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Decisive Victories or Negotiated Settlements:
Rebel-Government Bargaining over Lootable Resources during Civil War

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Abstract

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By Carleen Graham

What determines whether a civil war ends in absolute victory or negotiated settlement? If a negotiated ceasefire or peace agreement is reached, will it last? This paper argues that rebel funding influences the bargaining behavior of both the government and the rebels, the probability of both sides compromising on a settlement, and the likelihood of war resuming following a ceasefire or peace agreement. Previous literature has demonstrated the effect of rebel natural resource funding on the onset and duration of conflict. This paper builds on previous work by demonstrating that rebel funding can influence not only the duration of civil conflict but also the duration of civil peace by altering the ability of the government and the insurgents to credibly commit to an agreement. Moreover, if a conflict is longer and more intractable it should also be more likely to be resolved with a decisive victory by one side rather than a compromise or stalemate. Rebel groups profiting from illicit lootable resources during civil war are less likely to come to a successful settlement with the government compared to those who do not profit from illicit funding. Additionally, rebel groups who benefit from illicit funding during war are incentivized to renege on agreements by re-engaging in illicit activities and fighting following the signing of a peace agreement.

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Chapter 1

Introduction

What impact do natural resources have on civil war? A large body of literature on resource wars has argued that exogenously available lootable resources, such as diamonds, gems, and narcotics provide motivation for rebel groups and enable rebellions to last longer, consequently increasing the duration of civil conflict (Buhaug, Gates and Lujala 2009; Collier, Hoeffler and Soderbom 2004; Fearon 2004; Lujala 2010; Lujala, Gleditsch and Gilmore 2005; Ross 2003, 2006). The literature on natural resources and rebel funding, however, has yet to reconcile itself with the more recent literature on the bargaining model of war. The bargaining model of war proceeds from a rationalist tradition and argues convincingly that rebel profiting from resources during war is not sufficient for civil war to occur or to endure. As long as there are costs associated with violent conflict, war is inefficient, and there should be a settlement that both parties would prefer to a costly conflict (Fearon 1995, 2004; Powell 2006). Thus, the occurrence and intractability of resource wars is puzzling in light of the bargaining model of war.

In the case of resource wars—conflicts characterized by rebel profiteering from natural resources or by rebel and state conflict over access to lucrative resources—mutually preferable ex-ante settlement divisions should be characterized by a division of the resources and/or a division of government authority. That raises a question as to why we observe

rebel groups and governments fighting costly wars when a more efficient, peaceful division of the resources and/or government authority is mutually preferable? Moreover, why do nearly 43% of all civil wars resume following a ceasefire or peace agreement? (Fortna 2004). This paper argues that the characteristics of the resources themselves, particularly the degree of lootability and licitness, determine the feasibility of warring parties achieving and following through with a peace agreement.

The ability of rebels and the government to come to an agreement or to abide by an agreement in the present period depends on what each party expects to occur in the future peace period. Parties should be unwilling to settle and unwilling to abide by an agreement when they expect either that the agreement is unlikely to be upheld or that the other side will try to gain by exploiting them. What determines whether an agreement is credible? I argue resource funding characteristics, including lootability and licitiness, influence the ability of parties to construct credible agreements that will be honored.

I assume that rebel groups are revenue maximizing and want to either maintain their current source of resource funding during peace or be adequately compensated for forgoing funding in the post-conflict period. Furthermore, it is easier to form agreements about some types of resources compared to others. Most governments should be constrained and unable to allow rebels to continue to engage in illicit resource funding, such as drugs production or kidnapping ransoms in the post-conflict period. Hence, conflicts where rebels profit from illicit resources should be less likely to end in a compromise and more likely to end with a victory by one side, as both the rebels and the government have incentives to cheat on potential agreements and recognize that these agreements are unsustainable. Moreover, any settlements reached in these cases should be more likely to breakdown compared to cases where rebels do not make use of illicit funding.

Chapter 2

Literature Review

2.1 Commitment Problems and Civil War

Explanations from the bargaining model of war detail the role of commitment problems in understanding the duration of civil conflict. According to this logic, parties are unable to commit to peace because they fear the other side has dishonorable intentions and they will be exploited. Each party anticipates either that they have incentives to violate the terms of the agreement or else the other side does. These incentives prevent agreements from being credible and being honored by warring parties (Fearon 1995, 2004; Powell 2006). Observing that civil wars on average last longer than interstate wars, Walter (2002, 2009) argues that commitment problems are likely to be worse in civil wars – conflicts between a state and non-state actor. In civil wars, peace agreements frequently require that rebels demobilize and disarm, making themselves vulnerable to government attack. Rebels fear government exploitation, thus they become unwilling to settle and prefer to continue fighting until they defeat the government or are defeated definitively. Walter (2002, 2009) points to a number of solutions for overcoming the commitment problem during civil war, including third party monitoring and security guarantees.

Walter's (2002) commitment problem explanation would leave us to believe that all civil wars should be similarly lengthy. All rebel groups should fear government deception, and in the absence of third party security guarantees, all civil wars should be lengthy. Walter's (2002) explanation cannot fully account for the variation in the extent of commitment problems in civil wars. The explanation highlights the incentives of the government to cheat and does not consider the possibility that rebels may also face incentives to violate the terms of a peace settlement. Further, Walter (2002) does not explain the source of commitment problem dynamics in civil wars prior to a peace agreement and prospective third party involvement.

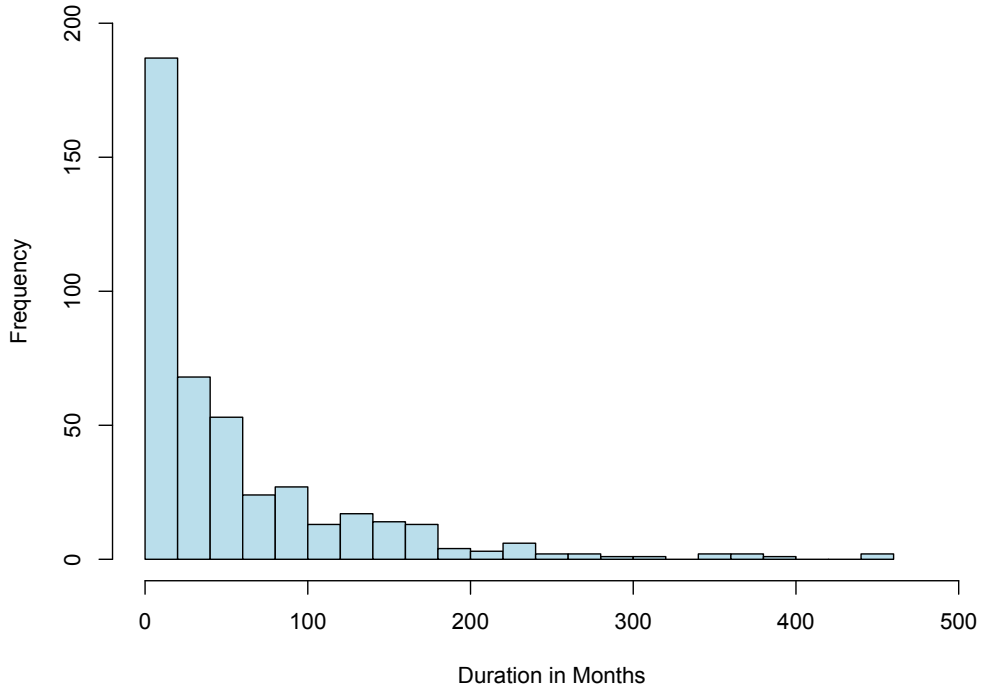
Figure 2.1 displays a histogram of the duration of civil wars by government–rebel group dyads by month from 1946-2003.[1] The majority of government–rebel dyads settled within twenty months or less than two years; the median duration was twenty nine months. A considerable number of government–rebel dyads, however, fought for decades before settling. This data reflects two different trends among civil wars: 1) those that end relatively quickly, within twenty months or less than two years, and 2) those that endure for decades. In explicating civil war duration it is important to be able to account for these two different trends. A commitment problem explanation would suggest that in the shorter wars either one side is defeated relatively quickly or the commitment problem dynamic is relatively insignificant. With regards to longer civil wars, a commitment problem explanation would predict that the commitment problems are worse in these wars. The purpose of this paper is to account for this variation in the severity of commitment problems across civil wars.

Others have used the logic of the commitment problem to explain the duration of peace (Fortna 2004, 2008). Fortna (2008) argues that civil wars frequently resume after a break in the fighting as a result of devious objectives and enduring mistrust among the parties. First, one or both sides may have aggressive rather than peaceful intentions during a break in the fighting and peace negotiations. A temporary break in fighting may provide warring parties

[1]The data is taken from the Expanded Uppsala Armed Conflict Data on Non-State Actors (EACD) which disaggregates civil wars into government–rebel group dyads. (Cunningham, Gleditsch and Salehyan 2009).

with the opportunity to re-group militarily. Second, former combatants often fear that the other side will break their peaceful promises and return to fighting. Neither party is fully able to commit to peace because they anticipate that the other side will try to gain militarily by a surprise attack and renewed fighting. Fortna (2004, 2008) focuses on demonstrating the effectiveness of an external solution to the commitment problem: peacekeeping. In summary, commitment problem dynamics can both prevent the occurrence of a negotiated settlement during civil war and result in the resumption of conflict after peace has been established.

Figure 2.1: Duration in Months of Civil Wars by Government-Rebel Dyads



2.2 An Illustrative Example: Rebel Groups in Colombia

Not only do we observe variation in the duration of civil wars across countries, but there is also significant variation in the willingness of some rebel group government dyads to settle within the same country and during the same time period. The case of the ELN (Army of National Liberation or Ejrcito Liberacin Nacional) and the EPL (The Popular Army of Liberation or Ejrcito Popular de Liberacin) in Colombia illustrates this within-country variation. The ELN and the EPL, among other armed opposition groups, emerged from La Violencia (1948-1958), a major civil war in Colombia between the two dominant political parties, the Liberals and the Conservatives. The National Front, a consociational agreement, was the formal truce signed by the Liberals and Conservatives in 1958, in which the two dominant parties agreed to share power. The armed rebel groups that persisted after La Violencia were connected to the Communist Party, an opposition party excluded from the National Front.

One armed opposition group, the ELN, formally originated in 1964 from a group of university students who travelled to Cuba and were inspired by the successful Cuban Revolution in 1959. The ELN aimed to overthrow the Colombian government, reform the economic capitalist structure of Colombia, and end U.S. imperialist influence in Colombia. Within the ELN's ranks included discontented students, peasants, and urban workers drawn from regions or departments in Northern Colombia, including Santander, Antioquia, and Bolivar. Another armed opposition group, the EPL appeared in 1967 as the self-proclaimed armed unit of the Communist Party. The EPL recruited among the landless farmers—los campesinos—in northern Colombia, particularly those residing in Santander and Antioquia. The EPL had similar goals as the ELN in that it sought to provoke a socialist revolution in Colombia and to overthrow the Colombian government and the reigning socioeconomic order. Later, the EPL also began to recruit among urban workers in these regions to augment their ranks.

Thus, the ELN and the EPL operated in similar areas of Northern Colombia, recruited supporters from the discontented landless rural poor and urban working class, and maintained similar strategic goals of overthrowing the government and reigning capitalist socioeconomic system. Both insurgent organizations also had a similar fighting capacity in terms of the size of their forces, a few hundred fighters during their weakest points and a few thousand fighters at their peaks.

In 1984, all four major armed insurgent organizations, including the ELN, EPL, FARC (Revolutionary Armed Forces of Colombia or Fuerzas Armadas Revolucionarias de Colombia), and M-19 (19th of April Movement or Movimiento 19 de Abril) signed a ceasefire with the Colombian government. While the EPL was the first insurgent organization to break with the agreement after its leader, Ernesto Rojas, was assassinated in 1985, the EPL ultimately settled with the government and demobilized in 1991. The M-19 also settled with the Colombian government during the same time period. The ELN, on the other hand, continues to operate as an insurgent organization in Colombia despite a series of peace negotiations with the Colombian government during the 1990s up to present.

This scenario presents an interesting puzzle. Why did the EPL demobilize and sign a successful peace agreement with the Colombian government in 1991, while talks between the ELN—a similar armed group—and the government have failed to produce any sustainable peace agreements?

Both the ELN and EPL saw their numbers significantly dwindle and were almost stamped out by government forces in the 1970s. While the EPL barely recovered from these mounting costs and decided to move into urban areas in Northern Colombia and recruit from discontented urban workers, the ELN began to use tactics including the extortion from local businesses and multinational corporations, the bombing of oil pipelines, and kidnappings for ransom (Kline 2007). The ELN has profited from the civil war and relative lawlessness in Colombia. While conflict became highly costly for the EPL in terms of economic resources, the conflict has been net profitable for the ELN. The argument in

this paper would predict that the conflict between the ELN and the Colombian government will continue until one side definitively defeats the other because the ELN employs illicit funding. Moreover, any future ceasefires between the two sides are likely to breakdown and both sides will anticipate their failure.

2.3 Resources and Rebel Funding

A large body of literature has emerged for the purpose of studying the relationship between natural resources and civil conflict. The research has built on Collier and Hoeffler's (2004) finding that natural resource exports are associated with civil war onset. There are three primary hypotheses that have been proposed by the existing literature. First, lootable natural resources, such as diamonds and gemstones, can be easily accessed and extracted by rebel groups, thus making rebellion more feasible and profitable. Second, nonlootable hydrocarbon natural resources lengthen conflict by increasing the value of the expected utility from winning the war. Third, state natural resource dependence results in state weakness, also contributing to the feasibility of rebellion. This paper draws from existing literature and contributes to our understanding of the role of lootable resources during and after war.

Lootable resources are proposed to be associated with civil war because they can easily be accessed by rebel groups to fund rebellion (Lujala 2009, 2010; Ross 2006; Snyder 2006; Weinstein 2007). Compared to nonlootable resources, lootable resources are easier for rebel groups to extract, transport, and sell. The relative lootability of resources can be classified according to three crucial dimensions: 1) inputs required for extraction, 2) transportation requirements, and 3) markets for sale. Lujala (2003) emphasizes that lootable resources are easier to explore, mine, store, transport, and do not require refinement.

According to these three dimensions, the most highly lootable resources include alluvial diamonds and gems because they require very low barriers to entry, can be extracted with

relatively little labor, and do not require capital inputs. Alluvial diamonds are those which have been removed from Kimberlite via natural erosion and can be uncovered in river beds using simple tools, such as shovels and sieves. Rebels typically make use of black markets in order to profit from alluvial diamonds and gems during a civil conflict, as nonstate armed groups typically cannot sell commodities on traditional international markets. Therefore, I assume that if a commodity can be sold on the black market, it is more lootable and easier for non-state groups to access and sell. Moreover, highly lootable and lucrative resources, such as alluvial diamonds, also have the advantages of being easier to transport and sell for above average profits [2]. During the 1990s the UNITA (National Union for the Total Independence of Angola) financed their war effort through the control of 60-70% of Angola's diamonds (*A Rough Trade: The Role of Companies and Governments in the Angolan Conflict* 1998). Angolan rough diamonds were often smuggled into neighboring countries and made their way onto international diamond markets as a result of a lack of verification and transparency prior to the Kimberley Certification Scheme (*A Rough Trade: The Role of Companies and Governments in the Angolan Conflict* 1998).

Lootable resources also can be extracted by rebels relatively easily during a conflict, but they are not as lootable as the highly lootable resources. Lootable resources include other kinds of resources that researchers typically have labeled under the contraband category (Fearon 2004; Ross 2006), such as timber, cocaine, and opium. These commodities also are sold on black markets. Lootable resources differ from the highly lootable resources, because they require greater labor inputs in addition to limited control over territory in order to extract. In Peru, one branch of the primary rebel movement, the Shining Path[3] in Huallaga, has been involved in coca growing and cocaine production and continues to remain active in cocaine production and trafficking.

[2]Kidnapping also could also be classified as a highly lootable resource, because of its minimal requirements for extraction, transportation, and transactions.

[3]The core of the Shining Path was not involved in drugs production and relinquished fighting after its leader Abimael Guzman was captured by Peruvian authorities in 1992 (Weinstein 2007).

Alternatively, nonlootable resources are more difficult for rebels to exploit. Nonlootable resources, include Kimberlite or deep shaft diamonds and gems, which must be mined, as well as metals and minerals. The extraction of these resources requires limited control over territories with mines as well as more intensive labor or capital inputs in comparison with highly lootable resources. Additionally, mined metals and mineral resources typically are sold in more traditional commodities markets, which are more difficult for rebel groups to gain access.

Finally, highly nonlootable resources are most commonly thought to be made up of oil and natural gas reserves. Oil and natural gas require huge capital investments for extraction, a large infrastructure for storage and transportation, and marketing in traditional commodities markets. Highly nonlootable resources are those over which the state is able to remain a monopoly producer[4] and control extraction in contrast to more lootable natural resources.[5]

Much recent literature has focused on disaggregating natural resources and examining their effect on the onset, duration, and severity of civil wars. More traditional research designs have grouped natural resources together, both lootable and nonlootable (Collier and Hoeffler 2004; Collier, Hoeffler and Soderbom 2004; Fearon and Laitin 2003). Others have distinguished between lootable and nonlootable resources and argue that lootable resources make civil conflict more likely and increase the duration of conflict by providing an easy accessible financing source for rebels (Buhaug, Gates and Lujala 2009; Fearon 2004; Lujala 2009, 2010; Lujala, Gleditsch and Gilmore 2005; Ross 2003, 2006). Some have demonstrated empirically that among nonlootables, oil increases the probability of onset

[4]In a recent notable exception, Libyan rebels have sold crude oil to Qatar in May 2011 from oil fields in Tubruq. Continued fighting and attacks from Muammar Gaddafi's forces, however, have temporarily halted oil production and sales in Tubruq.

[5]Another exception to the claim that highly nonlootable resources cannot be extracted by non-state armed groups during wartime has occurred in Nigeria in the Niger Delta region. The NDPVF (Niger Delta People's Volunteer Force) and other criminal gangs have been able to transform oil into a lootable resource, by using a process called "bunkering," allowing them to steal oil directly from pipelines (Ibeanu and Luckham 2007).

and duration of conflict (Buhaug, Gates and Lujala 2009; Fearon 2004, 2005; Lujala 2010; Ross 2003).

Lujala (2009) shows that locations with oil, natural gas or diamond production are characterized by more severe civil conflicts (higher incidence of combat deaths) compared to conflict locations without these resources. On the other hand, drug cultivation is associated with less severe civil conflicts (Lujala 2009). Lujala (2009) hypothesizes this finding may be due to strategic planning by rebels and the controlled chaos that successful drug trafficking requires. Lujala (2010) also disaggregates country-level data into conflict locations and provides evidence that both nonlootable and lootable lucrative natural resources, including drugs, alluvial diamonds, gemstones, oil, and natural gas are associated with the onset of civil conflict.

In terms of civil war duration, Fearon (2004) finds that civil wars where rebels derive funding from contraband, including diamonds, opium, and cocaine, are longer in duration than otherwise. Additionally, Fearon (2004) demonstrates that conflicts between a peripheral minority and the state over hydrocarbon resources last longer than other types of civil wars. Corroborating this finding with conflict and resource location data, Buhaug, Gates and Lujala (2009) find that conflict areas rich in gemstones, alluvial diamonds, oil, or natural gas last longer than resource poor conflict locations.

Overall, lucrative natural resources, such as oil, contraband, alluvial diamonds, gems, narcotics, and timber, have been found to have a significant impact on the onset, duration, and severity of conflict, while other natural resources, including other minerals and agricultural products, seem to have no effect on civil conflict (Buhaug, Gates and Lujala 2009; de Soysa and Neumayer 2007; Fearon 2004, 2005; Kaldor, Karl and Said 2007; Lujala 2009, 2010; Ross 2006; Weinstein 2007). Despite this emerging consensus from the empirical literature on which natural resources influence civil war, we still lack a deeper micro-level theoretical understanding of how these resources influence the dynamics of civil conflict, potential settlements, and post-war peace. The literature on natural resources

and civil war has yet to reconcile itself with the bargaining model of war and commitment problem dynamics, which are believed to lengthen conflict (Fearon 1995; Powell 2006; Walter 2002, 2009). Furthermore, commitment problems are believed to shorten the duration of peace and increase the likelihood of war reinitiation (Fortna 2008). While there has been significant examination of civil war onset, intensity, and duration, there has been no empirical and theoretical work on the effect of natural resources on war outcomes and the duration of peace following ceasefires.

Finally, there might be good reasons to expect that drugs and other illicit lootable resources have a different effect on bargaining behavior, the likelihood of a negotiated settlement, and the duration of peace following a settlement in comparison to legal lootable resources. The illicit nature of these resources makes it unlikely that they can be included in a peace settlement. Consequently, rebels have an incentive to deviate from the agreement and reinitiate fighting to continue profiting from illicits. Thus, the presence of rebel illicit funding increasing the likelihood that war will continue until one side wins decisively and any negotiated settlements are likely to be fragile. The game theoretic model that follows seeks to further explicate the differing effects of lootable resources on war outcomes and reinitiation.

Chapter 3

Theory

3.1 Game Theoretic Model

As mentioned previously, rebel groups who profit from lootable resources during war have preferences over the division of these resources in the future. This paper assumes that in addition to their political goals, resource rich rebels have economic preferences and prefer continued resource extraction to being excluded from their former profits. The government, on the other hand, prefers peace to war but wants to sacrifice as little governing authority and revenue as possible. The government would like to offer the rebels an agreement whereby the rebels can continue to profit from the resources they extracted during conflict; however, in the case of illicit lootables the government is unable to commit to allowing rebels' future extraction of the illicit resources in the post-conflict period. Also, unlike legal lootable resources sold on traditional commodity markets, the government typically cannot extract and profit from illicit lootables, thus decreasing their potential revenue and offer size to the rebels. Thus, the presence of illicit lootables should increase the likelihood that the government cannot offer the rebels a mutually preferable settlement. Any settlements, therefore, are likely to be broken by one or both parties. The primary claim of this paper is that rebel use of illicit lootable resources alters the strategic context and has a

direct effect on the willingness of governments and insurgent groups to negotiate with one another, ultimately increasing the likelihood that war will continue until a decisive victory and increasing the likelihood of peace breakdown, as exemplified by the case of the ELN and the Colombian government.

The paper presents a game theoretic bargaining model between the government and a rebel group in the period immediately preceding a militarized conflict. The model does not make any assumptions about why the rebels and the government are in conflict. The rebel group may be fighting the government because of political or economic grievances or for some other reason. The model assumes, however, that when the rebel group finds themselves at a juncture where they have to choose whether to engage in militarized conflict or not, they have preferences over their political power as well as their economic funding. A rebel group's funding influences not only their viability in a militarized dispute but also their organizational strength and bargaining power. As will be revealed, well-endowed rebel groups can demand more from the government under a peace settlement. Rebels may prefer to fight the government if they have a high probability of victory or if they can maximize their economic profits by extracting legal and illicit lootable resources during conflict; otherwise, they should prefer a peaceful agreement as long as they expect the government to uphold the bargain.

In the model, Nature determines the level of funding that rebels have available to them $B_R \in [0, 1]$ which is made up of legal lootable funding L, including diamonds, gems, and timber, as well as illicit lootable funding I, drug production and trafficking. The government then offers a deal to the rebel group, a share of its revenue $\tau \in (0, 1)$ and permits the rebels to continue to profit from their lootable funding in exchange of forsaking war and not engaging in illicit funding. The settlement may be a division of government authority or a monetary payoff. The rebels can either take the offer or leave it. If the rebels accept the offer, each party simultaneously decides whether or not to abide by the agreement. If the offer is rejected, a period of fighting occurs and each side faces a probability of defeat.

Crucially, the settlement offer must be sufficiently valuable to the rebels so that they prefer it to a costly conflict with the government where they can profit both from legal and illicit lootable resource funding and are defeated with probability p. Rebel groups are forward looking and make decisions on whether to wage war or not by taking into account the government's willingness to bargain and make concessions, as well as their anticipation that a settlement with the government is likely to be upheld. The government either wants to defeat the rebels if it is possible to do so cheaply and with a high probability of success or it wants to pay off the rebel group in exchange for its continued rule and peace.

Peace agreements fail and war occurs in the following cases: 1) the rebels reject the government's offer, 2) both parties decide not to uphold the agreement following the rebels' acceptance, and 3) the rebels unilaterally renege on the agreement after accepting the government's offer. On the other hand, if the government unilaterally decides to not follow the agreement, the rebels receive a "sucker's payoff". Finally, if both sides uphold the terms of the agreement following rebel acceptance, peace results and they receive peace payoffs.

The compliance part of the game is modeled as a simultaneous moves. The two sides are perfectly informed about each other's preferences and payoffs, but uninformed regarding one another's compliance decision. The government and the rebel group simultaneously decide whether or not to follow the terms of the agreement. Modeling this portion of the game as simultaneous moves captures the uncertainty involved in peace negotiations, both sides are uncertain of the other's willingness to comply, and compliance is observed imperfectly. Furthermore, neither side has the advantage of being a last mover in the game—benefitting by seeing if the other side complies first. Table 3.1 identifies the parameters in the model. Figure 3.1 provides a visual representation of the extensive game with imperfect information.

Figure 3.1: Game Theoretic Model

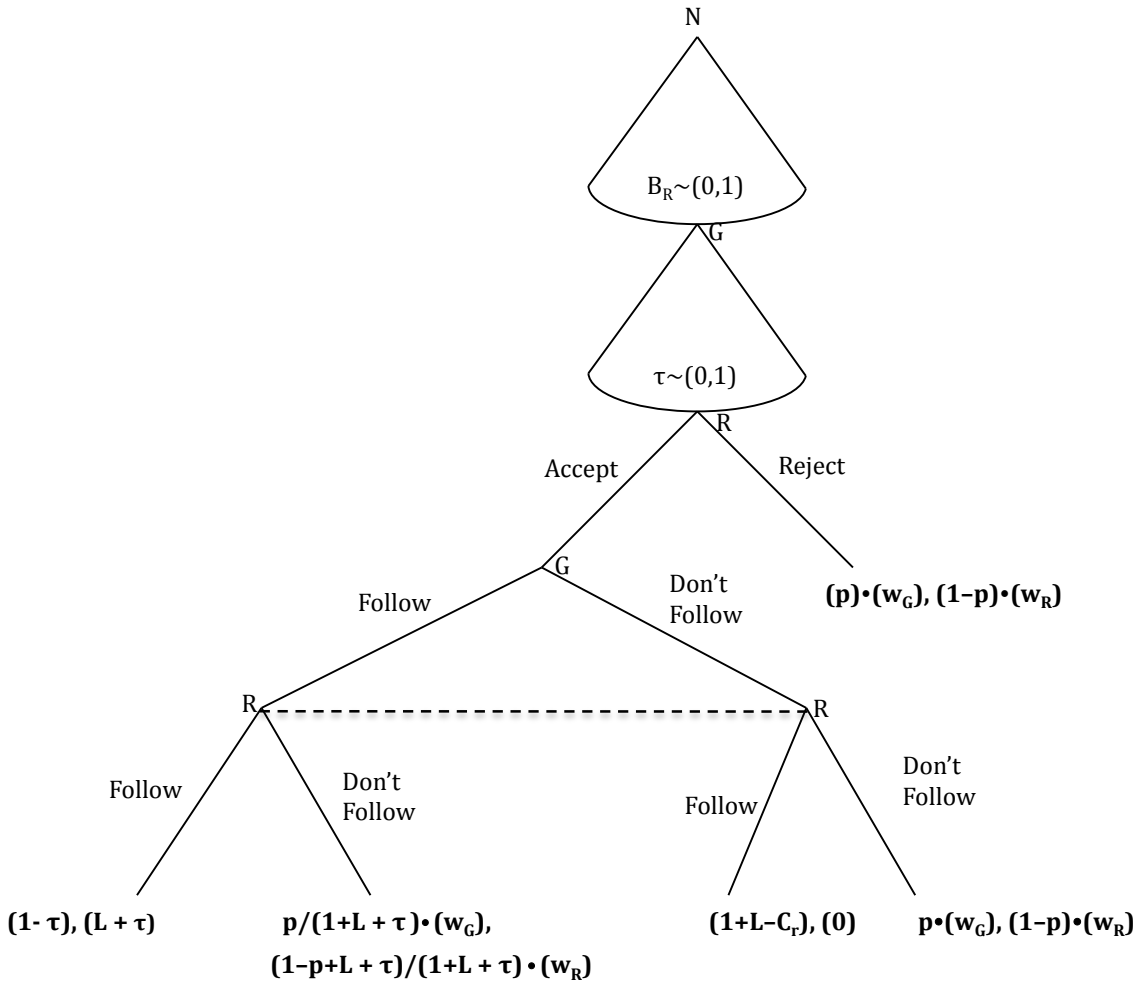


Table 3.1: Parameters in the Game Theoretic Model

p	Probability of Government victory
$(1-p)$	Probability of Rebel victory
$B_R \in [0,1] = L + I$	Rebels' funding drawn by Nature
$L \in [0,1)$	Rebels' Legal lootable funding drawn by Nature
$I \in [0,1)$	Rebels' Illicit lootable funding drawn by Nature
$w_R = 1 + L + I - c_W$	Rebel's War Payoff
$w_G = 1 + L - c_W$	Government's War Payoff
τ	Government's Settlement Offer out of its budget to Rebels
$\tau + L$	Total Settlement Offer to Rebels
c_W	Cost of War (same for Government and Rebels)
C_r	Government's Cost of Repression

3.2 Subgame Perfect Nash Equilibria

There are two possible conflictual subgame perfect Nash equilibria and one peaceful, cooperative subgame perfect Nash equilibria of the entire game. The conflictual and cooperative Nash equilibria separate on the basis of critical values of illicit lootable resource funding I^* and the cost of repression C_r^*. When the rebel group's illicit lootable funding sources are sufficiently large, $I \geq I^*$, or when the cost of repression is relatively cheap, $C_r \leq C_r^*$, the government and the rebels are more likely to end up in conflict. On the other hand, when the rebel group's illicit lootable funding is below the critical threshold, $I \leq I^*$, and the cost of repression is relatively high, $C_r \geq C_r^*$, the cooperative equilibrium results. The critical values I^* and C_r^* are given by equations (3.1) and (3.2) respectively.

$$I^* = \frac{(1+L)(p-1) + \tau(L+\tau)}{(1+L+\tau-p)} + c_W \tag{3.1}$$

$$C_r^* = L + \tau \tag{3.2}$$

3.3 Conflictual Subgame Perfect Nash Equilibria

A conflictual equilibria results either when the rebels' illicit lootable funding exceeds the crucial threshold value, $I \geq I^*$, or when the cost of repression is relatively cheap $C_r \leq C_r^*$. Additionally, there are two conflictual subgame perfect Nash equilibria possibilities. In one instance, the rebels reject the government's offer outright and both sides go to war. Another possibility is that the rebels accept the government's offer and both sides subsequently decide to not abide by the terms of the agreement and go to war. After accepting an offer, the rebels' best response is to follow when illicit lootable funding is sufficiently small and they anticipates the government will also follow. The rebels should choose to not follow when illicit lootable funding is sufficiently large or they anticipate the government will not follow. If the government anticipates that the rebels will not follow the agreement, its best response is to not abide by the agreement as well.

Given that a conflictual equilibria results, what offers will the rebels accept and reject? An interesting result of the model is that the rebel group is indifferent between accepting and rejecting any offer $\tau \in (0, 1)$ because the payoffs are the same to both parties on either side of the game tree when both parties plan to not follow the terms of the agreement. The rebels will accept any offer $\tau \in (0, 1)$ because they know it will not be followed, and the government will offer any $\tau \in (0, 1)$ because they also anticipate the agreement will not hold. The warring parties know what will result given the values of illicit lootable funding and the cost of repression. Thus, there is no value of $\tau \in (0, 1)$ that the government can offer to induce the rebels to accept and make up for the loss of illicit funding. Alternatively, the rebels may also decide to reject the offer immediately, resulting in conflict on the right side of the game tree. The important implication of the model here is that when the rebel's illicit lootable funding is sufficiently high or the cost of repression is sufficiently low, bargaining is ineffective and disingenuous ceasefires may result.

Notably, it is possible for I^* to be negative and when this occurs illicit funding is always greater than the critical value because $I \in [0, 1)$. Thus, when the critical value I^* is

negative both parties prefer the conflictual outcome and there is no cooperative equilibrium in this single period game. The value of I^* is given by equation (3.1). It depends on the value of lootable resources, the cost of war, the probability of government victory, and the government's peace offer. I^* is negative when war is relatively cheap. Intuitively, this implication makes sense. If war is relatively cheap, both parties may prefer to remain at war rather than settle even if the rebels do not make use of any illicit funding.

3.4 Cooperative Subgame Perfect Nash Equilibrium

If instead, the rebels' level of illicit funding falls below the critical threshold I^*, the rebel group prefers to follow the terms of the agreement as long as the government also prefers to follow. The government strictly prefers to follow the terms of the cooperative agreement as long as the rebels' illicit funding falls below the critical threshold and the government's cost of repression is prohibitively expensive. Under these conditions, the government will set $\tau = \tau^*$, the offer necessary to induce the rebels' acceptance. The offer τ^* is given by equation (3.3). Consequently, in the cooperative equilibrium the rebel group accepts the government's offer and both groups subsequently decide to follow the terms of the negotiated settlement.

$$\tau^* = [(1-p) \cdot (1 + L + I - c_W)] - L \tag{3.3}$$

The cooperative equilibrium depends on three conditions: 1) illicit funding is sufficiently small, 2) the government offer is set at τ^*, and 3) the cost of repression is sufficiently high. Recall that I^* is given by equation (3.1). It is possible for I^* to be negative, and if I^* is negative the level of illicit funding is never below the critical value I^* and a cooperative equilibrium is not possible. Whether I^* is negative or positive depends critically on the cost of war. As discussed previously, war must be sufficiently costly in order to achieve a cooperative equilibrium.

The second condition for the cooperative equilibrium is that the government's cost of repression is sufficiently large so that the government prefers following the peace agreement over not following. The critical value C_r^* is given by equation (3.2). The cost of repression depends on the rebels' strength. It is more expensive to repress a more formidable opponent. Thus, the cooperative equilibrium is more likely to result when the rebels have more legal and illicit lootable resource funding and a greater probability of victory.

The third condition for the cooperative equilibrium involves the government setting its offer to the rebels at τ^*, because the rebels only accept $\tau \geq \tau^*$. The government's offer of its budget constraint τ^* is given by equation (3.3) and $\tau \in (0, 1)$. This condition is satisfied as long as τ^* is positive. The government will be able to locate a positive τ^* as long as the rebel's source of lootable funding is not too large. The greater the value of the rebel's legal lootable funding, the more tempting it is for the government to renege on the agreement and try to sucker the rebels. The government is also more likely to be willing to offer the critical condition τ^* when the rebels' probability of victory is sufficiently large.

3.5 Comparative Statics

This section considers how other parameters in the model influence the critical equilibrium conditions, I^* and C_r^*. Changes in these critical values determine the likelihood of the parties ending up in conflict or peace. How does the critical value I^* change as the exogenous parameters in the model change? The comparative static calculations are calculated by taking the partial derivative of the critical value I^* with respect to the exogenous parameters in the model, including the cost of war c_W, the probability of rebel group defeat p, and the rebels' legal lootable resource funding L.[1] The partial derivative of I^* with respect to the cost of war is positive. As the cost of war increases for both sides the critical value of I^* increases. A cooperative equilibrium is more likely as war becomes

[1]Please see the Appendix for the calculations of the comparative statics.

more costly because the rebels' value of illicit funding is more likely to fall below the critical threshold. Similarly, the partial derivative of I^* with respect to the probability of rebel defeat p is also positive. If the rebels are more likely to be defeated, cooperation is also more likely. Figure 5.1 demonstrates that the cooperative space or probability of ending up in the cooperative equilibrium increases as either the cost of war or the probability of rebel defeat increases. Additionally, the partial derivative of I^* with respect to the rebel group's legal lootable resource funding is also positive. Higher legal lootable resource funding also makes cooperation more likely, as legal lootable resource funding can be included in the peace offer in contrast to illicit funding. In summary, increases in the following exogenous parameters: the probability of rebel defeat, the cost of war, and the value of rebel's legal lootable funding, increase the threshold I^*, heightening the likelihood of a peaceful outcome by increasing the rebels' preferences for cooperation.

In order for the cooperative equilibrium to result, a second condition must be met. The cost of repression must be significantly costly to the government, so that they prefer to follow rather than not follow $C_r \geq C_r^*$. The critical value for the cost of repression is given by equation (3.2). How is this cutoff value affected by changes in the other parameters? The partial derivative of C_r^* with respect to L is positive. As the value of lootable resources increases, the threshold value C_r^* increases, and the critical condition is less likely to be met, making the cooperative equilibrium less likely. Increases in the rebel's legal, lootable funding L has two distinct effects in this model: the rebels are more likely to want to settle and the government is less likely to prefer a settlement, see Figure 5.2. Increasing L increases C_r^* resulting in a decrease in the cooperative space; however, an increase in L also increases I^*, increasing the cooperative space. The effect of legal lootable resource funding on the probability of cooperation is unclear from this model because of its two opposing effects.

It is also possible to make predictions about the type of settlement offer necessary for cooperation. The partial derivative of τ^* with respect to I is positive. Thus, as the rebels'

illicit funding source I^* increases, τ^* increases and the government must offer a higher value of their budget τ in order to convince the rebels to accept the peace offer. The partial derivatives of τ^* with respect to p and c_W are both negative. As the probability that the rebels' will be defeated or as the cost of war increases, τ^*, the offer that the government needs to compensate the rebels in order to avoid war, decreases. Table 3.2 summarizes the comparative statics discussed here.

Table 3.2: Game Theoretic Model Comparative Statics

Parameters	I^*	c_r^*	τ^*
I $\uparrow$ (Illicit Resources)			$\uparrow$
p $\uparrow$ (Probability Rebels Defeated)	$\uparrow$		$\downarrow$
$c_W \uparrow$ (Cost of War)	$\uparrow$		$\downarrow$
L $\uparrow$ (Lootable Legal Resources)	$\uparrow$	$\uparrow$	

Figure 3.2: Impact on Critical Conditions: Increase in p or c_w

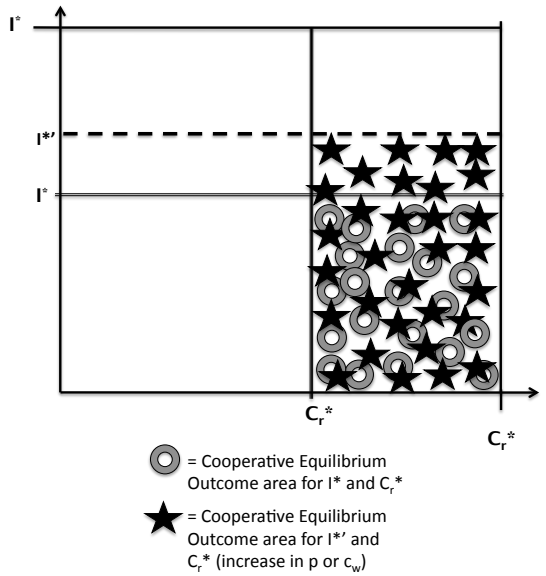
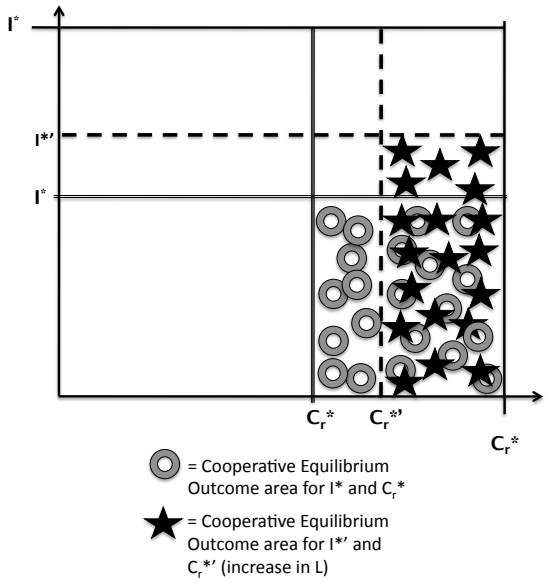


Figure 3.3: Impact on Critical Conditions: Increase in L



The model above sought to answer why civil wars vary in their outcome (decisive victory or negotiated settlement) and the durability of peace following a negotiated settlement by disaggregating various types of rebel group lootable funding. Rebel groups can employ either legal lootable resources or illicit lootable resources. Why does this distinction— legal versus illicit— matter? The model in this paper assumes that rebel groups can benefit from legal lootable funding both under conflict and peace. The rebels, however, are not able to benefit from illicit funding under peace because the government cannot allow rebel groups to continue profit from illicit funding under a peace settlement. Moreover, the government cannot profit from illicit resources during war or peace. Thus, in some cases a rebel group's illicit funding may exceed some critical threshold such that the government cannot adequately compensate them for their loss of illicit wartime funding because it is prohibitively expensive to do so. In these cases, conflict will likely persist until a decisive victory, and negotiated settlements will be unlikely, insincere, and/or fragile. Both parties will be likely to violate a negotiated settlement when the rebels' illicit funding is

sufficiently high because they anticipate that each side has an incentive to deviate from the agreement.

Additionally, the government's preference for war and peace is influenced by its cost of repression. When repression is relatively cheap and the benefit of taking advantage of the rebels is high or the rebels' lootable funding and peace demands are high, the government prefers to fight to the bitter end and not abide by a peace agreement. The rebels prefer to settle as long as the government also prefers peace. If the rebels anticipate that the government prefers conflict, they will also choose to fight and not abide by a peace settlement. Interestingly, a greater value of illicit funding helps a rebel group to achieve a better settlement offer from the government, but a sufficiently high level of illicit funding also makes peace less attractive to the rebels because they have to forgo more funding under peace. Legal, lootable funding may be either beneficial or deleterious to peace because it makes peace more attractive to the rebels and less attractive to the government by increasing the benefits of repressing the rebel group.

The hypotheses that follow make use of the equilibrium conditions and the comparative statics from the model to make predictions about the likelihood of war ending in a decisive victory and the likelihood of a ceasefire breaking down. In hypothesizing about the duration of peace following a negotiated settlement I employ an interaction term between war outcome (decisive victory or compromise) and lootable resources in order to accurately capture the effect of various lootable natural resources on the duration of peace when the fighting ends in a compromise or stalemate. In general, wars ending in decisive victories are less likely to resume because the defeated side typically does not have the strength to regroup and reinitiate fighting (Fortna 2004). Thus, to examine the independent effect of lootable resources on the duration of peace, I focus on their effect in cases where the fighting ended in a compromise or stalemate.

I examine both war outcome and the duration of peace settlements, arguing that certain types of lootable resources make both decisive victories and the breakdown of ceasefires

more likely. Why do ceasefires ever result if the conditions are such that both sides prefer a decisive victory over settlement? The model above demonstrates that the two sides may sign a ceasefire agreement disingenuously, knowing full well that they both intend to violate the agreement—the agreement is not credible. Fortna (2008) argues that both sides may enter into a peace agreement with dishonorable intentions in order to regroup militarily.

3.6 Hypotheses: Civil War Outcome and the Duration of Peace

1a. Wars where rebel groups benefit from illicit lootable resources should be more likely to end with a decisive victory than otherwise.

1b. The peace following civil wars ending in an indecisive victory where rebel groups benefit from illicit lootable resources should be less durable than otherwise.

2a. Wars where rebel groups benefit from legal lootable resources should be more (less) likely to end in a decisive victory than otherwise.

2b. The peace following civil wars ending in an indecisive victory where rebel groups benefit from legal lootable resources should be less (more) durable than otherwise.

3a. The greater the government's cost of repression, the less likely the war is to end in a decisive victory.

3b. The greater the government's cost of repression, the more durable the post-war peace.

4a. The greater the cost of war, the less likely the war is to end in a decisive victory.

4b. The greater the cost of war, the more durable the post-war peace.

5a. The greater the probability of rebel group victory, the less likely the war is to end in a decisive victory.

5b. The greater the probability of rebel group victory, the more durable the post-war peace.

Chapter 4

Research Design

4.1 Quantitative Analysis

The existing quantitative work has found considerable evidence that oil, diamonds, and narcotics lengthen the duration of civil war (Fearon 2004, 2005; Lujala, Gleditsch and Gilmore 2005; Ross 2006). More recently, Lujala (2009, 2010) and Buhaug, Gates and Lujala (2005) look at subnational data on civil wars disaggregated by conflict zones in combination with GIS data on the location of diamond mines, diamond deposits, oil fields, and drug cultivation. They find that the exogenous presence of these resources increases the risk of onset, the duration, and the intensity of civil conflict. The existing literature, however, has yet to fully explore the credible commitment problem that I argue is inherent in resource wars by looking at how the presence of lootable legal and illicit resources influence the war outcome (decisive victory or indecisive victory) and the durability of peace agreements. The research design proposed here will examine both the influence of lootable legal (alluvial diamonds) and illicit resources (cocaine and opium) on the likelihood of a decisive victory and the duration of peace.

The first part of the quantitative analysis considers an empirical test of the effect of lootable resources (legal and illicit) on the war's outcome. If civil wars involving illicit

lootable resources are more difficult to resolve and longer lasting, then we should observe that those conflicts are more likely to end in a decisive victory rather than a stalemate or compromise. Here I employ a logit model to estimate the impact of various types of lootable resources on the likelihood of the conflict ending in a decisive victory. The primary data source is Fortna (2008) and includes instances of civil war ceasefires between 1989-1999. Further, Fortna (2008) codes whether the war ended in a decisive victory or not. I also utilize various resource datasets on diamonds, gemstones, drug cultivation, and oil production to measure key independent variables (Floter, Lujala and Rod 2005; Gilmore, Gleditsch, Lujala and Rod 2005; Lujala 2002; Lujala, Rod and Thieme 2007).

The primary dependent variable is whether the war outcome is marked by a decisive victory or a compromise. The primary independent variables are the presence of lootable resources both legal and illicit. These lootable resources include drug cultivation (cocaine and opium) and alluvial diamond production. The production of drugs and diamonds is coded dichotomously by country. Other key independent variables identified in the hypotheses also come from Fortna (2008). The government's cost of repression is proxied with the variable mountainous terrain. The more mountainous the territory, the easier it is for rebels to hide and thus the greater the cost of government repression. The cost of war is measured according to battlefield-related casualties. Finally, the probability of rebel victory is proxied with a measure of the size of the government's army (in thousands). The larger the government's forces, the less likely the rebels are to win the war.

The second part of the quantitative analysis examines the effect of lootable resources (legal and illicit) on the duration of post-war peace using event history analysis. In event history analysis, the dependent variable is the time until failure, in this case the time until the breakdown of peace. I report the results from a Cox proportional hazards model and a Weibull model[1]. Again, I draw on both Fortna's (2008) data on the duration of peace after war and various resource datasets on diamonds, gemstones, drug cultivation, and oil

[1]I find no evidence that the proportional hazards assumption is violated.

production (Floter, Lujala and Rod 2005; Gilmore et al. 2005; Lujala 2002; Lujala, Rod and Thieme 2007). Fortna's (2008) data includes all instances of ceasefires following civil wars between 1945-1999 and identifies whether peace lasts up until December 31, 2004. The data consists of 107 ceasefires following civil wars from 1945-1999. Civil wars included in the dataset are those which resulted in 1,000 battle-related deaths (total, rather than in a single year as in the Correlates of War definition). The independent variables listed above for the logit analysis are also used in the analysis of peace durability.

4.2 Classification of Natural Resources

It is important to distinguish between natural resources that are lucrative enough for rebel groups to want to control and profit from them, and those which are not lucrative enough to fund a rebel movement or motivate civil conflict. It is likely that oil, alluvial diamonds, gems, and narcotics have been found to be influential in motivating civil war and in increasing its duration in comparison to agricultural resources, metals, and other minerals because the former are much more lucrative and in some cases more lootable than the latter. Rebels are interested in funding sources that are lucrative—they accrue large economic rents or above average rates of return—and relatively easy for them to access or loot.

Table 4.1 lists relevant lucrative natural resources that may be involved in civil conflict and scores them according to each of the three dimensions of lootability: inputs for extraction, transportation requirements, and markets for sale. Table 4.2 uses the classification from Table 4.1 on the lootability of various resources and codes whether they are considered by the international community to be licit or illicit—a distinction that is crucial for my theory. The licitness dimension is key to determining the post-conflict fate of rebel funding. The probability that the rebels will be able to continue resource extraction during peace directly influences the government and rebels' willingness to settle and lay down

their arms. Arguably, all resources that rebel groups extract and sell on black markets during civil conflict are illicit. The illicit dimension in Table 4.1 classifies resources as legal or illicit according to whether they are considered illicit in the post-conflict phase according to national and international law.[2] Oil and natural gas are considered to be legal and highly nonlootable, while kimberlite diamonds are legal and nonlootable. Alluvial diamonds are classified as legal and highly lootable, while cocaine and opium are classified as illicit and lootable.

4.3 Other Independent Variables

I also use a variety of control variables including those employed by Fortna (2008) in her analysis of peace duration in which peacekeeping is the primary independent variable. Peacekeeping is coded dichotomously here according to whether it was present or not. Additional control variable include victory, treaty, war type, log dead, war duration, factions, development, democracy, infant mortality, past agreement, P5 contiguity, former P5 colony, P5 involvement, and neighbor aid to rebels (Fortna 2008). Victory is coded according to whether the war ended in a decisive victory or not. Treaty captures whether a peace treaty was signed. War type distinguishes identity conflicts (ethnic, religious) from ideological conflicts and revolutions. War duration is measured in months. The level of development of a country is proxied with electricity consumption per capita and infant mortality. The democracy variable is measured using the average Polity score five years prior to the conflict. The P5 variables attempt to capture influence by the permanent Security Council members: whether the country is a former colony of a P5 member, whether the country is

[2] Alluvial diamonds are classified as licit or legal commodities in Table 4.2. The Kimberly Process Classification Scheme established in 2003 is an initiative by the international community to certify that diamonds did not come from rebel movements attempting to overthrow a sovereign government. As long as the government complies with the Kimberly Process Certification Scheme their diamonds in the post-conflict period would be classified as legal. Thus, the Kimberly Process has not changed the way in which I would code diamonds as a licit resource, but it does provide information to consumers and large diamond buyers, so that they can choose certified diamonds.

contiguous with a P5 member, and whether a P5 member was involved in the conflict. Factions measures the number of factions involved in the conflict. Fortna (2004, 2008) finds that peacekeeping, victories, development, longer war duration, and government army size reduce the likelihood of peace failure, while greater costliness increases the likelihood of peace failure. Additionally, I control for the presence of oil production. Fearon (2005); Fearon and Laitin (2003) have found that the natural gas and oil production lengthen the duration of war. These highly nonlootable resources may also influence the duration of peace.

4.4 Rebel Groups versus Criminal Organizations

By rebel groups I mean armed non-state organizations that are engaged in armed conflict with the state and have a political objective. This paper seeks to explain the outcome of war and the durability of peace agreements among government–rebel dyads. It is necessary to distinguish the unit of analysis, rebel groups, from other organizations which may behave similarly. Rebels may also have economic goals, resource rich rebellions prefer continued resource extraction over the absence of resource funding. Because I want to understand government–rebel bargaining during conflict, a group must also have political objectives in order to be considered in the sample. These include the following: 1) to overthrow the state, 2) to achieve political autonomy, or 3) to reform and participate in the state's political institutions. The theory developed in this paper also may have implications for bargaining interactions between the state and armed criminal organizations; however, these potential implications are not explored and tested here.

Criminal organizations may use violence against civilians, the state, or state security forces in order to protect their organization and further their economic goals (Fukumi 2003). There are many criminal organizations that engage in funding activities similar to those of some rebel groups, such as drug cartels; they may also exist coterminously with

rebel groups; and they may benefit from state weakness and the relative lawlessness associated with a civil war. Nonetheless, but they are excluded from the sample of rebel groups and civil wars. For example, the Zetas, the Sinaloa Cartel, the Gulf Cartel, and other criminal cartels in Mexico responsible for the recent upsurge in violence in Mexico over the last decade would not be included in the sample. On the other hand, the EZLN (Zapatista Army of National Liberation), which launched its rebellion against the Mexican government on January 1, 1994 and demands independence for the Chiapas state, would be be considered a rebel group.

Also excluded from this analysis are ethnic or ideologically motivated civil society groups that are not armed regardless of whether they are clamoring for limited autonomy or greater control over territory. For example, the MOSOP (Movement for the Survival of the Ogoni People) in Nigeria, a non-violent civil society organization demanding autonomy for the Ogoni people residing in Ogoniland (a small section of the Niger Delta) and control over the oil on their land, would not be considered a rebel group because they are unarmed and not engaging in combat with the state.

Table 4.1: Relative Lootability of Resources

Resource	Markets	Factor Inputs	Transportation	Lootability
Alluvial Diamonds	Black Markets	Labor	Minimal	Highly Lootable
Cocaine, Opium	Black Markets	Labor, Land	Minimal	Lootable
Kimberlite Diamonds	Traditional Markets	Labor, Land	Minimal	Nonlootable
Oil, Natural Gas	Traditional Markets	Capital	Infrastructure	Highly Nonlootable

Table 4.2: Intersection of Lootability and Illicitness

	Highly Nonlootable	Nonlootable	Lootable	Highly Lootable
Legal	Gas, Oil	Kimberlite Diamonds		Alluvial Diamonds, Gems
Illicit			Cocaine, Opium	

Chapter 5

Results

5.1 Decisive Victories

The results from the first part of the quantitative analysis (the logit model estimating whether the war ended in a decisive victory by one side or a compromise) are displayed below in Table 5.1[1]. I report the coefficients and the standard errors. The coefficient on the variable drugs, a measure of cocaine and opium production, is positive as predicted by the hypotheses. The theory predicts that conflicts where opium and cocaine cultivation occur are more likely to end with a decisive victory, but the variable does not achieve statistical significance in the model. Recall that the theoretical prediction for legal lootable resources or lootable diamonds was ambiguous. The presence of legal lootable resources should make the rebels more likely to settle, on the other hand, the government should prefer to continue fighting in the presence of legal lootable resources. The coefficient on lootable diamonds is negative, suggesting that a decisive victory is less likely, but this variable does not achieve statistical significance. Similarly, the other natural resource variables—nonlootable diamonds and oil— are in the negative direction and also do not achieve statistical significance. The other theoretically relevant variables: casualties and mountainous

[1] Other control variables included in the model but not listed in the table are democracy, infant mortality, past agreement, P5 contiguity, P5 Involvement, and Neighbor Aid to Rebels.

terrain are not in the correctly predicted direction or statistically significant. Only government army size is in the predicted direction and statistically significant. Government army size represents the probability of rebel victory, and the hypotheses predict that the greater the probability of rebel victory, the less likely the war is to end in a decisive victory. In other words, the greater the probability of government victory, the more likely the war is to end in a decisive victory. As predicted, I find that a larger government army makes decisive victory more likely. Of note, the longer the war, the less likely it is to end in a decisive victory, and ethnic wars are less likely to end with a decisive victory.

Table 5.1: Logit Analysis of Civil War Outcomes (Decisive Victories)

	Model 1
	Coefficients
	(S.E.)
Drugs	1.83
	(1.56)
Lootable Diamonds	-.45
	(2.92)
Nonlootable Diamonds	-2.81
	(2.61)
Oil	-.64
	(1.40)
Casualties	.55
	.36
Government Army Size	.006**
	(.002)
Mountainous	.81
	.66
War Type	-.280*
	(1.28)
War Duration	-.28*
	.12
Factions	-2.64
	(1.68)
Observations	81

* $p \leq 0.05$ ** $p \leq 0.01$ *** $p \leq 0.001$

In terms of substantive significance, Table 5.2 reports the predicted probabilities and marginal effects for changes in key independent variables. Although not statistically significant, the presence of drugs does appear to have a substantively significant effect on the likelihood of observing a decisive victory. Civil wars where cocaine and opium production are present are approximately ten percent more likely to experience a decisive victory compared to civil wars where drug production is not present. Other natural resources, including lootable diamonds, nonlootable diamonds, and oil, have smaller negative substantive effects on the likelihood of decisive victory. Wars in which lootable diamonds, nonlootable diamonds, or oil is involved appear to be somewhat less likely to end with a decisive victory. As predicted, the size of the government army has a positive effect: as the size of the government's army increases from 39,000 to 363,000 the conflict is nearly five percent more likely to conclude with a decisive victory.

Table 5.2: Predicted Probabilities for a Decisive Victory

Drugs (Opium/Cocaine)	
No	1.20
Yes	11.27
Change	+10.07
Lootables Diamonds	
No	3.27
Yes	2.11
Change	-1.16
Nonlootable Diamonds	
No	4.79
Yes	0.30
Change	-4.49
Oil	
No	3.20
Yes	1.71
Change	-1.49
Government Army Size	
Low (25%) 39	0.88
High (75%) 363	5.72
Change	+4.84

5.2 Duration of Peace

The results from the second part of the quantitative analysis concerning the durability of peace are displayed below in Table 5.3[2]. I report the hazard ratios and the standard errors. Any hazard ratio greater than one should be interpreted as increasing the hazard or probability of peace breakdown, and a hazard rate less than one means that the variable is decreasing the likelihood of peace breakdown or increasing the duration of peace. The results from the Cox hazard model and the Weibull model are reported in Table 5.3. The Cox model has the advantage of being more flexible and not specifying the underlying distribution of the hazard function. Still, the Weibull model results also are acceptable because statistical diagnosis demonstrates that the baseline hazard rate is monotonically decreasing.

Model 2 displays the estimates for the Cox model without the interaction terms. Recall that drugs and lootable diamonds are interacted with victory so that the effect of these lootable resources on peace durability independent of the outcome of the war can be estimated. In Model 2, the illicit drugs variable (opium and cocaine production) is in the correctly predicted direction (increasing the likelihood of peace failure) but does not achieve statistical significance. In terms of the legal lootables, lootable diamonds also appear to be increasing the probability of peace failure, but this variable does not achieve statistical significance. According to the theoretical model and predicted hypotheses, lootable legal resources may both increase and decrease the likelihood of peace simultaneously.

In Model 3, the interaction effects of drugs and victory as well as lootable diamonds and victory are included. In order to accurately interpret the effect of drugs and lootable diamonds, I present cumulative hazard functions using the interaction terms. The graphs compare the effect of these resources on the duration of peace when they are present and there is no decisive victory to when the resources are not present and there is also no

[2]Other Control Variables included in the models but not listed in the table are factions, democracy, infant mortality, past agreement, mountains, P5 Contiguity, P5 Involvement, Neighbor Aid to Rebels.

decisive victory. This comparison allows the estimation of the substantive effect of drugs and lootable diamonds for wars ending in a compromise. I anticipate that the effect of lootable resources in the post-conflict period will be diminished greatly when the war ended in a decisive victory, thus it is important to estimate the effect of lootable resources (illicit and legal) in wars that did not end in a decisive victory.

Figure 5.1 displays a graph of the cumulative hazard function by the presence and absence of drug cultivation (cocaine and opium) for wars not ending in a decisive victory. The presence of cocaine and opium cultivation appears to have a substantial effect on the hazard rate. The likelihood of peace failure is greatly increased when drug production exists in the country for wars not ending in a decisive victory compared to when drug production does not occur.

Figure 5.1: Cumulative Hazard by Drug Cultivation for Non-Victories

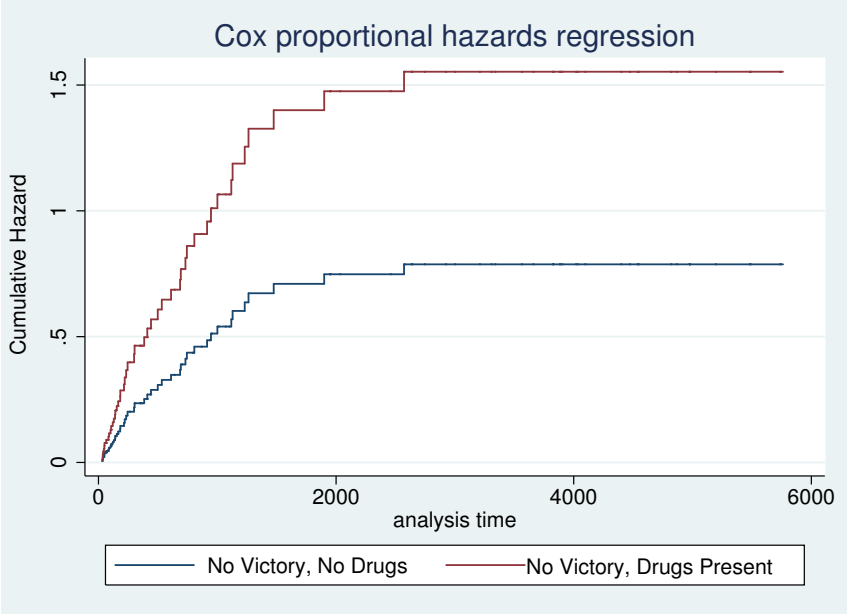
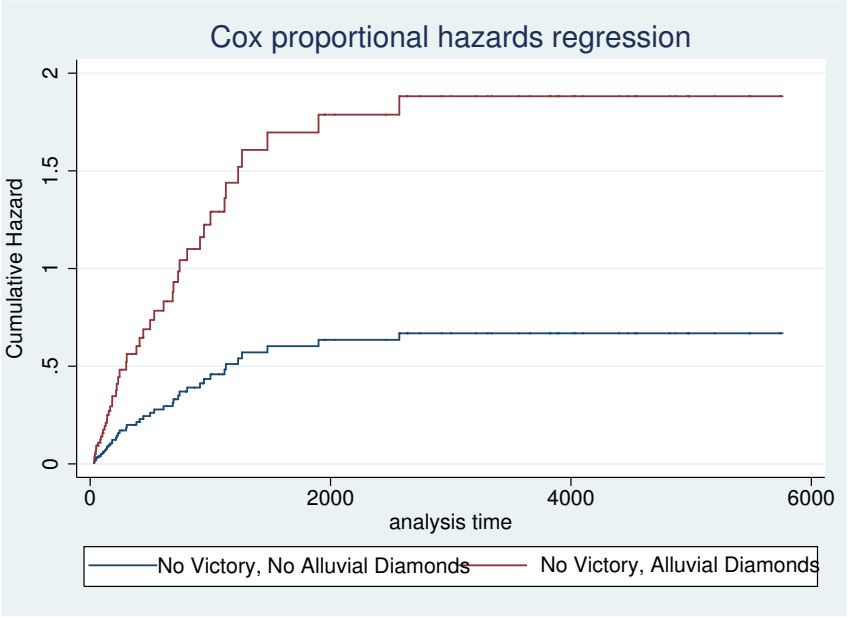


Figure 5.2 displays a graph of the cumulative hazard function by the presence and absence of lootable diamond production for wars not ending in a decisive victory. Lootable diamonds also appear to have a significant substantive effect on the hazard rate. Peace is likely to be much less durable in the presence of lootable diamonds for wars not ending in a decisive victory compared to wars in which lootable diamonds are not present.

Figure 5.2: Cumulative Hazard by Lootable Diamonds for Non-Victories

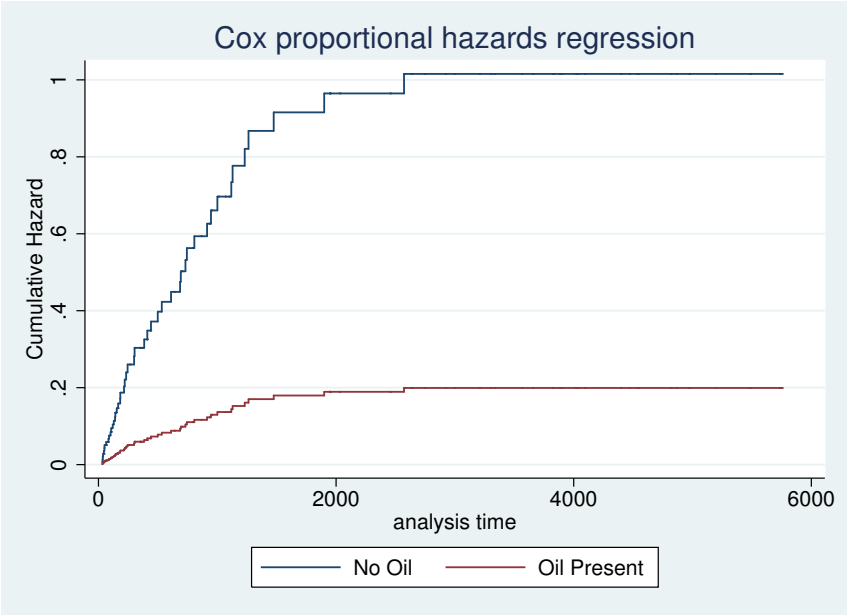


Looking at the other key independent variables in Models 2 and 3, the variable mountainous terrain is not in the predicted direction. It appears to increase the likelihood of peace breakdown rather than decrease it. Similarly, the variable casualties is also not in the predicted direction. In all of the models of peace duration, a greater number of casualties increases rather than decreases the likelihood that peace will fail. Additionally, the size of the government's army appears to have no effect on the durability of peace. Similar to Fortna; Fortna's (2004; 2008) findings: wars ending in decisive victories, those with peacekeeping, as well as those with a peace treaty have a longer peace duration.

While the overall estimates do not change much across the Cox and Weibull models, the variable oil is statistically significant in the Weibull model estimates (Models 4 and 5) but not in the Cox model estimates (Models 2 and 3). There are no theoretical predictions in this paper for the effect of oil on peace durability. Buhaug, Gates and Lujala (2009); Fearon (2004); Lujala (2010) have found that the presence of oil increases the duration of war. One might expect that oil should decrease the duration of peace. Interestingly, in all of the models of peace durability oil appears to strengthen the duration of peace. Figure 5.3 displays a graph of the cumulative hazard function by the presence and absence of oil

production. The presence of oil production appears to have a strong substantive impact on the hazard rate—decreasing the likelihood of peace failure.

Figure 5.3: Cumulative Hazard by Oil Production



5.3 Discussion

The theory in this paper assumes that there is a similar type of commitment problem operating during war and following the signing of a ceasefire. Other studies have found evidence that lootable resource funding is associated with the onset of civil war and lengthens the duration of civil war. I find weak evidence that lootable resources influence civil war outcomes and the duration of peace, substantively significant but not statistically significant. If the commitment problem dynamic is correct: Why do lootable resources lengthen the duration of conflict but do not have much effect on the likelihood of decisive victory and sustainability of peace agreements? The results from these empirical analyses suggest that there may be different dynamics occuring during war and after war. Notably, I do not find statistically significant results for the primary variables of interest: illicit lootables (drugs) and legal lootables (alluvial diamonds). The predicted probabilities from the logit

model demonstrate some support for the claim that wars in which rebel groups employ funding from drugs are more difficult to resolve and thus more likely to end in a decisive victory rather than a stalemate or compromise. Also, the hazard graphs for peace duration demonstrate some evidence that both drugs and lootable diamonds increase the likelihood of peace breakdown for wars not ending in a decisive victory.

The theoretical model predicts two contradictory effects for legal lootables, namely alluvial diamonds. On the one hand, lootable legal resources make rebel groups more likely to settle by providing a greater potential post-conflict payoff. On the other hand, lootable legal resources are also attractive to the government and decrease the government's cost of repression, making repression and reneging on the settlement a more attractive option for the government. These opposing effects may explain why lootable legal resources do not have a statistically significant effect on the likelihood of a decisive victory and the duration of peace. This explanation however, cannot account for the lack of statistically significant results for illicit drugs. The model clearly predicts that illicit lootable resources should make conflicts more difficult to resolve, more likely to continue until a decisive victory, and more likely that peace agreements will fall apart.

One explanation for the lack of substantial results is the limitations of the data. The lootable resource data is coded according to whether it exists in a given country during the conflict, but it is uncertain as to whether the rebels are employing these funding sources. It is possible that alluvial diamonds exist in a different part of the country than the rebels or that the rebels simply do not make use of certain resources. For example, the M-19 and the EPL in Colombia did not reap funding from kidnapping, drug production, or drug trafficking while the FARC and the ELN have benefitted from these funding sources. Future research should attempt to determine whether various rebel groups are actually employing various lootable funding sources and also need to identify and code other potential illicit funding, drug cultivation and trafficking in addition to kidnapping, theft, and extortion. The literature on natural resources and conflict has not yet considered looting in the form of kid-

napping, theft, and extortion. Moreover, it is important to note that the predictions from the theoretical model are principally about the amount of illicit funding and whether it crosses a certain threshold. Illicit funding does not necessarily make conflicts more difficult to resolve, rather it only does so when the amount of illicit funding exceeds a certain threshold such that the government cannot make an adequate peace offer to compensate the rebels and both sides are incentivized to defect from potential peace settlements. Ideally, rebel funding data would also estimate the amount of funding rebels receive from each funding source, both legal and illicit. These data improvements should enhance estimations of the effect of these resources on the likelihood of a decisive victory and the durability of peace.

Another possibility is that by ignoring the content of ceasefires and peace agreements this study suffers from some form of omitted variable bias. There may be ways of making peace agreements more credible and sustainable despite lootable resource funding (legal and illicit). Interestingly, the Weibull model results demonstrate that the presence of highly nonlootable resources—oil—greatly strengthens the durability of peace agreements. In order to assess how peace agreements may differ in their credibility, a first step would be to look at peace agreements involving oil. Do these agreements provide mechanisms for the sharing of oil revenues among warring parties and do these agreements have credible commitment mechanisms? By looking more closely at the content of ceasefires and peace agreements we may be able to better predict which agreements are likely to be sustained over time. Moreover, some of these settlement features may be correlated with lootable resources. By including these settlement features in the model we may be able to better estimate the true effects of legal and illicit lootable resources on war outcomes and the duration of peace.

Table 5.3: Duration of Peace Analysis

	Model 2 Cox Model	Model 3 Cox Model	Model 4 Weibull Model	Model 5 Weibull Model
	Hazard Ratios (S.E.)	Hazard Ratios (S.E.)	Hazard Ratios (S.E.)	Hazard Ratios (S.E.)
Drugs	1.10 (.77)	1.25 (.95)	1.12 (.83)	1.23 (.95)
Drugs x Victory		.46 (.95)		.40 (.60)
Lootable Diamonds	1.98 (1.55)	1.79 (1.48)	2.88 (2.31)	2.59 (2.28)
Lootable Diamonds x Victory		2.27 (3.05)		2.73 (3.49)
Nonlootable Diamonds	.91 (.85)	.84 (.91)	.71 (.69)	.66 (.66)
Oil	.18 (.16)	.20 (.19)	.14** (.10)	.16* (.12)
Casualties	1.21* (.11)	1.21* (.11)	1.25* (.12)	1.24* (.12)
Government Army Size	1.00 (.001)	1.00 (.001)	1.00 (.001)	1.00 (.001)
Mountainous	1.17 (.22)	1.17 (.23)	1.18 (.20)	1.18 (.21)
Peacekeeping	.23* (.14)	.24* (.15)	.21** (.11)	.22** (.12)
Decisive Victory	.08*** (.06)	.08*** (.05)	.06*** (.04)	.06*** (.04)
Treaty	.28* (.15)	.31* (.17)	.25* (.14)	.27* (.15)
War Type	1.12 (.55)	1.06 (.62)	1.06 (.51)	1.00 (.51)
War Duration	.90** (.03)	.90** (.03)	.88*** (.03)	.88*** (.03)
Observations	107	107	107	107

* $p \leq 0.05$ ** $p \leq 0.01$ *** $p \leq 0.001$

Chapter 6

Conclusion

In conclusion, this paper has argued that existing theoretical weaknesses in the literature on civil war and natural resources merit further theoretical and empirical investigation. The potential contributions of this paper are fourfold: 1) provide a more rigorous theoretical explanation for the role of lootable natural resources in civil war, 2) propose theoretically interesting distinctions across legal and illicit resources, 3) integrate the literatures on natural resources and conflict with the bargaining model of war, and 4) provide empirical tests for the predictions about different types of lootable resources (legal and illicit) on war outcome and the durability of peace. The rationalist argument proposed here is that rebels' resource funding during civil war lengthens the duration of conflict thereby increasing the likelihood that conflict will continue until a decisive victory and decreasing the durability of peace not because natural resources increase the viability and longevity of rebellion, but because lootable resources, particularly illicit lootable resources restrict the range of feasible settlement offers and make it more difficult for the government and the rebel group to credibly commit to a settlement.

Notably, the model predicts that when rebel illicit funding is sufficiently large or when the cost of repressing the rebels is relatively cheap, conflict will result and there is no feasible negotiated settlement that will prevent its outbreak or recurrence. Interestingly, the

model allows for both decisive victories (i.e. no agreements) and disingenuous ceasefire agreements under the same conditions. This prediction has real world implications for the design of peace agreements. Namely, under certain conditions, such as a large amount of rebel illicit funding, the design and content of peace agreements may not matter for the resolution of conflict. In these situations, I expect that the conflict will be resolved by a decisive victory rather than a negotiated settlement, and any negotiated ceasefires are likely to break down.

How can peace ever occur when the amount of illicit funding to rebels is very large? One possibility is that the government may be able to significantly undercut the rebels' illicit funding such that it no longer exceeds the critical value. When a rebel group's illicit funding is less than some critical value the government will be able to offer the rebel group an adequate concession such that the rebels prefer the terms of the peaceful settlement to that of the expected payoff from war.

Chapter 7

Appendix

7.1 Solving for the Subgame Perfect Nash Equilibria of the Game

Rebel Group:

First, consider the lowest subgame on the left side of the game tree after the rebels accept the government's offer. Given that the government decides to follow, what is the rebels' best response?

$$
\begin{aligned}
EU_{\text{Rebel}}(F_R|F_G) &\geq EU_{\text{Rebel}}(\sim F_R|F_G) \\
L+\tau &\geq \frac{(1-p)+(L+\tau)}{1+L+\tau}\cdot w_R \\
L+\tau &\geq \frac{(1-p)+(L+\tau)}{1+L+\tau}\cdot (1+L+I-c_W) \\
L+\tau &\geq \frac{1+L+I-c_W-p-pL-pI+pc_W+L+L^2+LI-Lc_W}{1+L+\tau} \\
&\quad + \frac{\tau+\tau L+\tau I-\tau c_W}{1+L+\tau} \\
(L+\tau)\cdot(1+L+\tau) &\geq 1+L+I-c_W-p-pL-pI+pc_W+L+L^2+LI-Lc_W \\
&\quad +\tau+\tau L+\tau I-\tau c_W \\
L+L^2+\tau L+\tau+\tau L+\tau^2 &\geq 1+L+I-c_W-p-pL-pI+pc_W+L+L^2+LI-Lc_W \\
&\quad +\tau+\tau L+\tau I-\tau c_W \\
-I+pI-LI-\tau I &\geq 1-L^2-L\tau-\tau^2-c_W-p-pL+pc_W+L+L^2-Lc_W-\tau c_W \\
I(1+L+\tau-p) &\leq -1+L\tau+\tau^2+c_W+p+pL-pc_W-L+Lc_W+\tau c_W \\
I &\leq \frac{-1-L+\tau L+\tau^2+p+pL-pc_W+c_W+Lc_W+\tau c_W}{(1+L+\tau-p)} \\
I &\leq I^*
\end{aligned}
$$

$$
\begin{aligned}
I^* &= \frac{-1 - L + \tau L + \tau^2 + p + pL + c_W + Lc_W + \tau c_W - pc_W}{(1 + L + \tau - p)} \\
I^* &= \frac{-1 - L + \tau L + \tau^2 + p + pL + c_W(1 + L + \tau - p)}{(1 + L + \tau - p)} \\
I^* &= \frac{-1 - L + \tau L + \tau^2 + p + pL}{(1 + L + \tau - p)} + c_W \\
I^* &= \frac{-1(1 + L) + p(1 + L) + \tau(L + \tau)}{(1 + L + \tau - p)} + c_W \\
I^* &= \frac{(1 + L)(p - 1) + \tau(L + \tau)}{(1 + L + \tau - p)} + c_W
\end{aligned}
$$

As long as the value of illicit funding I is less than or equal to some threshold I^* the rebel group will prefer to abide by the agreement rather than not follow given that they expect the government to follow as well. If instead, $I \geq I^*$ the rebel group will prefer to not follow the agreement when the government is following.

What is the rebel's best response when the Government is choosing to Not Follow?

$$
\begin{aligned}
EU_{\text{Rebel}}(\sim F_R | \sim F_G) &\geq EU_{\text{Rebel}}(F_R | \sim F_G) \\
(1 - p) \cdot w_R &\geq 0 \\
(1 - p) \cdot (1 + L + I - c_W) &\geq 0 \\
(1 - p) &\geq 0 \\
(1 + L + I - c_W) &\geq 0
\end{aligned}
$$

This statement is always true. The probability that the government is defeated $(1-p) \in (0, 1)$ is always greater than 0 by assumption. And, $(1+L+I-c_W)$ is always strictly greater than 0 by definition because L, I, and c_W are all bounded between 0 and 1. Therefore, if the Government pursues a strategy of not following, the rebel group always prefers to not follow as well.

$$
s_R = \begin{cases} F_R & \text{if } F_G \wedge I \leq I^*, \\ \sim F_R & \text{if } F_G \wedge I \geq I^*, \\ \sim F_R & \text{if } \sim F_G. \end{cases}
$$

Government:

What is the government's best response to the rebels strategy s_R? What is the government's best response when the Rebels choose Follow?

$$\begin{aligned} EU_{\text{Govt.}}(F_G|F_R) &\geq EU_{\text{Govt.}}(\sim F_G|F_R) \\ 1-\tau &\geq I+L-C_r \\ C_r &\geq L+\tau \\ C_r &\geq C_r^* \end{aligned}$$

$$\begin{aligned} EU_{\text{Govt.}}(F_G|F_R) &\leq EU_{\text{Govt.}}(\sim F_G|F_R) \\ 1-\tau &\leq I+L-C_r \\ C_r &\leq L+\tau \\ C_r &\leq C_r^* \end{aligned}$$

Therefore, when the rebels are following the terms of the agreement, the government prefers to follow when the cost of repression is relatively expensive, and they prefer not to follow when the cost of repression is relatively cheap.

What is the government's best response when the rebel group is choosing to not follow?

$$\begin{aligned} EU_{\text{Govt.}}(\sim F_G|\sim F_R) &\geq EU_{\text{Govt.}}(F_G|\sim F_R) \\ p\cdot w_G &\geq \frac{p}{1+L+\tau}\cdot w_G \\ 1 &> \frac{1}{(1+L+\tau)} \end{aligned}$$

This statement is always true because $L \in [0,1)$ and $\tau \in (0,1)$. The government always strictly prefers a history where it chooses to not follow when the rebels are not following over one in which it follows and gets suckered by the rebels.

$$s_G = \begin{cases} F_G & \text{if } F_R \wedge C_r \geq C_r^*, \\ \sim F_G & \text{if } \sim F_R, \\ \sim F_G & \text{if } F_R \wedge C_r \leq C_r^*. \end{cases}$$

Nash equilibria of the lower subgame:

$$\{F_R, F_G | I \leq I^* \wedge C_r \geq C_r^*; \sim F_R, \sim F_G | I \geq I^* \vee C_r \leq C_r^*\}$$

Rebel Group:

Subgame after the government makes an offer:

Will the rebel group chooses to accept or reject the offer?

We already know that there are two types of histories reached on the left side of the game tree: $\{Follow_R, Follow_G\}$ and $\{\sim Follow_R, \sim Follow_G\}$.

$$\begin{aligned} EU_{\text{Rebel}}(Accept_R, F_R | F_G | I \leq I^*) &\geq EU_{\text{Rebel}}(Reject_R, F_R | F_G | I \leq I^*) \\ L + \tau &\geq (1-p) \cdot w_R \\ L + \tau &\geq (1-p) \cdot (1 + L + I - c_W) \\ \tau &\geq [(1-p) \cdot (1 + L + I - c_W)] - L \\ \tau^* &= [(1-p) \cdot (1 + L + I - c_W)] - L \\ \tau &\geq \tau^* \end{aligned}$$

Thus, the willingness of the rebels to accept or reject an offer depends on the value of the government's offer τ. If τ is greater than or equal to a critical value τ^* the rebels will accept the offer, otherwise they will reject it.

Should the rebel group accept an offer if they anticipate that the government will follow the agreement, but they will not?

$$\begin{aligned} EU_{\text{Rebel}}(Accept_R, \sim F_R | F_G | I \geq I^*) &\geq EU_{\text{Rebel}}(Reject_R, \sim F_R | F_G | I \geq I^*) \\ \left(\frac{1 - p + L + \tau}{1 + L + \tau}\right) \cdot w_R &\geq (1-p) \cdot w_R \\ 1 - p + L + \tau &\geq (1-p) \cdot (1 + L + \tau) \\ 1 - p + L + \tau &\geq 1 + L + \tau - p - pL - p\tau \\ 1 &> -pL - p\tau \end{aligned}$$

This statement is always true by definition. If the rebels anticipate that the government will uphold an agreement, but their strategy calls for them to not follow, they are always better off accepting the government's offer $\tau \in (0, 1)$.

When the rebels know that neither side will follow the agreement, should they accept or reject the government's offer τ?

$$\begin{aligned} EU_{\text{Rebel}}(Accept_R, \sim F_R | \sim F_G | I \geq I^*) &= EU_{\text{Rebel}}(Reject_R, \sim F_R | \sim F_G | I \geq I^*) \\ (1-p) \cdot w_R &= (1-p) \cdot w_R \\ (1-p) \cdot (1 + L + I - c_W) &= (1-p) \cdot (1 + L + I - c_W) \end{aligned}$$

The payoffs for war on the right side of the tree are the same as the payoffs to accepting an offer and then both parties subsequently rejecting the offer on the left side of the tree. The rebel group is indifferent between these two histories.

$$s_R = \begin{cases} \text{Accept}_R, F_R & \text{if } F_G, I \leq I^* \wedge \tau \geq \tau^*, \\ \text{Accept}_R, \sim F_R & \text{if } F_G, I \geq I^* \wedge \tau \in (0,1), \\ \text{Accept}_R, \sim F_R & \text{if } \sim F_G \wedge \tau \in (0,1), \\ \text{Reject}_R, F_R & \text{if } F_G, I \leq I^* \wedge \tau < \tau^*, \\ \text{Reject}_R, \sim F_R & \text{if } \sim F_G \wedge \tau \in (0,1). \end{cases}$$

Government:

How will the government set its offer τ to the rebel group given s_R?

$$\begin{aligned} EU_{\text{Govt.}}(\tau = \tau^*, F_G | F_R | I \leq I^*) &\geq EU_{\text{Govt.}}(\tau < \tau^*, F_G | F_R | I \leq I^*) \\ 1 - \tau &\geq p \cdot w_G \\ 1 - \tau &\geq p \cdot (1 + L - c_W) \\ \tau &< p \cdot (1 + L - c_W) + 1 \end{aligned}$$

This statement is always strictly true because $\tau \in (0,1)$. When $I \leq I^*$ the Government prefers a history where it sets $\tau = \tau^*$, the rebels accept and choose to follow after the Government chooses to follow over a history where it sets $\tau < \tau^*$, the rebels reject the offer, and conflict results.

$$\begin{aligned} EU_{\text{Govt.}}(\tau \in (0,1), \sim F_G | \sim F_R | \text{Accept}_R,) &= EU_{\text{Govt.}}(\tau \in (0,1), \sim F_G | \sim F_R | \text{Reject}_R,) \\ p \cdot w_G &= p \cdot w_G \\ p \cdot (1 + L - c_W) &= p \cdot (1 + L - c_W) \end{aligned}$$

When both sides intend to not follow the terms of the agreement either because $I \geq I^* \vee C_r \leq C_r^*$ the payoffs for war on the right side of the tree are the same as the payoffs to those on the left side since both parties choose to not follow.

$$s_G = \begin{cases} \tau = \tau^*, F_G & \text{if } F_R \wedge C_r \geq C_r^*, \\ \tau \in (0,1), \sim F_G & \text{if } \sim F_R \wedge C_r \geq C_r^*, \\ \tau \in (0,1), \sim F_G & \text{if } F_R \wedge C_r \leq C_r^*. \end{cases}$$

$$SPNE(I \geq I^* \vee C_r \leq C_r^*) : \{\tau \in (0,1), \sim F_G, \text{Accept}_R, \sim F_R; \tau \in (0,1), \sim F_G, \text{Reject}_R, \sim F_R\}$$

$$SPNE(I \leq I^* \wedge C_r \geq C_r^*) : \{\tau = \tau^*, Follow_G; \text{Accept}_R | \tau \geq \tau^*, \text{Reject}_R | \tau < \tau^*, Follow_R\}$$

7.2 Comparative Statics for the Game

The cross-partial derivative of I^* with respect to c_W is positive.

$$\frac{\partial I^*}{\partial c_W} = 1$$

The cross-partial derivative of I^* with respect to p is positive.

$$\begin{aligned}
\frac{\partial I^*}{\partial p} &= \frac{(1+L)\cdot(1+L+\tau-p)-(p-1+Lp-L+\tau L+\tau^2)\cdot(-1)}{(1+L+\tau-p)^2} \\
\frac{\partial I^*}{\partial p} &= \frac{(1+L+\tau-p+L+L^2+\tau L-Lp+p-1+Lp-L+\tau L+\tau^2)}{(1+L+\tau-p)^2} \\
\frac{\partial I^*}{\partial p} &= \frac{(L^2+L+2\tau L+\tau^2)}{(1+L+\tau-p)^2}
\end{aligned}$$

The cross-partial derivative of I^* with respect to L is positive.

$$\begin{aligned}
\frac{\partial I^*}{\partial L} &= \frac{(p-1+\tau)\cdot(1+L+\tau-p)-(p-1+Lp-L+\tau L+\tau^2)\cdot(1)}{(1+L+\tau-p)^2} \\
\frac{\partial I^*}{\partial L} &= \frac{(p+pL+p\tau-p^2-1-L-\tau+p+\tau+\tau L+\tau^2-\tau p-p+1-Lp+L-\tau L-\tau^2)}{(1+L+\tau-p)^2} \\
\frac{\partial I^*}{\partial L} &= \frac{(p-p^2)}{(1+L+\tau-p)^2} \\
\frac{\partial I^*}{\partial L} &= \frac{p(1-p)}{(1+L+\tau-p)^2}
\end{aligned}$$

The cross-partial derivative of C_r^* with respect to L is positive.

$$\frac{\partial C_r^*}{\partial L} = 1$$

The cross-partial derivative of τ^* with respect to I is positive.

$$\frac{\partial \tau^*}{\partial I} = 1 - p$$

The cross-partial derivative of τ^* with respect to p is negative.

$$\frac{\partial \tau^*}{\partial p} = -1 - L - I + c_W$$

The cross-partial derivative of τ^* with respect to c_W is negative.

$$\frac{\partial \tau^*}{\partial c_W} = -1 + p$$

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