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PRODUCTIVITY OR PRIVILEGE: GAME-THEORETIC AND EXPERIMENTAL MODELS OF SOCIAL CLASS

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Productivity or privilege: Game-theoretic and experimental models of social class

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Abstract

Social stratification, segregation and inequity invite concerns about fairness and social harmony. Our game-theoretic and experimental results indicate that they can also be detrimental to productivity, efficiency, and welfare. Class is defined by players' resources, incentives to make a public contribution, and social mobility. We discuss the model's real-world applications, and ways to increase efficiency and welfare through increased equity, mobility, or competition. We also describe how the model can be adapted to represent and experimentally test different class structures, the interaction between demographic characteristics and class, and the effectiveness of policies that modify incentives. We experimentally test a two-class model. The poorer L-class are socially mobile: for them, effort is linked to social positioning and earnings akin to what is often referred to as a Middle-Class mindset. The productive L-players support a relatively efficient equilibrium that encompasses both classes. Upper-class H-players, notwithstanding their guaranteed privilege and superior resources, are relatively unproductive and display behavior akin to class-consciousness by contributing only what is necessary to remain above the L-class. The experimental results confirm that humans respond swiftly to incentives associated with their material status and economic opportunities and suggest that policies aimed at increasing welfare through incentive modification can be successful.

JEL classifications: Z13, Z18, C72

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1 Introduction

Social class stratifies people according to their access to resources broadly defined and shapes their lives in important ways (Moya & Fiske, 2017). Inequality decreased in the 20^{th} century but is now again on the increase, worldwide (see e.g., Piketty, 2020, for extensive global data; see e.g., Saez & Zucman, 2016, for US data). On the upside, the fact that class differences and social mobility are variable and changeable (Davis & Moore, 1945) offers opportunities for policy that modifies the access to -and distribution of- resources in a way that enhances productivity and welfare. However, which policies serve such purpose, and which ones could be counterproductive? Since experimental game theory not only tests behavior but also policy (Holt et al., 2015) we theoretically model a class-based society where players join cooperative units akin to simple organizations, and test it experimentally. We investigate how social mobility, competition, and privilege impact individuals' incentives, societal productivity, and welfare. We find that while inequity per se need not be detrimental to efficiency, privilege and lack of social mobility are. Our theoretic model predicts that policy aimed at increasing social mobility and equity increases welfare, and we discuss structural solutions in this vein. Our experimental results confirm that individuals randomly assigned to a class, respond rationally and predictably to their incentives. Our findings thus carry an optimistic message about the welfare-enhancing effect of structuring incentives to enhance productivity and welfare. In the concluding section we address how our model can be extended to examine different and more complex structures of social stratification, and the impact of various policy interventions.

We discuss real-world parallels to our model and describe ways to adapt the model to represent various class structures and examine their impact on welfare. In the simplest version of the model experimentally tested here, a materially disadvantaged "lower" (L) class faces, within their material constraints, a competitive and socially mobile environment where input is linked to reward. The "upper" (H) class enjoys guaranteed privilege thanks to superior resources. The two classes settle in a relatively efficient Two-Tier Equilibrium (TTE) where L-types contribute at a high level and are crucial in maintaining overall productivity while H-types contribute only the minimum required to stay above the L-class. Broadly interpreted, our model is reminiscent of Veblen's (1899) description of a society consisting of productive workers and an upper, "leisure class". Absent the L-players' efforts the system would collapse toward the alternative equilibrium of non-contribution by all. An equilibrium that surpasses the TTE in efficiency is possible if inequity between H and L is reduced or social mobility increased, either via competition within the H-class, or by L-players being able to penetrate the H-class.

The two player types interact in an institution of competitive grouping where players are ranked and grouped based on their contributions. Group members share equally in the earnings from their group's product. The contributions by members of the two classes are mainly driven by their class' material incentives. In a schematic representation of social mobility, L-types compete for placement in groups where earnings are higher. Privileged H-players do what is necessary to differentiate themselves from the L-class but beyond that, under-contribute relative to their superior means. Our experimental results show that H-types' non-monetary pro-social motivation is limited.

We first explain the model, followed by an experimental test of a society with two strata. We then link our findings to naturally occurring circumstances of unearned privilege, the role of the

Middle Class currently under threat, how self-interest drives class-specific behavior, and how members of the privileged class can be made to contribute more. Finally, we discuss extensions of the model and how it links to interdisciplinary approaches such as stratification economics, cultural economics, and the psychology of class.

2 Model

Our model of a stratified society is best explained as a combination of two mechanisms, the Voluntary Contribution Mechanism (*VCM*; Isaac et al., 1985) and the group-based Meritocracy Mechanism (*GBM*; Gunnthorsdottir et al., 2010a, henceforth *GVSM*). We first describe each component and thereafter explain the Multi-Tiered Mechanism and its equilibria.

2.1 The Voluntary Contribution Mechanism (VCM)

In a standard linear VCM, $i = (1, \ldots, n)$ group members decide simultaneously and privately how to allocate their endowment w. Each i contributes $x_i \in [0, w]$ to a public account and leaves the remainder $(w - x_i)$ in a private account that represents alternative use of their resources. For simplicity and without loss of generality set the return from the private account to one. The public contributions by all n group members are summed up and multiplied by a factor t which represents the efficiency gains from jointly contributing, before being equally divided among all n members. The rate t/n is the Marginal Per Capita Return (*MPCR*) to each i from an investment in the public account. Each i's payoff is therefore

$$\Pi_i = (w - x_i) * 1 + \left(\sum_{i=1}^{i=n} x_i \right) * \frac{t}{n} \tag{1}$$

The VCM can be adapted to model diverse settings where players have the option of contributing to a group, organization or community. The most common parameter setting is $(1 < t < n)$ since it creates a social dilemma: Welfare is maximized if all i contribute their entire w to the public account. However, a rationally self-interested player's dominant strategy is to contribute nothing while still earning an equal share of whatever is in the public account.[1]

2.1.1 Findings from VCM experiments

VCM experiments have shown some cultural variation (Gunnthorsdottir et al., 2023; Herrmann et al., 2008; Van Lange et al., 2013) but university students in industrialized countries typically display the following pattern: Mean contributions start at about $\frac{1}{2}w$ and, over repeat rounds, approach the equilibrium of non-contribution by all (Brandts et al., 2004; Croson, 2008; Zelmer, 2003).

2.2 The Group-Based Meritocracy Mechanism (GBM)

The VCM does not model how groups acquire members. In VCM experiments group membership is therefore randomly assigned. GVSM (2010a) incorporate contribution-based grouping into the VCM and call their mechanism " Group-Based Meritocracy" (*GBM*). In their model, N players

[1] If $t > n$ it is both individually and collectively optimal to invest everything in the public account. If $t < 1$ it is both individually and socially optimal that everyone keeps their endowments in their private accounts.

are partitioned into $g = \{1, 2, 3, \dots G\}$ groups of size n based on their public contribution. The $n = N/G$ players with the highest contribution are grouped together, then the next n players, and so on. Ties are broken at random. Thereafter, individual earnings are computed as per Eq. 1. All this is common knowledge.

GVSM (2010a) argue that theirs is a simple model of merit-based social organization where those who contribute more can expect to find themselves with similarly productive types in a segment of society where earnings are higher. Due to the random resolution of ties the grouping process retains a realistic chance factor: In natural settings too, effort is associated with a good probability of success but rarely a guarantee. Contribution-based grouping changes the game's equilibrium structure. Under the social dilemma parameters ($1 < t < n$) there are two pure-strategy equilibria: Non-contribution by all loses the seeming inevitability of a dominant strategy equilibrium but remains as a best response equilibrium. For symmetric players a second, payoff-dominant asymmetric "Near Efficient Equilibrium" (*NEE*) asymptotically approaches full efficiency as the number of groups increases. We next describe both these equilibria in more detail. For a formal treatment see GVSM.

2.2.1 The free-riding equilibrium

Assume that the payoff function of investments in the public account has the social dilemma properties $1 < t < n$ and the return from the private account is one. If nobody contributes it is not rational for a single individual to contribute since their rate of return would be $\frac{t}{n} < 1$.

2.2.2 The near-efficient equilibrium

The asymmetric NEE is of greater structural and policy interest. It is payoff dominant [2] (Harsanyi & Selten, 1988, Ch. 3.6, p. 81), and close to Pareto optimal. Nearly all N players contribute their entire endowment w; only $z < n$ players contribute nothing.[3] Since $z < n$ the NEE asymptotically approaches full efficiency as the number of groups increases; see Appendix A for an illustration. Our explanation of the NEE closely follows GVSM's (2010a) description.

We call a subset of players whose public contributions are identical a *category*. Category C_1 is the subset of players containing the c_1 highest contributors; the next category C_2 contains the c_2 players who contribute less, and so on. We refer to the group with the n highest-ranked contributors as Group 1, to the next group as Group 2, and so on; Group G is the group with the lowest-ranked contributors.

a) Identical positive contributions by all is not an equilibrium since any one player has an incentive to reduce her contribution to zero. In an equilibrium with positive contributions there must therefore be more than one category.

b) Group 1 can only contain one category, C_1. If it contained two or more categories, any C_1 player would have an incentive to decrease her contribution while remaining in Group 1. Similarly, C_1 must be larger than n and not fully divisible by n since else, any C_1 player can decrease her contribution without it affecting her group membership.

[2] Payoff dominant in terms of expected earnings prior to the random resolution of ties.

[3] Since the NEE is asymmetric while players in GVSM's model are symmetric and interchangeable when it comes to their roles (full contributor/non-contributor), ${}^{N}\mathrm{C}_z$ NEE profiles exist for each set of parameters.

c) It follows from (a) and (b) that if an equilibrium with positive contributions exists some C_1 players are grouped with C_2 players in a *mixed group*.

d) C_1 players contribute their full endowment w. If they did not, each of them would have an incentive to increase her contribution by a small ϵ to avoid the mixed group.

e) We now turn to the incentives of the C_2 players. Point (c) showed that a mixed group of C_1 and C_2 players must exist in an equilibrium with positive contributions. Imagine that there are one or more groups *below* this mixed group. There are two cases to consider:

   I. Category C_2 extends beyond the mixed group into one or more groups further below. In this case, each C_2 player has an incentive to increase her contribution by ϵ to be with certainty in the mixed group where she can free ride off the C_1 contributors.

   II. C_2 does *not* extend beyond the mixed group: in this case, each C_2 player has an incentive to decrease his contribution (and raise his payoff) without affecting her group membership.

f) The only situation in which a C_2 player has no incentive to either raise or lower her contribution is when the only mixed group is the lowest ranked group G, there are only two categories, and C_2 players contribute nothing.

g) To find the equilibrium one needs to determine how many $z < n$ non-contributors are in Category C_2 so that expected earnings of C_1 players[4] and the free-rider earnings of C_2 players are such that no player has a unilateral incentive to deviate. GVSM's (2010a) Theorem determines z and defines the NEE's existence and uniqueness as an equilibrium with positive contributions. Denote the MPCR t/n as m.

GVSM's Theorem: If $m < \frac{N-n+1}{Nn-n^2+1}$, the only equilibrium is if all GBM participants contribute nothing. If $m \geq \frac{N-n+1}{Nn-n^2+1}$, the GBM has, additionally, a Near-Efficient Equilibrium in which all but $z < n$ players contribute their entire endowment w and only the remaining z players contribute nothing.[5] z is the integer between a lower bound l and an upper bound u where

$$l := \frac{N - mN}{mN - mn + 1 - m} \text{ and } u := l + 1 \tag{2}$$

As the number of groups increases, the range of MPCRs (m) for which a NEE exists converges to the interval $(1/n, 1)$.

Proof: GVSM (2010).

2.2.3 Findings from GBM experiments

Experimental tests of the GBM with different (all Western) subjects have yielded consistent results: Subjects coordinate the asymmetric NEE rather than the FRE. This is even though they make their contribution decisions simultaneously, cannot communicate, and the NEE is probably not obvious to most of them.

[4]Since players in each class all contribute the same a random draw determines their rank. When assessing the expected payoff from fully contributing a C_1 player considers that she might end up in the mixed group with the z non-contributors. All players are assumed risk neutral.

[5]It can be verified that 1) a NEE exists unless m is very close to $1/n$ and 2) the m-threshold for the existence of a NEE is inversely related to n (and to a lesser extent, to N).

a) GVSM (2010a) tested the mechanism over 80 rounds, under $w = 100$, $n = 4$, $N = 12$, and with both $m = 0.5$ and $m = 0.3$. US students coordinated NEEs with surprising precision. Individual choices were unpredictable over rounds but NEE was a strong predictor of aggregate behavior from the earliest rounds.[6] To establish the robustness of such a result, Gunnthorsdottir & Thorsteinsson (2011) replicated GVSM's results with Icelandic subjects.

b) Nax et al. (2014) introduced a GBM where the ranking of the public contributions is perturbed so that the link between contributions and grouping is weakened. The result is an imperfect, "fuzzy" GBM which the authors call MERIT. Under moderate fuzziness a NEE exists. Beyond a certain noise threshold only the FRE remains. Nax et al. (2018) replicated prior GBM results on MTurk and with Swiss university students, under $N = 16$, $n = 4$, and $m = 0.5$, once more confirming that the tacit coordination of an asymmetric NEE is a robust phenomenon. They also tested MERIT with two different noise levels[7] both of which still support a NEE. The noise lowered the precision with which subjects coordinated a NEE and selected NEE strategies, but efficiency remained close to NEE levels.

c) Gunnthorsdottir et al. (2010b, *GVS*) relaxed the symmetry among players in a way that still allows for a NEE: US student subjects were randomly assigned to two different endowment levels fixed over 80 rounds. Six subjects had a per-round endowment of $w_H = 120$ tokens, the remaining six had $w_L = 80$ tokens. This was common knowledge. In general terms, GVS' distribution of player types is as follows: Let H be the count of high-endowment types and L the count low-endowment types. $H + L = N$; $H > n$ and $H \mod n \neq 0$; $L > n$ and $L \mod n \neq 0$. With this type distribution the NEE consists of three strategies. Under GVS' experimental parameters ($N = 12$, $n = 4$, $t/n = m = 0.5$) a NEE profile is $s* = \{0, 0, 80, 80, 80, 80, 120, 120, 120, 120, 120, 120\}$. The two types, H and L, meet in the mid-ranked group where the contributions are $\{80, 80, 120, 120\}$. GVS' subjects tacitly coordinated this more complex NEE with considerable precision. Note that their material disadvantage did not keep L-types from contributing at the high levels predicted in a NEE.

2.3 The Multi-Tiered Mechanism (MTM)

Our model also involves two different wealth levels, $w_H = 120$ and $w_L = 80$. Players are again ranked based on their contributions with ties broken at random, and partitioned into G groups, $g = (1, 2, \dots, G)$. There are again two pure-strategy equilibria: the FRE and a payoff-dominant equilibrium with positive contributions. However, the latter does not reach "near-efficiency". Unlike in GVS' (2010b) model where there is one group where the two wealth types meet, the type distribution in our model is such that in the payoff-dominant equilibrium H-players segregate from L-players into a separate layer. While L-types contribute at NEE levels the H-types under-contribute relative to their superior endowment; They contribute $x_{iH} = (w_L + \epsilon)$, just enough to maintain their status as a separate tier. Any contribution $x_{iH} > (w_L + \epsilon)$ is

[6] Such tacit coordination of asymmetric equilibria is a robust observation initially documented with binary choices. Puzzled by the apparent ease with which participants tacitly coordinated the equilibrium strategy proportions while individual decisions over repeated trials were unsystematic, Kahneman (1988, p. 12) wrote in an early description, "[...] to a psychologist, it looks like 'magic'". See also Camerer (2003, Ch. 7.3).

[7] The different noise levels were operationalized in the laboratory by varying the dispersion of a random variable added to each subject's contribution prior to ranking.

strictly dominated as in a social dilemma. We refer to this equilibrium as a Two-Tier Equilibrium, henceforth *TTE*. For simplicity we describe just two tiers, and assume equal-sized groups and that the MPCR is uniform across groups and endowment classes. However, the Multi-Tiered Mechanism (*MTM*) allows relaxing these restrictions, can be extended to a larger number of tiers, and can accommodate situations where in an equilibrium with positive contributions the tiers are not necessarily segregated. See Sections 6.3 and 7.4 below.

2.3.1 The free-riding equilibrium

If $1 < t < n$ there exists a best-response equilibrium of non-contribution by all. If no player contributes there is no incentive to unilaterally deviate. This applies to all wealth classes and all type distributions.

2.3.2 The two-tiered equilibrium

For a TTE, the following is necessary: The population consists of two wealth classes so that $H + L = N$; $w_H > w_L$. Let $n_{g=1}$ be the size of the group containing the top-ranked contributors; $n_{g=1} = H$. $L = N - n_{g=1}$ and $L \geq 2n_{g=2,3,\ldots,G}$ and $L \mod n_{g=2,3\ldots,G} = 0$. The payoff function for public contributions has social dilemma properties where $1 < t < n$. GVSM's (2010a) conditions for the existence of a NEE (Section 2.2.1) are satisfied for the L-class.

L-players: If $(L < n)$ L-types can compete for membership in the most profitable group open to them. If ($L \geq 2n$ and $L \mod n = 0$) L-players can coordinate a NEE within their stratum: $(L - z)$ L-types contribute their entire w_L while z L-types contribute nothing. z is determined by Eq. 2.

H-players. H-players segregate into a separate stratum by contributing $x_{iH} = w_L + \epsilon$. This way, they avoid the competitive and risky environment of the L-types. Recall that in a NEE, $(n - z)$ unlucky full contributors are assigned to the bottom group, free-ridden by the z non-contributors. By contributing $(w_L + \epsilon)$, H-players avoid this risk. If all H-players contribute $(w_L + \epsilon)$ they are in a group of their own and face a social dilemma: it does not behoove any one of them to contribute more than $(w_L + \epsilon)$. All H-players thus underperform notwithstanding their superior means w_H. Their under-contribution reduces the system's overall efficiency. We next show that under the necessary conditions for a TTE (see above) a TTE is the sole equilibrium with positive contributions.

a) No player i' of any type contributes $0 < x_i < w_L$ since doing so would lead to placement in the bottom group G, where i' is free ridden by the z non-contributors, as explained in 2.2.1.

b) No H-player contributes w_L: Assume that, as the L-players coordinate a NEE within their restricted strategy space, player i'_H contributes w_L instead of $w_L + \epsilon$ so that now $(L - z + 1)$ players contribute w_L. With ties broken at random i'_H enters a lottery among the fully contributing L-types for membership in any one of the following three types of groups, with (3) the most unfavorable, and his expected earnings are lower than if he had contributed $(w_L + \epsilon)$:

   I. Since $n_{(g=1)} = H$, the deviating choice by i'_H creates a vacancy in the top group where all other members contribute $(w_L + \epsilon)$. All players who contributed w_L (including

i'_H) can obtain this favorable spot with probability $1/(L-z+1)$. i'_H could have guaranteed himself this spot at the negligible cost of a minimal ϵ.

II. With probability $(L-n)/(L-z+1)$ player i'_H is placed in a group where everybody contributes w_L).

III. With probability $(n-z)/(L-z+1)$ player i'_H ends up in the bottom group, free-ridden by the z non-contributors.

c) What if deviator i'_H contributes nothing and ends up in the lowest group G, as one of $(z+1)$ non-contributors? This choice gives i'_H a certain payoff of

$$\Pi_{i'_H} = w_H + \left(\sum_{1}^{(n-z-1)} w_L\right) * \frac{t}{n} < \Pi_{i_H} = w_H - (w_L + \varepsilon) + \left[\sum_{1}^{n_{(g=1)}} (w_L + \varepsilon)\right] * \frac{t}{n_{(g=1)}} \quad (3)$$

for all MPCRs for which a NEE exists (see the Theorem in Section 2.2.1) and for any $w_H > W_L$. It thus does not behoove an H-player to contribute nothing.

d) So far, we have seen that in an equilibrium with positive contributions each H-player best-responds to the L-players by contributing $x^*_{iH} > w_L$ to avoid the L-stratum altogether. However, a rational H-player contributes only a minimal ϵ above w_L. This is because the payoff function from a public contribution has social dilemma properties and $H = n_{(g=1)}$ so that the H-players fill exactly one group. Once H-types are among themselves any contribution $x'_{iH} > (w_L + \varepsilon)$ is strictly dominated.[8]

In sum, to avoid the risk, competition, and inferior expected payoffs in the L-environment each H-player contribute just a small ε above what all but z L-types contribute. If the fully contributing L-types lowered their contributions rationally self-interested H-types would follow suit. The L-players are decisive for maintaining the TTE and overall productivity.

3 Hypotheses

A TTE payoff dominates (Harsanyi & Selten, 1988, Ch. 3.6, p. 81) the FRE: each player earns more or at least as much in a TTE as in the FRE. Experiments (Section 2.2.3) have shown that under contribution-based organization subjects coordinate a payoff dominant equilibrium even when wealth levels are unequal. We have thus both theory- and observation-based reasons to expect that our subjects will coordinate a TTE. Based on both theory and prior experiments we expect L-subjects to coordinate a NEE among themselves as they compete for placement in profitable groups. For the H-subjects however, expectations based on theory and on prior experimental findings diverge: In the payoff-dominant equilibrium rationally interested H-players contribute $w_L + \epsilon$ that is, the minimum required to stay above the competitive fray of the L-environment. However, VCM experiments (Section 2.1.1) show that in a social dilemma setting, in which H-subjects find themselves once they have separated from the L-layer, subjects

[8] Formally, for every H-player $\Pi^*_{iH} = w_H - (w_L + \varepsilon) + \left(\sum_1^{n(G=1)} *x_{iH}\right) \frac{*t}{n_{(G=1)}} > \Pi'_{iH} = w_H - (w_L + y) + \left(\sum_1^{n(G=1)} *x_{iH}\right) * \frac{t}{n_{(G=1)}}$ where $y > \epsilon$.

contribute above equilibrium levels albeit well below the social optimum, and specific to their culture. We therefore hypothesize as follows:

Hypotheses 1. *L-types coordinate a NEE among themselves.* $(L - z)$ *L-subjects contribute fully while* z *L-subjects contribute nothing.*

Hypotheses 2. *Driven by material self-interest the H-types contribute* $x_{iH} > w_L$ *to separate from the risky and competitive environment of the L-players.*

Hypotheses 3. *Since once separated, H-subjects face a social dilemma among themselves their contributions exceed the equilibrium prediction but are well below the social optimum. H-subjects' contributions in excess of* $(w_L + \epsilon)$ *resemble VCM contributions in their culture and subject pool.*

4 Experimental Design and Procedure

4.1 Experimental parameters and equilibrium prediction

To maintain comparability with other studies, parameters are as in most prior GBM experiments. Only the type composition is varied: $L = 8$ and $H = 4$ so that $N = 12$. $G = 3$, $n = 4$, $w_L = 80$, $w_H = 120$, and the MPCR m is 0.5. Subjects can contribute any integer amount within their budget. It can be verified (Eq. 2) that with these parameters, a TTE equilibrium profile is: $s^* = \{0, 0, 80, 80, 80, 80, 80, 80, 81, 81, 81, 81\}$.

4.2 Subjects

Students at the University of Iceland were invited to a two-hour experiment with a show-up fee of ISK 700 (about US$ 6.20) and further experimental earnings dependent upon their own and others' decisions in the experiment. Interested students selected multiple time slots. 48 randomly selected students were randomly assigned to one of the slots they had indicated availability for. Students who had previously participated in a social dilemma type experiment were excluded.

4.3 Procedure

There were four sessions with $N = 12$ subjects each, conducted in a computer lab with terminals separated by blinders, always by the same set of experimenters. A written protocol (available upon request) standardized the interaction between experimenters and participants. At the start, participants received their show-up fee, were randomly seated at terminals, and informed that communication was not permitted. Each terminal contained a hard copy of the instructions (Appendix E) and an informed consent form. The instructions were also projected onto a wall visible to all to assure subjects that they were the same for everyone. Participants were told to raise their hand at any time with questions or concerns and an experimenter would address them individually. Round 1 started after all subjects had indicated that they understood the instructions and had signed the paperwork. At the end, subjects were privately paid their cash earnings. Each session concluded within 110 minutes.

4.4 Type assignment (H or L)

Before Round 1, eight participants were randomly assigned type L with an endowment of w_L of 80 tokens per round; four participants were assigned type H with $w_H = 120$ tokens. The endowments were fixed over all 80 rounds. This was common information (Appendix E).

4.5 Group assignment

At each round, after all participants had made their public contribution, the software ranked them accordingly, with ties broken at random. The four highest contributors were grouped together, followed by those ranked 5-8, and the lowest contributors formed the last group of four. Thereafter, earnings for that round were computed based on Eq. 1 and displayed on subjects' screens.

4.6 Information

Subjects were informed in the instructions (Appendix E) that there would be 80 decision rounds, that prior to Round 1 they would be randomly assigned a fixed endowment level of either 80 or 120 tokens per round, and that in each round they would be grouped based how their public contribution ranked, with ties broken at random. At the start of each round, each participant received a message reminding them of the size of their endowment and asking them to divide their tokens between a public and a private account. After all participants had decided their contribution, group membership had been determined and earnings computed, subjects saw a screen reminding them of their public contribution just made, the total contributions in their group, and their earnings broken down into returns from the public and the private account. Subjects further saw a series of $N = 12$ boxes showing the contributions by everyone in the session with their own contribution highlighted. The order of the boxes corresponded to the ranking of the contributions. The boxes for each group were clustered together. This way, subjects saw the individual public contributions in their group and in the whole session. They could verify that grouping was contribution-based and that over repeat rounds, ties were broken at random.

4.7 Payments and earnings

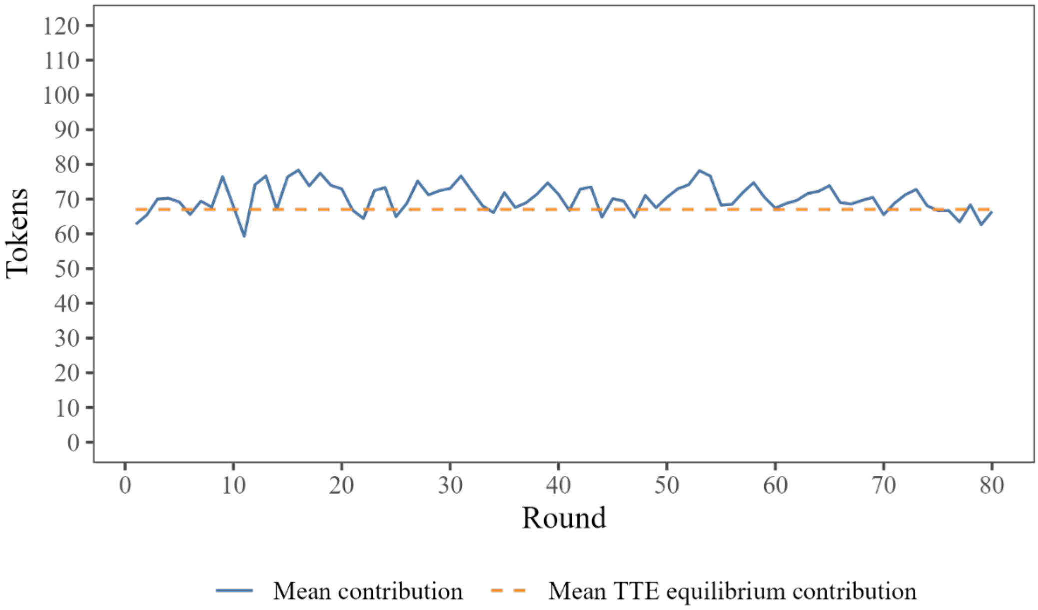
At the time of the experiments the exchange rate was 113.7 ISK to 1 US$. The minimum hourly wage was 954 ISK (US$ 8.40) (Confederation of Icelandic Enterprise, 2010). In addition to the show-up fee of 700 ISK (US$ 06.20) each token earned was worth 0.17 ISK (0.15¢). The mean earnings over 80 rounds were 11032 tokens (1875 ISK=US$ 16.50) for L-subjects, and 17187 tokens (2922 ISK=US$ 25.70) for H-subjects, excluding the show-up fee.

5 Experimental Results

Result 1. *Mean contributions are close to the TTE.*

In a TTE profile of $s^* = \{0, 0, 80, 80, 80, 80, 80, 80, 80, 81, 81, 81, 81\}$ the mean contribution is 67 tokens. The dashed line in Fig. 1 shows that from the earliest rounds, H- and L-types together get close to this prediction but there is slight yet consistent overcontribution. In fact, the observed mean contribution over 80 rounds is 70.19 tokens. To better understand this excess mean contribution, we next examine the choices of L- and H-types separately.

Figure 1: Mean per-round contributions by L-subjects and H-subjects together over four sessions, and MTE predictions.



Result 2. *L-subjects coordinate the NEE with considerable precision.*

In a TTE, the equilibrium profile for L-types is $s_L^* = \{0, 0, 80, 80, 80, 80, 80, 80, 80\}$, and the predicted mean is 60 tokens; see the horizontal dashed line in Fig. 2. The observed mean contribution of L-subjects over 80 rounds is slightly below that, at 57.10 tokens. Which single choices underlie this mean? Fig. 3 shows the choice frequencies of the L-subjects. The orange dots display the NEE frequencies. L-subjects predominantly select equilibrium strategies. Over 80 rounds, 18% of choices are zero tokens (predicted, 25%) and 62% are 80 tokens (predicted, 75%). Precision increases over time: If only Rounds 21 to 80 are considered 21% of the contributions are zero tokens and 64% are 80 tokens. In the last 20 rounds these percentages rise to 23% and 65%, respectively (Appendix B). In sum, L-subject behavior resembles behavior in prior experiments where a NEE was put to the test (Section 2.2.3). There is however less instantaneous coordination and more learning than what is for example reported by GVSM (2010a). The individual decision paths over rounds are shown in Appendix C. Appendix C shows that, as in prior related experiments, individual strategies over rounds are unpredictable. Many L-subjects oscillate unsystematically between the two equilibrium strategies while others keep contributing fully. Among the 4 x 8=32 L-subjects, only two (S.11 in Session 1 and S. 5 in Session 3) are consistent non-contributors. Two further participants (S.9 in Session 2 and S. 11 in Session 3) become steady non-contributors in the later rounds.

Result 3. *H-subjects separate from the L-subjects by contributing $x_{iH} > w_L$ but over-contribute relative to the TTE prediction.*

Figure 2: Mean per-round contribution per round by L-subjects, over four sessions.

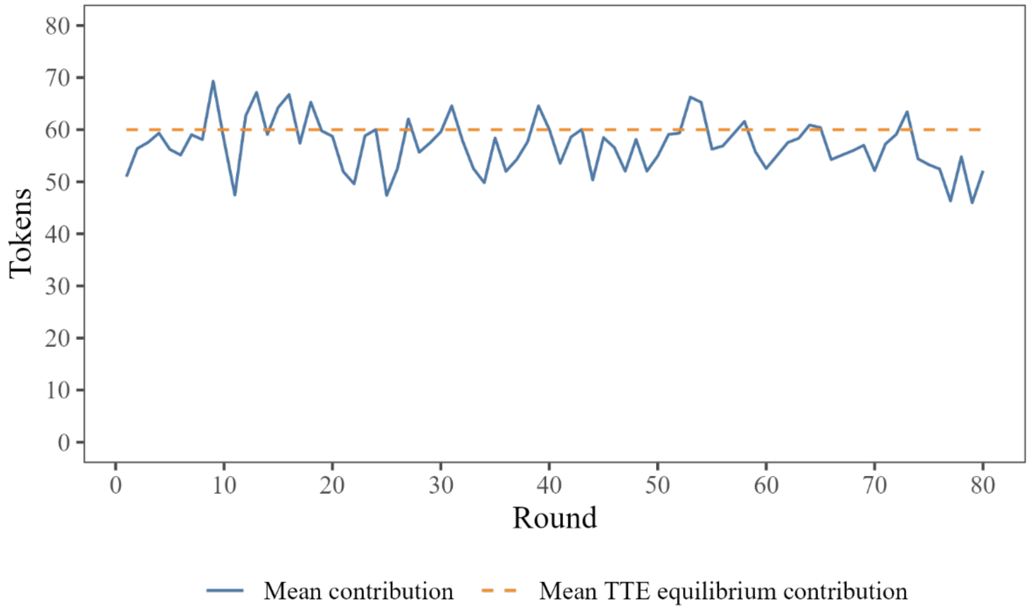
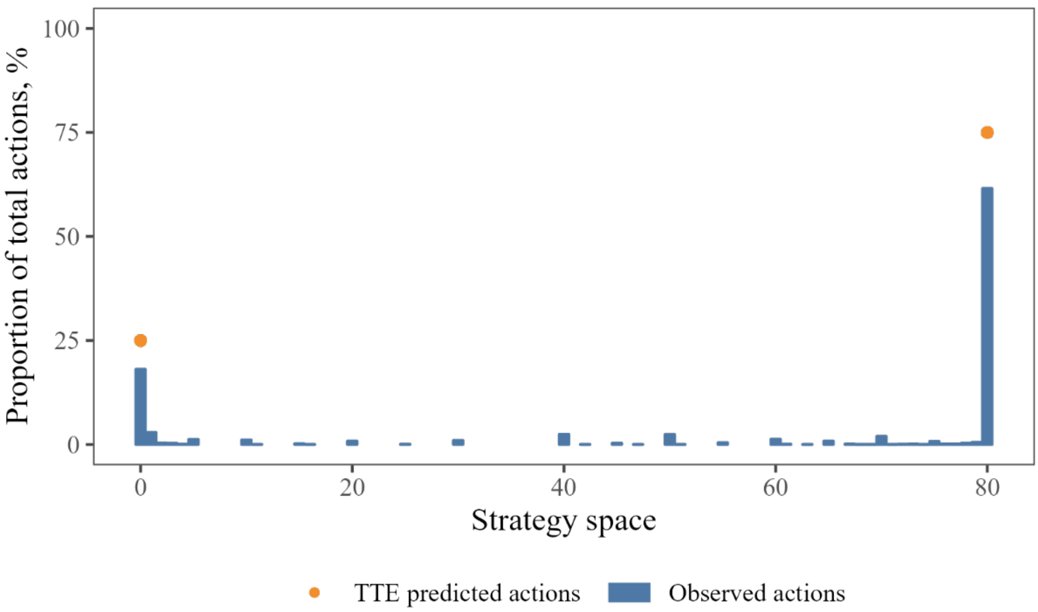
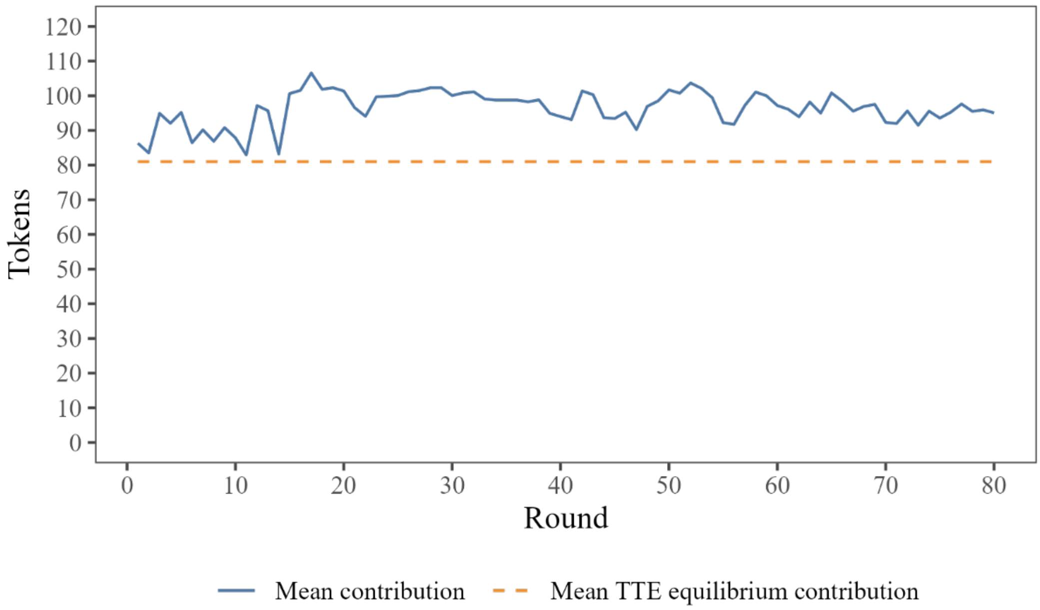


Figure 3: Choice proportions of the L-subjects over four sessions and 80 rounds.



Since the L-subjects under-contribute somewhat relative to the TTE prediction (Result 2) and the mean overall contribution is slightly higher than predicted (Result 1) the aggregate over-contribution must come from the H-subjects. Their mean contributions per round are shown in Fig. 4. The H-mean over 80 rounds is not the predicted 81 tokens but 96 tokens. Fig. 5 shows that the H-subjects separate from L-subjects by contributing $x_{iH} > w_L$ but contribute well above the TTE prediction of $x^*_{iH} = (w_L + \epsilon) = 81$. Since contributing $x_{iH} > x^*_{iH}$ is not in any H-subject's material self-interest the motive for the excess contribution is likely mostly pro-sociality. We cannot directly separate over-contribution due to error from over-contribution stemming from non-material pro-social motives. However, downward deviations from x^*_{iH} serve as an indicator of the frequency of errors since $x_{iH} < x^*_{iH}$ increases neither own earnings nor others' and can safely be classified as error. Over all 80 rounds, 5.7% of H-contributions are less than 81 tokens, nearly all in the earliest rounds, see Fig. 6. The figure shows that by Round 5 the count count of such contributions is small and starting with Round 15 it is either negligible or zero. This suggests that H-subjects learn that the strategy space within which they can express any off-equilibrium pro-sociality is $[w_L + \epsilon, w_H] = \{81, 82, \ldots, 120\}$.

Figure 4: Mean per-round contribution by H-subjects, over four sessions.



Result 4. *H-subjects' above-equilibrium contributions parallel their culture's VCM contributions.*

Do H-subjects perceive the game as a social dilemma among themselves as conjectured in Hypothesis 3? To answer this, we compare H-contributions where $x_{iH} \geq 81$ to standard VCM results from the same culture and subject pool (the University of Iceland). We contrast these data with two VCM data sets from US students who have a somewhat different contribution pattern from Icelanders (Gunnthorsdottir et al., 2023, *GTO*).Recall that there are no cultural differences known when it comes to NEE coordination; see Section 2.2.3.

Fig. 7 displays five-round lagged moving averages[9] of mean contributions per round from

[9]Moving averages rather than single round means because the former illustrate trends in the data more clearly.

Figure 5: Choice proportions of the H-subjects over four sessions and 80 rounds.

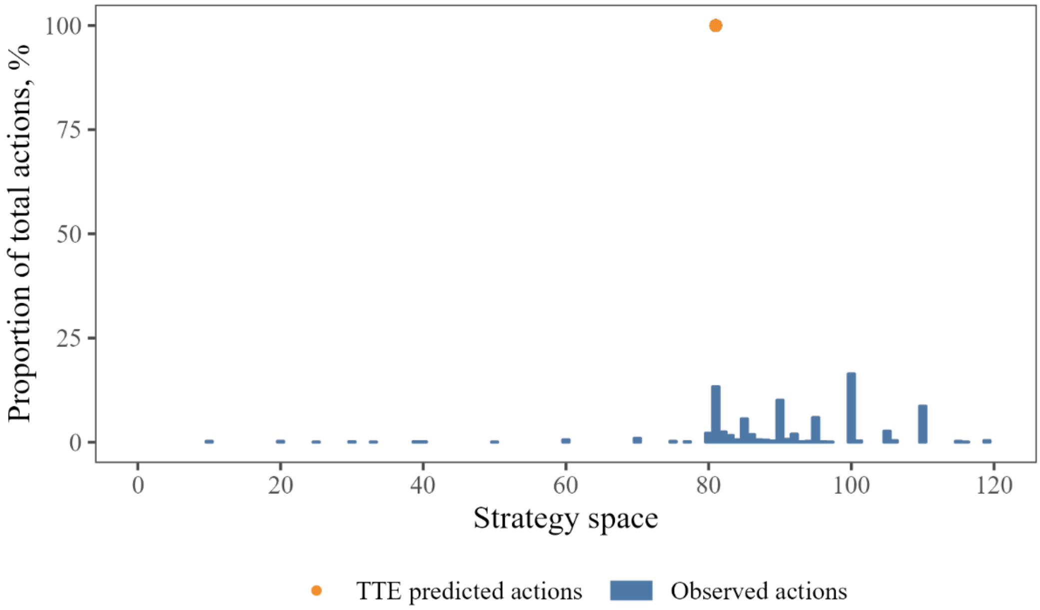
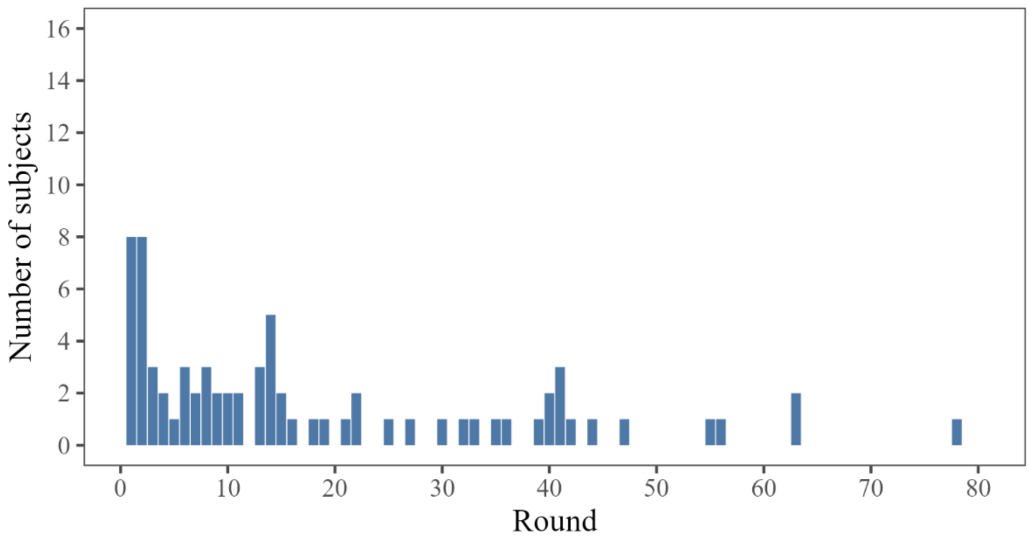
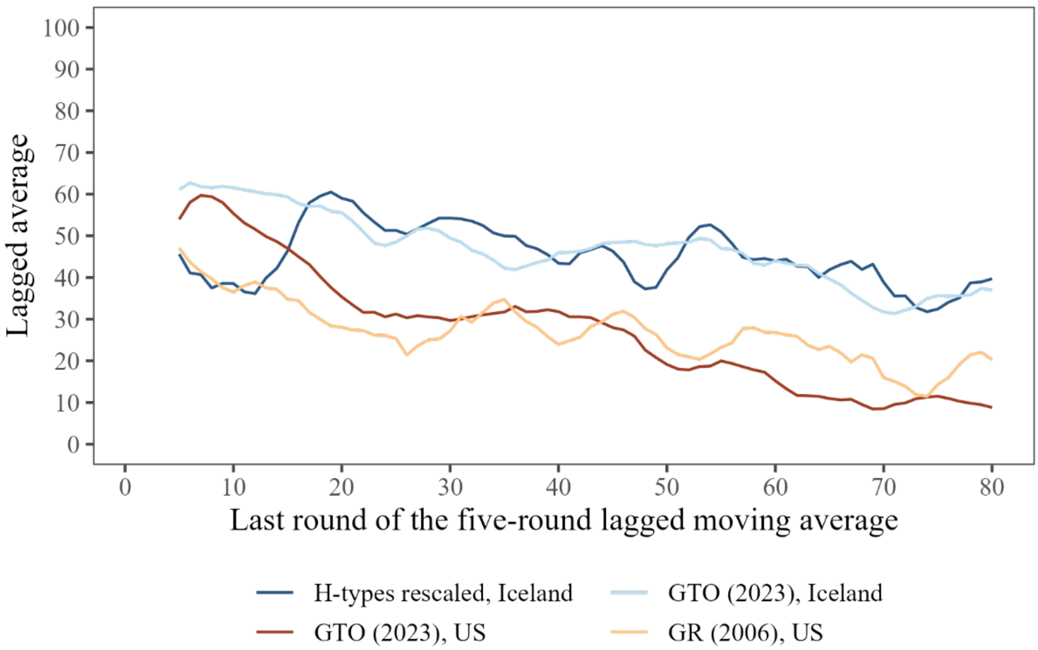


Figure 6: Per-round count of H-subjects who contributed < 81 tokens, over four sessions.



the four studies. In addition to the H-contributions, Fig. 7 shows the contributions of GTO's Icelandic VCM subjects, GTO's US VCM subjects, and Gunnthorsdottir & Rapoport (2006, *GR*) single VCM session from the same US subject pool.[10] In all four studies, $n = 4$, MPCR=0.5, and the number of rounds is 80. The sole parameter difference is in the strategy spaces. Once H-subjects understand to separate from the L-types their strategy space is effectively reduced to $\{81, \ldots, 120\}$; we map this space into $\{0, 1, \ldots, 100\}$ so that the strategy space is equivalent across the four studies.[11] Fig. 7 shows that the US data resemble each other. The Icelandic round means diverge at first but track each other closely starting at Round 15.[12] As stated, errors where $x_{iH} < 81$ are excluded from this analysis but recall that Round 15 is also when such errors become very rare (Fig. 6). Round 15 thus seems pivotal for H-subjects. Possibly, they needed the 14 initial rounds to learn a game with two player types and an asymmetric equilibrium with three contribution levels.

Figure 7: Lagged 5-round moving averages of mean contributions per round from four different VCM-type data sets (US/Iceland).



Nonparametric tests of significance. The hypothesis that starting with Round 15, the rescaled contributions of H-subjects who contribute $x_{iH} > w_L$ and the contributions by GTO's (2023) Icelandic VCM subjects are drawn from the same distribution cannot be rejected (Mann-Whitney-Wilcoxon, $n_1 = n_2 = 4$, p(2-tailed)=0.69; see Siegel & Castellan (1988, Ch. 6.4.3).[13] Icelandic H-contributions starting with Round 15 are significantly higher than the corresponding VCM contributions by GTO's US subjects: MWU, $n_1 = 4$, $n_2 = 3$, p(1-tailed)=0.056.[14] Since GR

[10]In all four studies, students who had previously been in any VCM-type experiment were excluded from participating.

[11]The endowment in GR's (2006) experiment was $\{0, 1, \ldots, 50\}$; it was also mapped into $\{0, 1, \ldots, 100\}$.

[12]Fig. 7 does not show single round means; GTO's Round 15 mean for Icelandic VCM subjects is 55 tokens; the Round 15 mean of our H-subjects (rescaled and excluding subjects who contributed $x_{iH} < 81$) is 60 tokens.

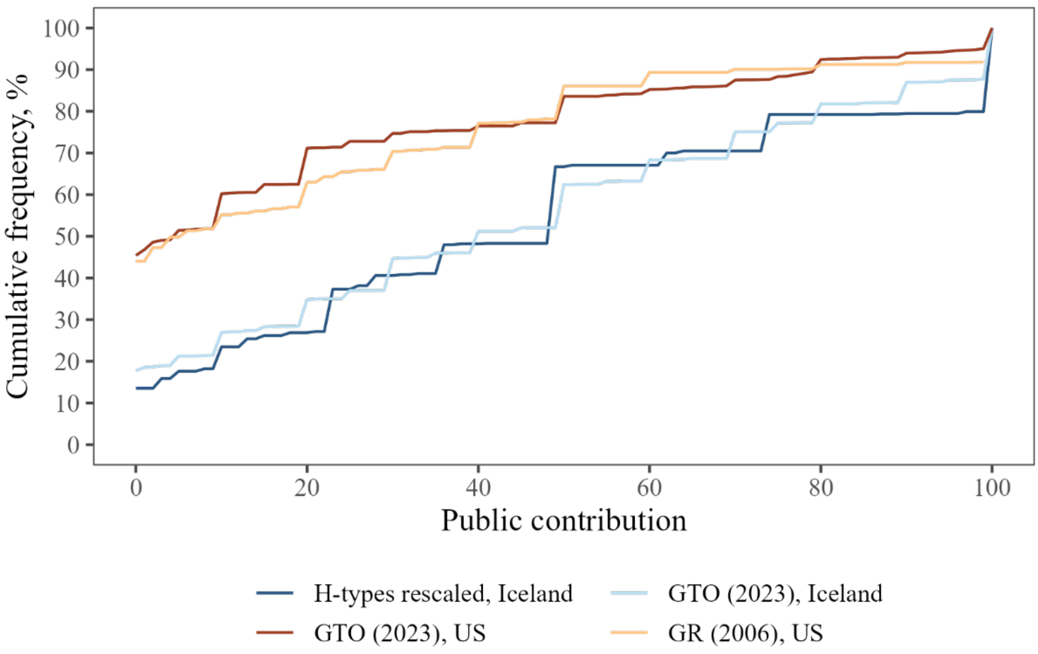
[13]When Rounds 1-80 are compared this result does not change; p(2-tailed)=0.45.

[14]The test is one-tailed since GTO found that Icelandic subjects contribute more than US subjects. We therefore expect the same difference with our H-data set.

(2006) report on a single session of $N = 16$ a statistical test with sessions as the unit of analysis is not possible but Fig. 7 speaks for itself.

Cumulative frequencies. As a further illustration that the contributions of H-subjects resemble contributions in the same subject pool and differ from contributions in a culturally different pool, Fig. 8 shows the cumulative frequency of individual contributions in the four experiments, starting with Round 15. The strategy space of H-subjects is again rescaled to $\{0, 1, \ldots, 100\}$ and only contributions $x_{iH} \geq 81$ are included. Intra-cultural similarities and cross-cultural differences are again obvious. We conclude that, starting with Round 15, H-subjects perceive their game as a social dilemma bounded from below at $(w_L + \epsilon)$.

Figure 8: Cumulative frequencies of public contributions in four different VCM -type data sets (US/Iceland), for Rounds 15-80 (for H-subjects, only contributions $x_{iH} > 80$ are included.)



Result 5. *The efficiency gains of the TTE over the FRE are substantial.*

Table 1 compares the two equilibria (FRE and TTE), the Social Optimum, and the experimental results. The FRE corresponds to the start of the game when players have yet to make any public contributions. It is the floor of the unit's productivity where total earnings equal the sum of the endowments, in our experiment $80 * 8 + 120 * 4 = 1120$ tokens. In the Social Optimum all $N = 12$ players contribute all their tokens to public accounts so that aggregate earnings are 2240 tokens[15], a 100% efficiency gain over the FRE. A TTE is not quite as efficient but still offers good welfare gains over the FRE. Table 1 shows that in a TTE with our experimental parameters, the L-players are somewhat more productive than the H-players: six out of eight L-players contribute fully so that L-types contribute on average 75% of their tokens while H-players contribute 81/120=67.5%. Since z is independent of how many L-types are in the game (see Eq. 2) L-players' average output would increase if there were more of them (see Appendix A

[15] $1120 * 4 * 0.5 = 2240$. See Eq. 1. Recall that $n = 4$ and $m = 0.5$.

Table 1: Contributions and earnings in the FRE, the social optimum, the TTE, and corresponding per-round means observed in the experiment. All figures are based on the experimental parameters.

	Contribution		[1] Earnings		Gini Coefficient
	Tokens	*% of total*	*Tokens*	*% increase over FRE*	
FRE					
All players	0	0	1120	..	0.1
L-individuals	0	0	80	..	
H-individuals	0	0	120	..	
SOCIAL OPTIMUM					
All players	1120	100.0	2240	100.0	0.1
L-individuals	80	100.0	160	100.0	
H-individuals	120	100.0	240	100.0	
TTE					
All players	804	71.8	1924	71.8	0.09
L-individuals	[2] 60	75.0	[3] 140	75.0	
H-individuals	81	67.5	201	67.5	
OBSERVED MEANS					
All players	842	75.0	1964	75.4	0.11
L-individuals	57.25	72.0	138	72.5	
H-individuals	[4] 96	80.0	215	79.2	

[1] Earnings are total earnings from the private and public account.
[2] Mean contribution over $(L - z) = 6$ full contributors and $z = 2$ non-contributors.
[3] Mean earnings over $(L - z) = 6$ full contributors and $z = 2$ non-contributors.
[4] Includes observed contributions of less than 81 tokens.

for an illustration). For example, if L increases from $2n$ (as in our experiment) to $20n$, that is from $L = 8$ to $L = 80$, the mean L-contribution in a TTE is 97.5%, greatly surpassing that of the H-players. In Section 6.3 below we expand on ways to increase productivity. Note though that already with a very small L-class, the TTE prediction is that the L-stratum contributes proportionally more than the H-stratum does.[16]

Result 6. *Inequality does not discourage the disadvantaged L-players from contributing.*

Inequality and how subjects respond to it is the driver behind our design. In a TTE there is some earnings inequality among L-players depending on the random resolution of ties among full L-contributors and on whether an L-type chose to contribute 0 or w_L. These earnings differences however, are either under a player's control or driven by an equal chance process; they are also negligible over repeat play (Appendix D). Our focus is the H-L gap which is of a different nature: The last column of Table 1 shows the Gini Coefficients for all N players in the FRE, the Social Optimum, a TTE, and for the experimental outcomes. A Gini Coefficient of one indicates extreme inequality where one player takes it all while a coefficient of zero indicates full equality (Charles et al., 2022; Giorgi & Gigliarano, 2017). All coefficients are around 0.10. Even if the L-subjects somehow rebelled against inequity by not contributing and letting the system collapse toward the FRE, the Gini Coefficient would hardly change. Table 1 shows that in the endowments as well as in the earnings theoretically predicted or realized in the lab, an H-type earns, on average, about 50% more than an L-type. This is impossible for L-types to overcome unless they somehow managed to endogenously change the rules of the game, maybe helped by an exogenous shock to the system. As pointed out by Piketty (2014, 2015, 2022) in naturally occurring settings attempts by L-types to change the game in their favor are relatively common but rarely easy since H-types rationally do their best to preserve their privilege.

Further mirroring naturally occurring settings, the absolute difference in the accumulated earnings of L- and H-players grows over rounds. The gap between the mean total earnings of L- and H-subjects is 6006 tokens, close to the total earnings of the least successful L-subject. (Subject 5 in Session 1 earned just 8917 tokens, see Appx. D.) The observed earnings gap exceeds the equilibrium prediction since H-subjects over-contribute relative to the TTE, which raises the income in their group above the TTE prediction. Even in a perfectly coordinated TTE however, the income gap between an H- and an L-player is 4900 tokens over 80 rounds.[17] In natural settings too, prolonged privilege such as for example long-term earnings differences, inter-generational wealth transfers, or higher return from capital than from labor Piketty (2014) increases the distance between classes over time.

[16] In most cases, the L-stratum is proportionally more productive than the H-stratum. However, by minimizing L, m, and the difference $(w_H - w_L)$ it is possible to construct cases where in an equilibrium with positive contributions the L-stratum is proportionally less productive than the H-stratum.

[17] Assuming the following: 1) each H-player contributes $x_{iH} = 81$ tokens in each round; 2) L-players select their two equilibrium strategies in TTE prescribed proportions in every round and furthermore switch between the two strategies in proportions that correspond to the TTE so that by Round 80 each player has chosen $x_{iH} = 0$ in 20 rounds and $x_{iH} = w_L$=80 tokens in 60 rounds.

6 Discussion

6.1 Summary of experimental findings

All three hypotheses are confirmed: As stated in Hypothesis 1, the L-subjects who operate in an environment where effort is linked to reward tacitly coordinate an asymmetric Near-Efficient Equilibrium (NEE) among themselves. Hypothesis 2 says that in the Two-Tier Equilibrium (TTE) H-players use their superior means to segregate from the competitive L-environment; this is also confirmed. Hypothesis 3 based on findings from social dilemma experiments, is confirmed as well: in their separate privileged group, H-subjects display typical social dilemma behavior with the associated inefficiencies. Unlike the L-subjects, the H-subjects under-contribute to a significant extent relative to their superior resources. We next turn to the policy implications of our findings.

6.2 Inequality need not be detrimental to efficiency

Our experimental results show that inequality and material disadvantage need not be detrimental to efficiency but assured privilege and absence of competition are. L-subjects contribute at high levels as they compete for membership in units where contributions and earnings are higher. In doing so they drive the H-subjects contribute $x_{iH} > w_L$. It is thus the "poor" L-players who are the most productive and provide the support for a relatively efficient Two-Tier Equilibrium (TTE).

Several social dilemma-type experiments have previously addressed the impact of inequality when endowment levels are randomly assigned as in our study.[18] The findings parallel ours: The disadvantaged tend to contribute proportionally at least as much and in most cases more, than the "rich". Sadrieh & Verbon (2006) varied the Gini Coefficient of their subjects' endowments with the wealth levels again randomly assigned. The degree of inequality was not linked to contribution levels and did not discourage the "poor". However, Haile et al. (2008b, *HSV*) report that when an already materially advantaged subject is given dictatorial power to determine the actual size of the wealth gaps within their group the "poor" subjects' contributions are inversely related to the size of the gap imposed. HSV conclude that inequality's origin matters. Random assignment to endowment levels is an equal-chance process perceived as fair. In contrast, HSV's "poor" subjects considered themselves victims of unfair abuse of power by a fellow group member. Comparing their laboratory results to macro-economic data on economic growth and corruption, HSV conclude that what is perceived as fair need not be equitable: inequality's origin matters. For example, under corruption and otherwise weak institutions, inequality tends to be perceived as due to unfair processes; this damages motivation, social capital, and social cohesion (see also e.g. Chang, 2021; Glaeser et al., 2003. In our study, subjects are not only randomly assigned to a wealth class (H or L) but our mechanism motivates the "poor" even further with competition and control over their outcomes due to the link between own choices and earnings. Note however that the FRE remains an option for a disgruntled L-population. Future studies might examine

[18] See e.g., Buckley & Croson (2006), Chan et al. (1996), Cherry et al. (2005), Hofmeyr et al. (2007), and Visser & Burns (2015). The exact design of experiments intended to examine the effect of inequality varies a great deal. We cite studies that share with our design the following aspects: Social dilemmas are contribution-focused rather withdrawal-focused, the inequality is common knowledge, decisions are simultaneous, and communication is not allowed.

what it takes for L-subjects to "rebel" this way, for example by varying the wealth gap between H and L, or its genesis.[19]

6.3 How to make a stratified society more productive

While a TTE offers good efficiency gains over the FRE there is room for improvement compared to the Social Optimum. See Table 1. How can efficiency be increased above TTE levels? We next discuss structural solutions aimed at type distribution, group formation, and MPCR.[20] The proposed solutions, experimentally testable, are introduced in the context of the two-class model but apply to more complex stratification as well. See Section 7 for the latter.

a) *Growing the L-layer.* The system's efficiency hinges on the productive L-players who coordinate a NEE with only $z < n$ non-contributors. Efficiency can be improved by increasing the count of L-players while holding H constant while as before, $L \mod n{=}0$. Growing $(L - z)$ the count of full L-contributors, reduces the relative impact of the $(z < n)$ L-type non-contributors. This way, as the L-layer asymptotically approaches full efficiency (Appendix A) the relative weight of the underperforming H-layer decreases.

b) *Reducing the H-layer.* Our model can accommodate unequal group sizes. Segregation and under-performance of H-types can only occur if $H = n_{g=1}$. Reducing the relative weight of the privileged but underperforming upper stratum by reducing both H and concomitantly, $n_{g=1}$, increases overall output.[21]

c) *Preventing segregation.* In GVS' (2010, see 2.2.3.c) model, $H > n$ and $H \mod n \neq 0$, $L > n$ and $L \mod n \neq 0$ so that in the payoff-dominant equilibrium H-players cannot segregate: In such an equilibrium, all but $(z < n)$ L-players contribute fully, all H-players contribute fully and some fully contributing H- and L-types meet in a mixed group. The reason for the high efficiency under this type composition is again, competition. The $(L-z)$ fully contributing L-types compete for a chance to enter the mixed group while all H-types contribute fully as they compete to avoid this group. The mixed group is attractive to L-players since they get an equal share of the full H-contributions which are higher than their own. It is unattractive to H-players since L-members' full contributions are lower than their own. A schematic example from naturally occurring circumstances would be a loosening of the borders of class: a setting where ambitious members of the lower class can aspire to mingle with the upper class while upper class members can experience downward mobility.

d) *Competition among H-players.* H-players can be incentivized to contribute more if competition is introduced into their privileged stratum. Leave L unchanged that is, $L \geq 2n$

[19] Coordinating a FRE under competitive grouping is possible but presents challenges: In such a setting the FRE is not a dominant strategy equilibrium but a best-response equilibrium. A NEE's basin attraction is larger than the FRE's (Nax et al., 2017b). Finally, even a competitive grouping incentive too weak to lead to an equilibrium with positive contributions is somewhat effective in raising contributions above VCM levels (Nax et al., 2018).

[20] Also feasible are psychological methods such as moral suasion (Dal Bó & Dal Bó, 2014), or fear of retribution (e.g. Fehr & Gächter, 2000; Ostrom et al., 1992).

[21] A growing H-layer has the opposite effect. For example, Israel's Haredis can be regarded as an H-layer, a "priestly leisure class" in a Veblen (1899, Ch. 6,7) sense. Their count has grown as they have responded rationally to policy designed to support them in religious activities instead of contributing to the economy or military. Initially about 3% of the population the Haredi stratum has grown to 14%, raising concerns for the country's competitiveness and defense readiness (e.g., Rettig Gur, 2023).

and $L \mod n = 0$, so that the L-players compete for group membership among themselves as before. Now set $H = yn$ where $y \in \mathbb{Z}^+$ and $y \geq 2$, and $H \mod yn = 0$. This way, in an equilibrium with positive contributions H-players segregate from L-players but fill two or more groups. Our experimental results reported above show indicate that H-subjects understand that it behooves them to segregate, and that L-subjects coordinate a NEE if one exists. This structural amendment is thus likely to lead to a highly efficient equilibrium outcome: L-players coordinate a NEE among themselves with $z < n$ non-contributors. The H-players coordinate a separate NEE where $z < n$ of them contribute $x_{iH} = w_L + \epsilon$ and the rest contribute their entire endowment. As any one or both layers grow the system asymptotically approaches full efficiency (Appendix A). An example from naturally occurring circumstances is members of a privileged class having opportunities that due to their privileged status, are open only to them but for which they must compete among themselves, such as appointments in industry or in government or historically, at court.

e) *Imposing equality through taxes and transfers.* Governments typically lower their citizenry's Gini Index by redistributing wealth through taxes and transfers (OECD, 2012). Imagine for example a tax on $w_H - w_L$ and re-distribution so that $w_H = w_L$. With endowments equalized, one can expect a NEE to be coordinated. Even just a partial equalization of resources increases efficiency since in a TTE where the H-class segregates and does not compete the L-players apply their endowment more efficiently than the H-players. Our model also allows to "tax" players' earnings with class-specific amendments to their payoff functions, which reduces the cumulative earnings gap between H and L. Consider in this context Piketty's (2022, Ch. 7) arguments for strong progressive taxation and extensive redistribution to equalize the playing field for everyone. A practical question is under which circumstances an H-class would support a reduction of their privileges (Veblen, 1899, Ch. 9). It is in the privileged class' rational self-interest to apply themselves in the opposite direction.[22] Further practical considerations include the complexities associated with taxation and redistribution including their effect on incentives and economic growth, and how a wealth gap's perceived origin impacts support for such policies (Alesina & Angeletos, 2005; Alesina & Giuliano, 2009).

7 Concluding remarks and further research

7.1 The TTE as a model of a class-based society

Organizational forms where value is cooperatively generated are a cornerstone of all societies, from hunting parties to modern businesses. We use a simple model thereof where gains are shared equally. Evidently, this can be relaxed so that the return from the group product (the MPCR) differs between individuals. Membership in our simple model of organizations is dynamic and based on output, as it generally is in naturally occurring settings. The TTE society resembles

[22] Examples include: 1) As European states strengthened from the Middle Ages onward, regressive taxes were commonly imposed by the ruling class well into the 19$^{\text{th}}$ century (Alfani, 2021; Piketty, 2022); 2) Under public pressure over the cost of the monarchy, Queen Elizabeth II agreed to pay income tax starting in 1992 but a 1993 agreement with the then-prime minister exempts inheritance "from sovereign to sovereign" from tax otherwise applied to everyone domiciled in the UK (Boffey, 2022); 3) In the 1970s in the US, wealthy individuals and business groups hit by inflation, lobbied for deregulation that served their interests and increased the wealth gap (see Gibbs, 2024, for an extensive overview).

Voltaire's description oe social structure of Great Britain resembling "... their own ... beer, froth on top, dregs at bottom, but the middle excellent" (Chaudon, 1786, p. 293). Voltaire describes a society of under-contributing H-players firmly on top, a majority of L-players sustaining overall performance, and $z<n$ "dregs" feeding off others. About a century later Veblen (1899) made a similar point about the US when he contrasted the suboptimal contribution of of a wealthy "leisure class" to the high output of working- and middle-classes.

L-players. The L-layer is similarly highly productive. L-incentives resemble a Middle-Class mindset where the expectation is that effort broadly defined is linked to reward (e.g., Office of the Vice President of the United States, 2010; Reeves et al., 2018).[23] Although they cannot breach the H-layer's wealth barrier the L-players experience social mobility since for them, contributions are competitively linked to earnings. If the productive L-players ever got discouraged the FRE is the alternative. This would be detrimental not just from a simple welfare perspective but also because no social unit can survive for long if its members are not productive. Social stratification, while likely inevitable should support performance (Davis & Moore, 1945). Resources must be generated internally so that a unit can compete in the ubiquitous between-unit competition for scarce resources; see Hausken & Cressman (2004) for an overview of bi-level games between unit members and between units.

H-players. H-subjects enjoy secure privilege thanks to the luck of the draw, akin to Rawls' (1971) lottery of birth. Encyclopaedia Britannica (2023) defines an upper class as follows:

> *The upper class in modern capitalist societies is often distinguished by the possession of largely inherited wealth. The ownership of large amounts of property and the income derived from it confer many advantages upon the members of the upper class. They are able to develop a distinctive style of life based on extensive cultural pursuits and leisure activities, ... and to procure for their children a superior education and economic opportunities that help to perpetuate family wealth.*

Lewis (1985) describes how the upper stratum maintains the existing order by reducing lower classes' upward mobility. In our study this is imposed exogenously through fixed levels of w. With this in place, H-types using their higher w to segregate from the "poor" is a rational response to incentives, as is contributing only the minimum required to remain above the L-stratum. If their privilege can be maintained with limited effort, rational H-players will not use their superior endowments more efficiently. w need not only represent monetary capital that serves accumulate experimental earnings. In a broader sense, w can be any resource that helps capture value. In a stratified society, $w_H > w_L$ can represent e.g., access to better schools, powerful connections, or being of a dominant race (Emerson, 1962; Grusky et al., 2019; Lewis, 1985; Piketty, 2022, 2020, 2015). In natural settings as in our experiment, the wealth gap grows over time unless/until countered, reversed, or undone by often forceful collective action (Piketty, 2022, 2015, 2014) or exogenous events that change the rules of the game (Alfani, 2021).

H-subjects' under-contribution relative to their level of w is expected not only theoretically but also from what is known about behavior in social dilemmas absent competition. H-subjects contributing above equilibrium (albeit well below optimum) also parallels natural settings. The "Warm Glow of Giving" (Andreoni J., 1989) is observed both in the laboratory and outside

[23] In defining someone as Middle Class, a belief in a link between effort and reward even dominates current income level (Office of the Vice President of the United States, 2010, p. 10).

of it (Gächter, 2007). In the latter settings, H-contributions to charity and philanthropy if conspicuous, can also be rational moves in a wider game to gain social approval and prestige or avoid hostility (Becker, 1974, p. 1083; Olson, 1965, p. 60), all of which helps consolidate H-status. To maintain the existing order H-types not only restrict lower classes' social mobility by reducing access to sources of w such as education (Lewis, 1985) but also justify their privilege with what Piketty (2020) terms "ideologies": Historically players in H-positions have for example invoked a "natural" order between classes or races, or birth privilege. Claims that H-types fulfill a special role such as preserving tradition or providing cultural refinement persist to this day. More recent ideologies draw on rewards for entrepreneurship and employment creation, merit, or property rights. H-types' superior resources are however often spent suboptimally on luxury and conspicuous consumption[24] (Bryant, 2017; Piketty, 2022; Veblen, 1899).

7.2 Class-based incentives

Human behavior adapts fast to incentives, opportunities and threats: This shows in economics experiments where subjects, randomly assigned to an environment, respond quickly and by and large rationally to their monetary incentives. Behaviorist psychologists have similarly documented speedy adaptation to opportunities and threats in the environment (see Ferster et al., 1975, for an overview). Historians similarly provide accounts, from the field, of how humans have adjusted to changes in their social and economic circumstances or in the power balance between players; see e.g., Alfani (2021) or Piketty (2022, 2015) for diverse examples. See also for example Tackett (2019) on how French and Chinese upper classes adapted successfully to disruptive change, or Bryant (2017) on how British aristocrats currently manage to preserve their wealth in an increasingly less favorable environment. While in naturally occurring settings H-types often possess superior means and oversight which translates into superior versatility (e.g., Gibbs, 2024; Tackett, 2019), individuals of all social classes adapt to changes in incentives. See e.g., Wike et al. (2019) on how the general citizenry of former communist countries modified their beliefs and aspirations as they transitioned from dictatorial command economies to democratic market systems.

Currently, traditional Middle-Class beliefs that effort is linked to reward are undergoing rational adaptation as their economic opportunities are threatened by globalization, outsourcing, computerization, and AI. Wealth gaps are on the increase as a minority, predominantly in finance and technology, benefit from these developments (Colegrave, 2019; Cooper, 2015; Fukuyama, 2012; Kochhar & Sechopoulos, 2022; Krause & Sawhill, 2018; Lanier, 2013; Ludwig, 2020; West, 2013; Zitner, 2023). Nax et al. (2018) report that subjects' contributions remained somewhat elevated even when the link between contribution and grouping was perturbed past the point where a NEE exists. This suggests that even a minor connection between contribution and reward can have somewhat of a positive impact on efficiency, but the impact is reduced as the link is weakened. If however, beliefs in such a link no longer sufficiently correspond to reality attitudes must change. Our equilibrium model suggests that if players in L-positions no longer feel that effort is sufficiently linked to reward, not only might their own productivity collapse but the productivity of other strata could follow suit. A Middle-Class mindset is thus not only

[24] For example, India's richest 5% own about 60% of the country's wealth (Mahendru et al., 2023, p. 14). Rich Indians spend about US$ 75 billion annually on weddings (Khosla, 2024) with the 2024 Ambani wedding the most expensive so far, estimated at between 132 and 156 million US$ (Mateen & Sebastian, 2024).

productive but, as previously pointed out by others in non-experimental contexts (e.g. Fukuyama, 2012; Kuznetsova & Tupitsyn, 2014; Ludwig, 2020; Office of the Vice President of the United States, 2010; West, 2013) socially and politically stabilizing and helpful to economic growth.

Incentives and policy. Taken together, our model and experimental results combined with prior findings (Haile et al., 2008b; Piketty, 2022, 2015; Veblen, 1899) indicate that incentive modification can be an effective policy measure: Social mobility, competition, equalization of resources, levelling the playing field between classes, and linking effort to reward supports productivity. Segregation, lack of competition and opportunity, and wealth differences perceived as unfair, have the opposite effect.

7.3 Further research

7.3.1 Modeling more extensive stratification

Our model allows for many testable variations and extensions. Some have already been discussed in Section 6.3. In addition to w-differences it is also possible to model discrimination by requiring that "underprivileged" subjects contribute more to join a profitable group. One can also build a four-class model common in sociology (underprivileged/lower-, working-, middle-, and upper class) and structure their incentives by varying the relationship between class member count and group size, the endowment w, or the MPCR. Underprivileged U-players' lack of marketable skills is captured by a low w_U. To add a U-class with no prospects let the count of U-players U equal the size of the lowest ranked group G: Keep other parameters as in the model tested here and set $w_U = 0$, or a very low positive value, possibly together with a class-specific low MPCR since in a MTM neither group size nor MPCR need to be uniform across groups or classes. Such a U-class has no chance to penetrate the next stratum up and little or no motivation and ability to contribute. In an equilibrium with positive contributions the next class up remains self-contained with $z < n$ members contributing $w_U + \epsilon$. Mingling of classes is possible if $U > n_{(g=G)}$ as in GVS's (2010b, see 2.2.3.c) model where in an equilibrium with positive contributions, one of the groups contains two classes. For a four-class model add a "working class" whose w is between that of a U-class and a "middle class". It too, could either be self-contained or its members could have a chance to be upwardly mobile into the "middle class" depending on how group size and type count are set. Downward mobility is modeled in the same manner. This and similar extensions are all empirically testable. All these modifications require keeping a close eye on the relationship between group sizes and type distribution since they determine not just the structure but also the existence of equilibria with positive contributions (Duca et al., 2018; Nax et al., 2017a).

7.3.2 Economic incentives and the psychology and sociology of class

We have defined class by resources, mobility, and incentives. A growing body of literature on the psychology of class examines long-lasting class-driven attitudes including beliefs about the Self (see, e.g., Kraus et al., 2012; Manstead, 2018 which can impact social mobility and the ability to seize opportunities. In addition to psychology, stratification economics incorporates sociology, most notably race and other identities, in the study of inequity (see Chelwa et al., 2022, for an overview). Highly abstracted, demographic or psychological features can be seen as factors of w. It is also possible to include such attributes into experimental tests of our model of class by assigning subjects to roles accordingly and if desired, providing this information to the other players. Examples of prior studies applying such methods include Gunnthorsdottir et al. (2002) and Haile et al. (2008a).

7.3.3 The perceived fairness of class differences

Finally, how does the perceived appropriateness of class differences (in our model, w, social mobility, MPCR) impact contribution levels? Recall that HSV (2008b) report that while it does not affect the equilibrium inequality's origin impacts subjects' willingness to contribute. In an experimental operationalization of social unrest HSV's Dutch subjects had the option to destroy everyone's earnings. The option was rarely exercised. Consider however that Herrmann et al. (2008) find important cultural differences in frequency of destructive (in the context of their study, spiteful) acts in cooperative settings, with subjects from the English Speaking and Protestant European cultural clusters (Holland belongs to the latter; see World Values Survey, 2023) engaging in it the least. In the model tested here, the "option to destroy" corresponds to L-subjects coordinating the FRE. What would it take for the FRE to happen, across cultures? As is so often the case, subjects' culture must be considered before generalizing from experiments to the anticipated success or failure of a policy. More generally, we caution against directly extrapolating from a simple model or a controlled experiment to naturally occurring settings: In addition to culture, a plethora of other facets specific to a given society must be considered. For example, Haile et al.'s (2008a) find, with trust games in a racially divided and economically unequal society, that investment levels are affected by demographic information about one's counterpart. Nonetheless, we believe that we have uncovered choice patterns associated with competition and privilege, equality or the lack thereof, that are probably quite general even though doubtlessly moderated by local social complexities.

References

Alesina, A. & Angeletos, G.-M. (2005). Fairness and Redistribution. *American Economic Review*, 95(4), 960–980.

Alesina, A. & Giuliano, P. (2009). Preferences for redistribution.

Alfani, G. (2021). Economic inequality in preindustrial times: Europe and beyond.

Andreoni J. (1989). Giving with Impure Altruism: Applications to Charity and Ricardian Equivalence.

Becker, G. S. (1974). A Theory of Social Interactions. *Journal of Political Economy*, 82(6).

Boffey, D. (2022). King Charles will not pay tax on inheritance from the Queen. *The Guardian*.

Brandts, J., Saijo, T., & Schram, A. (2004). How universal is behavior? A four country comparison of spite and cooperation in voluntary contribution mechanisms. *Public Choice*, 119(3-4).

Bryant, C. (2017). How the aristocracy preserved their power.

Buckley, E. & Croson, R. (2006). Income and wealth heterogeneity in the voluntary provision of linear public goods. *Journal of Public Economics*, 90(4-5), 935–955.

Camerer, C. F. (2003). *Behavioral game theory: experiments in strategic interaction*. Princeton, New Jersey: Princeton University Press.

Chan, K. S., Mestelman, S., Moir, R., & Muller, R. A. (1996). The Voluntary Provision of Public Goods under Varying Income Distributions. *The Canadian Journal of Economics*, 29(1).

Chang, W. C. (2021). Corruption and perceived fairness: Empirical evidence from east asian countries. *Journal of East Asian Studies*, 21(2).

Charles, V., Gherman, T., & Paliza, J. C. (2022). The Gini Index: A Modern Measure of Inequality. In *Modern Indices for International Economic Diplomacy*.

Chaudon, L. M. (1786). *Historical and Critical Memoirs of the Life and Writings of M. de Voltaire*. London: G. G. J. and J. Robinson.

Chelwa, G., Hamilton, D., & Stewart, J. (2022). Stratification Economics: Core Constructs and Policy Implications. *Journal of Economic Literature*, 60(2).

Cherry, T. L., Kroll, S., & Shogren, J. F. (2005). The impact of endowment heterogeneity and origin on public good contributions: Evidence from the lab. *Journal of Economic Behavior and Organization*, 57(3).

Colegrave, S. (2019). The Strange Death of Middle Class England.

Confederation of Icelandic Enterprise (2010). Kaupgjaldaskrá nr. 13.

Cooper, M. (2015). Americans Have Smaller Hopes for the American Dream.

Croson, R. T. A. (2008). Public Goods Experiments. *The New Palgrave Dictionary of Economics*, (pp. 1–11).

Dal Bó, E. & Dal Bó, P. (2014). "Do the right thing:" The effects of moral suasion on cooperation. *Journal of Public Economics*, 117.

Davis, K. & Moore, W. E. (1945). Some Principles of Stratification. *American Sociological Review*, 10(2), 242.

Duca, S., Helbing, D., & Nax, H. H. (2018). Assortative Matching with Inequality in Voluntary Contribution Games. *Computational Economics*, 52(3).

Emerson, R. M. (1962). Power-Dependence Relations. *American Sociological Review*, 27(1).

Encyclopaedia Britannica (2023). Social class: Characteristics of the principal classes.

Fehr, E. & Gächter, S. (2000). Cooperation and punishment in public goods experiments. *American Economic Review*, 90(4).

Ferster, C. B., Culbertson, S., & Boren, M. C. (1975). *Behavior principles, 2nd ed.* Oxford, England: Prentice-Hall.

Fukuyama, F. (2012). The future of history: Can liberal democracy survive the decline of the middle class?

Gächter, S. (2007). Conditional cooperation : Behavioral regularities from the lab and the field and their policy implications about the Centre or contact. *Economics and Psychology. A Promising New Cross-Disciplinary Field*, April 2006(2006-3).

Gibbs, D. (2024). *Revolt of the Rich: How the Politics of the 1970s Widened America's Class Divide*. Columbia University Press.

Giorgi, G. M. & Gigliarano, C. (2017). The Gini concentration index: A review of the inference literature. *Journal of Economic Surveys*, 31(4).

Glaeser, E., Scheinkman, J., & Shleifer, A. (2003). The injustice of inequality. *Journal of Monetary Economics*, 50(1).

Grusky, D. B., Hall, P. A., & Markus, H. R. (2019). The rise of opportunity markets: How did it happen & what can we do? *Daedalus*, 148(3).

Gunnthorsdottir, A., McCabe, K., & Smith, V. (2002). Using the Machiavellianism instrument to predict trustworthiness in a bargaining game. *Journal of Economic Psychology*, 23(1).

Gunnthorsdottir, A. & Rapoport, A. (2006). Embedding social dilemmas in intergroup competition reduces free-riding. *Organizational Behavior and Human Decision Processes*, 101(2), 184–199.

Gunnthorsdottir, A. & Thorsteinsson, P. (2011). Tacit Coordination and Equilibrium Selection in a Merit-based Grouping Mechanism: A Cross-cultural Validation Study. In F. Chan, D. Marinova, & R. Anderssen (Eds.), *MODSIM2011, 19th International Congress on Modelling and Simulation* (pp. 1292–1298).: Modelling and Simulation Society of Australia and New Zealand.

Gunnthorsdottir, A., Thorsteinsson, P., & Olafsson, S. P. (2023). Reciprocity or Community? Different Cultural Pathways to Cooperation and Welfare. *Cross-Cultural Research*, 57(4).

Gunnthorsdottir, A., Vragov, R., Seifert, S., & McCabe, K. (2010a). Near-efficient equilibria in contribution-based competitive grouping. *Journal of Public Economics*, 94(11-12), 987–994.

Gunnthorsdottir, A., Vragov, R., & Shen, J. (2010b). Tacit coordination in contribution-based grouping with two endowment levels. *Professor R. Mark Isaac and Douglas A. Norton (ed.) Charity with Choice (Research in Experimental Economics, Volume 13), Emerald Group Publishing Limited*, 13, 13–75.

Haile, D., Sadrieh, A., & Verbon, H. A. (2008a). Cross-racial envy and underinvestment in South African partnerships. *Cambridge Journal of Economics*, 32(5).

Haile, D., Sadrieh, A., & Verbon, H. A. (2008b). Self-serving dictators and economic growth. *Journal of Economic Behavior and Organization*, 67(3-4).

Harsanyi, J. C. & Selten, R. (1988). *A General Theory of Equilibrium Selection in Games*. Cambridge, MA: The MIT Press.

Hausken, K. & Cressman, R. (2004). Formalization of multi-level games. *International Game Theory Review*, 6(2).

Herrmann, B., Thöni, C., & Gächter, S. (2008). Antisocial punishment across societies. *Science*, 319(5868).

Hofmeyr, A., Burns, J., & Visser, M. (2007). Income inequality, reciprocity and public good provision: An experimental analysis. *South African Journal of Economics*, 75(3).

Holt, C., Johnson, C., & Schmidtz, D. (2015). Prisoner's dilemma experiments. In *The Prisoner's Dilemma*.

Isaac, R. M., McCue, K., & Plott, C. R. (1985). Public goods provision in an experimental environment. *Journal of Public Economics*, 26(1), 51–74.

Kahneman, D. (1988). Experimental economics: A psychological perspective. In R. Tietz, W. Albers, & R. Selten (Eds.), *Bounded Rational Behavior in Experimental Games and Markets* (pp. 11–18). Berlin: Springer.

Khosla, V. (2024). India's wedding industry soars to $75 billion, growing 7-8% annually.

Kochhar, R. & Sechopoulos, S. (2022). How the American middle class has changed in the past five decades.

Kraus, M. W., Piff, P. K., Mendoza-Denton, R., Rheinschmidt, M. L., & Keltner, D. (2012). Social class, solipsism, and contextualism: How the rich are different from the poor. *Psychological Review*, 119(3).

Krause, E. & Sawhill, I. V. (2018). Seven reasons to worry about the American middle class.

Kuznetsova, N. V. & Tupitsyn, A. Y. (2014). Middle class: The socio-economic stabilizer of the country development. *Asian Social Science*, 10(17).

Lanier, J. (2013). *Who owns the future?* New York: Simon & Schuster.

Lewis, W. A. (1985). *Racial Conflict and Economic Development.* Cambridge, MA: Harvard University Press.

Ludwig, G., Ed. (2020). *The Vanishing American Dream : A Frank Look at the Economic Realities Facing Middle- And Lower-Income Americans.* Disruption Books.

Mahendru, A., Gomes, K., Dutta, M., Noopur, & Mishra, P. R. (2023). *Survival of the richest: The India story.* Technical report, Oxfam India, New Delhi.

Manstead, A. S. (2018). The psychology of social class: How socioeconomic status impacts thought, feelings, and behaviour. *British Journal of Social Psychology*, 57(2).

Mateen, Z. & Sebastian, M. (2024). The Indian wedding turning heads around the world.

Moya, M. & Fiske, S. T. (2017). The Social Psychology of the Great Recession and Social Class Divides. *Journal of Social Issues*, 73(1).

Nax, H. H., Balietti, S., Murphy, R. O., & Helbing, D. (2018). Adding noise to the institution: an experimental welfare investigation of the contribution-based grouping mechanism. *Social Choice and Welfare*, 50(2).

Nax, H. H., Murphy, R. O., Duca, S., & Helbing, D. (2017a). Contribution-based grouping under noise. *Games*, 8(4).

Nax, H. H., Murphy, R. O., & Helbing, D. (2014). Stability and Welfare of 'Merit-Based' Group-Matching Mechanisms in Voluntary Contribution Game.

Nax, H. H., Murphy, R. O., & Helbing, D. (2017b). Nash dynamics, meritocratic matching, and cooperation. In B. Jann & W. Przepiorka (Eds.), *Social Dilemmas, Institutions, and the Evolution of Cooperation* (pp. 447–470). Berlin, Boston: De Gruyter Oldenbourg.

OECD (2012). Income inequality and growth: The role of taxes and transfers.

Office of the Vice President of the United States (2010). *Annual report of the White House task force on the middle class.* Technical report, Office of the Vice President of the United States, Washington.

Olson, M. (1965). *The Logic of Collective Action: Public Goods and the Theory of Groups.* Cambridge, MA: Harvard University Press.

Ostrom, E., Walker, J., & Gardner, R. (1992). Covenants with and without a Sword: Self-Governance Is Possible. *American Political Science Review*, 86(2), 404–417.

Piketty, T. (2014). *Capital in the twenty-first century.* Cambridge, MA: The Belknap Press of Harvard University Press.

Piketty, T. (2015). *The Economics of Inequality.* Cambridge, MA: The Belknap Press of Harvard University Press.

Piketty, T. (2020). *Capital and Ideology.* Cambridge, MA: The Belknap Press of Harvard University Press.

Piketty, T. (2022). *A Brief History of Equality*. Cambridge, MA: The Belknap Press of Harvard University Press.

Rawls, J. (1971). *A Theory of Justice: Original Edition*. Cambridge, MA: The Belknap Press of Harvard University Press.

Reeves, R. V., Guyot, K., & Krause, E. (2018). Defining the middle class: Cash, credentials, or culture?

Rettig Gur, H. (2023). Why the new state budget both favors and hurts Haredim... and deeply threatens Israel — The Times of Israel.

Sadrieh, A. & Verbon, H. A. (2006). Inequality, cooperation, and growth: An experimental study. *European Economic Review*, 50(5), 1197–1222.

Saez, E. & Zucman, G. (2016). Wealth Inequality in the United States since 1913: Evidence from Capitalized Income Tax Data. *The Quarterly Journal of Economics*, 131(2), 519–578.

Siegel, S. & Castellan, N. J. (1988). *Nonparametric Statistics for the Behavioral Sciences*. London: McGraw-Hill, 2nd edition.

Tackett, N. (2019). Violence and the 1 Percent: The Fall of the Medieval Chinese Aristocracy in Comparison to the Fall of the French Nobility. *The American Historical Review*, 124(3), 933–937.

Van Lange, P. A., Joireman, J., Parks, C. D., & Van Dijk, E. (2013). The psychology of social dilemmas: A review. *Organizational Behavior and Human Decision Processes*, 120(2), 125–141.

Veblen, T. (1899). *The theory of the leisure class*. Oxford: Oxford University Press, 2006 edition.

Visser, M. & Burns, J. (2015). Inequality, social sanctions and cooperation within South African fishing communities. *Journal of Economic Behavior & Organization*, 118, 95–109.

West, E. (2013). The strange death of the British middle class.

Wike, R., Poushter, J., Silver, L., Devlin, K., Fetterolf, J., Castillo, A., & Huang, C. (2019). *Political and economic changes across Europe*. Technical report, Pew Research Center.

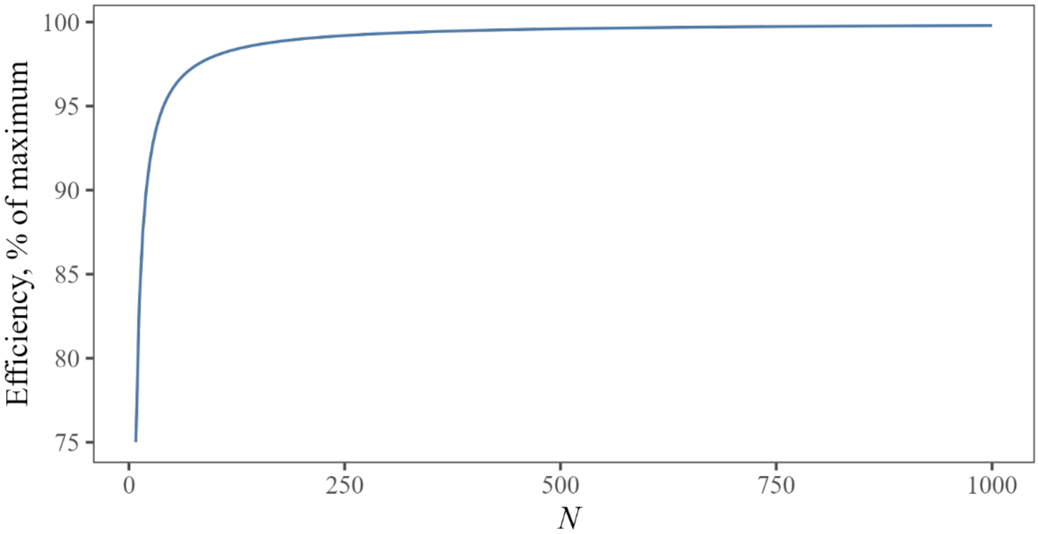
World Values Survey (2023). WVS cultural map: 2023 version.

Zelmer, J. (2003). Linear public goods experiments: A meta-analysis. *Experimental Economics*, 6(3), 299–310.

Zitner, A. (2023). Voters See American Dream Slipping Out of Reach.

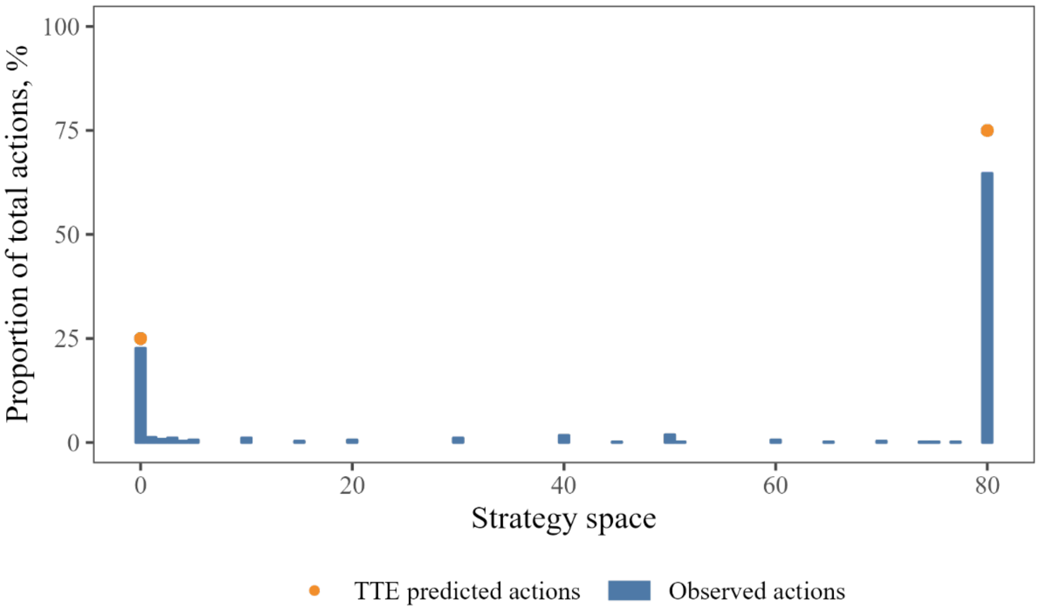
A Efficiency of a NEE as N gets larger

Figure 9: NEE efficiency for $n = 4$ and $m = 0.5$, for all N ranging from 8 to 1000 where $N \bmod 4 = 0$



B Choice frequencies of L-types in later rounds

Figure 10: Choice frequencies L-types Rounds 61-80.



C Individual choice paths

Figure 11: Session 1. Individual choice paths and earnings, ($\bar{x}$ = mean contribution over 80 rounds, $\bar{\pi}$ = mean total earnings over 80 rounds)

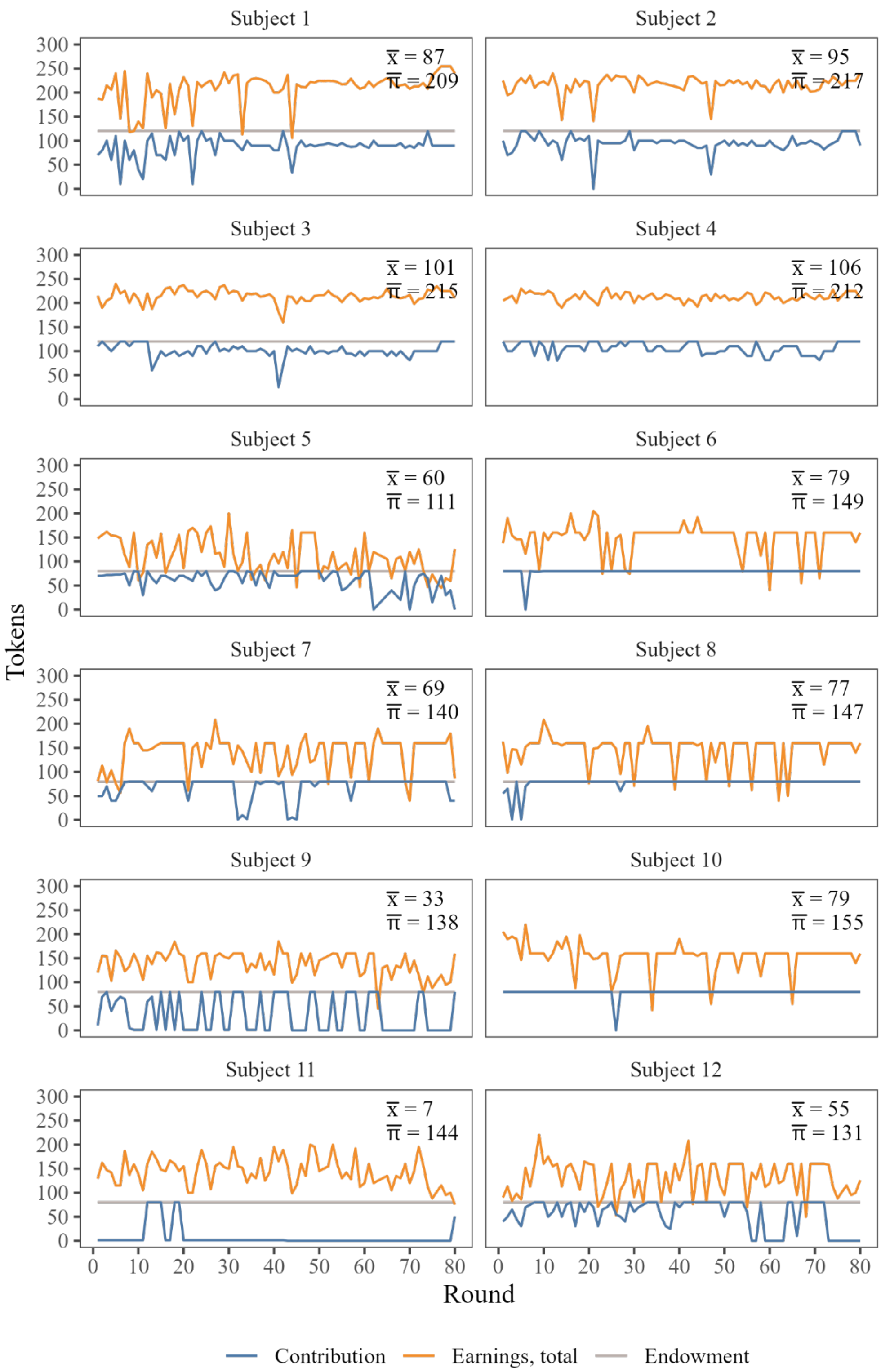


Figure 12: Session 2. Individual choice paths and earnings, ($\bar{x}$ = mean contribution over 80 rounds, $\bar{\pi}$ = mean total earnings over 80 rounds)

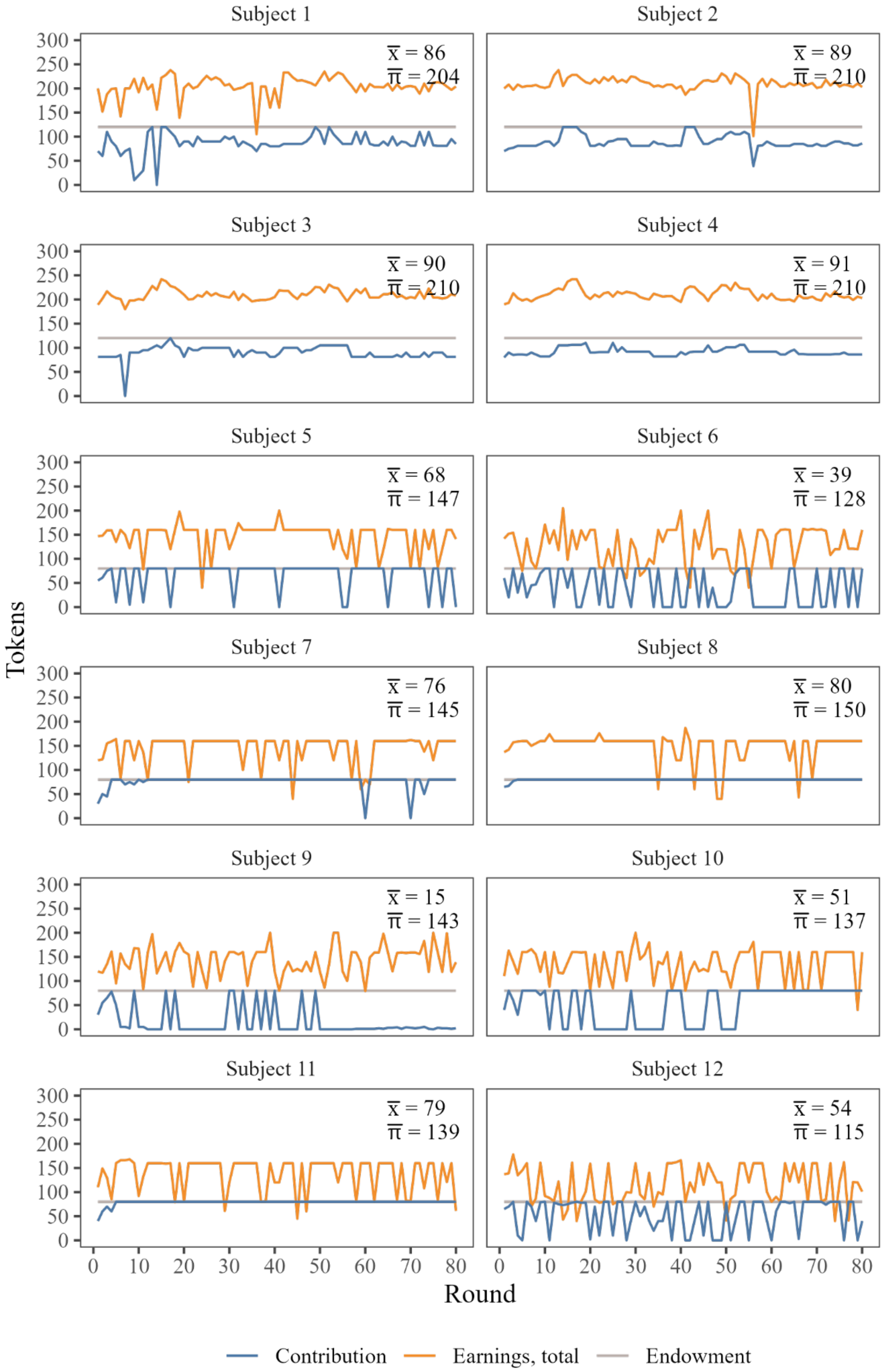


Figure 13: Session 3. Individual choice paths and earnings, ($\bar{x}$ = mean contribution over 80 rounds, $\bar{\pi}$ = mean total earnings over 80 rounds)

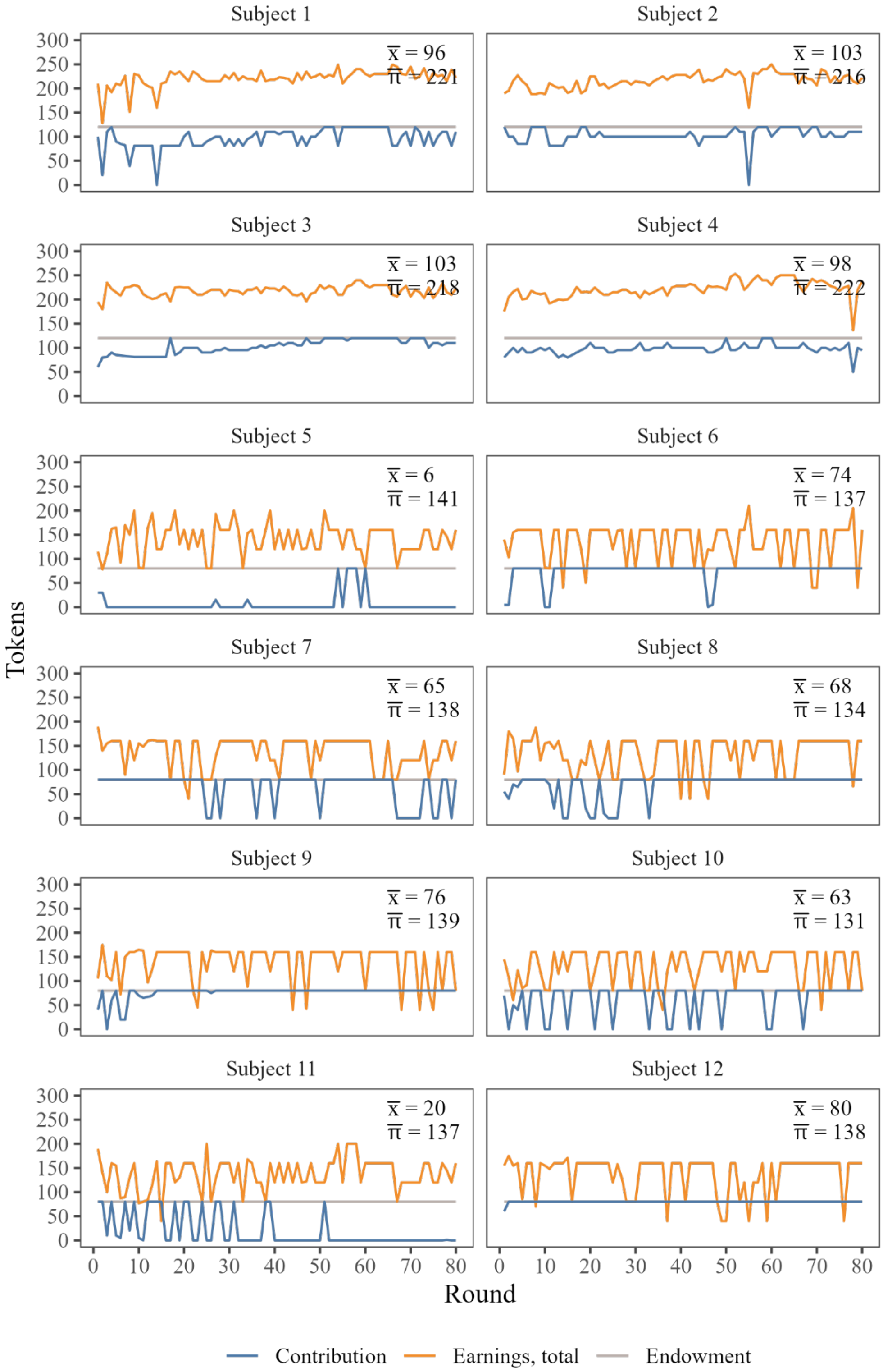
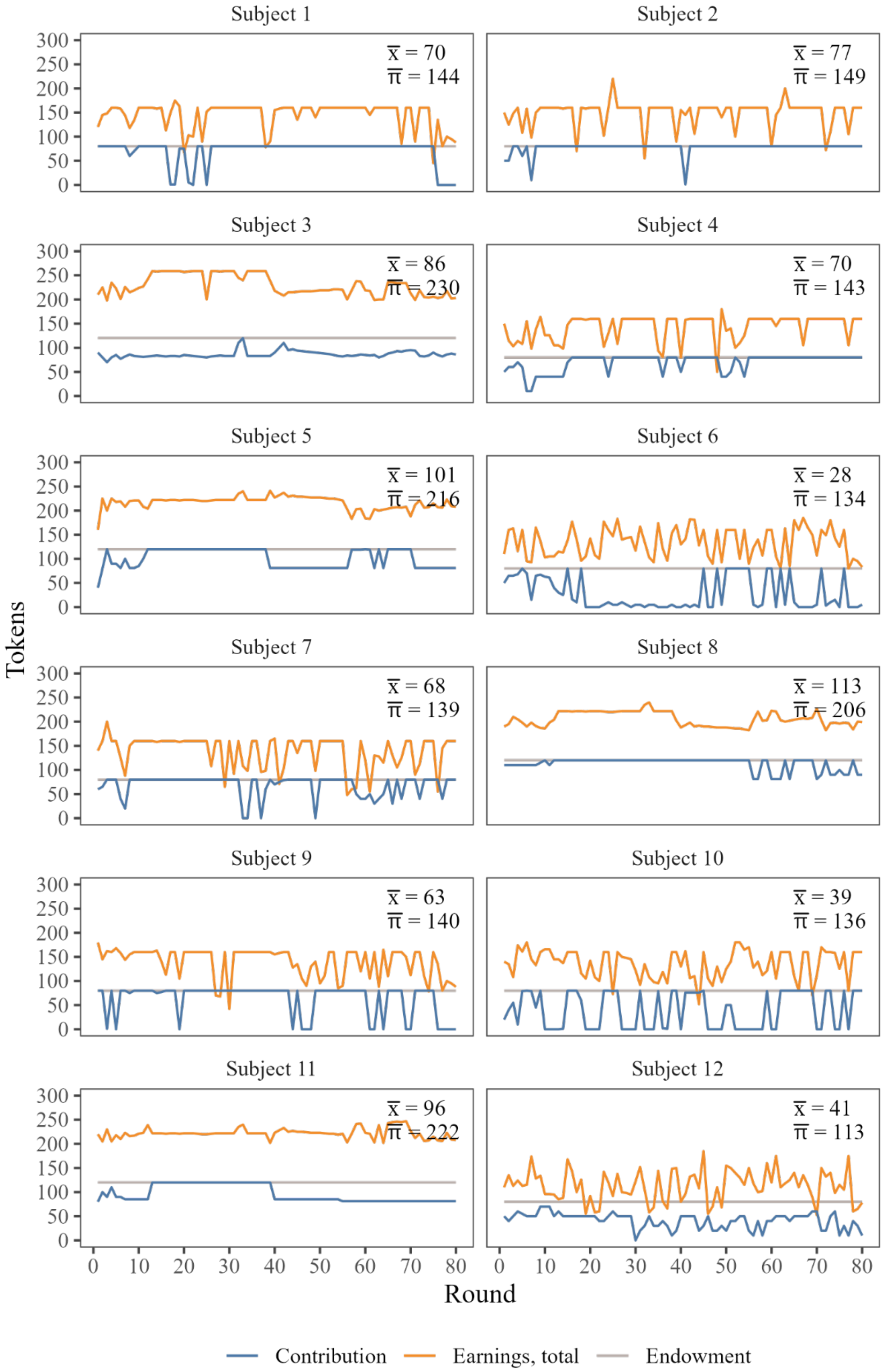


Figure 14: Session 4. Individual choice paths and earnings, ($\bar{x}$ = mean contribution over 80 rounds, $\bar{\pi}$ = mean total earnings over 80 rounds)



D Inequality among L-types

In addition to the insurmountable wealth difference between H and L, L-players in a TTE experience two different sources of earnings inequality among themselves, with the extent of the inequality depending on m, n, and G. Both however, end up being quite insignificant over repeat play. Firstly, under our experimental parameters, two fully contributing L-types are randomly grouped with $z = 2$ non-contributors and earn only 80 tokens each[25] while each of the remaining four full L-contributors grouped with like-contributors earns 160 tokens.[26] For a single round, fully contributing L-players' Gini Index is 0.13. However, over 80 rounds of randomly ranking and grouping the same set of fully contributing L-types, their individual earnings approach the expected value of 133 tokens per round. [27]

The second source of earnings inequality among L-types in a TTE is because under our experimental parameters, the ($z = 2$) L-types who contribute nothing earn 160 tokens per round.[28] Over repeated rounds however, many L-subjects oscillate between their two TTE strategies of $x_{iL} = 0$ and $x_iL = 80$. If all L-players oscillated in TTE-prescribed proportions, earnings differences between L-players would become negligible. [29] Note though that individual L-subjects decision paths over rounds are unsystematic (Appendix C). Furthermore, errors in the form of contributions of $0 < x_{iL} < 80$ depress own earnings while others profit from the mistake. Over 80 rounds, individual L-subjects therefore earned between 8917 to 12398 tokens (range = 3481; Gini Index[30] = 0.05).[31] If each L-subject had consistently selected either $x_{iL} = 80$ or the more profitable $x_{iL} = 0$, the final earnings difference between these two choice paths would only be 2160 tokens.[32]

[25] $(80 - 80) + (2 * 80) * 2/4 = 80$. See Eq. 1.

[26] $(80 - 80) + (4 * 80) * 2/4 = 160$. See Eq. 1.

[27] The ex-ante expected earnings of a fully contributing L-player are $(4/6) * 160 + (2/6) * 80 = 133$ tokens.

[28] $80 + (80 + 80) * 2/4 = 160$. See Eq. 1.

[29] The earnings difference between the non-contributing and fully contributing L-types shrinks if the count of L-players increases. For example, if L were 80 instead of 8 with all other parameters unchanged, $z = 2$ as before and the expected earnings of a fully contributing L-player rise to 158 tokens: $76/78 * 160 + 2/78 * 80 = 158$.

[30] Computed after binning the total 80-round earnings of L-subjects; bin size is 500 tokens.

[31] If our L-subjects contributed $x_{iL} = 0$ 25% of the time and $x_{iL} = w_L$ 75% of the time, balanced this way in every round, total earnings over 80 rounds would amount to 11180 tokens. Observed mean L-subject earnings were 11032 tokens.

[32] $160 * 80 - 133 * 80 = 2160$

E Experimental instructions

as

INSTRUCTIONS

This is an experiment in decision-making. You have already earned 700 kr. for showing up at the appointed time. If you follow the instructions closely and make decisions carefully, you will make a substantial amount of money in addition to your show-up fee.

Number of periods

There will be 80 decision-making periods.

Endowments differ between participants

There are twelve participants in total. In each period, each individual receives an endowment of experimental tokens. **By a random process, eight participants receive an endowment of 80 tokens per round, and four receive 120 tokens per round. You receive the same endowment in each round of the experiment.**

The decision task

In each period, you need to decide how to divide your tokens between two accounts: a **private** account and a **group** account. The group account is joint among all members of the group that you are assigned to in that period. See below for the group assignment process and for how earnings from your accounts are calculated.

How earnings from your two different accounts are calculated in each period:

- Each token you put in the **private account** stays there for you to keep.
- All tokens that group members invest in the **group account** are added together to form the so-called "group investment". The group investment gets doubled before it is equally divided among all group members. Your group has four members (including yourself).

A numerical example of the earnings calculation in any given period:

Assume that your endowment per period is 80 tokens. In a given period, you decide to put 30 tokens into your private account and 50 tokens into the group account. The other three members of your group together contribute an additional 300 tokens to the group account. This makes the total group investment 350 tokens, which gets doubled to 700 tokens (350 * 2 = 700). The 700 tokens are then split equally among all four group members. Therefore, each group members earns 175 tokens from the group investment (700/4=175). In addition to the earnings from the group account, each group member earns 1 token for every token invested in his/her private account. Since you put 30 tokens into your private account, your total profit in this period is 175 + 30 = 205 tokens.

HOW EACH DECISION-MAKING PERIOD UNFOLDS AND HOW YOU ARE ASSIGNED TO A NEW GROUP IN EACH OF THE PERIODS

First, you make your investment decision

Decide on the number of tokens to place in the private and in the group account, respectively. To make a private account investment, use the mouse to move your cursor to the box labeled "Private Account". Click on the box and enter the number of tokens you wish to allocate to this account. Do likewise for the box labeled "Group Account" Entries in the two boxes must sum up to your endowment. To submit your investment click on the "Submit" button. Then wait until everyone else has submitted his/her investment decision.

Second, you are assigned to the group that you will be a member of in this period

Once every participant has submitted his or her investment decision, you will be assigned to a group with 4 members (including yourself).

The group assignment proceeds in the following manner:

All participants' contributions to the group account are ordered from the highest to the lowest contribution. Participants are then grouped based on this ranking:

- The four highest contributors are grouped together.
- Participants whose contributions rank from 5-8 form the second group.
- The four lowest contributors form the third group.

As said, you will be grouped based on your group account investment. If there are ties for group membership because contributions are equal, a random draw decides which of these equal-contributors are put together into one group and who goes into the next group below. For example, if 5 participants contributed 200 tokens, a random draw determines which of the four participants form a group of like-contributors and who is the one who goes into the next group below.

Recall that group membership is determined anew in each period based on your group contribution in that period. Group membership does not carry over between periods!

After the group assignment, your earnings for the round are computed

Earnings from a given round are computed *after* you have been assigned to your group. See the numerical example above for details of how earnings are computed after you have been assigned to a group.

End-of period message

At the end of each period you will receive a message with your total experimental earnings for the period (total earnings = the earnings from the group account and your private account added together). This information also appears in your Record Sheet at the bottom of the screen. The Record Sheet will also show the group account contributions of *all* participants in a given round in ascending order. Your contribution will be highlighted.

A new period begins after everyone has acknowledged his or her earnings message.

At the end of the experiment your total token earnings will be converted into kronur at a rate of 0.17 kronur per token.

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