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Intragenerational inequality and intergenerational sustainability

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Abstract

Many global agendas are intergenerational, such as climate change, environmental problems and financial sustainability, and resolving such an intergenerational sustainability (IS) problem is pivotal for survival of humans. While there have been several works that address intergenerational problems, little is known about how people behave towards IS under the presence (or absence) of inequality. We investigate how inequality in a generation, i.e., intragenerational inequality, affects the members, hypothesizing that they behave selfishly and IS is compromised under the inequality as compared to the equality. An online intergenerational goods game (IGG) experiment is conducted with 340 subjects under three treatments that correspond to equality, high inequality and super-high inequality in a generation. In IGG, each subject in a generation of five members decides how much she harvests for herself from an intergenerational common good, given some endowment. If the members (do not) harvest too much, the common good shall be (replenished) depleted and (be transferred) not be transferred to the next generation. Our results indicate that intragenerational inequality induces the members not to harvest both fairly and sustainably, adversely affecting IS. Although the members with high endowments tend to reduce their harvests as compared to those with low endowments under inequality, the reduction is not enough to maintain IS. Overall, this study demonstrates that intragenerational inequality and IS shall be in a trade-off relationship. Thus, optimally finding a balance between the two will be a practical resolution, as capitalism is so dominant that intragenerational inequality is widening in the world.

Key Words: Intragenerational inequality; intergenerational sustainability; intergenerational goods

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Nomenclature

HI	High inequality
IGG	Intergenerational goods game
IS	Intergenerational sustainability
ISDG	Intergenerational sustainability dilemma game
JPY	Japanese yen
SHI	Super-high inequality
SI	Sustainability index
SVO	Social value orientation

1 Introduction

The world is rapidly changing due to technological advancements and dominance of capitalism (Robinson, 2020). With these rapid changes, we encounter sustainability problems affecting multiple generations, such as climate change, resource depletion and financial challenges. They are collectively referred to as intergenerational sustainability (IS) problems (see, e.g., Page, 1999, Padilla, 2002, Shahen et al., 2021, Timilsina et al., 2022, 2023). To address the problems, both meeting the needs of the current generation and preserving the welfare of future generations are necessary (Ehrlich et al., 2012, Steffen et al., 2015). At the same time, as part of the transformation driven by global capitalism, inequality in a generation, i.e., intragenerational inequality, becomes increasingly evident in income distribution, educational access and digital literacy for many countries (Carter, 2018). While some existing research illuminates the detrimental effects of such inequalities on intragenerational problems that bring about noncooperative behaviors and high tensions (Robinson, 2020, Melamed et al., 2022), the effects of intragenerational inequality on IS problems remain elusive. This paper experimentally addresses the relationship between intragenerational inequality and IS.

A group of studies utilizes an intergenerational sustainability dilemma game (ISDG) to understand people's behaviors toward IS problems (Kamijo et al., 2017, Shahrier et al., 2017, Shahen et al., 2021, Timilsina et al., 2022, 2023). In ISDG, a generation of three subjects over a generational sequence is asked to choose between a sustainable option with a low immediate payoff and an unsustainable option with a high immediate payoff at irreversible costs to future generations. Kamijo et al. (2017) explore the effect of involving an "imaginary future generation (IFG)" as a negotiator for future generations through laboratory experiments, finding that the negotiator enhances IS. Shahrier et al. (2017) examine the influence of the degree of capitalism on IS through a field experiment in urban and rural areas of Bangladesh, revealing that people in capitalistic urban areas are less likely to choose sustainable options than those in rural areas. Shahen et al. (2021) demonstrate the effectiveness of the future ahead and back (FAB) mechanism to promote sustainability in one-person ISDG where each subject is asked to take a perspective of the next generation and make a request to the current generation. After that, each subject returns to the original position and makes a decision. Timilsina et al. (2022) examine how intragenerational deliberation affects individual opinions to maintain IS through field experiments, indicating that rural subjects generally favor sustainable options, while urban subjects choose unsustainable ones, and the deliberation does not consistently lead to sustainable decisions. Timilsina et al. (2023) indicate the effectiveness of intergenerational accountability (IA) in maintaining IS through lab-in-the-field experiments where each generation is asked to provide reasons and advice to subsequent generations along with the decision. Collectively, these studies show the effectiveness of negotiation, perspective-taking, deliberation and accountability for IS.

Another group of studies employs an intergenerational goods game (IGG) to investigate IS problems (Hauser et al., 2014, Lohse and Waichman, 2020, Balmford et al., 2024). In IGG, each subject in a group of five, referred to as a generation, is asked to decide an extraction from a common good. If the total extraction by the group members remains at or below a certain threshold, the common good can be replenished and subjects in the next generation shall be able to proceed with the good. Otherwise, the good is depleted and they shall receive nothing by proceeding. Hauser et al. (2014) explore how median voting promotes sustainability of common goods through an online experiment. They suggest the effectiveness of binding voting by allowing cooperative majorities to control self-interested minorities in generational decisions. Lohse and Waichman (2020) examine the impact of peer punishment in a generation on cooperation by lab experiments, finding that the punishment maintains cooperation only in the short term. Balmford et al. (2024) analyze how voting can promote cooperation, particularly in the presence of ambiguity through IGG. They show that median voting institutions sustain cooperation even under ambiguous thresholds. Overall, these studies underscore an importance of democratic institutions and/or punitive measures for IS, although the long-term effectiveness needs to be further explored or remains limited.

There are several studies that analyze the effects of inequality among members in a group, i.e., intragenerational inequality, on their cooperation (Hauser et al., 2019, Markussen et al., 2021, Melamed et al., 2022). Hauser et al. (2019) investigate how such an inequality affects cooperation through conducting a public goods game under an online environment. They introduce a model that considers variations in endowments, productivities and benefits that get accrued from public goods. It is reported that extreme inequality reduces cooperation, but moderate inequality that gets well aligned with productivity can maintain it. Markussen et al. (2021) conduct a field experiment in rural Vietnam and examine the relation among economic inequality, voluntary contributions and institutional qualities. They show that people's perceptions to corruption exacerbate the negative impacts of inequality on the contributions. Melamed et al. (2022) execute an online experiment to study how wealth inequality affects cooperation and formation of social networks. They present that people are likely to cooperate with wealthy counterparts for benefits, causing wealth and social ties to concentrate on a few people as well as increasing inequality within the network over time. These studies indicate that intragenerational inequality is generally harmful to people's contemporaneous or intragenerational cooperation.

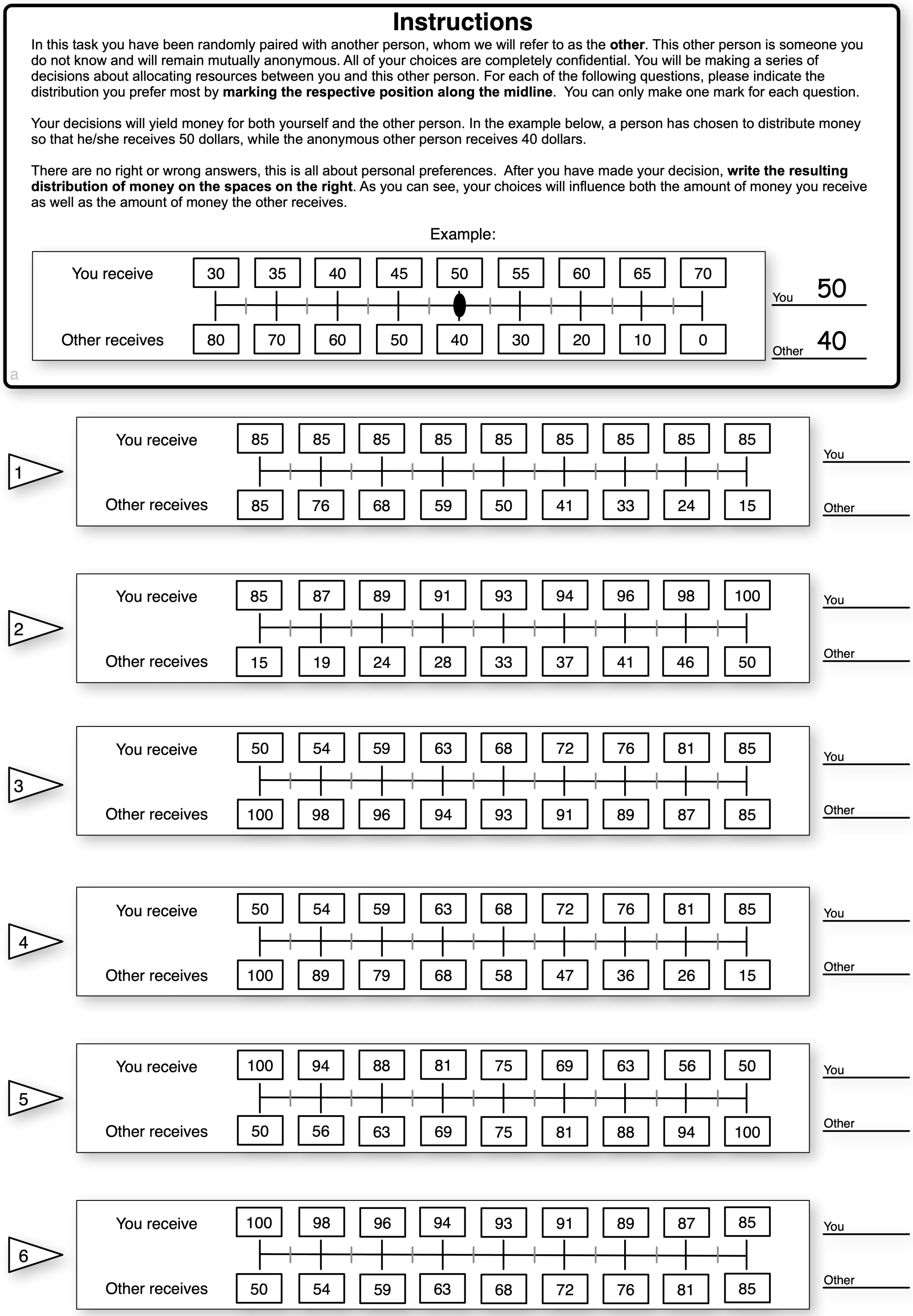
The literature suggests that there are some mechanisms and institutions to positively influence people for IS and that inequality adversely affects intragenerational cooperation. However, little is known about how people behave for IS under the presence (or absence) of inequality. We pose an open question "how does inequality in a generation, i.e., intragenerational inequality, affect the people's behaviors to future generations for IS?" It is hypothesized that people tend to behave selfishly and IS is compromised as the degree of the inequality rises. An online intergenerational goods game (IGG) experiment is conducted with 340 subjects under three treatments that correspond to the equality, high inequality and super-high inequality in a generation, respectively. In IGG, each subject in a generation of five members decides how much she harvests for herself from an intergenerational common good, given some endowment, and the endowments to the members are experimentally parameterized to mimic equality and inequality in a generation as the treatments. In the IGG, when the members in the current generation (do not) harvest too much, the common good shall be (replenished) depleted and (be transferred) not be transferred to the next generation. If the common good is depleted and not transferred, people in the next generation will suffer and their payoffs shall become very low.

2 Experimental procedures

The experiments were conducted online using the oTree platform for 16 sessions with 340 subjects, being monitored and supervised by Zoom (see Chen et al., 2016, for oTree). A subject attends only one session that accommodates 20 to 30 students. The subjects were recruited from the student pools of Kochi University of Technology, Kochi Prefectural University, Musashi University and Kochi University from various fields, such as economics, engineering, management and so on. Each session is divided into three parts. The 1st part involves playing a social value orientation (SVO) game. The 2nd part is an intergenerational goods game (IGG). The 3rd part consists of a questionnaire survey that collects sociodemographic information and psychometric measurements from subjects, such as a sustainability index (SI) proposed by Ogishima et al. (2023). The 1st part and 3rd part are the same across all sessions. The 2nd part varies by sessions, each of which is randomly assigned to one of the three treatments: (i) equality, high inequality (HI) and super-high inequality (SHI) one. We have five, five and six sessions for equality, HI and SHI, respectively.

An SVO game categorizes each subject's social preference to be one of altruistic, prosocial, individualistic or competitive types (Van Lange et al., 1997, 2007, Brosig et al., 2011, Carlsson et al., 2014, Sutters et al., 2018). This study employs a "slider method" to assess how subjects prioritize their benefits compared to others (Borghans et al., 2008, Murphy et al., 2011). Figure 1 presents that subjects respond to six items, each offering nine options for distributing points between oneself and an anonymous partner. Each subject selects one option for each item by marking a line at the point that represents her most preferred distribution. The mean allocations for the subject $\overline{A}_s$ and the partner $\overline{A}_p$ are computed from all six items. Then, 50 is subtracted from $\overline{A}_s$ and $\overline{A}_p$ to shift the base of the resulting angle to the center of the circle $(50, 50)$. A subject's SVO index is determined as SVO $= \arctan \frac{(\overline{A}_p)-50}{(\overline{A}_s)-50}$. Based on the SVO indices, social preferences are categorized as altruist (SVO $> 57.15°$), prosocial ($22.45° <$ SVO $< 57.15°$), individualist ($-12.04° <$ SVO $< 22.45°$), and competitive (SVO $< -12.04°$). In this study, "altruist" and "prosocial" types are categorized as "prosocial" subjects, whereas "individualistic" and "competitive" types are categorized as "proself" subjects (see Murphy et al., 2011).

Figure 1: Instructions to measure social value orientation by the slider method



Instructions

In this task you have been randomly paired with another person, whom we will refer to as the **other**. This other person is someone you do not know and will remain mutually anonymous. All of your choices are completely confidential. You will be making a series of decisions about allocating resources between you and this other person. For each of the following questions, please indicate the distribution you prefer most by **marking the respective position along the midline**. You can only make one mark for each question.

Your decisions will yield money for both yourself and the other person. In the example below, a person has chosen to distribute money so that he/she receives 50 dollars, while the anonymous other person receives 40 dollars.

There are no right or wrong answers, this is all about personal preferences. After you have made your decision, **write the resulting distribution of money on the spaces on the right**. As you can see, your choices will influence both the amount of money you receive as well as the amount of money the other receives.

Example:

You receive	30	35	40	45	50	55	60	65	70
Other receives	80	70	60	50	40	30	20	10	0

You 50

Other 40

a

1

You receive	85	85	85	85	85	85	85	85	85
Other receives	85	76	68	59	50	41	33	24	15

You ______ Other ______

2

You receive	85	87	89	91	93	94	96	98	100
Other receives	15	19	24	28	33	37	41	46	50

You ______ Other ______

3

You receive	50	54	59	63	68	72	76	81	85
Other receives	100	98	96	94	93	91	89	87	85

You ______ Other ______

4

You receive	50	54	59	63	68	72	76	81	85
Other receives	100	89	79	68	58	47	36	26	15

You ______ Other ______

5

You receive	100	94	88	81	75	69	63	56	50
Other receives	50	56	63	69	75	81	88	94	100

You ______ Other ______

6

You receive	100	98	96	94	93	91	89	87	85
Other receives	50	54	59	63	68	72	76	81	85

You ______ Other ______

In the online IGG experiment, we follow the basic design and procedures proposed by Hauser et al. (2014). In the IGG, five subjects are randomly assigned to form a group, referred to as a generation and each member independently decides her harvest from an intergenerational common good that has 100 points for the current generation in a sequence. Each member in a generation can harvest between 0 and 20 points from the common good. Figure 2 illustrates the rules of the IGG for each sequence within a session. If the group harvest, which is the sum of individual harvests by all five members in a generation, is 50 points or below and a white chip is drawn in a lottery (with an 80 % probability), the common good is replenished to 100 points for the next generation (Case 1, see figure 2). If the group harvest exceeds 50 points and a white chip is drawn (with an 80 % probability), the common good is depleted leaving no points available for the next generation (Case 2, see figure 2). If a red chip is drawn (with a 20 % probability), regardless of the group harvests, the sequence in the IGG terminates without proceeding to the next generation (Case 3, see figure 2).

Figure 2: Rules of the intergenerational goods game (IGG) per sequence in a session

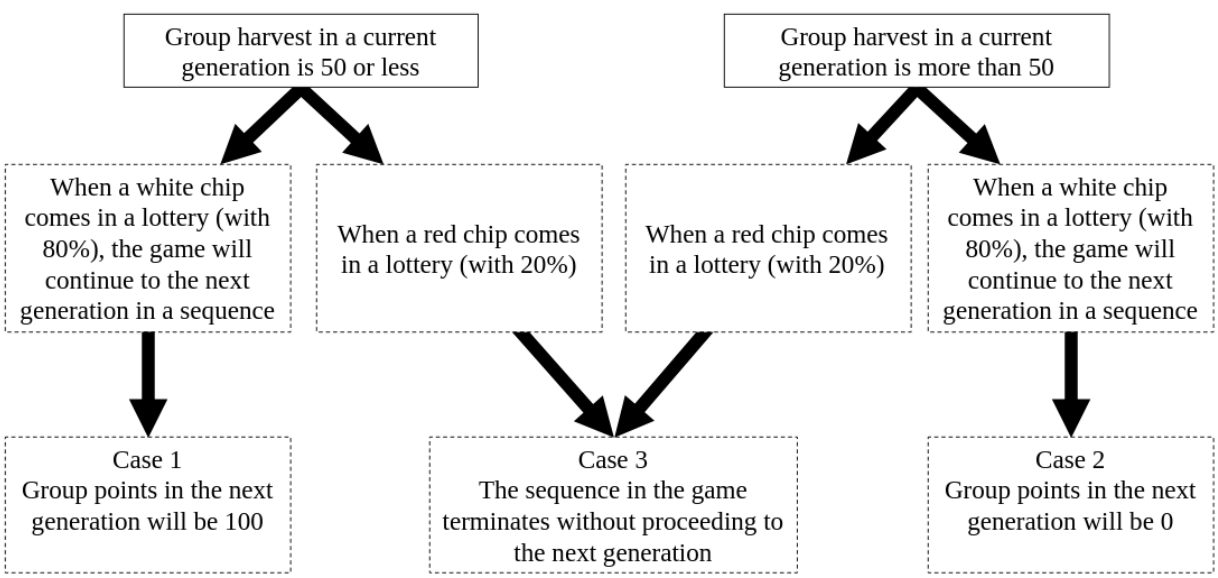
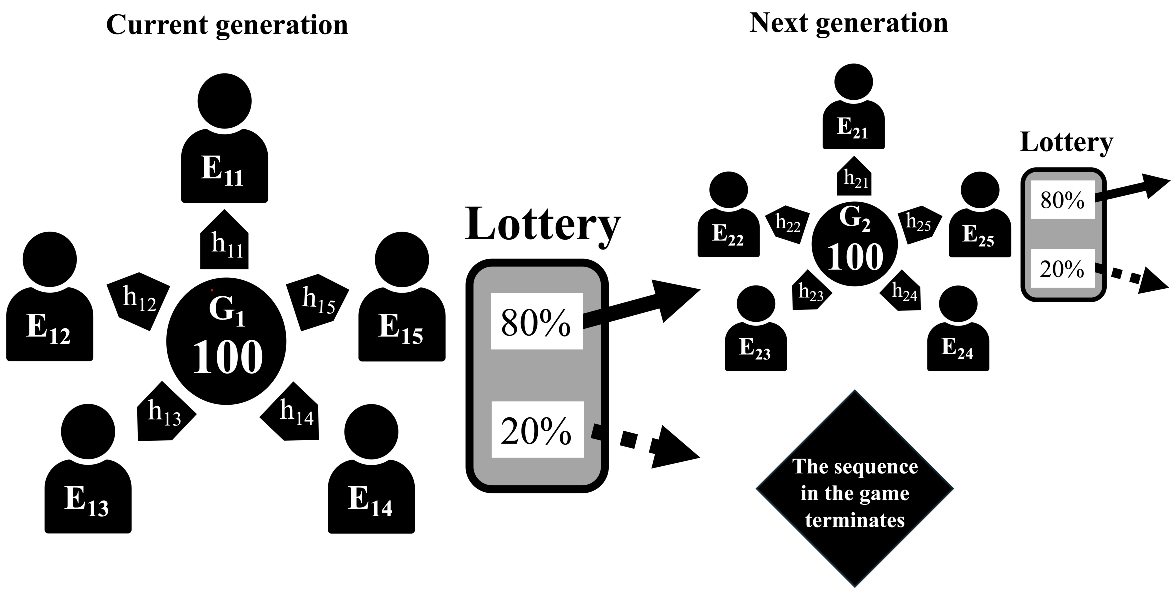


Figure 3 illustrates the design of the online IGG experiment. In this experiment, individual endowments and harvests are denoted by E_{ij} and h_{ij}, respectively where $i = 1, \ldots, n$ and $j =$

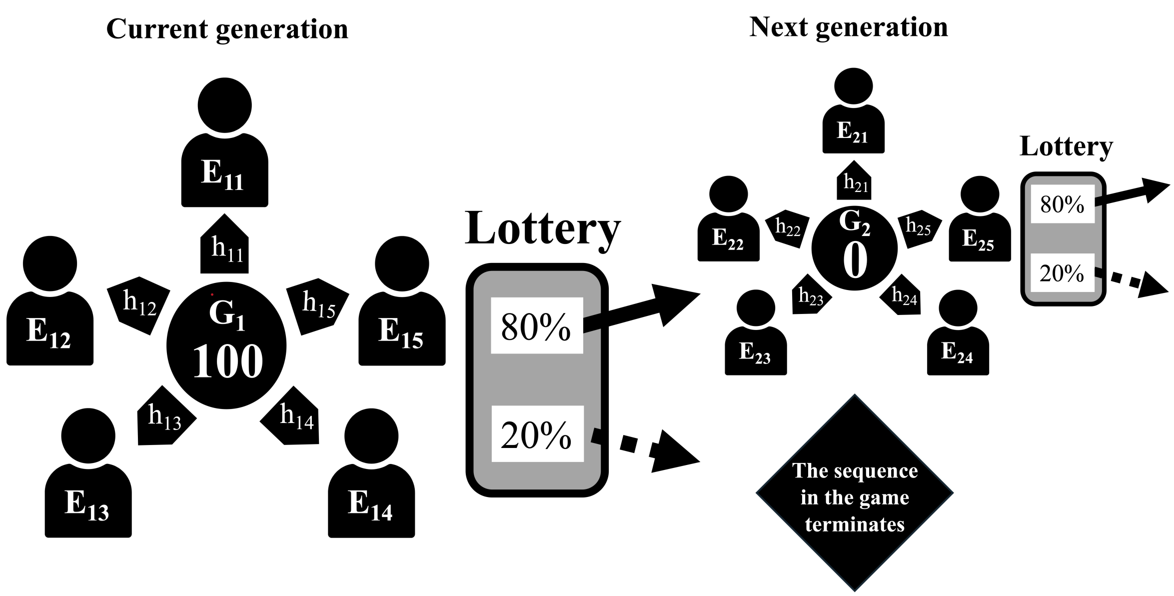
$1, \ldots, 5$ indicate the generation and the unique subject identification numbers in a sequence. The intergenerational common good and the group harvest are represented by G_i and H_i ($= \sum_{j=1}^{5} h_{ij}$). As depicted in Figure 3(a), if the group harvest by a generation is 50 points or below (say, members in the generation harvest 8, 11, 6, 15 and 5 points, respectively, and the group harvest would be 45 points, that is, $H_i \leq 50$) and a white chip is selected, then Case 1 is realized. Consequently, the common good is replenished and the next generation in the sequence is able to proceed with the common good of 100 group points as the previous generation. If the group harvest exceeds 50 points (say, members in the generation harvest 12, 11, 13, 5 and 15 points, respectively, and the group harvest would be 56 points, that is, $H_i > 50$) and a white chip is selected, then Case 2 is realized. Then, the common good is depleted and the next generation in the sequence cannot have the common good. If neither Case 1 nor Case 2 comes (i.e., a red chip is selected), then Case 3 is realized and the sequence in the IGG terminates without advancing to the next generation. In the game, a dominant strategy or a Nash equilibrium (NE) strategy for each subject is to harvest 20 points (Indh20), as it maximizes her payoff, irrespective of others' harvests in the group. A Pareto optimal allocation is achieved when each subject in a generation harvests an amount that allows the common goods to replenish and maximizes the total payoffs for current and next generations (Timilsina et al., 2017, 2023). The allocation is obtained when a group harvest just becomes 50 points, with an average of 10 points per subject (Indh10). Therefore, harvesting 10 points per subject in a generation, denoted by Indh10, can be considered to yield a fair and sustainable allocation in both intragenerational and intergenerational senses, and it is a benchmark for individual harvests (see tables 1 and 2 for the definition of Indh10 and the result).

An online IGG experiment is conducted under three treatments that correspond to equality, high inequality (HI) and super high inequality (SHI) and one treatment is assinged for each generational sequence. Under each treatment, endowments are randomly assigned to the members in a generation. The total endowment for each generation remains fixed at 50 points. Under equality, each member is endowed with 10 (E10). Under HI, two members in a generation are endowed with 0 (E0), one member with 10 (E10) and the remaining two members with 20 (E20). The mean

Figure 3: Experimental design in intergenerational goods game (IGG)



(a) Group harvest, $H_i \leq 50$ where $H_i = \sum_{j=1}^{5} h_{ij}$



(b) Group harvest, $H_i > 50$ where $H_i = \sum_{j=1}^{5} h_{ij}$

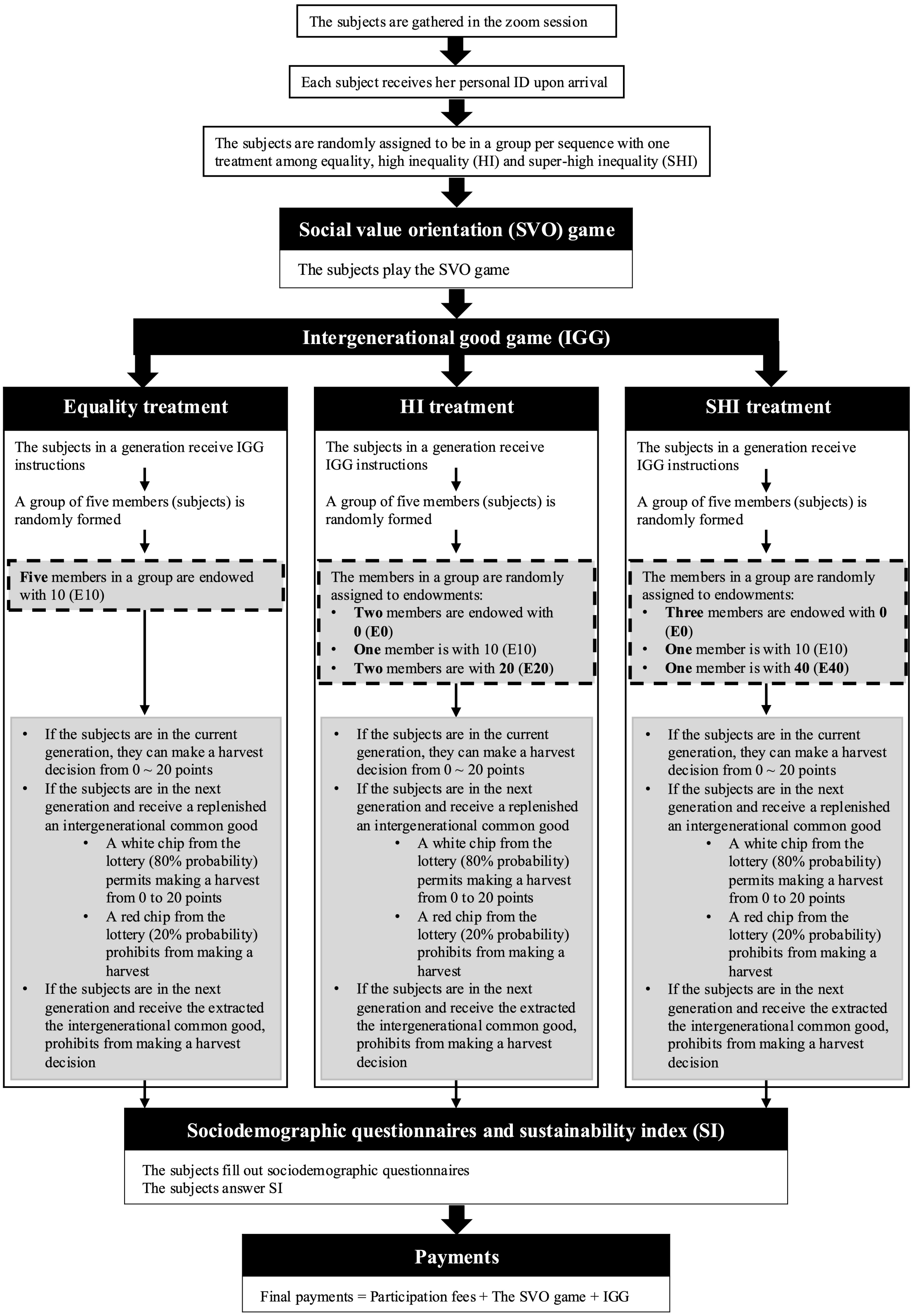
and median endowments under HI are 10 points, and the endowment distribution yields a Gini coefficient of 0.48, which is close to the inequality level in Angola or Brazil (World Bank, 2024). Under SHI, three members in a generation are endowed with 0 (E0), one member with 10 (E10) and one member with 40 (E40). The mean and median endowments in a generation under SHI are 10 and 0 points, respectively, and the distribution yields a Gini coefficient of 0.60, which is close to the inequality level in Nambia or South Africa (World Bank, 2024).

Subjects in a session first receive a briefing on and give their consent forms to participate in the experiment. Then, each of them joins the experiment through a unique URL link, starting SVO game and proceeding with IGG. In IGG, subjects must correctly answer some quizzes to demonstrate their understanding after the online instructions, and they advance to play the IGG in a generation per sequence with one treatment. After IGG, subjects proceed to provide sociodemographic information and answer the questions associated with psychometric measurements in the questionnaire survey. One session lasts approximately 45 minutes, being divided into 10 minutes for SVO game, 25 minutes for IGG and 10 minutes for the survey. Each subject receives a fixed participation fee of 300 JPY. From SVO game, the average payoff is 200 JPY ranging from 100 JPY to 300 JPY with an experimental exchange rate of 0.20 JPY per point. From IGG, the average payoff is 2500 JPY ranging from 1000 JPY to 4000 JPY at an exchange rate of 100 JPY per point. Overall, a subject earns an average total payoff of 3000 JPY ranging from 1500 JPY to 4500 JPY, depending on her performance, and the payoff was disbursed through Amazon gift cards. A flow chart of the experimental procedures for one session is summarized in figure 4.

3 Results

Tables 1 and 2 represent the definitions of the variables and the summary statistics from the 340 subjects across three treatments, respectively: equality treatment with 100, high inequality (HI) treatment with 110 and super-high inequality (SHI) treatment with 130 subjects. Recall that under equality, five members in a group are endowed with 10 (E10). Under HI, two members in a

Figure 4: A flow chart of experimental procedures for subjects to participate in one session



group are endowed with 0 (E0), one member is with 10 (E10) and the rest of two members are with 20 (E20). Under SHI, three members in a group are endowed with 0 (E0), one member is with 10 (E10) and the rest of one member is with 40 (E40). On the average, the individual harvests (Indhs) under equality, HI and SHI are 12.46, 14.03 and 13.66 points, respectively. The average Indhs for subjects with E0, E10 and E20 under HI are 16.14, 11.95 and 12.95 points, respectively, while those with E0, E10 and E40 under SHI are 14.45, 14.92 and 10.04 points. These results suggest that HI and SHI influence subjects to harvest as compared to equality, while those with low endowments tend to harvest more than those with high endowments in the presence of intragenerational inequality. Under equality, 25 % of subjects choose Indh20, which increases to 40 % and 39 % under HI and SHI, respectively. Harvesting 10 points, i.e., Indh10, decreases from 35 % under equality to 23 % under HI and 18 % under SHI. Regarding subjects' characteristics, 50 % to 65 % of subjects are male, 31 % to 38 % are prosocial and the sustainability indices are 102.90 to 105.60 across three treatments. Overall, they demonstrate that the subjects are sufficiently homogeneous among the treatments.[a]

Table 1: Definitions of the variables

Variables	Definitions of the variables included in regressions
Dependent variable	
Individual harvest (Indh)	A variable that represents the individual harvest from the intergenerational common good of 0 to 20 points.
Indh10 (20)	A dummy variable that takes 1 if a subject harvests 10 (20) points from the intergenerational common good; otherwise, 0.
Independent variables	
Treatments (Base group = equality)	
High inequality (HI)	A dummy variable that takes 1 if a subject is assigned to HI; otherwise, 0.
Super-high inequality (SHI)	A dummy variable that takes 1 if a subject is assigned to SHI; otherwise, 0.
Endowments (Base group = Subjects with E0)	
E10	A dummy variable that takes 1 if a subject is endowed with 10; otherwise, 0.
E20	A dummy variable that takes 1 if a subject is endowed with 20; otherwise, 0.
E40	A dummy variable that takes 1 if a subject is endowed with 40; otherwise, 0.
Prosocial (Base group = Proself)	A dummy variable that takes 1 if a subject is identified as prosocial; otherwise, 0.
Gender (Base group = female)	A dummy variable that takes 1 if a subject is identified male; otherwise, 0.
Sustainability index (SI)	A variable that represents a SI score.

Figure 5 presents the boxplots of Indhs across the treatments, suggesting that the median Indhs under HI and SHI (15 and 15 points, respectively) are higher than those under equality (10 points). Figure 6 displays the histograms of Indhs by percentages under equality, HI and SHI, demonstrat-

[a]The gender ratios of students in four universities are in line with those in our sample.

Table 2: Summary statistics of experimental results for number of subjects, harvests, prosociality, gender and sustainability index across treatments

Variables	Equality treatment (100)[a]			HI treatment (110)			SHI treatment (130)		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
Indh (overall)	12.64	10	5.11	14.03	15	5.87	13.66	15	6.23
E0	–	–	–	16.14	20	4.69	14.45	15	5.67
E10	12.64	10	5.11	11.95	10	4.85	14.92	16	5.52
E20	–	–	–	12.95	11.5	6.78	–	–	–
E40	–	–	–	–	–	–	10.04	9	7.29
Indh10	0.35	0	0.48	0.23	0	0.42	0.18	0	0.39
Indh20	0.25	0	0.44	0.4	0	0.49	0.39	0	0.49
Prosocial (Base group = Proself)	0.34	0	0.48	0.31	0	0.46	0.38	0	0.49
Gender (Base group = Female)	0.50	0	0.50	0.58	1	0.50	0.65	1	0.48
Sustainability index (SI)	105.60	106.50	10.91	105.14	105	10.18	102.90	102	10.33

[a] The number of subjects per treatment in the bracket
SD and Indh stand for Standard deviation and the individual harvest, respectively.
E10, E20 and E40 present dummy variables that take 1 if a subject is endowed with 10, 20 and 40, respectively, taking a base group of subjects with E0.
Indh10 (20) stands for a dummy variable that takes 1 if a subject harvests 10 (20) points from the intergenerational common good; otherwise, 0.
Prosocial stands for a dummy variable that takes 1 if a subject is identified as prosocial; otherwise, 0.

ing that the percentages of subjects who harvest 20 points (equivalently, Indh20) under HI and SHI (40 % and approximately 39 %) are high compared to those under equality (approximately 25 %). On the other hand, the percentages of subjects who harvest 10 points (equivalently, Indh10) under HI and SHI (23 % and 18 %, respectively) are low as compared to those under equality (35 %). The results confirm that the distributions under HI or SHI are different from the distribution under equality, being similar with each other regarding the median and modes. Specifically, the 1st and 2nd modes under inequalities (equality) are 20 (10) and 10 (20). The Mann-Whitney tests also demonstrate the distributional differences in Indhs between HI and equality as well as SHI and equality, meaning that the distributions between HI and equality (SHI and equality) are statistically different at 5 % (10 %) level.

We report how many generations in a sequence sustain an intergenerational common good across the treatments. There are 19, 21 and 26 sequences, respectively, for equality, HI and SHI ones. Under equality, only one sequence (13th sequence) sustained the good up to the 2nd generation. In the sequence, the 1st generation's group harvest was 39 $(10, 8, 5, 6, 10)$ and the generation drew a white chip. Next, the 2nd generation's group harvest was 73 $(20, 10, 10, 13, 20)$ and the good was depleted. Under HI, only one sequence (17th sequence) sustained the good up to the

Figure 5: Boxplots of the individual harvests (Indhs) under equality, high inequality (HI) and super-high inequality (SHI) treatments

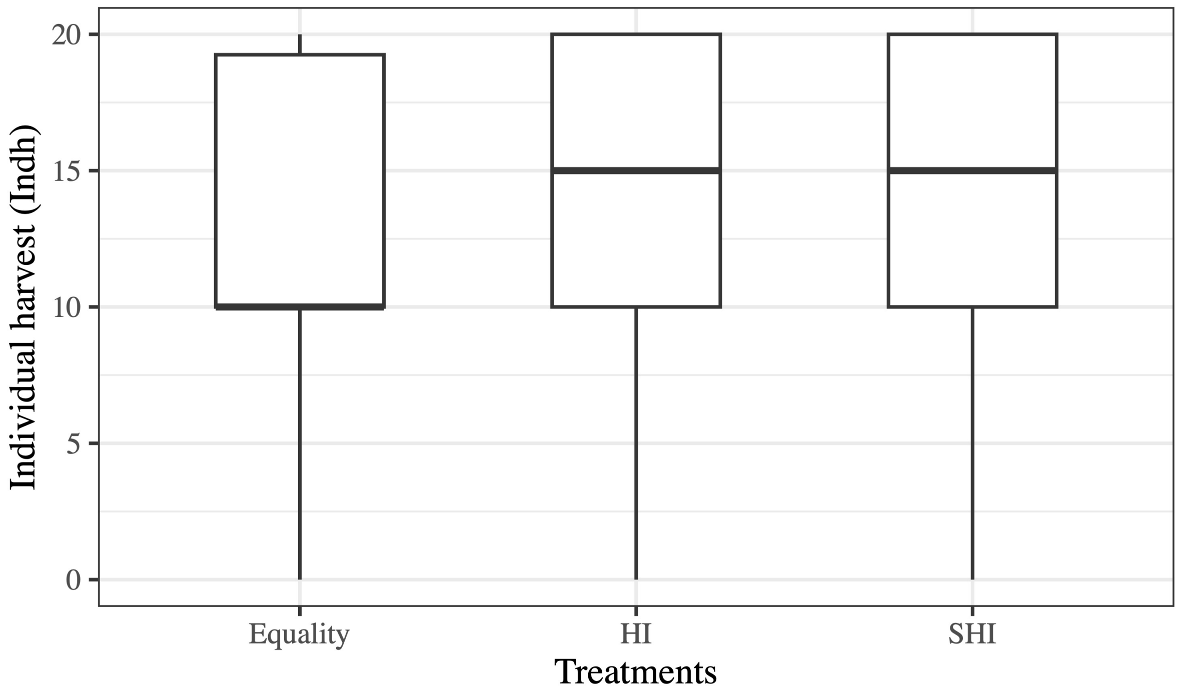
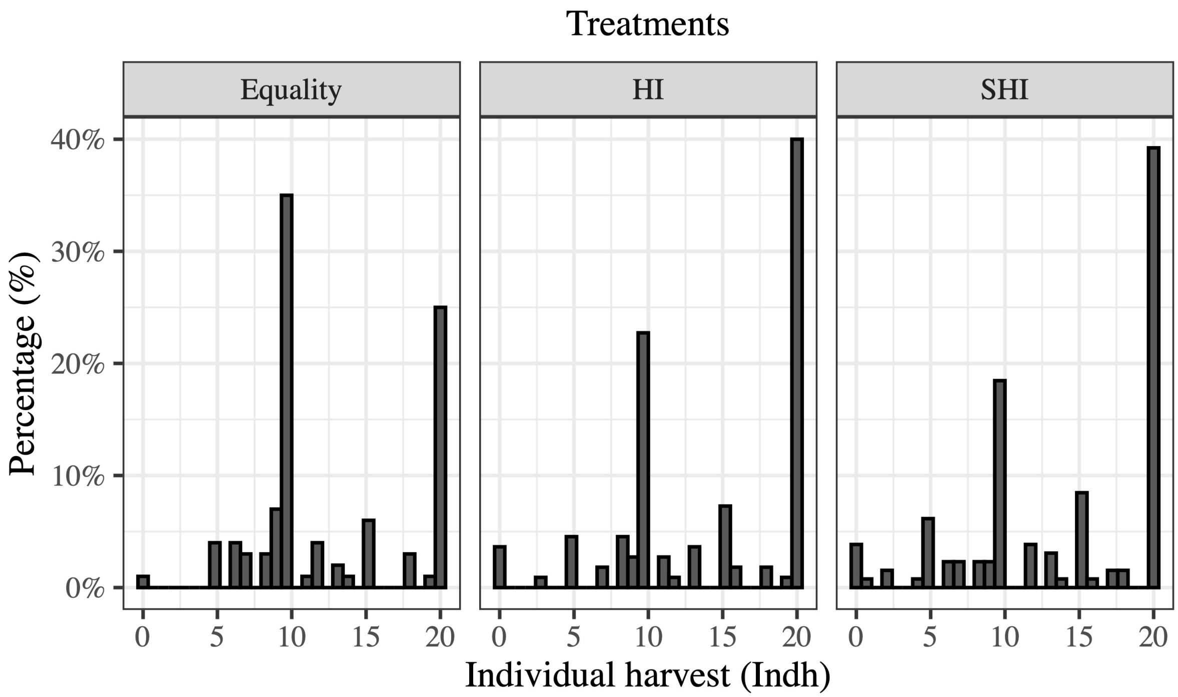


Figure 6: Histograms of the individual harvests (Indhs) by percentages across three treatments



2nd generation. In the sequence, the 1st generation's group harvest was 41 $(20, 8, 8, 0, 5)$, and the generation drew a white chip. The 2nd generation's group harvest was 94 $(15, 20, 20, 20, 19)$, and thus, the good was depleted. Under SHI, no sequences sustained the good up to the 2nd generation. In all 26 sequences, the 1st generations made group harvests to be more than 50, otherwise, a red chip was drawn for the termination of a sequence.

To quantitatively characterize Indhs, we consider two different types of regression models: Logit and Poisson regressions. The logit (Poisson) regression is estimated for the coefficients and marginal effects on the likelihood for a subject to harvest 10 points (individual harvests) by taking Indh10 (Indhs) as the dependent dummy (the ordered categorical) variable (see table 1 for the definition of each variable). Table 3 summarizes the estimation results and the associated marginal effects from the logit regression models. The marginal effect (ME) represents a change in likelihood for a subject to harvest 10 points when one independent variable increases by one unit, holding other factors fixed at sample mean. In models 1 and 2, HI (SHI) treatment is statistically significant at 5 % (1 %) level, demonstrating that subjects under HI (SHI) are 10 % (15 %) points less likely to harvest 10 points than those under equality. The results show that HI and SHI discourage subjects from Indh10, implying that intragenerational inequality is likely to adversely affect IS compared to the equality. In model 3, HI and the interaction between HI and E10 (HI $\times$ E10) are statistically significant at 1 % and 10 % levels, respectively. Subjects under HI are 19 % points less likely to harvest 10 points than those under equality. Moreover, subjects with E10 under HI are 12 % points more likely to harvest 10 points than those with E0. Subjects under SHI do not show any significant change in Indh10 compared to those under equality. While incorporating interaction terms in model 3, HI remains significant and confirms robustness across all three models.

Table 4 presents the results of Poisson regression models, showing the estimated coefficients and marginal effects of HI and SHI on Indhs compared to equality as the base group. The marginal effect (ME) represents the change in Indhs when an independent variable increases by one unit, holding other factors fixed at sample means. In models 1 and 2, the effects of HI are statistically significant at 10 % level, demonstrating that subjects under HI are likely to harvest by 1.40 and

Table 3: Regression coefficients and marginal effects of the independent variables on Indh10 in logit regressions

Variables	Model 1		Model 2		Model 3	
	Coefficient	ME	Coefficient	ME	Coefficient	ME
Treatments (Base group = equality)						
High inequality (HI)	−0.60*	−0.10**	−0.60*	−0.10**	−1.07**	−0.19***
	(0.31)	(0.05)	(0.31)	(0.05)	(0.45)	(0.07)
Super-high inequality (SHI)	−0.87***	−0.15***	−0.88***	−0.15***	−0.54	−0.11
	(0.31)	(0.05)	(0.31)	(0.05)	(0.34)	(0.07)
HI × E10					0.88	0.12*,[a]
					(0.61)	(0.71)
HI × E20					0.64	0.09[a]
					(0.53)	(0.06)
SHI × E10					−1.34*	−0.23[b]
					(0.07)	(0.14)
SHI × E40					−0.94	−0.17[b]
					(0.68)	(0.13)
Prosocial (Base group = Proself)			0.29	0.05	0.32	0.06
			(0.27)	(0.05)	(0.28)	(0.05)
Gender (Base group = Female)					0.05	0.01
					(0.27)	(0.05)
Sustainability index (SI)					−0.002	−0.0003
					(0.01)	(0.002)
Constant	−0.62***		−0.72***		−0.59	
	(0.21)		(0.24)		(1.37)	
Wald χ^2	8.42		10.19		16.04	
Number of observations	340		340		340	

***significant at the 1 percent level,**at the 5 percent level and *at the 10 percent level
Robust standard errors are reported in the parenthesis.
Indh10 stands for a dummy variable that takes 1 if a subject harvests 10 points from the intergenerational common good; otherwise, 0.
ME stands for marginal effect to indicate that a change in likelihood for a subject to harvest 10 points (above zero) when one independent variable increases by one unit, holding other factors fixed at sample mean.
E10, E20 and E40 represent dummy variables that take 1 if a subject is endowed with 10, 20 and 40, respectively, taking a base group of subjects with E0.
Prosocial stands for a dummy variable that takes 1 if a subject is identified as prosocial; otherwise, 0.

[a] The numbers show subjects with E10 (with E20) are more likely to harvest 10 points by 12 % (9 %) than those with E0 under HI.

[b] The numbers show subjects with E10 (with E40) are less likely to harvest 10 points by 23 % (17 %) than those with E0 under SHI.

1.28 units more than those under equality, respectively. In model 3, the effects of HI (SHI) are more pronounced than those in model 1 and 2, being statistically significant at 1 % (5 %) level. It suggests that subjects under HI (SHI) are likely to harvest by 3.39 (1.72) units more than those under equality. These findings highlight that subjects under the inequality tend to harvest more than those under the equality and intragenerational inequality hinders IS.

The interaction terms in our regression analysis provide insight into how different endowment levels under intragenerational inequalities (HI and SHI) affect Indhs. Under HI, the interactions for subjects with E10 (HI $\times$ E10) and those with E20 (HI $\times$ E20) are statistically significant at 1 % level. Specifically, subjects under HI $\times$ E10 and HI $\times$ E20 are likely to harvest by 4.50 and 4.29 units less than subjects with E0 under HI (HI $\times$ E0). Under SHI, subjects with E40 (SHI $\times$ E40) are statistically significant at 5 % level, indicating that the subjects are likely to harvest by 4.57 units less than those with E0 (SHI $\times$ E0). Overall, the results demonstrate that subjects with high endowments tend to reduce their harvests as compared to those with low endowments under intragenerational inequality, being partly consistent with some economic theory and evidence of inequality aversion, i.e, in a society, relatively oppressed people tend to be selfish or seek their gains selfishly, while relatively privileged people tend to be generous or give generously (Bolton and Ockenfels, 2000, Cappelen et al., 2007, Tricomi et al., 2010).

The estimation results associated with the interaction terms and marginal effects also illustrate that the harvest reductions by subjects with high endowments under HI and SHI are not enough to maintain IS. Consider five subjects in a generation under HI and recall that they are identified to harvest 3.39 more than those under equality on average (table 4). Given the marginal effect, the net harvest reduction for a subject with E10 (HI $\times$ E10) is –1.11 $(= 3.39 - 4.50)$ and that for two subjects with E20 (HI $\times$ E20) is –1.80 $(= (3.39 - 4.29) \times 2)$. Thus, the total net reduction out of the three subjects is –2.91 $(= -1.11 - 1.80)$. On the other hand, the net harvest increase for two subjects with E0 (HI $\times$ E0) is 6.78 $(= 3.39 \times 2)$. Therefore, the total net average change in a generation is 3.87 $(= 6.78 - 2.91)$. The logic also applies to explaining the net average change under SHI to be positive based on the results, being consistent with the average Indhs across the treatments in table 2. Overall, the results corroborate that the net harvest changes per generation under HI and SHI remain positive even with harvest reductions by subjects with high endowments, being negative on IS.

In table 4, the prosocial dummy from model 2, the gender dummy in model 3 and the sustainability index (SI) are included as independent variables to identify their impacts on Indhs. In model 2 and 3, the coefficients and the marginal effects of the prosocial dummy are statistically significant at 1 % level with a negative sign, indicating that prosocial subjects are likely to harvest 3.62 and 3.79 units less than proself subjects, respectively. This finding is consistent with the existing literature (Camerer and Fehr, 2006, Shahen et al., 2021). The gender dummy is statistically significant at 10 % level with a positive sign, suggesting that male subjects are likely to harvest 1.21 units more than female subjects. These results highlight that prosocial orientation and females are more inclined to support IS by reducing their harvest than their counterparts.

The results in figures 5 and 6 as well as tables 3 and 4 demonstrate the impact of intragenerational inequality on IS. Figure 5 illustrates that the median Indhs under both HI and SHI (15 points) are higher than those under equality (10 points). Figure 6 shows a similar trend with a high frequency of subjects that choose 20 points under HI and SHI compared to those under equality, indicating clear differences in individual harvests across the treatments. The results from logit regression models in table 3 indicate that subjects under HI and SHI are less likely to choose Indh10 than those under equality. Poisson regressions in table 4 reveal that subjects under HI and SHI harvest more than those under equality on average, suggesting that intragenerational inequality hinders IS. On the other hand, we identify that subjects with high endowments harvest less than those with low endowments under intragenerational inequality. Now, we are ready to answer our research question, "how does inequality in a generation, i.e., intragenerational inequality, affect the people's behaviors to future generations for IS?," and our hypothesis, "they behave selfishly and IS is compromised under inequality as compared to equality." Our results provide an answer to the hypothesis "yes, overall, people tend to be selfish under inequality" as well as an answer to the question "privileged (oppressed) people in a generation tend to be generous (not to be generous)

Table 4: Regression coefficients and marginal effects of the independent variables on the individual harvest (Indh) in Poisson regressions

Variables	Model 1		Model 2		Model 3	
	Coefficient	ME	Coefficient	ME	Coefficient	ME
Treatments (Base group = equality)						
High inequality (HI)	0.10*	1.40*	0.10*	1.28*	0.25***	3.39***
	(0.06)	(0.76)	(0.06)	(0.76)	(0.06)	(0.77)
Super-high inequality (SHI)	0.08	1.05	0.09	1.19	0.13**	1.72**
	(0.06)	(0.77)	(0.05)	(0.73)	(0.06)	(0.76)
HI × E10					−0.28***	−4.50***,[a]
					(0.10)	(1.61)
HI × E20					−0.28***	−4.29***,[a]
					(0.09)	(1.40)
SHI × E10					0.02	0.14[b]
					(0.07)	(1.07)
SHI × E40					−0.33**	−4.57**,[b]
					(0.13)	(1.84)
Prosocial (Base group = Proself)			−0.27***	−3.62***	−0.26***	−3.79***
			(0.05)	(0.68)	(0.05)	(0.72)
Gender (Base group = Female)					0.08*	1.21*
					(0.05)	(0.66)
Sustainability index (SI)					0.001	0.01
					(0.002)	(0.03)
Constant	2.54***		2.62***		2.51***	
	(0.40)		(0.04)		(0.03)	
Wald χ^2	3.64		30.96		66.95	
Number of observations	340		340		340	

***significant at the 1 percent level,**at the 5 percent level and *at the 10 percent level
Robust standard errors are reported in the parenthesis.
ME stands for marginal effect to indicate that a change in Indh when one independent variable increases by one unit, holding other factors fixed at sample mean.
E10, E20 and E40 represent dummy variables that take 1 if a subject is endowed with 10, 20 and 40, respectively, taking a base group of subjects with E0.
Prosocial stands for a dummy variable that takes 1 if a subject is identified as prosocial; otherwise, 0.

[a] The numbers show subjects with E10 (those with E20) are less likely to harvest by 4.50 (4.29) units than those with E0 under HI.

[b] The numbers show subjects with E10 (with E40) are more (less) likely to harvest by 0.14 (4.57) units than those with E0 under SHI.

for IS. However, in the end, intragenerational inequality is negative on IS as a whole."

It is known that absolute poverty has been gradually eradicated, while relative poverty has been widening over time (Chen and Ravallion, 2013, Ravallion, 2018). That is, inequality in a generation, i.e., intragenerational inequality, becomes increasingly huge through income, educational access and digital literacy as part of the transformation by the dominance of capitalism in the world (Carter, 2018). Economists know that it is inevitable to have a certain degree of inequality whenever goods and services are allocated by markets under capitalism, generating some groups of winners and losers as market outcomes (Dietsch, 2010, Boucoyannis, 2013). Since our world is intertwined and connected through international trade in globalized competitive markets, it is not reasonable to expect that intragenerational inequality shall be resolved or equalized in the near future (Birdsall, 2006, Furusawa et al., 2019). Further research shall be necessary to identify and characterize the "optimal balance" between intragenerational inequality and IS.

4 Conclusion

We investigate how inequality in a generation, i.e., intragenerational inequality, affects the members, hypothesizing that they behave selfishly and intergenerational sustainability (IS) is compromised under the inequality as compared to the equality. An online intergenerational goods game (IGG) experiment is conducted with 340 subjects under three treatments that correspond to equality, high inequality and super-high inequality in a generation, respectively. Our results indicate that intragenerational inequality induces the members not to harvest fairly and sustainably, adversely affecting IS. Although the members with high endowments tend to reduce their harvests as compared to those with low endowments under inequality, the reduction is not enough to maintain IS. Overall, this study demonstrates that intragenerational inequality and IS shall be in a trade-off relationship. Thus, optimally finding a balance between the two will be a practical resolution, as capitalism is so dominant that intragenerational inequality is widening worldwide.

We finally note some limitations of this study and future directions of research. The research focuses only on endowment inequality and does not consider any other types of inequality, such as productivity inequality. It shall be very important for us to investigating how other types of inequality influence IS. Additionally, the study does not explore possible institutions by which adverse effects of intragenerational inequality on IS can be reduced. Future research should be able to suggest new institutions or decision rules, considering economic and psychological factors for individual and collective behaviors toward IS. Lastly, this study does not address the detailed mechanisms of how inequality aversion theory is consistent with our experimental results. Future research should study how people's behaviors for IS under intragenerational inequality are actually driven by inequality aversion or some other behavioral theories. By doing so, some key theories and drivers shall be identified for characterizing the changes in people's sustainable behaviors under inequality. Despite these limitations, it is our belief that this study contributes to understanding the effects of intragenerational inequality on IS through IGG, laying a foundation for behavioral and experiment studies for betterment of IS.

Appendix

Table 5: Regression coefficients and marginal effects of the independent variables on Indh20 in logit regressions

Variables	Model 1		Model 2		Model 3	
	Coefficient	ME	Coefficient	ME	Coefficient	ME
Treatments (Base group = equality)						
High inequality (HI)	0.69**	0.16**	0.71**	0.16**	1.36***	0.31***
	(0.30)	(0.71)	(0.33)	(0.08)	(0.42)	(0.09)
Super-high inequality (SHI)	0.66**	0.15**	0.79**	0.18**	0.77**	0.16**
	(0.29)	(0.07)	(0.32)	(0.07)	(0.35)	(0.07)
HI × E10					−1.74**	−0.43**,[a]
					(0.72)	(0.18)
HI × E20					−0.97**	−0.24**,[a]
					(0.46)	(0.11)
SHI × E10					0.10	0.02[b]
					(0.45)	(0.14)
SHI × E40					−0.51	−0.12[b]
					(0.52)	(0.12)
Prosocial (Base group = Proself)			−1.51***	−0.33***	−1.53***	−0.36***
			(0.30)	(0.06)	(0.31)	(0.07)
Gender (Base group = Female)					0.56**	0.13**
					(0.27)	(0.06)
Sustainability index (SI)					0.001	0.0003
					(0.01)	(0.002)
Constant	0.66***		−0.71***		−1.12	
	(0.29)		(0.25)		(1.31)	
Wald χ^2	6.45		27.60		38.45	
Number of observations	340		340		340	

***significant at the 1 percent level,**at the 5 percent level and *at the 10 percent level
Robust standard errors are reported in the parenthesis.
Indh20 stands for a dummy variable that takes 1 if a subject harvests 20 points from the intergenerational common good; otherwise, 0.
ME stands for marginal effect to indicate that a change in likelihood for a subject to harvest 20 points (above zero) when one independent variable increases by one unit, holding other factors fixed at sample mean.
E10, E20 and E40 represent dummy variables that take 1 if a subject is endowed with 10, 20 and 40, respectively, taking a base group of subjects with E0.
Prosocial stands for a dummy variable that takes 1 if a subject is identified as prosocial; otherwise, 0.
[a] The numbers show subjects with E10 (with E20) are less likely to harvest 20 points by 43 % (12 %) than those with E0 under HI.
[b] The numbers show subjects with E10 (with E40) are more (less) likely to harvest 20 points by 2 % (12 %) than those with E0 under SHI.

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