Modeling Robust Settlements to Civil War: Indivisible Stakes and Distributional Compromises

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Abstract

Why do some civil war settlements prove robust, while others fail? I show how a settlement’s robustness, defined in terms of the risk factor of the mutual-compromise equilibrium, depends on the nature of the stakes of the conflict and the distributional terms of the settlement. I identify the distributional terms of the optimal settlement, namely, that most robust to exogenous shocks to the actors’ confidence that the other will continue to compromise. I introduce a measure of the degree of the perceived indivisibility of the stakes, an increase in which not only decreases the range of feasible distributional settlements, but decreases their robustness as well. I explore how intra-party heterogeneity and uncertainty regarding ex-post outcomes lessen the range and robustness of settlements. In the conclusion, I compile the predictions of the model and briefly consider the policy implications.
Some long and bitter civil wars are eventually resolved with self-enforcing agreements, as in El Salvador and South Africa. Others seem unamenable to negotiated resolution, as in Colombia. Even where extensive third-party intervention occurs negotiated resolution may be elusive, as in the Israeli/Palestinian conflict. According to one estimate, the parties to civil war engage in formal negotiations in about half the cases of civil war, yet less than 20 percent of civil wars end through negotiated settlements (Walter 2002a: 5-6). Even when the parties succeed in reaching an agreement, it is successfully implemented only about 60 percent of these cases (Walter 2002a; Hartzell and Hoddie 2003). Civil wars are less likely than inter-state wars to end with negotiated settlements (Licklider 1995; Doyle and Sambanis 2000). Two of the worse outbreaks of civil war violence in the 1990s occurred after agreements, in Angola in 1993 and Rwanda in 1994 (Stedman 2002). What characteristics of negotiated settlements increase the robustness of agreements, resulting in enduring peace?¹

In the context of extreme uncertainty that usually prevails during negotiations to resolve civil wars, a key challenge is to identify terms acceptable to both parties and credible commitments that the agreed-on terms will be implemented. One challenge emphasized in the literature (Walter 1997) is to arrive at security guarantees (usually in the form of third-party guarantees) strong enough that warring parties will in fact demobilize. A second, sometimes closely related, challenge is to negotiate a robust distributional settlement, the agreed-on rules for division of postwar political power and economic resources (Walter 2002a; Hartzell and Hoddie 2003). Here I address the second of these challenges: what distributional aspects of a civil war settlement make it more likely to succeed in the uncertain post-settlement environment?

According to the growing statistical literature on negotiated settlements to civil wars, agreements to share power and resources contribute to the robustness of peace agreements, as do third-party guarantees (Walter 1997; Hartzell 1999; Doyle and Sambanis 2000; Downs and Stedman 2002; Walter 2002a; Hartzell and Hoddie 2003). On the other

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hand, the presence of internal factions and of valuable commodities easy to market under wartime conditions impedes the implementation of agreements (Doyle and Sambanis 2000; Downs and Stedman 2002). Most authors reason that agreements are much harder to reach where at least one of the parties sees the stakes as indivisible (though the evidence is far from compelling); some suggest agreements in such cases are less robust.

I present a model in which the structure of the interests of the warring parties determines if there exists a distributional settlement which could (should other conditions be met) secure an enduring self-enforcing resolution of hostilities. As in other analytical models, the approach compares each party’s expected (net) benefits of continuing to fight versus those of pursuing peace (Hirshleifer 1987, 1995; Mason and Fett 1996). Drawing on recent models of institutional change as a shift between self-enforcing outcomes (Young 1998), this paper considers those issues in a framework of uncertain inter-temporal expectations, emphasizing the role of each party’s estimated likelihood that the other party will compromise and the challenged posed by indivisibility issues (Young 1995b).

Important formal contributions to the literature have explored aspects of negotiated settlements not addressed here: the role of credible commitments as an obstacle to negotiated resolutions (Fearon 1995, 2002) and war as bargaining for the terms of settlement (Wagner 2000, Reiter 2003). Rather, this article focuses on the robustness of civil war settlements once reached. I show how a settlement’s robustness, defined in terms of the risk factor of the mutual-compromise equilibrium, depends on the distributional terms of the settlement. In order to focus on settlement robustness, the model differs from others in the literature in several ways. In contrast to Fearon (1995, 2002) and others, I do not assume that continued fighting is inefficient in the sense that a deal preferable to both parties always exists: in the presence of war-time benefits not reproducible under peace (such as illicit commodities) or goods perceived by at least one party to be indivisible, that may not be the case. Nor do I assume that parties will always renege on an agreement in the absence of external enforcement (Walter 2002a), which renders war the dominant strategy, but instead explore the conditions for which mutual compromise might be sustainable once embarked on, even in the absence of external guarantees.

I show how the proposed distributional settlement defines for each party a critical belief threshold such that if the party believes the other party is at least that likely to compromise and seek peace, the best response is to do the same. I identify a range of self-enforcing settlements, those which are self-enforcing under some feasible set of beliefs. Not all settlements are equally robust to exogenous shocks to an actor’s confidence that the other will continue to compromise. I therefore identify the

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2 My model is thus complementary to Fearon (2002), which explores a distinct mechanism in which external shocks to government military capacity give rebels a window of opportunity to negotiate a settlement (but the terms of which are not credible as both parties anticipate the government’s reneging once its strength is regained). In contrast, in
distributional terms of the optimal settlement, which, if it were agreed to, would be most robust to such events. I also explore the effect of actor perceptions of the stakes as indivisible, introducing a measure of the perceived degree of indivisibility. I show how an increase in the degree of indivisibility not only decreases the range of possible distributional settlements, which may be eliminated, but decreases their robustness as well. I explore how intra-party heterogeneity and uncertainty regarding ex-post outcomes lessen the range and robustness of settlements, and analyze the conditions for the mutual compromise equilibrium to be the risk-dominant one. In the conclusion, I argue that the model captures some of the properties of robust settlements identified in the empirical literature and briefly consider the policy implications.

Distributional Aspects of Civil War Settlements: Divisible Stakes

The challenge of constructing an enduring peace through negotiation is that under precisely the conditions that both sides would be willing to consider negotiating a resolution, namely, the absence of a decisive military advantage, neither side can impose a solution. Moreover, it is unlikely that a third party can implement an enduring solution that is not in the interests of both parties. Thus adhering to the terms of the peace agreement must be a Nash equilibrium; that is, it must be in the interests of both parties to adhere to it as long as the other also adheres. But continuing the conflict may also be a Nash equilibrium. In these cases, both adherence to the peace and resumption of the previous conflict may be modeled as self-enforcing outcomes in a game with more than one stable equilibrium, commonly called an assurance game. In these games, each party's choice of an action depends on the player’s beliefs about the actions likely to be taken by the other. As a result, even outcomes with superior payoffs to both players may be unattainable and are vulnerable to unraveling where beliefs are uncertain and volatile. Some equilibria are more robust against this type of unraveling than others. In this and the following section, I show how the distributional terms of a peace agreement effect the range of beliefs required to support mutual compromise and the robustness of the settlement.

To model the conditions that may undergird a successful peace process, I assume that neither side believes it will have a decisive military advantage in the foreseeable

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my model, external shocks test the robustness of a settlement once reached. My model thus also differs from that of Caroline Hartzell (2003), where settlements break down because one of the parties decides to renegotiate the distributional settlement through renewed conflict.

Toft (2003) shows, however, that peace in the aftermath of civil war is more durable after military victory than after negotiated settlements.
In the post-World War II period, the number of long-standing conflicts has steadily accumulated; the average duration of civil wars has increased from two years in 1947 to 15 in 1999 (Fearon and Laitin 2003: 77-8).

I assume that the settlement is represented by a share, but it could as well be that the parties agree to a range of shares. The analysis that follows still holds, as long as the negotiated range lies within the range of feasible settlements defined below.

In this section, I also assume that under some conditions the parties can commit to the postwar rules of the game should hostilities end (although they are unable credibly to commit to a cessation of hostilities), that the stakes of the conflict are divisible, that the payoffs to compromising and fighting are common knowledge, and that the parties are unitary actors. With the exception of the military stalemate, I relax these assumptions in later sections.

The parties agree to meet because they judge that compromise may be in their interest, depending on the result of the negotiations. The two parties A and B (or more precisely, representatives of each party) meet and negotiate the terms of a possible settlement, which typically include the post-war institutions -- property rights, electoral and other regime rules, demobilization procedures, and other rules of the game -- that define the postwar payoffs to the two parties. Let the post-settlement stakes be \( \varphi > 0 \), A’s negotiated share of the stakes be \( \alpha \in [0,1] \), and that of B be \( 1-\alpha \). The distributional settlement is thus represented by the value of \( \alpha \). In light of the proposed settlement, A and B then (separately) evaluate the expected payoffs to compromise and fighting (the only two available strategies) in light of the value of \( \alpha \) and their beliefs about the likely actions of the other. They then simultaneously implement the strategy that maximizes their expected payoff.

The payoffs to combinations of the two strategies are given in Figure 1, where the first entry represents the payoff to the row player and the second that of the column player for the indicated combination of strategy choices. A's payoff to mutual fighting is \( \omega_a \), that to fighting if the other party compromises is \( \lambda_a \). Without loss of generality, I have normalized the payoffs such that the payoff to compromise if the other party fights is zero; all other payoffs are greater than zero. (The substance of the payoffs -- income, status, or power -- is unimportant: all that matters is that actors do not knowingly choose lower payoffs over higher.) I assume that each \( \lambda \) is greater than the corresponding \( \omega \), i.e. that the payoff to a player who plays “fight” is greater if the other party plays “compromise” than if the other player also plays “fight.”

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4 In the post-World War II period, the number of long-standing conflicts has steadily accumulated; the average duration of civil wars has increased from two years in 1947 to 15 in 1999 (Fearon and Laitin 2003: 77-8).

5 I assume that the settlement is represented by a share, but it could as well be that the parties agree to a range of shares. The analysis that follows still holds, as long as the negotiated range lies within the range of feasible settlements defined below.

6 In the conclusion, I discuss the general case where \( \varphi \) depends \( \alpha \).
Figure 1. The distributional logic of conflict and settlement in the case of divisible stakes: stage game

<table>
<thead>
<tr>
<th>Player B</th>
<th>fight</th>
<th>compromise</th>
</tr>
</thead>
<tbody>
<tr>
<td>fight</td>
<td>$\omega_A, \omega_B$</td>
<td>$\lambda_A, 0$</td>
</tr>
<tr>
<td>Party A</td>
<td>compromise</td>
<td>0, $\lambda_B$</td>
</tr>
</tbody>
</table>

The distributional outcomes of the post-war rules of the game thus form an essential part of the incentive structure: whether A will prefer compromise if B does as well depends on $\alpha$ and $\varphi$, as well as $\omega$, and $\lambda$. Fight-fight is a Nash equilibrium as neither would prefer to compromise if the other were to fight. Whether mutual compromise is also a Nash equilibrium depends on the value of fighting when the other compromises. If $\lambda$ is less than $\varphi\alpha$, and $\beta$ is less than $\varphi(1-\alpha)$, the compromise-compromise strategy profile is also a Nash equilibrium. In this case, both mutual compromise and mutual fighting are self-enforcing outcomes; the interaction is an assurance game. On the other hand, if $\lambda$ is greater than $\varphi\alpha$, and $\beta$ is greater than $\varphi(1-\alpha)$, then both prefer to fight whatever the strategy of the other side and the payoff structure describes a prisoners’ dilemma game, with “fight” the dominant strategy for each. The “ripeness” for resolution of a conflict (Zartman 1989 and 1995) is readily expressed by the transformation of the payoff matrix from one in which mutual compromise is not self-enforcing (the prisoners’ dilemma) to one in which the structure of the assurance game in which if compromise could be reached, neither side would have an incentive to defect.

However, a transition to peace is a process not a single event, so a repeated game framework is more likely to capture the relevant dynamics. I assume the parties consider the discounted present value of the stream of the payoffs to fight and to compromise over an infinite horizon, the stage game of which is given by the strategies and payoffs in Figure 1. In the first period, as before, A and B negotiate $\alpha$, evaluate the expected utilities of fighting and compromising, and simultaneously implement their choices. As the focus of this model is the robustness of settlements once reached, in the second and subsequent periods, A and B do not renegotiate, but evaluate the expected utilities of fighting and compromising in light of what both parties did in the previous round, and simultaneously implement their choices. In the second and subsequent periods, the only new information is what the other party did last period (the game is stationary, i.e. the stage game described in Figure 1 is time invariant). I assume the following learning rules. Neither party will switch from compromise to fight if the other party compromised in the previous period (mutual compromise can only strengthen confidence that the other will compromise again): neither party will switch from fight to compromise if the other party fought in the previous period.
(the other party’s having fought can only reinforce a party’s belief that the other will fight), and if a party compromised in the previous period and the other fought, both will fight (the other party’s having fought undermines the party’s belief that the other party will compromise). Formally, this implies that once either mutual compromise or mutual conflict occurs it persists. (I consider future exogenous shocks in the next section.)

There are thus two strategies of interest in the infinite-horizon game, “Compromise” (compromise in the first period, then do in the second and subsequent periods what your opponent did in the previous period, i.e. the parallel to the “tit-for-tat” strategy in the repeated prisoners’ dilemma game) and “Fight” (fight in the first period and thereafter), where the capitalization distinguishes strategies in the repeated game from those in the single-period game. The payoffs are shown in Figure 2, where \( \rho = \tau/(1+\tau) \) and \( \tau \) is the (common) rate of time preference.

Figure 2. The distributional logic of conflict and settlement in the case of divisible stakes: infinite-horizon game

<table>
<thead>
<tr>
<th>Player B</th>
<th>Fight</th>
<th>Compromise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fight</td>
<td>( \omega_a / \rho ), ( \omega_b / \rho )</td>
<td>( \lambda_a + (1-\rho)\omega_a / \rho ), ( (1-\rho)\omega_b / \rho )</td>
</tr>
<tr>
<td>Party A</td>
<td>Compromise</td>
<td>( (1-\rho)\omega_a / \rho ), ( \lambda_b + (1-\rho)\omega_b / \rho )</td>
</tr>
</tbody>
</table>

Note: Entries are present values of payoffs in the infinite-horizon game; for notational simplicity, I do not discount the first period. The off-diagonal expressions are derived as follows. The payoff in the first period is \( \omega_a \); the payoff to subsequent periods is just the present value of the payoff to mutual fighting forever, \( \omega_b / \rho \), less the payoff to mutual fighting in the first period, \( \omega_a \). Hence the accumulated payoff is \( \lambda_a + \omega_a / \rho - \omega_b = \lambda_a + (1- \rho) \omega_b / \rho. \)

If mutual-Compromise is to be a Nash equilibrium, the following two conditions are necessary:

1) \( \varphi \alpha / \rho > \lambda_a + (1- \rho) \omega_a / \rho \)

and

2) \( \varphi(1-\alpha)/ \rho > \lambda_b + (1- \rho) \omega_b / \rho. \)

The nub of the distributional challenge to forging an enduring peace is thus that \( \alpha \) must be such that both conditions are true. The first is satisfied for large \( \alpha \) while the second is
satisfied for small $\alpha$. If both conditions are satisfied a structural basis of compromise exists for some range of $\alpha$, and the mutual-Compromise strategy profile is a Nash equilibrium. In that case, there are two stable equilibria (Fight, Fight) and (Compromise, Compromise). When both conditions hold, whether or not each player prefers Compromise depends on the party's beliefs about the behavior of the other party; there is no dominant strategy. For the joint compromise outcome to occur, both sides must judge it sufficiently likely that their opponent will also Compromise. How likely is “sufficient”?

Let $\gamma_a$ be A’s estimated probability that B will Compromise. The expected payoff to A to Compromise is then the probability-weighted sum of the payoffs in the case that B also Compromises and in the case that B Fights:

$$\pi_a^C = \gamma_a \varphi a / \rho + (1 - \gamma_a)((1 - \rho) \omega_a / \rho)$$

and the expected payoff to A to Fight is

$$\pi_a^F = \gamma_a (\lambda_a + (1 - \rho) \omega_a / \rho) + (1 - \gamma_a) \omega_a / \rho$$

The expected payoffs to the two strategies are thus linear functions of $\gamma_a$, which ranges from 0 to 1. In the case that $\varphi a / \rho > \lambda_a + (1 - \rho) \omega_a / \rho$, expected payoff functions intersect in the unit interval, as shown in Figure 3. The intersection defines A’s critical belief threshold, $\gamma_a^*$. If $\gamma_a > \gamma_a^*$ (that is, A believes that the probability that B will cooperate exceeds the critical value), the expected payoffs to A of Compromise exceed those of Fight and A will Compromise.

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7 If both conditions are met, then $\varphi > \omega_a + \omega_b$, so for some $\alpha$, mutual Compromise is a Pareto improvement over mutual Fight. However, note that $\varphi > \omega_a + \omega_b$ is necessary but not sufficient for the stability of the mutual-Compromise equilibrium (if one or both of the $\lambda$ are sufficiently large, then Fight is that party’s dominant strategy).

8 There is also a mixed-strategy equilibrium at which A plays compromise with probability $\gamma_a^*$ and B plays compromise with probability $\gamma_b^*$, with the result that each is indifferent between Fight and Compromise. However, this equilibrium is unstable: a small deviation in the play of either player leads the other to play a pure strategy.

9 The model focuses on the strategic interaction of the parties, emphasized in this section by the common knowledge of the payoffs: even when both parties knows all payoffs with certainty, this knowledge is not sufficient to determine the outcome as the behavior of each continues to depend on her belief about what the other party will do.
I adopt the tie-breaking convention that if \( a = a^* \), A will Compromise (and similarly for B).

Setting \( \pi_c^a \) equal to \( \pi_f^a \) gives the following expression for \( a^* \):

\[
\gamma^* = \frac{\varphi_\alpha}{\varphi_\alpha - \rho \lambda_a - \omega_a + 2 \rho \omega_a}
\]

Thus two further conditions must also be met if the parties are both to Compromise:

3) the probability that A assigns to B’s Compromising is greater than or equal to A’s critical belief threshold (\( \gamma_a \geq \gamma^*_a \)),

and

4) the probability that B assigns to A’s Compromising is greater than or equal to B’s critical belief threshold (\( \gamma_b \geq \gamma^*_b \)).

If there exists some \( \alpha \) such that both conditions 1 and 2 are met, then for each party there exists some set of estimated probabilities that the other party will Compromise. Distributional settlements for those \( \alpha \) are feasible, and if both parties Compromise, the settlement will be self-enforcing.

Of course the two expected-payoff lines may not cross in the interval \( \gamma^*_a \in [0, 1] \), with the result that there is no relevant value of \( \gamma_a \) for which the expected payoffs to

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\(^{10}\) I adopt the tie-breaking convention that if \( \gamma_a = \gamma^*_a \), A will Compromise (and similarly for B).
compromise exceed those of fighting. In that case, A confronts a prisoners' dilemma with Fight the dominant strategy irrespective of her belief about B’s willingness to compromise. Similar reasoning defines a critical value of $\gamma_s$.

Further consideration of Figure 3 defines the range of feasible settlements. Note that as $\alpha$ increases, $\gamma^*_s$ shifts downward. When $\alpha$ is such that $\gamma^*_s = 1$ (the expected payoff lines cross at the right-hand edge), A’s expected payoffs to Fighting and Compromising are equal. This is the smallest $\alpha$, $\alpha_{\text{min}}$, for which A will Compromise, which requires that A be entirely sure that B will also compromise. Similarly, $\alpha_{\text{max}}$ is the smallest $(1-\alpha)$ for which B will Compromise (and hence the maximum value of $\alpha$ for agreement). Feasible settlements are those such that $\alpha_{\text{min}} \leq \alpha \leq \alpha_{\text{max}}$.

Comparing Agreements: Robust Settlements

Thus far, once the parties embark on mutual-Compromise, they will continue to do so. However, in the highly uncertain environment following an agreement, player’s beliefs may be disrupted by factors other than their opponent’s immediate past behavior. Thus one consideration in the negotiation of the distributional terms of the settlement should be how likely the subsequent peace process is to survive such shocks. If mutual Compromise will persist under a wide range of beliefs about the likelihood of the other party’s compromising (i.e. both $\gamma^*_s$ and $\gamma^*_a$ are low), that settlement is more robust. Although a shock may lessen the confidence of one or both parties that the other will continue to compromise, their estimated probabilities that the other will do so may still exceed the critical threshold. The optimal settlement (optimal from the point of view of the mutual-Compromise equilibrium enduring such shocks) is the most robust settlement.

These considerations raise the following question: what distribution of the postwar stakes (i.e. what value of $\alpha$) renders the peace process most robust? Following Harsanyi and Selten (1988) and Young (1998: 67-8), we can define the risk factor of the mutual-Compromise equilibrium as the smallest probability $p$ such that if each player believes the other player is going to Compromise with probability strictly greater than $p$, then Compromise is the unique best response. The risk factor for this equilibrium is therefore the larger of $\gamma^*_a$ and $\gamma^*_s$ (that is, $\gamma_a$ and $\gamma_s$ must both exceed their respective critical values for both to compromise, so the risk factor is the larger of the two). To see what the risk factor measures, suppose that in a given period with probability $\varepsilon$ both parties’ beliefs will be formed not by the learning rules identified above but will rather be drawn from a uniform distribution over the unit interval. If for at least one of the parties, these beliefs fall below the critical belief threshold, $\gamma^*$, that party will resume hostilities, resulting in mutual conflict in successive periods. The probability that this will occur is just $\varepsilon$ times the risk factor, so the resumption of war scales linearly with the risk factor. The smaller the risk factor of the mutual-Compromise equilibrium, the less likely that it may be derailed by belief shocks during the process of its implementation, and thus the more robust it will be.
Define the *robustness*, $r$, of a settlement as $1 - \text{risk factor} = 1 - \max \{\gamma_a^*, \gamma_b^*\}$. Figure 4 shows $\gamma_a^*$ and $\gamma_b^*$ as a function of $\alpha$. The thick v-shaped line indicates the risk factor as a function of $\alpha$. The robustness of the peace equilibrium corresponding to each $\alpha$ is the difference between the horizontal line $\gamma = 1$ (indicating certainty that the other will compromise) and the risk factor. As is evident in the graph, the $\alpha$ that maximizes the robustness is the $\alpha$ for which $\gamma_a^*$ equals $\gamma_b^*$; call it $\alpha_{\text{opt}}$. If both conditions 1 and 2 obtain, then such an $\alpha_{\text{opt}}$ exists and falls in that range.

![Figure 4: Critical Beliefs and The Optimal Distributional Settlement](image)

Note: the solid upper envelope of the two critical belief threshold functions is the risk factor of the mutual-Compromise equilibrium, which is minimized at the optimal distributional share. The solid portion of the horizontal axis indicates the range of feasible settlements.

To find $\alpha_{\text{opt}}$, set the two critical belief thresholds equal, which gives (see the Appendix for details):\(^{11}\)

\(^{11}\) The optimal settlement is the same as the solution to the Nash bargaining problem in the case that the players are identical. The Nash solution, $\alpha_N$, is that which maximizes the Nash product $(\alpha \varphi - \omega_a)((1-\alpha)\varphi - \omega_b)/\rho^2$, i.e. $\alpha_N = (\varphi + \omega_a - \omega_b)/2\varphi$. My approach shares with that of Nash the objective of defining a bargained outcome with certain desirable properties. However, the desired properties differ: the desiderata that Nash imposed are not equivalent to robustness. My model has much in common with evolutionary bargaining frameworks (Young 1993), especially the variants in which outcomes depend on the belief
\[ \alpha_{\text{opt}} = \frac{\rho(\omega_c \lambda - \omega_s \lambda_e) + \omega_c \phi}{(\omega_s + \omega_e) \phi}. \]

Changes in the relevant parameters effect the optimal settlement as we should expect. An increase in \( \omega_s \) (A’s fallback position) results in an increase in \( \alpha_{\text{opt}} \), A’s share in the optimal settlement. An increase in \( \omega_e \), (B’s fallback position), results in a decline in \( \alpha_{\text{opt}} \); that is, an increase in B’s share. Similarly, an increase in \( \lambda_e \), the immediate payoffs to defecting, results in an increase in \( \alpha_{\text{opt}} \), and an increase in \( \lambda_e \) in a decrease. In the case of symmetrical payoffs, \( \alpha_{\text{opt}} = 1/2 \) as it should.

We now have the following propositions summarizing these results:

i) a necessary and sufficient condition for a feasible agreement is that conditions 1 and 2 are met when \( \alpha \) takes the value of \( \alpha_{\text{opt}} \) (as defined by the preceding equation);

ii) where conditions 1 and 2 are strict equalities for an agreement with \( \alpha = \alpha_{\text{opt}} \), only \( \alpha_{\text{opt}} \) is feasible; and

iii) where for an agreement with \( \alpha = \alpha_{\text{opt}} \), 1 and 2 hold as strict inequalities, any agreement for which \( \alpha_{\text{min}} < \alpha < \alpha_{\text{max}} \) is feasible.

The comparative statics of this formulation capture many of the well-known properties of settlements through the dependence of \( \gamma_a^* \) on \( \phi, \omega_s, \lambda_e, \rho \), as well as \( \alpha \) (and similarly for \( \gamma_b^* \)). Inspection of Figure 3 (or signing the relevant derivatives) shows that, ceteris paribus, the greater is \( \phi \) -- higher “peace dividends” -- the lower are both the critical belief thresholds, the wider is the range of feasible settlements, and the more robust are the settlements. High peace dividends may reflect promises of postwar aid or trade (perhaps through free trade agreements available only in conditions of peace, as in Guatemala), or higher national income as a result of renewed production in the case that the warring parties are economically interdependent, as, for example, when they control complementary factors of production, such as capital and labor in South Africa (Wood 2000). Or higher national income may occur if peace would allow the exploration and development of as-yet untapped resources. An agreement in Sudan, for example, would more than double exploitable energy reserves (IGC 2002).

Higher \( \omega_s \) or \( \lambda_e \) have the opposite effect, decreasing the range of feasible settlements. If one party controls the production of lucrative commodities that they market with relative ease (e.g. alluvial diamonds), then, ceteris paribus, the resulting high belief threshold means that the party will not compromise unless correspondingly confident that

of each party in the likelihood of compromise by the other, initiated by Zeuthen (1968 [1930]). Both Young’s and Zeuthen’s approaches approximate the Nash outcomes under restricted conditions.
the other party will do so as well. The issue is particularly acute when high $\omega$ is not accompanied by high $\phi$, as when the party controlling the commodity does not believe that this income flow will be reproduced in the postwar period (as is usually the case with illicit commodities). One advantage such commodities offer for conflict resolution is their divisibility: under conditions explored below, the parties may agree on a postwar division of property rights and incomes from such resources that may leave them both better off. Another reason $\omega$ might be high is when one party benefits from income flows sent from its diaspora in other countries that may decrease with peace. Still another reason is that a party might benefit from military aid unlikely to continue in peacetime, a frequent occurrence during the Cold War. Similarly, if either party has a strong incentive to renege in the first round of the peace process (high $\lambda$), his critical belief threshold increases.

Indivisible Stakes

To this point, I have assumed that the parties see the stakes of the conflict as divisible. However, in many civil wars that is not the case. Where at least one party to the conflict perceives the stakes as indivisible, the players may be unable to reach an agreement because "splitting-the-difference" compromises are rejected by that player. Of course in principle, all stakes are divisible in some sense: even a child may be "divided" in divorce proceedings, in the sense that time with the child is divided between the parents (Young 1995b). Indivisibility thus does not refer to intrinsic properties of the good (except in the tautological case of the good being defined as the sole national language or religion) but to some actor’s perception of their indivisibility. Among the classic examples are sacred sites, for example, the Temple Mount/Harem al Sharif site in Jerusalem. In wars where ethnic cleansing takes place, the party carrying out the "cleansing" rejects any notion of sharing territory with the other group. Secessionist ethnic conflicts emerge precisely because although one party judges the nation-state to be highly divisible, the government rejects the notion of territorial division. Other examples include some strategic military sites, irrigation and other network systems, and in some circumstances, control of the

12 The empirical evidence whether the presence of lucrative commodities easily marketed during wartime renders civil conflicts more likely or longer is mixed. Collier and Hoeffler (2001) found that the likelihood that a civil war will emerge from civil conflict is significantly greater in those countries highly dependent on the export of primary commodities (an indicator intended to capture statistically how the availability of such commodities finance armed groups). Fearon and Laitin (2003) did not find this measure significantly contributed to civil war onset, however. And Collier, Hoeffler, and Söderbom (2001) did not find that such dependence contributed to the duration of civil wars. In a study of thirteen cases, Ross (2003) found that such commodities were not a source of insurgent finance before the conflict, but in cases where they were controlled by the weaker party, they contributed to the duration of conflict.
national executive, or other potentially "winner-take-all" positions.\textsuperscript{13}

To analyze the effect of indivisible stakes, we now must relax the implicit assumption made until now that the value a player places on access to a good is simply proportional to the amount of that good. In much of the empirical literature the stakes of civil conflicts are classified as "divisible" or "indivisible." If stakes were ever completely indivisible, however, conflicts could only be resolved by military defeat. To capture the differences between holy sites, strategic locations, network systems and the like, we need a measure of the degree of indivisibility, rather than the "pure" categories of perfectly divisible and perfectly indivisible. Indivisible goods are those where controlling a little bit more is worth little until you control a lot of it. To formalize this, by indivisible stakes I mean those for which the value placed on the payoff is convex in the share controlled. Consider the functions in Figure 5, which show how the value \( v(f) \) a player places on access to a good depends on the fraction \( f \) of that good the player controls. Define a perfectly indivisible good as a good whose value is zero unless \( f = 1 \) (as indicated by the lower dashed line).

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{diagram.png}
\caption{Divisible and Indivisible Goods}
\end{figure}

To define indivisibility formally, suppose \( v(f) \) is twice differentiable, with \( dv/df = v' > 0 \). Then for indivisible goods \( v'' = d^2v/df^2 \) is greater than zero (and less than or equal to

\textsuperscript{13} Note that some material goods may be seen as indivisible if they are subject to political determination of the distribution of payoffs to control of that good. While the goods themselves are divisible (share the revenue from state corporations, mining concessions, or marketing boards between the major parties; let every other public sector hire be from B’s constituency; etc.), control of the national executive may have winner-take-all aspects.

14
The value of many goods is concave ($\mu < 0$), as shown by the upper dashed line in Figure 5. This may be due to diminishing marginal utility of the good or because the marginal productivity of an input to production declines as the supply rises.

Let $\mu$, the degree of indivisibility of the stakes, be defined as\(^{15}\)

\[ \mu \equiv v''/v'. \]

So for indivisible goods, $\mu > 0$ and increases as the curve becomes more convex.

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**Figure 6: Effect of Indivisible Stakes on the Robustness of Settlements.**

Note: the dashed line gives the critical belief thresholds for $A$, when $A$ perceives the stakes to be indivisible.

To see the effect of increasing indivisibility of stakes on settlements, assume that $A$ perceives the stakes as indivisible of degree $\mu_A(\alpha)$. Because indivisibility depresses the value of a share of the stakes less than 1, $\gamma_s^*$ shifts upward (for all $\alpha$), as shown by the dashed curve in Figure 6. The range of feasible settlements is reduced to $\alpha \in [\alpha_{\min}'', \alpha_{\max}'']$, the optimal settlement increases to $\alpha_{\text{opt}}'$, and the robustness of settlements for $\alpha < \alpha_{\text{opt}}'$ is

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\(^{14}\) The value of many goods is concave ($\mu < 0$), as shown by the upper dashed line in Figure 5. This may be due to diminishing marginal utility of the good or because the marginal productivity of an input to production declines as the supply rises.

\(^{15}\) This is the negative of the Arrow-Pratt measure of risk aversion. The value of $\mu$ generally varies with $f$, but taking explicit account of this would not illuminate anything of importance in what follows.
reduced. If $\mu_A$ is sufficiently large, no feasible agreements will exist. If B also perceives the stakes as indivisible, the range decreases still more as $\alpha_{\text{max}}$ shifts downward, $\alpha_{\text{opt}}$ decreases, and the robustness of settlements for which $\alpha > \alpha_{\text{opt}}$ decreases. (The net effect on $\alpha_{\text{opt}}$ depends on whether $\mu_A$ or $\mu_B$ is greater.)

Thus increasing indivisibility is related to the robustness of the distributional settlement as follows. Let $\Delta = \alpha_{\text{max}} - \alpha_{\text{min}}$.

An increase in either $\mu_A$ or $\mu_B$ which preserves the value of the stakes if enjoyed in entirety by that party has the following effects (assume for the sake of concreteness that $\mu_A$ increases):

i. $\Delta/d\mu_A < 0$, i.e. the range of feasible settlements decreases, and

ii. Given a feasible distributional settlement over divisible stakes with $\alpha \in [\alpha_{\text{min}}, \alpha_{\text{max}}]$, there is some $\mu^*$ such that for $\mu_A > \mu^*$, the pact is no longer feasible.

The implication is that the less divisible are the actors’ perceptions of the goods at stake, the less amenable is the conflict to negotiated resolution for two reasons: the range of $\alpha$ for which the settlement is self-enforcing decreases and the robustness of settlements decreases as well.

Extensions: Non-unitary Actors and Outcome Uncertainty

I will now relax two additional assumptions. First, I have assumed that each party is a unitary actor. That is almost never the case; indeed, the prospect of a negotiated settlement frequently deepens conflict within parties to civil war. Heterogeneity of the actors will be an impediment to peace if -- as I assume in what follows -- all factions of both parties must endorse the settlement, or equivalently, any faction may be a "spoiler" (Stedman 1997).

Factions may be present because they disagree in their valuation of the payoffs implied by the proposed settlement. For the sake of concreteness, consider a particular setting where there are two factions in A, one of which believes the stakes to be indivisible of degree $\mu$. For members of that faction, the value of the proposed settlement is less than for members of the other faction (whose members perceive the stakes as divisible). This is represented in Figure 7 as a decrease in the effective value of the share of the postwar stakes $(\alpha \phi)^{\prime} < \alpha \phi$. The critical belief threshold for that faction (and the effective threshold for A), increases to $\gamma^{\prime \prime}$. As a result, the effective range of feasible settlements decreases as

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16 In particular, the robustness of the optimal settlement decrease because the risk factor of the mutual-Compromise equilibrium, $\max \{\gamma^*_a, \gamma^*_b\}$, increases with the upward shift in the belief threshold.
does their robustness (as in the previous section).

Another reason factions may disagree in their valuation of the postwar stakes arises from the fact that local supporters of a given party do not always fight for the official reason given by their party; civil conflict often mobilizes populations along regional or other cleavages quite distinct from the one supposedly driving the civil war (Harding 1984; Kalyvas 2003). If such grievances are not addressed in the settlement, the value of the expected payoff to peace for those faction members is reduced, with identical consequences for a settlement.

Second, I have assumed that uncertainty is limited to incomplete information about what the other party will do. Factions may arise because internal groups disagree about the likelihood of the other party to compromise (different $\gamma_s$), a not unlikely occurrence given the uncertainty surrounding negotiation contexts. If one faction’s $\gamma_s$ is less than the critical belief threshold, $A$ will not compromise.

17 Central to the problems that spoilers pose to peace processes is an additional information asymmetry: a party cannot observe whether the other party is attempting but failing to repress the spoilers or is tacitly allowing their activities perhaps to strengthen their bargaining position. For discussion of this aspect of peace processes, see Kydd and Walter (2002).
Uncertainty will make the peace process more difficult for several reasons arising from the fact that actors typically lack complete information about the likely consequences of a settlement even if both parties compromise. Consider the problem that arises when the parties cannot commit credibly to the negotiated division of the postwar stakes. Even if the agreed on rules for dividing the postwar stakes are implemented, they may not yield the negotiated distributional settlement $\alpha$. As a result, different factions within each party may hold differing estimates of the expected postwar payoffs. For example, suppose that control of the national executive is determined by elections (the outcome of which is not known with certainty) and that control of the executive will determine the actual postwar shares. Assume that A is made up of “optimists” and “pessimists”. Optimists anticipate that they will win a share of votes sufficient to secure the negotiated share $\alpha$. Pessimists believe that their share of votes will lead to a lesser implemented share. This shifts their effective critical belief threshold upward, with the same deleterious consequences for settlement as when factions based on indivisibility perceptions are present.

There are other sources of outcome uncertainty that also result in less robust settlements. The postwar stakes may be less than the value assumed in the negotiations, perhaps for entirely exogenous reasons such as a shift in international prices, the failure of international aid and investment to materialize, or the discovery of smaller than expected deposits once prospecting begins after the end of the war. Or they may be less for endogenous reasons such as the failure of one or both parties to deliver their constituents on the implicit terms of the settlement (wealth holders may not invest domestically, for example), or the failure of international investment to arrive as a result of postwar security concerns. Anticipating such possibilities, a pessimistic faction with a lesser estimate of the postwar stakes may emerge.

A spoiling faction may emerge for another reason. Some members of a party may anticipate that other members will control an unacceptably large share of the party’s share of the postwar stakes, cutting them out of the benefits of peace. Such problems appear to have made a negotiated settlement more difficult in Liberia, for example, where thirteen of fourteen peace accords failed between 1990 and 1996, partly as a result of competition among rebel factions for the opportunity to loot the country’s abundant resources (Ellis 1999, Ross 2002).

*Equilibrium Selection and Risk Dominance*

To this point, I have not addressed the formation of beliefs concerning the likelihood of the other party’s compromising (other than the learning model that allowed a restriction of the strategy set in the infinite horizon game). It might be thought that those estimates would be endogenous in the sense that they would likely depend on the proposed division of the stakes. On this reasoning, B’s estimate of the likelihood that A will compromise would increase with A’s share of the postwar stakes: $\gamma$ would be an increasing function of $\alpha$. However, B would also be aware that A would on the same grounds reason
that B would be less likely to compromise as \( \alpha \) increased, and B could thus not be sure that A’s likelihood to compromise increases with \( \alpha \). It is not clear how this line of reasoning would allow a convincing model of endogenous beliefs.

An alternative is to suppose that each party assumes that the other party will adopt his risk dominant strategy. If A has no information about what B will do, A might follow the principle of insufficient reason and assume that B is equally likely to play either strategy, i.e. \( \gamma_a = \frac{1}{2} \). The risk dominant strategy is the strategy that A will adopt under this assumption. As is clear from Figure 3, if \( \gamma_a^* > \frac{1}{2} \), A will Fight and if \( \gamma_a^* < \frac{1}{2} \), A will Compromise, and the analogous condition is true for B.

Thus if both \( \gamma_a^* \) and \( \gamma_b^* \) are less than \( \frac{1}{2} \), then both A and B will compromise and peace is the risk dominant equilibrium as shown in Figure 8. These considerations define a second, narrower range of \( \alpha, \alpha \in [\alpha_{RD-}, \alpha_{RD+}] \), that -- if it exists -- lies entirely within \( \alpha_{min} \) and \( \alpha_{max} \). If the parties follow this decision rule, if such a range of \( \alpha \) exists and if the distributional share \( \alpha \) is set within that range, the parties will compromise and peace will be the outcome. The optimal settlement \( \alpha_{opt} \) necessarily falls within the range if it exists, so this is consistent with previous considerations of robustness.

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On risk dominance, I draw on the recent work of Young (1995a and 1998) and Harsanyi and Selten (1988).
An alternate decision strategy would be for A to assume that the probability that B Compromises is proportional to 1- \( \gamma_b^* \) (the lower B’s critical belief threshold, the more likely is B to Compromise). Then A will Compromise if 1- \( \gamma_b^* > \gamma_a^* \). Analogous reasoning gives the condition for B to Compromise, 1- \( \gamma_a^* > \gamma_b^* \), i.e. the same condition. If this condition is met and if A and B form their beliefs this way, then both will Compromise. Inspection of these two decision strategies shows that if the risk dominant criteria is met, then so is this condition. Thus the range of \( \alpha \) for which the risk dominant criteria is met lies within the range of \( \alpha \) for this second condition, \( \alpha \in [\alpha_-, \alpha_+] \). Similarly, the range of \( \alpha \) for this second condition, \( \alpha \in [\alpha_-, \alpha_+] \), lies entirely within the range of \( \alpha \) for which settlements are feasible, \( \alpha \in [\alpha_{\text{min}}, \alpha_{\text{max}}] \). Thus \( \alpha_{\text{min}} < \alpha_+ < \alpha_{\text{rd}} < \alpha_{\text{opt}} < \alpha_{\text{rd+}} < \alpha_+ < \alpha_{\text{max}} \).

While the mutual adoption of either decision rule determines conditions such that the players will select mutual-Compromise as the equilibrium, such rules are of course artifices that neglect the politics of the negotiation process. International mediators corral representatives of the parties in splendid isolation in order to influence each party’s beliefs concerning the possibility of compromise. And representatives of the two parties will attempt to persuade each other of their sincerity, with sometimes positive results as in South Africa where (late in the negotiating process) the ANC’s Cyril Ramaphosa and the National Party’s Roelf Meyer made several key decisions merely by consulting with each other. Neither process is captured in this model.

**Conclusion**

The contributions of this paper are three. First, I provide a framework allowing the unified analysis of some of the myriad factors thought to effect the robustness of civil war settlements. Second, I develop a formal measure of the robustness of settlements, show that if any feasible settlement exists so does an optimal distributional settlement, and analyze the determinants of the optimal settlement. Third, I provide a continuous measure of indivisibility and show how increasing indivisibility of the stakes reduces the range of feasible settlements as well as the robustness of the optimal settlement.

The predictions of the model based on comparative static analysis of the degree of robustness with respect to the indicated variables are gathered together in Figure 9.\(^{19}\)

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\(^{19}\) While it is beyond the scope of this theoretical paper to assess its predictions in light of particular cases, I do so in a related paper using Boolean techniques as in Chan’s analysis of inter-state wars (Chan 2003).
Figure 9. Predictions of the Model: Effects on Settlement Robustness

<table>
<thead>
<tr>
<th>Factor</th>
<th>Examples</th>
<th>Effect on Robustness</th>
<th>Policy Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \gamma_i )</td>
<td>Estimated probability that the other will Compromise</td>
<td>Positive if ( \gamma_i &gt; \gamma_i^* )</td>
<td>Diplomatic efforts to increase mutual confidence; positive personal interactions among key leaders</td>
</tr>
<tr>
<td>( \omega_i )</td>
<td>Payoff to continued conflict</td>
<td>Resources whose value is higher in wartime</td>
<td>Negative</td>
</tr>
<tr>
<td>( \lambda_i )</td>
<td>Payoffs to reneging on an agreement</td>
<td>External aid conditional on reneging</td>
<td>Negative</td>
</tr>
<tr>
<td>( \varphi )</td>
<td>Postwar stakes</td>
<td>Parties hold complementary resources</td>
<td>Positive</td>
</tr>
<tr>
<td>( \alpha )</td>
<td>Distributional settlement share</td>
<td>Power-sharing; land reform; revenue sharing agreements</td>
<td>Positive for ( \alpha &lt; \alpha_{\text{opt}} ); negative for ( \alpha &gt; \alpha_{\text{opt}} )</td>
</tr>
<tr>
<td>( \mu_i )</td>
<td>Degree of indivisibility</td>
<td>Holy sites, network systems</td>
<td>Negative</td>
</tr>
<tr>
<td>( \rho )</td>
<td>Time preference</td>
<td>Leaders’ personal insecurity</td>
<td>Negative</td>
</tr>
</tbody>
</table>

Note: The “effect on robustness” is the sign of \( d\gamma_i/dx_i \), where \( \gamma_i \) is robustness and \( x_i \) is the symbol in the first column.

Several policy implications are suggested by this analysis (some are listed in the
While none of them is new, the model captures them in the same analytical framework. One important task of mediators is to work to increase the mutual confidence of the parties in the process, i.e. to push them past their critical belief thresholds. International actors can further contribute to peace by focusing their resources on reducing those thresholds, thereby widening the range of feasible settlements and increasing their robustness. Among the ways to do this are increasing the peace dividend through credible promises of postwar assistance, implementing effective sanctions against trade in commodities from countries at war, limiting the benefits to reneging on an agreement, and limiting income flows from diasporas that finance warring parties.

We have seen one impediment to robust settlements is uncertainty over the postwar division of the stakes. One way to limit the impact of elections on distributional outcomes is to ensure the representation of both parties in the postwar government through power-sharing arrangements such as consociational or federal institutions that decentralize certain powers to sub-national units, parliamentary rather than presidential regime forms, or guaranteeing certain number of ministries or other high-level posts to the likely minority group, for a limited transition period or the indefinite future.

Another way that actors may seek to limit the variation of the postwar share is by adopting institutions to directly bound that variation. For example, the parties may agree to institutions that lessen the role of electoral outcomes in determining the ex-post share, thereby reassuring pessimistic factions. In the case of conflicts where one party represents the interests of labor and the other party those of capital, the parties might agree on liberal market institutions that would keep the effective $\alpha$ and $1-\alpha$ within bounds acceptable to all factions of both sides irrespective of future electoral outcomes. In South Africa, for example, the parties agreed to entrench in the constitution the rights to private property and to strike, thereby limiting future distributional outcomes (Wood 2000). In both El Salvador and South Africa, elites unilaterally liberalized the economies before the settlement to put a further ceiling on future redistributive policies: if a populist party were to attempt unfavorable policies, capital could be withdrawn and invested elsewhere. Thus one reason that settlements are more robust where the warring parties are economically interdependent is because uncertainty concerning postwar incomes can be limited through market

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20 On the role of international actors in peace settlements, see Doyle and Sambanis (2000), Downs and Stedman (2002), and Regan (2002).

21 See Renner (2002: 55) for a list of sanctions. It appears that UN sanctions against "war diamonds" may have played a role in the recent settlements in Sierra Leone and Angola, for example. The recent agreement to certify the origins of diamonds is a further attempt to lessen the payoff to war.

22 See Rothchild (2002) for an analysis of the possible negative consequences of such agreements for enduring conflict resolution in the long-term.
determination of distributional outcomes, even in cases where the economic cleavage coincides with long-standing racial and ethnic identities as in South Africa. In such distributive conflicts, if an economy is fully “marketized” then the diversity of interests between firms and between sectors is lessened (one party becomes less heterogeneous), and thus the disruptive potential of hardliner and softliner factions is less as well.

The uncertainty of the postwar shares can also be lessened through explicit revenue-sharing institutions that are intended to credibly commit both parties to the settlement. Such agreements are particularly important when armed actors benefitted from trade in commodities that comprise part of the postwar stakes. In Sierra Leone under the terms of the 1999 Lomé Peace Agreement, insurgent leader Foday Sankoh became both Vice President and chairman of a new commission that would control mineral concessions throughout the country. Similarly, as part of the 1994 Lusaka accord, UNITA leader Jonas Savimbi was promised the ministry of Mines and Geology, which would imply control of Angola’s alluvial diamond revenues as well as new kimberlite deposits. However, the implementation of such revenue-sharing arrangements is extraordinarily difficult in practice (Herbst 2001); indeed, in both cases, war soon recurred. International actors could contribute to the robustness of settlements by expanding their role in postwar revenue-sharing arrangements through the founding and monitoring of institutions dedicated to this task. The challenges in this area are formidable: while the stakes are divisible, institutional reforms to credibly signal commitment to the proposed distributional settlement are difficult to implement, particularly in the case where the commodity is seen as inherently illicit and is therefore worth more in a state of war than peace.

In conflicts over stakes perceived by some factions as indivisible, international actors should also reinforce the efforts of moderate leaders to render the good at stake divisible through multiple national languages and advocacy of religious tolerance or through power-sharing institutional innovations such as parliamentary dominance,

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23 However, some revenue sources pose particularly difficult challenges to the negotiated resolution of civil wars because the often large income flows that they generate may not be reproducible under peace, and thus do not comprise part of the postwar stakes, for varying reasons. The commodity itself may be illicit. While the marketing of such a commodity is likely to continue to some degree in peacetime conditions (postwar police forces are generally weak), armed groups will probably have less control over its production and marketing. The production of some commodities may not be cost-effective in peacetime if costs rise as a result of regulation. Transnational flows of income from diasporic populations or international donors may decrease after the exigencies of civil war subside.

24 Ongoing peace negotiations in Sudan under the Intergovernmental Authority on Development are attempting to design an acceptable revenue-sharing agreement between the forces in the civil war; under discussion is the possible role of international actors in guaranteeing the distributional settlement (IGC 2002).
proportional representation, federalism or consociationalism. However, this poses exceedingly difficult challenges as such attempts may in the eyes of some groups demean the good understood as indivisible, thereby reinforcing that their commitment to armed conflict.

Future research will analyze the endogeneity of postwar stakes, in particular, the dependence of $\varphi$ on the distributional share $\alpha$.\textsuperscript{25} For example, consider the case of a class conflict where $\alpha$ is the postwar split for labor and $1-\alpha$ that for capital. For very low values of $\alpha$, there is limited output for nutritional, motivational or other reasons; output rises as $\alpha$ increases; and for very high values of $\alpha$, output declines as wealth holders will not invest if their share is not sufficient. As before, if the conditions analogous to conditions 1 and 2 above are met, a range of feasible settlements exist. The optimal settlement, which minimizes the risk factor for the mutual-compromise equilibrium, is not the same as the settlement that would maximize output, however. Another extension is to explore the case where the parties explicitly trade off their preferences for higher payoffs with a preference for greater robustness of the settlement.

\textsuperscript{25} See Wood (2002) for details.
Appendix

For values of the parameters meeting the conditions 1 and 2, $\gamma_a^*$ and $\gamma_b^*$ are in the range (0, 1). Equating the expected payoffs to Compromise and Fight for A gives

$$\gamma_a^* = \frac{\rho \omega_a}{(\varphi \alpha - \rho \lambda_a - \omega_a + 2 \rho \omega_a)}$$

and for B gives

$$\gamma_b^* = \frac{\rho \omega_b}{[\varphi(1-\alpha) - \rho \lambda_b - \omega_b + 2 \rho \omega_b]}.$$

Setting equal the two above expressions to find $\alpha_{opt}$ gives

$$\alpha_{opt} = \left[ \frac{\rho(\omega_a \lambda_a - \omega_b \lambda_b) + \omega_a \varphi}{(\omega_b + \omega_a) \varphi} \right].$$

For symmetric payoffs, $\omega_a \lambda_a = \omega_b \lambda_b$ and $\omega_b = \omega_a$ so $\alpha_{opt} = \frac{1}{2}$ as it should.

To evaluate the effect of a change in the value of one of the parameters, we need to sign the derivative of $\alpha_{opt}$ with respect to that parameter.

It is easy to show that $d\alpha_{opt}/d\lambda_a > 0$ and $d\alpha_{opt}/d\lambda_b < 0$.

Other derivatives are less straightforward.

1) $d\alpha_{opt}/d\omega_a = \frac{\omega_b [\varphi - \rho(\lambda_a + \lambda_b)] / \varphi (\omega_b + \omega_a)^2$.

I sign this as follows. The sum of conditions 1 and 2 gives $\varphi > \rho(\lambda_a + \lambda_b) + (1-\rho) (\omega_b + \omega_a)$, from which it follows that $\varphi > \rho(\lambda_a + \lambda_b)$ and so $d\alpha_{opt}/d\omega_a > 0$.

2) $d\alpha_{opt}/d\omega_b = \frac{\omega_a [\rho(\lambda_a + \lambda_b) - \varphi] / \varphi (\omega_b + \omega_a)^2}$. From the preceding, the numerator is negative. Hence $d\alpha_{opt}/d\omega_b < 0$.

3) $d\alpha_{opt}/d\varphi = \frac{\rho(\omega_b \lambda_b - \omega_a \lambda_a) / \varphi^2 (\omega_b + \omega_a)^2}$. In general this last expression cannot be signed. But in the case of symmetric payoffs, it equals zero, as it should (because $\alpha_{opt} = \frac{1}{2}$).

Finally,

6) $d\alpha_{opt}/d\rho = \rho(\omega_a \lambda_a - \omega_b \lambda_b) / \varphi (\omega_b + \omega_a)$.

Again, this cannot generally be signed, but for symmetric payoffs equals zero, as it should.
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