Historical Responsibility in Climate Change Negotiations

Alessandro Del Ponte[*], Aidas Masiliūnas[†], & Noah Lim[‡]

Abstract

Despite worsening climate change, the international community is still unable to agree on a solution. A key source of disagreement is how the burden of climate change mitigation should be divided between the industrialized nations, which are responsible for the bulk of historical emissions, and the developing nations. We use an economic experiment to study how information about historical responsibility influences the willingness to pay for climate change mitigation in negotiations. In a four-player game, participants are split into two fictional countries and assigned to either the first or the second generation. The first generation creates wealth by exerting real effort and generating carbon emissions. The second generation inherits their predecessor's wealth and negotiates how to split the climate change mitigation costs. We manipulate whether the second generation knows that production by the previous generation created the current wealth and mitigation costs. We find that second-generation participants with greater historical responsibility offered to pay more when they knew the origins of their wealth and mitigation costs. Moreover, participants' offers were accepted more often when they proposed to divide the costs proportionally to historical responsibility. Our results suggest that developed countries may have to take responsibility for their historical emissions if they wish international climate agreements to succeed. Popular support for such expenditure could be garnered by informing the public about the link between historical emissions, present wealth, and climate change.

Keywords: climate change, historical responsibility, climate negotiations, experimental economics

Significance

Solving the climate change crisis requires cooperation between countries that differ in their historical responsibility for climate change. We created a new two-stage game modeling different generations to study how a more precise attribution of historical emissions, which is enabled by recent advances in climate science, changes the outcomes of the climate change negotiations. In the experiment, agreements were thwarted by differences in historical responsibility, as less responsible participants rejected offers that did not track historical emissions. These results suggest that successful international cooperation may require developed countries to take responsibility for historical emissions. The public may show greater support of paying for past emissions if they know that present wealth largely comes from these emissions.

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Introduction

Mitigating climate change is a global social dilemma that spans across geography and, importantly, generations[1]. However, after nearly three decades of diplomatic effort and 25 UN Climate Change Conferences, countries have failed to reach an agreement that can effectively curb global carbon emissions. Even if countries reached their Nationally Determined Contributions under the Paris Agreement, it would not be enough to keep the global average temperature within 2 °C above preindustrial levels[2,3]. A major hurdle in climate negotiations is the disagreement on how the burden of climate change mitigation should be divided between the industrialized and the developing countries[4]. Developing countries believe that industrialized countries should lead the mitigation effort since they are responsible for the bulk of historical emissions[5]. For example, China supports historical responsibility both in academic and official communication[6]. Instead, industrialized countries believe that mitigation should be implemented most cost-effectively, rather than based on historical responsibility[5]. Unlike previous climate agreements (e.g. the Kyoto Protocol), the current Paris Agreement leaves it up to the individual countries to decide whether to take historical responsibility into account.

In this paper, we study how the more accurate knowledge of historical responsibility that countries have today[7] may affect the division of mitigation costs between countries and the success of international climate negotiations. To this end, we designed an economic experiment that models historical responsibility across generations (pre- and post-industrialization in developed countries). Participants in the first generation work to develop their country and create wealth for themselves and their successor, but production also generates emissions and exacerbates climate change. Participants in the second generation inherit the wealth created by their predecessors and negotiate how to divide the climate change mitigation costs to prevent a disaster. In this setup, second-generation participants are not personally responsible for climate change, although they owe their prosperity to their predecessor's historical emissions. We compare two treatments: in the history treatment, second-generation participants are aware that their current wealth and the climate change problem was created by their predecessor; in the baseline, participants did not know the origins of climate change or their wealth. The difference between these two treatments reveals how the willingness to pay for climate change mitigation changes in response to accurate information about historical emissions provided by the recent advances in climate science[7].

By studying how historical responsibility affects the division of climate mitigation costs, we expand the present knowledge on how history shapes efforts for climate change mitigation. Several papers studied how climate change negotiations depend on the decisions made in a previous stage[8–12]. However, in these experiments, the same participants took part in both stages, therefore second-stage decisions would be driven by personal rather than collective responsibility. Instead, in our experiment, second-generation participants simply inherit the consequences of the first generation's decisions. The separation of the two generations has two important consequences. First, it reflects the fact that industrial development in Western countries occurred many generations ago and current leaders are not directly responsible for them. Second, the exogenous assignment of historical responsibility eliminates alternative explanations. For example, the correlation between production and offers found in the previous literature could be driven by personal characteristics, such as pro-social preferences, or offers in the second stage could be driven by the expectations about the behavior of other players with whom participants interacted in the previous stage.

Design

We designed a game in which higher production by the first generation increases both the wealth and the costs that the next generation will need to pay to avert a climate disaster. Two participants were the first-generation leaders of countries A and B (we denote them A1 and B1) and two other participants were the leaders of these countries in the second-generation (A2 and B2). A1 and B1 could create wealth, at the expense of environmental costs. A2 and B2 inherited the wealth of their predecessor (A1 or B1) and decided how to divide the costs of mitigating climate change to prevent a disaster that could destroy their earnings (for an illustration, see figure 1).

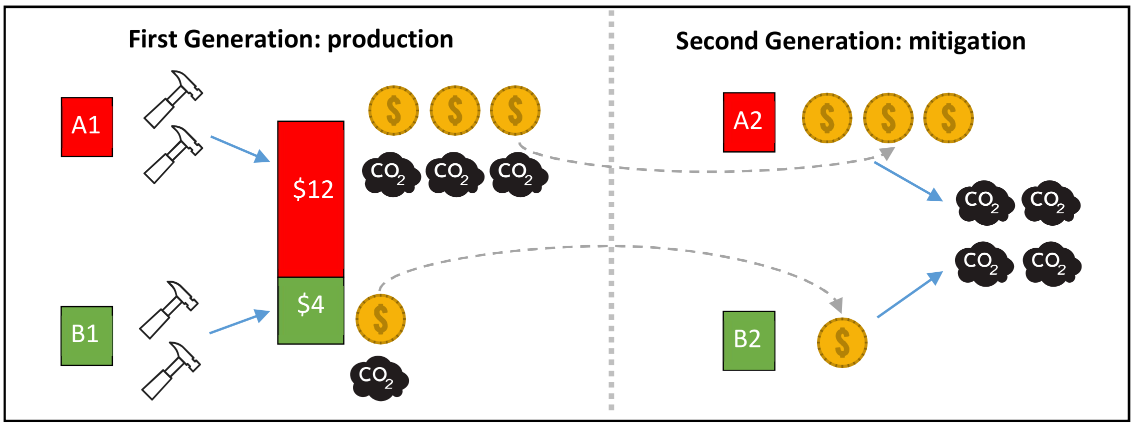


Figure 1. Illustration of the game structure. Participants A1 and B1 provide effort at a certain piece rate (in the example, A1 earns $12 per task and B1 earns $4), creating wealth and emissions. Participants A2 and B2 inherit the wealth of their predecessors and use it mitigate climate change.

To earn money, A1 and B1 could complete up to 40 real-effort tasks by moving sliders from a random starting position to the middle. Earnings for completing each task (piece rates) varied across pairs: there were equal probabilities that the piece rates would be equal ($8 per task for A1, $8 for B1), moderately unequal ($10 for A1, $6 for B1), or highly unequal ($12 for A2, $4 for B1). We used three sets of piece rates to create heterogeneity in responsibility and wealth in the second generation. In addition to generating income, first-stage production increased the climate change mitigation costs that the second generation would need to pay to avoid a climate disaster. In line with the literature[13,14], the costs were convex in production (see *Materials and Methods* for more details).

To pay for climate mitigation, the second generation inherited the earnings of their respective predecessors: the starting endowment of A2 (B2) was equal to the total earnings of A1 (B1), plus $600. Participants used their endowments to pay for climate change mitigation in an ultimatum game with a strategy method. The proposer made an offer on how to split the costs and the responder set the maximum amount they were willing to pay. The proposer's offer was implemented if it was acceptable to the responder; otherwise, it was rejected. If the offer was rejected, there was a 90% chance that participants will earn nothing because of a climate disaster and a 10% chance that the participants would keep their original endowments. Each participant made decisions both as a proposer and as a responder and their role was determined by a random draw once all data had been collected. Second-generation participants played the game four times, using the outcomes from four different first-generation pairs. Multiple observations allow us to classify each participant based on their sensitivity to the outcomes from the first generation.

We compared choices in two treatments. In the *history treatment*, second-generation participants were fully informed about how their endowments and climate change mitigation costs were determined, as well as the choices that the first generation made. In the *baseline treatment*, no information about the first generation was provided; instead, participants were seeded with the same outcomes (endowments and costs) as the participants in the history treatment but were not informed about the origins of these variables. This design allows us to identify the effect of information about historical responsibility, holding the outcomes generated by the first generation constant.

Theory

In the Nash equilibrium, proposers and responders always reach an agreement (see Appendix S3 for details). Risk-neutral responders have a dominant strategy to accept any offer that requires them to pay less than 90% of their endowment. The proposer's equilibrium offer must make the responder indifferent between accepting and rejecting, therefore the proposer would ask the responder to pay an amount equal to 90% of the responder's endowment (if the mitigation costs exceed 90% of the responder's endowment) or to pay all of the mitigation costs (if costs do not exceed 90% of the endowment). Equilibrium predictions are identical in both treatments since information about historical responsibility does not change the incentives.

However, information about historical responsibility might make participants feel guilty for the climate change created by their ancestors. The type of guilt experienced in climate change negotiations is related, yet different from the concepts discussed in previous literature. Personal guilt is experienced if a wrongdoer feels regret for hurting somebody else[15]. In our setup, greater production by A1 increases the costs and therefore the expected earnings of B2, which might make A2 feel guilty and willing to make amends by offering to pay a greater share of the costs. However, the wrongdoer (A1) is not the same person as the one who can make amends (A2); therefore, the decisions of the second generation would be driven by collective, rather than personal guilt[16]. We modeled three features that define the collective guilt in climate negotiations: Current leaders share the same national identity with their predecessors (reinforced in the experiment using framing), personally benefit from their predecessor's emissions, and are temporally separated from the predecessors. These three elements of shared identity, personal benefit, and temporal separation that makes this type of guilt interesting to study empirically.

Whether historical responsibility should drive offers in climate change negotiations has been debated in the normative ethics literature. Most writers agree that the countries which created the problem should be primarily responsible for solving it[17–19], although some argue that the role of historical responsibility should be limited[20] or supplemented by other principles, such as the capacity to pay[21,22]. The discussion about the importance of historical responsibility centers around two issues. First, it has been debated whether the current generation should be morally accountable for the actions that their predecessors took in distant past[23]. As a counterargument, it has been suggested that each person should receive the same benefits from the emissions, and the people from developed nations enjoy a higher standard of living due to the emissions of previous generations; therefore, they are not entitled to emit as much as those who have not received such benefits[24]. The second issue is whether emissions in the distant past should be discounted due to the lack of scientific evidence at that time. Some authors refute the argument on the basis that ignorance does not exempt responsibility[18], while others prefer to discount or exclude the emissions before the second half of the twentieth century, when the effects of emissions were not widely known[25]. We contribute to this debate empirically, by studying the role of historical responsibility in an economic experiment.

If the second generation experiences collective guilt, the descendants of the leaders who created more emissions should agree to pay more for mitigation, both as proposers and as responders. An increase in the responder's willingness to pay decreases the likelihood that a disaster would destroy the earnings of both participants. This way, responders from countries that generated the bulk of emissions can lower the risk that a third party would suffer from their predecessor's actions. The fact that the potential harm has not yet occurred might further increase the feelings of guilt[26]. Similarly, proposers should offer to pay more to decreases the disaster risk and to increase the earnings of the responder if the disaster does not occur. Making such reparations is a common method of relieving guilt[16]. Furthermore, the proposer's decision depends on their beliefs about the responder's willingness to pay; consequently, even if historically responsible proposers did not experience any guilt themselves, they would offer to pay more if they expected responders to experience collective guilt and reduce their willingness to pay.

Results

Division of costs

First, we look at how the second-generation participants divided the climate mitigation costs if they reached an agreement. For each first-generation outcome, we calculated the expected division of costs by averaging across all proposals that would have been accepted by responders. Figure 2 plots the expected share of the costs paid by the proposer against the proposer's historical responsibility. We find that in the history treatment, participants divided costs tracking responsibility more closely than in the baseline (Pearson's $r = 0.86$ in the history treatment, $r = 0.42$ in the baseline). An OLS regression confirmed these results (Table A1 in Appendix S1). In the history treatment, participants with greater historical responsibility covered a larger share of the costs (coefficient for responsibility $\hat{\beta} = 0.53$, $t_{86} = 13.90$, $p < .001$). In the baseline, the responsibility effect is also significant, yet much smaller ($\hat{\beta} = 0.13$, $t_{83} = 2.93$, $p = .004$). This difference in the responsibility effect is statistically significant (interaction effect of responsibility and the treatment variable when data from both treatments is pooled, $\hat{\beta} = 0.40$, $t_{171} = 6.73$, $p < .001$).

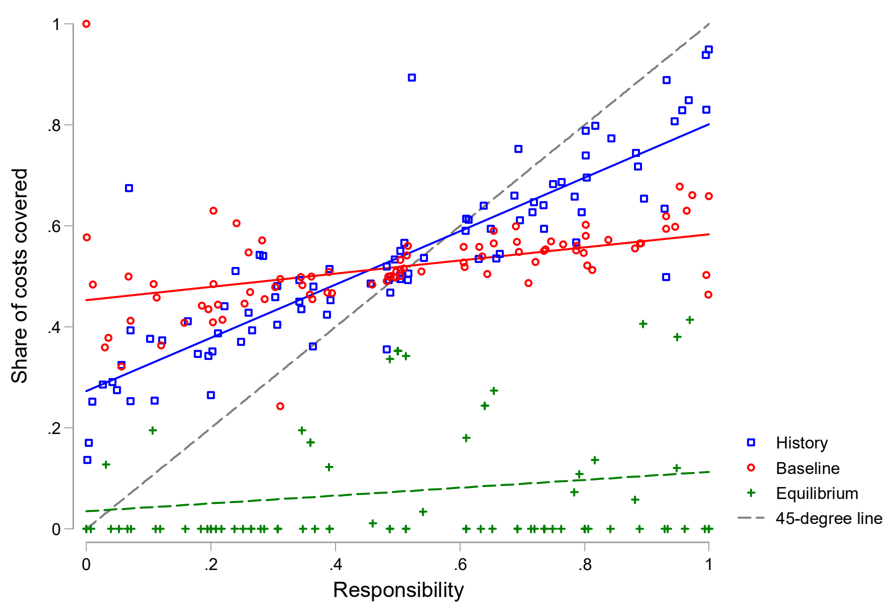


Figure 2. Division of climate mitigation costs in the history treatment (blue squares) and the baseline (red circles). Each marker represents a different outcome created by a first-generation pair of

participants. Blue and red solid lines indicate the best linear fit for the data; green crosses mark theoretical predictions; green dashed line indicates the best linear fit for the theoretical predictions; the 45° line indicates how costs would be divided if division perfectly followed responsibility.

Result 1: *Participants in the history treatment divided the costs more in line with responsibility than in the baseline treatment.*

The effect of responsibility in the baseline treatment could be explained by wealth since the more responsible countries are also wealthier. Wealthier countries are predicted to pay more, either because of inequality aversion or because poorer responders would reject more offers due to an insufficient budget, as predicted by Nash equilibrium. When we replicate the analysis by controlling for relative wealth (models 4 and 5 in Table A1), we find that responsibility is no longer significant in the baseline ($\hat{\beta} = -0.19, t_{83} = -1.03, p = .31$), but still significant in the history treatment. The correlation between responsibility and costs paid in the baseline treatment is nearly identical to the correlation predicted by the theory (green dashed line in figure 2).

Decisions of proposers and responders

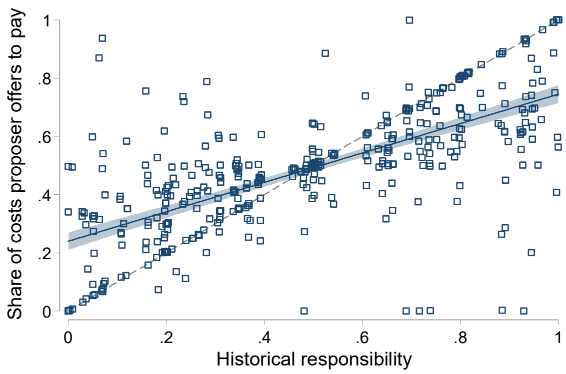
To investigate whether the effect of responsibility on cost division was driven by proposers, responders, or both, we examined individual-level data. We account for the panel data structure and the dependence between the four decisions that each participant made by estimating a panel data GLS regression with a random effect for each participant, clustering the standard errors on the individual level. As dependent variables, we use the share of costs the proposers offered to pay and the maximum share of costs the responders were willing to pay. In the history treatment, responsibility explains the decisions of both proposers ($\hat{\beta} = 0.55,\ z = 12.79, p < .001$; Table A2) and responders ($\hat{\beta} = 0.36,\ z = 5.72, p < .001$; Table A3) and the effect remains unchanged when controlling for relative wealth. In the baseline, responsibility had a significant yet smaller effect on both proposers and responders, which is no longer significant when wealth differences are accounted for. We also find that information about history significantly increases the responsibility effect, both for proposers ($\hat{\beta} = 0.42,\ z = 7.28, p < .001$; Table A2) and for responders ($\hat{\beta} = 0.23,\ z = 3.04, p < .01$; Table A3).

Result 2: *In the history treatment, choices of both proposers and responders are explained by historical responsibility. In the baseline, responsibility does not explain behavior once wealth differences are taken into account.*

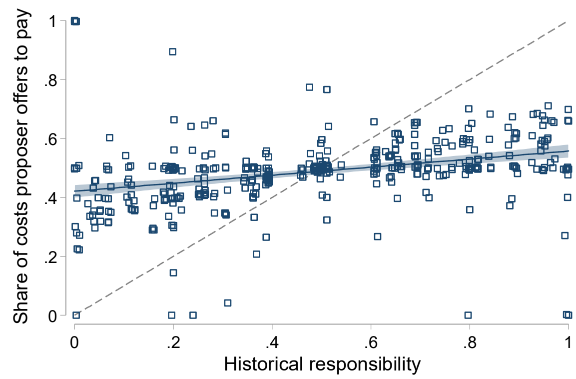
Next, we compare the decisions of the participants who were historically responsible for more than half of the costs to those who were responsible for less than a half. Figure A1 shows that in the history treatment, more responsible proposers offer to pay a much larger share of the costs (61%) than the less responsible ones (36%). This difference was more muted in the baseline treatment (respectively 53% and 44%). We find a similar pattern for the choices of the responders (an increase from 43% to 61% in the history treatment but from 51% to 59% in the baseline). A GLS regression confirms that in both treatments, more responsible proposers and responders are willing to pay significantly more than their less responsible counterparts (model 1 and 2 in Table A4), but the effect size is larger in the history treatment than in the baseline (the estimated interaction effect is $\hat{\beta} = 0.20,\ z = 6.89, p < .001$ for proposers, $\hat{\beta} = 0.098,\ z = 2.57, p = .01$ for responders; Table A4).

We also study how information about history affects the decisions of participants with greater historical responsibility, compared to those with lower responsibility. GLS regression shows that proposers with greater historical responsibility offered to pay more when they were informed about the history ($\hat{\beta} = 0.11,\ z = 4.95,\ p < .001$; Table A4) while proposers with less historical responsibility offered to pay less ($\hat{\beta} = -0.093,\ z = -4.47, p < .001$, Table A4). For responders, we find that information about history did not affect the more historically responsible responders ($\hat{\beta} = -0.0092,\ z = -0.31, p = .755$; Table A4) but decreased the maximum willingness to pay among those who were less historically responsible ($\hat{\beta} = -0.091,\ z = -2.76, p < .01$; Table A4).

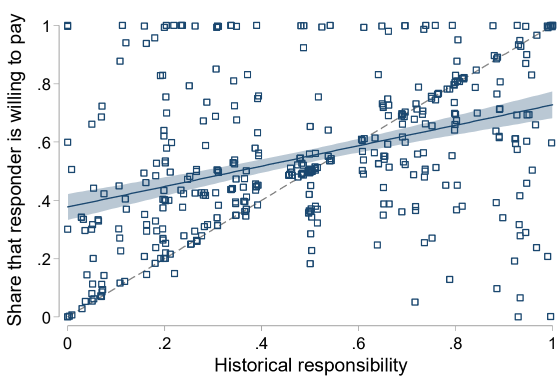
Result 3: *Proposers whose predecessor created more than half of the costs offered to pay 11 percentage points more in the history treatment than in the baseline. In contrast, proposers and responders whose predecessor created less than half of the costs were willing to pay 9 percentage points less in the history treatment than in the baseline.*



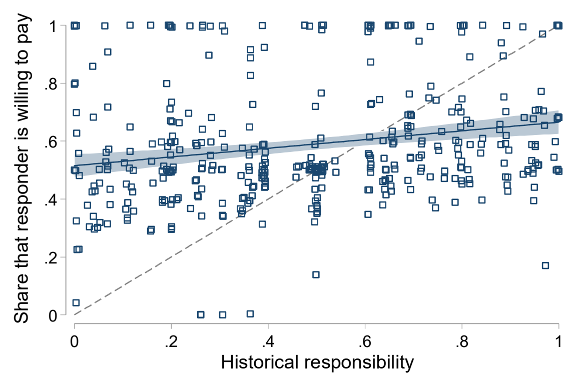
Panel A. Proposer (History treatment)



Panel B. Proposer (Baseline treatment)



Panel C. Responder (History treatment)



Panel D. Responder (Baseline treatment)

Figure 3. Choices of the proposers and responders and their historical responsibility.

Data shows that many offers in the history treatment closely follow historical responsibility (Figure 3). It is interesting to calculate how many participants consistently apply the principle of historical responsibility when making their offers. To do that, we exploited the panel data structure to classify individual proposers and responders. We classified individuals by regressing their four decisions on historical responsibility and evaluating whether the regression coefficient was close to 1, i.e. where $\hat{\beta} = 1 \pm 0.05$. We also computed the share of participants whose decisions were almost perfectly *orthogonal* to responsibility, i.e. where $\hat{\beta} = 0 \pm 0.05$. We find that in the history treatment 22% of proposers and 17% of responders tracked responsibility almost perfectly but none did so in the baseline. Instead, in the baseline, 20% of proposers and 15% of responders made choices that were nearly orthogonal to their share of the costs. For comparison, just 7% of proposers and 8% of responders did so in the history treatment (see Table A5 for full results). The cumulative distribution functions of individually-estimated regression coefficients were significantly different between the two treatments (two-sample Kolmogorov-Smirnov test, $\mathrm{p} < .001$ for both proposers and responders; see Figure A2 for further details).

Result 4: *In the history treatment, about one in five responders and proposers made decisions almost perfectly in line with their historical responsibility, while no participants did so in the baseline.*

Likelihood to reach an agreement

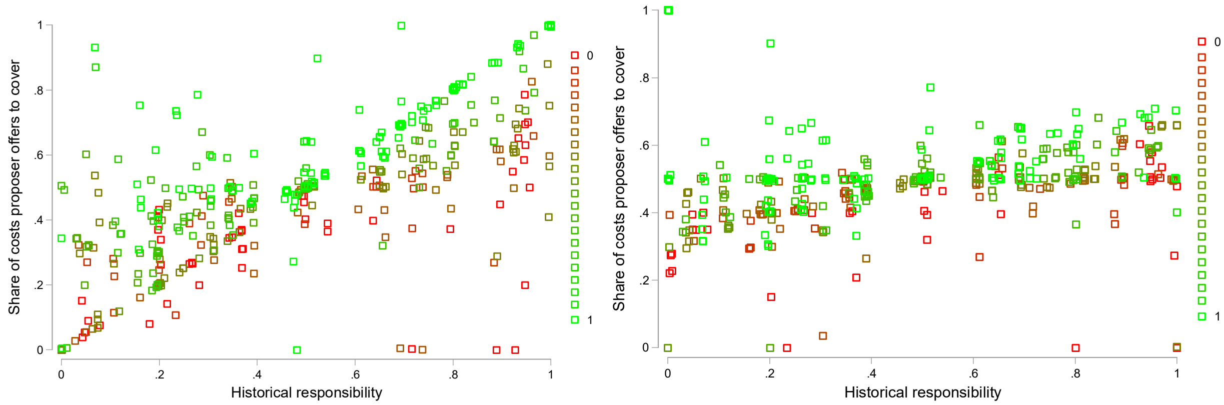
Next, we studied which second-generation pairs were more likely to reach an agreement. We calculated the expected likelihood of agreement by aggregating the choices of all proposers and responders assigned to the same pair of first-generation participants. Then, we regressed the likelihood of agreement on the climate mitigation costs and inequality (measured by the Gini coefficient) in either the wealth of the second generation or in the climate costs created by the first generation (Table A6). We found that agreements were less likely when the climate costs were higher. We also found a negative effect of inequality on the likelihood of agreements, both in terms of inequality in wealth ($\hat{\beta} = -2.66$, $p < .01$ in the history treatment; $\hat{\beta} = -2.34$, $p < .05$ in the baseline) and inequality in responsibility ($\hat{\beta} = -0.42$, $p < .01$ in the history treatment; $\hat{\beta} = -0.36$, $p < 0.05$ in the baseline). Across treatments, there was no difference in acceptance rates (treatment variable was not significant) or in the effect of either type of inequality (the interaction of the treatment variable and inequality was not significant). We conclude that reaching an agreement was more difficult when participants were further apart in terms of wealth or historical responsibility. Moreover, information about the predecessor's responsibility did not alter the likelihood of reaching an agreement.

Result 5: *Greater inequality in wealth or historical responsibility reduced the likelihood to reach an agreement. The likelihood to reach an agreement was the same across treatments.*

To understand how the likelihood of agreement depends on historical responsibility, we calculated the likelihood that proposer's offer will be accepted by aggregating data across all the responders with whom the proposer could have been matched. Figure 4 shows all the offers that were made and the color indicates the likelihood that the offer will be accepted by responders. In the history treatment, proposers often divided costs proportionally to historical responsibility, and such offers were almost always accepted when the proposer's predecessor created more climate costs than the responder. Offering to pay less than the historical responsibility suggests (below the 45-degree line) often led to a rejection. In contrast, in the baseline treatment, the probability of getting an offer accepted depended primarily on the proposed division of costs and not on historical responsibility.

We found that proposers offer to pay more than Nash equilibrium predicts (figure 2) and responders tend to reject offers that would have yielded positive profits (figure 4). We will therefore test whether the generous offers are ex-post rational given the behavior of the responders. For each combination of wealth and climate costs created by the first generation, we calculated the optimal proposer's offer given the acceptance thresholds of all potential responders. In the history treatment, proposers maximized their payoffs if they divided costs almost proportionally to responsibility (Figure A3, panel A). In the baseline, proposers chose optimally if they divided the costs evenly (Figure A3, panel B). On average, chosen offers were very close to ex-post rational offers.

Result 6: *In the history treatment, proposing to divide costs proportionally to responsibility was ex-post rational for the proposers, because responders often rejected offers that ignored responsibility.*



Panel A. History treatment **Panel B**. Baseline treatment

Figure 4. Offers of the proposers and the likelihood that they will be accepted by the responders (red color indicates low likelihood; green color indicates high likelihood).

Discussion

We found that when countries with greater historical responsibility were informed about it, they offered to pay a larger share of the climate mitigation costs. This behavior is consistent with feelings of collective responsibility[27,28], even though the two generations never interacted. Our findings suggest that citizens in Western countries may accept paying more for climate change mitigation if the link between past emissions, present wealth, and present climate costs is made clear to them. Recent scientific advances enable policymakers to communicate this information with greater accuracy than ever before[7].

Our experiments also show why developed countries should take greater responsibility for climate change mitigation. In the history treatment, which represents the current state of knowledge about historical responsibility, responders frequently reject the proposals that do not take historical responsibility into account. The risk of rejection creates incentives for the proposers to divide the costs proportionally to responsibility. Most proposers do so, resulting in a division of costs based on responsibility. Consequently, countries in the history treatment reach agreements as often as in the baseline treatment. These findings suggest that to find a way out of the climate negotiation impasse, countries with higher historical emissions should offer to cover a larger share of the costs.

We also found that greater inequality in wealth or historical responsibility made successful agreements more difficult. Participants were most successful in mitigating climate change when second-generation pairs were bequeathed with similar wealth. This finding complements the previous results about how international inequality thwarts efforts to curb climate change[31–34] and shows that the reduction in international inequality may also help to solve the climate change problem, in addition to the other benefits that have been identified in previous literature[35].

By using different participants to model each generation, the present experiment overcomes key limitations of previous work that studied the role of climate responsibility. For example, in previous studies, the same participants played both stages of the game[8,11,12]; responsibility was not studied in a social dilemma game[36]; or the focus of responsibility was on the creation of climate costs, not their mitigation[37]. Accordingly, our results are different. For example, we find that information about historical responsibility did not reduce the likelihood to reach an agreement, in contrast to a previous finding that participants were reluctant to cooperate with partners who created higher thresholds in the first stage[12]. In our experiment, motives for negative reciprocity are eliminated because the second generation is not personally responsible for the first-stage outcomes.

Our study has several limitations that could be addressed in future work. For simplicity, the experiment involved only two participants per generation, modeling two large economies with different historical responsibilities and wealth (e.g. the United States and China). If experiments were replicated with a larger number of players, results might be different, for instance due to diffusion of responsibility. We also used a one-shot negotiations game and it would be interesting to see if the results would change if participants could adjust their offers over multiple rounds. Future research could also use real national identities instead of fictional ones. Previous research has shown that national identity can influence attitudes toward globalization[38] and international solidarity[39]. It would be interesting to see if national attachments would further increase people's willingness to pay for the climate wrongs committed by their co-national ancestors.

Amid the Covid-19 pandemic, countries increasingly struggle to reach the targets set by the Paris Agreement[2]. As the world nears the point of no return to stop disastrous climate change[40] and needs costlier investments in high-risk, high-return investments[41], harnessing global support for climate change mitigation efforts will be an increasingly pressing challenge. Communicating to the public in developed countries the relationship between their present wealth and the carbon emissions of previous generations may increase the support for more ambitious mitigation efforts in these countries. In turn, more ambitious efforts in historically responsible countries may induce developing countries to play a greater role, too.

Materials and Methods

All experiments were conducted online using Qualtrics in November 2020. The experiments were approved by the Institutional Review Board at the National University of Singapore (NUS). All participants were NUS students, recruited from the pool of the NUS Centre for Behavioural Economics using ORSEE[42]. The earnings were denominated in experimental dollars, converted at the rate: 100 experimental dollars = 1 SGD (at the time of the experiment, the exchange rate was 1 SGD = 0.75 USD). First, we recruited 103 participants for the first generation. The average earnings of the first-generation participants were 4.9 SGD (including the 3 SGD show-up fee) and the median duration of the experiment was 17 minutes. We used the first-generation data to calculate the outcomes for the second generation. For the second generation, we recruited 103 participants for the baseline treatment and 101 participants for the history treatment. Each participant in the second generation was assigned a fixed role (either A2 or B2) and matched with four different first-generation pairs. For each pair, the participants made decisions both as a proposer and as a responder. Once all second-generation data has been collected, we randomly selected one of the four outcomes for each participant, randomly matched the participant with someone who made choices in the complementary role, randomly selected which participant was the proposer, and calculated the final earnings. If no agreement was reached, we performed a lottery to determine whether the climate disaster occurred or not. The average earnings of the second-generation participants were 7.1 SGD (including the 3 SGD show-up fee) and the median duration of the experiment was 18 minutes.

Before starting the experiment, participants read the instructions and answered a comprehension quiz. Participants passed the comprehension quiz if they answered at least 5 out 6 questions correctly. All participants passed the comprehension quiz. After the game, participants answered questions about their attitudes toward climate change[43] and demographic items (see Appendix S4 for the full text of the instructions, comprehension quiz, and demographic items).

In the experiment, the climate change mitigation costs were increasing in the production by the first generation: if we denote the piece rates of A1 and B1 by p_A and p_B and the number of completed tasks by t_A and t_B, the total climate change mitigation costs were calculated as $C(p_A, p_B, t_A, t_B) = \frac{(p_A t_A)^2}{160} + \frac{(p_B t_B)^2}{160}$. The set of piece rates was either $\{p_A = 8, p_B = 8\}$, $\{p_A = 10, p_B = 6\}$ or $\{p_A = 12, p_B = 4\}$, chosen with equal probabilities and revealed to the participants at the start of the experiment. Environmental costs were convex in production because of the empirical evidence that the relationship between the temperature and emissions[13,14] and between crop yields and temperature[44,45] is not linear. Convexity also ensures that pro-social participants would produce an amount between 0 and 40, thereby increasing the variance of first-stage outcomes needed to understand how the second generation responds to different levels of historical responsibility. The scaling parameter was set such that the socially efficient production would not exceed 40 (the maximum number of tasks that participants could complete) for any of the possible piece rates.

To clarify the incentives for the first-generation participants, we explained the relationship between production, earnings, and climate mitigation costs using a table and a figure (see Appendix S4). We also gave real-time feedback: after completing each task, participants saw their accumulated earnings and generated costs, as well as by how much they would increase if they completed the next task. In addition, we framed the game using concrete terms, rather than using abstract language: participants were told that completing each task will build a factory, which will produce a certain number of cars; cars generate earnings but also contribute to climate change, which will need to be mitigated by the next generation (see full instructions in Appendix S4).

In the history treatment, second-generation participants knew that their endowments and climate mitigation costs were determined by the previous generation; they were also fully informed about the incentives that the first generation faced and the decisions that they made. In the baseline treatment, second-generation participants were informed about the endowments and climate mitigation costs but did not know how these values were determined. In each treatment, participant's starting endowment was equal to the wealth of their predecessor, plus \$600. All second-generation participants were assigned to four pairs of first-generation participants and made decisions for each potential predecessor. Participants had to choose how to divide the climate change mitigation costs using an ultimatum game with a strategy method. First, each participant acted as a proposer and chose how to split the costs between themselves and the other participant. Then, participant acted as a responder and chose the maximum amount they were willing to pay to accept the proposer's offer. Both proposers and responders made their decisions using a slider on their screen and saw real-time information about the resulting division of climate mitigation costs and earnings. The proposer's offer was implemented if it was acceptable to the responder; otherwise, it was rejected. If the offer was rejected, there was a 90% chance that participants will earn nothing because of a climate disaster and a 10% chance that the participants would keep their original endowments. Whether the participant was a proposer or a responder was determined by a random draw once all data had been collected.

The inheritance of wealth by the second generation simulates how the development of a country generates wealth for future generations but can also create problems that future generations will need to solve. We added \$600 to the endowments in the second generation to ensure that participants were not budget-constrained and could cover the climate mitigation costs.[1] The destruction of endowments

[1] The highest possible value of costs equals \$1600 and occurs if participants in the first generation complete all the tasks and productivities are (12, 4). In that case, the endowments of the second-generation participants would be \$1080 and \$760, therefore participants have enough to cover the costs and the poorer participant has enough to cover almost half of the costs.

was probabilistic to reflect the probabilistic nature of climate change and in line with the previous literature[8,11,12]. The destruction probability was set to 90%, in line with previous literature[37,46,47], and ensures that reaching a deal is always socially optimal.

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Appendix

S1. Supplementary Tables

Table A1. OLS regression with heteroscedasticity-robust standard errors.

	(1)	(2)	(3)	(4)	(5)
	H	B	H and B	H	B
Historical responsibility	0.53***	0.13**	0.13**	0.76***	-0.19
	(13.90)	(2.93)	(2.90)	(12.35)	(-1.03)
Climate costs	-0.018	-0.037	-0.027	-0.020	-0.039
	(-0.81)	(-1.24)	(-1.47)	(-1.05)	(-1.42)
H treatment			-0.18***		
			(-4.88)		
H # Responsibility			0.40***		
			(6.73)		
Relative wealth				-1.69***	2.33*
				(-3.45)	(2.13)
Constant	0.28***	0.47***	0.47***	1.01***	-0.53
	(10.22)	(10.66)	(12.65)	(4.59)	(-1.21)
Observations	90	87	177	90	87
R^2	0.758	0.199	0.647	0.777	0.327

Note: *t* statistics in parentheses, costs measured in thousands. * $p < .05$, ** $p < .01$, *** $p < .001$
The dependent variable is the expected fraction of climate costs paid by the proposer. To calculate it, we look at all the potential pairings between all proposers and responders assigned to the same first-stage outcome. We find the expected division of costs by calculating the average offer, conditional on it being accepted by the responder. *Historical responsibility* is calculated as a ratio of climate mitigation costs created by the predecessor to the total climate mitigation costs created by the first generation. *Climate costs* indicates the total climate mitigation costs created by the first generation (in thousands of experimental dollars). *H # Responsibility* is the interaction between historical responsibility and the history treatment variable. *Relative wealth* is calculated as the proposer's endowment, divided by the sum of endowments received by the proposer and the responder. H denotes the history treatment; B denotes the baseline.

Table A2. GLS regression with a random effect for each participant, clustering the standard errors at the individual level.

	(1) H	(2) B	(3) H and B	(4) H	(5) B
Historical responsibility	0.55^{***}	0.12^{***}	0.12^{**}	0.71^{***}	-0.087
	(12.79)	(3.55)	(3.17)	(7.08)	(-0.70)
Climate costs	-0.027	-0.0095	-0.019	-0.025	-0.012
	(-1.64)	(-0.56)	(-1.63)	(-1.58)	(-0.69)
Round	0.0015	0.0023	0.0021	0.00075	0.0013
	(0.30)	(0.56)	(0.66)	(0.16)	(0.28)
H treatment			-0.21^{***}		
			(-6.61)		
H # Responsibility			0.42^{***}		
			(7.28)		
Relative wealth				-1.21	1.63^{*}
				(-1.88)	(2.19)
Constant	0.23^{***}	0.43^{***}	0.43^{***}	0.76^{**}	-0.28
	(8.29)	(16.19)	(17.96)	(2.77)	(-0.92)
Observations	404	412	816	404	412
R^2	0.45	0.10	0.36	0.46	0.14

Note: z statistics in parentheses, costs measured in thousands. * $p < .05$, ** $p < .01$, *** $p < .001$

The dependent variable is the share of climate mitigation costs that the proposers offer to cover (proposer's offered amount divided by total climate costs). *Historical responsibility* is calculated as a ratio of climate mitigation costs created by the predecessor to the total climate mitigation costs created by the first generation. *Climate costs* indicates the total climate mitigation costs created by the first generation (in thousands of experimental dollars). *Round* indicates the round number (from 1 to 4). *H # Responsibility* is the interaction between historical responsibility and the history treatment variable. *Relative wealth* is calculated as the proposer's endowment, divided by the sum of endowments received by the proposer and the responder. H denotes the history treatment; B denotes the baseline.

Table A3. GLS regression with a random effect for each participant, clustering the standard errors on the individual level.

	(1) H	(2) B	(3) H and B	(4) H	(5) B
Historical responsibility	0.36^{***}	0.14^{***}	0.13^{***}	0.32	0.058
	(5.72)	(3.56)	(3.32)	(1.92)	(0.46)
Climate costs	-0.18^{***}	-0.24^{***}	-0.20^{***}	-0.18^{***}	-0.24^{***}
	(-6.80)	(-7.96)	(-10.47)	(-6.69)	(-7.94)
Round	0.0068	0.0036	0.0046	0.0070	0.0031
	(0.92)	(0.52)	(0.91)	(0.93)	(0.45)
H treatment			-0.15^{***}		
			(-3.33)		
H # Responsibility			0.23^{**}		
			(3.04)		
Relative wealth				0.27	0.65
				(0.28)	(0.76)
Constant	0.46^{***}	0.65^{***}	0.63^{***}	0.34	0.37
	(10.16)	(17.85)	(19.85)	(0.83)	(1.03)
Observations	404	412	816	404	412
R^2	0.22	0.20	0.21	0.22	0.20

Note: z statistics in parentheses, costs measured in thousands. * $p < .05$, ** $p < .01$, *** $p < .001$

The dependent variable is the maximum share of climate mitigation costs that the responders are willing to cover (responder's maximum willingness to pay divided by the total climate costs). *Historical responsibility* is calculated as a ratio of climate mitigation costs created by the predecessor to the total climate mitigation costs created by the first generation. *Climate costs* indicates the total climate mitigation costs created by the first generation (in thousands of experimental dollars). *Round* indicates the round number (from 1 to 4). *H # Responsibility* is the interaction between historical responsibility and the history treatment variable. *Relative wealth* is calculated as the responder's endowment, divided by the sum of endowments received by the proposer and the responder. H denotes the history treatment; B denotes the baseline.

Table A4. GLS regression with a random effect for each participant, clustering the standard errors on the individual level.

	(1) Proposer	(2) Responder	(3) High resp. proposer	(4) Low resp. proposer	(5) High resp. responder	(6) Low resp. responder
H treatment	-0.094***	-0.084**	0.11***	-0.093***	-0.0092	-0.091**
	(-4.56)	(-2.61)	(4.95)	(-4.47)	(-0.31)	(-2.76)
Climate costs	-0.021	-0.22***	-0.031	0.0056	-0.21***	-0.18***
	(-1.38)	(-9.88)	(-1.51)	(0.26)	(-7.80)	(-6.01)
Round	0.0046	0.0088	0.0038	0.00027	0.020**	-0.011
	(1.24)	(1.64)	(0.71)	(0.05)	(2.81)	(-1.41)
High responsibility	0.070***	0.080***				
	(4.09)	(3.88)				
H # High resp.	0.20***	0.098*				
	(6.89)	(2.57)				
Constant	0.45***	0.65***	0.53***	0.45***	0.72***	0.69***
	(24.71)	(24.19)	(27.62)	(17.64)	(25.31)	(20.56)
Observations	749	749	359	390	359	390
R^2	0.30	0.17	0.10	0.077	0.12	0.10

Note: z statistics in parentheses, costs measured in thousands. * $p < .05$, ** $p < .01$, *** $p < .001$

The dependent variable is the share of climate mitigation costs that the proposers offer to cover (in models 1, 3 and 4) or the maximum share of climate mitigation costs that the responders are willing to cover (in models 2, 5 and 6). *High/low responsibility* indicates whether participant has higher/lower historical responsibility than the counterpart. Observations from cases when both participants are equally responsible are excluded from the regressions (8.2% of observations). *Climate costs* indicates the total absolute value of climate costs to be divided between the proposer and responder (in thousands of experimental dollars). *Round* indicates the round number (from 1 to 4). *Relative wealth* is calculated as the responder's endowment, divided by the sum of endowments received by the proposer and the responder. H denotes the history treatment; B denotes the baseline.

Table A5. Classification of proposers and responders based on all their decisions.

	Regression coefficient					
	< -0.05	0 ± 0.05	$0.05 - 0.5$	$0.5 - 0.95$	1 ± 0.05	≥ 1.05
Proposers in B	15%	20%	59%	5%	0%	1%
Proposers in H	9%	7%	32%	26%	22%	5%
Responders in B	38%	15%	29%	15%	0%	4%
Responders in H	27%	8%	25%	17%	17%	7%

Note. We regressed the four decisions of each participant (relative share of costs that the proposers offer to pay or the maximum relative share of costs that the responders are willing to pay) on their relative historical responsibility and classified the participant based on the estimated value of the regression coefficient. H denotes the history treatment; B denotes the baseline.

Table A6. OLS regression with heteroscedasticity-robust standard errors.

	(1) H	(2) B	(3) H and B	(4) H	(5) B	(6) H and B
Total costs	-0.23***	-0.29***	-0.26***	-0.30***	-0.35***	-0.33***
	(-4.04)	(-5.21)	(-6.48)	(-5.58)	(-6.13)	(-8.19)
Wealth inequality	-2.66**	-2.34*	-2.44**			
	(-2.90)	(-2.54)	(-2.68)			
H treatment			-0.0043			0.012
			(-0.09)			(0.19)
H # Wealth inequality			-0.11			
			(-0.09)			
Responsibility inequality				-0.42**	-0.36*	-0.35*
				(-2.74)	(-2.22)	(-2.17)
H # Responsibility ineq.						-0.084
						(-0.38)
Constant	0.83***	0.87***	0.85***	0.89***	0.91***	0.89***
	(21.31)	(19.65)	(21.92)	(16.55)	(16.41)	(18.90)
Observations	94	90	184	94	90	184
R^2	0.253	0.311	0.279	0.243	0.296	0.267

Note: *t* statistics in parentheses. * $p < .05$, ** $p < .01$, *** $p < .001$

The dependent variable is the expected likelihood to reach an agreement. For each first-generation outcome, we calculate the expected likelihood to reach an agreement by calculating the average acceptance probability across all potential pairings between proposers and responders assigned to the same outcome. *Wealth inequality* is calculated as the Gini coefficient of the initial endowments received by the proposer and the responder. *Responsibility inequality* is calculated as the Gini coefficient of the climate mitigation costs created by the ancestors of the proposer and responder. H denotes the history treatment, B denotes the baseline.

S2. Supplementary Figures

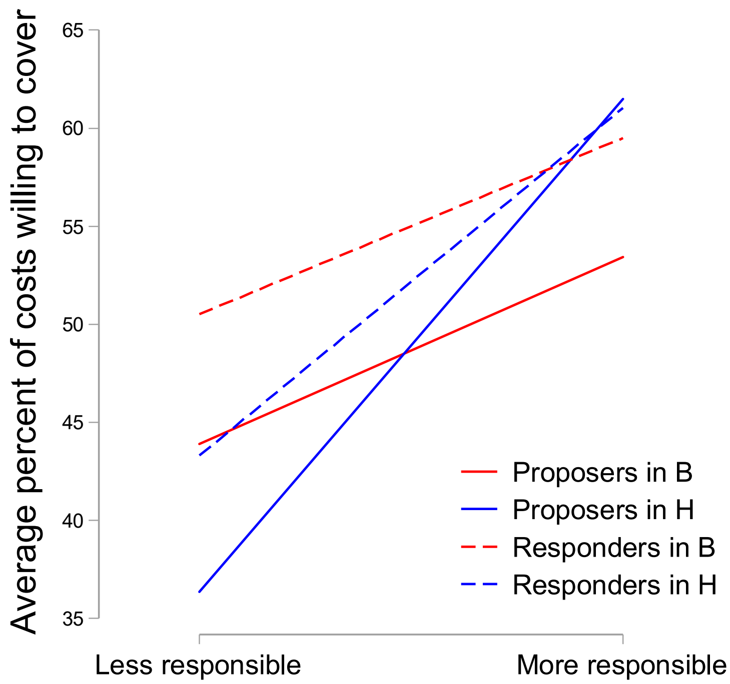
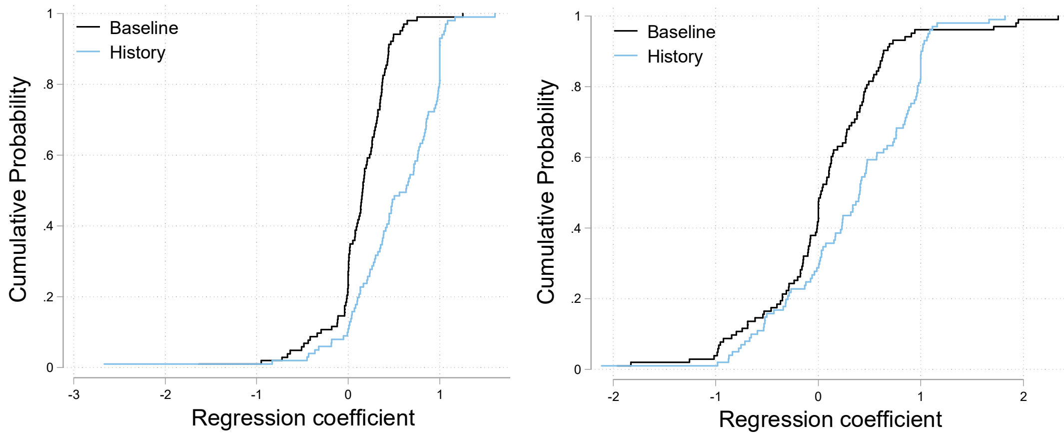


Figure A1. Average percent of climate costs that proposers and responders offer to cover, divided by treatment and historical responsibility.

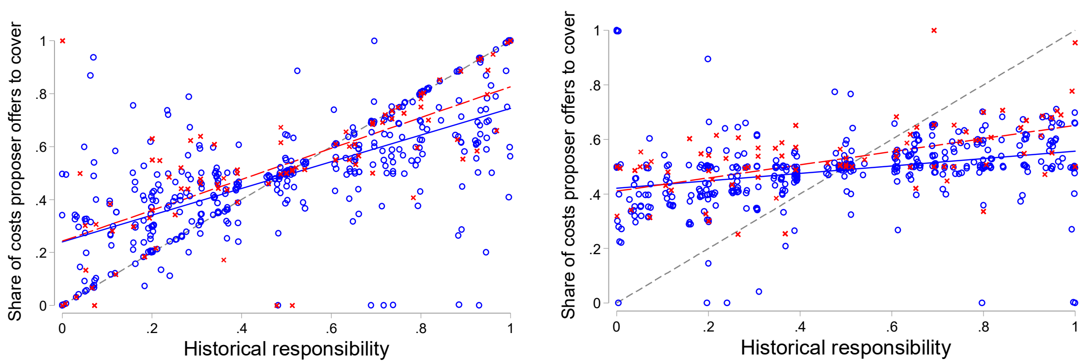
Note. High/low responsibility indicates whether participant has higher/lower historical responsibility than the counterpart. Observations from cases when both participants are equally responsible are excluded from the regressions (8.2% of observations). Average percent of costs are calculated by adding the amounts that all participants in that category are willing to cover and dividing it by the total amount of climate mitigation costs. H denotes the history treatment; B denotes the baseline.



Panel A. Proposers **Panel B**. Responders

Figure A2. Cumulative distribution of individually estimated regression coefficients.

Note. Coefficients are estimated by regressing the four decisions of each participant (relative share of costs that the proposers offer to pay or the maximum relative share of costs that the responders are willing to pay) on their relative historical responsibility.



Panel A. History treatment **Panel B**. Baseline treatment

Figure A3. Proposers' offers in the experiment (blue circles) and ex-post rational offers (red crosses).

Note. Blue line marks the best linear fit of actual choices, red dashed line marks the best linear fit of ex-post rational offers. The ex-post rational offers were calculated by matching each proposer with the responders who have been assigned to the same first-generation outcome and by finding the offer that would have maximized proposer's expected payoffs.

S3. Equilibrium predictions

In the first generation, a selfish participant would complete all 40 tasks, as long as the time and effort required to move a slider do not exceed the monetary incentives. Efficiency-oriented participants would complete less than 40 tasks because the climate costs are convex in the number of completed tasks. In particular, if the cost of effort is zero, participants who seek to maximize total earnings received by all four participants would produce up to the point where the collective marginal benefits (increase in own wealth and the starting endowment of the successor) are equal to the collective marginal costs (increase in the climate change mitigation costs). This holds because in equilibrium, second-generation participants would always reach an agreement, keeping their endowments and covering the climate mitigation costs. The socially efficient production is summarized in Table A7. Regardless of the productivity parameters, each efficiency-oriented participant would generate \$160 of climate change mitigation costs.

Table A7. Socially efficient production in the first generation

Productivities	(8, 8)	(10, 6)	(12, 4)
Equilibrium production in G1	(40, 40)	(40, 40)	(40, 40)
Socially optimal production in G1	(20, 20)	(16, 26.7)	(13.3, 40)

In the second generation, participants play a one-shot ultimatum game using a strategy method. If the responder is not willing to pay the amount offered by the proposer, no agreement is reached and both participants lose all their earnings with probability $p = 0.9$. Under risk neutrality, the probabilistic loss of earnings makes the game similar to an ultimatum game with an outside option (Knez & Camerer, 1995).

Each proposer-responder pair in generation 2 is assigned a set of parameters based on the decisions that another pair of participants made in generation 1. Denote the climate mitigation costs by C, the endowment of the proposer by E_p and the endowment of the responder by E_r. The proposer makes an offer on how to split C between the two players. The proposal is made by choosing the amount of costs that the proposer is willing to cover; denote this amount by $s_p \in [0, \min\{E_p, C\}]$. The responder chooses the maximum amount costs they are willing to pay to accept the proposer's offer; denote the amount by $s_r \in [0, \min\{E_r, C\}]$. If the responder is asked to pay less than the chosen maximum willingness to pay, the agreement is reached and the costs are divide based on the proposer's offer (proposer pays s_p and responder pays $C - s_p$); otherwise, no agreement is reached. The expected payoffs of the proposer (π_p) and the responder (π_r) are calculated as:

$$\pi_p = \begin{cases} E_p - s_p, & if\ s_p + s_r \geq C \\ (1-p)E_p, & otherwise \end{cases}$$

$$\pi_r = \begin{cases} E_r - (C - s_p), & if\ s_p + s_r \geq C \\ (1-p)E_r, & otherwise \end{cases}$$

The responder is better off accepting proposer's offer $(s_p, C - s_p)$ if the earnings from accepting the offer exceed the expected earnings from the rejected offer:

$$E_r - (C - s_p) \geq (1-p)E_r \quad \Leftrightarrow \quad pE_r \geq C - s_p$$

Consequently, the responder has a dominant strategy $s_r^* = pE_r$: there are no incentives to choose any $s_r' > pE_r$ because then the responder would earn less than the expected earnings in case no agreement is reached; there also are no incentives to choose any $s_r'' < pE_r$ because choosing a lower value of s_r would not decrease the amount the responder needs to pay in case the offer is accepted, but it would reject offers that satisfy $C - s_p \in (s_r'', pE_r)$, which are more profitable to the responder than reaching no agreement. The only case in which a responder might choose $s_r < pE_r$ is if $C < pE_r$ as the proposer is not able to ask the responder to pay more than C; all strategies $s_r \in [C, pE_r]$ would therefore generate the same outcome, as the responder would cover all the costs. In the experiment, responders were not allowed to submit strategies that exceed the total costs C, therefore the optimal strategy for any responder is $s_r^* = \min\{pE_r, C\}$.

Proposers do not have a dominant strategy, but we can calculate their best response for any s_r chosen by the responder. Note that if proposer chooses $s_p \geq C - s_r$, an agreement will be successful. The proposer would never choose any $s_p > C - s_r$ because it would increase the costs the proposer has to cover, compared to choosing $s_p = C - s_r$, without affecting the probability to reach the agreement. If the proposer chooses $s_p < C - s_r$, no agreement will be reached, therefore the earnings are the same for all $s_p \in [0, C - s_r)$. The proposer would make an offer that leads to a rejection either because the endowment is not sufficient to cover the costs (i.e. $E_p < C - s_r$) or because the earnings from making no agreement exceed the earnings from an agreement with $s_p = C - s_r$. The latter condition holds if:

$$E_p - (C - s_r) < (1 - p)E_p \quad \Leftrightarrow \quad pE_p < C - s_r \tag{1}$$

In equilibrium, the responder must choose $s_r^* = \min\{pE_r, C\}$. If $s_r^* = C$, (1) does not hold, therefore it is optimal to choose $s_p = 0$, asking the responder to cover all the costs. If $s_r^* = pE_r$, condition (1) holds if $p(E_p + E_r) < C$. In other words, the proposer would submit an offer that leads to it being rejected only if there were no collective gains from making an agreement (the costs that need to be paid exceed the expected loss of all earnings). With the parameters used in the experiment, this condition never holds. It also implies that $E_p + pE_r > C$, i.e. proposer's endowment E_p is always sufficient to pay the amount $s_p = C - pE_r$. Consequently, equilibrium strategies are:

$$\begin{aligned} s_p^* &= C - pE_r, \quad & s_r^* &= pE_r, \quad & if\ pE_r &< C \\ s_p^* &= 0, & s_r^* &= C, & if\ pE_r &\geq C \end{aligned}$$

In equilibrium, the agreement will always be reached, and proposer's distribution of costs will be implemented.

In the experiment, we set $p = 0.9$, therefore the responder would cover the amount equal to 90% of the starting endowment and the proposer would cover the remaining amount. If total costs are lower than 90% of responder's endowment, the responder would cover all the costs and the proposer would pay nothing. As in the standard ultimatum game, the payoffs of the responder are equal to the expected value of earnings if no agreement was made (10% of the endowment) while the proposer receives the entire surplus.

S4. Instructions

Instructions for all treatments

Overview

In this study, you can earn money based on your decisions in a game with three other participants. This money is in addition to your $3 payment for completing the survey, which you will earn regardless of what happens in the game.

Your decisions in the game will determine your bonus. For each dollar you have at the end of the game, you will receive 1 cent in real money as an additional bonus. **To receive this bonus and credit for completing the survey, you must complete the game and the questionnaire that follows.**

Please read the instructions carefully as there will be comprehension questions to test your understanding of the instructions. If you do not answer at least 5 out of 6 questions correctly, you will be ineligible to participate in the game and there will not be compensation. You will be given 2 attempts to answer the questions.

After the study, **you will be matched with 3 other participants** and everyone's choices will be carried out to complete the game.

Before proceeding, please read the Participant Information Sheet (PIS) available at the link below:

[Link]

- I have read the PIS and I consent to having my data collected for this study
- I do not consent to having my data collected for this study.

Please enter your NUS Student ID (starts with A). You must enter the same ID you used to register at cbelab.nus.edu.sg.
[textbox]

Payment will be made to the bank account listed in EduRec, which is linked to your student ID. If there are any mistakes in the information provided or if you do not have a bank account registered in EduRec, we will not be able to make the payment.

Participants in Generation 1

Overview of the Experiment

1. **Instructions** of the overall experiment
2. [2 attempts] **6 comprehension questions** - you can proceed only if you get at least 5 out of 6 questions correct
3. **Decision Task** - with short instructions
4. **1 open-ended response question** regarding the decision
5. **Questionnaire** - 10 questions
6. **End**

You can refer to the progress bar below for your progress in the survey.

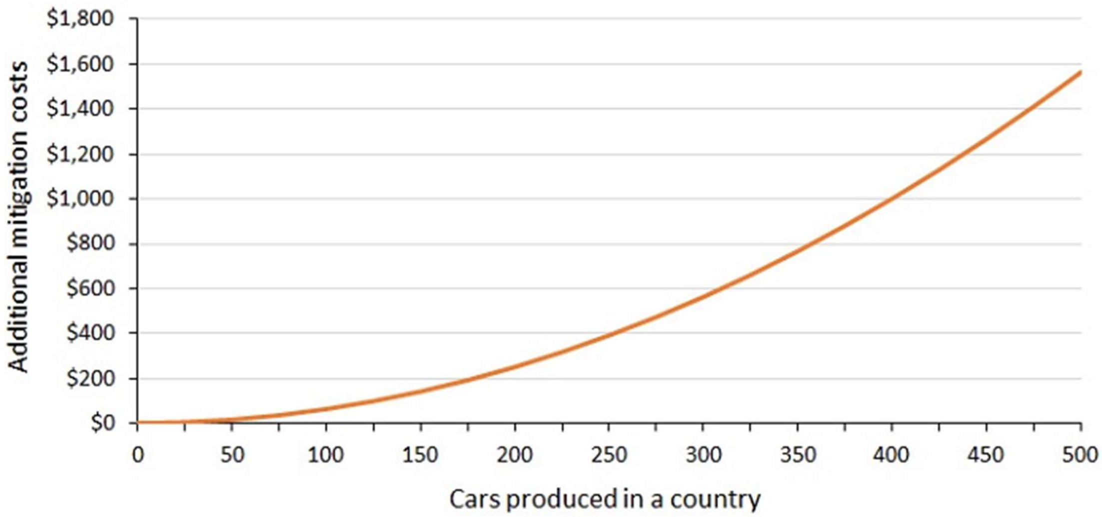
Please read the instructions carefully as there will be comprehension questions to test your understanding of the instructions. The 'next' button will appear after 60 seconds.

Instructions

In this experiment, you and **three other participants** will be the leaders of two countries at two different stages of economic development. The computer assigned you to be the **leader of Averna (country A) in stage 1** and your teammate will be the leader of A in stage 2. Two other participants will be the leaders of Bessonia (country B) in stages 1 and 2. Your decisions in stage 1 will determine your bonus. In stage 2, your teammate will start with the same amount of money as your bonus in stage 1.

You will choose **how many car factories to build**. To build a factory, you must move a slider on your screen to the "100" position. You can build up to 40 factories, therefore you will see 40 slider tasks on your screen. It is completely up to you how many factories to build: you can exit the stage at any time. The **more factories** you build, the **more cars** you will produce and the **more money** you will make: you will earn $1 per car produced. You will produce **[4/6/8/10/12] cars** per factory and B will produce **[12/10/8/6/4] cars** per factory.

However, **cars generate carbon emissions** that have a 90% chance of causing climate change that would **destroy the earnings of the leaders of A and B in stage 2**. To mitigate climate change, **stage 2 leaders** will have to **divide and pay mitigation costs**. The more cars you and B produce, the exponentially higher the mitigation costs will be. This means that the mitigation costs will increase faster the more cars you produce, as illustrated in the figure below. For example, producing the first 40 cars will increase the mitigation costs by $10. But if you have already produced 400 cars, the next 40 cars will increase the mitigation costs by $210. The total mitigation costs in stage 2 are calculated by adding the costs generated by cars in A to the costs generated by cars in B.



In stage 2, **your teammate** will negotiate with the leader of B how to split these costs. To pay for these costs, **your teammate will receive a new pot of money that is equal to your earnings in stage 1**, plus an additional $600 to cover expenses. Similarly, the new leader of B will receive the same amount of money that the previous leader of B earned in stage 1, plus $600. To conduct the negotiation, each leader will propose how to divide the costs and indicate the maximum they are willing to pay to accept a proposal. After both leaders have submitted their decisions, the computer will select one leader as the proposer, and their proposed division will be carried out if it is compatible with the maximum amount that the other leader is willing to pay. If the negotiation fails, the leaders of A and B in stage 2 will lose all their money with a 90% probability. However, you and the other participant from stage 1 will keep all of your earnings regardless of what happens in stage 2.

Summary:

- **Four participants** take part in this experiment: two are leaders of A and B in stage 1, the other two are leaders of A and B in stage 2. **You are the leader of A in stage 1**.
- **Stage 1** leaders can do tasks to build factories. **Factories** produce **cars**, which increase **earnings** in stage 1 but also increase the **climate change mitigation costs** in stage 2.
- **Stage 2** leaders will have to agree on how to **divide the mitigation costs** or face a 90% risk to lose all their money.
- The **starting balance** of leaders in stage 2 is equal to **their teammate's earnings** in stage 1 + $600.

Quiz for Generation 1 participants *[randomized order of response options; correct answer bolded]*

1. How can you increase your earnings in this game?

    a. By mitigating carbon emissions
    b. By taking earnings from your teammate
    c. By building more factories
    d. By negotiating with the leader of B

2. Who will pay the cost of mitigating carbon emissions?

a. You
b. Leader of B in stage 1
c. **Leaders of A and B in stage 2**
d. The country that produced more emissions

3. What are the roles of the participants in this game?
    a. **Two participants are the leaders of A and B in stage 1. Other two participants are the leaders of A and B in stage 2.**
    b. One participant is the leader of A, another participant is the leader of B.
    c. One participant is the leader of A in stages 1 and 2. Another participant is the leader of B in stages 1 and 2.
    d. One participant is the leader of A in stage 1. Another participant is the leader of A in stage 2.

4. What will be the starting balance of your teammate?
    a. $600
    b. **$600 + the amount you earned**
    c. $600 + the climate change mitigation costs created in your country
    d. $600 + number of car factories your teammate built

5. What is the maximum number of factories that you can build?

    a. 10
    b. 20
    c. **40**
    d. 60

6. What will your teammate in stage 2 have to do?

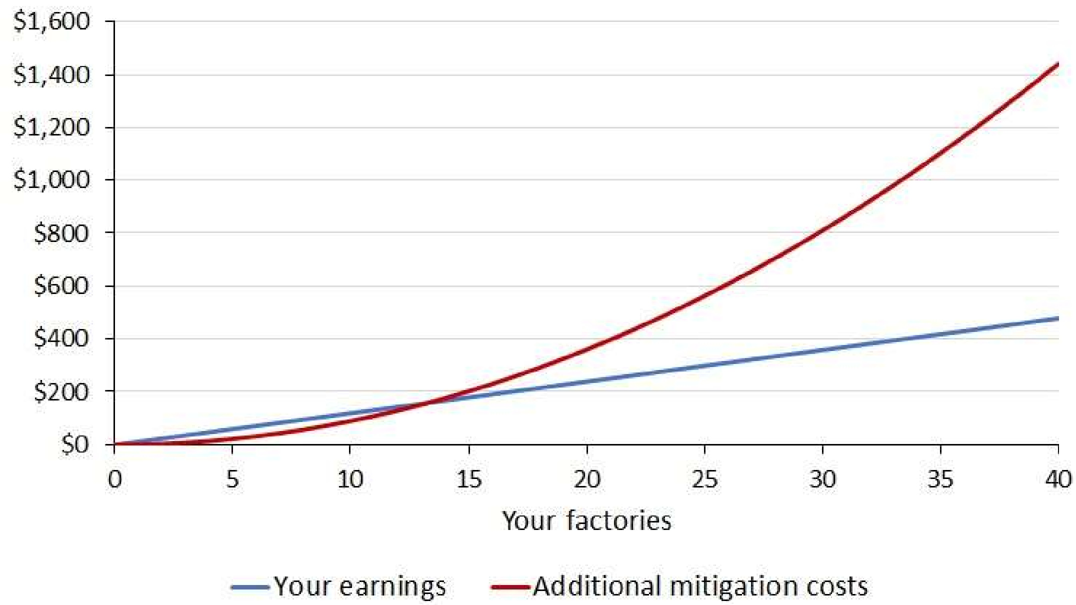
    a. Propose how to build more factories
    b. **Propose how to divide the mitigation costs with the other leader**
    c. Propose a strategy for reducing emissions
    d. Propose the maximum number of cars in each country

Factory Decision
[The example shows information seen by participants with $12 piece-rate. Information in the text, table and figure was updated accordingly for participants with other piece-rate values.]

Each factory you build will produce **12 cars** and each factory B builds will produce **4 cars**. Now, you can choose how many factories to build (from 0 to 40). Each built factory will produce **12 cars** and therefore increase your earnings by **$12**. The table and figure below show the relationship between the number of factories you build and the **cars** produced, the **earnings** those cars would generate for you and your teammate and the additional **mitigation costs** that this production would generate in stage 2. For your convenience, the table displays the earnings for every ten factories you build.

As a reminder, your teammate in stage 2 will start off with the amount that you have earned in this stage + $600. However, your teammate will also have to negotiate with the other leader in stage 2 to split the mitigation costs for emissions that stage 1 leaders generated. If they fail to agree on how the costs should be divided, there will be a 90% chance that they will lose all their earnings.

Number of factories you built	0	10	20	30	40
Cars produced	0	120	240	360	480
Your earnings	$0	$120	$240	$360	$480
Additional mitigation costs borne by participants in stage 2	$0	$90	$360	$810	$1440



Tasks

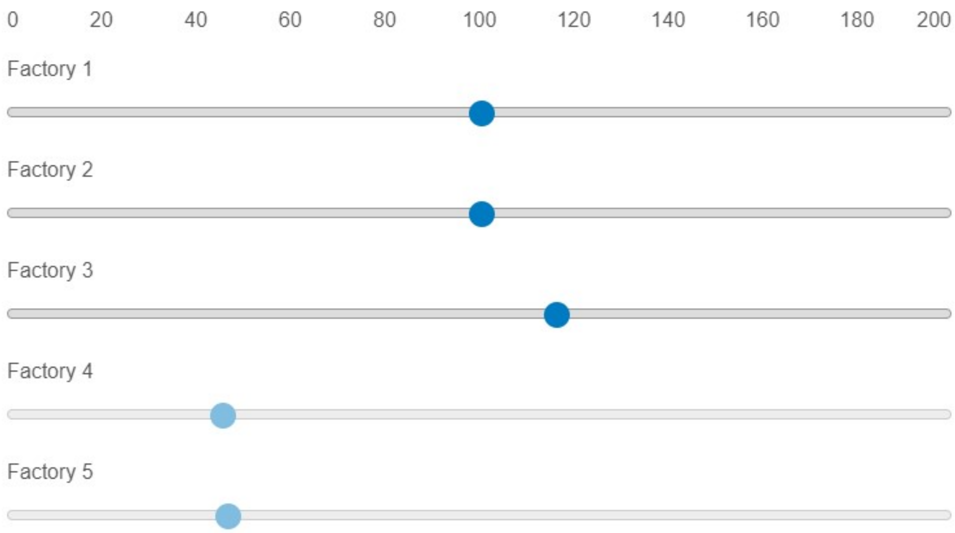
Below, you see 40 sliders, which represent the maximum of 40 factories that you could build. **To build a factory, you must move the slider to the "100" position.** Initially, sliders are in random positions between 0 and 200.

As you complete the tasks, you will see **real-time information** about the total **number of factories** built so far, the total number of **cars produced** by those factories, your **earnings** so far, the **current mitigation costs** and the **additional mitigation costs** that building the next factory will generate. There is no time limit for the stage and it is up to you to decide whether to build all the factories, some factories, or none at all. You can exit this stage whenever you want.

[The figure below illustrates the information seen while completing the real-effort tasks; initially, sliders were shuffled and had to be moved to "100" position. A total of 40 sliders were shown on the screen. Participants saw real-time information about accumulated and marginal earnings and costs, updated after each completed task.]

Factories built	Cars produced	Your earnings	Additional mitigation costs
2	**24**	**$24**	**$3.6**

The next factory will increase your earnings by **$12** and increase mitigation costs by **$4.5**



Generation 2 participants in the History treatment

Overview of the Experiment

1. **Instructions** of the overall experiment
2. **6 comprehension questions -** you can proceed only if you get at least 5 questions correct (2 attempts)
3. [4 rounds] **Question** to guess other players' decisions
4. [4 rounds] **Decision Task**
5. **1 open-ended response question** regarding your decision
6. **Questionnaire** - 10 questions
7. **End** of survey

You can refer to the progress bar below for your progress in the survey.

Please read the instructions carefully as there will be comprehension questions to test your understanding of the instructions. The 'next' button will appear after 60 seconds.

Instructions

In this experiment, you and **three other participants** will be the leaders of two countries at two different stages of economic development. Your teammate was the leader of Averna (country A) in stage 1 and **you will be the leader of A in stage 2**. Two other participants are the leaders of Bessonia (country B) in stages 1 and 2. Below, we will describe what choices the two leaders had to make in Stage 1. Please read the explanation closely because later we will ask you to answer a few quiz questions and to guess what the two leaders chose.

Stage 1

In stage 1, each leader was choosing **how many car factories to build** in their country. To build a factory, the participant had to complete a task (move a slider on the computer screen). Each leader could build up to 40 factories. It was completely up to them how many factories to build: they could exit the stage at any time. **Factories produce cars, and each leader earned $1 for each car produced.**

How many cars each factory in A and B produces depends on the resources in A and B. Since A has the same amount or more resources than B, each factory in A will produce either more or the same number of cars as each factory in B. In particular, each of the following three outcomes were equally likely:

1. Each factory in **A** and **B** produced **8 cars**.
2. Each factory in **A** produced **10 cars** whereas each factory in **B** produced **6 cars**.
3. Each factory in **A** produced **12 cars** whereas each factory in **B** produced **4 cars**.

One of these three outcomes was randomly chosen by the computer. The leaders in stage 1 knew how many cars their factories will produce when making their decisions.

However, **cars generate carbon emissions** that have a 90% chance of causing climate change that would **destroy your earnings**. To mitigate climate change, **you and the leader of B** will have to **divide and pay the mitigation costs**. The more cars your teammate and the first leader of B produce, the exponentially higher the mitigation costs will be. The total mitigation costs are calculated by adding the costs generated by cars in A to the costs generated by cars in B in stage 1.

Stage 2

In stage 2, you and the new leader of B will have to pay the costs to mitigate climate change, which is a result of carbon emissions by cars in your countries. The two of you will have to decide which part of the costs will be paid by A and which part by B. If you fail to reach an agreement, there will be a 90% chance that you and the leader of B will lose all the earnings. Note that leaders of stage 1 have already received their earnings, thus whether or not you reach an agreement will not affect them. To pay for these costs, you will receive a pot of money that is equal to **the earnings of your teammate in stage 1**, plus an additional **$600**. Similarly, the new leader of B will receive the same amount of money that the previous leader of B earned in stage 1, plus $600.

The procedure for deciding how to divide the costs is as follows. One of you will act as the **Proposer.** The Proposer will **propose how to divide the costs.** The other participant will act as the **Responder.** The Responder will choose the **maximum amount of money they are willing to pay** to accept the Proposer's offer (e.g. "I would accept an offer if I am asked to pay less than $100").

Each of you will make a decision both as a Proposer and as a Responder. Afterward, the computer will randomly choose who is the Proposer and who is the Responder.

- If the Responder is **willing** to pay the costs asked by the Proposer (i.e. the maximum amount the Responder is willing to pay is **higher** than the amount the Proposer asked), the agreement will be **successful**, and each participant will **pay the costs suggested by the Proposer**.
- If the Responder is **not willing** to pay the costs asked by the Proposer (i.e. the maximum amount the Responder is willing to pay is **lower** than the amount the Proposer asked), the agreement will **not be successful**, and both of you will **lose all of your money with 90% probability**.

Summary:

- **Four participants** take part in this experiment: two are leaders of A and B in stage 1, the other two are leaders of A and B in stage 2. **You are the leader of A in stage 2**.
- **Stage 1** leaders can do tasks to build factories. **Factories** produce **cars**, which increase **earnings** in stage 1 but also increase the **climate change mitigation costs** in stage 2.
- **Stage 2** leaders will have to agree on how to **divide the mitigation costs** or face a 90% risk to lose all their money.
- The **starting balance** of leaders in stage 2 is equal to **their teammate's earnings** in stage 1 + $600.

Quiz for Generation 2 participants [randomized order of response options; correct answer bolded]

1. What will you and the leader of B have to decide on?

    a. **How to divide the mitigation costs**
    b. How to select the role of the Proposer and Responder
    c. How much money to give to the other leader
    d. How to increase car emissions

2. What is the role of the Proposer?

a. To propose how to divide the mitigation costs
b. To propose strategies of reducing car emissions
c. To propose the roles of the participants
d. To propose how many cars each leader has

3. What is the role of the Responder?
   a. To respond to the Proposer's suggestions of strategies for reducing car emissions
   b. To choose the maximum amount they are willing to pay to accept the Proposer's offer
   c. To agree with the Proposer's assignment of roles
   d. To decide on the minimum number of cars they want to have

4. What happens to you and the leader of B if no agreement is reached?

   a. There is a 50% chance that you will lose your money
   b. There is a 90% chance that you will lose your money
   c. There is a 90% chance that you will keep your money
   d. You will lose your money for sure

5. Suppose that the Responder indicates that the maximum amount of money they are willing to pay is $150. Which offer would lead to a successful agreement?
   a. Proposer asks the Responder to pay $50
   b. Proposer asks the Responder to pay $200
   c. Responder asks the Proposer to pay $120
   d. None of the above

6. What will be your role in the game?
   a. You will be the Proposer
   b. You will be the Responder
   c. You will be either the Proposer or the Responder
   d. You will observe the decisions of a Proposer and a Responder

[Next page – the example is for participants whose predecessors had a $12 piece-rate]
You will play 4 rounds of the game. In each round, you will be matched with one potential teammate (leader of A in stage 1). In each round, you will guess how many factories your teammate built and then make your decision as a Proposer and as a Responder.

One of these 4 rounds will be selected at random, and your choices for that round will determine your earnings. The leader of B in stage 2 will be assigned to the same two leaders of A and B in stage 1 as you. We will calculate your final earnings once we receive the decisions of the leader of B in stage 2.

[Next page]

It is round 1 and you will be matched with potential teammate #1.

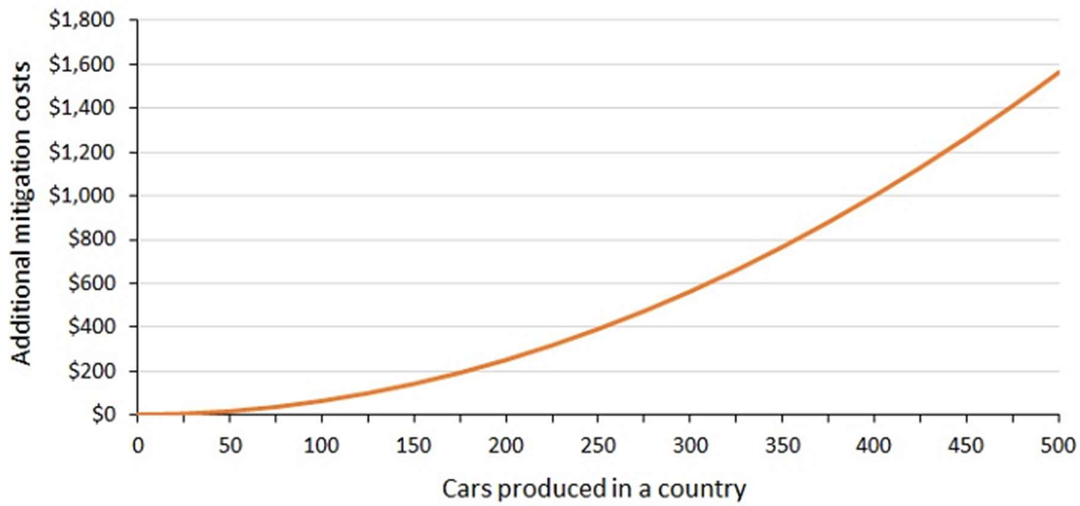
<u>Round 1</u>

Each factory in A produced **12 cars** and each factory in B produced **4 cars**.

Next, you will be guessing the number of factories that teammate #1 has built in stage 1.

Your Guess about Teammate's Factory Decision

The table below shows how many **factories** could have been built by your teammate in stage 1, the **cars** that would have been produced, the **earnings** that this production would generate for your teammate and for yourself, and the **additional mitigation costs** that you and the leader of B would have to pay in stage 2. The more cars are produced in a country, the exponentially higher the mitigation costs will be, as shown in the figure below. Your teammate knew all this information. For your convenience, the table displays the earnings for every ten factories.



Number of factories in A	0	10	20	30	40
Cars produced	0	120	240	360	480
Earnings of your teammate = Your starting funds in stage 2	$0	$120	$240	$360	$480
Additional mitigation costs borne by you and the second leader of B	$0	$90	$360	$810	$1440

Please guess how many factories your teammate in stage 1 has built. Recall that the maximum number of factories that can be built is 40.

How many factories do you think your teammate has built? [0-40]

[Next page]

Decisions in Stage 1 *[X and Y were replaced by the values depending on the generation 1 decisions]*

The table below summarizes what happened in stage 1. Your teammate built **X out of 40 factories** whereas the leader of B in stage 1 built **Y out of 40** factories. Computer chose that each factory in A produced **12** cars and each factory in B produced **4** cars. It means that A produced **X*12** cars and generated climate mitigation costs equal to **$XX.** B produced **Y*4** cars and generated climate mitigation costs equal to **$YY.** The total mitigation costs that will have to be paid by you and the new leader of B are **$(XX+YY).**

Your teammate earned **$XXX** in stage 1. Thus, you will start stage 2 with the same amount of money that your teammate earned and an additional $600, which adds up to a total of **$(XXX+600)**.

The first leader of B earned **$YYY** in stage 1. Thus, the second leader of B will start stage 2 with the same amount of money that their teammate earned and an additional $600, which adds up to a total of **$(YYY+600).**

[Table summarizes outcomes from generation 1]

	Factories	**Cars**	**Generated mitigation costs**	**Earnings**	**Money in stage 2**
Country A					
Country B					
Total					

Now, we will ask you to choose how to divide the **$(XX+YY)** climate change mitigation costs that were generated by A and B in stage 1. These costs are a result of a total of **(X+Y)** car factories that have produced **(X*12+Y*4)** cars in both A and B. To pay for these costs, you will receive **$(XXX+600)** and the leader of B in stage 2 will receive **$(YYY+600)**.

<u>Proposer's decision</u>

If you are chosen to be the Proposer, you will propose how to divide the **$(XX+YY)** mitigation costs. If B rejects your offer, there will be a 90% chance that you will lose all your money. Please choose how much to ask B to pay:

[Slider from $0 to $(XX+YY)]

<u>Responder's decision</u>

If you are chosen to be the Responder, you will decide whether to accept the Proposer's offer. Please choose the highest amount you are willing to pay to accept an offer:

[Slider from $0 to $(XXX+600)]

[Next page – participants make decisions in rounds 2, 3 and 4]

Generation 2 participants in the Baseline treatment

Overview of the Experiment

1. **Instructions** of the overall experiment
2. **6 comprehension questions** - you can proceed only if you get at least 5 questions correct (2 attempts)
3. [4 rounds] **Decision Task**
4. **1 open-ended response question** regarding your decision
5. **Questionnaire** - 10 questions
6. **End** of survey

You can refer to the progress bar below for your progress in the survey.

Please read the instructions carefully as there will be comprehension questions to test your understanding of the instructions. The 'next' button will appear after 60 seconds.

Instructions

In this experiment, you and **another participant** will be the leaders of two countries. You will be the **leader of Averna (country A)** and the other participant will be the leader of Bessonia (Country B).

You and the leader of B will have to pay the costs to mitigate climate change, which is a result of carbon emissions by cars in your countries. The two of you will have to decide which part of the costs will be paid by A and which part by B. If you fail to reach an agreement, there will be a 90% chance that you and the leader of B will lose all the earnings. To pay for these costs, both you and the leader of B will receive a certain amount of money.

The procedure for deciding how to divide the costs is as follows. One of you will act as the **Proposer.** The Proposer will **propose how to divide the costs.** The other participant will act as the **Responder.** The Responder will choose the **maximum amount of money they are willing to pay** to accept the Proposer's offer (e.g. "I would accept an offer if I am asked to pay less than $100").

Each of you will make a decision both as a Proposer and as a Responder. Afterward, the computer will randomly choose who is the Proposer and who is the Responder.

- If the Responder is **willing** to pay the costs asked by the Proposer (i.e. the maximum amount the Responder is willing to pay is **higher** than the amount the Proposer asked), the agreement will be **successful**, and each participant will **pay the costs suggested by the Proposer**.
- If the Responder is **not willing** to pay the costs asked by the Proposer (i.e. the maximum amount the Responder is willing to pay is **lower** than the amount the Proposer asked), the agreement will **not be successful**, and both of you will **lose all of your money with 90% probability**.

Summary:

- **Two participants** take part in this experiment: one is the leader of A and another is the leader of B. **You are the leader of A**.

- The two leaders will have to agree on how to **divide the mitigation costs** or face a 90% risk to lose all their money.

[Next page]
[Quiz, identical to the History treatment]
[Next page]

There are a total of 4 decision rounds, where you will have to make decisions as the proposer and the responder. The climate change mitigation costs and the amount that you will receive will be different in each round.

At the end of the survey, the computer will randomly select one of the four rounds and your earnings will be based on that decision round. Your final earnings will be calculated after the leader of B has made their decisions for that decision round.

[Next page]

Round 1

In round 1, we will ask you to choose how to divide the **$(XX+YY)** climate change mitigation costs. These costs are a result of a total of **(X+Y)** car factories that have produced **(X*12+Y*4)** cars in both A and B. To pay for these costs, you will receive **$(XXX+600)** and the leader of B in stage 2 will receive **$(YYY+600)**.

<u>Proposer's decision</u>
If you are chosen to be the Proposer, you will propose how to divide the **$(XX+YY) }** mitigation costs. If B rejects your offer, there will be a 90% chance that you will lose all your money. Please choose how much to ask B to pay:

[Slider from $0 to $(XX+YY)]

<u>Responder's decision</u>
If you are chosen to be the Responder, you will decide whether to accept the Proposer's offer. Please choose the highest amount you are willing to pay to accept an offer:

[Slider from $0 to $(XXX+600)]

[Next page – participants make decisions in rounds 2, 3 and 4]

Questionnaire for all participants

How did you make your decisions? Please be specific and give us as much information as you can (minimum 100 characters).

[textbox]

For the following statements, please answer how strongly do you agree or disagree. [5-point scale from "strongly agree" to "strongly disagree"]

1. People should care more about climate change.
2. Climate change should be given top priority.
3. It is annoying to see people do nothing for climate change problems.
4. People worry too much about climate change.
5. The seriousness of climate change has been exaggerated.
6. Climate change is a threat to the world.

Lastly, please answer a few questions about yourself.

We hear a lot of talk these days about liberals and conservatives. Here is a 7-point scale on which the political views people might hold are arranged. Where would you place yourself on this scale (from 1 being extremely liberal to 7 being extremely conservative)?

a) Extremely liberal
b) Liberal
c) Slightly liberal
d) Moderate, middle of the road
e) Slightly conservative
f) Conservative
g) Extremely conservative

What is your sex?

a) Male
b) Female

What is your age? [textbox]

Additional comments, if any: [textbox]