Peaceful alternatives to asymmetric conflict
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Chapter 3 - Costly Peace and Wasteful Conflict: Theory and Experimental Evidence

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Abstract

Agents can gain wealth through economic production and through predatory capture of wealth produced by others. Whether and how these two mechanisms relate to each other remains largely unresolved. Here we provide formal theory and experimental tests integrating earlier work on wealth production and protection with recent theory on attacker-defender contests. In principle, having opportunities for economic production should reduce conflict investments. When 'production thresholds' are low, facilitating easy wealth acquisition, agents should invest less in predatory attacks and protective defense. An experiment comparing attacker-defender contests with or without a production option confirms that the latter reduces investment in conflict yet does not eradicate it; agents continue to invest in attacks, forcing counterparts to invest in defense rather than production. When production is comparatively difficult, predatory attacks persist and post-conflict wealth inequality between attackers and defenders is amplified.

Keywords: conflict, attacker-defender contest, production, inequality

Introduction

To advance social and economic prosperity, humans invest in the production of goods and services or in the appropriation of goods and services provided by others (Pareto, 2014; Haavelmo, 1954). Investing in production can provide agents with economic wealth and lead to collectively beneficial trade. In contrast, investing in the appropriation of goods and services produced by others can create costly conflict between those who seek to appropriate and those who seek to defend and protect what they have produced (De Dreu & Gross, 2018; Duffy & Kim, 2005; Usher, 1987). Compared with wealth creation through economic production, wealth creation through predatory capture and conflict is collectively inefficient (Besley & Mueller, 2018; De Dreu & Gross, 2018; McGuirk & Burke, 2020; Smith et al., 2012). A key question for economic theory and conflict resolution is thus when and why humans invest in economic production rather than investing "effort on injuring others, and protecting against being injured" (Mill, 1978).

Scholars in political economy and conflict studies have argued that opportunities for wealth creation through economic production lower the incentives for engaging in conflict (Maoz & Russett, 1993; Jablonski & Oliver, 2013; Rousseau et al., 1996; Wittman, 2000). Political commentator Thomas Friedman argued, for example, that "[no] two countries … fight a war against each other as long as they are both part of the same global supply chain" (Friedman, 2006, p. 421). Shortly after World War I, John Maynard Keynes conjectured in a similar vein that excessive war compensation payments demanded from Germany will harm its national economy and might push the country to seek prosperity through (renewed) attack: "If we aim deliberately at the impoverishment of Central Europe, vengeance, I dare predict, will not limp" (Keynes, 2019, p. 192). Yet, the idea that creating opportunities to generate wealth through production reduces predatory capture and conflict (both within and between nation-states) is not without its critics (Luce, 2015) and both theoretical and empirical findings are mixed. In fact, the assumption that economic production opportunities decrease conflict is not always supported. Furthermore, there is also reason to assume that creating such opportunities increases rather than decreases the probability and intensity of conflict (cf. the “natural resource curse”; Brunnschweiler & Bulte, 2009; Lujala et al., 2005; van der Ploeg, 2011).

Here we ask not whether, but rather *when* opportunities for wealth creation through economic production reduce or increase the “effort spent on injuring others and protecting against being injured.” To this end, we develop a formal model on production and predation and test its predictions in a behavioral experiment. In doing so we integrate economic theory on wealth creation with recent advances in the study of asymmetric conflicts. This allows us to gain a better understanding of when and why individuals initiate and escalate conflict, or, alternatively, move towards peaceful co-existence.

Predation, Defense and Production

The starting point in our analysis is that conflict emerges when the interests and values of interdependent (groups of) individuals are incompatible (Coombs, 1987; De Dreu, 2010; Schelling, 1981). Incompatible interests can revolve around the distribution of power and resources, opposing standpoints on economic policy and the governance of public goods, or social policy concerning social/religious values, including, for example, justice, minority rights, and freedom of speech (De Dreu, 2010; Raiffa, 1985; Rapoport et al., 1965). Crucially, whereas incompatibilities can concern something both parties want and only one can have, most concern something that one party wants that another party owns and maintains. Examples of such asymmetric conflicts between an ’attacker’ and ‘defender’ include international disputes between revisionist and non-revisionist states (Wright, 2014), piracy (Jablonski & Oliver, 2013), terrorist attacks (Burgoon, 2006), hostile take-over attempts in industry (Schwert, 2000), and politicians contesting (versus defending) the socio-economic status quo (De Dreu et al., 2021). In all these and similar cases, one party seeks to advance its own interests – exclusionary access to scarce resources, market share and production capacities, or political influence – at the expense of those of another party who, in turn, invests in protecting its interests against predatory capture (Carter & Anderton, 2001; Cornes & Hartley, 2005; Dechenaux et al., 2015; De Dreu & Gross 2019; Grossman & Kim, 1996a, 1996b; Hirshleifer, 1988; Tullock, 1980; McGuirk & Burke, 2020; Pruitt et al., 2004; Shane & Magnuson, 2016).

Recent work has teased apart these two reasons for conflict investments—predatory attack and protective defense—in asymmetric "attacker-defender" contests in which one agent, as an "attacker", invests to capture resources from the other, who, as a "defender," invests to protect against such predatory attack (Chowdhury & Topolyan, 2016; Clark & Konrad, 2007; De Dreu & Gross, 2018; Hausken & Zhuang, 2011; Powell, 2007). Experiments implementing both one-shot and repeated interaction versions of such attacker-defender contests have shown that humans invest in attack and defense, and that these investments frequently deviate from rational-choice equilibrium play (Chowdhury et al., 2018; Chowdhury & Topolyan, 2016; De Dreu et al., 2021). Such deviations have been attributed to, for example, overconfidence (Johnson & Fowler, 2011; Tversky & Kahneman, 1992), anti-social preferences and competitive arousal (De Dreu et al., 2019), and incorrect beliefs about the counterpart's aggressiveness (Jervis, 1978; Rojek-Giffin et al., 2020).

The attacker-defender contest provides a tool to identify not only why individual contestants over-invest, but also when and why conflict emerges in the first place. We can begin by asking what motivates attackers to avoid conflict and instead seek economic prosperity through other, more peaceful means. As already noted at the outset, providing agents with alternative opportunities to produce wealth may reduce the temptation to invest in predation and—for the targets of predation—the need to invest in defense (Maoz & Russett

1993; Rousseau et al., 1996; Williams, 2019; Wittman, 2000). Evidence for this would resonate with Keynes' intuition about the detrimental effects of war compensation payments and fit with the evidence that providing criminal offenders with job opportunities reduces their likelihood to commit burglary (Becker, 1968; Uggen & Shannon, 2014), and that firms with more innovative research and development activities are more likely to engage in friendly rather than hostile takeovers (Bena & Li, 2014).

The possibility that adding opportunities for production reduces conflict comes, however, with the heretofore ignored caveat that agents with strong production capacities and concomitant wealth appear as attractive targets for exploitation. When both attacker and defender are given opportunities for production, defenders may become wealthier, increasing the potential spoils of war for would-be attackers (Durham et al.,1998; Hirshleifer, 1991; Skaperdas, 1992; Lacomba et al. 2014). Similarly, studies on the "natural resource curse" have shown that countries richer in natural resources are more often involved in ethnic clashes (Lujala et al, 2005) and international conflicts (van der Ploeg, 2011), are more likely to be the target of aggression (Koubi et al., 2014), and tend to invest more in territorial defense (Ali & Abdellatif, 2015; Khan et al., 2022). In short, when both sides can produce wealth through economic production, attackers need to strike a balance between the attractiveness of substantial spoils of war from predation, and the risk of wasting resources on unsuccessful attacks (also see Carter & Anderton, 2001; Grossman & Kim, 1996b, 1996a). Conversely, defenders need to strike a balance between investing in economic production and the risk of mounting too weak a defense to prevent predation. Accordingly, opportunities to create wealth through economic production could, somewhat paradoxically, increase rather than decrease investment in predatory attacks and protective defense, depending on the costs and benefits of production.

Modeling Predation and Production

To identify whether adding production opportunities decreases or increases investment in predatory attack and protective defense, we contrast contests in which agents lack a production opportunity, i.e., 'pure' contest environments, with environments in which such an opportunity is available. Giving agents the discretionary freedom to invest in conflict and, when available, production, allows us to see whether and how adding opportunities for production decreases or increases investment in predation, in defense, or both. In addition, we can track the emergence of post-conflict wealth inequality between attackers and defenders, a common outcome of such asymmetric contests (De Dreu & Gross, 2019).

The Attacker-Defender Contest. The starting point in our model is a simple attacker-defender contest (De Dreu & Gross, 2019; henceforth, AD-C). Both attacker and defender enter the interaction with an endowment *e*, and decide how much of their endowment to invest in attack (for the attacker, *a*) or in defending against such an attack (for the defender, *d*). Conflict investments are lost, but if the attacker's investment exceeds that of the defender ($a > d$), the attacker appropriates the defender's remaining endowment and adds it to their own. In contrast, if *d* is equal to or larger than *a*, both keep their remaining endowments. The attacker's payoff is therefore:

$$\pi_{Att}(a,d) = \begin{cases} e - a & if\ a \le d \\ 2e - a - d & if\ a > d \end{cases}$$

while the defender's payoff is:

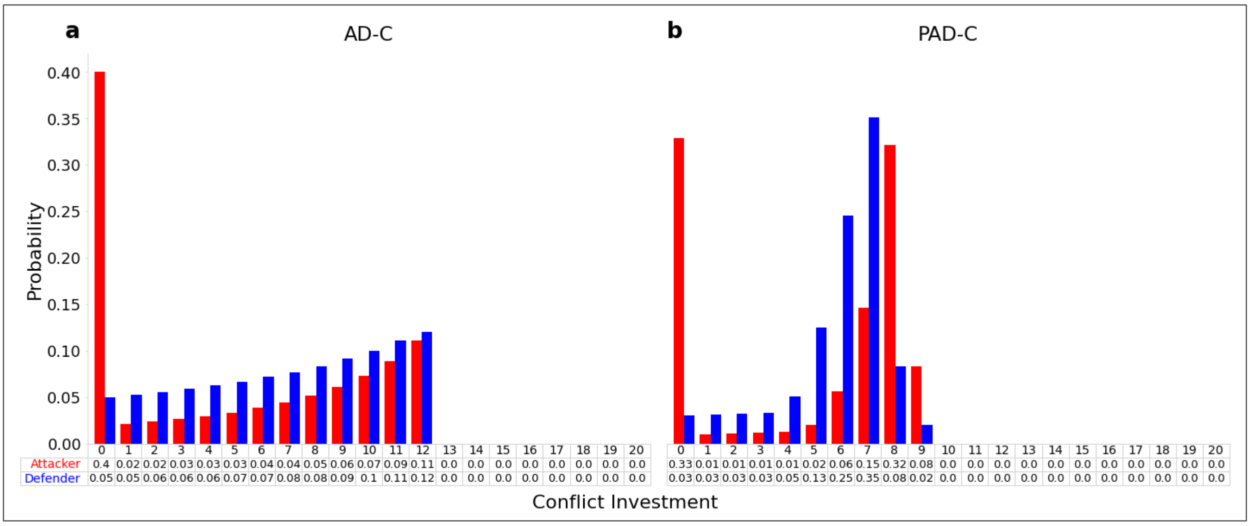
$$\pi_{Def}(a,d) = \begin{cases} e - d & if\ a \le d \\ 0 & if\ a > d \end{cases}$$

Players in the AD-C have no dominant strategies: the level of attack that maximizes the attacker's payoff depends on the investment made by the defender. Likewise, for the defender, the level of optimal defense depends on what the attacker invests. As shown elsewhere (Méder et al., 2022), the AD-C has a single Nash equilibrium in mixed strategies.

In equilibrium, rational players randomize between devoting 0, 1, 2… resources to the contest, up to a certain highest investment, around 1 - 1/e ≈ 63% of the original endowment. The attacker's strategy is bimodal, assigning a relatively high probability (close to 1/e ≈ 37%) to entirely refraining from attacking, but making a 'weak' attack unlikely. The defender's equilibrium strategy also assigns higher probabilities to stronger rather than weaker defensive actions, but—in contrast to the attacker's equilibrium mix—not defending at all is the least likely action (an example with $e_{\mathrm{A,D}}$ = 20 is shown in Figure 1a). Because investments are non-recoverable, neither attacker nor defender should invest anything in conflict from a collective welfare perspective. Nonetheless, if agents play equilibrium strategies, they will collectively spend about 12 MU of their initial endowments on conflict (see Table 1).

Figure 1

Nash equilibrium strategies in AD-C and PAD-C



Note. Probabilities with which each conflict investment strategy from 0 to 20 (x-axis) should be chosen for attacker (red) and defender (blue), assuming rational selfish play and risk neutrality, under equilibrium. (a) Predictions for the Attacker-Defender Contest (AD-C) as implemented in the experiment. (b) Predictions for the Production Attacker-Defender Contest (PAD-C) as implemented in the experiment.

Table 1

Average play for key variables calculated with the probability weights of the equilibrium distribution for attacker and defender for the experimental version of AD-C and PAD-C (i.e., with endowment e = 20).

	Attacker-Defender Contest (AD-C)		Production Attacker-Defender Contest (PAD-C)	
	Attacker	Defender	Attacker	Defender
Conflict Investment	4.961	7.039	4.896	5.79
Conflict magnitude	4.961	7.039	4.896	5.791
Conflict frequency	0.600	0.950	0.672	0.970
Production investment	–	–	8.951	12.684
Earnings	20.000	8.000	33.484	11.000

The Production Attacker-Defender Contest. We contrast the AD-C with a production attacker-defender contest (henceforth, PAD-C) where agents may also invest all or part of their endowment in production, denoted by b_{Att} and b_{Def}. To be successful at production, an individual's production investment must meet or exceed a certain fixed threshold T (with $0 \leq T \leq e$). If they reach or exceed threshold T, each player receives a fixed reward k. Production investments are non-recoverable and made simultaneously with the conflict investments (a and d). The total amount invested in production and attack (or defense) is thus constrained by e such that $a + b_{\text{Att}} \leq e$ and $d + b_{\text{Def}} \leq e$. Henceforth we assume that agents know the threshold at the start of the game.

Like the AD-C, the PAD-C has a single mixed-strategy equilibrium (Figure 1; for formal analysis see Méder et al., 2022). However, adding production opportunities with threshold *T* changes the equilibrium prediction for investments into attack and defense for two reasons. First, defender payoffs are conditioned by the production return *l(b)*:

$$\pi_{Def}(a, d, b_{Def}) = \begin{cases} 0 & if\ a \leq d \\ e + l(b_{Def}) - d - b_{Def} & if\ a > d \end{cases}$$

Therefore, the attacker's spoils of conflict in case of victory are conditioned by the defender's production return, as well as the attacker's own production return:

$$\pi_{Att}(a, b_{Att}, d, b_{Def}) = \begin{cases} e + l(b_{Att}) - a - b_{Att} & if\ a \leq d \\ 2e + l(b_{Att}) + l(b_{Def}) - a - d - b_{Att} - b_{Def} & if\ a > d \end{cases}$$

For both attacker and defender, the production return *l(b)* depends on meeting or exceeding the production threshold T:

$$l(b) = \begin{cases} k & if\ b > T \\ 0 & if\ b \leq T \end{cases}$$

Our model makes two assumptions regarding the relationship between the parameters. First, production is only feasible if the initial endowment can cover it, that is, with $e \geq T$. Second, whenever $k \leq T$, and investments in production give a negative return, the production technology is deemed inefficient and not used. Since this reduces the PAD-C game to the AD-C, we also assume $k > T$. Accordingly, we can represent the PAD-C game by modifying the payoff matrix of the AD-C in the following way: whenever each side invests not more than e - T in conflict, their respective payoff is increased by k - T, and is otherwise unchanged. In addition, whenever the attacker wins the conflict, this payoff increase is transferred from the defender to the attacker (see Table 2).

Table 2

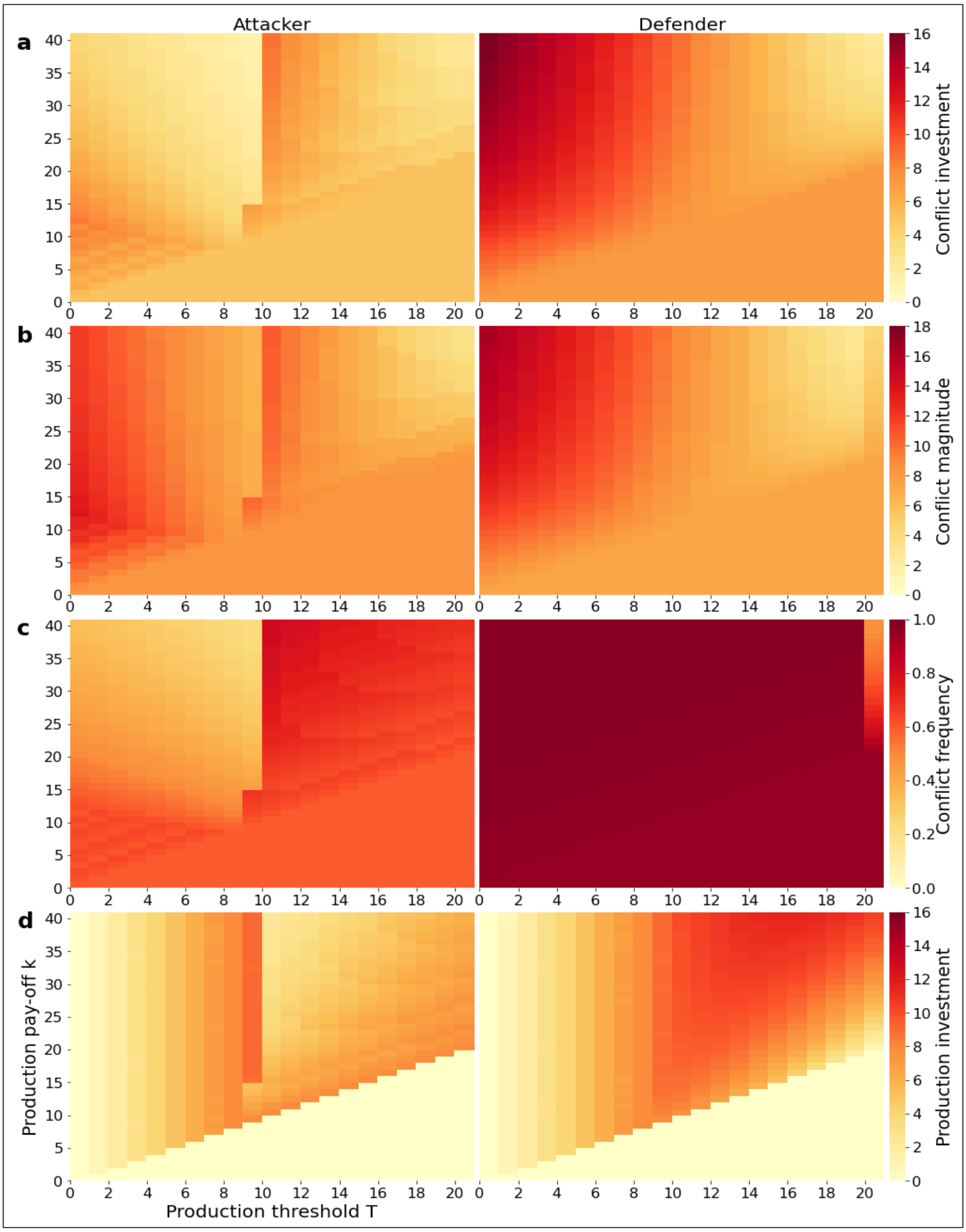
Pay-off matrix for the AD-C (top) and PAD-C (bottom) as a function of attacker (columns) and defender (rows) investment in conflict, with endowment e = 4 and, in the PAD-C, production reward k = 5, production threshold T = 3. Within each cell, the attacker (defender) earns the right (left) payoff. Bold digits (bottom panel) indicate payoff changes compared to the AD-C game (top panel).

Attack\Defense	0	1	2	3	4
0	4,4	4,3	4,2	4,1	4,0
1	7,0	3,3	3,2	3,1	3,0
2	6,0	5,0	2,2	2,1	2,0
3	5,0	4,0	3,0	1,1	0,0
4	4,0	3,0	2,0	1,0	0,0
0	**6,6**	**6,5**	**6**,2	**6**,1	**6**,0
1	**11**,0	**5,5**	**5**,2	**5**,1	**5**,0
2	**8**,0	**7**,0	2,2	2,1	2,0
3	**7**,0	**6**,0	3,0	1,1	0,0
4	**6**,0	**5**,0	2,0	1,0	0,0

To map equilibrium predictions as a function of production threshold T, production payoff k and $e = 20$ (as used in the experiments reported below), we used the Lemke-Howson algorithm (Lemke & Howson, 1964). Figure 2 shows the mixed-strategy equilibrium in which both attacker and defender assign positive probabilities to using 0, 1, … up to a certain upper bound, which we denote with l^*. Since the support of the equilibrium strategy always includes refraining from attack ($a = 0$), the expected payoff of the attacker is simply $e + k - T$. For the defender, using the upper bound l^* guarantees successful protection and her equilibrium payoff is thus either $e - l^* + k$ or $e - l^*$, depending on whether there are enough resources left over to cover the cost of investing in production.

Figure 2

Heatmaps of average equilibrium play for different variables in the PAD-C



Note. Heat maps showing average values for different variables of interest in equilibrium as a function of production threshold T (x-axis) and production payoff k (y-axis) in the PAD-C. Subplots depict averages for the attacker (left) and defender (right) for (a) conflict investment, (b) conflict investment magnitude, (c) conflict investment frequency and (d) production investment.

As can be seen in Figure 2, the step change in expected payoffs induces changes in equilibrium strategies. When economic production is an ‘easy’ technology to create wealth (i.e., e - $l^* \geq T$), attackers behave in accordance with Keynes’ intuition that providing opportunities for economic production reduces investment in predation (see Figure 2a and 2d for Attacker). Crucially, however, in such settings, defenders *increase* their investment in defense (see Figure 2a and 2b for Defender). This supports the intuition in the natural resource curse literature that increasing wealth through economic production also increases the need to defend against predatory threat. All this changes dramatically, however, when economic production is an ‘expensive’ technology to create wealth (i.e., e - $l^* < T$). Expensive production constraints defenders from mounting strong defenses, making them attractive targets of predatory acquisition. At the same time, such environments also shift the attackers’ focus from production to appropriation, as the latter becomes a relatively attractive technology to create additional wealth (see Figure 2a and 2d for Attacker).

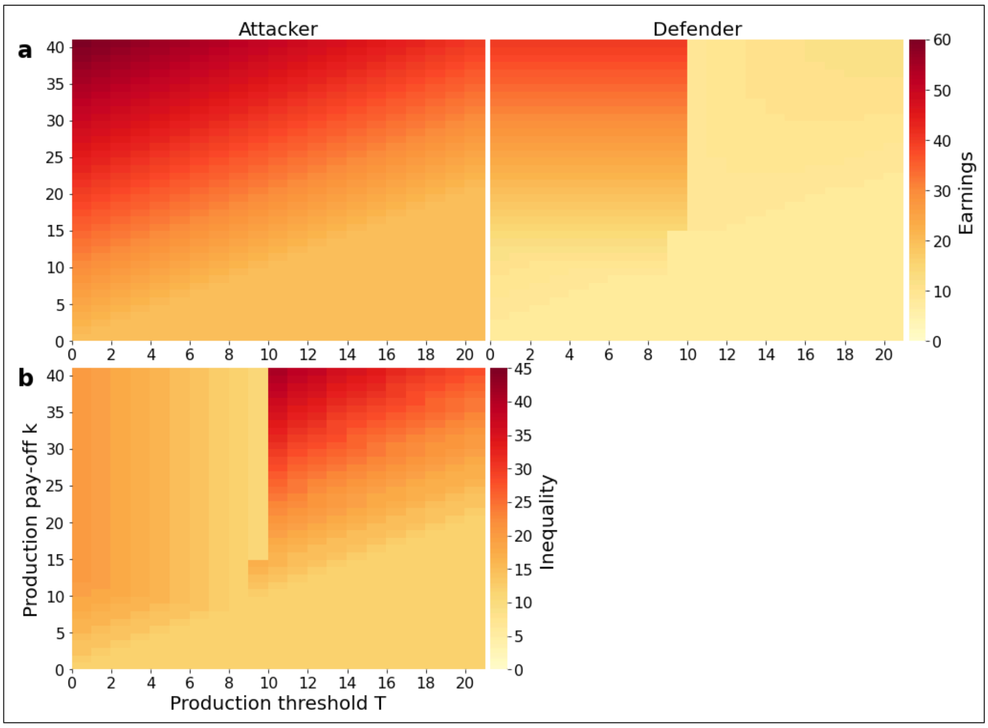
We note that the pattern we observe here for conflict investment also holds for two related but distinct manifestations of ‘conflict’: conflict magnitude, defined as the average conflict investment when excluding non-conflictual choices (i.e., $a = d = 0$), and conflict frequency, defined as the proportion of rounds of each party with conflict investments greater than zero, under equilibrium (De Dreu & Gross, 2018; De Dreu et al., 2015). In fact, for both attack magnitude and frequency we observe a stark increase when e - $l^* < T$ (see Figure 2b and 2c for Attacker). In contrast, defense magnitude declines gradually with T, while defense frequency stays consistently high over the range of T and k (see Figure 2b and 2c for Defender). Defense magnitude declines because of the increasing cost of production, while frequency remains steady to maintain protection against potential attack.

In short, adding opportunities for economic production may reduce conflict, but only when production thresholds are low compared to endowments and are therefore easy to meet.

Environments in which production thresholds require higher relative investments embolden predatory capture instead, and result in more frequent and forceful conflicts and a more pronounced inequality in the distribution of wealth. As to the latter, when either l^* or T becomes so large that, when employing the highest level of defense, the defender cannot afford the production investment anymore, we indeed expect a notable collapse in expected defender earnings (see Figure 3a for Defender). Environments with $e - l^* < T$ reinforce conflict and further tilt the balance of earnings towards attackers (Figure 3b). Compared to settings in which individuals have no economic production opportunities whatsoever – the standard AD-C – having expensive production technologies can intensify predatory attack and lead to larger post-conflict inequality in wealth between attackers and defenders.

Figure 3

Heatmaps of average equilibrium play for earnings and inequality in the PAD-C



Note. Heat maps showing average values for different variables of interest in equilibrium as a function of production threshold T (x-axis) and production payoff k (y-axis) in the PAD-C. Subplots depict (a) earnings and (b) expected average inequality where higher values indicate a higher earning difference in the attacker's favor.

Experimental Tests

Our model reveals that opportunities for production can reduce conflict depending on the ease with which production can be realized – the production threshold. We performed experiments to test predictions about (i) conflict investment in attacker-defender contests when production opportunities are absent (AD-C) versus present (PAD-C) and, within the PAD-C, (ii) investment in production in relation to (history of) investment in attack and defense.

In the experiment, we compared the AD-C to the PAD-C as described above. Attackers and defenders were given an endowment $e = 20$ and received a reward $k = 30$ in case of successful production in the PAD-C. We implemented iterative, multi-round contests in both conditions, with attackers and defenders being fixed in dyads for the entire duration of the experiment. In such iterative contests, contestants face uncertainty about their opponent's next move and try to increase uncertainty in their opponent by varying investments across rounds (De Dreu & Gross, 2018; De Dreu et al, 2016). Uncertainty is also a common factor in production environments such as manufacturing (Mula et al., 2006) or agriculture (Ullah et al., 2016), and to mimic this in our experiments we randomly varied threshold T across rounds using a Bernoulli distribution between $T = 9$ (0.45e in Figure 2a and 2b) and $T = 17$ (0.85e) with an expected value of $T = 13$ (0.65e). Accordingly, the production payoff (l) for both attacker and defender in the PAD-C treatments was:

$$l(b) = \begin{cases} 0 & if\ b \leq 8 \\ 30 \ \cdot \mathrm{P}(b \geq T) & if\ 9 \leq b \leq 17 \\ 30 & if\ 18 \leq b \end{cases}$$

where $\mathrm{P}(b \geq T)$ is the probability of the production investment b exceeding the randomly selected threshold T. Note that we specified parameters such that $e - l^* \geq T$ – economic production is comparatively expensive – constraining defenders in their ability to successfully produce and defend simultaneously.

The mixed strategy equilibrium of the analogous PAD-C environment prescribes for attackers (defenders) an average conflict investment of 4.9 (5.8), production investment of 9.0 (12.7), and expected total earnings of 33.5 (11) (see Table 1). Applying backward induction, both the AD-C and PAD-C equilibria can be extended to finitely repeated interactions. Prior empirical work suggests that in repeated interactions, attackers randomize their actions across rounds to make it difficult for defenders to anticipate their best response on a given round. Especially when production thresholds are relatively high (i.e., $e - l^* < T$) and individuals must trade off production and predation to be successful in either, attackers may also alternate across rounds between investing in production and predatory attack. In short, for settings with $e - l^* < T$, our model predicts:

(1a) Production opportunities reduce conflict investment, especially in predatory attack.

(1b) Production opportunities reduce conflict magnitude but increase conflict frequency.

With regards to the role in the conflict, our model predicts:

(2a) Individuals invest in production especially when in the role of attacker.

(2b) Individuals meet the production threshold especially in the role of attacker.

From these predictions, it follows that:

(3) The individual wealth of attackers (defenders) is compromised the least (most) when production opportunities are present (rather than absent).

Method and Materials

Ethics and Participants. The experiments were approved by the Psychology Research Ethics Committee of Leiden University (Protocol #CEP19-0211/75). Participants provided written informed consent and received full debriefing upon conclusion of the study. They were explicitly informed about the study involving fully-incentivized decisions and no deception.

Sample size was determined to be $n = 100$ attacker-defender dyads following a power analysis for a multivariate within-dyad repeated measures (60 contest rounds) design with f = 0.2, α = 0.05 and 1 - β = 0.90. We recruited 124 participants for the AD-C treatment (93 female; age M = 21.15, SD = 2.52, range 18–35 years; five participants did not provide demographic data) and 118 participants for the PAD-C treatment (86 female; age M = 21.80, SD = 3.33, range 17–42 years; 3 participants did not provide demographic data), resulting in 62 and 59 dyads for the AD-C and PAD-C, respectively. Participants received either credits for their participant or a €6.50 show-up fee, as well as the outcome of four randomly selected rounds of decision-making for which earned units were summed and then converted into Euros at a rate of 1 unit = 0.20€ (range €1 to €14.5; M = €7.40).

Experimental Procedures and Treatments.[1] Upon arrival in the laboratory, participants were seated at computers in closed cubicles and then randomly assigned to the roles of attacker and defender. Dyads were randomly allocated to either the AD-C or the PAD-C condition. Participants individually read instructions and answered comprehension questions to make sure they understood the rules of the experiment (for the exact instructions, see De Dreu et al., 2019). All instructions used neutral language to avoid framing effects.

Participants in both treatments made decisions in 60 consecutive contest trials with the same partner. After each trial, participants received full feedback about their own and their counterpart's investments (in conflict and, if applicable, economic production), alongside earnings (from conflict and, if applicable, economic production). We implemented both AD-C and PAD-C as fixed-partner matching protocols and participants were thus able to learn how to compete (and produce) best and to calibrate their strategies over time.

Analytic strategy. Our data set has a hierarchical structure in which each data point (i.e., an investment decision per round) is nested within participants, which are nested within

[1] Participants completed an online questionnaire at least one day before the laboratory experiment. They provided demographic data (gender and age) and filled out some additional surveys which served otherwise unrelated MSc projects. These survey data were not relevant to, and therefore not included in the present analysis.

dyads. To account for possible violations of independence of observations within participants and dyads, we analyzed data with 3-level random intercept regression models with predictors 'game' (AD-C/PAD-C), 'role' (Attacker/Defender), and the 'game × role' interaction:

$\text{OutcomeVar}_{ijk} = \beta_{0jk} + e_{ijk}$, $e_{ijk} \sim \text{N}(0, \sigma_e^2)$ Level 1 - i = investment

$\beta_{0jk} = \gamma_{00k} + u_{0jk}$, $u_{0jk} \sim \text{N}(0, \sigma_u^2)$ Level 2 - j = participant

$\gamma_{00k} = \mathit{0}_{000} + v_{00k}$, $v_{00k} \sim \text{N}(0, v_u^2)$ Level 3 - k = dyad

Of primary importance were *conflict investment* (hypothesis 1a), *production investment* (hypothesis 2a), and *earnings* (hypothesis 3). For hypothesis 1b, we calculated the *conflict frequency* (the proportion of rounds with conflict investments greater than zero) and *conflict magnitude* (the average amount invested in conflict in rounds with non-zero conflict investment). Additionally, we analyzed attackers' *conflict victory* rate (the number of attacker victories across all rounds). For hypothesis 2b, we looked at the *production success* rate (the number of rounds in which participants were successful at production). We also investigated the *production magnitude* (the average amount invested in production in rounds with non-zero production investment) and the *return on investment* for production (average overall production earnings per unit spent on production). For hypothesis 3, we calculated the difference between average defender earnings and average attacker earnings.

To explore how participants responded to their opponents' behavior during the experiment, we created lagged variables for conflict investment and regressed both attackers' and defenders' conflict and production investments on their opponents' previous-round conflict investments. For all such cross-round "response" models, we used random intercept regression models in which participants were nested within dyads (i.e., with the random effect dyad). Since for the cross-round analysis we were specifically interested in how participants responded to each other's behavior across rounds, we removed seven dyads in which both attacker and defender had a conflict investment of 0 in all 60 rounds (for all other analyses we used the complete data set). All analyses were performed using the statistical programming language R 3.5.1 (Team, 2016). Linear mixed models were fitted using the lme4 package (Bates et al., 2015) and *p*-values were derived from lme4 extension lmerTest (Kuznetsova et al., 2017).

Results

Investment in Conflict

Hypotheses 1a and 1b addressed conflict investment in attack and defense in the AD-C and PAD-C. In line with hypothesis 1a, we found that adding a production opportunity to the AD-C reduced overall investment in conflict (*game effect*, $p < 0.001$). This reduction did not significantly differ between attackers and defenders (*game* × *role interaction*, $p = 0.896$; Table 3; Figure 4a). Moreover, whereas conflict investments exceeded equilibrium values in the AD-C ($t(61) = 4.32$, $p < .001$ for attackers, and $t(61) = 2.76$, $p = .008$ for defenders), they closely matched equilibrium values in the PAD-C ($t(58) = -1.24$, $p = 0.219$ for attackers, and $t(58) = -1.71$, $p < .093$, for defenders).

In support of hypothesis 1b, we observed a substantial decrease in conflict magnitude between the AD-C and PAD-C (from 54% to 38% of endowment; *game* effect, $p < .001$). For conflict frequency, however, this difference was not significant (*game* effect, $p = .110$; Table 3). This indicates that allowing for production reduced the magnitude of conflict but not its presence. Furthermore, attacker victory-rates were similar in the AD-C (30%) and PAD-C (27%) (*game* effect, $p = .276$; Table 3), meaning that defenders were not less likely to lose their remaining endowments when production opportunities were present.

Table 3

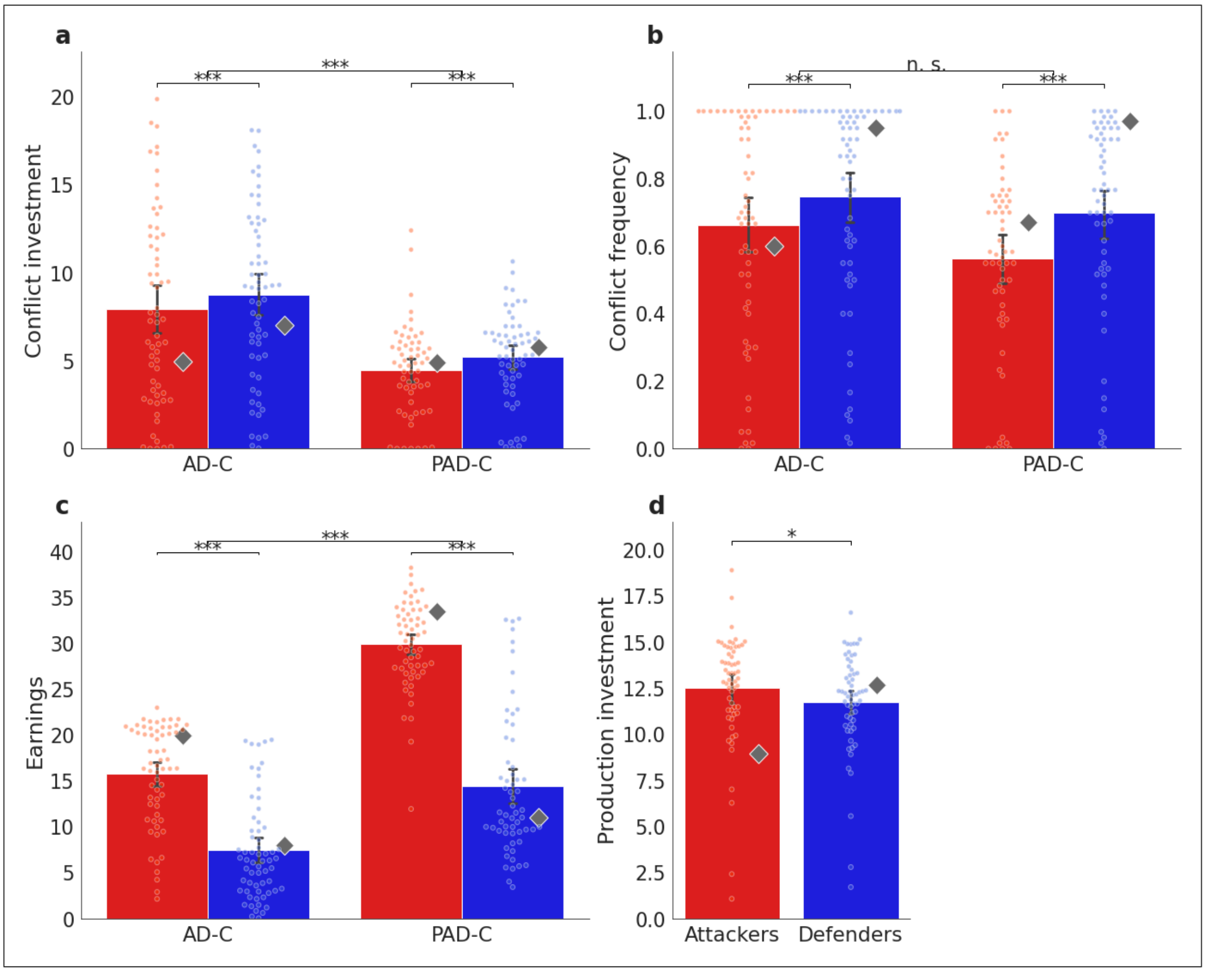
Results of linear random intercept mixed models for conflict investment and outcomes

Dependent Variable	Predictor	Estimate (*b*)	Test statistic (*t*)	*p*
Conflict investment	(Intercept)	7.94	15.17	< .001
	Game	-3.48	-4.64	< .001
	Role	0.82	3.35	.001
	Game×Role	-0.05	-0.13	.896
Conflict magnitude	(Intercept)	10.94	25.09	< .001
	Game	-3.31	5.26	< .001
	Role	0.11	0.43	.666
	Game*Role	-0.20	-0.56	.575
Conflict frequency	(Intercept)	0.69	19.90	< .001
	Game	-0.08	-1.61	.110
	Role	0.08	3.84	< .001
	Game×Role	0.05	1.88	.063
Victory rate (Attacker)	(Intercept)	0.30	15.65	< .001
	Game	-0.03	-1.10	.276

Note. Estimates for aggregated effects of *game: PAD-C* and *role: attacker* on various outcome variables using linear mixed model with random effects *participant* and *dyad.*

Figure 4

Behavioral data and game-theoretic benchmarks for attackers (red) and defenders (blue) in the Attacker-Defender Contest (AD-C) and the Production Attacker-Defender Contest (PAD-C)



Note. Shown are mean values (bars), standard errors (± 1 SE), aggregated investment by subject (dots), and Nash equilibrium predictions (Diamonds). Contrasts are significant at * p < .05, ** p < .01, and *** p < .001.

Production

We hypothesized that individuals in the PAD-C would invest in production, especially when in the role of attackers (hypothesis 2a), and that they would meet the production threshold, especially in the role of attackers (hypothesis 2b). In line with hypothesis 2a, both parties invested in production, but attackers invested more than defenders (*role* effect, $p < .018$; Table 4; Figure 4d). Moreover, production investments exceeded the equilibrium benchmark for attackers ($t(58) = 9.09$, $p < .001$), but fell below the equilibrium for defenders ($t(58) = -2.58$, $p < .012$) (Figure 4d). While the frequency of investing in production was similar for attackers and defenders (*role* effect, $p = .778$, Table 4), attackers invested in production with greater magnitude (*role* effect, $p < .001$, Table 4).

Table 4

Results of linear random intercept mixed models for production variables

Dependent Variable	Predictor	Estimate (*b*)	Test statistic (*t*)	*p*
Production investment	(Intercept)	12.54	3.42	< .001
	Role	-0.78	-2.44	.018
Production magnitude	(Intercept)	14.32	71.61	< .001
	Role	-0.71	-3.78	< .001
Production frequency	(Intercept)	0.87	37.02	< .001
	Role	-0.01	-0.28	.778
Production success rate	(Intercept)	0.68	26.59	< .001
	Role	-0.08	-4.23	< .001
Production ROI	(Intercept)	1.59	43.69	< .001
	Role	-0.10	-2.86	.006

Note. Estimates for aggregated effects of *Role: Attacker* on various outcome variables using linear mixed model with random effects *participant* and *dyad*.

Confirming hypothesis 2b, both parties reached the production threshold in the majority of rounds. Attackers were, however, more often successful (68.06%) than defenders (59.2%; *role* effect, $p < 0.001$; Table 4). As a result, over the 60-round period, attackers attained the production reward of 30 MU on average in five more rounds compared to defenders, resulting in a sizable difference in earnings, as we show below. Finally, attackers were more efficient in their production spending: For every unit invested in production, attackers earned on average 1.59 units, compared to 1.49 units for defenders (*role* effect, p = 0.006; Table 4). Thus, attackers and defenders differed in how much they were able to exploit the opportunity to create wealth through economic production.

Earnings and Wealth Disparity

Our final hypothesis (3) concerned earnings and wealth disparity. Resonating with the reduced expenditures on conflict, both attackers and defenders realized higher earnings in the PAD-C than in the AD-C (*game* effect, $p < 0.001$, Table 5; Figure 4c). At the same time, and due to the observed disparities in production efficiency and success alongside the unchanged likelihood for defenders to lose their endowment (and winnings), attackers earned disproportionately more than defenders (*game* × *role* effect, $p < 0.001$; Table 5). Having a production option, hence, decreased conflict expenditure but increased wealth inequality between attackers and defenders (*game* effect, $p < 0.001$; Table 5).

Table 5

Results of linear random intercept mixed models for earnings and inequality

Dependent Variable	Predictor	Estimate (b)	Test statistic (t)	p
Earnings	(Intercept)	15.83	20.84	< .001
	Game	14.09	12.95	< .001
	Role	-8.35	-11.25	< .001
	Game×Role	-7.09	-6.66	< .001
Inequality	(Intercept)	8.35	11.25	< .001
	Game	7.09	6.66	< .001

Note. Estimates for aggregated effects of *Game: PAD-C* and *Role: Attacker* on various outcome variables using linear mixed model with random effects *participan*t and *dyad*.

Cross-Round Dynamics in Conflict and Production

Previous research on repeated interactions between attackers and defenders indicates that especially defenders adjust their conflict investment as a response to attackers' aggression (De Dreu and Gross, 2018). We thus explored this possibility and examined how having production opportunities modulates such action-reaction tendencies. We found that defenders indeed conditioned conflict investment more strongly on their attackers' previous round behavior (in AD-C: b = 0.35, p < .001; in PAD-C: b = 0.31, p < .001; Table 6) than attackers conditioned investments on their defenders' previous round behavior (AD-C: b = 0.10, p < .001; PAD-C: b = -0.02, p = .329; Table 6). Furthermore, although attackers and defenders were less responsive to their opponents' previous round investment in the PAD-C than in the AD-C, this decrease in responsiveness was more pronounced for attackers than for defenders (the interaction effect *conflict investment defender lag 1* × *game* when predicting attacker conflict investment was b = -0.13, p < .001; the interaction effect *conflict investment attacker lag 1* × *game* when predicting defender conflict investment was b = -0.06, p = .01; Table 6). Possibly, the presence of a production opportunity allowed attackers more independence in their investment decisions, reducing their reliance on defender behavior. In contrast, the same production opportunity did not reduce this reliance for defenders, for whom unsuccessful defense was equally costly across conditions.

A similar pattern was observed when analyzing investment in production. Here too, defenders' production investment was strongly predicted by attackers' conflict investment in the previous round (*conflict investment attacker lag 1* effect, p < .001; Table 6), whereas attackers' investment in production was not predicted by defenders' past decisions (*conflict investment defender lag 1* effect, p = .566; Table 6). Our analysis therefore suggests that defenders' investment in production and conflict was constrained by their need to follow the attackers' conflict behavior more closely than vice versa. Because attackers could more freely decide to invest in production and/or predation, they reached the production threshold more often and earned relatively more than defenders.

Table 6

Results of linear random intercept mixed models for attacker and defender investment behavior predicted by opponents' conflict investment on the previous round

Dependent Variable	Predictor	Estimate (*b*)	Test Statistic (*t*)	*p*
Conflict investment	(Intercept)	7.06	10.80	< .001
attackers (AD-C)	Conflict investment defenders (lag 1)	0.10	5.65	< .001
Conflict investment	(Intercept)	5.95	13.74	< .001
defenders (AD-C)	Conflict investment attackers (lag 1)	0.35	24.06	< .001
Conflict investment	(Intercept)	5.18	15.90	< .001
attackers (PAD-C)	Conflict investment defender (lag 1)	-0.02	-0.98	.329
Conflict investment	(Intercept)	4.40	19.49	< .001
defenders (PAD-C)	Conflict investment attackers (lag 1)	0.30	19.18	< .001
Conflict investment	(Intercept)	6.99	13.36	< .001
attackers	Conflict investment defender (lag 1)	0.11	6.36	< .001
	Game	-1.76	-2.29	.023
	Interaction	-0.13	-4.94	< .001
Conflict investment	(Intercept)	5.89	16.86	< .001
defender	Conflict investment attackers (lag 1)	-0.64	-46.74	< .001
	Game	-1.47	-2.88	.005
	Interaction	-0.06	-2.59	.010
Production investment	(Intercept)	12.12	27.78	< .001
attackers (PAD-C)	Conflict investment defenders (lag 1)	0.01	0.57	.566
Production investment	(Intercept)	12.75	37.43	< .001
defenders (PAD-C)	Conflict investment attackers (lag 1)	-0.27	-14.57	< .001

Note. Estimates for effects of opponent previous round conflict investment on attackers and defenders conflict and production investment using linear mixed model with random effect *dyad*. Models 1 – 4 and 7 – 8 are treatment specific. Model 5 and 6 include both treatments and the effect of *Game: PAD-C.*

Conclusions and Discussion

The intention to increase wealth is among the key reasons for conflict – individuals, groups and nation states initiate and escalate predatory attacks on others to appropriate resources, to increase access to precious materials and territories controlled by others, or to benefit otherwise from what neighbors hold and produce. Even the mere anticipation of such predatory attacks can lead individuals, groups, and nation states to introduce a range of preventive measures, from legally-binding contracts to investing in military defense and pre-emptive strikes (Abbink & de Haan, 2014; Jervis, 1978). The inevitable arms-race set in motion by predatory attacks can be excessively costly, reducing (rather than increasing) economic wealth and prosperity in both conflict initiators and responders (De Dreu et al., 2022). Already in the simple attacker-defender contest studied here, attackers on average lost 20.87% of their original wealth, and defenders 62.63%. Whereas both sides started out equally wealthy, attackers on average earned 111.73% more post-conflict than their defending counterparts.

Next to using predatory attacks on others, individuals gain wealth through economic production, including technological innovation and investing in human capital. Individuals, groups, and nation states oftentimes face a tradeoff between investing in ‘peaceful’ economic production and ‘aggressive’ predation on what others have and produce. We modeled such tradeoffs under various cost levels and found that having rather than not having ‘peaceful’ production opportunities can indeed reduce overall conflict, and investment in predatory attacks in particular. We also found that when economic production becomes a more costly way to create wealth, predatory attacks become more rather than less likely. Our results therefore suggest that preventing renewed aggression would not only require opportunities for economic production but also opportunities that are comparatively easy to implement and realize. Indeed, both our model and our experiments revealed that while introducing costly production opportunities reduces the intensity of conflict, it does not eliminate predatory attacks. With the threat of predatory attacks looming, individuals continue to invest in defense and cannot fully focus on 'peaceful' creation of wealth through economic production (also see Antonakis, 1999). When peace is costly, wasteful conflicts emerge and persist, diminishing wealth and intensifying inequalities.

Using recent advances in theory on conflict in general and on asymmetric attacker-defender contests in particular, our findings integrate disparate literatures on the 'guns versus butter' tradeoffs that agents make (Carter & Anderton 2001; Durham et al., 1998; Lacomba et al., 2014) and on when and how natural resources and economic wealth can be a curse rather than blessing (van der Ploeg, 2011; Koubi et al., 2014). Combined, this allows us to conclude, first, that individuals invest in predatory attacks and, consequently, invest even more in defensive protection. Second, our theoretical results suggest that when economic production is a comparatively 'cheap' technology for wealth creation, predatory attack loses its appeal and wasteful conflict is reduced. Yet when economic production is comparatively costly, predatory attack gains in appeal and wasteful conflict re-emerges. Third, when peace is costly and conflict increasingly likely, especially those under attack become impoverished. Attackers are not only in the 'driver's seat' when it comes to initiating and intensifying conflict, they also suffer the least from costly opportunities for peace and wasteful conflict.

Limitations and Open Questions

Our conclusions need to be appreciated in light of several boundary conditions. First, our theoretical analysis relies on the Nash equilibrium prediction. Humans are bounded in their rationality and may hold social preferences and moral codes that may prevent them from investing in predatory attacks (see, e.g., De Dreu et al., 2019). Whereas our theoretical predictions were largely confirmed in our experiment, future work is needed to examine how social preferences and moral codes influence the tradeoff between creating wealth through more or less costly production on the one hand, and predatory aggression on the other. Second, we modeled economic production as a step-level technology for creating wealth. This made economic production similar to predatory attack, which also has a step-level success function. Alternative technologies for the economic production of wealth are conceivable, including linear relations between effort and return. The current theoretical model can be adapted to examine whether and how alternative technologies alter the tradeoffs between investing effort in economic production versus predatory attacks. Third, and although some of our hypotheses were inspired by work on international conflict, we tested predictions in stylized experimental contests between two individuals. While the strength of this approach lies in internal validity and enables us to draw causal inferences, further work is needed to examine whether and to what extent our experimental results generalize to more complex and multifaceted conflicts in which, next to investing in production, a range of behaviors other than investing in either attack or defense is possible (see also Mintz et al., 2006). Finally, our theory and experiment are limited to unitary actors akin to individuals involved in dyadic disputes or dictator-led nation states (also see De Dreu et al., 2021). Whether and to what extent the current model and conclusions can be extended to non-unitary actors like coalitions of several individuals, established groups, or democratic countries is an important question for future research.

Implications for Economic Theory and Conflict Resolution

Limitations notwithstanding, our findings contribute to several disparate literatures on economics and conflict resolution. As noted, both theoretically and empirically, we find some support for Keynes' intuition that agents lacking peaceful means to create wealth are more likely to become aggressive. Innovation alongside economic aid may be effective means to reduce the intensity of conflict in general and especially predatory capture (De Dreu & Gross, 2018; Maoz & Russett, 1993; Rousseau et al., 1996; Wittman, 2000). And yet, we also found that having (versus not having) possibilities to peacefully create and generate wealth did not lead to peaceful coexistence. Behaviorally, the frequency of predatory attacks and their success did not drop when production opportunities were present. This means that defenders lost their funds to attackers just as frequently, despite the presence of peaceful means of production, making successful attack no less costly for them. Furthermore, this unchanged frequency of conflict constrained defenders in the resources available for production, and they were consequently unable to accumulate as much wealth as their attackers did. Adding opportunities for costly peaceful production reduces the magnitude of conflict but not its likelihood or the waste it can cause.

Second, our theory and experimental evidence suggest qualifications to earlier work on the "natural resource curse" that showed that wealthier agents are more likely to become the target of aggression and, therefore, need to invest in defense (Brunnschweiler & Bulte, 2009; Hirshleifer, 1988, 1991; Olsson, 2007; van der Ploeg, 2011). Our analysis points to the possibility that this "natural resource curse" should emerge especially when wealth can be transferred easily to the victorious predator (also see Lujala et al., 2005). Relatedly, our results add to previous work on the "paradox of power" (Durham et al., 1998; Hirshleifer, 1991), which suggests that initially poorer (and thus weaker) agents are motivated to "fight harder" and thereby can improve their position relative to their richer (and thus stronger) opponents. In other words, conflict can equalize ex ante differences in wealth and power. The present results suggest that role asymmetries – i.e., being an attacker or defender – can qualify these insights, especially when agents have 'peaceful' alternatives to produce wealth. Specifically, because defenders "fight harder" overall, they are constrained in what they can invest in production (also see Grossman & Kim, 1996a, 1996b). To secure their existing wealth, defenders need to accept decreased productive capacity. The possibility of being attacked requires defenders to reduce their investment in production, and herein lies another reason for a possible reduction in ex ante wealth differences between (poor) attackers and (rich) defenders. Our analysis thus suggests that the very threat of outside hostility may lower both the ability and motivation to invest in, for example, innovation and product development (also see Aghion et al., 2005; Brown et al., 2017; Chemmanur & Tian, 2018; Conti, 2014).

Coda

Pioneering thinkers like John Stuart Mill and Adam Smith already distinguished between two opposing means aimed at increasing individual wealth: peaceful production and attempts to appropriate resources from others. To quite some extent, the science of economic production developed in relative isolation from the study of economic and political conflict. Only recently have efforts been made to integrate these lines of inquiry and start addressing the dynamic interplay between investing in economic production on the one hand and in predatory capture and protective defense on the other. Here we show that this interplay evolves dramatically differently when production is cheap versus costly, incentivizing versus dis-incentivizing conflict expenditure. Our experiment provided initial support for these possibilities, and revealed that adding (costly) production options to create wealth and prosperity in a peaceful way reduces only some aspects of conflict. Indeed, it reduced the magnitude, but not the frequency of investing in conflict, with defenders facing defeat at a rate similar to situations without peaceful alternatives to aggression. Finally, and even though costly production options reduced the intensity of conflict, they also increased wealth disparities, potentially setting the stage for future conflicts between haves and have-nots.