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Peace in an unequal world? Experimental evidence on the relationship between inequality and conflict in a guns-vs-butter setting ☆

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ABSTRACT

This study addresses the emergence of (unarmed) peace and investments in arms within a guns-vs-butter conflict setting. We introduce a novel feature within the conflict game and separate the decision to start a conflict and the investment in arms, following the theoretical framework of Garfinkel and Syropoulos (2021). Based on this model we experimentally examine the emergence of peace while varying resource inequality among conflicting parties. We find that inequality leads to more conflicts and higher investments in arms. Despite these trends, achieving a state of unarmed peace is rarely observed in both treatments. Our results highlight the critical role of trust in attaining peaceful outcomes and show that armed peace, although not an optimal strategy in either treatment, is one of the most frequently chosen decisions.

1. Introduction

We study the emergence of (unarmed) peace and conflict in a guns-versus-butter setting. Our design is based on the theoretical model by Garfinkel and Syropoulos (2021) in which conflicting parties allocate their endowment between production and arming, and decide whether to start a *destructive* conflict or not. This decision setting allows unarmed peace to arise as a Nash equilibrium as

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long as inequality between conflicting parties is sufficiently low. We experimentally test this proposition and provide a causal link between (in)equality and the possibility of peace.

Our study is motivated by the fact that most governments - as well as nongovernmental groups and militias - spend significant portions of their income on military and security forces.[1] This high level of spending is puzzling, given that these investments in arms are often sunk costs, incurred whether or not there is a conflict. This makes conflict socially wasteful as opponents would be better off finding a peaceful solution and saving their spending on arms. In addition, most countries are not currently engaged in active warfare and could have used those resources for other essential social and economic needs, such as education, healthcare, or infrastructure.[2] Although the motivations behind military spending are complex, some scholars argue that military strength serves as a deterrent against potential threats and helps maintain a balance of power (Powell, 1993). Additionally, it is argued that a strong military increases bargaining power in diplomatic discussions (Anbarci et al., 2002). Hence, in their view, peace is not threatened but maintained by high military spending, by increasing the cost of conflict (Schelling, 1960).

The tremendous costs, however, associated with military spending, both directly and indirectly, raise the question of whether unarmed peace could be a feasible alternative and whether there are more effective ways to promote peace without resorting to military solutions. In this spirit, economists have explored conditions under which military expenditures can be reduced while avoiding conflicts at the same time (Davis and Reilly, 1998; Gneezy and Smorodinsky, 2006; Kimbrough and Sheremeta, 2013; Lacomba et al., 2014; Parco et al., 2005; Sheremeta and Zhang, 2010, among others). Interestingly, the vast majority of theoretical and experimental studies in economics have missed a crucial aspect of military spending: the possibility that arming does not necessarily indicate an intention to attack another party. Put differently, a group, nation, or leader may choose to invest in arms as a means of deterrence or to defend against a potential attack by someone else.

In a recent paper, Garfinkel and Syropoulos (2021) extend the guns-versus-butter by this consideration and allow arming decisions to be independent of the decisions to initiate a destructive conflict. They show that under certain circumstances, no party chooses to engage in conflict and a state of unarmed peace becomes a possible scenario. For this to happen, two conditions must be met: first, the destructiveness of conflicts must be high enough to deter parties from engaging in them, and second, the level of inequality between the parties must be low enough. Still, even if conflict is destructive, inequality between parties can lead to conflict if it enables the party with fewer resources to improve its position.[3] Hence, the model infers that inequality hinders the emergence of (unarmed) peace and thus adds an important theoretical perspective to a growing literature that examines the relationship between inequality and conflict (see Cederman et al., 2013; Cramer, 2003; Hillesund et al., 2018; Østby, 2013, among others). According to this literature, high levels of political and economic inequality between groups can increase the likelihood of armed conflict. While there is no consensus on the precise causal mechanisms linking inequality and armed conflict, this literature suggests that addressing inequality could play a critical role in reducing the risk of conflict and allow countries or groups to cut military spending.

We aim to further address this question by experimentally testing the effect of (resource) inequality on conflict decisions. More precisely, we vary the initial distribution of resources among parties and examine how much they invest in arms and whether they decide to start a destructive conflict. In our laboratory experiment, students in the roles of conflicting parties play a conflict game based on the extended *guns-versus-butter* model introduced by Garfinkel and Syropoulos (2021). Players make two *separate* decisions: first, they allocate their resources between arming and producing, and second, they decide whether or not to start a conflict (attack). We consider conflict to be destructive, so whenever a conflict occurs, parts of the potential prize are lost. To study the effect of inequality, we vary the initial endowments of conflicting parties. In one treatment (*EQUAL*), both parties start off with equal resources, while in the other (*UNEQUAL*), one player (the *advantaged*) has more resources than the other (the *disadvantaged*). The theory suggests that unarmed peace can only emerge in *EQUAL*, while in *UNEQUAL*, the *disadvantaged* player always has an incentive to deviate from a peaceful equilibrium.

We find that players do indeed choose peace more often and invest fewer resources in arming when resources are distributed equally among them, compared to a situation where the initial resource distribution is unequal. Regarding the choice of unarmed peace, we find that, contrary to theory, players choose unarmed peace in both treatments and that this choice is not significantly more likely in *EQUAL* than in *UNEQUAL*. Furthermore, we find no significant difference between the advantaged and disadvantaged players in the decision to start a conflict, and both types of players regularly choose not to start a conflict. In addition, we often observe what we call “armed peace”, where players choose to arm, however without initiating a conflict. This outcome differs from the benchmark theories’ prediction and accounts for most observed peaceful scenarios. Lastly, we explore behavioral mechanisms and show that trust significantly influences player’s decisions. Trusting players are more likely to choose peace, and when they do, they devote fewer resources to arming.

Our study adds to two strands of literature. First, it extends the experimental literature on conflict resolution, particularly in the context of a guns-versus-butter setting. In Powell and Wilson (2008), the authors create a *Hobbesian jungle*, in which individuals are placed into an environment without property rights where they can either invest in protecting their own resources or steal those of

[1] In 2022, global military spending amounted to 2240 billion U.S. dollars, led by the United States, which alone spent 877 billion U.S. dollars (Tian et al., 2023). As for non-governmental groups, Hezbollah is estimated to have a budget of at least $700 million per year, of which a large proportion is invested in (the production of) weapons (see https://www.state.gov/wp-content/uploads/2020/09/Outlaw-Regime-2020-A-Chronicle-of-Irans-Destabilizing-Activity.pdf, accessed 03.05.2023). Another indicator is the number of firearms recovered by security forces, for example in Mexico. Between 2014 and 2018 Mexican authorities recovered more than 79,000 firearms, most of which were linked to drug cartels (see https://www.gao.gov/assets/gao-21-322.pdf, accessed 03.05.2023).

[2] According to the latest peace report published by leading German peace research institutes, part of these global military expenditures has been diverted from economic stimulus programs to mitigate the COVID-19-pandemic (see https://friedensgutachten.de/en/2021/ausgabe, accessed 22.04.2023).

[3] This argument was first formulated by Hirshleifer (1991), who coined it the *Paradox of Power*.

others. Surprisingly, they found a substantial share of cooperation among participants where participants did not try to steal.[4] Further studies, such as those conducted by McBride and Skaperdas (2014) and Tingley (2011), have explored repeated games and show that destructive conflicts that shape future positions become more likely as the future gets more important.

All of the mentioned experiments focus, however, mostly center around on decisions made during conflict (such as investments into arming or production), rather than the decision to engage in conflict in the first place. In these experiments, conflict cannot be prevented.[5] Therefore, the studies do not address the choice between conflict and peace. Furthermore, these experiments employ the "original" guns-versus-butter framework, which distributes the prize among players according to their relative power, rather than a more realistic setting, where the winner appropriates the entire production. The study most closely related to ours was conducted by Lacomba et al. (2014). The authors use the original guns-versus-butter model, while also allowing peaceful conflict resolution in cases where neither player allocates any resources towards arming. In addition, they introduce the option to destroy (parts of) their production after losing a conflict. This particular mechanism reduces the profitability of winning parties, ultimately leading to lower investments in arms. Even though Lacomba et al. (2014) allow for peaceful resolutions, they do not separate arming from the decision to start a conflict. Thereby, they fail to distinguish between offensive and defensive arming, which, in our opinion, is crucial for understanding arming decisions.

Our study explores alternative methods for resolving conflicts through experiments. Previous studies have examined several approaches to conflict resolution such as assessing the decisiveness of the conflict (Lacomba et al., 2017), using side-payments (Herbst et al., 2017; Kimbrough and Sheremeta, 2013, 2014), allowing for fixed payments as alternative to conflict (Ke et al., 2023), evaluating the length of the conflict (McBride and Skaperdas, 2014), analyzing the role of dynamic arming in conflict (Abbink et al., 2021), and utilizing random devices like coin flips (Kimbrough et al., 2014; Lacomba et al., 2014). None of the existing papers allow for the separation of decisions related to conflict and arms in a setting with an endogenous prize.[6] Our study contributes to the literature by differentiating the decision to arm from that of initiating a conflict. This distinction enables the identification of offensive versus defensive arming, and also the examination of whether parties select unarmed peace when it is a viable option.

The second strand of literature our study relates to, is the literature on inequality as a cause of armed conflicts. Conflicting parties often exhibit inequalities in the resources available to them, which can include political and economic power, among others. The relationship between inequality and conflict has been investigated empirically, with inconclusive results (see for example Cederman et al., 2013; Cramer, 2003; Hillesund et al., 2018; Østby, 2013). Limitations within this literature have been acknowledged, particularly regarding the poor quality of data and the methodologies employed to measure inequality (Cramer, 2003; Østby, 2013). The use of different definitions and measurement techniques for inequality significantly affects the drawn conclusions. While *vertical* inequality (between individuals or households) does not seem to be a causal factor for conflicts, there is substantial evidence linking *horizontal* inequality (among established groups within a society) to the outbreak of violent conflicts (see Hillesund et al., 2018, for a review).

From the theoretical perspective, Hirshleifer (1991) provides a seminal model for resource inequality in conflict which predicts that disadvantaged players have an incentive to initiate a conflict to improve their relative position. This has been experimentally tested and confirmed by Durham et al. (1998). Consistent with this notion, Lacomba et al. (2017) show that the paradox of power holds in a guns-versus-butter setting when the decisiveness of a conflict is rather low. Experimental studies considering inequalities between players within other conflict settings, however, reveal partly puzzling results. Kimbrough and Sheremeta (2014) analyze inequality in capabilities in a Tullock contest with a "peaceful" alternative and demonstrate that, contrary to theoretical predictions, inequality in ability does not necessarily result in higher conflict rates. Fonseca (2009) predicts and confirms that asymmetric effort costs lead to lower levels of effort invested in a classic simultaneous Tullock contest without a peaceful alternative. Hargreaves Heap et al. (2015) investigate endowment inequality in an inter-group contest and find that group members' efforts decrease for high levels of inequality. Fallucchi et al. (2021) investigate the effect of asymmetry in resources, ability, and prize valuation on effort expenditure in a Tullock contest. They find that asymmetry in ability leads to higher efforts (driven by the disadvantaged player) compared to symmetric settings and other types of asymmetry.

2. Experimental design and hypotheses

We base our experiment on the theory of Garfinkel and Syropoulos (2021), a recent extension of the *guns vs butter* model. In what follows, we provide a brief overview of this model and the derived predictions relevant to our experimental test. Please refer to Appendix A for a more detailed theory description.

In the model, two players allocate resources between production and arming and decide whether to attack (i.e., start a conflict). If neither attacks, peace is maintained, allowing both players to consume their own production. When a conflict occurs, some of the joint production is destroyed, and the players compete for the remaining production. The probability of winning the conflict depends on each player's relative level of arming. Thus, the expected payoffs under peace depend solely on initial resources, while those under conflict also consider the destructiveness of conflicts and total resources. The theory predicts that a state of unarmed peace emerges as a stable Nash Equilibrium (NE), as long as conflicts are sufficiently destructive and initial resource distributions sufficiently equal.

4 See Carter and Anderton (2001) and Duffy and Kim (2005) for sequential versions of this game. Both studies find results consistent with the theory of Grossman and Kim (1996).

5 Please note, that in the case that both contesting players invest *zero* into guns, they still face a probabilistic contest wherein there is a 50/50 chance of appropriating total production.

6 Ke et al. (2023) separate conflict and arming decision in a Tullock contest with an exogenous prize. Their design therefore allows for offensive arming (to appropriate the exogenous prize) but does not account for defensive arming (to protect own resources).

Our experiment consists of three parts. In part 1, we measure individual preferences that have previously been associated with decisions in coordination games, social dilemmas, and contests. Following Falk et al. (2018) we elicit preferences toward risk and competitiveness, as well as impulsiveness using unincentivized survey questions. We further elicit distributional preferences (Kerschbamer, 2015), trust and trustworthiness (Berg et al., 1995), and loss aversion (Gächter et al., 2022) through incentivized economic games. To avoid potential confounding with our treatment variation, we collect these preferences before the conflict game.

In part 2, participants play seven rounds of the conflict game, described in the next section. We implemented a perfect stranger-matching to ensure that participants do not face the same opponent twice, which we communicated to them at the beginning of the conflict game. More precisely, the matching is based on a protocol that ensures that each participant meets every other in the matching group exactly once. See Table S1 and Table S2 in the supplementary material for the matching protocols.

Subsequently, in part 3, immediately after the conflict game, we implemented a brief questionnaire to elicit participants' motivations for their actions. Final payoffs were defined as the sum of participants' earnings in the three games at the beginning of the experiment (part 1) and their earnings in a randomly drawn round of the conflict game (part 2). This procedure was clearly communicated to all participants prior to the start of the experiment. In the following sections, we describe the structure of the conflict game. We provide the translated experimental instructions and screenshots of the game in Section 3 and Section 4 of the supplementary material.

In each of the seven rounds, players are matched into pairs of two according to the matching protocol described above. They play the conflict game structured into two stages:

Stage 1: Players make two decisions. First, they must decide whether to start a tournament (choose "*Tournament*") or not (choose "*No Tournament*").[7] Second, they must allocate their endowments between production and tournament. Individual decisions take place separately and simultaneously. We additionally elicit participants' beliefs about the decision of the other player in the very first round.[8]

Stage 2: Dependent on the decisions of the two players, the game either results in a tournament or not. If both players choose "*No Tournament*", their payoff for this round is simply their individual production. Players are informed that there was no tournament and are presented with their own decisions, as well as those of the other player. Further, they see their own payoff. The round ends at this point.

If at least one of the players opts for tournament, both players enter a destructive Tullock contest where 55% of the production is destroyed.[9] The winner of the contest receives the prize, which is the surviving part (45%) of the sum of both productions. The winning probability of a player is given by her investment in tournament relative to the total investments in tournament of both players. A wheel of fortune visualizes the winning probabilities and the process of drawing the winner. The wheel of fortune is partitioned into two colors, each representing a player. The proportions of the colors precisely correspond to the ratio of the respective player's level of arming to the total level of arming of both players and hence represent the winning probabilities. The wheel starts to turn and stops randomly. The player whose color the arrow points to win the Tullock contest Next to the wheel, a table displays the two players' respective levels of arming, the resulting winning probabilities, the prize that they compete for, and, once the wheel has stopped, the winner of the contest, and their payoffs.

Treatment variations

In the first treatment (*EQUAL*), both players are endowed with 100 Tokens in every round. In the second treatment (*UNEQUAL*), endowments are allocated unevenly with Type A (the advantaged) receiving 120 Tokens and Type B (the disadvantaged) only receiving 80 Tokens. At the beginning, in *UNEQUAL*, players are informed about their assigned type and reminded that they will remain the same type throughout all rounds of the game. The distribution of endowments is set in a way such that the total production per pair is constant in both treatments (200 Tokens), thereby ensuring consistent equilibrium predictions concerning the level of arms in both treatments. In addition, we aimed at avoiding extreme levels of inequality.[10] Table 1 summarizes the chosen parameters as well as the predicted equilibrium outcomes in our experiment.

The outlined expected payoffs in Table 1 show that – given a player expects the other to choose conflict and both arm accordingly (U_i^C) – all players face the same payoff. If a player, however, expects the other player to choose peace and zero arming, there exist two possible outcomes and corresponding payoffs. Either, the player chooses to attack, arms a minimal amount, and wins the surviving part of the total production ($U^C_{i|G_{-i}=0}$) or she chooses peace as well and both consume their own production (U_i^P). The decision to choose peace or conflict when expecting the other to choose peace therefore depends on the comparison of these two payoffs. Table 1 demonstrates that, in this situation, only the disadvantaged player (Type B) in *UNEQUAL* has an incentive to deviate from peace and to choose to attack instead. Her expected payoff from attacking if the other does not invest in arms ($U^C_{i|G_{-i}=0}$) is higher than her payoff from peace (U_i^P). Correctly anticipating the attack, the advantaged player (Type A) will arm accordingly. Hence, players in *UNEQUAL*, expecting a conflict, will arm accordingly. In *EQUAL*, apart from the possibility of armed conflict, there is the possibility of unarmed peace. This is because no player has an incentive to deviate from peace – with zero arming – given that they could only

[7] Note that we use neutral language in the instructions. Instead of emotionally charged terms such as "conflict" and "attack", we use "tournament" and "start a tournament".

[8] This provides an unbiased measure of their expectations regarding an unknown opponent without being influenced by experiences from prior interactions.

[9] If a substantial part of production survives the conflict ($\beta \geq 0.5$), there exists no distribution of resources that allows peace as a NE (see Appendix A). To guarantee the existence of unarmed peace as an NE without excessively discouraging participants from engaging in conflict through extreme destruction rates, we chose a relatively moderate rate of 55%.

[10] We aimed to avoid extreme levels of inequality by selecting relatively low levels of inequality. Thus, our findings may be interpreted as closer to the lower bound, indicating even stronger results for higher levels of inequality. Future research could investigate the comparison of varying levels of inequality.

Table 1
Parameters and predicted equilibrium outcomes.

	Type	R_i	β	X_i	G_i	U_i^C	$U_{i\|G_{-i}=0}^C$	U_i^P	ITD	*Peace*
EQUAL	·	100 100	0.45	50 50	50 50	23 23	90 90	100 100		*yes*
UNEQUAL	A B	120 80	0.45	70 30	50 50	23 23	90 90	120 80	✓	*no*

Note: This table shows the chosen parameters in the experiment and the resulting theoretical predictions. Our treatment variation concerns the initial resource distributions (R_i) of players. In one treatment (*EQUAL*), both players are endowed with 100 Tokens. In the other treatment (*UNEQUAL*), endowments are allocated unevenly. The advantaged player (Type A) received 120 Tokens, and the disadvantaged player (Type B) received 80 Tokens. Conflicts lead to the destruction of resources and β (45%) represents the survival rate of output. X_i and G_i are the optimal production and arming levels when expecting to enter a conflict. U_i^C is the resulting expected conflict payoff rounded to the next integer. $U_{i|G_{-i}=0}^C$ denotes the expected conflict payoff if $-i$ chooses unarmed peace and i attacks with minimum arming level $G_i = 1$; rounded to the next integer. U_i^P is the expected payoff if both players choose unarmed peace. ITD indicates whether players have an incentive to deviate from an outcome of unarmed peace - which is the case if $U_{i|G_{-i}=0}^C > U_i^P$. Finally, the last column shows whether unarmed peace is a stable Nash Equilibrium, given the parameters (initial resource distribution and survival rate of output).

lose by deviating. If players in *EQUAL* do indeed choose peace, we expect to observe fewer attack decisions and consequently lower levels of arming than in *UNEQUAL*. Based on these expectations, we formulate two testable hypotheses concerning the decision to start a conflict (H1) and the investment in arms (H2):

Hypothesis 1. Compared to a situation where the distribution of resources is unequal, we expect players to start fewer conflicts when resources are distributed equally among them.

Hypothesis 2. Compared to a situation where the distribution of resources is unequal, we expect players to invest fewer resources in arms when resources are distributed equally among them.

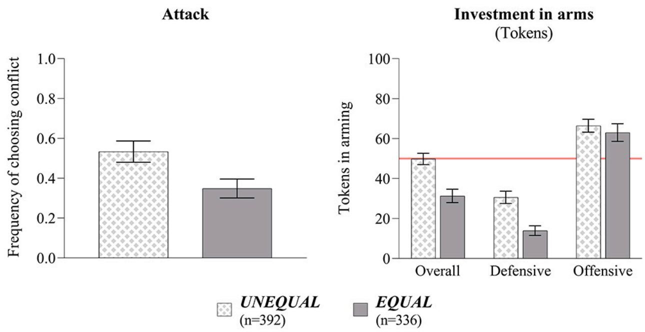
As previously outlined, these hypotheses stem from theoretical predictions suggesting that the disadvantaged player will attack and both players in this setting will arm accordingly. Consequently, the expectation is that armed conflicts will consistently be observed in *UNEQUAL* while unarmed peace is anticipated to prevail only in *EQUAL*. Following the examination of the primary hypotheses, we will proceed to scrutinize these predictions.

The two hypotheses rely on standard game theory, assuming rational players, who simply aim to maximize their monetary payoff. There are, however, good reasons to expect behavior to differ and that people have other motives.[11] In Figure S1 in the supplementary material, we provide the predicted payoff matrices for players in the two treatments when playing equilibrium strategies. Based on these payoffs, it is apparent that the conflict game resembles a coordination game (for *EQUAL*) and a social dilemma (for *UNEQUAL*). This resemblance only evolves due to the separation of attacking and arming decisions and is absent in most other contest models. Given this structure, we expect that behavioral factors which have been extensively studied in those settings will also have a significant impact in our conflict setting. In what follows we briefly present evidence from those games and discuss behavioral factors that might influence decisions in our setting.

The two potential NE in *EQUAL* exhibit characteristics that resemble those of coordination games, such as the assurance or stag hunt game. In such games, decisions depend on the anticipated action of others, which introduces a high level of uncertainty and allows for behavioral factors to influence decisions. Trust is one such factor, which has been shown to be highly predictive of cooperation rates in coordination games. Trusting individuals are more likely to coordinate on the cooperative "risky" NE than on the uncooperative "safe" one (as demonstrated by Bornstein and Gilula, 2003; Bosworth, 2013; Skyrms, 2004).[12] With regard to the structure of *UNEQUAL*, we consider other social dilemmas like the prisoner's dilemma, to gain insights into the behavioral factors influencing decisions. Common to those games is that they have only one (uncooperative) NE which, however, is socially inefficient. Hence, both players could be better off by cooperating. Studies have demonstrated that individuals tend to approach a prisoner's dilemma in the same way as an assurance game (see Kiyonari et al., 2000; Kollock, 1998; Watabe et al., 1996) and frequently choose to cooperate even though this does not constitute an NE. Again, trust has been identified as a significant factor in explaining behavior (see Ostrom and Walker, 2003, for an extensive review of experimental studies). Additionally, higher trust levels are associated with more cooperation within the prisoner's dilemma (see Chaudhuri et al., 2002; Fox and Guyer, 1977; Hayashi et al., 1999; Parks et al., 1996).

[11] Behavior in experiments that deviates from standard game theoretical predictions has been documented in various contexts (see e.g., Cramer, 2003, for a review).

[12] Following Coleman (1994), an individual is considered to trust if she voluntarily puts resources at the disposal of another party without any legal commitment from the other.



Note: Mean levels (with 95%-CIs) for the decision to attack the other player, and investment in arms. The horizontal line in the right panel marks the predicted arming level (50 Tokens). For this figure, we consider data from all players (104) in all seven rounds (N = 728).

Fig. 1. Frequency of attacking and arming-levels.

In our conflict game, the cooperative decision is not to attack. Therefore, we expect trusting players to choose this option more often than players with lower levels of trust. It is worth noting, however, that our framework introduces an additional "safe" choice alongside arming and starting a conflict, namely the option to invest in arming without attacking. Players may opt for this choice if they desire to maintain peace while still safeguarding their production in the event of a conflict. We anticipate that players with lower levels of trust will tend to invest more resources in arming even when they choose not to start a conflict. Hence, contrary to the standard theory, we expect to find situations where both players abstain from starting a conflict but invest positive amounts in arms to protect themselves. We refer to this outcome as "armed peace".

Besides trust, risk- and loss-aversion have been frequently investigated in the context of coordination games (Bornstein and Gilula, 2003; Engel and Zhurakhovska, 2016; Heinemann et al., 2009), social dilemmas (Dolbear Jr and Lave, 1966; Sabater-Grande and Georgantzis, 2002), as well as contests (refer to Dechenaux et al. (2015) for a review, and to Shupp et al. (2013), Chowdhury et al. (2018) for further examples). Therefore, we elicit individual preferences towards risk and loss to be able to control for them in our analysis.

3. Results

We collected data from 104 students at the EconLab of the University of Innsbruck in January 2023.[13] Participants were recruited via hroot (Bock et al., 2014) and the experimental software was programmed in oTree (Chen et al., 2016). We conducted six experimental sessions and randomly assigned the treatment.[14] Table S3 in the supplementary material provides descriptive statistics on individual background characteristics.[15] There are no significant differences among participants across treatments, suggesting that the randomization was effective and that the sample is balanced across treatments. On average, an experimental session lasted for 50 minutes, and participants earned 15 Euros.

3.1. Main treatment effects on decisions in the conflict game

In this section, we provide a concise overview of the conflict game's descriptive results and the main treatment effects to address our research question. We use multilevel mixed effects regressions to estimate the average treatment effects.[16] The average treatment effect is identified because of the random treatment assignment. Additional covariates are not required to identify these causal effects, but they may increase the precision of our estimates. Therefore, we present regressions with and without covariates.

Fig. 1 presents a first overview of the individual decisions in the conflict game. The decision to attack and the investment in arms. First, we analyze the individual decisions about whether to attack before turning to investments in arms. Based on the data presented in the left panel of Fig. 1, it is evident that players in *UNEQUAL* choose to attack substantially more often than those in *EQUAL* (54% vs. 35%, MWU on independent observations, $p = 0.057$). This difference is confirmed by a multilevel mixed effects regression (column 1 of Table 2).[17] Nonetheless, the result does not reach statistical significance at the 5% level once we control for additional

[13] The sample size was determined by a pre-registered power analysis available under https://www.socialscienceregistry.org/trials/10588.

[14] Please note that the sessions vary in the number of participants and matching group sizes. We ran four sessions with each including one matching group á 14 participants in *UNEQUAL*. We ran two sessions with each including three matching groups á eight participants in *EQUAL*. These numbers resulted from the choice to implement a perfect stranger-matching over the seven rounds. This leaves us with a total of ten independent matching groups, four for *UNEQUAL* and six for *EQUAL*. These numbers present the number of independent observations within each treatment.

[15] Incentivized games (loss aversion, trust, and distributional preferences via the Equity Equivalence Test) were conducted prior to the conflict-game, whereas self-assessments and demographic data were gathered afterward.

[16] Multilevel models allow us to (*i*) account for dependencies between observations on different hierarchical levels and (*ii*) control for relevant background characteristics. If not stated otherwise, we account for the dependency of observations at the player and matching group levels.

[17] In addition to the examination of data from all seven rounds (Table 2), running the regression analysis solely for the initial round (Table S4 in the supplementary material), reveals qualitatively similar results, although, not statistically significant.

Table 2
Average Treatment Effect: Starting a conflict and the investment in arms.

	Attack		Arming		Arming (offensive)		Arming (defensive)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
EQUAL	-0.185* (0.076)	-0.147 (0.099)	-18.506*** (5.449)	-17.019* (6.808)	-4.651 (6.478)	-8.748 (7.342)	-14.954*** (3.297)	-13.768*** (2.916)
Covariates		✓		✓		✓		✓
Control Mean[1]	0.533		49.821		63.720		30.905	
Observations	728		728		329		399	
Standardized Effect Size	0.37	0.29	0.64	0.59	0.21	0.39	0.65	0.60
Minimal Detectable Effect Size (MDES)	0.21	0.28	15.26	19.06	18.14	20.56	9.23	8.17

Note: The table presents results from multilevel models with random effects at the matching group and individual levels. The dependent variables are whether the participant chooses to attack the other player, absolute arming levels (Tokens invested into arming), as well as offensive arming (in order to attack the other player), and defensive arming (not attacking the other player). The independent variable is an indicator of the treatment. In uneven columns, we only control for the time trend. In even columns, we additionally for players' background characteristics. Covariates include gender (participant identifies as male), age in years, whether participant reports being competitive, likes to win, and being compulsive measured on an 11-point Likert scale, trust and trustworthiness elicited using a standard trust game (Berg et al., 1995), a measure for loss-aversion (Gächter et al., 2022), self-reported risk-aversion measured on an 11-point Likert scale following (Falk et al., 2018), classification of distributional preferences (altruist, selfish, and maximin) of participants using the Equality Equivalence Test by Kerschbamer (2015), and the periods (as time trend).
In the last two rows, we present effect sizes in units of a standard deviation in *UNEQUAL* and minimum detectable effect sizes (MDES). We follow Haushofer and Shapiro (2016) in effectively calculating MDES with 80% power at a significance level of 5% by multiplying the standard errors by 2.8.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
[1] Mean level of the outcome variable in *UNEQUAL*.

covariates (see Column 2 in Table 2). Still, our results provide weak evidence in favor of Hypothesis 1 and we carefully formulate our first main result as:

Result 1. *The probability of an attack is lower when resources are distributed equally among players compared to a situation where the distribution of resources is unequal.*

Next, turning to the investments in arms, the right panel of Fig. 1 shows that players in *UNEQUAL* invest significantly more resources in arms than those in *EQUAL* (50 ECU vs. 31 ECU, MWU on independent observations, p = 0.038). Our regression analysis (columns 3-4 of Table 2) is in line with this observation. Hence, our results lend support Hypothesis 2 and we can formulate the second main result as:

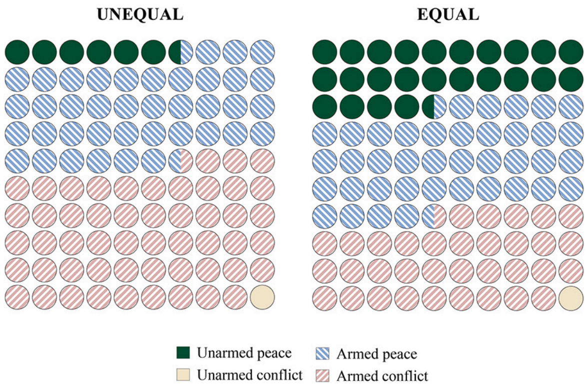
Result 2. *The average investment in arms is lower when resources are distributed equally among players compared to a situation where the distribution of resources is unequal.*

As we have noted earlier, investments in arms do not necessarily stem from an intent to attack the other player. A player may arm purely to protect herself against a potential attack from another player. The right panel of Fig. 1 therefore distinguishes between offensive and defensive investments in arms. We categorize investments in arms as offensive if the player decides to start a conflict, and as defensive if the player decides not to do so.[18] Fig. 1 shows that in both treatments offensive arming is, on average, higher than defensive arming. While offensive arming levels seem similar in both treatments, players in *EQUAL* invest less in defensive arming than players in *UNEQUAL*. Columns 5-8 of Table 2 reveal that the treatment effect in overall arming is primarily driven by lower investments in defensive arming in *EQUAL*. This is particularly interesting, given that previous experimental studies could not distinguish between defensive and offensive arming.

Summarizing the individual decisions analyzed so far, we find that players decide to start fewer conflicts and invest fewer resources in arms in *EQUAL*, compared to *UNEQUAL*. Looking at the combination of the two separate decisions of attacking and arming, we can classify four different choices: unarmed peace (UP), armed peace (AP), armed conflict (AC), and unarmed conflict (UC).[19] Fig. 2 shows the distribution of these choices in the two treatments. Given that the benchmark theory predicts peace always to be unarmed and to potentially emerge in *EQUAL* but not in *UNEQUAL* (see Appendix A), we test whether players indeed choose unarmed peace and whether they do so more often when resources are distributed equally. We find that players choose unarmed peace 7% of the

[18] One could argue, that theoretically, a player expecting the other player to attack arms accordingly. Since she knows that conflict will occur for certain and independent of her conflict choice she randomly chooses between attack and not attack. In this case, our data would not allow us to distinguish between defensive and offensive arming. Given that we find substantial differences between offensive and defensive arming levels, we are confident that individuals still opt for their preferred conflict decision in such situations.

[19] We will henceforth use the term "choices" when referring to the combination of the attack decision and investment in arms. Note that the choice of unarmed conflict (UC) is nonsensical since it leads to a certain loss due to the conflict one initiates, if the other player invests anything in arming.



Note: Relative frequencies of choices with every circle representing 1%. Participants could essentially choose among four different choices: not to attack the other player and not to invest into arming (*unarmed peace*), not to attack the other player but invest a positive amount into arming (*armed peace*), attack the other player and invest a positive amount into arming (*armed conflict*), attack the other player but invest nothing into arming (*unarmed conflict*). Choosing unarmed conflict however cannot be rational, given that one would certainly lose if the other one invests only one Token into arming. We find that this choice was played seven times (less than 1%) over the course of the experiment. Number of observations: N = 392 in UNEQUAL and N = 336 in EQUAL.

Fig. 2. Distribution of different choices.

time in *UNEQUAL* and 25% of the time in *EQUAL*. However, this substantial difference of 18 percentage points is not statistically significant, neither when using a Mann-Whitney-U test on independent observations (MWU, $p = 0.457$), nor when using a multilevel mixed-effect regression as presented in columns 1-2 of Table S5 in the supplementary material. Our results suggest that the treatment difference is driven by a few players who always choose unarmed peace in *EQUAL*. Controlling for this either by analyzing only groups (in the case of MWU) or explicitly accounting for it in a multilevel model shows that, while the treatment motivates six players to choose UP when resources are allocated equally among them, most players still choose to invest in arms.

Concerning the other choices, we find that players opted for armed conflict 53% of the time in *UNEQUAL* compared to 35% in *EQUAL*. This difference is significant at the 5%-level when analyzing simple treatment differences (column 5 of Table S5 in the supplementary material).[20] Finally, we find similar rates of choosing armed peace (40%) and unarmed conflict (less than 1%) in both treatments.[21] Hence, players in *UNEQUAL* choose armed conflict more often compared to *UNEQUAL* but peaceful choices (armed and unarmed peace) prevail in both settings.

Up to this point, we have focused on individual decisions and choices. Additionally, a matter of concern is whether peace will ultimately emerge as an outcome resulting from both players' choices. Remember that the decision of one player to attack the other is sufficient for a conflict to break out. Fig. 3 depicts the development of outcome, i.e., (unarmed) peace and conflicts over rounds. Conflicts were the dominant outcomes in both treatments. Still, it appears that a state of (unarmed) peace was more likely to evolve in *EQUAL*. Our results suggest that the decisions of participants lead to fewer conflicts in *EQUAL* than in *UNEQUAL* (60% vs. 79%).[22] There is, however, no difference when looking at unarmed peace. Even though there are only 0.5% of occasions of unarmed peace in *UNEQUAL* compared to 9.5% in *EQUAL*, this difference is not significant at a 5% level, as demonstrated in column 2 of Table S6 in the supplementary material. Thus, we do not find (significantly) fewer incidents of *unarmed peace* in *EQUAL* than in *UNEQUAL*. Interestingly, we find many instances of armed peace in both treatments (21% in *UNEQUAL* and 31% in *EQUAL*), a state not constituting a NE according to theory.

In sum, our findings concerning the impact of (un)equal resource distribution show that, as predicted, unequal resource distribution leads to more attacks and higher investments in arms. Consequently, inequality makes it more likely that players find themselves in a state of conflict. Yet, we do not find evidence that unarmed peace prevails only in situations where players have equal resources. In the subsequent analysis, we further scrutinize the effect of resource inequality on the individual decisions of the players.

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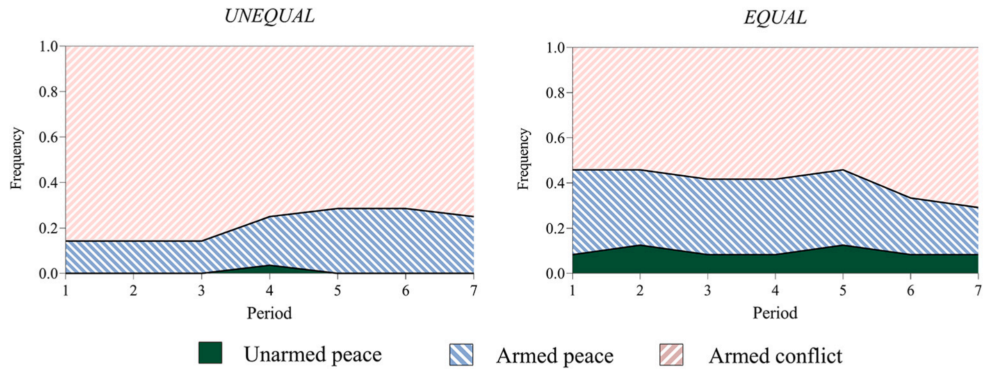
[20] If adding covariates, the difference between treatments of choosing armed conflict ceases to be significant ($p = 0.177$).

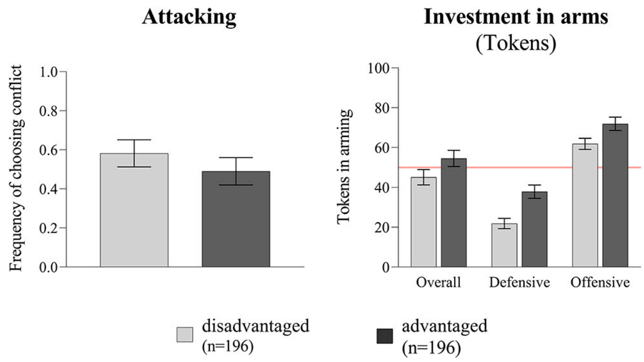
[21] It's reassuring that most of the choices for unarmed conflict occurred in the first three rounds. Five of the six participants who chose unarmed conflict stated that they had trouble understanding the game in the first rounds, while one participant reported not understanding the game at all.

[22] We estimate a multilevel probit regression model on the likelihood of conflict with only a binary treatment indicator as the explanatory variable and one random effect at the matching group level. The results show that the likelihood of conflict is 19 percentage points lower in *EQUAL* compared to *UNEQUAL* as indicated in column 1 of Table S6 in the supplementary material.



Note: This figure shows the development of outcomes over the course of the conflict game. Number of observations: N = 392 in UNEQUAL and N = 336 in EQUAL.

Fig. 3. Development of outcomes.



Note: Mean values (with 95%-CIs) for the frequency of choosing to attack the other player and investments in arms. In every period participants chose whether to attack the other player and how much of their endowment they want to invest into arming. In UNEQUAL, resource distributions among participants were unequal. The disadvantaged player only had 80 Tokens, while the advantaged player had 120 Tokens at the beginning of each period. For this figure, we only consider data from players in *UNEQUAL* (56) in all seven rounds (N = 392).

Fig. 4. Frequency of attacking and investments in arms.

3.2. The effect of being (dis)advantaged

After analyzing treatment differences, we now explore the effects of different resource distributions within *UNEQUAL*. The underlying theory posits that the disadvantaged player decides to attack the advantaged one, which drives the pair into a conflict. We separately analyze the behavior of disadvantaged and advantaged players to determine whether this behavior is present in our experimental setting.

Fig. 4 displays the decision to attack (left) and the investment in arms (right) for the two types of players. Both types of players, decide to attack frequently, however, the disadvantaged player does so more often. We test these findings in columns 1 and 2 in Table 3 and find no significant difference in attack rates between advantaged and disadvantaged players. Interestingly though, disadvantaged players still decide not to attack 42% of the time, contradicting the theory predictions, which postulates that disadvantaged players would never do so. A post-estimation Wald test confirms that the likelihood of choosing peace is greater than zero (p-values < 0.001) for disadvantaged players.[23] Table 3 columns 3 and 4 further show that the investment in arms differs significantly between the two types of players despite the theory predicting that they should arm equally in anticipation of conflict. However, the data reveals that disadvantaged players invest less in arms than advantaged players.[24] Distinguishing between offensive and defensive arming, the right panel in Fig. 4 shows that players invest more in arms when starting a conflict. Additionally, advantaged players generally invest more, irrespective of their decision to attack the other or not.

Result 3. *Disadvantaged players do not always choose to start a conflict, and are equally likely to do so as advantaged players. Disadvantaged players invest fewer resources in arms.*

[23] Testing the coefficients of the indicator for disadvantaged in Table 3.

[24] Please note that given the unequal resource distribution, disadvantaged players spend a higher fraction of their resources on arming.

Table 3
Average effect of different resource endowments.

	Attack		Arming		Arming (offensive)		Arming (defensive)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Player is disadvantaged	0.095 (0.088)	0.032 (0.052)	-9.418** (3.083)	-9.542* (4.523)	-10.873*** (3.218)	-8.477 (5.990)	-11.931*** (2.141)	-13.694*** (2.003)
Covariates		✓		✓		✓		✓
Control Mean[1]	0.486		54.531		69.627		36.600	
Observations	392		392		210		182	
Standardized Effect Size	0.19	0.06	0.32	0.33	0.50	0.58	0.45	0.33
Minimal Detectable Effect Size (MDES)	0.25	0.15	8.63	12.66	9.01	16.77	6.00	5.61

Note: For this table we only consider the experimental condition with unequal resource distribution (UNEQUAL). The table presents results uni- (uneven columns), and multivariate (even columns) from multilevel models with random effects at the matching group and individual levels. The dependent variables are whether the participant chooses to attack the other player, absolute arming levels (Tokens invested into arming), as well as offensive arming (in order to attack the other player), and defensive arming (not attacking the other player). The independent variable is an indicator of whether the player was advantaged (120 Tokens) or disadvantaged (80 Tokens). Covariates include gender (participant identifies as male), age in years, whether participant reports being competitive, likes to win, and being compulsive measured on an 11-point Likert scale, trust and trustworthiness elicited using a standard trust game (Berg et al., 1995), a measure for loss-aversion (Gächter et al., 2022), self-reported risk-aversion measured on an 11-point Likert scale following (Falk et al., 2018), classification of distributional preferences (altruist, selfish, and maximin) of participants using the Equality Equivalence Test by Kerschbamer (2015), and the periods (as time trend). In the last two rows, we present effect sizes in units of a standard deviation when the player is advantaged and minimum detectable effect sizes (MDES). We follow Haushofer and Shapiro (2016) in effectively calculating MDES with 80% power at a significance level of 5% by multiplying the standard errors by 2.8.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
[1] Mean level of the outcome variable if the player is advantaged (endowment = 120 Tokens).

3.3. Additional motivations for peace and conflict

Notably, we observe peaceful outcomes in *UNEQUAL* and many occurrences of armed peace in both treatments. These outcomes, do not qualify as Nash equilibria and should not be prevalent. In Section 2, we briefly discussed behavioral factors that have been established as predictors of decisions in coordination games and social dilemmas. Recognizing these factors is often instrumental in comprehending the reasons behind off-equilibrium outcomes. The literature has established trust as a highly predictive factor of cooperative behavior. People who trust others typically tend to cooperate more than those who distrust others. Apart from trust, risk-, and loss-aversion have been frequently investigated to explain behavior in contest settings. Consequently, we investigate whether trust, risk-, and loss-aversion, apart from treatment effects, can help explain the observed decisions in our conflict game.[25]

Fig. 5 displays the probability of the above-discussed choices as a function of the level of trust, risk, and loss aversion of a player. The depicted results stem from a multinomial logistic regression that is presented in Table S7 in the supplementary material and show the predicted frequencies of the respective choices for different levels of trust, risk-, and loss aversion. Higher levels of trust are associated with a lower probability of starting a conflict. The opposite holds for both choices of peace. Individuals with higher levels of trust are more likely to choose (armed or unarmed) peace. The result for loss aversion is less clear. Individuals with higher levels of loss aversion tend to choose armed conflict more often and armed peace less often. Using a multinomial logistic model in Table S7 in the supplementary material, however, reveals that only the latter association is significant. We do not find any statistically significant associations between risk aversion and either choice.

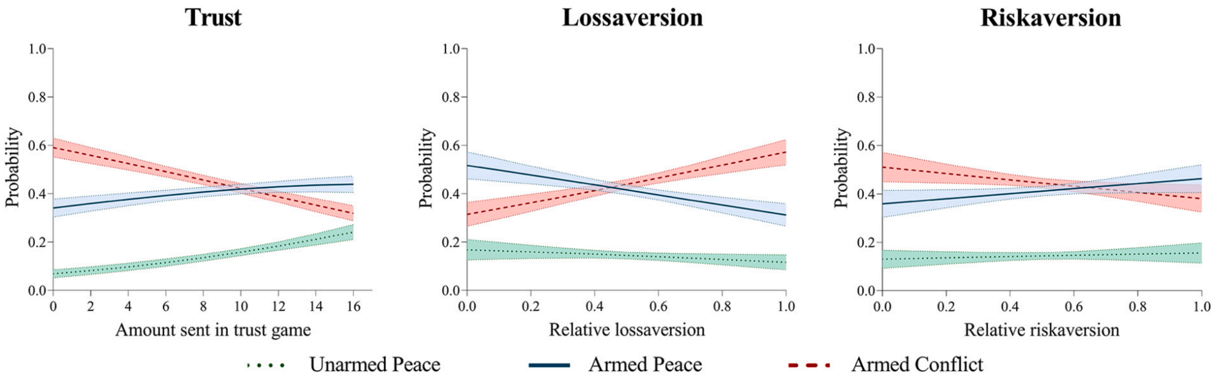
Another way to look at the influence of trust on decisions is to only consider defensive arming. Following the reasoning from above, we would expect that trusting players invest less in defensive arming than distrusting ones, given that they trust the other players to cooperate. Reassuringly, we find that higher levels of trust are associated with lower levels of defensive arming (see the coefficient on trust in Table S8 in the supplementary material). To summarize, we can say:

Result 4. *Players exhibiting high levels of trust are more likely to choose peace and invest fewer resources into defensive arming.*

4. Discussion and conclusion

In this study, we examine the emergence of (unarmed) peace in a guns-versus-butter setting. We explore the impact of (un)equal resource distribution on individuals' decisions and shed light on how inequality impacts choices related to conflict and peace. Our

[25] Please note that next to behavioral factors, beliefs regarding the other player influence behavior in our setting. We separately discuss the effect of beliefs in Section 2 in the supplementary material. We find that players who refrain from attacking invest significantly more in arms when they believe they will be attacked. However, when players decide to start a conflict themselves, their arming decision does not depend on their beliefs about whether the other player will attack them. In *UNEQUAL*, we find that advantaged players believe to be attacked more frequently than disadvantaged players. For more details please refer to Section 2 in the supplementary material.



Note: This figure depicts the marginal probabilities of individual choices (unarmed peace (UP), armed peace (AP), and armed conflict (AC)). We only consider meaningful choices, hence omitting the seven occasions where a participant chose Unarmed Conflict (UC). Higher values indicate a greater probability of selecting a particular choice. (Table S7 in the supplementary material shows the regression output).

Fig. 5. Marginal probabilities of individual choices.

experimental setting, based on the theoretical model of Garfinkel and Syropoulos (2021) allows us to separate conflict from arming decisions in a guns-versus-butter setting – a feature hitherto unexplored in the experimental conflict literature.

Our findings unveil compelling insights into the effects of resource distribution on the probability of starting a conflict and investment in arms. When players have equal resources, we find that they are indeed less likely to attack one another compared to a situation where resources are distributed unequally among them. The lower likelihood of an attack is accompanied by reduced investments in arms. Consequently, we find fewer occasions of armed conflicts when players have equal resources. These results align with theoretical predictions, highlighting the influence of resource equality on mitigating the risk of armed conflicts. However, contrary to the theoretical expectation, we do not find a significant increase in the occurrence of unarmed peace when resources were distributed equally among players. The propensity to choose unarmed peace remains comparable across treatments, suggesting that factors beyond mere resource distribution contribute to decisions toward this choice. Our analysis shows that armed peace is among the two most frequently played choices and consequently outcomes in both treatments, even though it does not constitute an NE. We extended our analysis to encompass previous findings on the importance of trust as a predictor of pro-cooperative behavior. Consistent with prior research, we find that high levels of trust emerge as a significant predictor of peaceful choices and reduced defensive arming.

Within the treatment with resource inequality, we find surprising patterns among the decisions of disadvantaged and advantaged players. Disadvantaged players frequently choose peace and show similar tendencies to attack, yet invest less into arming than to advantaged players. This unexpected finding warrants additional investigation into decisions in conflicts under inequality.

Our study, although providing valuable insights, is not without limitations. A controlled environment like ours does not capture the complexity of real-world conflict situations. However, causally identifying the relationship between inequality and conflicts with naturally occurring data is hardly possible, as exogenous variation is usually missing. Using a controlled experiment allows us to circumvent this identification and our results suggest that - all other things equal - inequality hampers the prospect of peace and spurs armed conflicts.

A further limitation of our study is the relatively small sample size of 104 students. Assuming similar effect sizes ($\tilde{3}7\%$) as Kimbrough and Sheremeta (2014), our power analysis suggested including 80 participants in the study. Although our budget allowed us to increase the sample size somewhat, it is arguably still tiny. The combination of the small sample size and the fact, that we applied strict significance levels ($p \leq 5\%$) and very conservative tests,[26] might be the reason why some of our (sizable) effects, like the choice for and the occurrence of unarmed peace, does not reach statistical significance. Arguably, a 9-11 percentage-point change in the choice of unarmed peace, and a 7 percentage-point change in the respective outcome would be economically relevant. We expect that this difference is not due to chance, although, for now, we can only speculate. Our results should be interpreted as preliminary evidence of the occurrence of unarmed peace in this novel setting. Further research using the same setting is crucial to establish the robustness of our findings.

In conclusion, this study contributes to the economic literature on conflict resolution, proposing that addressing inequality, while not a standalone solution for ensuring unarmed peace, may prove to be a promising avenue for preventing armed conflicts. An avenue for further research may be to explore whether decision-makers are willing to reduce inequality ex-ante to reduce the risk of conflicts if they have the chance to do so, and how the degree of inequality affects choices and outcomes.

Declaration of competing interest

The authors declare that they have no relevant or material financial interests that relate to the research described in this paper.

[26] We use non-parametric tests to analyze purely independent observations or accounted for dependencies using multi-level mixed-effects regressions.

Data availability

You can access the data, code, and OTree code at the Open Science Framework: https://osf.io/kmry4/.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this manuscript, the authors used *OpenAI* and *DeepL Writing* to improve readability and language. After using this tool/service, the authors reviewed and edited the content as needed. We take full responsibility for the content of the publication.

Appendix A. Theoretical background

Our experiment is based on a simplified version of the model by Garfinkel and Syropoulos (2021). In the model, two players ($i = A, B$), privately and simultaneously, divide their resources R_i between production X_i, and arming G_i, such that $R_i = X_i + G_i$, and decide whether or not to start a conflict (attack). If neither player attacks, peace is sustained and both consume their own production, X_i. If at least one of them attacks, however, both enter into conflict. In this situation, the sum of production constitutes the contestable output $\overline{X} = X_1 + X_2$.[27] Importantly, armed conflict results in the destruction of production, where $\beta \in [0, 1)$ represents the survival rate of production.[28]

The probability of winning the conflict (if it occurs) depends on the level of arming of both players. If $\overline{G} = G_1 + G_2$ is the total amount of arming and $\overline{G} > 0$, probability of winning for player $i's$ is specified by the *conflict success function* (CSF)[29]:

$$\Phi_i = \Phi_i(G_i, G_j) = \frac{G_i}{\overline{G}} \tag{A.1}$$

Based on the CSF, (expected) payoffs can be calculated as follows. If no player attacks, peace is sustained, and player $i's$ payoff U_i^P is given by

$$U_i^P = X_i. \tag{A.2}$$

Please note that player i does not derive any benefit from arming in this situation. On the contrary, arming reduces consumption by diverting resources away from production. Therefore, player i will not arm if she expects peace ($G_i = 0$ and $X_i = R_i$).

If anticipating conflict, the expected payoff U_i^C is

$$U_i^C = \Phi_i \beta \overline{X} \tag{A.3}$$

In this setting, arming, while still diverting resources away from production, positively affects $i's$ expected payoff, as it increases the probability of winning. Given that players are not resource-constrained,[30] deploying a quarter of the initial total resources into arming ($G_i = \frac{1}{4}\overline{R}$) maximizes their expected payoff when anticipating conflict. If both players anticipate conflict and arm accordingly, their expected payoffs in equilibrium are given by

$$U_i^C = \frac{1}{4}\beta \overline{R} \tag{A.4}$$

Equation (A.2) implies that the payoff under peace depends only on player $i's$ initial endowment, while the expected payoff of conflict depends further on the destructiveness of conflict (β), and the total resources of both players $\overline{R}$.

The main focus of the model is on conditions that allow unarmed peace as a stable Nash Equilibrium (NE) in pure strategies. While conflict is always a stable NE,[31] unarmed peace despite being Pareto dominant does not necessarily qualify as another NE. What is necessary is that neither player has an incentive to unilaterally deviate from peace — by arming and attacking — given the anticipation of (unarmed) peace. In order to see whether i has an incentive to deviate, we compare $i's$ payoff under peace (U_i^P) to $i's$ expected payoff under conflict, assuming the opponent stays unarmed. If payoffs under conflict are larger than under peace, player i will decide to attack. Conflict payoffs of i given that $-i$ is not arming are presented by

$$U^C_{i|G_{-i}=0} = \beta(\overline{X} - G_i) \tag{A.5}$$

[27] Note that in the setting of Garfinkel and Syropoulos (2021), the output is potentially secure, i.e., a fraction $\sigma \in [0, 1)$ of each player's production X_i is secure, while the remaining fraction $1 - \sigma \in (0, 1]$ is insecure and contestable. For the purpose of this paper, we set $\sigma = 0$, so that players can lose (or win) the entire production of the opponent. This reflects, for example, wars fought over natural resources or political leadership. In addition, it simplifies the experimental environment without affecting relevant aspects concerning our research question.

[28] In Garfinkel and Syropoulos (2021), the authors include an additional parameter representing the potential difference in survival rates between contested and uncontested production (γ). Since we set $\sigma = 0$, we do not need to distinguish between contested and uncontested output and can ignore γ from here on.

[29] In the case that $\overline{G} = 0$, the CSF is given as $\Phi_i(G_i, G_j) = \frac{R_i}{\overline{R}}$ where $\overline{R} = R_1 + R_2$.

[30] In this setting, player i would be considered resource-constrained if $R_i \in (0, \frac{1}{4}\overline{R})$.

[31] Note that if player i attacks and arms accordingly, then the best response of $i's$ opponent is to do the same.

When anticipating $G_{-i} = 0$, player i needs to invest only a marginal amount into arming, $G_i = \epsilon$, in order to secure a certain payoff $\beta(\overline{X} - \epsilon) \approx \beta\overline{X}$. When deciding whether or not to attack, player i has to consider the initial distribution of resources, $\frac{R_i}{R_{-i}}$, and the destructiveness of war, β, because both affect the contestable total production $\overline{X}$. The lower player i's resources are compared to those of her opponent ($\frac{R_i}{R_{-i}} \downarrow$), the less attractive it becomes for her to choose peace and consume only her own resources instead of attacking and trying to appropriate the opponent's relatively larger resources. It is straightforward that attacking becomes more attractive to player i the more the initial resources distribution favors $i's$ opponent ($\frac{R_i}{R_{-i}} \downarrow$), and the less destructive war is ($\beta \uparrow$).

Hence, the necessary conditions for (unarmed) peace to evolve are (*i*) that conflicts are sufficiently destructive and (*ii*) that initial resource distributions are sufficiently equal. Garfinkel and Syropoulos (2021) show that for any $\beta \geq 0.5$ there exists no stable NE in peace, regardless of the distribution of resources.[32] However, if conflicts are sufficiently destructive ($\beta < 0.5$), a stable NE in unarmed peace can exist, depending on the distribution of resources.

Based on this theoretical framework, we aim to experimentally study the emergence of unarmed peace and the potential impact of initial resource distribution on its likelihood.

Appendix B. Supplementary material

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.geb.2024.06.006.

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[32] Note that, when the distribution of resources is perfectly equal ($R_i = R_{-i}$) the payoff under peace is $U_i^P = \frac{1}{2}\overline{R}$, while the expected equilibrium payoff of conflict would be $U_i^C = \frac{1}{2}\frac{1}{2}\overline{R}$. However, a player i would be indifferent between unarmed peace and conflict when anticipating $G_{-i} = 0$. Put differently, if a player believes that the other player will not invest in arming, choosing unarmed peace or investing a minimum amount in arms and starting a conflict results in the same expected payoff $U_{i|G_{-i}=0}^C = \frac{1}{2}\overline{R}$.

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