of investment



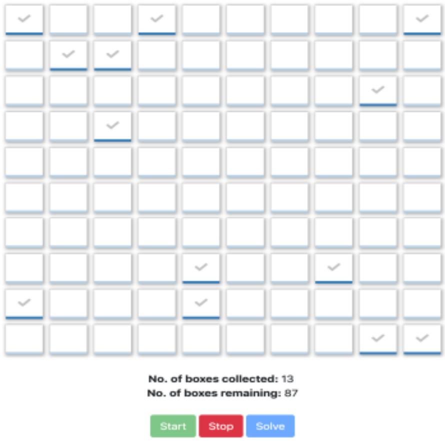
Dependent Variable	**Investment_Dummy**		
Predictors	*Estimates*	*Std. Error*	*p*
(Intercept)	.68	.30	.200
Gender	.74	.12	**.010**
Risk_seekingness	1.01	.00	.001
Period	.94	.02	.005
Pre_earned	1.00	.00	.222
Pre_investment_rate	1.17	.30	.600
Pre_Success_num	1.19	.04	<.001
Pre_Participation_rate	3.90	.25	**<.001**
PL_dummy	.84	.16	.278
CO_dummy	.85	.17	.322
PL_dummy * CO_dummy	1.86	.23	.006
Random Effects			
Individual	Yes		
Group	Yes		
Observations	2128		
R^2	.159		
AIC	2415.233		
Note: Multicoliniality does not occur among explanatry variables.			

Note: Multicollinearity does not occur among explanatory variables. Gender (dummy), if participant is male, it takes 1, otherwise 0.

Risk_seekingness (numeric) is measured by the number of boxes that a participant collects in “Bullet” question (for detail, see Appendix D). Period (numeric), the 1st period is omitted because we use several variables of the previous period. Pre_earned (numeric) is the points that participants earned in the previous period. Pre_investment_rate (numeric) is the proportion of participants who invested among eight members in the previous period. Pre_Success_num (numeric) is the number of successful investments by the previous period. Pre_Participation_rate (numeric) is the frequency of investment by the previous period. PL_dummy (dummy), if there is a plenty of information, it takes 1, otherwise 0. CO_dummy (dummy), if the wealth is carried over, it takes 1, otherwise 0.

Appendix D: BRET

The BRET (bomb risk elicitation task) by Holzmeister and Armin (2016) recently gained much attention in eliciting people’s risk preferences. The BRET is represented on the PC screen as a square formed by 10 × 10 cells, each one representing a box (see the figure below). In one box, a bomb is hidden, but the participants are not informed in which box the bomb is hidden until the end of the task. Below the square is a “Start” and a “Stop” button. From the moment the subject presses “Start,” one cell is automatically deleted from the screen in each second, representing a box that is collected. The figure below is a screenshot of the visual version after 13 seconds. At each time, the participants are informed about the number of boxes collected, and they can stop the procedure at any time by hitting the “Stop” button. After stopping this task or waiting to the end of the task, the participants learn whether there is a bomb in the collected box or not. If the bomb is in one of the collected boxes, they gain nothing. If the bomb is not in one of the collected boxes, they gain an earning in proportion to the number of boxes collected. Since the tradeoff between the amount of money that can be earned and the likelihood of obtaining it exists, we can assume that the number of boxes collected is an index of their risk-seekingness: the greater the number of boxes collected, the stronger their risk-seekingness.

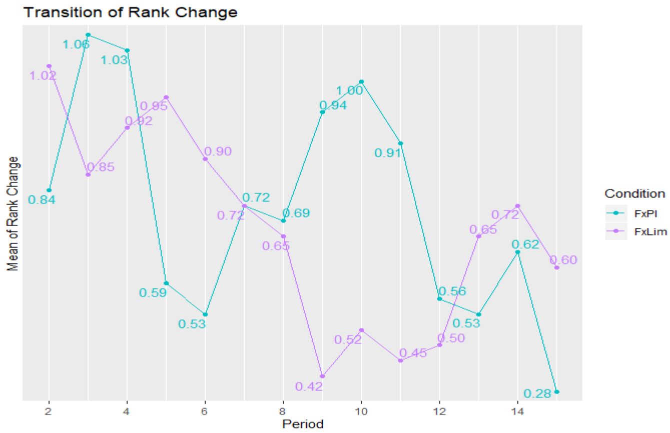


Appendix E: Data analysis of CoPl: the Periods 2–7 and Periods 8–15

	From 2nd to 7th period			From 8th to 15th period		
Dependent Variable	**Investment_Dummy**			**Investment_Dummy**		
Predictors	*Estimates*	*Std. Error*	*p*	*Estimates*	*Std. Error*	*p*
(Intercept)	-.7523	1.4901	.6140	-3.2189	1.9274	.0950
Gender	-.2617	.3497	.4540	-.3284	.3599	.3620
Risk_seekingness	.0060	.0084	.4800	.0228	.0105	**.0310**
Period	-.1935	.1654	.2420	-.0350	.0964	.7170
Pre_earned	-.0032	.0047	.4970	.0014	.0019	.4640
Pre_investment_rate	-.6055	.8998	.5010	.9157	.7759	.2380
Pre_Success_num	-.0719	.6772	.9150	.8960	1.3245	.4990
Pre_Participation_rate	2.0507	.5924	**.0010**	3.2470	.7962	**<.001**
Pre_rank	.2000	.2073	.3350	.1342	.1343	.3180
Pre_Dif_Max_Own	.0018	.0071	.7970	.0045	.0016	**.0060**
Pre_Dif_Max_Min	.0071	.0054	.1870	-.0014	.0008	.0680
Pre_rank * Pre_Dif_Max	-.0011	.0011	.3500	-.0007	.0002	**<.001**
Pre_rank * Pre_Dif_Max_Min	.0001	.0013	.9440	.0003	.0002	.0930
Random Effects						
Individual	Yes			Yes		
Group	Yes			Yes		
Observations	288.0000			384.0000		
R^2	.1650			.2400		
AIC	355.2110			404.0740		

Note: Multicollinearity does not occur among explanatory variables. Gender (dummy); if the participant is male, it takes 1, otherwise 0. Risk_seekingness (numeric) is measured by the number of boxes that a participant collects in "Bullet" question. Period (numeric), the 1st period is omitted because we use several variables of the previous period. Pre_earned (numeric) is the points that participants earned in the previous period. Pre_investment_rate (numeric) is the proportion of participants who invested among eight members in the previous period. Pre_Success_num (numeric) is the number of successful investment by the previous period. Pre_Participation_rate (numeric) is the frequency of investment by the previous period.

Appendix F: Transition of rank change in FxPl and FxLim



The rank change does not significantly differ during the entire period (the mean of FxPl is 0.74, that of FxLim is 0.71, and *p*-value is .58)