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Preventive wars ☆

Klaus Abbink [a], Lu Dong [b], Lingbo Huang [c,*]

[a] *Monash Business School, Clayton, VIC, Australia*
[b] *SUSTech Business School, Southern University of Science and Technology, Shenzhen 518055, China*
[c] *Center for Economic Research, Shandong University, Jinan 250100, China*

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The rise of a new power may lead the dominant power to seek a preventive war. We study this scenario in an experimental two-stage bargaining game. In each stage, the rising power makes a bargaining offer and the declining power must choose whether to accept it or fight. Between the two stages, the winning probability shifts towards the rising power. We find fewer preventive wars when the power shift is smaller and when the rising state has the commitment power. Communication and repeated interaction decrease the likelihood of preventive wars. High fighting costs almost eliminate such wars when the rising power's first-stage offer is sufficiently large.

1. Introduction

When the Cold War ended, it looked like the world had become unipolar, with the United States as the only superpower left. The subsequent rise of China took place predominantly in the economic arena, while the Chinese government still followed Deng Xiaoping's doctrine of keeping a low profile in the geopolitical sphere. This changed when Xi Jinping took over as the Chairman of the Chinese Communist Party in 2012. China is now well on course towards parity with the U.S. in economic strength, and has started flexing its geostrategic muscles by investing heavily in its military. The election of Donald Trump as the U.S. president in 2016 did not improve Sino-American relations. Though Trump's rhetoric and actions mainly revolved around trade issues rather than geopolitics, the U.S. attitude towards China became increasingly icy during Trump's term in the office, and the Biden administration does not show much intent to change that. Ferguson (2019) argues that a new Cold War has already begun, though he does not expect it to become hot in the near future.

The rise of a new power challenging the incumbent hegemon's position inevitably leads to tensions. Allison (2017) coined the term 'Thucydides's Trap' after the ancient Greek historian who wrote on the Peloponnesian War (431−404 BCE): "It was

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* Corresponding author.
E-mail addresses: dongl6@sustech.edu.cn (L. Dong), lingbo.huang@outlook.com (L. Huang).

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the rise of Athens and the fear that this instilled in Sparta that made war inevitable."[1] Allison analyzed 16 modern historical events in which a rising power challenged a ruling power and found that war was the outcome in 12 of those instances. Most famously, the rise of the German empire in the late 19th century threatened a still dominant, but slowly declining British empire. It can be argued that this shift in power was the underlying cause of World War I, which was eventually triggered by a minor event, the assassination of Archduke Franz Ferdinand by a Serbian terrorist.[2]

Historical examples can only ever go so far; for every aspect that parallels the historical blueprint there is another one that deviates from it. Concurring with this view, Allison is adamant that war between the U.S. and China is *not* inevitable. Nonetheless, there are many fault lines along which conflict can break out. Allison (2017) lays out four realistic scenarios of how a minor incident, an accident or a targeted provocation, can escalate into full-fledged war. In addition, both sides have developed significant capabilities for cyber warfare. A comprehensive shutdown of the other side's communication networks can be as devastating as a nuclear strike, but the psychological threshold for actually attempting such an attack might be lower than that for unleashing a widely feared nuclear exchange.

Shifts in relative power are also dangerous because they create an incentive for the *ruling* power to initiate conflict, to destroy the rising power before it can become too big. Such type of conflict, termed *preventive war*, is argued to be theoretically inevitable (Fearon, 1995; Powell, 1999; Copeland, 2000) because the rising power faces a commitment problem stemming from bargaining divisions spread over multiple stages. Once the rising power has become superior, it has every reason to renege on any promise about future bargaining agreements. Foreseeing this adverse outcome, the declining power must launch an early attack—preventive war—while it is still stronger than the rising power. A sufficiently large shift in power is at the core of the commitment problem, and preventive wars are launched precisely to forestall a shift in the balance of power in favor of the opponent and avoid losing any bargaining advantages in the future.

This outcome, however, is inefficient because there would be bargaining solutions in which both powers would be better off, as dictated by the Coase theorem. To achieve them, the rising power would have to commit to a bargaining division at the second stage even though, once this stage is reached, it could improve its outcome by reneging on the promised division. If it could commit, the declining power could faithfully abstain from a preventive war and achieve an outcome that is overall more beneficial for it than the risky outcome of a preventive war. However, since this is not possible, a costly war is inevitable. This argument holds even in the absence of any information asymmetries, which is the standard explanation for the failure of bargaining and the outbreak of inefficient conflicts (Brito and Intriligator (1985); see reviews by Ausubel et al. (2002) and Sanchez-Pages (2012)).

In the present study, we employ a highly parsimonious model to capture the essence of the logic of preventive wars, building on the seminal works by Fearon (1995) and Powell (1999). In this simple scenario, there are two players, a rising and a declining player, who interact for at most two bargaining stages. In each stage, the rising player makes a bargaining offer to the declining player who then decides whether to accept the offer or go to war. However, the war is costly and inefficient. If war breaks out in the first stage, a lottery strongly in favor of the declining player will determine who wins the total pie (i.e., all payoffs across two stages) and the game ends. If war occurs in the second stage, however, a lottery strongly in favor of the rising player will determine who attains all the gains. Thus, the exogenously varied probability of winning captures the shift in power over the two stages. Finally, if peace is kept in both stages, both players simply receive their respective bargaining payoffs.

It is worth noting that our simple model allows only the rising player to make the bargaining offer and only the declining player has the right to declare a war. The deprivation of the rising player's right to declare war emphasizes that the occurrence of war does not rely on the fear of being attacked but rather on the unease with "the peace it will have to accept after the rival has grown stronger." (Fearon, 1995, p. 406) The reason for isolating the fear of being attacked is that it is typically associated with preemptive war, which is often confused with preventive war. A preemptive war is launched in anticipation of an imminent attack by the opponent whose intentions are unknown (Schelling, 1960; Jervis, 1976; Abbink et al., 2021). By contrast, the aim of a preventive war is stopping an opponent from developing the capability to attack. In his just war theory, Walzer (1977) justifies a preemptive war as a form of self-defense, while no such argument can be made for a preventive war, as the mere capability to attack does not imply any intention to do so. Thus, our modeling choice is intended to differentiate the logic of preventive war from that of preemptive war as clearly as possible.

In the theoretical model we adopt here, war is inevitable. In practice, agents may find a way out of the Thucydides Trap. To test whether and how the trap can be avoided, we carry the game theoretic model into the experimental laboratory, as it is an ideal environment for testing the behavioral validity of game theoretic predictions. Countless experiments on social dilemma games, ultimatum games, trust games and others have shown that even clear game theoretic predictions often break down when they are at odds with human instincts. Often, experimental subjects choose to cooperate where game theory says they should not and achieve much more efficient outcomes, and particularly in public good and trust games.

[1] It has been doubted whether this translation and interpretation of the original source is entirely accurate. We view the term Thucydides's Trap as a catchy, if somewhat hard-to-pronounce expression for a more general concept of an interplay between a rising and a ruling power.

[2] Germany, being a rising power, feared that another rising power, Russia, could gain in strength and become a threat on Germany's eastern border (the two empires were neighbors at the time). This perceived risk prompted strategists in the German government to consider an attack on Russia as a preventive war, as discussed in detail by Clark (2014). Other than wars between major states, the outbreak of many other conflicts of limited scale has been attributed to the logic of preventive wars. For example, in the Gulf War, the U.S. attacked Iraq because it feared that Iraq would gain more monopoly power over oil supplies and thus more bargaining leverage due to the U.S. reliance on oil.

Sometimes, however, we observe a tendency toward much greater aggression than theory would imply. This is true for many rent-seeking games (Dechenaux et al., 2015). Under the present context, if the conflict propensity were observed not to depend on model parameters that dictate whether preventive war should occur, this would imply that the opportunity for making nonbinding bargaining offers across multiple stages rather than the preventive motivation for war would have a first-order effect. This effect could be explained by agents' intrinsic motives to keep promises about future bargaining offers (Ellingsen and Johannesson, 2004; Charness and Dufwenberg, 2006).

In different treatments, we study the role of shift in power and commitment capability in reducing the likelihood of preventive wars. First, we compare a treatment in which theory predicts war (*PreventiveWar*) with a treatment which is similar, but the parameters are set up so that war should not happen in theory (*NoWar*). Second, we examine the commitment problem more directly, allowing the rising player to commit to the bargaining offer at the second stage (*RP-Commit*). In theory, this scenario should lead to peace. In the experiment, we indeed observe a lower conflict rate, but the separation is far less sharp than the theory predicts.

Under these conditions, we find that treatment differences are rather small, especially compared with the clearly demarcated theoretical predictions. We therefore conduct two further treatments in which we make fighting more or less attractive than in the previous treatments. We find that, if the costs of fighting are very high, preventive wars can almost be eliminated if the rising player offers as much as possible in the first stage. Thus, this treatment shines a light of hope that war is indeed not inevitable especially between major states with devastating military powers such as nuclear weapons. Low fighting costs, however, increase the likelihood of conflict.

The previous set of treatments is primarily designed to test the predictions of the theoretical model and the experimental results confirmed the model's comparative statics. Following this, we shifted our experiment to a more "realistic" setting where equilibrium reasoning could be less impactful. We investigate the role of two mechanisms that are often invoked to resolve conflict, one of which is direct communication between the two parties who may attempt to resolve conflict via diplomatic means. To test the role of communication, in addition to the baseline treatment, we also allow the two players to send free-form messages to each other before the game starts in each round (the *Chat* treatment). Another mechanism involves repeated interaction which may encourage the players to avoid conflict by building reputation via their bargaining and fighting decisions. To test its role, we turn to a partner matching protocol and fix the players' roles for each pair throughout the experiment (the *Repeat* treatment). Compared to the baseline treatments, both conflict resolution mechanisms help reduce the frequency of preventive wars, thus instilling more confidence in Allison's (2017) claim that the Thucydides Trap is indeed not inevitable.

Our study marks one of the first attempts to thoroughly examine the logic of preventive wars through an experimental game. The work that most closely aligns with our research was Tingley (2011) who conducted an experiment on international relations. Using an infinitely repeated experimental game, Tingley (2011) tested whether a larger discount factor leads to more preventive wars and found evidence supporting this outcome. The approach adopted in our study is substantially different as, instead of varying the discount factor, we manipulate a host of other parameters (i.e., probability of winning and fighting cost) and situational conditions (i.e., commitment capability, communication and repeated interaction). This strategy allows us to test more directly and comprehensively the underlying logic of and the remedial mechanisms to preventive wars.

By contrast, the literature on dynamic power shifts and associated commitment problems in conflict has been almost exclusively theoretical. The formal models of preventive wars were originally analyzed by Fearon (1995) and Powell (1999). Using infinitely repeated games, they demonstrate that states' inability to commit to bargaining divisions over multiple stages combined with a large discontinuous change in the distribution of military power can lead to war when both parties have complete information. Powell (2004) shows that lack of commitment power and large shifts in power are two common threads across several seemingly diverse studies, the topics of which were originally thought to be unrelated to preventive wars. These include Fearon's (1996) analysis of prolonged civil wars, Acemoglu and Robinson's (2000, 2001) model of costly coups and political transitions, and De Figueiredo's (2002) account of limited term of office and inefficient policy insulation. Powell (2006) further includes Fearon's (1996) model of bargaining over issues that affect future bargaining power as another case where the same mechanism is at work even when the shifting distribution of power is endogenous to past concessions in bargaining. Baliga and Sjöström (2013) provide a theoretical review of several formal models of bargaining and conflict, including ones about commitment problems. In a more recent work, using a markedly different setup, Baliga and Sjöström (2020) study a type of two-sided commitment in which both parties can commit to challenge the status quo and the party that unilaterally commits will gain a first-mover advantage in the ensuing conflict. In their model, a power shift can also lead to greater conflict when the rising state is initially weak; however, when the rising power becomes sufficiently strong, a further power shift would actually make conflict less likely.[3]

Our investigation is also related to the experimental studies about conflict resolution mechanisms such as side payments in Ultimatum bargaining games (Coursey and Stanley, 1988; Kimbrough and Sheremeta, 2013, 2014; Kimbrough et al., 2014, 2015) and in Nash demand games (Herbst et al., 2017), which may be followed by a conflict stage. In most of these studies, side payments or other bargaining arrangements are binding, thereby implicitly eliminating the commitment

[3] The relationship between outbreak of war and commitment was also discussed by Beviá and Corchón (2010), Chadefaux (2011), Wolford et al. (2011) and Krainin (2017).

problems. As an exception, Kimbrough and Sheremeta (2013) compare the effect of binding and non-binding side payments on reducing conflict. They find that non-binding side payments do not help reduce conflict, whereas binding ones do. Kimbrough et al. (2015) also study commitment problems, albeit in a different setup. In their game, a coin flip serves as a conflict resolution mechanism, the outcome of which, if not accepted by both players, would lead to a conflict stage where players exert costly effort to win a prize. They find that this non-binding coin flip may nevertheless reduce conflict rates. The commitment problem we study is, however, fundamentally different because it pertains to the inability to commit to bargaining allocations across *multiple* stages, which alongside the power shift may create the incentive to strike early by the untrusting opponent. In this scenario, conflict arises in anticipation of the commitment problem and is also theoretically inevitable. By contrast, in the setup adopted by Kimbrough et al. (2015), conflict follows immediately from a breakdown of commitment and does not convey the sense of inevitability.[4]

2. Theoretical framework

We model the preventive war scenario as a two-stage two-player bargaining game. In each stage, two players bargain over a pie worth one unit. In Stage 1, a rising player makes an offer to a declining player, $x_1^{DP} \in [0, 1]$. The declining player then observes x_1^{DP} and responds with either "accept" or "fight". If the declining player chooses "accept", the game moves on to Stage 2. If the declining player chooses "fight", there will be no Stage 2. In Stage 2, the two players bargain over another pie worth one unit. The rising player makes an offer $x_2^{DP} \in [0, 1]$. The declining player then observes x_2^{DP} and again responds with either "accept" or "fight". If the declining player chooses "accept" again, the game ends with both players receiving their respective share of the total bargaining pie according to the rising player's allocation decisions in the two stages. If "fight" occurs in either stage, any agreement about offers in Stage 1 will be nullified. In particular, suppose "fight" occurs in Stage 2, the offer in Stage 1 will not count and players' payoffs will only depend on the outcome of the fight. If the two players fight in either stage, they will compete for a prize worth two units, which is the total payoff across both stages.

An alternative modeling choice is that the fight would only affect the division of the current and future total bargaining pie, but not previous pie divisions. This setup is suitable for studying conflicts over a flow of resources that are immediately consumed. We, however, favor the current setup largely because it allows for a simpler model that can still reproduce the preventive war logic and is easier for laboratory implementation. Otherwise, the preventive war scenario could only arise when the future bargaining pie or the shadow of the future (embodied in an infinitely repeated game with a discount) is large enough. Further, in real life, many past agreements about resource sharing reached during peacetime can be revocable or retrievable during the conflict. One prominent example is territorial control, as in the case of the ongoing Russia-Ukraine War, in which each side is contending over the control of the regions of Crimea, Luhansk, and Donetsk.

To model the inefficiency of war as opposed to peace, each player also has to incur an irrevocable cost of fighting, C, which we set to $C < 1$ to avoid trivial outcomes. Each player's probability of winning the prize depends on their relative strength in the current stage. Importantly, compared to Stage 1, the rising player becomes stronger while the declining player becomes weaker in Stage 2. We model the relative strength directly as the declining player's probability of winning in a stage, which is P_1^{DP} in Stage 1 and P_2^{DP} in Stage 2 whereby $0 < P_2^{DP} < 0.5 < P_1^{DP} < 1$. Correspondingly, the rising player's probabilities of winning in the two stages satisfy $0 < P_1^{RP} < 0.5 < P_2^{RP} < 1$, $P_1^{RP} + P_1^{DP} = 1$ and $P_2^{RP} + P_2^{DP} = 1$. Fig. 1 displays the timing, decisions and payoffs of the game.

We apply the subgame perfect equilibrium (SPE) concept to solve the game. We need to distinguish two fundamentally different parameter constellations that lead to distinct SPE outcomes. Whether the SPE prediction is war or peace depends on whether or not it is possible to make an offer in Stage 1 that keeps the declining player satisfied.

Proposition. *Assume the power shift across the two stages* $0 < P_2^{DP} < 0.5 < P_1^{DP} < 1$. *If* $2P_1^{DP} - C \leq 1$, *then every SPE involves peace. If* $2P_1^{DP} - C > 1$, *then every SPE involves war.*

Proof. Let us first examine the latter case, in which war is strategically inevitable. We solve the game by backward induction. The declining player will fight in Stage 2 if

$$x_1^{DP*} + x_2^{DP} < 2P_2^{DP} - C \tag{1}$$

If the first-stage offer has been sufficiently high, the declining player has no interest in fighting. Hence, if $x_1^{DP*} \geq 2P_2^{DP} - C$, the declining player will accept the offer even if he is offered zero payoff in Stage 2. Note that this amount is less than one due to the assumption that $P_2^{DP} < 0.5$.[5] The declining player foresees that he (for convenience we will use 'he' for the declining player and 'she' for the rising player without inferring any particular gender) will not be offered a positive amount

[4] Our study may also be linked to market entry games in which an incumbent must decide whether or not to fight entry by a challenger. What may resemble the preventive war is the incumbent's commitment to a competitive pricing strategy if the challenger enters the market. In equilibrium the challenger enters with a certain probability. Lab experiments of this game typically find that aggregate behavior is remarkably consistent with the theoretical prediction (e.g., Sundali et al., 1995; Erev and Rapoport, 1998; Rapoport et al., 1998).

[5] This assumption also implies that the current setup lacks the capability to predict preventive war when the declining player's probability of winning shifts from, say, 0.95 in Stage 1 to 0.55 in Stage 2, for a sufficiently small conflict cost. A more generalized model, like an infinitely repeated version of the

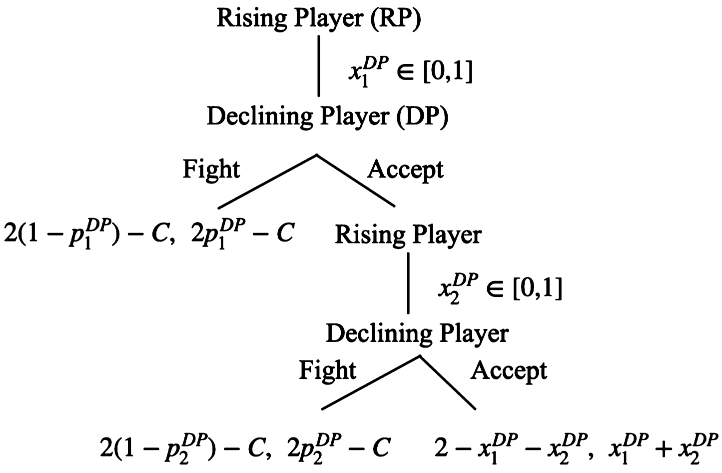


Fig. 1. The game tree.

in Stage 2 if the first-stage offer matches his expected payoff from fighting in the second stage. His total payoff will thus be no greater than 1. His payoff from fighting in Stage 1 is $2P_1^{DP} - C > 1$ (which is only possible if $P_1^{DP} > 0.5$), whereas his payoff from accepting is $x_1^{DP} + 0 \leq 1$. The problem here is that, even if the rising player offers everything she can offer in Stage 1 the declining player cannot be satisfied. Thus, in the absence of an enforcement mechanism, no commitment the rising player makes in Stage 1 would be credible. It is therefore more advantageous for the declining player to seek war in Stage 1.

If $2P_1^{DP} - C \leq 1$, fight at any stage is not an SPE outcome. As in the previous scenario, the declining player will fight if $x_1^{DP*} + x_2^{DP} < 2P_2^{DP} - C$. In an SPE, Stage 2 is only reached if the rising player's offer in Stage 1 was sufficiently high to deter the declining player from fighting at this stage. Thus $x_1^{DP*} \geq 2P_1^{DP} - C$. Since $2P_1^{DP} - C \leq 1$ this is now a feasible offer. And the declining player will not fight in stage 2 even if he is offered zero payoff in this stage because $x_1^{DP*} + x_2^{DP} \geq 2P_2^{DP} - C$ is automatically satisfied. Consequently, this condition together with (1) implies that the declining player will not fight even if offered zero payoff in the second stage. Hence, in an SPE, the rising player will offer zero in Stage 2.

It remains for us to show that it is in the rising player's interest to make a first-stage offer of at least $x_1^{DP*} = 2P_1^{DP} - C$. Recall that $P_1^{RP} < 0.5$. If the rising player offers less than that, the declining player will fight in Stage 1, and the rising player's payoff will be $2P_1^{RP} - C < 1$. If the rising player offers at least $x_1^{DP*} = 2P_1^{DP} - C$, the declining player will refrain from fighting and the game proceeds to Stage 2. As in this stage alone, the rising player receives a payoff of 1 (because $x_2^{DP*} = 0$), it is in the rising player's interest to move the game further to Stage 2. The rising player offers the smallest amount that ensures game continuation, hence $x_1^{DP*} = 2P_1^{DP} - C$. □

To demonstrate that commitment is the key issue in preventive wars, we retain the condition $2P_1^{DP} - C > 1$ and assume that the rising player has the commitment power. Specifically, in Stage 1, in addition to making the actual offer x_1^{DP} for this stage, the rising player also announces the plan of offer $x_2^{\hat{D}P} \in [0, 1]$ in Stage 2, which is binding, i.e. $x_2^{DP} = x_2^{\hat{D}P}$. Knowing that the declining player's war payoff in Stage 1 is $2P_1^{DP} - C$, the rising player's offers must satisfy $x_1^{DP} + x_2^{DP} \geq 2P_1^{DP} - C$. That is, any combination of x_1^{DP} and x_2^{DP} which is no less than the declining player's war payoff in Stage 1 will satisfy the declining player (who will choose "accept" in both stages) and will thus preclude the costly war. In the SPE, the rising player's payoff is $2(1 - P_1^{DP}) + C$ and the declining player's payoff is $2P_1^{DP} - C$. By allowing the declining player to commit to an offer in Stage 2, the game is essentially reduced to a single-stage game. As long as the rising player offers the declining player at least the declining player's war payoff, fighting will not occur and the commitment problem is irrelevant.

While lack of commitment should generally be considered as a real-world feature that is difficult to resolve, the proposed scenario is still reminiscent of some real-world situations in which at least partial commitment is possible. For example, the rising player's credibility of committing to future offers provides an analog to situations in which a nation's ability to renege on an agreement may be constrained by reputational concerns or anticipation of domestic or international backlash against repudiating the deal.

In the current model, the power shift is entirely exogenous. Chadefaux (2011) and Debs and Monteiro (2014) argued that power shifts, when made endogenous, for example, by the rising state's military investments but with relayed returns, may

game, could cover such an extensive range of power shifts and may predict preventive war under certain parameterization. However, the current setup is primarily designed to facilitate lab experimental implementation, thus some of its assumptions are intentionally simplified, compromising on the extent of generalization.

be precluded by the threat of preventive war. Hence the commitment problem does not arise in the first place, and peace prevails regardless of the degree of possible power shifts, because the rising state is deterred from making investments that produce such power shifts. This argument, however, only holds when investments in military capabilities are transparent. When the rising state may secretly make investments, the declining state may again find preventive war a rational action, even without evidence that such investment is underway. We hope to study the role of endogenous power shift under our experimental framework in the future.

3. Experimental design and hypotheses

3.1. Treatments

3.1.1. The PreventiveWar treatment (baseline)

The basic experimental design follows the model setup and commences with the baseline *PreventiveWar* treatment, whereby each session consists of 20 rounds. In each round, two players are randomly matched and randomly assigned to the role of the rising player and the declining player (which are referred to as Person A and Person B respectively in the experiment). Each player starts with an endowment of 5 tokens per round, which can be used to cover any potential loss from the game. Each round has two stages. In Stage 1, the rising player makes an offer out of a pie worth 10 tokens as well as announces the plan for her offer in Stage 2 (fraction of another pie worth 10 tokens). Upon considering the rising player's offer and plan, the declining player decides whether to "accept" or "reject" in this stage.[6] Both players' decisions and plans made in Stage 1 will be revealed after this stage is completed. The players are informed in the instructions as well as on their computer screens that their plans are not binding, and therefore, they will be free to change their decisions whenever the game proceeds to Stage 2.

If fighting occurs (i.e., the declining player chooses "reject") in Stage 1, the rising player's offer will not be implemented and the two players will compete for a prize worth 20 tokens, whereby participation in conflict incurs a cost of 5 tokens per person. The computer will decide who receives the prize according to their probability of winning in Stage 1: 20% for the rising player and 80% the declining player ($P_1^{DP} = 0.8$). The round will end without proceeding to Stage 2.

When the game proceeds to Stage 2 (i.e., the declining player chooses "accept" in Stage 1), the rising player makes an offer out of another pie worth 10 tokens. The declining player observes the rising player's offer and decides whether to "accept" or "reject" it. If the declining player chooses "reject", this will nullify the rising player's offers in *both* stages, which will thus not be implemented and the two players will compete for a total prize worth 20 tokens, each incurring a cost of 5 tokens. The computer will decide who receives the prize according to their probability of winning in Stage 2, which is set to 70% for the rising player and 30% for the declining player ($P_2^{DP} = 0.3$). This scenario represents a large power shift favoring the rising player in Stage 2. If, however, the declining player chooses "accept", both players will receive their respective payoffs corresponding to the rising player's offers in the two stages.

According to the theoretical analysis in the previous section, the declining player will choose "reject" in Stage 1 regardless of the rising player's offer and plan. Thus, the declining player's expected equilibrium payoff in a round is $20 * 0.8 - 5 = 11$ tokens and the rising player's expected equilibrium payoff is $20 * (1 - 0.8) - 5 = -1$ token. Hence, the baseline PreventiveWar treatment illustrates the scenario of preventive wars.

3.1.2. The NoWar treatment

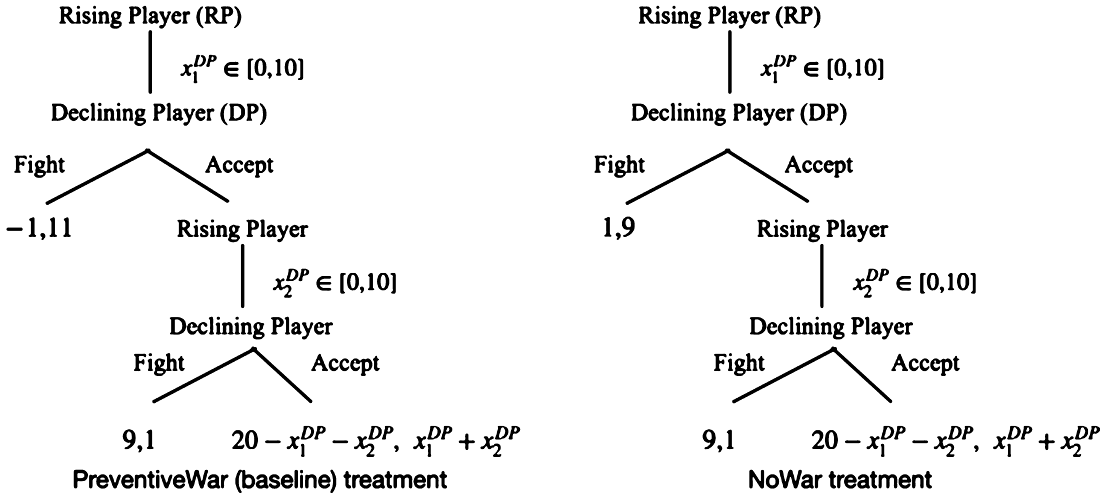
To examine the influence of power shifts (which cause the commitment problem), we implemented the *NoWar* treatment which differs from the PreventiveWar treatment only in terms of the rising player's winning probability in Stage 1, which is increased from 20% to 30%, thereby reducing the declining player's winning probability to 70%. This seemingly small parameter change eliminates the commitment problem because the declining player's expected war payoff in Stage 1 is now $20 * 0.7 - 5 = 9$ tokens, which is less than the maximum possible offer (10 tokens) the rising player can make in Stage 1. Therefore, in the SPE, the rising player's offer is exactly 9 tokens in Stage 1 and 0 token in Stage 2. In equilibrium, the declining player chooses to accept the offer in both stages and receives 9 tokens while the rising player's payoff is 11 tokens. Fig. 2 displays the game trees pertaining to the PreventiveWar and NoWar treatments with their respective parameterization.

Owing to a slight difference in the rising player's winning probability in Stage 1 (as a sort of "discontinuity" design), the PreventiveWar and NoWar treatments produce sharply contrasting theoretical predictions. However, the comparison between these two treatments provides a rather conservative test of the logic behind preventive wars since the change in incentive seems subtle. In Section 5.2, we will introduce two additional treatments with a much stronger separation and additionally test whether the likelihood of preventive wars is sensitive to the fighting cost.

3.1.3. The RP-commit treatment

While the NoWar treatment is designed to test for the commitment problem through change in the parameter and therefore the incentive for launching a preventive war, in the *RP-Commit* treatment we manipulate directly the rising player's

[6] In addition to deciding whether to accept or reject the first-stage offer, the declining player is also asked to make a non-binding announcement of his plan for Stage 2. If he chooses "accept", he announces whether he would be willing to "accept" or "reject" each of the possible the rising player's offers in Stage 2. If the declining player chooses "reject" in Stage 1, such an announcement becomes superfluous.



Notes: The fighting payoffs are the expected payoffs given the winning probabilities in each situation. The payoffs are chosen such that theory predicts preventive war (fighting at Stage 1) in the baseline treatment and peace in the NoWar treatment.

Fig. 2. Parameterization in the PreventiveWar and NoWar treatments.

Table 1
The experimental design.

Main treatments	DP's prob. of winning in stage 1 (P_1^{DP})	Fighting cost (C)	Preventive war? (SPE)	Equilibrium payoff[a]	No. of participants
PreventiveWar	0.8	5	Yes	$\pi_{RP} = -1$ $\pi_{DP} = 11$	80
NoWar	0.7	5	No	$\pi_{RP} = 11$ $\pi_{DP} = 9$	80
RP-Commit	0.8	5	No	$\pi_{RP} = 9$ $\pi_{DP} = 11$	70
Additional treatments					
Chat	0.8	5	Yes	$\pi_{RP} = -1$ $\pi_{DP} = 11$	80
Repeat	0.8	5	Yes	$\pi_{RP} = -1$ $\pi_{DP} = 11$	80
HighCost	0.8	9	No	$\pi_{RP} = 13$ $\pi_{DP} = 7$	40
LowCost	0.8	1	Yes	$\pi_{RP} = 3$ $\pi_{DP} = 15$	40

Notes: [a] All payoffs exclude a 5-token per-round endowment. The specifics of additional treatments are introduced in Section 5. In the *Chat* treatment, players could send free-form messages to each other for two minutes at the beginning of each round. In the *Repeat* treatment, each RP—DP pair is always matched and their roles are fixed across all rounds.

ability to commit to her plan. Specifically, the rising player must commit to her plan for Stage 2. In the instructions, the rising player is told that the computer will automatically implement her plan if the game proceeds to Stage 2. Thus, the rising player essentially makes decisions for both stages at the same time and the game essentially reduces to a one-stage game. All other parts of the design are the same as in the PreventiveWar treatment. The SPE predicts that the sum of the rising player's demands in both stages will be 20 * (1 – 0.8) + 5 = 9 tokens; the declining player chooses to accept in both stages and receives 20 * 0.8 – 5 = 11 tokens.

The upper panel of Table 1 summarizes the key features and equilibrium predictions of the three main treatments.

3.2. Hypotheses

Our main hypotheses regarding whether the declining player initiates the preventive war follow immediately from the SPE prediction:

Hypothesis 1. The declining player is more likely to choose to fight in Stage 1 in PreventiveWar than in NoWar treatment.

Remark 1. According to the SPE, we also expect that the declining player's likelihood to fight in Stage 1 is not conditional on the rising player's offer in PreventiveWar. However, we expect to observe a sharp decline in this likelihood when the rising player's offer in Stage 1 is at least 9 tokens in NoWar. Furthermore, we expect the rising player's non-binding announcement of her plan to be a mere cheap talk and thus it should not have any impact on the declining player's decision. If this is the case, this would provide indirect evidence supporting our theoretical claim that commitment is the key issue.[7]

Hypothesis 2. The declining player is more likely to choose to fight in Stage 1 in PreventiveWar than in RP-Commit treatment.

Remark 2. In RP-Commit, according to the SPE, RP's combined offer across both stages should be 11 tokens. Consequently, we expect to observe a sharp decline in the declining player's likelihood of fighting in Stage 1 when RP's total offer is higher than 11 tokens.[8]

3.3. Experimental procedure

The experiment was programmed in z-Tree (Fischbacher, 2007) and was conducted at the Economics Experimental Laboratory of the Nanjing Audit University (NEXL). We recruited 230 participants from a university-wide student pool and organized 23 sessions, each with 10 participants. The participants were randomly assigned to partitioned computer terminals upon arrival. They received experimental instructions (see Appendix A) in written form, which were also read aloud by the experimenter at the start of each session. The experiment started once all participants completed their comprehension quiz questions about the instructions. At the end of the experiment, participants completed a survey inquiring into their demographics and strategies used in the game. Participants were paid 1 RMB for every 5 tokens they accumulated in all rounds, in addition to 15 RMB for taking part in the experiment (with decimals in the final amount rounded to the nearest tenth). A typical session lasted about one hour with average earnings of 64.1 RMB (approximately US$9.9).[9]

4. Experimental results

4.1. Comparing PreventiveWar and NoWar: does a larger power shift lead to more preventive wars?

Fig. 3 shows the frequency of preventive wars, i.e. the likelihood of declining players' decision to fight in Stage 1 across treatments. As shown in Column (1) of Table 2, on aggregate, the declining player was significantly more likely to initiate preventive wars in PreventiveWar than in NoWar (56.6% vs. 41.0%, see hypothesis test H0: $\beta_0 = 0$, $p = 0.004$),[10] in line with Hypothesis 1. Fig. B1 in Appendix B shows the frequency of preventive wars across rounds, suggesting a lower frequency in NoWar than in PreventiveWar in almost all rounds as well as a somewhat widened treatment difference in later rounds.

Fig. 4 shows rising players' offers in both stages. In the NoWar treatment, the rising player's offer of at least 9 tokens in Stage 1 should theoretically satisfy the declining player who should then refrain from fighting. However, in the PreventiveWar treatment, offering all 10 tokens, which is the most the rising player can do in Stage 1, should still be theoretically insufficient. We indeed observe that the amount offered in Stage 1 increases as the rounds progress and tends to the maximum amount that the rising player could offer in Stage 1. In the NoWar treatment, the rising player offered on average 7.7 tokens to the declining player, with 9 tokens accounting for 9.4% and 10 tokens for 41.4% of cases. In the PreventiveWar treatment, the average offer was 8.3 tokens, with 9 tokens accounting for 7.5% and 10 tokens for 54.3% instances. Thus, offering 10 to the declining player in Stage 1 was the modal behavior in both treatments. On the other hand, if the game proceeds to Stage 2, the rising player should optimally offer 0 in this stage. Indeed, the rising player's Stage 2 offer declined to almost zero. In the NoWar and PreventiveWar treatments, the average offer was 0.78 and 0.47 tokens, respectively. There is no evidence of treatment difference in offers made in either stage.[11] These results strengthen our confidence that our subjects correctly interpreted the underlying incentive: those in the rising player role tried their best to satisfy the declining player in Stage 1 even when it was impossible to do so, especially in the PreventiveWar treatment. However, they seized the chance to secure almost all tokens in Stage 2 when they were more powerful than the declining player.

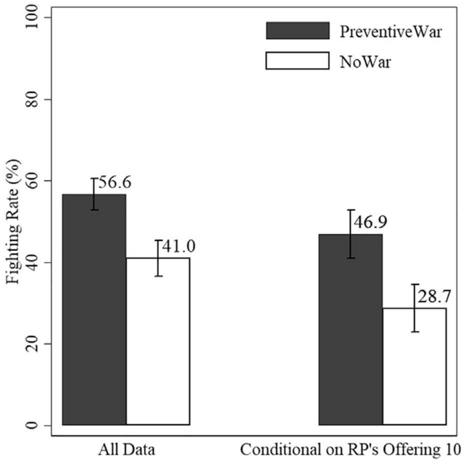
[7] Note that non-binding announcements may facilitate tacit bargaining agreement. But this feature would not affect our inferences based on treatment comparisons as it is implemented in all but one treatment. The potential reason for caution is the comparison between the PreventiveWar and RP-Commit treatments, where the announcement is non-binding in the former but binding in the latter. Suppose the non-binding announcements would work as a form of tacit commitment that is strong enough to reduce conflict propensity. In that case, the frequency of preventive war might be underestimated in the PreventiveWar treatment. But this would work in favor of our hypothesis regarding the commitment capacity: the frequency of preventive war should be lower in the RP-Commit treatment than in the PreventiveWar treatment.

[8] It is worth noting that, in equilibrium, the declining player's expected payoff in RP-Commit is the same as in PreventiveWar. Thus, the declining player could have chosen to fight in RP-Commit and would have obtained the same expected payoff. However, the resolution via fighting is both socially costlier and more uncertain than that via bargaining. Hence, if the declining player is risk-averse, one may expect that he would prefer not to initiate the preventive war when the rising player has the commitment power. However, risk aversion does not undermine the logic of preventive wars because the effectiveness of commitment power lies precisely in resolving the uncertainty about the rising player's offer in Stage 2. In the absence of this logic, risk aversion alone is unlikely to explain any differences in treatment outcomes.

[9] The average per-hour earnings in the experiment were substantially higher than the minimum hourly wage which is about 15-20 RMB in the local region.

[10] Unless otherwise stated, all p values in this subsection relate to the coefficient estimates from random effects probit regressions reported in Table 2.

[11] The test is conducted using a random effects regression by regressing either Stage 1 or Stage 2 offer on the "treatment" variable and "round" variable with standard errors clustered at the session level.



Notes: This figure shows the frequency of preventive wars using the full sample as well as conditional on the rising player's offering 10 tokens at Stage 1. Error bars represent one standard error of the mean clustered at the session level.

Fig. 3. The frequency of preventive wars.

Table 2
Random effects probit regressions of preventive wars (without commitment).

Dependent variable: fight in Stage 1 = 1	(1)	(2)	(3)	(4)
β_0: NoWar	-0.189^{***}	-0.193^{**}	-0.271^{***}	-0.224^{***}
	(0.055)	(0.096)	(0.075)	(0.085)
β_1: **1**[RP's Stage 1 offer = 10]		-0.396^{***}		0.396^{***}
		(0.055)		(0.054)
β_2: NoWar × **1**[RP's Stage 1 offer = 10]		−0.102		−0.097
		(0.090)		(0.084)
β_3: **1**[RP's Stage 1 offer < 9]			0.381^{***}	
			(0.070)	
β_4: NoWar × **1**[RP's Stage 1 offer < 9]			0.104	
			(0.102)	
β_5: RP's Stage 2 plan				−0.003
				(0.006)
β_6: NoWar × RP's Stage 2 plan				0.007
				(0.011)
Round	−0.001	0.016^{***}	0.017^{***}	0.016^{***}
	(0.003)	(0.004)	(0.004)	(0.004)
H0: $\beta_0 + \beta_2 = 0$		$p = 0.001$		$p = 0.002$
H0: $\beta_0 + \beta_4 = 0$			$p = 0.142$	
Observations	1600	1600	1600	1600
Clusters	16	16	16	16

Notes: Standard errors clustered at the session level are given in parentheses. Average marginal effects are reported. PreventiveWar serves as the benchmark.
** $p < 0.05$.
*** $p < 0.01$.

Next, we conduct conditional analyses to examine the influence of the rising player's Stage 1 offer on the declining player's decision.[12] Conditional on the rising player offering 10 tokens, which is theoretically sufficient to avoid preventive wars in NoWar but not in PreventiveWar, we find a somewhat widened and significantly higher frequency of fighting in PreventiveWar than in NoWar (46.9% vs. 28.7%, see Fig. 3, Column (2) in Table 2, and hypothesis test H0: $\beta_0 + \beta_2 = 0$, $p = 0.001$).[13] This is again consistent with Hypothesis 1. Conversely, conditional on the rising player offering fewer than 9 tokens, which is theoretically insufficient to avoid preventive wars in either treatment, the frequency of fighting was

[12] Fig. B2 in Appendix B shows the distribution of the rising player's Stage 1 offer and the frequency of preventive wars conditional on each possible offer in this stage.

[13] Theoretically, the rising player's offer of 9 tokens is sufficient to avoid preventive wars in the NoWar treatment. The regression results are robust to this offer amount in Stage 1 as the independent variable.

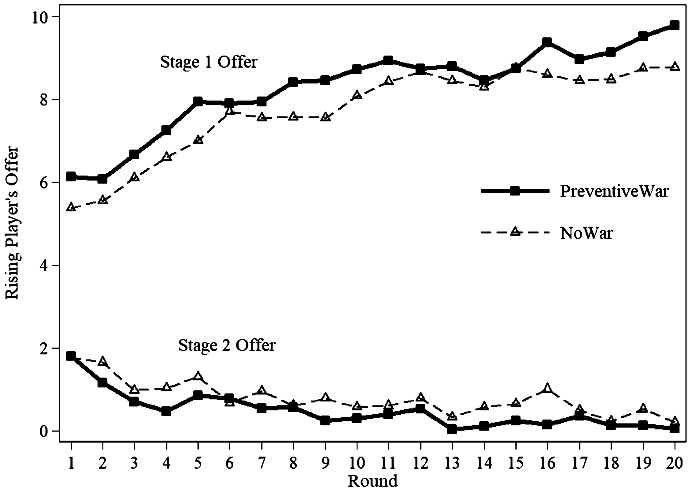


Fig. 4. Rising players' offers in both stages over rounds.

69.3% in PreventiveWar and 53.6% in NoWar. The difference is smaller and not statistically significant (see Column (3) in Table 2 and hypothesis test H0: $\beta_0 + \beta_4 = 0$, $p = 0.142$). Thus, as predicted, when the rising player's Stage 1 offer could not satisfy the declining player (as it is below 9 tokens), the declining player's propensity to initiate preventive wars was not significantly different between the two treatments. Furthermore, the significant estimate of the "round" variable indicates that, in PreventiveWar, the declining player rejected the rising player's insufficient offer in Stage 1 more often in later rounds, suggesting that the declining player learned to adopt the equilibrium strategy more often.

It is worth noting that the declining player's propensity to initiate preventive wars significantly increased even in PreventiveWar when the rising player's offer was sufficiently low (see Column (3) in Table 2 and hypothesis test H0: $\beta_3 = 0$, $p < 0.001$). Thus, contrary to the theoretical prediction, the declining player's decision was conditional on the rising player's Stage 1 offer even when preventive wars were theoretically unavoidable. This observation might be attributed to the declining player's risk aversion, since securing 9 or 10 tokens might be more attractive to the declining player than receiving 11 tokens in expectation through the preventive war. It might also be ascribed to the focal behavior when the Stage 1 offer was 10, which—albeit not theoretically sufficient for the declining player to avoid fight—was perceived as fair allocation and was thus accepted with high likelihood.[14]

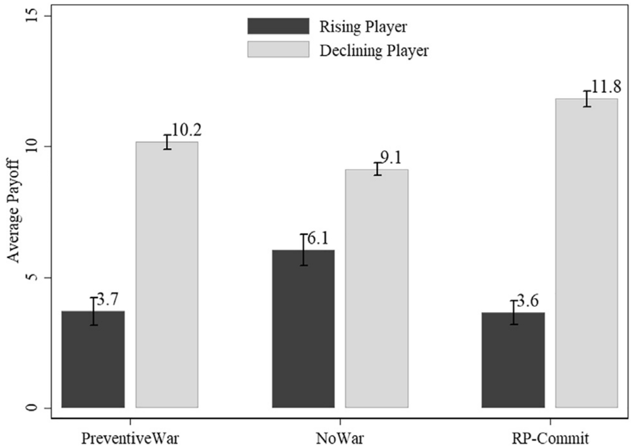
The theory also predicts that the rising player's announcement of the allocation plan for Stage 2 should not have any impact on the declining player's decision in either treatment. This is confirmed in the data (see Column (4) in Table 2, where β_5 and β_6 estimates are insignificant), providing further evidence that our subjects understood the commitment problem and treated such announcement as a mere cheap talk.

Next, we briefly examine players' decisions when the game proceeds to Stage 2 (i.e. when the preventive war did not occur). In PreventiveWar, the declining player chose to fight in Stage 2 in 11.0% of the cases, almost exclusively when the rising player offered fewer than 10 tokens in total. A similar pattern was observed in NoWar, in which the declining player chose to fight in Stage 2 in 12.3% cases, again mostly in response to the total offer of fewer than 10 tokens. We also find that in both treatments the rising player's total offer was never lower than 3 tokens. Given that the declining player's expected payoff from fighting in Stage 2 (excluding the 5-token endowment) was only one token, fighting in this stage was never a materially optimal decision for the declining player. Thus, although the Stage 1 fighting rate is generally low, the fact that the declining player sometimes chose to fight suggests that they might care about fair allocation even at their own cost.

Last, because of the less frequent war at Stage 1 in NoWar but otherwise similar behavior in Stage 2, the rising player's final payoff (excluding the endowment) was significantly higher in NoWar than in PreventiveWar (6.1 vs. 3.7, see Fig. 5 and Column (1) of Table B1 in Appendix B for statistical evidence yielded by a random effects regression, H0: $\beta_0 = 0$, $p = 0.003$). By contrast, the declining player's final payoff was significantly lower in NoWar than in PreventiveWar (9.1 vs. 10.2, see Column (1) of Table B1, H0: $\beta_0 + \beta_3$, $p = 0.004$). These results are qualitatively consistent with the theoretical prediction. However, the rising player still earned much more than the declining player, let alone reversing the earning gap in NoWar as theory would predict (see Table 1). Finally, by summing up both players' payoffs in Fig. 5, we also learn that the overall loss due to conflict as a share of the total pie is around 30.5% and 24.0% in PreventiveWar and NoWar, respectively.

In sum, the results related to the PreventiveWar and NoWar treatments suggest that the initiation of preventive wars is not due to the declining player's unconditional propensity to fight. In contrast to the NoWar treatment, the rising player is simply unable to satisfy the declining player at Stage 1 in the PreventiveWar treatment. Observing more fighting at Stage 1

[14] Güth et al. (2001) find in a mini Ultimatum game that the absence of the equal split option significantly reduces the frequency of fair offers. In light of their finding, the presence of the equal split option in our setting may drive up the frequency of such focal behavior.



Note: Error bars represent one standard error of the mean clustered at the session level.

Fig. 5. The rising player's and declining player's average payoffs (excluding 5-token endowment).

Table 3
Random effects probit regressions of preventive wars (with commitment).

Dependent variable: fight in Stage 1 = 1	(1)	(2)
β_0: RP-Commit	-0.150^{***}	
	(0.056)	
β_1: $\mathbf{1}$[RP's total offer $\geq$ 11]		-0.366^{***}
		(0.039)
Round	-0.005	-0.003
	(0.004)	(0.005)
Observations	1500	700
Clusters	15	7

Notes: Standard errors clustered at the session level are given in parentheses. Average marginal effects are reported. PreventiveWar serves as the benchmark in Column (1), and Column (2) only includes RP-Commit.
*** $p < 0.01$.

in the PreventiveWar treatment confirms our theoretical claim that the inability to commit to one's decision in the future stage is one of the key reasons for the preventive war.

Result 1. *The greater power shift, which results in the rising player's inability to satisfy the declining player within one stage, causes more preventive wars. As a result, the rising player earned less while the declining player earned more compared to the scenario in which the rising player could satisfy the declining player within one stage.*

4.2. Comparing PreventiveWar and RP-commit: does commitment capability lead to fewer preventive wars?

To provide more direct evidence for the commitment problem, in the RP-Commit treatment we allowed the rising player to commit to offers in both stages at the beginning of the game. On aggregate, the declining player was less likely to initiate the preventive war compared to PreventiveWar (44.3% vs. 56.6%, $p = 0.003$, see Column (1) in Table 3 and hypothesis test H0: $\beta_0 = 0$, $p = 0.007$),[15] in line with Hypothesis 2. Thus, the commitment power does help reduce the likelihood of the preventive war. Fig. B1 in Appendix B shows the frequency of preventive wars across rounds, suggesting a lower frequency in RP-Commit than in PreventiveWar in most rounds. The frequency also tends to decrease across successive rounds in RP-Commit.

To examine in more detail whether the rising player used her commitment power to her advantage, we next test how the declining player's decision depends on the rising player's offers in two stages.[16] In RP-Commit, the rising player offered 10 tokens in Stage 1 in only 24.1% of the cases because the rising player tended to even out the offers across two stages. Given the rising player's commitment power, it is thus more informative to directly examine the rising player's total offer,

[15] Unless otherwise stated, all p values in this subsection relate to the coefficient estimates from random effects probit regressions reported in Table 3.
[16] Fig. B3 in Appendix B shows the distribution of the rising player's total offer and the frequency of preventive wars conditional on each possible total offer.

which steadily increased across successive rounds and generally exceeded the theoretical optimal amount of 11 tokens. Conditional on the rising player offering at least 11 tokens in total, which is theoretically sufficient to avoid preventive wars, the frequency of fighting was 31.8%. By contrast, conditional on the rising player offering fewer than 11 tokens in total, the frequency was 59.8%. The difference is statistically significant (see Column (2) in Table 3 and hypothesis test H0: $\beta_1 = 0$, $p < 0.001$). These findings suggest that commitment helps reduce the likelihood of preventive war whenever the rising player's total offer is sufficiently high according to the theoretical threshold. However, the rising player did not always use her commitment power to avoid the war, as her total offer was still lower than 11 tokens in 42.2% of the cases (in which preventive wars were prevalent, as noted earlier).

In addition to the issue of making inadequate offer, the rising player sometimes offered more than 11 tokens, which helped avoid conflict. One possible explanation is that some rising players might have been uncertain about how much they needed to offer to appease the declining player and, therefore, they chose to offer a more-than-equilibrium amount to avoid conflict. On balance, the rising player's offer-making pattern failed to improve her final payoff as shown in Fig. 5. The rising player's final payoff in RP-Commit was almost the same as that in PreventiveWar (3.6 vs. 3.7, see Column (2) of Table B1 in Appendix B, H0: $\beta_1 = 0$, $p = 0.943$). On the other hand, the declining player's final payoff was significantly higher in RP-Commit than in PreventiveWar (11.8 vs. 10.2, see Column (2) of Table B1 in Appendix B, H0: $\beta_1 + \beta_4 = 0$, $p < 0.001$). The overall loss due to conflict as a share of the total pie is around 23%. Thus, while the rising player used her commitment power to reduce the frequency of preventive wars, she failed to generate material advantage. In the end, perhaps surprisingly, it was the declining player who benefited from the rising player's commitment power.

Result 2. *Endowing the rising player with the power of committing to the future offer led to less frequent preventive wars. However, the rising player's offer sometimes exceeded the equilibrium level, resulting in no improvement in her final payoff.*

5. Additional treatments

5.1. Can behavior be closer to the theoretical prediction?

In two of our main treatments (PreventiveWar and NoWar), we only slightly changed the expected payoff of preventive wars so that the theory predicts preventive war in one case and peace in the other. Given such parameterization, however, these treatments provide a rather tough test of the theoretical prediction. The results also suggest that the declining player was far from making theoretically optimal decision in either treatment (the frequency of preventive wars was 56.6% instead of 100% in PreventiveWar, and 41.0% instead of 0% in NoWar). Here, we introduce two additional treatments that allow a greater treatment separation by widening the gap in the expected payoffs of preventive wars still further. We achieve this goal by changing the fighting cost C (see Fig. 1).

In the *HighCost* treatment, $C = 9$ and the declining player's expected payoff of fighting in Stage 1 is only 7 tokens. Therefore, as in the NoWar treatment, the rising player could satisfy the declining player in Stage 1 and preventive wars could be avoided in theory. By contrast, in the *LowCost* treatment, we adopt $C = 1$ and the declining player's expected payoff of fighting in Stage 1 increases to 15 tokens. Therefore, as in the PreventiveWar treatment, as the rising player cannot satisfy the declining player in Stage 1, preventive wars are unavoidable. Note that the gap in the expected payoff of preventive wars between HighCost and LowCost increases to 8 tokens compared to merely 2 tokens between NoWar and PreventiveWar.

We conducted four sessions for each treatment, recruiting a total of 80 participants from the same student pool. The lower panel of Table 1 summarizes the design of the HighCost and LowCost treatments. Fig. 6 displays the game trees of the two treatments with their respective parameterization.

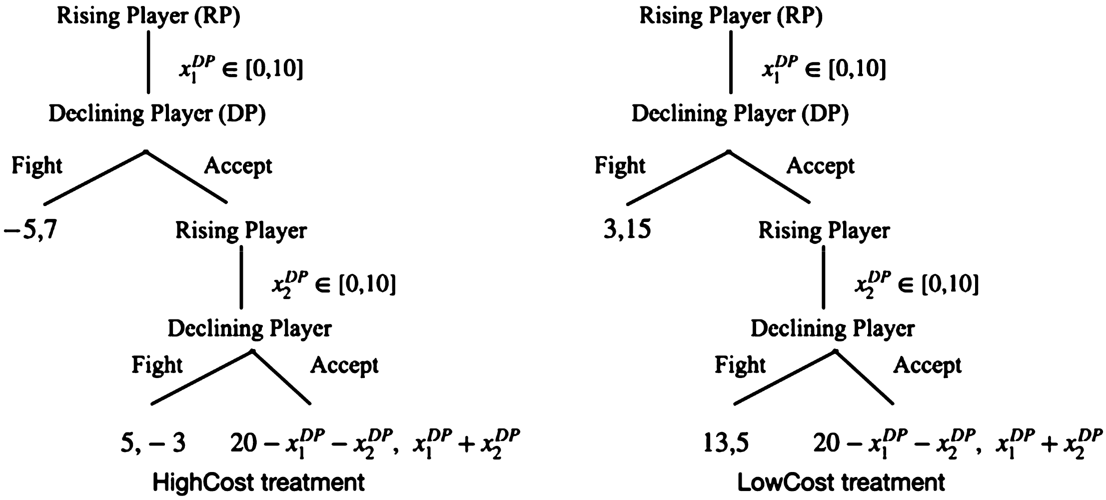
5.1.1. Main results

Fig. 7 shows the frequency of preventive wars in the HighCost and LowCost treatments. Compared to PreventiveWar, the declining player was significantly less likely to initiate the preventive war when the fighting cost was high (56.6% vs. 26.8%, see Column (1) in Table 4, H0: $\beta_0 = 0$, $p < 0.001$). By contrast, the frequency of preventive wars was significantly higher when the fighting cost was low (56.6% vs. 71.8%, see Column (1) in Table 4, H0: $\beta_1 = 0$, $p = 0.006$). This finding is consistent with the theoretical prediction. Fig. B4 in Appendix B shows the frequency of preventive wars across rounds, revealing a consistently higher fighting rate in the HighCost treatment and a lower fighting rate in the LowCost treatment compared to the PreventiveWar treatment. In particular, the preventive war frequency in the HighCost treatment was close to zero in later rounds. Thus, the declining player's decision was indeed sensitive to the fighting cost parameter, leading to a much greater treatment difference and almost eliminating preventive wars when the fighting cost was high enough.[17]

Turning to the conditional analysis, conditional on the rising player offering 10 tokens, the frequency of preventive wars was only 7.8% in the HighCost treatment, which was significantly lower than that in the PreventiveWar treatment (see Fig. 7 and Column (2) in Table 4, H0: $\beta_0 + \beta_3 = 0$, $p < 0.001$). The frequency remained high (65.2%) in the LowCost treatment, and was significantly higher than that in the PreventiveWar treatment (see Column (2) in Table 4, H0: $\beta_0 + \beta_4 = 0$, $p = 0.014$).[18]

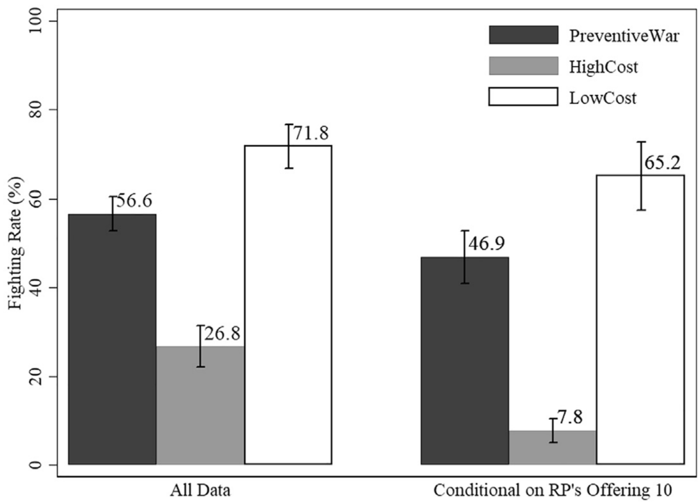
[17] Fig. B5 in Appendix B shows rising players' offers in both stages, exhibiting a very similar pattern in both treatments as in the PreventiveWar treatment.

[18] Fig. B6 in Appendix B shows the distribution of the rising player's stage 1 offer and the frequency of preventive wars conditional on each possible Stage 1 offer in the HighCost and LowCost treatments.



Notes: The fighting payoffs are the expected payoffs given the winning probabilities and fighting cost ($C = 9$ in *HighCost* and $C = 1$ in *LowCost*) in each situation. The payoffs are chosen such that theory predicts preventive war (fighting at Stage 1) in the HighCost treatment and peace in the LowCost treatment.

Fig. 6. Parameterization in the HighCost and LowCost treatments.



Notes: This figure shows the frequency of preventive wars using the full sample as well as conditional on the rising player offering 10 tokens at Stage 1. Error bars represent one standard error of the mean clustered at the session level.

Fig. 7. The frequency of preventive wars (HighCost and LowCost treatments).

It is worth noting that, when the fighting cost was low, the frequency of preventive wars was no longer sensitive to the Stage 1 offer: the frequency did not differ between cases in which the offer was 10 and less than 10 tokens (see Column (2) in Table 4, H0: $\beta_4 = 0$, $p = 0.468$). This result implies that the equal split of all resources is not necessarily considered as a focal behavior, which appears to have contributed to the low frequency of preventive wars when the Stage 1 offer was 10 tokens in the PreventiveWar treatment. Instead, the declining player considered the size of the expected payoff of preventive wars, as implied by the logic of preventive wars.

However, when the fighting cost was high, as shown in Fig. B6 in Appendix B, the preventive war frequency was particularly sensitive to whether the Stage 1 offer was 10 tokens (see Column (2) in Table 4, H0: $\beta_3 = 0$, $p < 0.001$). Thus, the declining player did not apply the logic of preventive wars “asymmetrically” but rather insisted on fair allocation although a Stage 1 offer exceeding 7 tokens was theoretically sufficient to avoid preventive wars. This behavior might be explained by the declining player’s willingness to teach the rising player a hard “lesson” at his own cost. This strategy appears to work well for both players since the Stage 1 offer was almost always 10 tokens and the preventive war was almost eliminated in later rounds.

Finally, as expected, because of the rather low frequency of preventive wars in the HighCost treatment, the rising player’s and the declining player’s payoffs became more equalized. The rising player’s payoff was significantly higher than that in the PreventiveWar treatment (5.8 vs. 3.7, see Fig. B7 and Column (1) of Table B2 in Appendix B, H0: $\beta_0 = 0$, $p = 0.021$),

Table 4
Random effects probit regressions of preventive wars (HighCost and LowCost treatments).

Dependent variable: reject in Stage 1 = 1	(1)	(2)
β_0: HighCost	-0.328^{***}	-0.025
	(0.061)	(0.067)
β_1: LowCost	0.190^{***}	0.158^{***}
	(0.069)	(0.053)
β_2: $\mathbf{1}$[RP's Stage 1 offer = 10]		-0.348^{***}
		(0.049)
β_3: HighCost $\times$ $\mathbf{1}$[RP's Stage 1 offer = 10]		-0.422^{***}
		(0.095)
β_4: LowCost $\times$ $\mathbf{1}$[RP's Stage 1 offer = 10]		0.073
		(0.101)
Round	-0.004	0.016^{***}
	(0.006)	(0.004)
H0: $\beta_0 + \beta_3 = 0$		$p < 0.001$
H0: $\beta_0 + \beta_4 = 0$		$p = 0.014$
Observations	1600	1600
Clusters	16	16

Notes: Standard errors are clustered at the session level. Average marginal effects are reported. PreventiveWar serves as the benchmark.
*** $p < 0.01$.

whereas the declining player's payoff was significantly lower than that in the PreventiveWar treatment (9.0 vs. 10.2, see Column (1) of Table B2, H0: $\beta_0 + \beta_3 = 0$, $p < 0.001$). By contrast, because of the high frequency of preventive wars in the LowCost treatment, the rising player's and the declining player's payoffs became even more unequal. However, due to the lower fighting cost, the rising player's payoff was still marginally significantly higher than that in the PreventiveWar treatment (4.8 vs. 3.7, see Fig. B7 and Column (2) of Table B2 in Appendix B, H0: $\beta_1 = 0$, $p = 0.059$). On the other hand, the declining player's payoff was significantly higher than that in the PreventiveWar treatment (13.7 vs. 10.2, see Column (2) of Table B2, H0: $\beta_1 + \beta_4 = 0$, $p < 0.001$).

Result 3. *A higher fighting cost led to much lower frequency of preventive wars and almost eliminated them in later rounds. By contrast, a lower fighting cost led to even higher frequency of preventive wars which was insensitive to the Stage 1 offer.*

5.2. Do other mechanisms help reduce preventive wars in the absence of commitment capability?

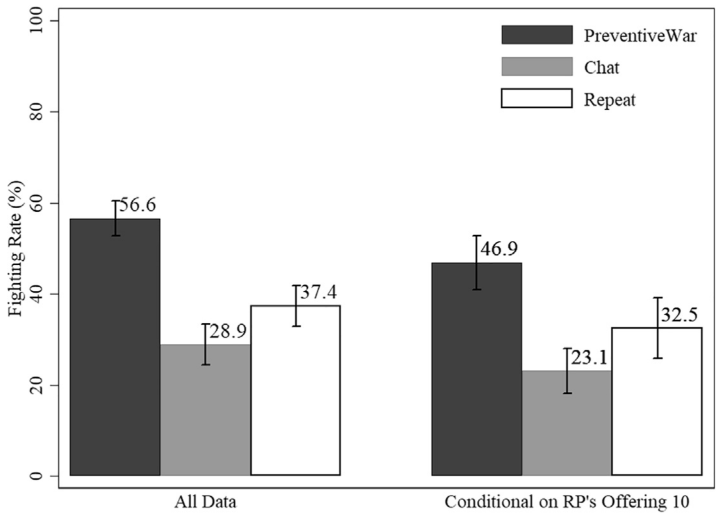
The main three treatments have shown that the lack of power to commit to bargaining allocations over multiple stages is the key to the logic of preventive wars. However, absence of commitment power is a real-world feature which we cannot simply assume away or expect some party to either self-commit or be forced to commit. In reality, states with conflicting interests usually strive to maintain peace through other mechanisms. One diplomatic strategy commonly adopted in this case is resolving conflict of interest through bargaining via direct communication. A large body of behavioral economics literature has shown that communication, even cheap talk, can promote cooperation and achieve higher efficiency (e.g., Dawes et al., 1977; Balliet, 2009). Moreover, throughout history, potential conflicts such as the Cuban Missile Crisis were indeed avoided via diplomatic means.

Another conflict-prevention mechanism involves building reputation by maintaining a tough position during the bargaining process or even by engaging in limited conflict. Reputation is, however, often developed gradually and requires repeated and consistent interaction. A considerable effort has been devoted in the extant theoretical and experimental literature to understanding how two interacting parties maintain cooperation through history-dependent strategies such as tit-for-tat (e.g., Axelrod, 1984; Dal Bó and Fréchette, 2018).

In this section, we investigate whether communication and repeated interaction help decrease the risk of preventive wars in the absence of commitment capability (note that both mechanisms might convey "soft" commitment). We thus designed two additional treatments based on the baseline PreventiveWar treatment.

To investigate the effect of communication, we introduce the *Chat* treatment, which differs from PreventiveWar only in that the rising player and the declining player could send free-form messages to each other for two minutes at the beginning of each round.

To investigate the effect of repeated interaction, we introduce the *Repeat* treatment, which differs from PreventiveWar only in that a pair of the rising player and the declining player would interact in all 20 rounds and each participant would assume the same role as either the rising player or the declining player throughout the session. All other aspects of the experimental procedure are the same as in the PreventiveWar treatment.



Notes: This figure shows the frequency of preventive wars using the full sample as well as conditional on the rising player offering 10 tokens at Stage 1. Error bars represent one standard error of the mean clustered at the session level.

Fig. 8. The frequency of preventive wars (Chat and Repeat treatments).

We conducted eight sessions for each treatment, for which 160 participants were recruited from the same student pool. The lower panel of Table 1 summarizes the design of the Chat and Repeat treatments. Note that, as shown in Table 1, in both treatments, the SPE predicts the occurrence of preventive wars.

5.2.1. Main results

Fig. 8 shows the frequency of preventive wars in the Chat and Repeat treatments. Compared to PreventiveWar, the declining player was significantly less likely to initiate preventive war both when he could talk to the rising player in the Chat treatment (56.6% vs. 28.9%, see Column (1) in Table 5, H0: $\beta_0 = 0$, $p < 0.001$) and when he could repeatedly play with the same the rising player in the Repeat treatment (56.6% vs. 37.4%, see Column (1) in Table 5, H0: $\beta_1 = 0$, $p < 0.001$). Furthermore, comparing Chat and Repeat, the communication mechanism was not significantly more effective in curbing preventive wars than the reputation mechanism ($\beta_0 = \beta_1$, $p = 0.288$). Fig. B8 in Appendix B shows the frequency of preventive wars across rounds, suggesting a lower frequency in Chat and Repeat than in PreventiveWar in almost all rounds.[19]

Fig. B9 in Appendix B shows rising players' offers in both stages, exhibiting a similar pattern in the Repeat treatment as in the PreventiveWar treatment: Stage 1 offer was increasing across successive rounds and approached the maximum amount that the rising player could offer in Stage 1, whereas the rising player's Stage 2 offer was close to zero across all rounds. In the Chat treatment, we observe that the rising player often offered either 10 or 5 tokens in Stage 1. Interestingly, the offer of 5 tokens was rejected only slightly more frequently (31.2%, see Fig. B10) than that of 0 token. This pattern was different from that in PreventiveWar in which 5-token offer was rejected 66.1% of the time. Thus, it appears that players coordinated on one of the two types of division of the total prize amount. One is the most typical combination of the rising player offering 10 tokens in Stage 1 and 0 tokens in Stage 2. The other is the rising player's offer of 5 tokens in both stages. Both types of division would result in an equal split of the total winnings.[20]

Next, we turn to the conditional analysis and test how the declining player's decision depends on the rising player's Stage 1 offer.[21] Conditional on the rising player offering 10 tokens, the frequency of fighting was 23.1% in the Chat treatment and 32.5% in the Repeat treatment, both of which are significantly lower than that in the PreventiveWar treatment (see Fig. 8 and Column (2) in Table 5, H0: $\beta_0 + \beta_3 = 0$, $p < 0.001$, H0: $\beta_0 + \beta_4 = 0$, $p = 0.001$). Conditional on the rising player's offer of fewer than 9 tokens, the frequency of fighting was 42.3% and 38.3% in the Chat and Repeat treatments, respectively, both of which were again significantly lower than that in PreventiveWar treatment (Column (3) in Table 5, H0: $\beta_0 + \beta_6 = 0$,

[19] In previous literature on conflict games, repeat interaction has not typically reduced conflict intensity (Sheremeta, 2013). There are several important differences between our game and typical contest games upon which previous experiments are based. First, in our game, agents could bargain over the prize before deciding to fight, while in contest games, fighting is essentially the only option to obtain payoffs. Second, the conflict cost in our game is exogenously imposed and constitutes half the total prize amount. In contrast, in contest games, the cost is endogenously caused by agents' conflict efforts and fighting technology. We speculate that when reputation could be established by repeat interaction, the bargaining opportunity and the relatively high destructiveness of conflict lead agents to try to steer away from conflict.

[20] Content analysis of players' communication messages provides supporting evidence of players' coordination on these divisions. Further details are available upon request.

[21] Fig. B10 in Appendix B shows the distribution of the rising player's Stage 1 offer and the frequency of preventive wars conditional on each possible Stage 1 offer in the Chat and Repeat treatments.

Table 5
Random effects probit regressions of preventive wars (Chat and Repeat treatments).

Dependent variable: reject in Stage 1 = 1	(1)	(2)	(3)	(4)
β_0: Chat	−0.326***	−0.280***	−0.323***	−0.245***
	(0.053)	(0.072)	(0.071)	(0.070)
β_1: Repeat	−0.243***	−0.306***	−0.281***	−0.355***
	(0.065)	(0.080)	(0.082)	(0.086)
β_2: **1**[RP's Stage 1 offer = 10]		−0.358***		−0.359***
		(0.066)		(0.065)
β_3: Chat × **1**[RP's Stage 1 offer = 10]		−0.018		−0.052
		(0.085)		(0.092)
β_4: Repeat × **1**[RP's Stage 1 offer = 10]		−0.008		−0.010
		(0.091)		(0.090)
β_5: **1**[RP's Stage 1 offer < 9]			0.326***	
			(0.073)	
β_6: Chat × **1**[RP's Stage 1 offer < 9]			0.025	
			(0.091)	
β_7: Repeat × **1**[RP's Stage 1 offer < 9]			−0.030	
			(0.094)	
β_8: RP's Stage 2 plan				−0.002
				(0.006)
β_9: Chat × RP's Stage 2 plan				−0.008
				(0.010)
β_{10}: Repeat × RP's Stage 2 plan				0.010
				(0.011)
Round	−0.001	0.012***	0.010***	0.012***
	(0.002)	(0.003)	(0.003)	(0.003)
H0: $\beta_0 + \beta_3 = 0$		$p < 0.001$		
H0: $\beta_0 + \beta_4 = 0$		$p = 0.001$		
H0: $\beta_0 + \beta_6 = 0$			$p < 0.001$	$p < 0.001$
H0: $\beta_0 + \beta_7 = 0$			$p < 0.001$	$p < 0.001$
Observations	2400	2400	2400	2400
Clusters	56	56	56	56

Notes: Standard errors are clustered at the session level for PreventiveWar and Chat, and at the group level for Repeat. Average marginal effects are reported. PreventiveWar serves as the benchmark.
*** $p < 0.01$.

$p < 0.001$, H0: $\beta_0 + \beta_7 = 0$, $p < 0.001$). Thus, compared to PreventiveWar, both mechanisms help reduce the likelihood of preventive wars regardless of the rising player's Stage 1 offer. Nonetheless, the higher the Stage 1 offer, the lower the frequency of preventive wars.[22]

Next, in line with the theory and the findings from the PreventiveWar treatment, the rising player's announcement of her plan for Stage 2 had little impact on the declining player's decision in either Chat or Repeat treatments (see Column (4) in Table 5, where β_8, β_9 and β_{10} estimates are insignificant). This result also suggests that the effectiveness of the two mechanisms cannot be attributed to the declining player's confidence that the rising player would execute her plan when making Stage 2 allocation.

Last, because of the lower frequency of preventive wars and the low frequency of rejection in Stage 2,[23] both mechanisms help increase the rising player's payoffs. Compared to PreventiveWar, the rising player's payoff was significantly higher in both the Chat treatment (6.4 vs. 3.7, see Fig. B11 and Column (1) of Table B3 in Appendix B, H0: $\beta_0 = 0$, $p = 0.001$) and the Repeat treatment (5.6 vs. 3.7, see Column (2) of Table B3 in Appendix B, H0: $\beta_1 = 0$, $p = 0.010$). Neither mechanism, however, decreased the declining player's payoff (in Chat, 10.4 vs. 10.2, see Column (1) of Table B3, H0: $\beta_0 + \beta_3 = 0$, $p = 0.586$; in Repeat, 10.1 vs. 10.2, see Column (2) of Table B3, H0: $\beta_1 + \beta_4 = 0$, $p = 0.865$). Finally, by summing up both players' payoffs in Fig. B11, we also learn that the overall loss due to conflict as a share of the total pie is around 16.0% and 21.5% in the Chat and Repeat treatments, respectively.

Result 4. *Both communication and reputation mechanisms helped reduce the frequency of preventive wars and led to higher the rising player's final payoff.*

22 It is worth noting that the decision to initiate preventive war is clearly path-dependent in the Repeat treatment: the declining player was significantly more likely to fight in Stage 1 if preventive wars occurred in previous rounds (see Table B4 in Appendix B for probit regression analysis probing into the effect of the occurrence of preventive wars in previous rounds on the likelihood of preventive wars in the current round). After accounting for the path-dependent effect, the size of Stage 1 offer no longer seemed to be relevant.

23 Similar to PreventiveWar, in Chat, the declining player fought in Stage 2 in 4.4% of the cases, and only when the total offer consisted of fewer than 10 tokens. A similar pattern was observed in Repeat, where the declining player fought in Stage 2 8.0% of the time, but sometimes for the total offer exceeding 10 tokens.

6. Summary and conclusions

Emergence of a new power carries the risk that the incumbent hegemon would seek conflict to prevent the newcomer from taking over its position. We model this scenario as a two-stage bargaining game in which the rising power makes an offer to the declining power as to how to split a pie. The declining power can either accept the offer or fight. This process is repeated, whereby the probability of winning the fight shifts towards the rising power between the stages. Depending on the parameter selection, the subgame perfect equilibrium involves either war or peace.

In this study, we tested (1) the game theoretic predictions in the laboratory, and (2) institutions that are often shown to be effective in resolving conflict. Overall, our results support the comparative statics of the theory. In the treatments in which war is predicted, conflict rates are higher than in those for which theory predicts peace. However, the expected sharp separation—only war or only peace—does not materialize. Conflict rates in the baseline treatments are surprisingly similar, which has both positive and negative ramifications. On a positive note, even where war should be inevitable, subjects in the lab often find ways to avoid it. The downside is that, even where peace should prevail, the situation is still volatile and many players fail to implement the more efficient peaceful solution. Wars virtually disappear only when fighting costs are so high that conflict becomes very unattractive. The policy implications of these observations are both obvious and counter-intuitive. They are readily apparent because they imply that significant fighting costs would deter wars. Yet, they are also counter-intuitive because fighting costs are most easily increased by enhancing the destructive potential of war through massive military build-up, which is not what we would naturally regard as a recipe for peace.

Still, as was shown here, several remedial mechanisms can be employed to reduce the likelihood of conflict. Both repeated interaction (which may serve as a proxy for an intensive exchange between powers) and pre-play communication lead to lower conflict rates. These findings imply that diplomacy can play a decisive role in conflicts between a rising and a declining power. That said, diplomacy is unlikely to result in miracles as, while it led to a significant reduction in the likelihood of conflict, its impact was quantitatively less substantial than one might hope for.

We have used the subgame perfect equilibrium because it makes clear-cut predictions and provides clear guidance for data analysis. The experimental data generally show *qualitative* support for these predictions. However, due to the extreme nature of the *quantitative* predictions (either 0% or 100%), it is perhaps unavoidable that the observed behavioral patterns also exhibit significant deviations from these quantitative predictions. For example, the frequency of fighting in the PreventiveWar treatment is nowhere near the predicted 100% level (see Fig. 3). We also did not observe a sharp cutoff strategy used by the declining player who should reject an offer below nine tokens in the NoWar treatment (see Fig. B2 in Appendix B). Similarly, in the RP-Commit treatment, players often agree to the settlement of equal split, although the cutoff strategy predicts that the declining player would only accept an offer no fewer than 11 tokens (see Fig. B3). Nevertheless, these quantitative deviations are not that surprising given the extreme quantitative predictions and the stylized experimental findings in similar bargaining games (Ultimatum games, trust games, etc.) in which subjects often express other-regarding preferences such as fairness, reciprocity and image concerns.[24] Since the present study primarily aims to demonstrate the logic of preventive wars, we leave a deeper understanding of the role of individual other-regarding preferences in different variants of our game for future research.

Since, as suggested by Powell (2004, 2006), the same mechanism may be at work not only in international conflicts, but may be involved in a wide range of diverse phenomena such as civil wars, revolutions, policy insulation, strikes, and predatory pricing, the evidence presented in this work may also be useful to informing research in these areas. In future studies in this domain, our experimental framework may be extended to allow for endogenous winning probabilities. For example, a higher bargaining gain today increases one's military capacity tomorrow. We expect two opposing effects depending on how much the rising state is willing to concede today. The declining state would have less reason to attack today when the concessions offered by the rising state are sufficient because of the reduced fear associated with a smaller (endogenous) power shift. Conversely, the declining state would have more reason to strike today when the rising state fails to offer adequate concessions due to the stronger fear associated with a greater power shift.

Of course, our study has limitations which should be noted when interpreting our findings. The most obvious one is the small scale of our experimental scenario compared to an armed conflict in the real world, especially if both powers have substantial nuclear arsenals. Losing a few yuan in the lab is substantial for a university student, but it is not the same as losing hundreds of millions of lives in an all-out war between, say, the U.S. and China. Unfortunately, we cannot wait for a sufficiently large set of real-life observations to appear that would allow us to run empirical analysis beyond studying historical anecdotes, as too many lives would be lost in the process. In addition, in contrast to historical studies, we can control the experimental conditions and can ensure that everything else is equal when required. The laboratory, with its controlled, replicable and damage-free environment is thus a valuable tool for testing various war scenarios. Laboratory experiments should therefore be seen as a complement to historical analysis, as both have their particular strengths and weaknesses.

[24] Note that the game underlying the RP-Commit treatment is essentially a one-stage Ultimatum game with asymmetric outside options. The resemblance with Ultimatum games suggests that similar forces that drive the stylized behavior in Ultimatum games may also be at work in our setting. For example, as shown in Cooper and Dutcher (2011), rejection rates in Ultimatum games are a relatively smooth function of the proposer's offer to the receiver. In light of this finding, a possible explanation for the observation that the declining player does not always reject low offers is that he cares about the opponent's welfare and/or social efficiency which tends to smooth out his response function.

Declaration of competing interest

All authors declare no conflict of interest.

Data availability

Data will be made available on request.

Appendix. Supplementary material

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.geb.2023.08.018.

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