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Peaceability and Conflict^{*}

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Abstract

Individuals have different psychological predispositions for conflict, or peaceabilities. Whether they actually engage in conflict depends on the (institutional) context. We show how peaceabilities and context interact when players differ in three ways: peaceful shares, fighting strengths, and peaceabilities. The context produces two basic behaviors, opportunistic or matching; behavior, in turn, determines if higher peaceability (or its probability) increases the likelihood of conflict. Consequently, for the same change in peaceabilities, the context can produce opposite predictions regarding peace and conflict.

Key words: Conflict; Peaceful Sharing; Psychology; Peaceability; Bellicosity; Fighting Strength; Institutional Context; Incomplete Information

JEL Classification: C72, D74, D91

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1 Introduction

Barry and Kim are partners in gold prospecting. They agree that if they hit gold, they will share the proceeds 50-50. Barry is 6'2", weighs 200 pounds, has a quiet nature and doesn't like to fight. Kim is 5'6", weighs 140 pounds, is hot-tempered and so easily gets into a fight.

After six months of prospection, they hit gold in a remote, isolated spot. Each must make a decision: peacefully respect the initial sharing arrangement or fight. While Barry may win a fight "materially", he incurs significant psychological cost from conflict. Kim ends up with little materially, even suffers physical harm, but he is not much tormented from a fight.

What will they do? Share peacefully, fight, or concede? Suppose the initial sharing had been set at 75-25 in favor of Kim; how would that affect the decisions? What if Kim is unsure about Barry's mindset? What if they both carry a six-shooter pistol, thus equalizing forces?¹

Explaining why parties engage in wasteful conflict instead of accepting a peaceful sharing arrangement is a central question in conflict analysis. Two well-studied core determinants are the terms of the (peaceful) *sharing arrangement* and the players' *strengths* under conflict. A third determinant that is arguably just as important, but has received far less attention in theoretical analysis, is that of a player's psychological (or emotional) predisposition for peace; we refer to this determinant as a player's *peaceability*.²

The idea that emotions play a role in conflict was already recognized by Schelling (1960). The ensuing theoretical literature, however, has mostly concentrated on the emotions of *one* party only, who moreover must respond with a one-sided punishment, as portrayed by Hirshleifer (1987). What we

¹See Umbeck (1981) for an argument about the importance of pistols as strength "equalizers" between gold diggers during the 1848 gold rush in the American west.

²A word regarding terminology is warranted here. We use the term *peaceability* because it fits best with the flow of our analysis. We use it according to one definition typically found in dictionaries, such as the following one from Wiktionary: "peaceable. Adjective. Favouring peace rather than conflict; not aggressive, tending to avoid violence (of people, actions etc.)." The term *bellicosity* will sometimes be used, where higher bellicosity is equivalent to lower peaceability. The important point is that this refers to a person's *state of mind* about engaging into conflict which is distinct from the *decision to engage*. In psychology, one encounters the expression *aggression proneness* (Benjamin 2016). In war politics, the terms *hawkish*, *dovish* and *pacifist* are often used. Loewenstein (2000) talks of *hot* versus *cold* states.

have in mind is different: we wish to account for psychological predispositions of *both* parties, and in situations where *both* parties must decide whether to engage in conflict or not. This enables us to contribute to our understanding of peace and conflict by painting a full-grid picture of the *three-way* interactions between an initial Sharing arrangement, Fighting strengths, and the players' Peaceabilities – the *SFP* configuration – under both complete and incomplete information settings. Indeed, we could not find a game theoretic model of conflict that considered heterogeneity in all three dimensions.

The *SFP* configuration is taken as exogenous to our analysis, i.e., we do not attempt to explain where the initial sharing arrangement or fighting strengths come from and, most crucially, what determines peoples' peaceabilities. One can think of this setting as the *last stage* of a multi-stage game in which the parties have agreed on a sharing arrangement and/or built-up fighting abilities. As for their peaceabilities, they may depend on past actions or be intrinsic to the individuals; we simply take them as given at this stage in order to anticipate their impact on peace and conflict.

The players are offered to share a prize according to an exogenous sharing rule. They can then choose between acting peacefully or engaging into a potential fight. Peaceability is represented by a psychological cost of engagement. If a player engages into a fight while the other does not, then the first player collects the entire prize. Based on purely material self-interest, players would therefore always engage into a fight; the fact that they don't can therefore only be due the presence of peaceability. *This setting allows us to most simply and starkly bring out the role of peaceability in conflict.*

The most important take-away from the analysis is that two individuals with the same psychological predisposition (peaceabilities) for conflict may behave quite differently under a different institutional *context* (sharing rule and fighting strengths), sometimes even in opposite directions.³ *This is because context alone determines if a player has a “tendency” to behave as an opportunist or a matcher.* Practically, an opportunist is most averse to conflict, while a matcher has a highest preference for peace. Not surprisingly then, how peaceability and context interact to produce a peaceful outcome is not trivial. We shed light on this.

We show, for instance, that under complete information and mixed-

³This result is consistent with the main running theme of Sapolsky's (2017) bestseller, which is that neurobiology must account for the context in order to explain propensity for aggression.

strategies, the likelihood of peace increases with the peaceability level of an opportunist, but that the opposite holds with a matcher. Moreover, increasing the strength of a matcher paradoxically decreases her expected gain. Under complete information and pure strategies, being bellicose may provide an advantage to a weak player, but that this may backfire if the player has slightly overestimated the peaceability of the other player. Under a one-sided, incomplete information setting, the presence of uncertainty about the other player’s peaceability level reduces the scopes for both conflict and peace equilibria if the common-knowledge player is a matcher. The opposite occurs if she is an opportunist.

The introduction of emotions in more formal theoretical modeling in economics has taken off in the late 1980s. For instance, Hirshleifer (1987) and Frank (1988) used emotions with the aim to explain the presence of human cooperation in one-shot games with an evolutionary perspective.⁴ Geanakoplos et al. (1989) more generally introduced the concept of *subgame perfect psychological equilibrium*. This theoretical framework has motivated others to analyse the effects of specific types of emotions on economic behavior, such as guilt, blame, anger or frustration (Battigalli and Dufwenberg 2007, 2009; Battigalli et al. 2019; Celen et al. 2017; Dufwenberg 2002).

This work was accompanied by a flurry of laboratory experiments on the role of (one-sided) punishment as a cooperation-inducing mechanism.⁵ But to our knowledge, De Dreu (1995), Dale et al. (2002) and Duffy and Kim (2005) are among the few early instances with an explicit consideration of (two-sided) conflict in an experimental setting; the idea seems to have truly taken hold more recently with the experiments by Smith et al. (2014), Kimbrough et al. (2014), Kimbrough and Sheremeta (2014), McBride and Skaperdas (2014) and Herbst et al. (2017).

In psychology, “proneness for aggression” is of course an important parameter used to explain violent behavior at the individual level (Anderson and Bushman 2002).⁶ This proneness may be a stable characteristic of the

⁴Trivers (1971), a biologist, made similar arguments.

⁵This literature is too vast to cite here. See, for instance, Fehr and Gächter (2002) and Bowles and Gintis (2011). A noteworthy recent theoretical contribution is that of Akerlof (2016), who considers the role of anger and contends that the “possibility of retaliatory punishment” by the punished would be a natural extension as it “presents the possibility of capturing feuding”.

⁶Interestingly, psychologists Sell et al. (2009) suggest that stronger individuals also tend to be more prone to anger. We do not consider such correlations.

individual (person factors) or depend on past events (situational factors).⁷ Hirshleifer (1993) argues that the distinction is relevant in order to explain cooperation in one-shot games; in his terminology, the *affections* are action-independent and stable over time while the *passions* are action-dependent. Our analysis does not distinguish between the two; however, it explicitly accounts for *both* parties' psychological predispositions instead of just one.⁸

In the literature on the politics of war, our analysis contributes to Levy (2011;2013), who makes the case that a complete theory of war should consider psychological variables along with “rational” factors.⁹ Indeed, Levy forcefully underscores the role played by the psychological predispositions of political leaders in explaining war. In a way, we incorporate Levy’s main argument into the model developed by Powell (2002), which looks at the interactions between the sharing rule and fighting power, but does not explicitly consider the role of psychology.

The structure of our model is closest to that of Gretlein et al. (1996) who consider asymmetries in strengths and peaceful shares; however, they assume common-knowledge symmetrical fixed costs. In a similar setting, Baliga and Sjostrom (2004;2012) make a forceful case about the importance of fixed cost asymmetries; their analysis, however, posits (the equivalent of) symmetrical peaceful shares and fighting strengths. Baliga and Sjostrom (2015) consider the role of asymmetric strengths, though in a different setting where those strengths depend on the presence of a first-mover advantage. Peaceful shares are still assumed equal. As far as we could tell, no-one has yet considered heterogeneities in the three dimensions; our results suggest that this is relevant to understand the role of psychological predispositions in peace and conflict.

In the incomplete information setting, arguably the closest paper to ours is Battigali et al. (2019). The authors explore the behavioural consequences of emotions, specifically frustration and anger. In their analysis, the authors

⁷Our model could in fact be construed as a game-theoretical application of the general aggression model (GAM) described in Anderson and Bushman (2002).

⁸For detailed discussions on the introduction of emotions in economic theory, see the surveys by Elster (1998) and Loewenstein (2000).

⁹The use of the term “rational” often leads to confusion. In economics typically, a rational decision-maker is one who maximizes an objective function (which may include psychological costs and benefits) under some constraints. In the cited literature on the politics of war, “rational” behavior corresponds to calculations based on purely material interests and ignores psychological costs. See Fearon (1995) for an excellent treatment on “rationalist explanations for war”.

use (nontraditional) belief-dependent utility functions. We examine the role of psychological predispositions in a Bayesian-Nash setting, which contributes additional insights.

The paper is organized as follows: The game is described in the next section. In section 3, we consider the situation in the absence of peaceability. We solve for all possible equilibria in a complete information setting under asymmetric SFP configurations in section 4. The case of incomplete information is analyzed in section 5. Some additional discussions and policy implications appear in section 6. Section 7 concludes.

2 The game

2.1 The general setting

There is a prize of value $V > 0$ to be shared between two players, 1 and 2. The *sharing rule* (exogenously) dictates that player i receives a share s_i of the prize, $s_i > 0 \forall i \in \{1, 2\}$. With $s_1 + s_2 = 1$, this entails no waste and is thus coined *peaceful sharing*. The total value of the part received by player i is denoted $g_i \equiv s_i V$, $g_1 + g_2 = V$. The sharing rule can be represented by either vector $S = (s_1, s_2)$ or $G = (g_1, g_2)$.

Players have the option to reject peaceful sharing by engaging into a potential contest for a different share of the prize. If both players opt for a contest, then *material* wastage occurs because this entails contest efforts along with eventual destruction of value; for this reason, it is referred to as a situation of conflict. Conflict is summarized by the following reduced form: at the outcome of a conflict, player i appropriates a value $f_i = r_i V$, $r_1 + r_2 < 1$ and $r_1, r_2 > 0$. Fighting costs, wastage and destruction are thus represented by the fact that $r_1 + r_2 < 1$. We will refer to f_i as player i 's *fighting strength* and vector $F = (f_1, f_2)$ as the *strength configuration*. Note that this representation of conflict has the advantage of being both simple and very general as it allows us to consider any degree of asymmetric strengths in combination with any degree of wastage.

The players must decide whether to contest or accept the peaceful sharing rule, respectively denoted HAWK and DOVE. This choice is simultaneous and is represented by $\varepsilon_i \in \{HAWK, DOVE\}$. The final payoff for player i is denoted $v_i(\varepsilon_i, \varepsilon_j)$.

We further assume that a player who opts to contest the peaceful sharing rule by choosing HAWK suffers a *psychic* cost b_i . Player 1 is therefore said

to be more *peaceable* than player 2 if $b_1 > b_2$. To simplify, we assume that $b_i \geq 0$ such that individual peaceability is at its lowest when $b_i = 0$.¹⁰¹¹

If both players choose HAWK, a *conflict* ensues as described above. Conversely, if both choose DOVE, *peace* ensues and the prize is apportioned according to the sharing rule.

The case in which player i chooses HAWK and player j chooses DOVE is referred to as a *concession* by player j . Here, only player i incurs the psychic cost. For brevity's sake, we assume that $v_i(\text{HAWK}, \text{DOVE}) = V - b_i$ and $v_j(\text{HAWK}, \text{DOVE}) = 0$, i.e., a conceding player yields the entire prize to the other player. While some generality is lost in making this assumption, it is worth the gain in the concise analysis and insights that it yields given our primary goal of untangling the three-way interactions between the sharing rule, peaceabilities and strengths. The game in reduced form is illustrated in figure 1.

		Player 2	
		<i>HAWK</i>	<i>DOVE</i>
Player 1	<i>HAWK</i>	$f_1 - b_1, f_2 - b_2$	$V - b_1, 0$
	<i>DOVE</i>	$0, V - b_2$	g_1, g_2

Figure 1: The game in reduced form

For clarity, we represent the choices with the terms HAWK and DOVE as they are self-explanatory (respectively H and D to conserve space). Keep in mind, however, that the payoff matrix does not always correspond to that of a hawk-dove game, as will be seen below. Before we characterize the various equilibrium types, the following concepts will prove useful.

2.2 *Opportunism, matching, and intrinsic tendencies*

We refer to opportunistic behaviour as a situation in which a player's reaction function dictates to play HAWK against DOVE, and DOVE against HAWK. Player i is called an *opportunist* when $g_j - f_i > 0$, a necessary condition

¹⁰Using the psychologists' jargon, peaceability corresponds to a person's "valence" associated with engaging in conflict. On the concept of valence, see Elster (1998).

¹¹A negative value for b_i would correspond to a willingness-to-pay to engage into a fight or hurt the other player. This could occur, for instance, with the presence of hatred against another player, or a desire for revenge. We leave the analysis of this possibility for future work.

for opportunistic behavior. Player i will then behave as an opportunist in equilibrium if, and only if, his peaceability level falls within the range $b_i \in (f_i, g_j)$.

Matching behavior is when someone plays HAWK against HAWK, and DOVE against DOVE. Player i is called a *matcher* when $g_j - f_i < 0$, a necessary condition for matching behavior. Player i will match in equilibrium if, and only if, $b_i \in (g_j, f_i)$.

A player is therefore either a matcher or an opportunist, a distinction that will be crucial for the analysis. In any SFP configuration, we either have two opportunists, or one opportunist facing one matcher; the possibility of having two matchers is ruled out because it requires $f_1 + f_2 > V$, implying that conflict would create value.

Keep in mind that the difference in behavior between opportunists and matchers holds even though the *gross* payoff from fighting a dove is always higher than that from fighting a hawk; what matters is the *net gain* from playing HAWK instead of DOVE.¹² And contrary to peaceability, opportunism is not intrinsic to a player as it is dictated by the context. One should therefore be cautious to conceive of matching behavior as being more virtuous than opportunism; indeed, matching behavior may come about as the result of increased fighting strength or higher peaceful share.

3 The absence of peaceability

We denote player 1 and 2's respective choices as follows: $\Sigma = (\varepsilon_1, \varepsilon_2)$ where $\varepsilon_i \in \{HAWK, DOVE\}$.

Proposition 1 *In the absence of peaceability, i.e., $b_1 = b_2 = 0$, the PSNE $\Sigma = (HAWK, HAWK)$ is a unique equilibrium.*¹³

We thus see that regardless of the sharing rule, players will always engage into a conflict when peaceability is negligible. This underscores the important role of peaceability in peaceful equilibria. We next consider cases with $b_i \geq$

¹²One may be tempted to call the matcher's behavior as equivalent to the *tit-for-tat* strategy (Axelrod 1981). That would be misleading as the later requires multiple interactions between the players. A matcher's behavior corresponds more closely to the *silver rule* proposed by Hirshleifer (1993), with the distinction that in our case, the behavior is not intrinsic to a player.

¹³Proofs of propositions appear in the Appendix.

$0, \forall i \in \{1, 2\}$. We begin by considering a complete information setting before turning to incomplete information.

4 Complete information

We now consider all cases with $b_i \geq 0, \forall i \in \{1, 2\}$. We begin by considering pure strategy equilibria only. Mixed-strategies are considered in section 4.4.

4.1 Peace as PSNE

We refer to an equilibrium where both players accept the sharing rule, i.e. $\Sigma = (DOVE, DOVE)$, as a *peace equilibrium*. We have the following proposition:

Proposition 2 Peace as PSNE

The necessary and sufficient conditions for a peace equilibrium in pure strategies are

$$g_j - b_i < 0, \forall i \neq j. \quad (1)$$

Proposition 2 implies the following two corollaries, which we state without proof:

Corollary 3 On peace and power

Variations in the fighting strength of the players has no effect on the peace equilibrium in pure strategies.

Corollary 4 On the existence of a peace equilibrium *A necessary condition for a peace equilibrium in pure strategies to exist is that the sum of the players' peaceabilities exceed the value of the prize, i.e.,*

$$b_1 + b_2 > V. \quad (2)$$

Moreover, there exists a sharing rule that achieves peace with certainty if, and only if, the above inequality holds.

Interpretation: For player i , fighting a dove brings additional material gain g_j compared to peaceful sharing, but adds the psychic cost b_i . The difference yields the net gain from fighting a dove. If this net gain is negative for both players, then peace is a PSNE (sufficiency). Moreover, if this net

gain is positive for one player when the other plays *DOVE*, that player will play *HAWK* against *DOVE* and consequently, peace cannot be a PSNE (necessity). The absence of a role for fighting strength comes from the fact that a concession involves no fighting.

4.2 Conflict as PSNE

We refer to an equilibrium where both players fight, $\Sigma = (HAWK, HAWK)$, as a *conflict equilibrium*. We have:

Proposition 5 Conflict as PSNE

The necessary and sufficient conditions for a conflict equilibrium in pure strategies are

$$f_i - b_i \geq 0, \forall i. \tag{3}$$

Corollary 6 On conflict and peaceful sharing

The peaceful sharing arrangement has no effect on the conflict equilibrium in pure strategies.

Interpretation: If player i engages against a hawk instead of conceding, she gets additional material gain f_i but suffers psychic cost b_i , a net gain of $f_i - b_i$. If that gain is positive for both players, then both players will prefer to engage against a hawk (sufficiency). If it is negative for one player, then that player prefers to concede (necessity). Since a concession involves giving up the entire peaceful share, its value has no bearing on the conflict equilibrium in pure strategies.

We therefore conclude that peaceabilities play a role for both peace and conflict PSNE. However, fighting strengths are not relevant for peace PSNE, while the sharing arrangement is not relevant for a conflict PSNE.

4.3 Concession as PSNE

For concession equilibria, we must distinguish between two cases: one with two opportunists facing each other, and one where an opportunist faces a matcher. We have:

Proposition 7 *Conceding as PSNE*

- 1) A sufficient condition for a concession PSNE is $b_i \geq f_i$ and $b_j < g_i$, $i \neq j$.
- 2) Two opportunists ($g_j - f_i > 0$, $\forall i, i \neq j$):
 - a) Assume that $b_i > g_j$ and $b_j < g_i$. Then concede by i is a unique PSNE.
 - b) Assume that $b_i > f_i$ and $b_j < f_j$. Then concede by i is a unique PSNE.
- 3) An opportunist facing a matcher ($g_j - f_i > 0$ and $g_i - f_j < 0$, $i \neq j$):
 - a) Assume that $b_i > f_i$ and $b_j < g_i$. Then concede by i is a unique PSNE.
 - b) Assume that $b_i < g_j$ and $b_j > f_j$. Then concede by j is a unique PSNE.

We have now characterized all PSNE. These are illustrated in figure 2, where a) represents the case with two opportunists, while in b), player 2 is an opportunist and player 1 is a matcher. These two cases lead to distinct, sometimes opposite outcomes.

4.3.1 Case a) Two opportunists

This case is illustrated in part a) of figure 2. The sharing line is defined by equation $g_1 + g_2 = V$; fighting outcomes lie below that line due to wastage and destruction.

Propositions 2 to 7 yield five regions in the $b_1 - b_2$ plane. In the *peace* region, both players accept the sharing rule. In the *conflict* region, both decide to engage. The two regions labelled *concede i* (Ci) correspond to situations where player i concedes to player j . This leaves a fifth region, denoted $C1C2$, which admits two pure strategy equilibria: one in which player 1 concedes, another in which player 2 concedes, as will be determined in section 4.4.

4.3.2 Case b) An opportunist and a matcher

Part b) of figure 2 illustrates a case where player 1 is a matcher. We have the same initial four equilibria as above. The difference now is that no PSNE exists in the box delimited by $g_2 < b_1 < f_1$ and $f_2 < b_2 < g_1$; for these values, we need to turn to mixed-strategy equilibria.

4.4 Mixed strategy Nash equilibria (MSNE)

Let σ_i be the probability that player i chooses HAWK, $i \in \{1, 2\}$. Given σ_j , player i may choose a mixed strategy only if she is indifferent between engaging or not, i.e., $E[v_i(\text{HAWK}, \sigma_j)] = E[v_i(\text{DOVE}, \sigma_j)]$, where $E[\cdot]$ denotes

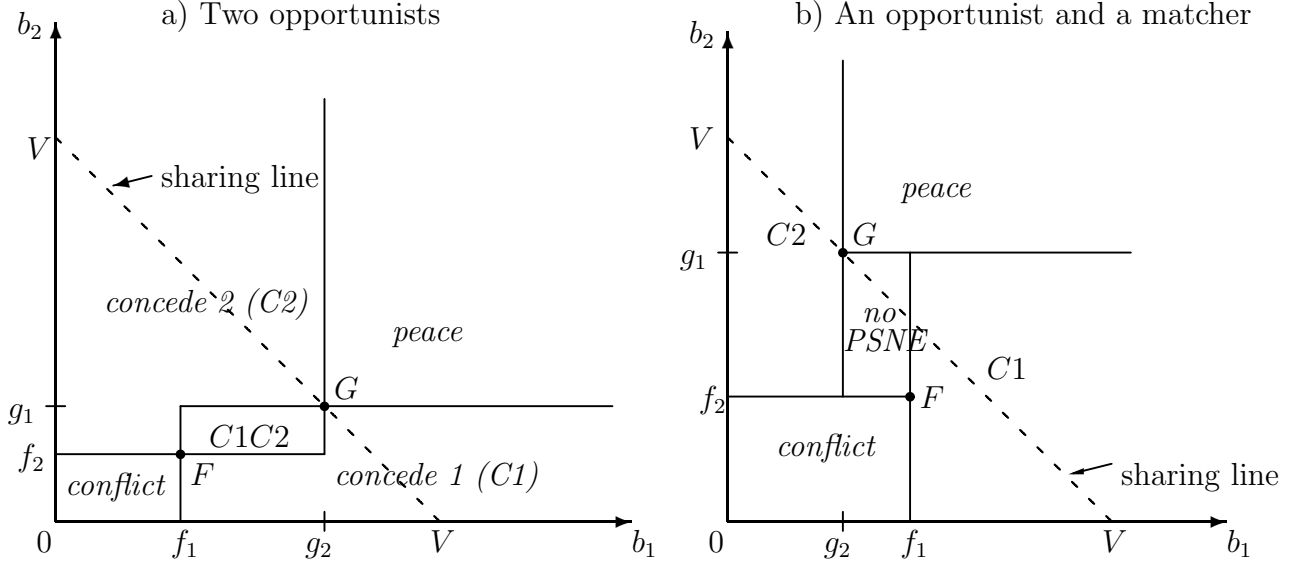


Figure 2: The pure strategy Nash equilibria

the expectation operator. We have:

$$\begin{aligned}
 E[v_i(\text{HAWK}, \sigma_j)] &= \sigma_j v_i(H, H) + (1 - \sigma_j) v_i(H, D) \\
 &= \sigma_j f_i + (1 - \sigma_j) V - b_i
 \end{aligned} \tag{4}$$

$$\begin{aligned}
 E[v_i(\text{DOVE}, \sigma_j)] &= \sigma_j v_i(D, H) + (1 - \sigma_j) v_i(D, D) \\
 &= (1 - \sigma_j) g_i
 \end{aligned} \tag{5}$$

By equating the two values, using the fact that $g_i + g_j = V$ and the symmetry between the players's problems, we obtain that player i will play a mixed strategy only if player j 's probability of engaging is given by the following:

$$\sigma_j^m = \frac{b_i - g_j}{f_i - g_j}, \quad i \neq j. \tag{6}$$

A mixed strategy equilibrium is thus admissible only when the following inequalities are respected:

$$0 < \frac{b_i - g_j}{f_i - g_j} < 1, \quad \forall i \neq j. \tag{7}$$

The associated expected final payoffs are

$$E[v_i(\sigma_i, \sigma_j)] = \frac{b_i - f_i}{g_j - f_i} g_i. \quad (8)$$

Again, there are two separate cases to consider: with $g_j - f_i > 0$, (7) requires that $f_i < b_i < g_j$, while $g_j - f_i < 0$ requires that $g_j < b_i < f_i$. Consequently, it can be seen from figure 2 that a MSNE can only occur within the *C1C2* region in part a), and the *no PSNE* region in part b). The reaction functions corresponding to the aforementioned regions in parts a) and b) of figure 2 are illustrated in figure 3, respectively parts a) and b). Either way, one notes from (8) that under a MSNE, the expected payoff for each player i is strictly lower than her peaceful share g_i .

A comparison of $\sigma_1(\sigma_2)$ in cases a) and b) of figure 3 indicates that an opportunist's reaction to an increase in the probability that the other player plays HAWK is opposite to that of a matcher. As we next explain, this derives from that fact that these two types differ in terms of their best and worse outcomes.

4.4.1 Case a) An opportunist's ranking of outcomes

$b_1 < g_2$ implies that opportunistic player 1 prefers to force a concession from player 2 than to share peacefully; this is due to player 2's high peaceful share *relative* to player 1's peaceability. But with $b_1 > f_1$, player 1 prefers to concede everything than to fight; this is due to player 1's low fighting strength *relative* to his peaceability. We have:

$$C2 \succ \textit{peace} \succ C1 \succ \textit{conflict} \quad [\textit{Opportunist outcome rankings}] \quad (9)$$

*An opportunist must balance a high desire to force a concession,
against a strong aversion for conflict.*

With low σ_2 , this desire to force a concession dominates as the risk of ending up in a conflict is low; player 1 consequently chooses HAWK with certainty, as illustrated by $\sigma_1(\sigma_2)$ in part a). Conversely, player 1's strong aversion for conflict dominates when player 2 is very likely to engage (high σ_2), in which case player 1 chooses DOVE with certainty. σ_2^m in (6) denotes that probability for which player 1 is indifferent between engaging or not.

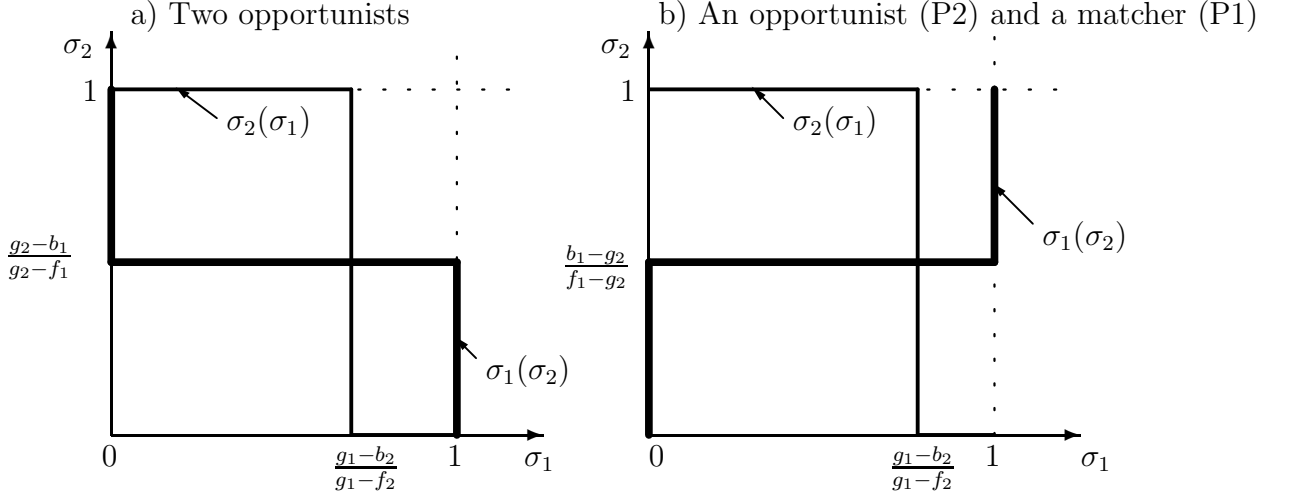


Figure 3: The reaction functions for the mixed strategy Nash equilibria

4.4.2 Case b) A matcher's ranking of outcomes

Things are opposite with a matcher. With $b_1 > g_2$, matching player 1 prefers peaceful sharing to a concession by player 2, a consequence of the matcher's high peaceability *relative* to player 2's peaceful share. $b_1 < f_1$ implies, on the other hand, that the matcher prefers conflict over conceding, due to her low peaceability *relative* to her fighting strength. We have:

$$peace \succ C2 \succ conflict \succ C1 \quad [\text{Matcher outcome rankings}] \quad (10)$$

*A matcher is characterised by a high desire for peace,
while not being so averse to conflict.*

Player 1's desire for peace dominates when player 2 is unlikely to engage (low σ_2), so that player 1 plays DOVE with certainty, as illustrated by $\sigma_1(\sigma_2)$ in part b). Conversely, if player 2 is very likely to engage (high σ_2), player 1 plays HAWK as she is not so afraid of conflict. σ_2^m in (6) defines that intermediate probability for which player 1 is indifferent between engaging or not.

In equilibrium, a MSNE exists at the intersection of the reaction functions for both cases a) and b). In case a), we also recover the two previously

identified concession PSNE at points $(\sigma_1, \sigma_2) = (0, 1)$ and $(\sigma_1, \sigma_2) = (1, 0)$; the game structure is therefore that of a (asymmetrical) *Hawk-Dove game*. In case b), the reaction functions are consistent with the fact that no PSNE exists; the game structure is therefore that of a (asymmetrical) *matching-pennies game*.

Under a MSNE, the probabilities of peace and conflict occurring, respectively denoted Π^P and Π^C , are given by $\Pi^P = (1 - \sigma_2^m) \times (1 - \sigma_1^m)$ and $\Pi^C = \sigma_2^m \times \sigma_1^m$. The following proposition can be readily seen from figure 3, and the corollary derives from (8):

Proposition 8 *In a MSNE, the likelihood of peace (conflict) increases (decreases) with a player i 's peaceability level if she behaves opportunistically ($g_j > f_i$). The signs are reversed if the player behaves like a matcher ($f_i > g_j$).*

Corollary 9 *In a MSNE, the expected payoff of a player increases (decreases) with his own peaceability level if he behaves opportunistically (like a matcher). The expected payoff is, however, unaffected by the other player's peaceability level.*

In a MSNE, only a matcher gains from being more bellicose.

These results underscore the importance of the institutional context in understanding an individual's behavior in peace and conflict. Intrinsic peaceabilities are part of the equation, to be sure, but they interact with the institutional context – i.e., here the sharing arrangement and the fighting strengths – to produce opposite behavioral responses and welfare gains to increases in peaceability levels.

5 Incomplete Information

We now extend the analysis to the more realistic case of uncertainty about other players' peaceable sentiments. We adopt the Bayesian game framework whereby player i knows the value of his own type b_i but is uncertain about type b_j of the other player. Players hold *beliefs* about each other's peaceability level, represented by a prior probability distribution over a set of b_i values. These beliefs are common knowledge. Fighting strengths and peaceful shares are perfectly known by all.

In order to find a Bayesian Nash equilibrium (BNE) for this game, we need a pair of strategies $(\epsilon_1^*(\cdot), \epsilon_2^*(\cdot))$ such that $\epsilon_i^*(\cdot)$ maximizes player i 's expected payoff $E_{b_j} v_i(\epsilon_i, \epsilon_j^*(b_j), b_i)$, for both players and all types.¹⁴

Let ρ_j denote the probability that player j chooses HAWK, given j 's equilibrium strategy $\epsilon_j^*(b_j)$ and player i 's priors over types b_j . For a player i of type b_i , the expected gain from playing HAWK is then $\rho_j(f_i - b_i) + (1 - \rho_j)(V - b_i)$, while playing DOVE yields $(1 - \rho_j)g_i$. Player i will consequently choose HAWK if, and only if, $\rho_j f_i + (1 - \rho_j)V - b_i > (1 - \rho_j)g_i$. There is therefore a *cutoff type* b_i^* who will be indifferent between playing HAWK or DOVE. After rearranging, the cutoff type is defined by:

$$b_i^* = \rho_j f_i + (1 - \rho_j)g_j = g_j + \rho_j(f_i - g_j), \quad i \neq j. \quad (11)$$

b_i^* denotes the peaceability level that makes the *expected* net gain from engaging equal to zero. If player i is more (less) peaceable, then he strictly prefers DOVE (HAWK), in which case he runs a probability ρ_j of conceding everything (entering in a conflict), and a probability $(1 - \rho_j)$ of sharing peacefully (a concession by player j). We thus have the monotonicity property that for all types $b_i > b_i^*$ ($b_i < b_i^*$), i 's best strategy is to play DOVE (HAWK). From (11), we have:

Proposition 10 *Assume that a BNE in pure strategies exists. If player i is an opportunist (matcher), then $f_i < b_i^* < g_j$ ($g_j < b_i^* < f_i$) and b_i^* decreases (increases) with ρ_j .*

This proposition underscores the fact that the manner in which uncertainty affects the likelihoods of conflict or peace rests crucially on a comparison of the sharing rule with fighting abilities. Note the analogy with our analysis of the MSNE: *much hinges on whether the cutoff type acts like an opportunist or a matcher*. To gain insight, we begin with the case of a one-sided, incomplete information setting before considering two-sided incomplete information.

5.1 One-sided, incomplete information

Suppose that player 2 can be of two types only, i.e., $b_2 \in \{\underline{b}, \bar{b}\}$, and consider the case where $\underline{b} < f_2 < g_1 < \bar{b}$. We refer to \underline{b} and \bar{b} as *bellicose* and *peaceable*

¹⁴The notation and equilibrium derivation procedure are inspired by Fudenberg and Tirole (1991:chapter 6).

types, respectively. Nature determines types \underline{b} and \bar{b} with probabilities ϕ and $1 - \phi$, respectively. Player 2 is aware of her own type with certainty.

Player 1's peaceability level $b_1 \geq 0$ is perfectly known to both players. However, he is unsure about player 2's type. His prior beliefs are as described by nature above. We have:

Proposition 11 *A Bayesian Nash equilibrium of the above-described game of incomplete information is one in which:*

- Player 1 chooses HAWK if, and only if, $b_1 < b_1^*$ where $\rho_2 = \phi$;
- A player 2 of type \underline{b} plays HAWK;
- A player 2 of type \bar{b} plays DOVE.

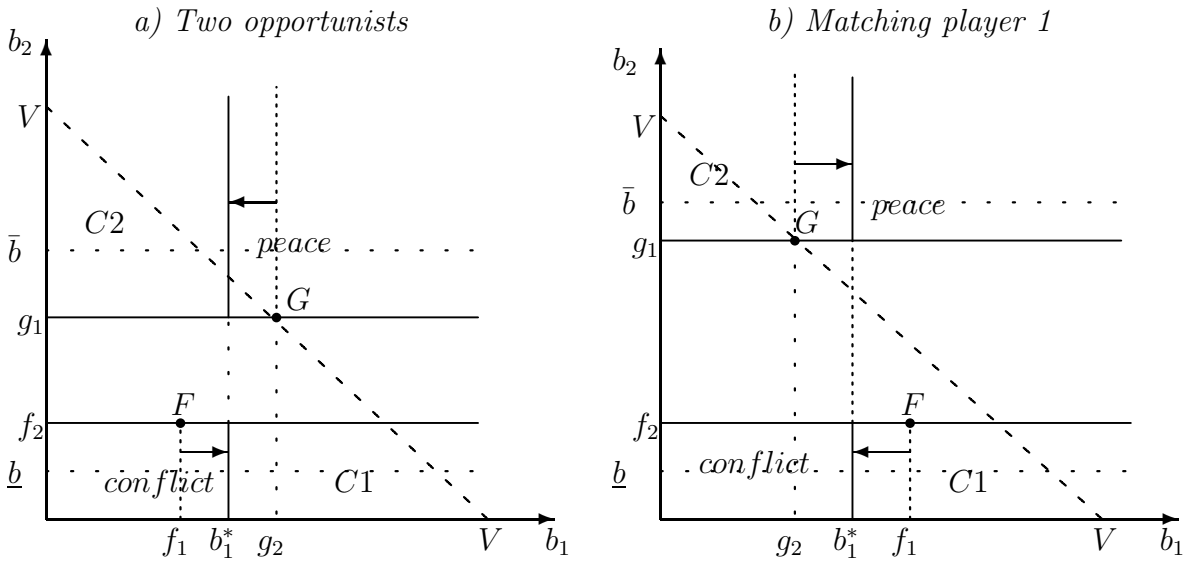


Figure 4: BNE with one-sided incomplete information

The properties of this equilibrium are represented in figure 4. Once again, we must distinguish between opportunists and matchers. We begin with a matching player 1.¹⁵

¹⁵Note that the region where b_2 values fall between f_2 and g_1 will never occur as we assumed that $\underline{b} < f_2 < g_1 < \bar{b}$. It is therefore left blank.

5.1.1 A doubting matcher

In case b) of figure 4, $g_2 < f_1$ implies that the cutoff type behaves like a matcher. Therefore, uncertainty over the opponent's type reduces the scopes for *both* conflict and peace equilibria, as illustrated by the arrows. This can be interpreted as follows.

Suppose player 2's true type is peaceable and thus she plays DOVE with certainty. If player 1 is certain about this, she matches if $b_1 > g_2$ and peace ensues (see figure 2). Any doubt about player 2's type means, from the (mistaken) perspective of player 1, that player 2 plays HAWK with some probability. *Player 1 being a matcher*, she will now feel compelled to play HAWK for some b_1 values above g_2 , up to b_1^* . However, player 2 being truly peaceable, a type $b_1 \in \{g_2, b_1^*\}$ will regret having played HAWK against a DOVE. The doubt has thus reduced the scope for peace, and increased that of concessions by player 2.

Suppose instead that player 2's true type is bellicose. If player 1 knows that with certainty, a conflict occurs for $b_1 < f_1$. If player 1 (mistakenly) thinks that player 2 might be peaceable, she assigns a probability that player 2 plays DOVE. *Player 1 being a matcher*, she will feel more inclined to try DOVE, at least for some b_1 values just below f_1 . $b_1^* < f_1$ thus reflects the uncertainty over player 2 types, with the consequence that player 1 will regret her decision to play DOVE when $b_1 \in \{b_1^*, f_1\}$; meanwhile, the uncertainty has reduced the scope for conflict outcomes, though at the cost of more concession scope by player 1.

What does the above say about an increase in the probability ϕ that a matcher faces a bellicose player? To answer this, let $d(b_1)$ denote the density distribution of player 1 types, with associated cumulative distribution $D(b_1)$. The *ex-ante* probabilities of conflict and peace outcomes are respectively given by $\Pi^c = \phi D(b_1^*)$ and $\Pi^p = (1 - \phi)(1 - D(b_1^*))$. This yields:

$$\frac{\partial \Pi^c}{\partial \phi} = D(b_1^*) + \phi d(b_1^*)(f_1 - g_2), \quad (12)$$

$$\frac{\partial \Pi^p}{\partial \phi} = -(1 - D(b_1^*)) - (1 - \phi)d(b_1^*)(f_1 - g_2). \quad (13)$$

Given that player 1 is a matcher, the above implies that increasing the probability of facing a bellicose player 2 unambiguously increases the occurrences of conflict and reduces those of peace, as the effect is positive at both the intensive and extensive margins. While this may seem intuitive, we will next

see that things can be quite different with an opportunist.

5.1.2 *An uncertain opportunist*

In part a) of figure 4, with $g_2 > f_1$, type b_1^* behaves as an opportunist. The effect of introducing uncertainty about player 2's sentiments are opposite to those of the matcher: the scopes now increase for both conflict and peace. The discussion of section 5.1.1 helps understand why. If opportunistic player 1 is certain that player 2 is bellicose and plays HAWK, player 1 responds with DOVE. Introducing a probability that player 2 is peaceable and plays DOVE, makes it more interesting for player types $b_1 \in \{f_1, b_1^*\}$ to play HAWK, thus increasing the scope for conflict. An analogous reasoning holds if player 1 initially thinks that player 2 is peaceable with certainty.

A somewhat counterintuitive implication is that increasing the probability that player 2 is bellicose may reduce the *ex-ante* occurrences of conflict and increase those of peace. Indeed, as can be seen from (12) and (13), with $f_1 - g_2 < 0$, the intensive and extensive margins move in opposite directions: For fixed $D(b_1^*)$, a higher ϕ increases the odds of a conflict. But a higher ϕ simultaneously decreases $D(b_1^*)$ by $d(b_1^*)(f_1 - g_2)$; hence, some b_1 types will switch from HAWK to DOVE, thus reducing the odds of a conflict. This is summarized by the following:

Proposition 12 *When peaceability is not pacifism*

If player 1 is an opportunist (a matcher), increasing the probability that player 2 is peaceable induces some player 1 types to switch from DOVE to HAWK (HAWK to DOVE). This reduces the ex-ante odds of a conflict with a matcher. The effect on the odds of a conflict are ambiguous with an opportunist.

Again, the above underscores the fact that the institutional context may produce opposite responses from individuals who have the same psychological predispositions.

5.2 *Two-sided, incomplete information*

Suppose now that both players are uncertain about the other player's peaceability level. Player j , $j \neq i$, believes that player i 's b_i value follows density distribution $d(b_i)$ with $b_i \in [0, +\infty]$ and associated cumulative distribution

$D(b_i)$.¹⁶ In accordance with (11), player j will play HAWK with probability $\rho_j = D(b_j^*)$. Cutoff types b_1^* and b_2^* are thus defined by simultaneous equations:

$$D(b_2^*)f_1 + (1 - D(b_2^*))g_2 - b_1^* = 0, \quad (14)$$

$$D(b_1^*)f_2 + (1 - D(b_1^*))g_1 - b_2^* = 0, \quad (15)$$

and player i plays HAWK if, and only if, $b_i < b_i^*$. Consequently, the probability of conflict is given by $D(b_1^*)D(b_2^*)$ and that of peace by $(1 - D(b_1^*))(1 - D(b_2^*))$. Let us look at some implications for variations in the fighting strengths and sharing rule.

5.2.1 Variations in the fighting strengths

Consider an increase in the fighting strength of player 1, while f_2 remains unchanged. Through implicit differentiation, we have,

$$\frac{db_1^*}{df_1} = \frac{D(b_2^*)}{\Delta}, \quad (16)$$

$$\frac{db_2^*}{df_1} = \frac{d(b_1^*)(f_2 - g_1)}{\Delta}, \quad (17)$$

where $\Delta = 1 - d(b_1^*)d(b_2^*)(f_1 - g_2)(f_2 - g_1)$. The sign of Δ is therefore positive if a matcher faces an opportunist, and ambiguous with two opportunists. This leads to the following set of results:

1. Assume a matcher faces an opportunist. Then $\Delta > 0$ and,
 - (a) a player is more likely to play HAWK when his own strength increases ($db_1^*/df_1 > 0$);
 - (b) the matcher is more likely to play HAWK if the opportunist's strength increases ($db_2^*/df_1 > 0$);
 - (c) the opportunist is more likely to play DOVE if the matcher's strength increases ($db_2^*/df_1 < 0$);

¹⁶To simplify the notation, we assume that each player has the same distribution function. It would be straightforward to assume that players have different distribution indexed as follows $d_i(b_i)$, $i = 1, 2$, but no new insight would be gained.

2. Assume two opportunists are facing each other. Then the sign of Δ is ambiguous, such that the signs of db_1^*/df_1 and db_2^*/df_1 are opposite. Consequently, if the increased strength of player 1 makes him more likely to play HAWK (DOVE), then player 2 is more likely to play DOVE (HAWK).

5.2.2 Variations in the sharing rule

Using the fact that $g_2 = V - g_1$, we have

$$\frac{db_1^*}{dg_1} = \frac{-(1 - D(b_2^*)) + (1 - D(b_1^*))d(b_2^*)(f_1 - g_2)}{\Delta}, \quad (18)$$

$$\frac{db_2^*}{dg_1} = \frac{(1 - D(b_1^*)) - (1 - D(b_2^*))d(b_1^*)(f_2 - g_1)}{\Delta}, \quad (19)$$

If a matcher faces an opportunist, then an increase the peaceful share of the matcher (opportunist) increases the likelihood that the opportunist plays HAWK (DOVE). The effect on the matcher herself is ambiguous. We also have ambiguous predictions when two opportunists are facing each other.

6 Some predictions and policy implications under complete information

In this section, we look at some implications of the model regarding changes in peaceability levels, sharing rule and fighting powers. We begin by discussing cases of PSNE and then turn to MSNE.

6.1 Pure-strategy Nash equilibria

6.1.1 Aiming for a sure peace

Corollary 3 implies that in order to achieve peace with certainty (under pure strategies), fighting strengths are not relevant. Given proposition 2, the relevant variables for peace are the psychic costs and the peaceful shares. And with $g_i = s_i V$, the prize's value is relevant. The use of the sharing rule can be tricky as increasing the share of one player requires decreasing that of the other, with the risk that the latter may now choose to engage.

6.1.2 Being bellicose can backfire

While being bellicose may provide a strategic advantage to a weak player, it is a knife edge situation.

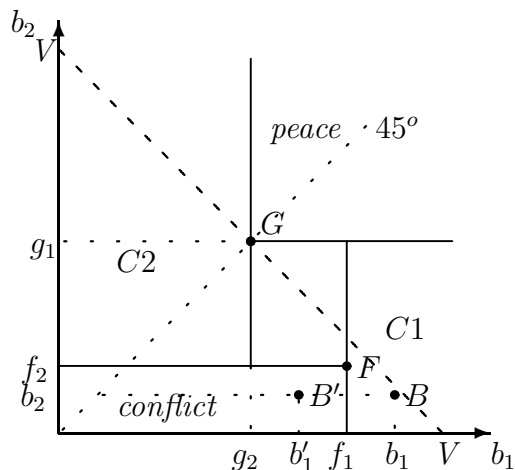


Figure 5: The strategic advantage of being bellicose

Suppose both players intend to share equally as per point G in figure 5. Player 2 is however much weaker and bellicose than player 1, as depicted by points F and B . The unique equilibrium is one where player 1 concedes everything, despite being much stronger than player 2. This is because player 2 has very little qualms in playing HAWK, while player 1 finds a conflict emotionally very costly. One can see, however, that using this strategic advantage comes with a risk. Indeed, if player 1's peaceability level turns out to be b'_1 instead of b_1 , then a conflict emerges and player 2 is left with very little. Player 1's net gain is also small in this situation because his material gain is almost all eaten up by his emotional cost. The presence of a bellicose player can therefore be a curse even for a strong player.

6.2 Mixed-strategy Nash Equilibria

6.2.1 The effect of the sharing rule under a MSNE

Through differentiation one can verify that $\partial \Pi^P / \partial g_i \geq 0 \Leftrightarrow g_j - f_i \leq g_i - f_j$. We thus have:

Proposition 13 *Peaceful shares and conflict under MSNE*

Under a MSNE,

a) if both players are opportunists, then a (local) increase in the peaceful share of player i increases (decreases) the likelihood of peace (conflict) iff player i is comparatively less opportunistic than player j ($g_j - f_i \leq g_i - f_j$).

b) if player i is an opportunist and player j is a matcher, then a (local) increase in the peaceful share of player i increases (decreases) the likelihood of peace (conflict).

c) if player i is a matcher and player j is an opportunist, then a (local) increase in the peaceful share of player i decreases (increases) the likelihood of peace (conflict) outcome.

6.2.2 The paradox of fighting strength for an opportunist

From (8), we have:

Proposition 14 *The expected gain of player i decreases (increases) with own power f_i if he is an opportunist (matcher).*

7 Conclusion

Our analysis sheds light on the manner in which the institutional context can interact with individual psychological predispositions for conflict. We show, for instance, that an increase in the peaceability of an individual tends to reduce the likelihood of conflict only if the individual behaves like an opportunist. If he behaves like a matcher, the likelihood of conflict increases instead. Context is fundamental because the tendency to behave opportunistically, as opposed to matching, is not intrinsic to an individual; it is rather entirely determined by the terms of the peaceful sharing arrangement and the fighting strengths.

While the foregoing analysis contributes elements to our understanding of conflict and peace in relation to psychology, it begs for additional research. For one, the observation that being bellicose may confer an advantage raises the prospect of a player posturing as bellicose. It would also be natural to introduce a precursor stage in which the players bargain over the sharing agreement, in the spirit of Anabarci et al. (2002), and then determine how fighting strengths and peaceabilities affect the terms of the agreement.

The model should also lend itself to an experimental setting along the lines of Herbst et al. (2017). This would require, however, to distinguish between behavioral types, as highlighted by Houser et al. (2005). One possibility would be to prime the subject, as in Falk et al. (2003), who conduct an experiment in which “spite” plays a role as an emotional state and players may build a reputation for conflict proneness. In the spirit of Houser and Xiao (2010), this would highlight the role of heterogeneities, though not just in the initial sharing arrangements, but also in fighting strengths and psychological predispositions for conflict.

APPENDIX

Proof of proposition 1: With the help of figure 1, it is straightforward to verify that *HAWK* is a dominant strategy for both players. QED

Proof of proposition 2: i) Sufficiency: We have $v_i(DOVE, DOVE) = g_i$. We must show that no player can gain by choosing *HAWK* while the other player chooses *DOVE*. We have $v_i(HAWK, DOVE) = V - b_i = g_i + g_j - b_i$. With $b_i \geq g_j$, we have $v_i(HAWK, DOVE) \leq v_i(DOVE, DOVE)$. QED
ii) Necessity: Assume $b_i < g_j$ for some $i \neq j$. Then, for any $b_j \geq 0$, we have $v_i(HAWK, DOVE) = V - b_i = g_i + g_j - b_i$. With $b_i < g_j$, this implies $v_i(HAWK, DOVE) > v_i(DOVE, DOVE)$. Hence, peace is not a PSNE. QED

Proof of proposition 5: i) Sufficiency: We have $v_i(HAWK, HAWK) = f_i - b_i$. We must show that no player can gain by choosing *DOVE* while the other player chooses *HAWK*. We have $v_i(DOVE, HAWK) = 0$. With $b_i \leq f_i$, we have $v_i(DOVE, HAWK) \leq v_i(HAWK, HAWK)$. QED
ii) Necessity: Assume that $b_i > f_i$ for some i . Then, for any $b_j \geq 0$, we have $v_i(DOVE, HAWK) = 0$ and $v_i(HAWK, HAWK) < 0$. Hence, conflict is not a PSNE. QED

Proof of proposition 7: Part 1) Take $\varepsilon_i = DOVE$ and $\varepsilon_j = HAWK$. We then have $v_i(DOVE, HAWK) = 0$ and $v_j(DOVE, HAWK) = V - b_j$. We must show that no player can gain by unilaterally deviating. Indeed, we have $v_i(HAWK, HAWK) = f_i - b_i < 0$ and $v_j(DOVE, DOVE) = g_j < V - b_j = g_j + g_i - b_j$. QED

For parts 2 and 3, note that peace and conflict PSNE equilibria are ruled out

by the fact that their respective N&S condition is not respected.

Part 2.a) Assume not. Then $\Sigma = (HAWK, DOVE)$ is the only other admissible PSNE. We have $v_i(HAWK, DOVE) = V - b_i = g_i + g_j - b_i < v_i(DOVE, DOVE) = g_i$ since $b_i > g_j$. Hence player i would prefer to play $DOVE$. A contradiction. QED

Part 2.b) Assume not. Then $\Sigma = (HAWK, DOVE)$ is the only other admissible PSNE. We have $v_j(HAWK, DOVE) = 0 < v_j(HAWK, HAWK) = f_j - b_j > 0$. Hence player j would prefer to play $HAWK$. A contradiction. QED

Part 3.a) Assume not. Then $\Sigma = (HAWK, DOVE)$ is the only other admissible PSNE. We have $v_i(HAWK, DOVE) = V - b_i = g_i + g_j - b_i < v_i(DOVE, DOVE) = g_i$ since $b_i > g_j$. Hence player i would prefer to play $DOVE$. A contradiction. QED

Part 3.b) Assume not. Then $\Sigma = (DOVE, HAWK)$ is the only other admissible PSNE. We have $v_i(DOVE, HAWK) = 0 < v_i(HAWK, HAWK) = f_i - b_i > 0$ since $b_i > g_j$. Hence player i would prefer to play $DOVE$. A contradiction. QED

Proof of proposition 11 From player 1's perspective, player 2 plays HAWK (DOVE) with probability ϕ ($1 - \phi$). Player 1's cutoff type is thus given by expression (11). Hence, player 1's strategy maximizes his expected payoff. As for player 2, it is easy to verify that HAWK (DOVE) is a dominant strategy when $\underline{b} < f_2 < g_1$ ($\bar{b} > g_1 > f_2$). QED

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