Essays on Durations of War and Postwar Peace

by

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To my parents, Kikuo and Sakuyo Chiba.

ABSTRACT

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This dissertation consists of three self-contained essays that investigate the duration of war and the duration of postwar peace. The first essay studies both durations jointly, with a particular focus on the interdependence between the two processes. It demonstrates that membership in security organizations can prolong the durability of peace after conflict, but that the expected longer peace after conflict can also prolong the duration of conflict. The second essay analyzes the duration of war in a greater detail, exploring how third-party actors influence the process. It shows that balanced intervention can shorten the duration until a negotiated settlement is reached between the disputants. The third essay looks at the stability of postwar peace by focusing on the strength of cease-fire agreements. It argues that stronger agreements can maintain longer peace after wars by helping the disputants resolve the bargaining problems. The statistical analysis that corrects for the endogeneity of agreement strength provides support for the argument.

Acknowledgments

I first wish to thank my advisor Ashley Leeds, who has been very encouraging and helpful throughout the course of this project. Ashley has read countless iterations of my work, from the very earliest stages, when I was struggling to specify my research questions, to the final stages, when I was trying to locate my dissertation research into a broader context. Even outside my dissertation project, she has constantly offered me useful advice and intellectual inspiration. Ashley's mentoring made it possible for me to complete my graduate work.

I also wish to thank other advisors I have had at Rice. Songying Fang has taught me a great deal about our discipline. Understanding the kinds of challenges that an Asian student may encounter in the American academia, Songying kindly shared with me her own experiences and provided me with a lot of practical advice. She also invested considerable amount of time and effort in making sure that the oral and written presentation of my work is appealing and understandable. Also serving on my committee, Cliff Morgan has always pushed me to think harder about the logic behind my arguments. I am also grateful to Ric Stoll, who has been willing to give me feedback whenever I present my work. He was also very helpful when I was teaching my own course for the first time. I wish to extend a special thanks to Richard Boylan from the Economics Department, who kindly agreed to serve as the dissertation's external reviewer.

When I first arrived at Rice, I was fortunate to have the opportunity to work with Bill Reed on various research projects. Bill has shown me an important part of the academic life: publishing an article. At times when I was being stressed out by the amount of work in graduate school, he would take me out for a beer at Valhalla. Even after he left Rice, Bill generously agreed to stay in my dissertation committee. I expect our cooperative research projects will continue for some time yet.

My fellow graduate students in the department were constant sources of inspiration and encouragement throughout the writing of this dissertation. Among others, I am very grateful to Jesse Johnson. Jesse has read almost all of my papers I ever wrote in graduate school, and always gave me insightful comments and useful suggestions to polish them. I also thank Aki Matsuo, Yoshi Kobayashi, Toby Heinrich, Tiffany Barnes, and Carla Martinez Machain.

Finally, I wish to convey a very special thanks to my parents, Kikuo and Sakuyo Chiba, for bringing me up in a loving home and for constantly supporting me in my long and winding academic journey. This dissertation is dedicated to them.

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Chapter 1

Introduction

During the Sri Lankan Civil War that lasted for over two decades, more than 55,000 people were killed in battles, [1] and countless more Sri Lankan people suffered significant hardships as a result of the environmental and economic damages caused by the war. Large scale violence began in 1984 as an insurgency against the government by the Liberation Tigers of Tamil Eelam (LTTE). Intense fighting between the government and the LTTE continued throughout the late 1980s and 1990s, killing people in battles each year. After a number of failed attempts at peace talks over the course of the conflict, a cease-fire was finally declared in December 2001. However, in December 2005 the government and the LTTE resumed another large scale conflict that has claimed more than 20,000 lives by the end of 2009.

These observations lead us to ask important questions: once a violent conflict breaks out, how do we make the disputants stop fighting? Relatedly, once the disputants reach a cease-fire, how do we prevent them from fighting again? Questions of conflict termination and recurrence have been relatively understudied, as most of the past research on violent conflict has been focused on the onset of a new conflict.

[1] The death toll for the Sri Lankan Civil War is based on the Uppsala Conflict Data Program (UCDP) Battle-Related Deaths Dataset available online at http://www.pcr.uu.se/research/ucdp/datasets/ucdp_battle-related_deaths_dataset/ (accessed on April, 2012.)

However, the duration of conflict and the durability of post-conflict peace are also important aspects of the conflict process. In this dissertation, I investigate these related subjects in a series of three self-contained essays.

Why is it important to focus on conflict duration and post-conflict peace duration rather than conflict onset? To illustrate the empirical significance of continued conflict and conflict recurrence, let me introduce three important patterns in violent conflicts in the world. First, most armed conflicts we observe in the world are a continuation of old conflicts rather than new onsets. Figure 1.1 shows the number of armed conflicts fought in the world during the period of 1946–2009, taken from the Uppsala Conflict Data Program (UCDP). [2] In this figure, the horizontal axis shows the year of observation, and the height of the bars shows the number of civil and international conflicts involving more than 25 battle deaths in a given year. The gray bars at the bottom show the number of new onsets, whereas the black bars on top of the gray bars show the number of continued conflicts from the previous years (i.e., those conflicts that were initiated in previous years but were still ongoing in a given year). We can see from this figure that, once a conflict breaks out, it tends to linger.

In fact, some conflicts last for years. Figure 1.2 shows the duration of battles for terminated conflicts. In this histogram, the horizontal axis shows the duration measured in years, and the vertical axis shows the frequency (the number of terminated conflicts that have certain durations). As we can see, even though the modal duration is less than one year, a great number of conflicts have lasted for decades,

[2] The UCDP data sets are available online at http://www.pcr.uu.se/research/ucdp/datasets/ (accessed on March, 2012.)

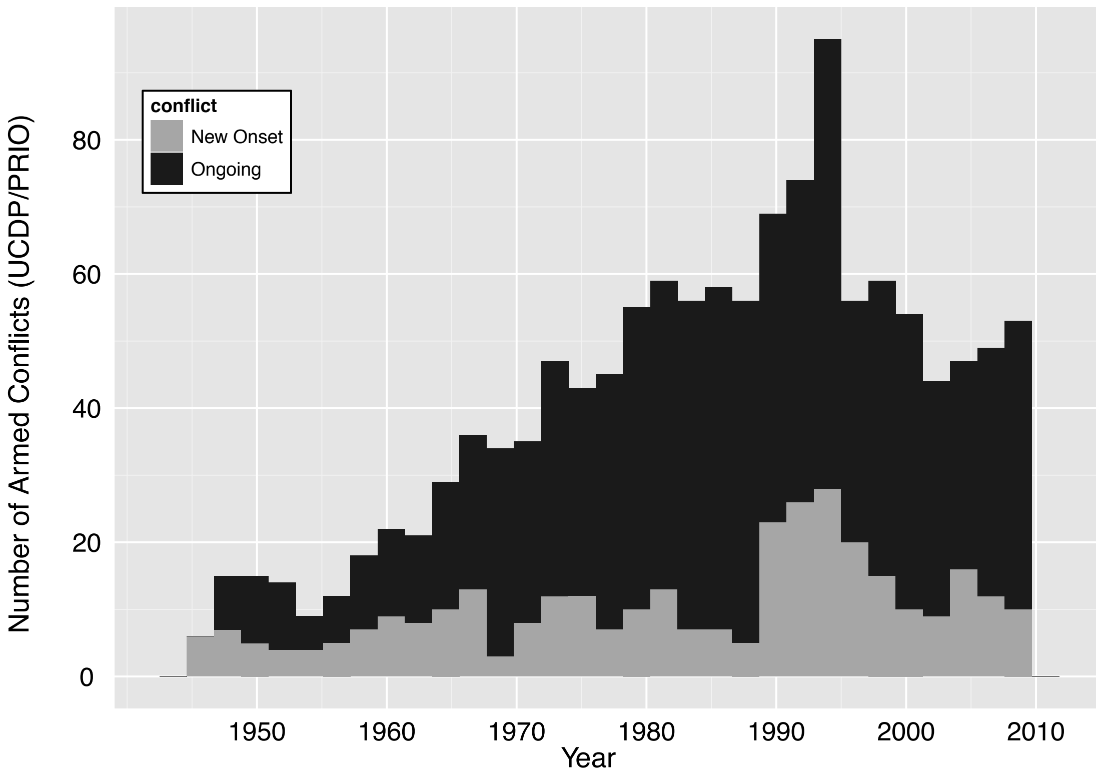

Figure 1.1 : Global trend in armed conflict 1: new onset vs. ongoing

(*Notes.* This figure shows the number of armed conflicts observed in a given year, taken from the UCDP data set. The gray bars show the number of armed conflicts initiated in a given year, and the black bars show the number of armed conflicts that were initiated in previous years but were still ongoing in a given year.)

sometimes more than 50 years.

Furthermore, even after one conflict was terminated, many of the disputants have resumed fighting. In Figure 1.3, the horizontal axis shows the year of observation, and the vertical axis shows the number of armed conflicts that are terminated in a given year, taken from the UCDP data set. The black bars show the number of terminated

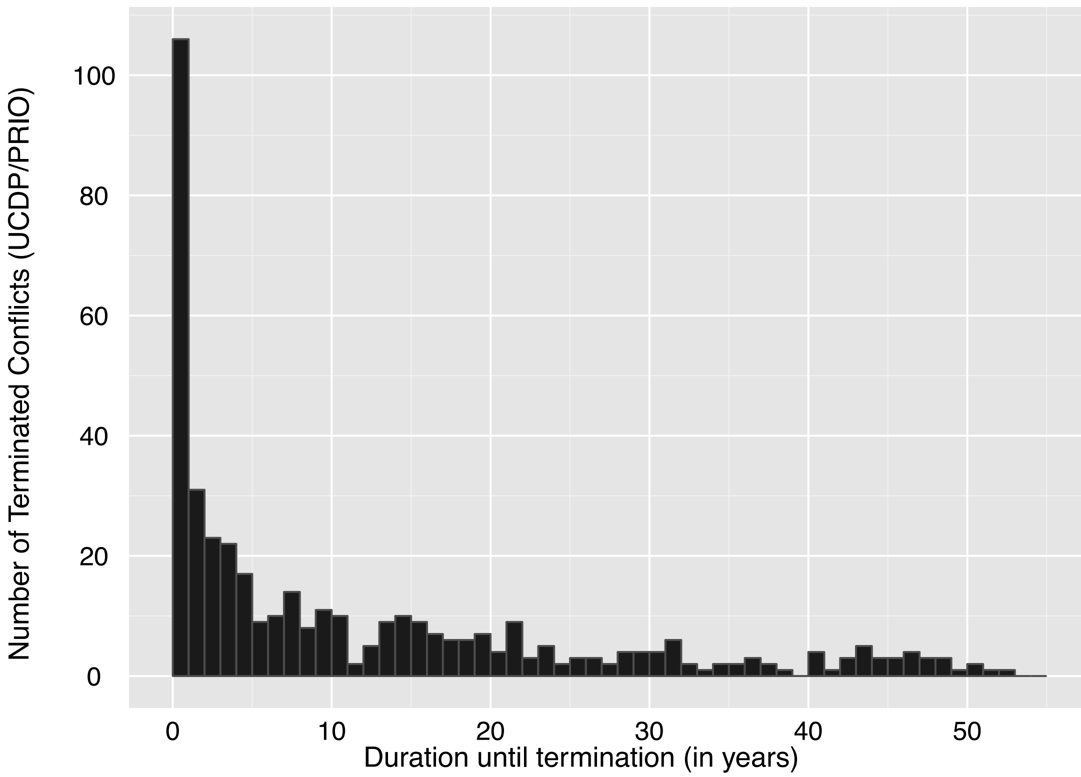

Figure 1.2 : Global trend in armed conflict 2: duration of armed conflict
(*Notes.* This figure shows the histogram of observed conflict duration, taken from the UCDP data set. The horizontal axis shows the duration measured in years, and the height of the bars shows the number of terminated conflicts that have a given duration.)

conflicts that have recurred in less then 20 years after the termination, whereas the gray bars show the number of terminated conflicts that have not recurred in 20 years. We can see that, especially in recent years, more than half of the terminated conflicts have recurred after the termination.[3]

[3] Note that, for those recent conflicts that are terminated less than 20 years prior to 2009 (the end of observation), the number of recurrence shown here is the *lower limit*: there may be even more recurrences in the future.

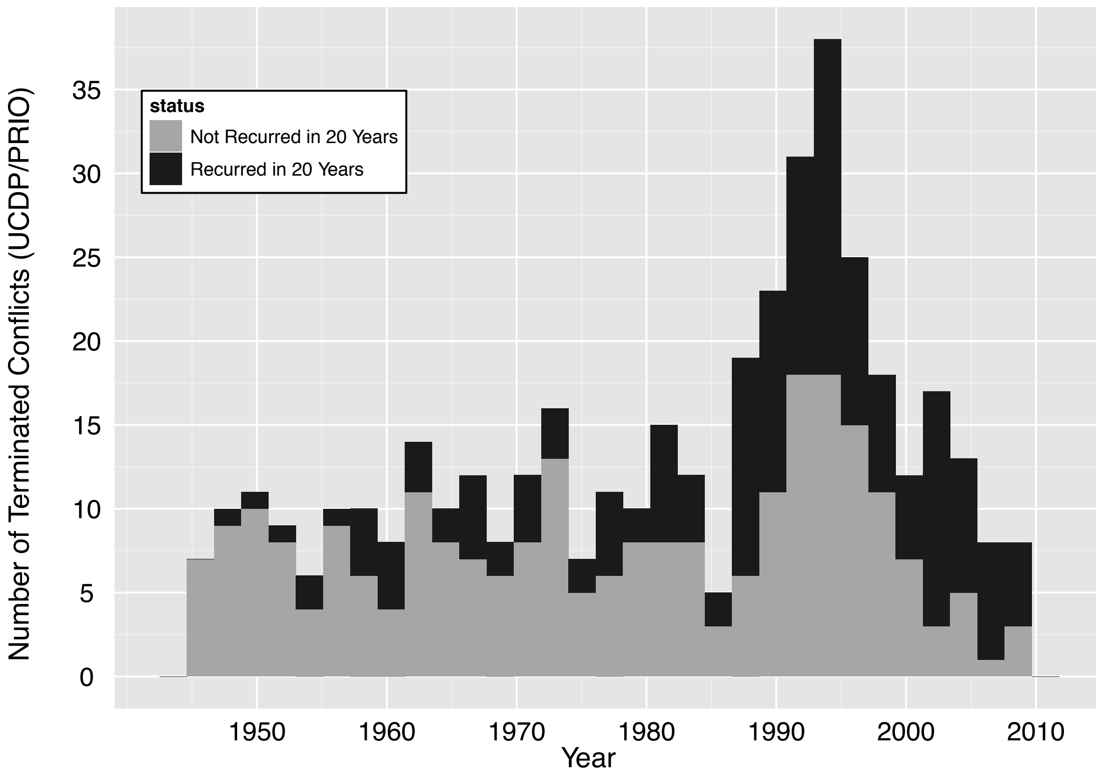

Figure 1.3 : Global trend in armed conflict 3: recurrence of armed conflict
(*Notes.* This figure shows the frequency of conflict recurrence, taken from the UCDP data set. The height of the bars shows the number of armed conflicts terminated in a given year. The gray bars show the number of terminated conflicts that have not recurred in 20 years after termination, and the black bars show the number of terminated conflicts that have recurred in less than 20 years.)

These three patterns suggest that we as political scientists need to investigate the causes of conflict duration and recurrence in order to better understand the conflict process as a whole. A lot of research studies the onset of violent conflict, but this is only a part of the picture. A great proportion of armed conflicts we observe are either a continuation or a recurrence of old conflict.

It is also normatively important to understand why some conflicts last as long as they do, and what explains the durability of peace after a conflict is terminated. The longer a conflict lasts, the more people will be killed, injured, or forced to migrate. Moreover, wars divert valuable resources into fighting and economic growth is reduced considerably. Military expenditures rise during a war and do not return to normal levels years after the fighting ends. Even though post-conflict countries experience economic recovery as a result of improved trade relationship and increased growth, violent conflicts often recur. Understanding the causes of conflict duration and recurrence will help us prescribe a policy to address these phenomena. In the remainder of this chapter, I lay out my plan of investigation for the following three substantive chapters as well as the intended contribution of the dissertation.

1.1 Plan

In the first essay (Chapter 2), I investigate the effect of some contextual factors that are relatively constant over time on durations of conflict and post-conflict peace. More specifically, I look at how joint membership in security organizations influences the disputants' ability to terminate conflict and maintain post-conflict peace. I argue that membership in security organizations can improve the enforcement conditions after conflict, and thereby prolong the durability of peace after conflict. This is because these organizations have the ability and willingness to punish a unilateral violation of a cease-fire by a member state, which increases the disputants' expectation that the terms of peace they agree to will be long-lasting. However, precisely because of the expected longer peace after conflict, the disputants that have membership in such organizations will have greater incentives to fight longer in order to get better terms of peace, thereby prolonging the duration of conflict as well. Analyzing data on durations of conflict and post-conflict peace from 1918 to 2004, I find empirical support for my hypotheses.

While working on the first essay, I came across some additional questions and puzzles, which motivated my two other essays. That is, even though contextual factors such as institutional membership may have unfortunate conflict-prolonging effect, the international community need not just sit back and let the disputants fight. In fact, the international community sometimes seeks to intervene in an ongoing conflict in order to shorten conflict duration. Moreover, the disputants themselves would also want to react and to try to reduce conflict duration or to prolong the durability of peace after conflict. Accordingly, the second and the third essays look at factors that are changing over time possibly because of the strategic interactions between political actors.

The second essay (Chapter 3) looks at the effect of third-party actors on the duration of conflict. Specifically, I look at the effect of third-party interventions on the duration and outcome of civil wars. By employing a research design that takes into account the strategic dependence between multiple duration processes, I reveal a conflict-reducing effect of some kinds of external interventions in civil wars. Contrary to the conventional wisdom that interventions tend to prolong civil war, the results show that balanced interventions can shorten the duration of wars until a negotiated settlement is reached between the government and the rebel group.

The third essay (Chapter 4) looks at the effort of the disputants to stabilize peace after conflict. One of the policy measures that disputants can use to prevent recurrence of wars is to sign strong cease-fire agreements at war's end. However, there is no consensus in the literature that suggests that such agreements are effective in promoting peace after wars. So, the research question I am addressing in the third essay is: Can strong cease-fire agreements maintain peace after war? I argue and demonstrate with evidence that agreement strength is endogenous to the baseline prospect for peace. That is, disputants tend to sign stronger agreements in tougher cases. This endogeneity problem is one of the reasons why past studies have not found a robust relationship between agreement strength and post-war peace duration. Moreover, I show that, once we correct for the endogeneity, stronger cease-fire agreements indeed keep peace longer after wars. The finding that states can sign stronger peace agreements to lower the danger of war recurrence should be very encouraging to policy makers who are concerned with conflict management. If well designed agreements can enhance the prospect for peace even under difficult circumstances, then it provides policy makers with an effective and low-cost policy measure to deal with this problem.

The dissertation as a whole makes a contribution to the literature on violent conflict by revealing several exciting dynamics that have not been appreciated in past studies. Moreover, it also shows the importance of designing appropriate statistical tests that incorporate strategic interactions between political actors. In each of the three essays, I propose new statistical models that are specifically designed to address the empirical challenges I face. With these models, I offer a number of policy-relevant findings.

Chapter 2

International Organizations and the Durations of International Conflict and Post-conflict Peace

Chapter Abstract

How do international organizations (IOs) influence states' conflict behavior in the absence of centralized enforcement? This study develops and tests a theory about how IO membership helps solve the enforcement problems states face in the aftermath of a militarized conflict. It argues that joint membership in IOs that explicitly promote peaceful settlement of disputes improves enforcement conditions by increasing the costs of cease-fire violation in the long run. As a result, these IOs make a cease-fire more durable once the disputants agree to stop fighting. However, precisely because they expect longer peace after conflict, the member states have incentives to adopt tougher bargaining positions during conflict, causing a delay in reaching a cease-fire. A survival analysis that recognizes the interdependence between the durations of conflict and subsequent peace demonstrates that IO membership lengthens both the duration of conflict and the duration of subsequent peace.

2.1 Introduction

There has been a growing body of research on the relationship between international organizations (IOs) and militarized interstate conflict. Many researchers have concluded that joint membership in IOs makes the onset of militarized conflict less likely. Nevertheless, there have been numerous violent conflicts fought between countries that belong to the same IOs. Despite its prevalence, less attention has been devoted to the potential effects of IOs on conflict that has already been initiated. Do IOs reduce the recurrence of conflict between member states? If so, how does this influence the disputants' behavior during conflict? This study develops and tests an argument about how IO membership influences the disputants' ability to reach and maintain a durable cease-fire agreement after conflict has begun.

Applying a model of bargaining and enforcement of international agreements to the case of cease-fire cooperation, I argue that IOs have two effects: they can make a cease-fire agreement more durable, but more difficult to achieve in the first place. More specifically, membership in IOs with a security mandate and resources to intervene can improve the enforcement conditions by making it more costly for the ex-belligerents to violate a cease-fire agreement. However, precisely because they expect longer peace after conflict, member states of these IOs will have incentive to hold out longer in conflict in hopes of obtaining better terms of a cease-fire, causing a delay in agreement.

To evaluate these predictions empirically, I develop a statistical model that recognizes that the duration of conflict and the durability of peace after conflict are a jointly determined outcome of international bargaining. The theoretical model suggests that the processes of bargaining and enforcement are interdependent, which means that the durations of militarized conflict and post-conflict peace are correlated. I use a copula function to characterize the joint distribution of the two correlated duration variables. Survival analysis of the data on conflict termination and recurrence from 1918 to 2004 provides support for the predictions.

The paper proceeds by laying out a theoretical argument about the effects of IO membership on the delay and durability of a cease-fire agreement in militarized conflict. The following section introduces the data and develops a research design to test the hypotheses. I then present the empirical findings. The final section concludes by discussing policy implications and the directions for future research.

2.2 IOs and Interstate Conflict

Scholars of international relations have devoted significant attention to the relationship between international institutions and militarized conflict. Earlier studies have reported that pairs of countries that share more memberships in IOs are less likely to become involved in militarized conflict (Oneal & Russett 1999, Oneal, Russett & Berbaum 2003, Russett & Oneal 2001, Russett, Oneal & Davis 1998). Subsequent studies have tried to provide specific causal mechanisms of conflict reducing effect of the IOs by drawing on bargaining theories (e.g. Boehmer, Gartzke & Nordstrom 2004). Bargaining models of war posit that militarized conflict occurs when bargaining fails to produce a more favorable outcome than war, and conflict is terminated when the disputant states reach some agreement that is better than continued fighting (Fearon 1995, Powell 2002, Reiter 2009). Building on the bargaining framework, recent empirical studies on IOs and conflict argue that joint membership in IOs reduces conflict by helping states overcome obstacles related to the bargaining process (Bearce & Omori 2005, Bearce, Floros & McKibben 2009, Boehmer, Gartzke & Nordstrom 2004, Haftel 2007, Hansen, Mitchell & Nemeth 2008, Mitchell & Hensel 2007, Pevehouse & Russett 2006, Shannon 2009, Shannon, Morey & Boehmke 2010).

While these studies contribute to our understanding of conflict processes, they have focused only on the onset, or the duration of conflict while ignoring what happens after the conflict is terminated. As a result, much remains to be learned about the effect of IO membership on the stability of peace after conflict. For example, does the conflict-reducing effect of IOs last after the fighting is terminated? If so, how does that affect states' behavior during conflict? If state leaders are rational and forward-looking, they will take into account what they think will happen in the future when they make decisions about their current course of actions. In other words, factors associated with the stability of post-conflict peace (such as IO membership) will also influence how the disputants fight a conflict before a cease-fire is reached between them. This calls into question the previous findings on IOs and conflict behavior that failed to take into account the disputants' expectation of future interaction.

In a similar vein, existing research on the duration of post-conflict peace has not fully explored how some exogenous conditions influence both the durability of a cease-fire *and* whether and when a cease-fire is achieved in the first place. Previous studies have focused on the effect of factors that are endogenously determined during conflict, such as institutional strength of a cease-fire agreement

(Fortna 2003, 2004), the amount of informational asymmetries reduced in the battle fields (Werner & Yuen 2005), international mediation (Beardsley 2008, Gartner & Bercovitch 2006), types of political and military outcomes achieved by the disputants (Senese & Quackenbush 2003, Quackenbush & Venteicher 2008), or victor-imposed regime change at war's end (Lo, Hashimoto & Reiter 2008). While these factors are rightly of important considerations for scholars and practitioners of international politics, they are a consequence, not cause, of the expected difficulty of enforcing a cease-fire agreement in a given environment. As a result, much still remains to be learned about how the underlying enforcement conditions shape the likelihood and success of cease-fire cooperation. The challenge here is that simply looking for the correlates of successful enforcement of an agreement does not give us much leverage in pinpointing the determinant of cooperation, because the disputant states strategically choose whether and how to cooperate in the first place (Downs, Rocke & Barsoom 1996).

I address this problem by applying a formal model of international cooperation developed by Fearon (1998) that analyzes the bargaining process and the enforcement of an agreement jointly. The model consists of the initial stage where states bargain over the terms of cooperation, followed by the enforcement stage where states implement the the agreed terms in the face of temptations to renege. The key feature of the model is that the (expected) durability of a cooperative agreement in the second stage influences how long the states are willing to hold out in the first stage in hopes of obtaining better terms of cooperation. Although the model is not directly about militarized conflict, disputants in militarized conflict face similar incentives:

the longer the disputants expect the cease-fire agreement to last, the longer they are willing to fight in hopes of obtaining better terms of a cease-fire. Then, if joint membership in IOs indeed makes post-conflict peace more stable, it may also have an unfortunate effect of prolonging conflict. Below, I discuss Fearon's model in detail and relate it to the specific subject of IO membership and cease-fire cooperation.

2.3 IOs, Bargaining, and Enforcement

The game captures strategic interaction between two states, 1 and 2, fighting over some flow of benefit worth one to each side per unit of time. As the states incur per-unit-time costs of conflict ($-c_i$, $i = 1, 2$) while fighting, they have incentive to agree on a cease-fire and split the disputed good according to some division. But, the disputants disagree over how to divide the disputed good. In addition, the anarchic nature of the international system allows either state to deviate from the agreed division, even if it is reached in bargaining. Therefore, the disputants face two distinct problems as they go through two consecutive stages. In the initial bargaining stage, they must agree on which of the potential cease-fire agreements to implement after they stop fighting. In the subsequent enforcement stage, they must ensure that the agreed deal is implemented in the face of temptations to renege. In the following two sections, I discuss each of the two stages and derive testable hypotheses based on the model's comparative statics. The two stages are analyzed in the backward order because the disputants' bargaining behaviors in the initial stage are determined by their anticipation of what will happen after they agree to stop fighting.

IOs and Enforcement of a Cease-fire

The enforcement stage begins when the disputants reach some agreement about the division of the disputed good. Let $x \in [0, 1]$ be such an agreement that gives x to state 1 and $1 - x$ to state 2 per unit of time. The two states now face the problem of ensuring compliance with x by both sides. If both sides deviate from the agreed cease-fire, they go back to the bargaining stage, where neither gets the disputed good and both pay the costs of conflict, c_i. If one state deviates from the agreement while the other state complies with it, the defector can get a payoff greater than the agreement payoff ($a > x$ and $a > 1-x$). The compliant state is assigned the "sucker" payoff ($-b < -c_i$) during this period, giving it incentive to defect as well. Therefore, a unilateral defection is profitable for the defector as long as the other state does not respond with retaliatory defection in future rounds for some period of time. Such a delay in response is captured by a response delay parameter, $\Delta > 0$, such that if one state unilaterally defects at time t, the other state is unable to detect or to respond to this defection until $t + \Delta$. Table 2.1 describes the per-unit-time payoffs of the enforcement stage, where states choose between C (comply) or D (defect). As this game is played continuously over time, the disputants evaluate streams of future per-unit-time payoffs according to a constant discount rate $r > 0$, meaning that receiving x over d consecutive units of time into the future is worth $e^{-rd}x$ now. Smaller discount rates indicate that states discount future payoffs less, making the shadow of the future longer.

A cease-fire agreement is upheld in the enforcement stage as long as both sides can make a credible threat of retaliation. It is the disputants' ability and willingness to

		State 2	
		C	D
State 1	C	$(x,\, 1-x)$	$(-b,\, a)$
	D	$(a,\, -b)$	$(-c_1, -c_2)$

Table 2.1 : Per-unit-time payoffs of enforcement stage

punish a unilateral defection that guarantees mutual compliance with the cease-fire. To see this more precisely, Fearon (1998) shows that a simple and severe grim-trigger enforcement scheme can maintain cooperation when the following condition holds:

$$r\Delta \leq \min\left\{\ln\frac{a+c_1}{a-x}, \ln\frac{a+c_2}{a-(1-x)}\right\}. \tag{2.1}$$

This condition suggests that an agreement is easier to enforce the longer the shadow of the future (smaller r); the quicker the detection of a unilateral defection (smaller Δ); the lower the per-unit-time benefit of unilateral defection (smaller a); the greater the costs of non-agreement (greater c_i).

I argue that membership in IOs improves the enforcement condition in the context of cease-fire cooperation by extending the shadow of the future. The shadow of the future is interpreted as players' assessment of the probability of continued interaction under the same payoff structure, or how much values players assign to future payoffs.[1] Longer shadows of the future make it more costly for the states to defect unilaterally from the agreed cease-fire, because the opponent can more

[1] Having longer shadow of the future is equivalent to having smaller r, or lower discount rate. Bearce, Floros & McKibben (2009) and Mitchell & Hensel (2007) make a similar assumption in their analyses of IO membership and international cooperation.

credibly threaten to punish the defection in future rounds of interactions.[2] The improved prospect for enforcement, in turn, further extends the shadow of the future by encouraging the states to weigh future payoffs more relative to present payoffs.

How does joint participation in IOs extend the shadow of the future of member states? First, an important aspect of membership in IOs is that it fosters an expectation that the member states will interact with each other for a very long time. Unless states have some intention to continue interacting with other members, they will not form or join an IO in the first place. In addition, some IOs are equipped with institutional devices to make unilateral violation of a cease-fire less attractive even in the short run, which will in turn stabilize the relationship in the long run. Although many IOs have been created in hopes of promoting peace, not all institutions have a security mandate and resources to help states enforce the agreed cease-fire. I thus focus on *pacific settlement IOs*, defined as international institutions (including both intergovernmental organizations and multilateral treaties) that call for peaceful settlement of disputes among members (Hensel 2005). [3] It is these IOs that can monitor compliance behavior with respect to the agreed cease-fire, facilitate communication among the ex-belligerents, and increase opportunity costs of conflict.

There are numerous historical case examples where pacific settlement IOs take

[2] Of particular importance here is the stability of payoff ordering between b and c_i. This is because the credibility of enforcement threats depends on the willingness of the other state to bear the costs of mutual defection ($-b < -c_i$) in case a unilateral defection is detected.

[3] The analysis below thus excludes institutions that are primarily about economic cooperation, or other non-security issues. There have been 51 pacific settlement IOs in the world. Examples of these institutions include global IOs, such as the United Nations, and Non-aligned Movement, as well as regional institutions, such as the African Union, League of Arab States, and the Organization of the American States.

proactive actions to help disputants enforce a cease-fire. For example, in the 1991 crisis in Yugoslavia, a handful of international organizations, including the United Nations (UN), the European Community (EC), Conference for Security & Cooperation in Europe, and North Atlantic Treaty Organization (NATO), were involved in the cease-fire process. After several violations of the cease-fire agreements brokered by these IOs, the UN, EC, and NATO imposed economic sanctions and launched air strikes on Yugoslavia to enforce the peace agreement (Hufbauer, Schott, Elliott & Oegg 2007, Woodward 1995). Regional IOs outside the Europe have also been actively involved in the conflict management processes in disputes between their member states. For example, the League of Arab States (LAS) was highly involved in the war between North and South Yemen in 1979. The mediation efforts sponsored by the LAS culminated in a cease-fire between the disputants on March 3, 1979. As fighting continued despite the cease-fire agreement, on the 5th, the LAS further adopted a resolution to supervise the implementation of the cease-fire and the process of normalizing relations between the disputants. Then, the withdrawal of the troops by both sides was completed in several days under the auspices of the LAS (Bidwell 1983).

In addition to these instances where actions of IOs were directly observable, there are many more instances where pacific settlement IOs exercise an implicit pressure on the member states. Recent formal works show that IOs may be able to influence states' conflict behavior even when they are not directly involved in the dispute processes (e.g. Fang 2010). Moreover, because of the explicit treaty obligation to resolve their disputes peacefully, member states of these IOs find it more costly to make a credible threat to revise the status quo distribution of benefit with force, which adds an additional stability to the agreed terms of a cease-fire. I expect that the greater the number of pacific settlement IOs that the disputants both belong to, the greater these effects will be. This logic suggests that membership in pacific settlement IOs has an effect of stabilizing the peace after a conflict is terminated between member states.

Hypothesis 1 (IO effect in the enforcement stage) *The disputants will have a longer duration of peace after a termination of militarized conflict when they share memberships in more IOs that explicitly promote pacific settlement of conflicts among member states.*

IOs and Bargaining for a Cease-fire

Although pacific settlement IOs make a cease-fire agreement more durable in the long run, improved enforcement can also make a cease-fire agreement more difficult to achieve. In other words, when states anticipate that they will be stuck with the agreed terms for a long time, they have incentive to fight longer to obtain better terms of a cease-fire before agreeing to it. This can result in a costly delay in a cease-fire. To explore the effect of longer shadows of the future on the disputants' incentive to terminate conflict, I now turn to the initial bargaining stage that precedes the enforcement stage.

Prior to the enforcement stage, the states are in dispute over two possible deals (divisions of the disputed good) that both parties prefer to continued fighting. The problem is that the disputants disagree over which one to implement in the subsequent enforcement stage. Denote State i's preferred division by $x_i \in [0, 1]$, where $x_1 > x_2$. I assume that the two feasible divisions are fixed for reasons exogenous to the model, such that it is prohibitively costly for the disputants to come up with a new offer. The disputants resolve this disagreement by playing a continuous time war-of-attrition game where the player who quits fighting first has to concede the preferred division to the other.

A pure strategy for state i is the quit time $t_i \geq 0$ that specifies how long it will hold out in hope of getting the better agreement. When either state quits fighting, a cease-fire agreement is struck, and the states move to the enforcement game where the winner's preferred division is implemented. For example, if $t_1 > t_2$, the enforcement game begins at time t_2 with per-unit-of-time payoffs of mutual compliance is $(x_1, 1 - x_1)$. While fighting, states incur per-unit-time costs of non-agreement, $c_i > 0$, the magnitude of which determines the relative power of states on the disputed issue. That is, states with smaller c_i will be willing to fight longer for a better deal, on average. Ex ante, the states do not know who is stronger (have lower costs of non-agreement) and thus willing to hold out longer in bargaining. [4] However, after they enter into a costly war of attrition, the states can credibly signal their "strength" by bearing the costs of non-agreement. Fearon (1998) shows that in a symmetric Bayesian equilibrium in the bargaining phase, the ex ante expected

[4] Fearon (1998) specifies that the states know their own costs, but that they know only the distribution of their opponent's costs. For convenience, it is assumed that the costs are randomly drawn from uniform distributions on the interval $[1, 2]$.

time until agreement is [5]

$$\bar{t} = \frac{\ln 8 - 1}{r} \simeq \frac{1}{r}. \tag{2.2}$$

This means that the longer the shadow of the future (smaller r), the longer the duration of costly conflict until agreement will be.

While condition (2.1) suggests that the longer shadow of the future facilitated by IO membership contributes to better prospect of enforcement, condition (2.2) implies that it is a double-edged sword. If disputants expect more durable peace after agreeing to terminate conflict, they have incentive to adopt tougher bargaining strategies and hold out longer in conflict (the quit time t becomes greater) so as to extract better terms of peace. On the other hand, if the disputants expect that post-conflict peace will be fragile because of greater risk of changes in the payoff structure, they will quickly terminate conflict with little intention to follow through on the cease-fire agreement for very long. [6] I thus have the following testable hypothesis.

Hypothesis 2 (IO effect in the bargaining stage) *The disputants will have a longer duration of conflict when they share memberships in more IOs that explicitly promote pacific settlement of conflicts among member states.*

5 Fearon (1998) also solves the complete information version of the game. Although the structure of the game is common knowledge, costly fighting occurs in equilibrium as states employ mixed strategies.

6 Note that a mere expectation of future changes in the payoff structure can undermine mutual compliance because of the "last-period effect" in repeated games.

2.4 Research Design

To test the hypotheses, I analyze historical data on the duration of violent conflict and the subsequent duration of peace after the termination of active fighting. These two outcome variables are constructed using information from the International Crisis Behavior (ICB) project. I use Hewitt's (2003) dyadic version of the data set.[7] The initial analysis includes those crises that involve actual fighting, while excluding non-violent crises.[8] There are 435 crisis-dyads from 1918 to 2004, involving 234 unique international crises. [9] All the crisis observations in the sample have been terminated by the end of 2004.

I operationalize the first-stage outcome variable, duration of conflict until a cease-fire agreement, as the time elapsed between the date of initiation and date of termination of international crises in a dyad. A "cease-fire" here does not necessarily mean a complete resolution of the underlying contentious issues between the disputants nor a formal armistice treaty signed by the disputants; it is simply defined as a cessation of active fighting. Therefore, a cease-fire here can be informal (e.g., oral declaration or tacit understanding). As long as neither side of the former belligerents is engaged in active fighting, the disputants are considered to be in the post-conflict peace phase, be it fragile and short-lived. This operationalization reflects the notion of cooperation in the theoretical discussion above, where cooperation represents an absence of

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7 I expanded the data set by adding newer ICB cases, based on the latest version of the actor-level and crisis-level data (version 10, July 2010).

8 That is, I include those ICB crises that reach at least the second level of violence ("Minor clashes") in the ICB data set. I relax this assumption later in the paper.

9 There are several overlapping crises in the data set, where a next crisis begins before the previous one is terminated. In these cases, I combine the two crises into a single crisis observation.

unilateral and mutual defection in the face of short-term benefit of reneging.

With this coding rule, there are 427 crisis-dyads where the disputants stop active fighting and proceed to the post-conflict peace phase. In the remaining 8 ($= 435 - 427$) cases, the defeated country ceases to exist as an independent state because of annexation by the victor. [10] I treat these 8 observations as right-censored. That is, I allow the "true" duration of conflict until a cease-fire (i.e., the duration that would have been observed if the defeated state had not lost independence) for these cases to be at least as long as the observed (censored) duration. [11] For the uncensored 427 observations, the duration of conflict ranges from 1 to $1,462$ days in the sample, with median 110 and mean 198 days.

The second-stage outcome variable, the durability of enforcement phase following a cease-fire agreement, is operationalized as the time elapsed between the termination and recurrence of international crisis in a dyad. Among those 427 post-crisis-dyad observations, a crisis has recurred in 168 cases (39.3%), for which the uncensored duration of post-conflict peace is fully observed. Since post-conflict peace has not broken down in the remaining 259 post-crisis-dyads as of 2004, the peace duration for these cases is treated as right-censored at the end of 2004. Uncensored duration of post-conflict peace is highly skewed to the right, ranging from 8 to $17,916$ days (49 years), with a median of $1,473.5$ days (4 years) and a mean of $2,825$ days (8 years). To incorporate time-varying covariates, those crisis-dyads and post-crisis-dyads that span multiple years are duplicated accordingly, yielding a total of 675

[10] All of these incidences are from the crises that happened during the Second World War.

[11] Alternatively, I also run all the analyses below by dropping these 8 observations entirely from the data set. The results are qualitatively the same.

crisis-dyad-year observations for conflict duration and $7,706$ observations for peace duration.

Explanatory Variables

Data on the key explanatory variable, membership in pacific settlement IOs, are taken from the Multilateral Treaties of Pacific Settlement (MTOPS) data set of the Issue Correlates of War (ICOW) project (Hensel 2005). The MTOPS data set contains annual observations of state membership in qualifying IOs from 1816 to 2004. To be qualified as such, pacific settlement IOs must call explicitly for peaceful settlement of disputes among signatories, rather than simply mentioning the desirability of peace. The MTOPS data set is limited to those IOs that have more than five member states. To capture the effects of IO membership on the disputants' shadow of the future, I count the number of shared membership in these IOs in a dyad. The variable ranges from 0 to 11, with a median of 2. Table 2.6 lists all the Pacific Settlement IOs included in the data analysis, and Figure 2.3 in Appendix 2 shows the histogram of the IO membership variable.

I also include an interaction term between the IO membership and the analysis time, which allows for the effects of IO membership to change over time. This is to account for the disputants' diminishing uncertainty about each other's resolve to bear the costs of conflict. In the initial phase of conflict, there is much to learn about the other side's private information about their resolve to bear the costs of conflict. In fact, this uncertainty about each other's costs of conflict is the very reason they enter the conflict in the first place. Fighting allows the disputants to learn about each other's private information, and to update their beliefs accordingly (Slantchev 2003). As time goes by, however, the amount of additional information to be learned will necessarily shrink. This is where the expectation of the future begins to loom large. Therefore, IO membership will have greater effect in the later phases of conflict when the information asymmetries are relatively leveled down.

A set of control variables that may confound the relationship between IO membership and conflict are also included in the analysis. *Contiguity* is a binary indicator measuring whether or not the disputants share borders; *Major Power* takes the value of 1 if a crisis-dyad involves at least one major power; *Capability Balance* is the ratio of the stronger state's military capability over the sum of capabilities in a dyad; *Joint Democracy* is a binary variable coded as 1 if both states in a dyad have a 6 or higher polity score (democracy minus autocracy score), and 0 otherwise; and the *Year of Initiation* measures the year in which the crisis breaks out. [12]

Statistical Model

In order to conduct a systematic analysis of the data, we need a statistical model that can appropriately capture the theoretical insight of Fearon's (1998) formal model that the duration of conflict and the duration of peace are a jointly determined outcome of bargaining. The model shows that enforcement conditions affect not only how long the agreed cease-fire will last once it is reached but also how long the disputants are willing to hold out before a cease-fire. Then, if some unmeasurable enforcement conditions influence both processes, the "residual" duration of conflict

[12] Data on *Contiguity*, *Major Power*, and *Capability Balance* are taken from the Correlates of War data set. Data on democracy score is from the Polity IV data set.

(conflict duration conditional upon all the observables) will be correlated with the residual duration of peace. For example, suppose some dyads have shorter shadows of the future than other dyads, because of some unmeasurable variables. Conditions (2.1) and (2.2) imply that these dyads would experience shorter delays in reaching an agreement, but the post-conflict peace in these dyads would necessarily be fragile. This yields a positive correlation between the two residual durations. Similarly, a failure to measure and control for costs of conflict generates a negative correlation in the error term. [13] To the extent that common unmeasured factors systematically influence both bargaining and enforcement stages, analyzing one stage while ignoring another will lead to bias in our inferences about the determinants of both processes. [14]

To cope with this, I construct a unified statistical model of bargaining and enforcement that controls for unobservable enforcement conditions influencing the delay and durability of a cease-fire agreement. The proposed solution is to jointly estimate the durations of conflict and post-conflict peace while accounting for the correlation between the two. The model is a generalization of the parametric univariate duration model in the sense that it can readily resolve the issues of right-censoring and duration dependence as in other duration models.

Let $i = 1, \ldots, n$ denote a pair of states in a crisis, the observation unit I call crisis-dyad. The goal is to make inferences about the duration of the initial bargaining

[13] Some dyads with unobserved greater costs of non-agreement should experience *shorter* durations of conflict and *longer* durations of post-conflict peace, on average, than other dyads with similar observable characteristics.

[14] Furthermore, there may be some factors *outside the theoretical model* that cause a correlation between the two durations. For example, the war-weariness argument suggests that there will be longer peace after longer conflicts because the disputants become weary of wars after a long fighting.

stage, or time until crisis-dyad i agree to stop fighting, T_{ci}, and the duration of peace enforcement stage, or time until crisis-dyad i resumes conflict after a cease-fire, T_{pi}. For crisis-dyads where a cease-fire agreement is reached, we observe the actual value of t_{ci} as a realization of the underlying random variable T_{ci}. For right-censored cases, we only observe the right-censoring point, t^0_{ci}. I define a binary cease-fire indicator, A_i, that takes on the value of 1 in crisis-dyads with a cease-fire, and 0 in the right-censored crisis-dyads. Then, for crisis-dyads where a cease-fire is reached and post-agreement peace has failed by the end of observation period, we observe the actual value of peace duration t_{pi} as a realization of the underlying random variable T_{pi}. For crisis-dyads where crisis was terminated and post-conflict peace has not failed yet, we only observe the right-censoring point, t^0_{pi}. I define another binary indicator, B_i, that takes on the value of 1 in post-agreement crisis-dyads with recurrence, and 0 otherwise.

With these notations, the likelihood function is given as follows:

$$\mathcal{L} = \prod_{i=1}^{n} \Pr(T_{ci} > t^0_{ci})^{(1-A_i)} \Pr(T_{ci} = t_{ci} \cap T_{pi} > t^0_{pi})^{A_i(1-B_i)} \Pr(T_{ci} = t_{ci} \cap T_{pi} = t_{pi})^{A_i B_i}. \tag{2.3}$$

The first component of the likelihood function, $\Pr(T_{ci} > t^0_{ci})$, represents the likelihood contribution from observations that are right-censored during the conflict phase, the second component, $\Pr(T_{ci} = t_{ci} \cap T_{pi} > t^0_{pi})$, corresponds to those observations that are right-censored during the peace phase after the disputants reached an agreement to stop fighting. The last component, $\Pr(T_{ci} = t_{ci} \cap T_{pi} = t_{pi})$, is for those observations where disputants reach an agreement once and then fighting resumes.

To specify the likelihood function (2.3), I begin by characterizing the univariate marginal distribution of the two random variables, T_{ci} and T_{pi}. I allow the durations of conflict and peace to be conditioned on vectors of covariates, z_{ci} and z_{pi}, respectively. Then the hazard rates governing the two durations are specified as $\lambda_{ci} = \exp(-z_{ci}\beta_c)$ for conflict duration and $\lambda_{pi} = \exp(-z_{pi}\beta_p)$ for peace duration, where β_c and β_p are vectors of the coefficient parameters. Using the flexible Weibull specification, the univariate density function $f(t)$, the survivor function $S(t)$, and the distribution function $F(t)$ are each given as a function of λ and the shape parameter σ. [15] The shape parameter determines whether the risk of "failure" event (i.e., conflict termination in the bargaining stage or conflict recurrence in the enforcement stage) is increasing ($\sigma > 1$), decreasing ($\sigma < 1$), or constant ($\sigma = 1$) over analysis time.

The challenge here is to characterize the joint distribution of two duration variables, which is necessary to specify the second and the third components of the likelihood function (2.3). I utilize a copula function to derive a joint distribution from the two univariate marginal distributions. A copula is a function that binds together two or more univariate marginal distributions of known form to produce a new joint distribution (Trivedi & Zimmer 2005). As we have two marginal distributions, the association between the two marginals is represented by a single association

[15] I chose the Weibull model because of its flexibility and simplicity. One limitation of the Weibull specification, however, is that it does not allow for non-monotonic change in hazard. As a robustness check, I also estimate a log-logistic model that allows for non-monotonicity (but does not allow for a monotonic increase) in hazard. Statistical results are qualitatively the same, and Vuong's (1989) test of non-nested models does not reject the null hypothesis that the two models are equally good.

parameter, θ, which captures the correlation between the residual durations of conflict and subsequent peace. The appendix 1 provides the derivation of the statistical model in greater details.

2.5 Estimation Results

Using the data described so far, I maximize the likelihood function (2.3) with respect to the coefficient (β_c, β_p), the shape (σ_c, σ_p), and the correlation (θ) parameters jointly in full information maximum likelihood. Table 2.2 reports the maximum likelihood estimates of each parameter. Since there are two dependent variables, there are two sets of coefficients: in the top panel, the first numerical column shows the estimates of the coefficients for the conflict duration (β_c), and the second numerical column shows those for the peace duration (β_p). These coefficients are in the accelerated failure time metric, which means that positive estimates are associated with longer durations and negative estimates are associated with shorter durations.

The second panel in the table shows the estimates of the auxiliary parameters. The Weibull shape parameters for conflict (σ_c) and peace (σ_p) durations are greater than (and statistically distinguishable from) 1. This indicates that the baseline hazard of conflict termination and that of recurrence are both increasing over time. The correlation parameter (θ) measures the interdependence between the two residual durations, and assumes values between -1 (perfect negative correlation) and $+1$ (perfect positive correlation). The estimated θ is negative, and statistically distinguishable from zero. This result suggests that the residual durations of conflict and post-conflict peace are negatively correlated. As discussed above, one possible explanation for a negative correlation is our inability to measure the costs of conflict.

[Table 2.2 About Here]

As for the effects of IO membership variables on conflict and peace durations, we obtain negative estimates for the raw IO variables and positive estimates for the interaction terms between IO membership and the analysis time in both stages. Since this is a non-linear model and there are interaction terms, it is not immediately clear what these estimates mean substantively. I thus calculate and plot probabilities of continued fighting and those of conflict recurrence for different values of the IO variable and observation time, while setting all the other variables at their median values. Figure 2.1 illustrates the estimated effect of IO membership on the duration of conflict. The horizontal axis shows time (measured in months) and the vertical axis represents the survival probability of conflict, or the probability of continued fighting beyond time t. Greater probabilities of conflict survival mean that the duration of conflict is longer. The vertical ticks at the bottom of the graph show the observed distribution of conflict in the data set. For this figure, I compare two values of the IO membership variables. The first is 1, which corresponds to the case where the disputants are members of one pacific settlement IO. The other is 3, which is the case where disputants are members of three IOs. These values correspond to the 25th and 75th percentile values of the IO membership variable in the data set. The curve in light gray shows the estimates when membership is set equal to 1, with 95 % confidence intervals, and the dark gray curve shows them when the membership is 3. These curves show the estimated survivor function $\Pr(T_c > t_c)$, conditional

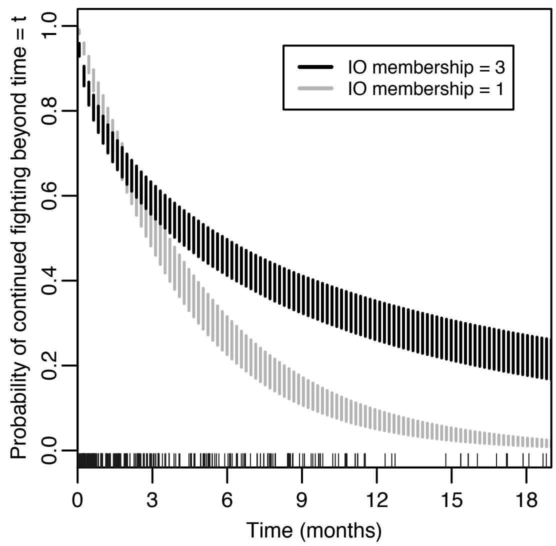

Figure 2.1 : Substantive effects of IO membership on conflict duration

(*Notes.* This figure shows the estimated impacts of IO membership on conflict duration along with 95 % confidence bands. The vertical axis shows the predicted probabilities of continued fighting beyond time = t, and the horizontal axes show the analysis time in months).

on 1,000 simulated values of the parameters and substantively interesting covariate profiles. [16]

We can see form Figure 2.1 that the overall effect of IO membership is to increase the duration of conflict, lending support for Hypothesis 1. Membership in pacific settlement IOs indeed makes a violent conflict more difficult to terminate. At the same time, we can also see that, in the initial days of conflict (when $t < 1.5$ month), the IO membership has a small negative impact on the probability of continued fighting, but as time passes the effect becomes positive and grows larger. This

[16] Simulated parameters are generated by randomly drawing 1,000 values from a multivariate Normal distribution characterized by the maximum likelihood estimates of the parameters and the estimated variance-covariance matrix (King, Tomz & Wittenberg 2000).

observed pattern is consistent with the following interpretation. First, members of pacific settlement IOs have a better chance of terminating conflict in the very initial phases of conflict where the disputants face greater uncertainties about the likely outcome of conflict. This is perhaps because the informational gap between the disputants is smaller among IO members than among non-members. However, once a conflict "survives" the first two months or so, the informational asymmetry between the disputants has already diminished through fighting. This is when the disputants' concerns about enforcement conditions in the future begin to dominate. In other words, beyond this point, the improved enforcement conditions in the future as a result of membership in pacific settlement IOs start to lead to longer conflict.

Figure 2.2 shows the estimated substantive effects of IO membership on the durability of a cease-fire after a conflict. The vertical axis represents the estimated conditional probabilities of conflict recurrence beyond time = t, given the median duration of conflict. Smaller probabilities of conflict recurrence mean that the duration of post-conflict peace is longer. Again, the curve in light gray corresponds to the case where IO membership is 1, and the dark gray curve to the case where the membership is 3. The figure shows that an increase in IO membership decreases the probability of recurrence, lending support for Hypothesis 2. We can also see that the pacifying effect of IO membership is initially small in the immediate aftermath of a conflict, but it becomes greater over time. Specifically, the conflict reducing effect is statistically indistinguishable from zero in the first three or four years after the termination of conflict, but it achieves statistical significance after that. [17]

[17] Although it appears that the confidence intervals of the two curves overlap in the first six

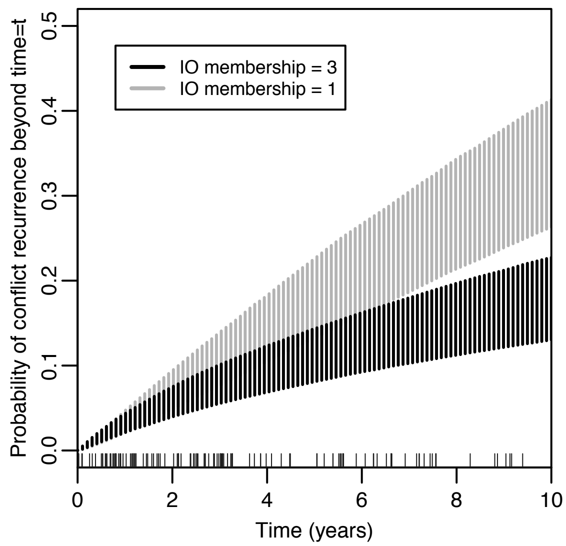

Figure 2.2 : Substantive effects of IO membership on peace duration

(*Notes.* This figure shows the estimated impacts of IO membership on post-conflict peace duration, along with 95 % confidence bands. The vertical axes show the predicted conditional probabilities of conflict recurrence beyond time = t, and the horizontal axes show the analysis time in years. The vertical ticks at the bottom of the graph show the observed (i.e., uncensored) distribution of peace duration in the data set).

Robustness Checks

The statistical findings provide evidence that the theorized causal mechanisms are indeed at work in historical data. As a robustness check, I examine the sensitivity of the initial results to several assumptions I make in analyzing the data. Table 2.3 reports results from four additional tests along with the baseline estimates discussed above.

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years or so, the *difference* between the two curves is statistically distinguishable from zero after about 3.5 years.

[Table 2.3 About Here]

First, we will see the consequences of ignoring the correlation between the durations of conflict and peace. Column (1) in Table 2.3 shows the results from a naive model that assumes independence between the conflict and peace durations. [18] Compared with the interdependent model, the naive model fits the data poorly, as the maximized log likelihood value from this model (−4289) is significantly smaller than that from the interdependent model (−4188). [19] In addition, there are several major differences in direction, size, and the statistical significance of the estimates. For example, the estimated Weibull shape parameter for the peace duration is smaller than 1 (indicating negative duration dependence) in the naive model, whereas it is greater than 1 (indicating positive duration dependence) in the interdependent model. This means that the naive model fails to capture the shape of underlying probability of conflict recurrence trending over time.

Second, I consider the possibility that the observed conflict-prolonging effect and/or peace-stabilizing effect of IOs depend on the types of international conflict included in the sample. Some may argue that IO membership has little effect on serious conflict that involves large scale violence while it may affect small scale disputes involving verbal threats or non-violent displays of force. Column (2) in Table 2.3 shows the results from an analysis that focuses on conflicts that involve serious military clashes. This model excludes those conflicts that do not reach the third

[18] This is equivalent to estimating two duration models separately, one for conflict duration and another for peace duration.

[19] Akaike's information criteria for the naive model and the interdependent model are 8613 and 8414, respectively, showing that the interdependent model is better.

level of violence ("Serious clashes") in the ICB data set. [20] The statistical results show that the estimated values of the important parameters are qualitatively the same as those obtained from the baseline model, indicating that the same dynamics emerge even when we focus exclusively on high-intensity conflicts. I also consider the possibility that excluding non-violent conflict biases the initial results. An analysis shown under column (3) includes those conflicts that do not reach the second level of violence ("Minor clashes"), along with more violent conflicts. Again, the results are qualitatively the same as the original results. Model (4) looks at those conflicts that occurred after the second World War to see if the findings are driven by the existence of the United Nations. Once again, the estimation results underline the same pattern.

Finally, I examine the threats to inference caused by potential sample selection effect. The set of international conflicts analyzed in this study may not be an appropriate sample to explore the effects of IO membership on the durations of conflict and post-conflict peace if there is a systematic relationship between IO membership and conflict occurrence. To address the issue of nonrandom sample selection, I analyze a three-stage model that incorporates the initial selection process into the interdependent duration model. For this analysis, we must first identify a set of observations that are at risk of experiencing (but do not necessarily experience) militarized conflict. I consider all pairs of countries that have competing territorial claims with one another, as identified by Huth & Allee (2002). Territorial disputes are particularly

[20] The analysis thus includes the duration of conflict for 297 crisis-dyad observations and the duration of subsequent peace for 289 post-crisis-dyad observations, which yields a total of $5,907$ time-varying observations.

prone to escalate to violent conflict, but not all dyads with competing territorial claims experience conflict. The data set spans the time frame from 1919 to 1995. In this time period, there are 249 dispute-dyad observations, where an ICB crisis breaks out in 131 of the cases.

The model's first stage predicts the selection into conflict, which is specified as duration of peace after the initiation date of territorial claims and before the outbreak of violent conflict. [21] Once there is a conflict, the second stage predicts the duration of conflict given selection, and the third stage predicts the duration of post-conflict peace given selection and the duration of conflict. [22] The estimation is conducted by combining two interdependent duration models. That is, I first estimate the initial two stages jointly, and then estimate the latter two stages jointly by treating the second stage estimates as given. Table 2.4 displays the estimation results.

[Table 2.4 About Here]

The estimated coefficients from the second and third stages show that IO membership has the hypothesized conflict-prolonging effect and peace-stabilizing effect even after accounting for the selection into conflict. We can thus conclude that the initial results are not an artifact of selection bias. Moreover, the estimated coefficients from the first stage show that IO membership has no discernible effects on

[21] Those dispute-dyads that do not experience violent conflict are treated as right-censored. There are 118 (= 249 − 131) such observations in the data.

[22] Although the other aspects of the research design are similar to the previous models discussed above, there are several differences in the measurement of covariates. First, the *Year of Initiation* variable in this model measures the year in which the territorial claim begins. Second, the cut point for the binary *Joint Democracy* in this model is 0, instead of 6. Since there are not many democratic dyads that experience territorial claims, the variable has little variation if we use 6.

the duration of peace before conflict. In other words, IO membership does not seem to be a good predictor of whether and when potential disputants experience violent conflict.

2.6 Conclusion

States create a variety of international institutions to help them achieve cooperation with other states in the absence of centralized enforcement. These institutions, once in force, alter the strategic environment in which states interact with others. To explore how IOs shape the member states' conflict behavior, this study applies a model of bargaining and enforcement to the case of cease-fire cooperation. The theoretical discussion suggests that the conflict-reducing effect of IOs manifests itself after the conflict is terminated. It maintains that membership in IOs that have an explicit obligation for member states to resolve disputes will make a conflict-ending settlement more durable. But, the improved enforcement, in turn, can encourage the disputants to stick to tougher bargaining positions, prolonging the duration of costly fighting preceding a cease-fire. I evaluate these arguments empirically, and find support for the hypotheses.

This research not only contributes to the scholarly debate about institutional influence on states' conflict behavior but also provides important implications for policy makers. Given that the great proportion of international conflicts have been fought between the same pairs of countries many times, the finding that IO membership reduces conflict recurrence suggests that extending the membership in pacific settlement IOs to these countries may be one way to address this problem. At the same time, we should also be aware of the danger in doing so. That is, if states anticipate that they will be stuck with the agreed terms of peace in the long run once they stop fighting, they have less incentive to terminate conflict. Once we recognize this trade-off, we can begin to think about possible ways to mitigate it. This recognition becomes of critical importance when we are to evaluate the effectiveness of various policy tools, such as third-party mediation, that have received significant attention in previous studies of militarized conflict. More specifically, research on third-party conflict management will be benefitted by taking into account the dual effects of IO membership demonstrated in this study in order to devise an optimal way to intervene in conflict.

Table 2.2 : Maximum Likelihood Estimates from the Interdependent Duration Model

	Conflict duration	*Peace duration*
IO Membership	-0.70^{**}	-1.10^{**}
	(0.02)	(0.10)
IO Membership × log(time)	0.18^{**}	0.18^{**}
	(0.007)	(0.02)
Capability Balance	0.29^{**}	0.60
	(0.11)	(0.57)
Contiguity	-0.32^{**}	-0.46^{**}
	(0.10)	(0.17)
Major Power	-0.41^{**}	−0.02
	(0.10)	(0.20)
Joint Democracy	−0.18	0.46
	(0.25)	(0.48)
Year of Initiation	-0.01^{**}	-0.01^{*}
	(0.002)	(0.004)
Constant	5.33^{**}	9.02^{**}
	(0.13)	(0.49)
Weibull shape parameter (σ) [(a)]	1.23^{**}	1.21^{**}
	(0.04)	(0.08)
Correlation parameter (θ) [(b)]		-0.21^{**}
		(0.02)
Number of observations	435	427
Number of uncensored obs.	427	168
Time-varying observations	675	7706
Total number of obs.		7954

(*Notes.* As coefficients are shown in the accelerated failure time metric, positive coefficient estimates are associated with longer duration and negative ones are associated with shorter duration. Standard errors in parentheses. Significance levels: * : 5% ** : 1%, two-tailed tests).

[(a)] The Weibull shape parameters (σ) only take positive values. The null hypothesis in testing the significance of σ is $\sigma = 1$.

[(b)] The correlation parameter (θ) takes values between −1 and +1.

Table 2.3 : Robustness checks

	(0)	(1)	(2)	(3)	(4)
Conflict duration					
IO Membership	-0.70^{**}	-0.66^{**}	-0.97^{**}	-0.75^{**}	-0.67^{**}
	(0.02)	(0.02)	(0.03)	(0.01)	(0.01)
IO Membership $\times$ **log(time)**	0.18^{**}	0.15^{**}	0.21^{**}	0.18^{**}	0.17^{**}
	(0.007)	(0.007)	(0.009)	(0.005)	(0.006)
Capability Balance	0.29^{**}	0.08	0.07	0.34^{**}	0.10^{**}
	(0.11)	(0.28)	(0.05)	(0.02)	(0.004)
Contiguity	-0.32^{**}	-0.34^{**}	-0.14	-0.37^{**}	-0.20^{**}
	(0.10)	(0.09)	(0.08)	(0.06)	(0.06)
Major Power	-0.41^{**}	-0.40^{**}	-0.43^{**}	-0.39^{**}	-0.14^{**}
	(0.10)	(0.10)	(0.10)	(0.06)	(0.01)
Joint Democracy	-0.18	0.15	0.75^{**}	-0.09	-0.41
	(0.25)	(0.23)	(0.02)	(0.11)	(0.25)
Year of Initiation	-0.01^{**}	-0.01^{**}	-0.01^{**}	-0.01^{**}	-0.01^{**}
	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)
Constant	5.33^{**}	5.66^{**}	5.55^{**}	5.21^{**}	5.37^{**}
	(0.13)	(0.25)	(0.07)	(0.08)	(0.06)
Weibull shape parameter (σ)	1.23^{**}	1.26^{**}	1.49^{**}	1.19^{**}	1.20^{**}
	(0.04)	(0.05)	(0.06)	(0.02)	(0.02)
Peace duration					
IO Membership	-1.10^{**}	-0.71^{**}	-1.44^{**}	-1.16^{**}	-1.05^{**}
	(0.10)	(0.19)	(0.20)	(0.07)	(0.11)
IO Membership $\times$ **log(time)**	0.18^{**}	0.11^{**}	0.22^{**}	0.19^{**}	0.18^{**}
	(0.02)	(0.03)	(0.03)	(0.01)	(0.02)
Capability Balance	0.60	0.21	0.43	0.57	0.14
	(0.57)	(0.73)	(0.81)	(0.42)	(0.66)
Contiguity	-0.46^{**}	-1.017^{**}	-0.54^{**}	-0.51^{**}	-0.43^{*}
	(0.17)	(0.25)	(0.25)	(0.13)	(0.18)
Major Power	-0.02	-0.48	-0.07	-0.18	-0.22
	(0.20)	(0.27)	(0.29)	(0.15)	(0.23)
Joint Democracy	0.46	0.70	0.35	-0.01	0.41
	(0.48)	(0.54)	(0.73)	(0.26)	(0.49)
Year of Initiation	-0.01^{**}	-0.001^{*}	-0.01	-0.004	-0.02^{**}
	(0.004)	(0.005)	(0.006)	(0.03)	(0.005)
Constant	9.02^{**}	10.15^{**}	9.58^{**}	8.61^{**}	9.55^{**}
	(0.49)	(0.49)	(0.71)	(0.36)	(0.59)
Weibull shape parameter (σ)	1.21^{**}	0.79^{**}	1.20^{*}	1.20^{**}	1.29^{**}
	(0.08)	(0.08)	(0.11)	(0.06)	(0.10)
Correlation parameter (θ)	-0.21^{**}	0	-0.18^{**}	-0.19^{**}	-0.23^{**}
	(0.02)	(assumed)	(0.02)	(0.01)	(0.02)
N: Conflict duration	435	435	297	595	336
N: Peace duration	427	427	289	586	336
N: Total	7954	7954	5907	9483	5959
Log likelihood	−4188	−4289	−2618	−6231	−3270

(0) The baseline model, as shown in Table 2.2.
(1) A naive model, where the two durations are assumed independent.
(2) Analyzing conflicts that involve serious clashes.
(3) Including non-violent conflicts.
(4) Post-1945 conflicts only.

Table 2.4 : Interdependent Duration Analysis with Selection

	1st Stage (*Peace before conflict*)	*2nd Stage* (*Conflict duration*)	*3rd Stage* (*Peace after conflict*)
IO Membership	-0.45	-0.64^{**}	-0.77^{**}
	(0.28)	(0.06)	(0.18)
IO Membership × log(time)	0.05	0.11^{**}	0.12^{**}
	(0.04)	(0.02)	(0.03)
Capability Balance	2.14^{*}	2.28^{**}	-0.94
	(1.09)	(0.59)	(0.85)
Contiguity	-1.57^{**}	-0.61^{**}	0.09
	(0.49)	(0.23)	(0.40)
Major Power	-0.51	-0.58^{**}	-0.01
	(0.40)	(0.19)	(0.33)
Joint Democracy	1.84^{**}	0.89^{*}	$2.09^{\dagger}$
	(0.57)	(0.35)	(1.09)
Year of Initiation	0.004	-0.01^{**}	0.001
	(0.007)	(0.004)	(0.008)
Constant	8.56^{**}	4.58^{**}	8.78^{**}
	(0.96)	(0.43)	(0.72)
Weibull shape parameter (σ)	0.62^{**}	1.26^{**}	1.32^{**}
	(0.06)	(0.12)	(0.15)
Correlation parameter (θ) [(a)]		0.45^{**}	-0.15^{**}
		(0.14)	(0.04)
Number of Observations	249	131	113
Number of Uncensored Obs.	131	113	59
Time-varying Observations	3097	197	951

(*Notes.* Standard errors in parentheses. Significance levels: † : 10% * : 5% ** : 1%, two-tailed tests).
[(a)] The correlation parameter under the second column (0.45) measures the correlation between residual durations from the 1st and 2nd stages, whereas that under the third column (-0.15) measures the correlation between 2nd and 3rd stages.

Table 2.5 : List of Pacific Settlement IOs

Name of Treaty Organizations	Year
Global / Cross-regional Treaties	
1899 Hague Treaty (Permanent Court of Arbitration)	1900–
1907 Hague Treaty (Permanent Court of Arbitration)	1910–
League of Nations	1920–46
Optional clause (Permanent Court of International Justice)	1921–46
Kellogg-Briand Pact	1929–46
United Nations	1945–
Optional clause (International Court of Justice)	1945–
Commonwealth of Nations	1971–
Non-Aligned Movement	1961–
Organization of the Islamic Conference	1973–
Western Hemisphere	
Treaty on Compulsory Arbitration	1903–
1907 General Treaty of Peace and Amity	1908–18
1923 General Treaty of Peace and Amity	1923–32
Gondra Treaty	1923–
General Convention of Inter-American Conciliation	1929–
General Treaty of Inter-American Arbitration	1929–
Saavedra Lamas Pact	1933–
Montevideo Convention	1934–
1936 Convention on the Existing Treaties between the American States	1937–
Rio Pact	1948–
Organization of American States	1951–
Pact of Bogota	1949–
Andean Community	1989–
Europe	
Locarno Pact	1925–36
Litvinov Protocol	1929–39
Western European Union	1948–
North Atlantic Treaty Organization	1949–
Warsaw Pact	1955–91
Strasbourg Treaty (Council of Europe)	1958–
Helsinki Final Act (OSCE / CSCE)	1975–
Commonwealth of Independent States	1991–
Yalta GUAM Charter	2001–

Table 2.5 : List of Pacific Settlement IOs

Name of Treaty Organizations	Year
Stability Pact for South Eastern Europe	1999–
South-East European Cooperation Process	2000–
Asia and Oceania	
ASEAN	1976–
Treaty of Amity and Cooperation (ASEAN)	1976–
South Asian Association for Regional Cooperation	1985–
Conference on Interaction and CBMs in Asia	1999–
Shanghai Cooperation Organization	2001–
Africa	
OAU/African Union	1963–
African and Malagasy Union for Defense	1961–64
Protocol on Non-Aggression (Economic Community of West African States)	1978–
Revised charter (Economic Community of West African States)	1993–
Southern African Development Community	1993–
Defense-Security Protocol (Southern African Development Community)	2001–
Common Market for Eastern and Southern Africa	1994–
COPAX Protocol (Economic Community of Central African States)	2000–
Community of Sahel-Saharan States	2000–
Middle East	
Arab League	1945–
Baghdad Pact (Central Treaty Organization)	1955–79

2.7 Appendix 1: Interdependent Duration Model

I begin by characterizing the univariate marginal distribution of the random variables, T_{ci} and T_{pi}. Using the Weibull specification, the univariate density function $f(t)$, the survivor function $S(t)$, and the distribution function $F(t)$ are given as:

$$\begin{aligned} f(t) &\equiv \Pr(T = t) = \lambda\sigma\,(\lambda t)^{(\sigma-1)} \exp\left(-\lambda t\right) \\ S(t) &\equiv \Pr(T > t) = \exp\left(-\left(\lambda t\right)^{\sigma}\right) \\ F(t) &\equiv \Pr(T < t) = 1 - S(t) \end{aligned}$$

where λ and σ are as defined in the text. Then, I characterize three parts of the likelihood function in turn.

$$\mathcal{L} = \prod_{i=1}^{n} \Pr(T_{ci} > t^0_{ci})^{(1-A_i)} \Pr(T_{ci} = t_{ci} \cap T_{pi} > t^0_{pi})^{A_i(1-B_i)} \Pr(T_{ci} = t_{ci} \cap T_{pi} = t_{pi})^{A_i B_i}. \quad (3)$$

Specification of the first component of the likelihood function (2.3) is trivial, since this is just a univariate survivor function evaluated at t^0_{ci}. The next step is to calculate the second and the third component of the likelihood function, both of which are bivariate joint distributions of T_{ci} and T_{pi}. This is done by utilizing a copula function. A copula is a function that parameterizes the dependence between univariate marginal distributions to form a joint distribution function (Trivedi & Zimmer 2005). Consider two random variables x and y with associated univariate distribution functions $F_x(x)$ and $F_y(y)$. Sklar's (1959) theorem establishes that there exists a copula $C(\,\cdot,\ \cdot\,;\theta)$ such that a bivariate joint distribution is defined for all

x and y in the extended real line as

$$F_{xy}(x, y) = C(F_x(x), F_y(y); \theta) \tag{2.4}$$

where the association between the two marginal distributions is represented by the association parameter, θ. This result is remarkable because it shows we can construct a new bivariate distribution based on univariate marginal distributions of known form. As long as the univariate marginal distributions are known, an appropriate choice of copula function C in (4.4) enables one to represent the unknown bivariate distribution.

Now, the second component of the likelihood function, the probability that disputants reach an agreement at time t_{ci} in conflict and have not yet resumed fighting at least until t_{pi}^0 is obtained by using the Bayes' rule and copula function

$$\begin{aligned}
\Pr(T_{ci} = t_{ci} \cap T_{pi} > t_{pi}^0) &= \Pr(T_{pi} > t_{pi}^0 | T_{ci} = t_{ci}) \times \Pr(T_{ci} = t_{ci}) \\
&= \Pr(T_{pi} > t_{pi}^0 | T_{ci} = t_{ci}) \times f_c(t_{ci}) \\
&= \frac{\partial C \left\{ F_p(t_{pi}^0), F_c(t_{ci}); \theta \right\}}{\partial F_c(t_{ci})} \times f_c(t_{ci}).
\end{aligned}$$

Similarly, the third component of (2.3), the probability that disputants reach an agreement at time t_{ci} in conflict and then resumed fighting at t_{pi} is obtained as

$$\begin{aligned}
\Pr(T_{ci} = t_{ci} \cap T_{pi} = t_{pi}) &= f_{cp}(t_{ci}, t_{pi}) \\
&= \frac{\partial^2 C \left\{ F_c(t_{ci}), F_p(t_{pi}); \theta \right\}}{\partial F_c(t_{ci}) \partial F_p(t_{pi})}.
\end{aligned}$$

To complete the derivation, the last step is to choose a particular copula function for $C(,;\theta)$. There are a number of different copula functions that can be used to construct a multivariate distribution from univariate marginals (Trivedi & Zimmer 2005), but some copulas are more flexible than others in that they can accommodate greater range of dependency between the marginals. In this application, I use the Gaussian copula, one of the most flexible copula functions that can accommodate both positive and negative dependency. It has the following form

$$C(u, v; \theta) = \int_{-\infty}^{\Phi^{-1}(u)} \int_{-\infty}^{\Phi^{-1}(v)} \frac{1}{2\pi(1-\theta^2)^{1/2}} \exp\left[\frac{-(s^2 - 2\theta st + t^2)}{2(1-\theta^2)}\right] dsdt$$

where $\Phi^{-1}()$ is the Gaussian quantile function, $-1 < \theta < 1$ is the association parameter, and $u = F_x(x)$ and $v = F_y(y)$ for random variables x and y. The Gaussian copula has a number of desirable characteristics. First, it allows for independence as a special case ($\theta = 0$). We can thus test the existence of interdependence between the two processes by testing whether θ is different from 0. Second, the Gaussian copula is *comprehensive* in that as θ approaches the lower (upper) bound of its permissible range, the copula approaches the theoretical lower (upper) bound. [23] This is not true with other copulas that have been utilized to address selection bias in political science. For example, the estimator proposed by Sartori (2003) forces one to *assume* either one of the theoretical bounds as representing the true data generating process. The consequence of this is not only that we are unable to test the existence of interdependence but also that, depending on the assumption made about the direction

[23] The upper and lower theoretical bounds of a joint distribution, called Fréchet bounds, F^- and F^+, are defined as $F^-(u, v) = \max[0, u + v - 1]$ and $F^+(u, v) = \min[u, v]$.

of the dependency, we make completely opposite inferences about the effects of explanatory variables on outcomes. The copula function utilized in Boehmke, Morey & Shannon (2006) can accommodate both positive and negative dependency and allows for testing the direction of dependency, but the permissible range is limited to $\theta \in (-0.25, 0.25)$.

2.8 Appendix 2: Descriptive Statistics

Figure 2.3 shows the histogram of IO membership variable for the 435 crisis-dyads.

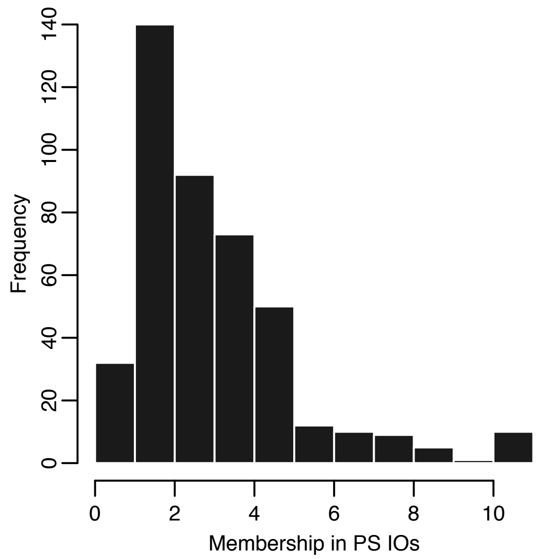

Figure 2.3 : Distribution of IO membership variable

(*Notes.* This figure shows the distribution of IO membership for the 435 crisis-dyads. The horizontal axis shows the number of Pacific Settlement IOs that both sides of the crisis-dyad both belong to, and the vertical axis shows the frequency.).

Table 2.6 below shows the descriptive statistics of the explanatory variables for the main analysis shown in Tables 2.2 and 2.3.

Table 2.6 : Descriptive statistics: main model

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
IO Membership	3.082	2.302	0	11	7954
Capability Balance	0.794	0.156	0.5	1	7954
Contiguity	0.532	0.499	0	1	7954
Major Power	0.441	0.497	0	1	7954
Joint Democracy	0.096	0.295	0	1	7954
Year of Initiation	42.592	21.594	0	86	7954

Table 2.7 below shows the descriptive statistics of the explanatory variables for the interdependent duration analysis with selection shown in Table 2.4.

Table 2.7 : Descriptive statistics: three-stage model

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
IO Membership	2.642	2.41	0	11	3097
Capability Balance	0.851	0.145	0.5	1	3097
Contiguity	0.677	0.468	0	1	3097
Major Power	0.446	0.497	0	1	3097
Joint Democracy	0.21	0.407	0	1	3097
Year of Initiation	23.072	22.11	1	77	3097

Chapter 3

Estimating Interdependent Durations in Militarized Conflict and Beyond

Chapter Abstract

This paper introduces a simple method to analyze interdependent duration processes that typically arise in studies of intra- and interstate conflict duration. The method is suitable for situations where an analyst is interested in not only *when* but also *how* a violent conflict terminates. Duration models commonly used in such situations, such as independent competing risks models or multinomial logit models, suffer from bias as they ignore the interdependence between the risks of an event occurring for different reasons. The proposed method addresses this problem by constructing a statistical model based on a strategic model of conflict termination. Monte Carlo simulation shows that the proposed approach outperforms conventional duration models. I provide an empirical application of the method by studying the effect of outside intervention on duration and outcome of civil wars.

3.1 Introduction

Why do some militarized conflicts last longer than others? What determines when disputants terminate violence? Scholars of civil and international wars have investigated these questions for a number of reasons. Understanding the determinants of conflict duration will help us prescribe an effective policy measure to shorten the duration of violent conflict. This is important because the longer a conflict lasts, the more people will be killed and the more resources will be destroyed. In addition, studies of conflict duration can also inform general theories of violent conflict by providing ways to test competing theories of conflict onset. For example, recent studies by Ramsay (2008) and Slantchev (2004) test novel implications of the bargaining models of war using data on war duration.

An equally important question is *how*, not just *when*, a conflict terminates. Military conflict can end in various ways, and the mode of termination can have an important impact on the likelihood of conflict recurrence (Hensel 1994, Hensel 1999, Lo, Hashimoto & Reiter 2008, Quackenbush & Venteicher 2008). Existing studies on intra- and interstate war outcomes distinguish three major forms of conflict termination: victory of one side, that of the other side, and a draw (e.g. Balch-Lindsay, Enterline & Joyce 2008, Stam 1999). As a method of estimating these competing risks of conflict termination, most studies use the multinomial logit model and explore how some explanatory factors (e.g., third-party intervention on behalf of one side) may raise the probability that a conflict ends for one reason (such as victory of the assisted side) but not for the others (such as draw or defeat of the assisted side).

This competing-risks approach is particularly useful because it provides answers to the questions of *how* and *when* a conflict ends at the same time.

However, a potential drawback of the commonly used competing-risks models is that they assume that competing risks are independent, although this assumption is often unreasonable. For example, disputants that incur significant cost of conflict might choose to give in to the other side before a negotiated settlement is reached. Then, the observed rate of negotiated settlement is a deceptively low indicator of the effect of some policy measures intended to induce settlement by pressuring the disputants (such as third-party intervention) on the success of negotiated settlement. In such situations, the multinomial logit model suffers from bias and underestimates the effectiveness of policy measures taken to facilitate a settlement of conflict.

Two related methods have been proposed to address the problem of dependent competing risks, but each method suffers from limitations. The frailty model, or *stochastically* dependent competing-risks model, captures the dependence among competing risks by allowing the error terms governing multiple duration processes to be correlated. A drawback of this method is that it is prohibitively difficult to handle more than two risks because of computational burden (Gordon 2002). On the other hand, Fukumoto's (2009) *systematically* dependent competing-risks model can readily accommodate more than two risks. However, this method requires relatively strong assumptions about the structure of risk dependence.

This paper proposes a strategic competing-risks (hereafter, SCR) model, which is robust against bias induced by the dependence among competing risks. The model is derived from a strategic theory of conflict duration, and is suitable for analyzing the duration of intra- and interstate conflict. In short, the model assumes that two disputants play a war of attrition game where whichever player who holds out longer in the costly conflict wins the contest. It allows a set of independent variables to influence each of the two disputants' willingness to incur the cost of conflict separately. The model thus allows us to estimate the effect of such explanatory variables as third-party intervention, relative military power, the existence of natural resources, etc., on the duration and outcome of conflict at the same time. Moreover, it is easy to implement this method using a standard statistical software, such as STATA or R.

Although the main goal of this paper is methodological, it also contributes to conflict studies by correcting bias in existing analyses of third-party intervention in conflict. The substantive message of this paper is that balanced third-party intervention is more effective in facilitating conflict termination than is conventionally thought. Even when the rate of successful negotiated settlement is low, the disputants may be terminating hostilities so as to avoid the cost of continued fighting in the face of strong opposition by the international community. By discouraging the disputants to continue fighting, third-party intervention shortens not only the duration until a negotiated settlement but also the duration until other modes of termination.

The remainder of this paper proceeds as follows. The first section introduces an SCR model of survival analysis, using the running example of civil war between the government and the rebel group. The next section conducts Monte Carlo simulation to show how much the SCR model reduces bias which the conventional independent competing-risks model is prone to. The third section reanalyzes the Balch-Lindsay, Enterline & Joyce (2008) data on civil war duration and outcome and illustrates that the SCR model reveals important effects of third-party intervention that the original analysis underestimates. The last section concludes by summarizing methodological and empirical findings of the paper.

3.2 Model

This paper adopts the tools and terminologies of survival analysis (also called duration analysis or event history analysis) for studying when and how a civil conflict ends. This section introduces some of the basic concepts of survival analysis and then discusses the proposed SCR model of survival analysis. It employs a discrete time approach to survival analysis, although it can easily be extended to a general model using continuous time.

Each observation unit is a pair of disputants fighting a civil war, or government–rebel dyad, at time period t. [1] The dependent random variable Y represents the status of the disputants at the end of the time period. If the conflict ends in government's victory by the end of the period, $Y = 1$. If the conflict ends in rebel's victory, $Y = 2$. If the conflict ends in a negotiated settlement between the government and the rebel, $Y = 3$. Finally, if the disputants are still at war until the end of the period, the period is said to be "right-censored" and $Y = 4$.

[1] The length of the time period depends on the precision of the measurement of the dependent and independent variables. For example, if the dependent variable is measured in days, t may be one day.

In the discrete time model, an observation of a pair of disputants (i.e., government–rebel dyad) appears in the dataset only if the disputants survive the previous periods $s(< t)$. Thus, the hazard at period t is the same as the probability that an event occurs during period t. The quantity of interest is the marginal hazard for risk r: $h_r(t) = \Pr(Y = r|t), r \in \{1, 2, 3, 4\}$. If one assumes that these three hazards are independent of each other conditioned on covariates, one can use a single multinomial logit model. That is, the log odds of the marginal hazard for risk r are parameterized by the log odds of a baseline hazard for risk r ($\log \lambda_r^0(t)$) plus a linear predictor ($g_r(\cdot)$) of time-varying covariates ($x(t)$, not including the constant term). Then, the model is expressed as

$$\Pr(Y = r|t) = \frac{\lambda_r^0(t) \exp(g_r(x(t)))}{1 + \sum_r \lambda_r^0(t) \exp(g_r(x(t)))}, \tag{3.1}$$

where $r \in \{1, 2, 3, 4\}$. In their study of civil war duration and outcome, Balch-Lindsay, Enterline & Joyce (2008)[2], Cunningham, Gleditsch & Salehyan (2009)[3], De Rouen & Sobek (2004)[4], and Humphreys (2005)[5] use this model. [6] One of the core assumptions of this model is independence of irrelevant alternatives, that com-

---

[2] In Balch-Lindsay, Enterline & Joyce's (2008) study, competing risks are $r \in$ {Government Victory, Rebel Victory, Negotiated Settlement}. They use the continuous time model with Cox semi-parametric specification.

[3] In Cunningham, Gleditsch & Salehyan's (2009) study, competing risks are $r \in$ {Government Victory, Rebel Victory, Formal Agreement, Low Activity}.

[4] In De Rouen & Sobek's (2004) study, competing risks are $r \in$ {Government Victory, Rebel Victory, Truce/Treaty}.

[5] In Humphreys's (2005) study, competing risks are $r \in$ {Government Victory, Negotiation}.

[6] Bennett & Stam (1998) use this model to analyze duration and outcome of interstate war. In their study, competing risks are $r \in$ {Initiator Victory, Draw}.

peting risks are independent of each other. However, one competing risk may be dependent on another risk. For example, in situations where both sides expect that they can defeat the other side militarily, both sides would rather continue fighting than negotiate a settlement. Thus, the hazard of war continuation (h_4) should be dependent on the hazard of negotiated settlement (h_3). Then, if one uses the multinomial logit model, the coefficients of negotiated settlement hazard covariates will be biased toward zero.

Dependence between Competing Risks

A common method to deal with dependent competing risks is the frailty model (Gordon 2002). To address bias induced by correlated hazards, it introduces correlated error terms into equation (3.1). The model of negotiated settlement and civil war continuation hazard can be written as:

$$g_3(x) = x_3\beta_3 + \epsilon_3$$
$$g_4(x) = x_4\beta_4 + \epsilon_4$$

where x_r is a vector of covariates for risk r, β_r is a vector of coefficients, and the ϵ_r is the error term (frailty) that is independent of covariates but dependent of each other. More specifically, ϵ_3 and ϵ_4 are distributed bivariate normal with a correlation ρ. Conditional upon the covariates and the error terms, the hazards (h_3 and h_4) are independent. To estimate the model, one needs to integrate out these error terms via numerical integration. When there are more than two risks (as in the running example of conflict outcomes, where there are four risks), however, numerical integration of multivariate normal distribution becomes extremely difficult.

Fukumoto (2009) proposes an alternative method to address dependence among competing risks. His method, called systematically dependent competing-risks model, modifies the deterministic (i.e., systematic) component, namely, the linear predictor $g_r(\cdot)$ in equation (3.1), so that the hazard for one risk is conditioned on the same linear combination of covariates explaining the other hazard(s). For example, if one suspects that the hazard s depends on the hazard r, one specifies

$$
\begin{aligned}
g_r(x) &= x_r\beta_r \\
g_s(x) &= x_s\beta_s + \alpha_{rs}(g_r(x)) \\
&= x_s\beta_s + \alpha_{rs}(x_r\beta_r),
\end{aligned}
$$

where the parameter α_{rs} captures the influence of the hazard r on the hazard s. The analyst can similarly allow one hazard to be dependent on more than two other hazards, or more than two hazards to be dependent on one hazard, although reciprocal dependence of two hazards is not allowed (Fukumoto 2009, 744). Unlike the frailty model, estimation of this model does not involve numerical integration of multiple error terms, so one can easily estimate more than two risks simultaneously.

There are two practical challenges in implementing this approach, however. First, the analyst must be able to specify the structure of hazard dependence prior to the estimation of a model, which can be extremely cumbersome when there are more than two hazards. Second, model identification requires that some covariates must be excluded from the hazard that is dependent on other hazards (Fukumoto 2009, 744). In the specification example given above, more than two variables that appear in x_r cannot appear in x_s to identify the model. These two limitations make this approach a less desirable candidate for studying conflict duration and outcome.

Strategic Competing-Risks Model

To address these problems, this paper proposes a strategic competing-risks model that is based on a strategic model of conflict duration. The statistical model is closely related to a formal model known as the War of Attrition model. The War of Attrition model is commonly used in conflict research to study the duration of conflict (Krustev 2006, Langlois & Langlois 2009). In the model, two players (government and the rebel group) are fighting over division of some good. Fighting is costly for both players, but the player who quits fighting first must concede the disputed good to the other player. When both players quit at the same time, the disputed good is divided equally by the players. In each time period t, the government and the rebel group simultaneously determine whether or not they quit fighting by the end of the period. Then, combinations of the players' decisions correspond to the four outcomes of civil war discussed above. If the rebel quits and the government does not, the war ends in government's victory, $Y = 1$. If the government quits and the rebel does not, the war ends in rebel's victory, $Y = 2$. If both disputants quit, the war ends in negotiated settlement, $Y = 3$. Finally, if neither side quits, the war does not end in this time period, $Y = 4$.

Denote player i's decision to quit at time t as $u_i(t) = 0$ and his decision not to quit as $u_i(t) = 1$ for $i \in \{\text{G(overment)}, \text{R(ebel)}\}$. The disputants' decision indicator function $u_i(t)$ takes the value of 1 when the latent utility for i at time t ($u_i^*(t)$) is greater than 0 and takes the value of 0 otherwise. That is,

$$u_i(t) = \begin{cases} 1 & u_i^*(t) > 0 \\ 0 & u_i^*(t) \leq 0. \end{cases} \tag{3.2}$$

In order to capture the effect of covariates on conflict duration and outcome, I let the latent utility $u_i^*(t)$ be a function of time-varying covariates ($x_i(t)$), time (t), and an error term (ν_i) that is independent of the covariates and time but dependent on the error term for the other disputant's latent utility. I follow Carter & Signorino's (2010) measure of time dependence, namely, cubic Talor series approximation of the trending hazard. More specifically, the latent utility function is given as

$$\begin{aligned} u_i^*(t) &= x_i(t)\beta_i + \lambda_i(t) + \nu_i \\ \lambda_i(t) &= \zeta_{1i}t + \zeta_{2i}t^2 + \zeta_{3i}t^3. \end{aligned} \tag{3.3}$$

This specification allows one to test the impact of covariates on duration and outcome of conflict by estimating how they influence the disputants' willingness to hold out in costly conflict. The analyst can include the same set of covariates in both latent utility functions. [7] This does not mean, however, that one must assume that a covariate influences the two disputants' utilities in the same way. In fact, one can

[7] That is, it is possible (but not necessary) that $x_G(t)$ and $x_R(t)$ are the same. In what follows, whenever I drop the subscript for $x_i(t)$, it means that the same set of covariates appear in $x_G(t)$ and $x_R(t)$.

expect that some covariates (such as third-party intervention supporting the government) may increase the government's willingness to fight while decreasing the rebel's incentive to fight, and that some other covariates (such as the existence of natural resources) may increase or decrease both disputants' incentive to hold out. I thus allow the coefficient vector (β_i) to be different for each disputant. Moreover, as the disputants can learn the other side's ability and willingness to fight through the course of conflict, the disputants' latent utilities are allowed to change over time. Finally, the model captures the influence of some unobservable factors (such as longstanding feud between the disputants) on the disputants' decisions through correlated error terms. With the specification of the utility function in hand, the marginal hazards for four competing risks at time t can be specified as

$$
\begin{aligned}
\text{Government Victory}: &\quad \Pr(Y=1|t) = \Pr(u_G(t)=1 \cap u_R(t)=0) \\
\text{Rebel Victory}: &\quad \Pr(Y=2|t) = \Pr(u_G(t)=0 \cap u_R(t)=1) \\
\text{Negotiated Settlement}: &\quad \Pr(Y=3|t) = \Pr(u_G(t)=0 \cap u_R(t)=0) \\
\text{War Continuation}: &\quad \Pr(Y=4|t) = \Pr(u_G(t)=1 \cap u_R(t)=1). \qquad (3.4)
\end{aligned}
$$

In essence, the SCR model addresses dependence among competing risks by directly modeling the structure of strategic interaction between two disputants. [8] It captures the effect of covariates on conflict duration and outcome through a two-layer

[8] In this sense, the model shares similar features of existing discrete choice models of strategic interaction (Lewis & Schultz 2003; Signorino 1999, 2002, 2003; Smith 1999). Among others, Smith's (1999) Strategically Censored Discrete Choice model employs a structure similar to that of the present paper. The notable difference is that the SCR model incorporates time component and can be generalized to continuous time model.

structure. First, the SCR model specifies how the covariates impact each of the disputants' willingness to bear the cost of continued fighting, as shown in (3.3). It then specifies the mechanism through which disputants' decisions give rise to different conflict outcomes, as shown in (3.4). The model avoids bias induced by strategic dependence between competing risks, which independent competing-risks models (such as the multinomial logit model or independent competing-risks Cox model) are prone to. Consider the aforementioned example situation where, because of some unobserved factors, both of the disputants expect that they can defeat the other side militarily. In such situations, the disputants would rather continue fighting than negotiating settlement. The SCR model captures the inflated hazard of war continuation and the deflated hazard of negotiated settlement via the (positively) correlated error terms that appear in the latent utility of war continuation. On the other hand, the multinomial logit model suffers from bias because the hazard of war continuation is underestimated whereas the hazard of negotiated settlement is overestimated.

The SCR model has a number of advantages over the conventional approaches to dependent competing risks. Although the specific version of the SCR model introduced here has as many as four competing risks (three conflict outcomes plus one "censored" outcome), the model is based on just two utility functions (one for government and the other for the rebel group) and has only two error terms. Therefore, estimation of the model is significantly easier than the frailty model with four competing risks. Moreover, the SCR model can easily be extended to include any number of distinct conflict outcomes without increasing the number of utility functions. [9] Finally, it is possible (but not necessary) that the two utility functions have the same set of covariates. Therefore, the analyst does not have to identify a covariate that influences one player's utility function but not the other, which is extremely difficult to find in practice.

Estimation

To estimate the model, I assume that ν_G and ν_R are distributed standard bivariate normal with correlation ρ. Then, the first line in (3.4) can be expressed as

$$\begin{aligned}
\Pr(Y=1|t) &= \Pr(u_G^*(t) > 0 \cap u_R^*(t) < 0) \\
&= \Pr(x(t)\beta_G + \lambda_G(t) + \nu_G > 0 \cap x(t)\beta_R + \lambda_R(t) + \nu_R < 0) \\
&= \Pr(x(t)\beta_G + \lambda_G(t) + \nu_G > 0 \cap x(t)\beta_R + \lambda_R(t) + \nu_R < 0) \\
&= \Phi_2(x(t)\beta_G + \lambda_G(t), -x(t)\beta_R - \lambda_R(t), -\rho), \qquad (3.5)
\end{aligned}$$

where $\Phi_2(,,\rho)$ is the standard bivariate normal distribution with correlation ρ. Similarly, the other three hazards in (3.4) can be specified as

$$\begin{aligned}
\Pr(Y=2|t) &= \Phi_2(-x(t)\beta_G - \lambda_G(t), x(t)\beta_R + \lambda_R(t), -\rho) \\
\Pr(Y=3|t) &= \Phi_2(-x(t)\beta_G - \lambda_G(t), -x(t)\beta_R - \lambda_R(t), \rho) \\
\Pr(Y=4|t) &= \Phi_2(x(t)\beta_G + \lambda_G(t), x(t)\beta_R + \lambda_R(t), \rho). \qquad (3.6)
\end{aligned}$$

[9] To increase the number of outcomes, one can introduce threshold parameter(s) into the latent utility functions, thereby increasing the number of values that the decision functions can take.

Suppose there are n paris of disputants and a pair of disputants j is observed up to the T_jth period. Then the likelihood function is obtained as

$$L(\theta) = \prod_{j=1}^{n} \prod_{t=1}^{T_j} \prod_{r=1}^{4} \Pr(Y = r|t)$$

where θ is a set of parameters (the β's, the ζ's, and the ρ) and $\Pr(Y = r|t)$ is given in (3.5) and (3.6). The likelihood function can be evaluated using a bivariate probit model that is available in standard commercial statistical software packages. To estimate the SCR model via the bivariate probit, one uses the binary decision indicators $u_G(t)$ and $u_R(t)$ as the dependent variables.

3.3 Monte Carlo Simulation

This section performs Monte Carlo simulation to demonstrate that, when the true data generation process is what the SCR model assumes, conventional independent competing-risks models (such as the multinomial logit model and Cox independent competing-risks model) produce biased estimates. The results show that these models underestimates the frequency of negotiated settlement, thereby underestimating the effect of some covariates associated with negotiated settlement. The Monte Carlo simulation is designed so that it is easy to compare with the estimated parameters one obtains by applying the SCR model to the civil war data, which we will see in the next section. The number of observations is 200. The independent variables are three binary variables measuring the types of third-party intervention: intervention supporting the government (z_G), intervention supporting the rebel group (z_R), and balanced intervention (z_B). The values of these variables are deterministic and fixed through the whole process of this simulation. Specifically, z_G takes the value of one only in the first 50 (25%) observations, z_R takes the value of one only in the second 50 (25%) observations, and z_B takes the value of one in the third 50 (25%) observations.

A single iteration of the simulation begins by randomly drawing the values of two error terms governing the latent utility of the disputants, e_G, e_R, from a standard bivariate normal distribution with correlation 0.8. Positive correlation between the error terms means that there are some unobservable factors (such as both sides' mutual optimism about the prospect of military victory) that influence the disputants' willingness to continue fighting in the same direction. In other words, positively correlated error terms increase the probability that both sides make the same decisions at a given time (i.e., quit at the same time, or continue fighting at the same time). These error terms are unobservable to the analyst, and a failure to correct for these correlated error terms will underestimate the frequency of negotiated settlement and war continuation.

With the three independent variables and the error terms, we obtain the latent utility as follows:

$$u_G^*(t) = z_G - z_R + z_B + e_G$$
$$u_R^*(t) = -z_G + z_R + 0.5 * z_B + e_R.$$

That is, third party intervention supporting one side increases the supported disputant's willingness to fight while decreasing that of the other side. Balanced in-

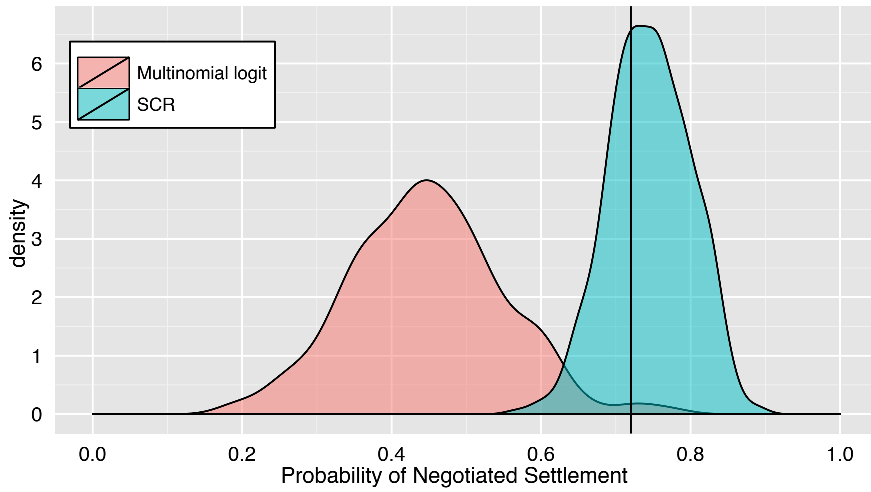

Figure 3.1 : Biased estimates of the multinomial logit model

(*Notes.* This figure illustrates the results of Monte Carlo simulation. The densities show the predicted probabilities of Negotiated Settlement when there is balanced intervention in civil war. The left density (red) is obtained from the multinomial logit model, whereas the right density (green) is obtained from the SCR model. The vertical line is drawn at the mean of the true rate of Negotiated Settlement when there is balanced intervention. We can see that the multinomial logit model underestimates the frequency of Negotiated Settlement.)

tervention increases both sides' utilities, but the effect is greater for the government than for the rebel. Using these utility functions, I obtain civil war outcomes according to the rules (3.2) and (3.4). I then apply an independent competing-risks model (i.e., the multinomial logit model) and the SCR model to the resulting data set, and store the estimates. These processes are repeated 500 times.

Results

Figure 3.1 illustrates the results of the Monte Carlo simulation. It shows the predicted probabilities of Negotiated Settlement estimated from the multinomial logit model (left density in red) and the SCR model (right density in green) when balanced intervention (z_B) takes the value of one. The vertical line drawn at 0.72 shows the mean value of the true frequency of Negotiated Settlement from the 500 iterations of simulation. From this figure, we can see that the multinomial logit model significantly underestimates the frequency of Negotiated Settlement whereas the estimates from the SCR model are very close to the true value. This means that the multinomial logit model underestimates the effect of balanced intervention on the likelihood of Negotiated Settlement. The source of this bias is its inability to account for dependence among competing risks that stem from the correlation between the disputants' latent utilities.

3.4 Empirical Application

This section continues to demonstrate the usefulness of the SCR model by applying this model to the civil war data by Balch-Lindsay, Enterline & Joyce (2008). The data set contains information on duration and outcome of 213 civil wars from 1816 to 1997 taken from the Correlates of War (COW) project. 194 of the 213 civil wars were terminated by the end of 1997. For those terminated civil wars, the dates of initiation and termination and three types of outcomes were recorded: Government Victory (109 wars), Rebel Victory (45 wars), and Negotiated Settlement (40 wars). The remaining 19 ($= 213 - 194$) civil wars that were ongoing at the end of 1997 are treated as right-censored. In the terminology of the present paper, each civil war is simultaneously being exposed to four competing risks at any moment, and one of the four risks is realized at the end of the observation period (day). Total time at risk is

246, 538. [10]

Balch-Lindsay, Enterline & Joyce's (2008) theoretical focus is to understand the effect of third-party intervention on civil war duration and outcome. Does a third-party intervention shorten or lengthen the duration of civil war? Does a biased intervention in support of one side of a conflict shorten the time until the supported side wins? To investigate these questions, the authors collect information on the nature of all observed third-party interventions in civil war as well as the initiation and termination dates each intervention. Using the COW Intra-State War Participants Data, the authors identify three types of interventions: third-party intervention supporting the government, intervention supporting the rebel group, and balanced intervention supporting both the government and the rebel group. More specifically, `Intervention for Government` is coded 1 when there is at least one third-party intervention supporting the government and 0 otherwise. [11] `Intervention for Rebel` is coded 1 when there is at least one third-party intervention supporting the rebel group and 0 otherwise. [12] `Balanced Intervention` is coded 1 when there is at least one third-party intervention supporting both the government and the rebel group and 0 otherwise. [13] These three binary variables are time-varying covariates. Balch-Lindsay, Enterline & Joyce (2008) hypothesize that a third-party intervention in

[10] That is, there are 246, 538 days in the data set. Note that, in Balch-Lindsay, Enterline & Joyce's (2008) original analysis, the total time at risk is 249, 462, which is about 1% larger. This discrepancy is due to some errors in the original article with respect to the recording of the initiation and termination dates of a few civil wars. Correction of these errors does not cause any significant changes to the findings of the original article.

[11] Of the 213 civil wars, 29 (14%) had intervention supporting the government.

[12] Of the 213 civil wars, 18 (9%) had intervention supporting the rebel group.

[13] Of the 213 civil wars, 6 (3%) had intervention supporting both the government and opposition.

support of one side reduces time to a military victory of the supported side while increasing time to the other civil war outcomes. They also expect that a balanced intervention reduces time to negotiated settlement while increasing time to the other civil war outcomes.

In addition to these main independent variables, Balch-Lindsay, Enterline & Joyce (2008) have the following five control time-invariant covariates: `Separatist` is a binary variable measuring whether or not the goal of the rebel group in a civil war is separatist. `War Costs` is a per capita indicator of civil war costs, measured by the total number of battle deaths sustained by all state participants at the end of the civil war divided by the prewar total population of the civil war state. `Government Reputation` is measured as the prior frequency of negotiated settlements agreed to by a civil war state divided by the prior total frequency of civil war outcomes (negotiated, victory, defeat). It ranges from 0 to 1. `Economic Development` is calculated as the natural log of the sum of energy consumption and iron/steel production. It is lagged by one year prior to the civil war. Finally, `Democracy` measures whether or not the civil war state's Polity score in the year prior to the civil war was greater than 5.

To analyze these data, Balch-Lindsay, Enterline & Joyce (2008) utilize an independent Cox competing-risks model. The Cox competing-risks model is the continuous-time equivalent of the discrete-time multinomial logit model. [14] While both Cox and the multinomial logit models allow a covariate to have a different effect on time to different civil war outcomes, they assume that competing risks are independent, conditioned on covariates. However, as discussed above, this assumption is not rea-

[14] On the relationship between continuous-time duration models and discrete-time logit duration model, see Beck, Katz & Tucker (1998).

sonable due to the strategic interaction between the disputants. I demonstrate below that the SCR model reveals different dynamics than does the Cox competing-risks model.

Results

I begin by re-estimating the original Cox models using the slightly modified version of the original data set. [15] Then, I estimate the SCR model using the same modified data set. This way, I can ensure that any difference in the results from the Cox and the SCR models are not driven by the differences in the data sets used. For the purpose of model comparison, I use the same set of independent variables used in Balch-Lindsay, Enterline & Joyce (2008). [16]

To implement an independent Cox competing-risks analysis, one estimates multiple Cox models separately for each civil war outcome. Specifically, using the right-censored cases as the baseline, one estimates three Cox duration models for three different outcomes. Estimation results are reported in Table 3.1. This table almost exactly replicates the results reported in Table I of Balch-Lindsay, Enterline & Joyce (2008).

[Table 3.1 About Here]

Based on these results, I calculate the survival functions for three competing risks. A survival function for outcome Y represents how many observations have survived

[15] As mentioned above, I corrected some minor coding errors found in the original data set. Nevertheless, I was able to replicate almost the same results reported in the original article.

[16] The authors interact `Intervention for Government`, `Separatist`, `War Costs`, and `Economic Development` with a natural log of time to capture the time-varying effects of these variables.

the risk of a civil war ending in Y up to a particular point time. For example, if the survival function for Government Victory at the 100th day is 0.8, it means that 80% of the civil wars have survived the risk of Government Victory up to the 100th day, or equivalently, 20 % of the civil wars have ended in Government Victory by the 100th day. Thus, if a survival function for outcome Y has a steeper slope, the time to a civil war ending in outcome Y is shorter.

Figure 3.2 reports the estimated survival functions from the Cox models. [17] In this figure, three types of third-party interventions are contrasted: Intervention for Government (top left panel), Intervention for Rebel (top right panel), and Balanced Intervention (bottom right panel). In each panel, solid curves in red shows the survival probability for Government Victory, dotted curves in green show that for Rebel Victory, and dashed curve in blue show that for Negotiated Settlement. We can see from the top two panels that third-party intervention supporting the government shortens the duration until government victory relative to the duration until rebel victory, and that intervention supporting the rebel shortens the duration until rebel victory relative to the duration until government victory. These results support Balch-Lindsay, Enterline & Joyce's (2008) hypotheses. However, as the bottom right panel shows, balanced intervention does not appear to facilitate negotiated settlement. If anything, the results show that balanced intervention leads to shorter time to government victory while making negotiated settlement almost impossible (survival function for negotiated settlement takes the values very close to 1 up to

[17] Three panels in Figure 3.2 correspond to Figures 1 to 3 in Balch-Lindsay, Enterline & Joyce (2008, 358–359). We can see that my graphs based on the modified data set are almost indistinguishable from the original graphs.

15th year). Balch-Lindsay, Enterline & Joyce (2008) thus do not find support for their hypothesis about balanced intervention.

I now apply the SCR model to the same data. I first transform Balch-Lindsay, Enterline & Joyce's (2008) data set from a continuous-time duration format into a discrete-time duration format. This is done by creating multiple rows of observations per each civil war corresponding to the number of time at risk (i.e., $246,538$ days). For example, a civil war that lasted for 100 days will have 100 rows in the transformed data set. Then, for the transformed data set, I code two binary decision indicator functions $u_G(t)$ and $u_R(t)$, which are used as the dependent variables in the bivariate probit estimation. If the aforementioned civil war ended in Government Victory after 100 days, $u_G(t)$ takes the value of one for all the 100 rows (because the government did not quit) whereas $u_R(t)$ takes the value of one for the first 99 rows and zero for the 100th row (because the rebel group quit on the 100th day). [18] As there are 109 civil wars that ended in government victory, 45 civil wars that ended in rebel victory, and 40 civil wars that ended in negotiated settlement, $u_G(t)$ takes the value of zero in $45 + 40 = 85$ rows and $u_R(t)$ takes the value of zero in $109 + 40 = 149$ rows.

[Table 3.2 About Here]

Table 3.2 reports the estimation results of the SCR model. The latent utility functions for the government and the rebel groups are explained by the vector of time-varying covariates $x(t)$ that has the same set of independent variables used in the Cox models and a smoothed function of time $\lambda(t)$ (i.e., linear combination of time,

[18] Using the terminology of Beck, Katz & Tucker (1998), one can call the transformed data set as in a bivariate binary time-series cross-section (BBTSCS) format.

$time^2$, $time^3$). The SCR model reveals how each covariate influences the disputants' willingness to hold out in costly war of attrition. Those covariates with a positive coefficient increase the corresponding disputant's incentive to continue fighting, while those with a negative coefficient give the corresponding disputant incentive to give in to the other side. The easiest way to understand how such changes in disputants' incentives to fight translate into conflict duration and outcome is to calculate the survival function for each outcome. Before turning to the survival functions, however, I briefly discuss the estimated effects for the main independent variables measuring three types of third-party interventions.

First, third-party intervention supporting government has its linear term and an interaction term with ln(time). Although the individual coefficients are not independently significant, they are jointly statistically significant at a 5 % significance level. For both the government and the rebel equations, the linear terms are estimated negative and the time interactions are estimated positive. This means that third-party intervention for the government that occurs in earlier phases of a civil war decreases the disputants' willingness to fight, whereas it increases the disputants' willingness to fight if the intervention occurs in later phases of a civil war. We can find out when such a switching happens by calculating the point at which the combined coefficient changes from negative to positive. For example, the linear term for the government utility is -0.15 and the time interaction is 0.03. Then, the combined coefficient is $-0.15 + 0.03 \times \ln(\text{time})$, which becomes positive on the 149th day. [19] Second, the Intervention for Rebel variable significantly decreases the government's willingness

[19] This can be obtained by solving the equality: $-0.15 + 0.03 \times \ln(\text{time}) > 0$, which gives us: time > 148.4132.

to fight, which makes an intuitive sense. Third, the Balanced Intervention variable significantly increases the government's willingness to fight while exerting little influence on the rebel group's incentive. How are these changes in disputants' incentive translated into civil war duration and outcomes?

Figure 3.3 reports the estimated survival functions from the SCR model. As in the previous figure, three types of third-party interventions are contrasted: Intervention for Government (top left panel), Intervention for Rebel (top right panel), and Balanced Intervention (bottom right panel). Again, the top two panels demonstrate that third-party intervention supporting the government shortens the duration until government victory relative to the duration until rebel victory, and that intervention supporting the rebel shortens the duration until rebel victory relative to the duration until government victory. These results are consistent with Balch-Lindsay, Enterline & Joyce's (2008) hypotheses and their findings. The most notable difference between the results of the SCR model and the Cox model can be seen in the bottom right panel where I plot the effect of balanced intervention. We can see that the survival function for negotiated settlement generated by the SCR model has a much steeper slope than that generated by the Cox model. That is, the SCR model reveals that balanced intervention indeed facilitates negotiated settlement. Balch-Lindsay, Enterline & Joyce (2008) predict this result, but they fail to find an empirical support for their argument using the Cox model.

3.5 Conclusion

Competing-risks survival analysis has become a widely used tool for analyzing whether, when, and how an event occurs. These competing risks are often dependent on one another, but the commonly used competing-risks models (such as the independent Cox competing-risks model and the multinomial logit model) assume that they are independent. The SCR model proposed in this paper addresses the problem of dependent competing risks by specifying the underlying strategic interaction based on a War of Attrition model. Monte Carlo simulation demonstrated that the oft-used multinomial logit duration model suffers from bias. The proposed model is easy to implement and robust against bias induced from the strategic dependence among competing risks.

This paper also has relevance to the civil war research by applying the SCR model to data on civil war duration and outcome. The main substantive contribution of the paper is to demonstrate that balanced third-party intervention has a much stronger impact on the likelihood of negotiated settlement between the disputants than previously thought. This finding has relevance for policy debates on the desirability of third-party intervention.

Although I use the example of civil war duration and outcome throughout the paper, the model is applicable to a number of areas of research other than civil war, where duration and outcome of a certain event are determined by decisions of two players. For example, research on duration and outcome of territorial claims, international rivalry, alliance agreement, and trade negotiation can all be benefitted by using the SCR model.

Table 3.1 : Independent Cox Competing-Risks Analysis of Civil War Duration & Outcome, 1816–1997

	Government Victory	Rebel Victory	Negotiated Settlement
Intervention for Government	2.51†	1.87	5.78†
	(1.84)	(1.61)	(3.76)
Intervention for Government × ln(time)	-0.63*	−0.41*	−0.76†
	(0.28)	(0.23)	(0.49)
Intervention for Rebel	−1.65†	1.74**	1.40**
	(1.12)	(0.47)	(0.56)
Balanced Intervention	1.76†	−36.36**	−2.65*
	(1.36)	(1.07)	(1.21)
Separatist	0.96	−0.09	8.17**
	(1.04)	(1.70)	(2.92)
Separatist × ln(time)	−0.23†	−0.18	−1.23**
	(0.17)	(0.26)	(0.41)
War Costs	111.56	171.54**	−212.48†
	(205.39)	(63.01)	(157.83)
War Costs × ln(time)	−35.31	−33.60**	25.22
	(38.20)	(11.82)	(20.35)
Government Reputation	−1.36**	−0.67	0.14
	(0.52)	(0.58)	(0.62)
Economic Development	0.96**	0.92**	0.50†
	(0.15)	(0.22)	(0.35)
Economic Development × ln(time)	−0.17**	−0.18**	−0.08†
	(0.02)	(0.03)	(0.05)
Democracy	0.33	−0.35	−1.19
	(0.33)	(0.53)	(1.21)
Civil wars	213	213	213
Civil war failures	109	45	40
Time at risk	246,538	246,538	246,538
Spells	926	926	926
Log likelihood	−425.77	−174.08	−132.48
Wald $\chi^2_{(12,12,12)}$	79.50**	4239.04**	36.01**

Significance (one-tailed): † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$.

Robust standard errors in parentheses.

Table 3.2 : Strategic Competing-Risks Model of Civil War Duration & Outcome, 1816–1997

	Utility for Government	Utility for Rebel
Intervention for Government	-0.15	-0.16
	(0.38)	(0.43)
Intervention for Government × ln(time)	0.03	0.06
	(0.05)	(0.06)
Intervention for Rebel	-0.48^{**}	0.02
	(0.10)	(0.15)
Balanced Intervention	0.86^{**}	0.13
	(0.29)	(0.24)
Separatist	0.21	0.11
	(0.22)	(0.17)
Separatist × ln(time)	0.00	0.00
	(0.03)	(0.03)
War Costs	9.11	$67.57^{\dagger}$
	(26.04)	(44.23)
WarCosts × ln(time)	-0.78	-7.45
	(3.39)	(5.86)
Government Reputation	0.08	0.23^{*}
	(0.09)	(0.10)
Economic Development	-0.03	-0.05^{**}
	(0.03)	(0.02)
Economic Development × ln(time)	0.01^{*}	0.01^{*}
	(0.01)	(0.01)
Democracy	-0.04	0.14
	(0.10)	(0.13)
time	0.0004^{**}	0.0003^{**}
	(0.0002)	(0.0001)
time^2	$-1.23\text{e-}07^{*}$	$-7.81\text{e-}08^{**}$
	(5.39e-08)	(4.26e-08)
time^3	$8.52\text{e-}12^{\dagger}$	4.97e-12
	(5.70e-12)	(4.80e-12)
Constant	2.98^{**}	2.84^{**}
	(0.10)	(0.06)
athrho	1.38^{**}	
	(0.09)	
Number of observations	246,538	246,538
Number of zeros	85	149
Log likelihood	-1686.60	

Significance (one-tailed): † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$.
Robust standard errors in parentheses.

3.6 Appendix: Descriptive Statistics

The following table shows the descriptive statistics of the explanatory variables used in the analyses.

Table 3.3 : Descriptive statistics of the explanatory variables

Variable	Mean	Std. Dev.	Min.	Max.	N
Intervention for Government	0.172	0.378	0	1	246538
Intervention for Rebel	0.096	0.295	0	1	246538
Balanced Intervention	0.07	0.255	0	1	246538
Separatist	0.369	0.483	0	1	246538
War Costs	0.005	0.01	0	0.088	246538
Government Reputation	0.128	0.286	0	1	246538
Economic Development	6.584	3.33	0	13.896	246538
Democracy	0.092	0.289	0	1	246538
time	1646.8	1463.773	0	7395	246538

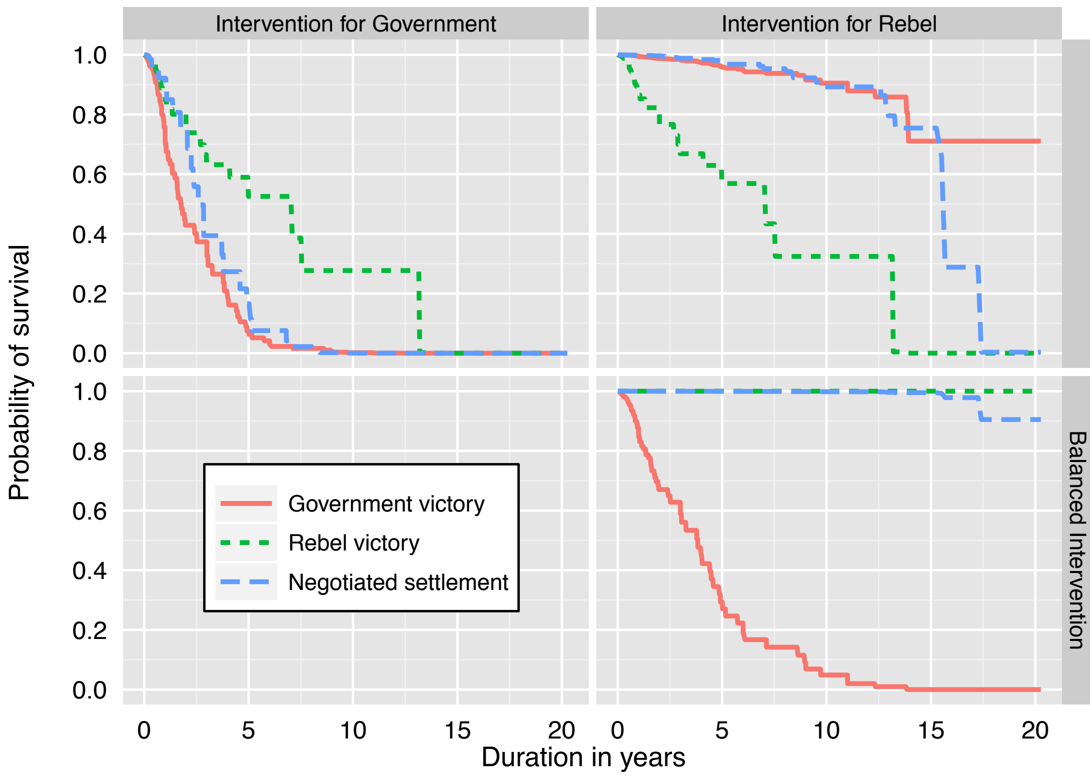

Figure 3.2 : Estimated survival functions from the independent Cox competing-risks model

(*Notes.* Survival probabilities are calculated for three intervention scenarios: Intervention for Government, Intervention for Rebel, and Balanced Intervention. Binary covariates are held at their median values, and continuous variables are held at their mean values. The results are based on the independent Cox models reported in Table 3.1.)

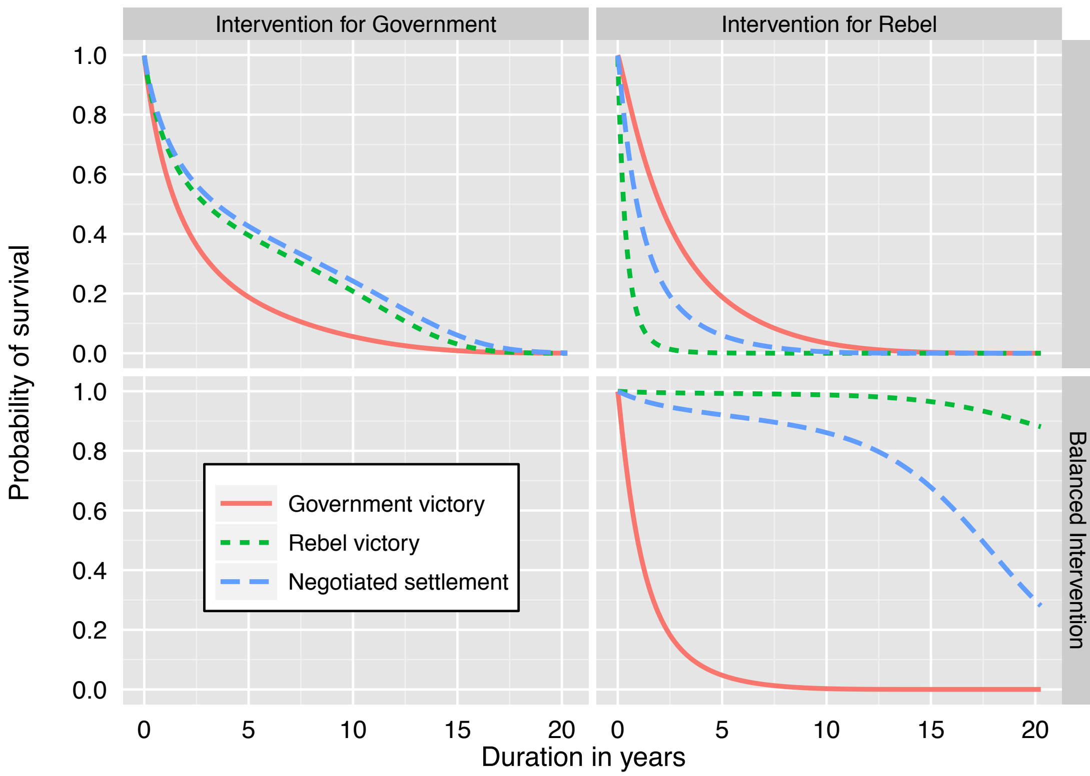

Figure 3.3 : Estimated survival functions from the SCR model

(*Notes.* Survival probabilities are calculated for three intervention scenarios: Intervention for Government, Intervention for Rebel, and Balanced Intervention. Binary covariates are held at their median values, and continuous variables are held at their mean values. The results are based on the SCR model estimates reported in Table 3.2.)

Chapter 4

The Strength of Cease-fire Agreements and the Duration of Postwar Peace

Chapter Abstract

Do stronger cease-fire agreements keep peace longer after war? Although there are theoretical reasons to expect that stronger agreements promote durable peace, the extant empirical research provides mixed support for this expectation. This paper reexamines this argument empirically, addressing two inferential problems overlooked in the past studies. First, since the strength of cease-fire agreements is endogenous to the baseline prospect for peace, I employ a copula-based two-stage estimation that explains agreement strength and peace duration jointly. Second, I allow the effect of agreement strength to vary over time. This is important because agreement strength matters little right after the war, for there exists a rough consensus among the ex-belligerents about the likely outcome of a next war. As time passes, however, the effect of agreement strength will start to show because there will be a greater chance that some exogenous shocks distort this consensus. Analyzing the duration of postwar peace from 1914 to 2001, I demonstrate that stronger cease-fire agreements indeed stabilize peace but only after a few years have passed.

4.1 Introduction

Do stronger cease-fire agreements keep peace longer after war? Are the ex-belligerents able to maintain more durable peace when they sign an agreement that incorporates institutional mechanisms designed to alter the strategic environment in which states interact with each other? Scholars of international relations have argued that international agreements can change states' behaviors even when there is no central authority that enforces an agreement. Studies have demonstrated that international agreements are not merely scraps of paper, but can indeed constrain states' behavior and promote cooperation even in the absence of direct enforcement in wide range of issue areas, such as militarized conflicts (Leeds 2003), territorial disputes (Mattes 2008), human rights protection (Hathaway 2002), monetary affairs (Simmons 2000), and environmental protection (Young 1999). Fortna (2003, 2004) argues that stronger cease-fire agreements, characterized by mechanisms such as confidence building measures, dispute settlement procedures, peacekeeping forces, etc., are able to help ex-belligerents overcome the obstacles to peace, hence prolonging the duration of peace after war.

However, although we have good theoretical reasons to believe that stronger cease-fire agreements promote durable peace, empirical findings on this relationship are rather mixed. On the one hand, Fortna (2003, 2004) finds empirical support for her argument using data on duration of peace after interstate wars for the period from 1946 to 1998. On the other hand, subsequent studies have provided little support for this relationship. Analyzing the data from the same period, Werner & Yuen

(2005) find a weak relationship or no effect of agreement strength, depending on the specification. Moreover, a recent study by Lo, Hashimoto & Reiter (2008) also finds no effect using an expanded data set that covers the interstate wars from 1914 to 2001.

This paper reevaluates this argument empirically and demonstrates that agreement strength indeed prolongs postwar peace duration. In doing so, I address two inferential problems that have troubled previous studies. The first challenge in uncovering the true effect of agreement strength is that agreement strength is endogenous to the prospect for peace: ex-belligerents will seek to reach stronger cease-fire agreements when they have more fragile prospect for peace. This means that, if we fail to correct for this endogeneity, our estimate will be negatively biased. To address this issue, I develop an empirical strategy that allows me to estimate the effect of agreement strength in the face of endogeneity. The second inferential challenge is that the effect of agreement strength will be likely to vary over time as the underlying conditions change.

The remainder of the paper is organized as follows. In the next section, I explain the theoretical reasons as to why we should expect stronger cease-fire agreements to foster longer peace after war. Then, the following section discusses two inferential problems that have plagued previous empirical efforts. I will then introduce a research design that addresses both of the problems, and present the empirical results. The last section concludes with policy implications. The results of this study should be encouraging to policy makers concerned with conflict management. Well designed agreements can enhance the prospect for peace even under difficult circumstances.

4.2 Why Stronger Agreements Promote Peace

Why does war occur? This has been one of the most important questions that concerns scholars of international relations for a long time. Thanks to the development of bargaining theories, the past two decades have seen a significant development in the scholarly efforts to answer this question. The bargaining model of war attributes the causes of war to a failure of pre-war bargaining between disputants. Given that war is costly and most wars end in an agreement, under broad conditions, there exists a bargain (division of the disputed good) that can make both sides better off than fighting. The bargaining model of war maintains that pre-war bargaining can break down in costly fighting when 1) disputants have uncertainties about the underlying balance of power (and hence about the outcome of war), or 2) disputants cannot commit to following through an agreement under anarchy (Fearon 1995).

One of the strengths of the bargaining model of war is that it can not only explain the outbreak of war but also provide insight into duration, termination, and recurrence of war. Logical consistency of an argument requires that the "causes" of a war must be resolved for the war to end (Wagner 2000). If states fight because both sides are uncertain about the other side's military power, for example, then fighting must contribute to a resolution of this uncertainty, and the war ends when both sides have learned the other side's strength and neither side has incentive to continue fighting. This means that, at war's end, the disputants must be both 1) in agreement about the underlying power balance and 2) capable of committing to following through on a cease-fire. This argument further implies that postwar peace may break down in another war when the underlying conditions that have led to a termination of fighting change in the future (Werner 1999).

War is not always inevitable, however, even when such a change in underlying conditions arises and the war-ending settlement becomes obsolete after war. One viable way for ex-belligerents to maintain stable postwar peace in the face of changing conditions is to devise strong cease-fire agreements that have institutional mechanisms that help them resolve bargaining problems that may arise in the future. For example, some cease-fire agreements incorporate institutional devices such as dispute settlement mechanisms or confidence building measures that will provide the ex-belligerents with information about the actions and intentions of the other side, thus reducing uncertainties that may precipitate violence. Those agreements that are characterized by the presence of third-party involvement or peacekeeping force will enhance ex-belligerents' ability to commit to compliance with the cease-fire by raising the reputational cost or audience cost of noncompliance. In addition, Fortna (2003, 2004) argues that stronger cease-fire agreements can also contribute to longer peace by controlling accidents. Those agreements that incorporate arms control provisions, confidence building measures, demilitarized zones, or specify treaty obligations in more precise wordings, will be able to prevent accidents or involuntary defection from happening, or prevent such accidents from escalating into more violent conflicts.

Given that it would be costly for the disputants to negotiate and implement these mechanisms, it is highly unlikely that the disputants would bother signing stronger agreements if they do not expect agreement strength to make a difference.

Nevertheless, previous studies have been unable to find a robust relationship between agreement strength and the duration of postwar peace. Whereas Fortna's (2003, 2004) initial statistical analyses that cover the period from 1946 to 1998 lend support for this expectation, subsequent studies have found little support. Analyzing the same time period, Werner & Yuen (2005) find that agreement strength matters little once they control for the conditions under which bargaining obstacles are particularly likely to arise. They conclude that institutional devices incorporated in cease-fire agreements may not be strong enough when the war-ending settlement becomes obsolete. Moreover, a recent study by Lo, Hashimoto & Reiter (2008) extends the time frame of Fortna's (2003, 2004) original dataset and finds that agreement strength has no effect on postwar peace duration.

I argue that the lack of empirical support for this relationship is because previous studies do not offer a fair test of the theoretical argument. The next section discusses two inferential problems that have plagued previous research and offers a way to overcome these problems.

4.3 Two Problems with Existing Studies

The first inferential problem is that the strength of agreements is not randomly assigned but strategically determined by the disputants, which generates an endogeneity problem. As Fortna (2004) demonstrates, the disputants will seek to sign stronger agreements when they face a fragile prospect for peace after war. Then, if we do not control for this process of self-selection into stronger agreements, there will be negative bias in our estimate of the effect of agreement strength. Figure 4.1

illustrates this problem graphically. The theoretical argument suggests that stronger agreements prolong the duration of postwar peace, implying positive correlation between the two observable variables in the Figure, Strength of Agreement and Duration of Postwar Peace. However, the endogeneity of agreement strength can make it difficult for us to find the implied positive correlation. Suppose that the disputants tend to sign stronger cease-fire agreements when they expect that the underlying conditions are likely to fluctuate, thus the prospect for peace is fragile. This means that there will be a positive correlation between Strength of Agreement and Fragile Prospect for Peace. Then, if the disputants have, on average, correct estimates about their future prospect for peace, the correlation between Fragile Prospect for Peace and Duration of Postwar Peace should be negative. In situations like this, if we fail to control for Fragile Prospect for Peace in our regression analysis, the estimated effect of Strength of Agreement on Duration of Postwar Peace will be smaller than it actually is. The challenge for inference here is that the disputants' expectation (Fragile Prospect for Peace) is unobservable to the researcher, and hence difficult if not impossible to control for.

Recognizing this endogeneity, researchers have tried to alleviate the problem by controlling for *observable* variables that are supposedly correlated with the unobservable fragile prospect for peace. However, it is impractical to assume that a researcher can control for all the variables that are associated with the unobservable prospect for peace. Therefore, it is likely that, even after controlling for the observables, there exist some unobservable factors that are negatively correlated with the duration of peace and positively influencing the strength of agreement. If we fail to control

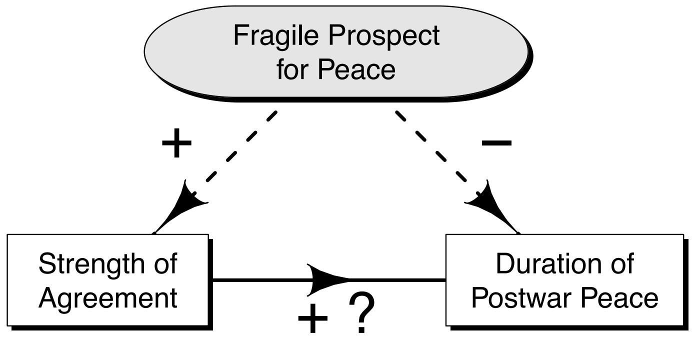

Figure 4.1 : Endogeneity of agreement strength

(*Notes.* This figure graphically illustrates the endogeneity problem. Observable variables (Strength of Agreement and Duration of Postwar Peace) are shown in white squares, and an unobservable variable (Fragile Prospect for Peace) is shown in a gray ellipse.)

for such unobservables, our empirical results will still be biased against finding the expected positive effect of stronger agreements on peace duration.

The second problem is that the existing studies have assumed that the effect of cease-fire treaties is constant over time, although the effect of agreement strength will probably vary over time. In fact, we have theoretical reasons to believe that the effect of agreement strength will depend on the underlying conditions that change over time. In the context of international agreements that promote peaceful settlement of territorial disputes, Mattes (2008) demonstrates that the conflict reducing effect of such agreements is much greater when the underlying conditions have changed since the time of signing of agreements.

Applying the logic of Mattes's (2008) theoretical argument, we should expect that the effect of cease-fire agreement will grow stronger as time passes. Immediately after a war ends, there will exist a rough consensus among the ex-belligerents about the distribution of power between them, and hence about the likely outcome of a next war should one happen. From the viewpoint of the bargaining theory of war discussed above, this convergence of expectation is the very reason why the disputants stop fighting in the first place (Wagner 2000). This means that, right after the war ends, there are few sources of bargaining problems, and so, the agreement strength will probably not make much of a difference. However, as time passes, there will be a greater chance that some exogenous shocks distort this consensus, creating bargaining problems. It may be the case that some new issues to fight over arise between the ex-belligerents, or a more hawkish leader comes into power in one country who sees greater benefit in challenging the previously agreed status quo, or one country's military power grows faster than that of the other country, which creates dynamic commitment problems. These are the situations in which the agreement strength will make a greater difference. In other words, the agreement strength will only be truly tested after the underlying conditions change over time. Therefore, by treating the effect of agreement strength to be constant over time, the existing empirical tests have been biased against finding support for the theoretical expectation.

4.4 The Empirical Strategy

To address these two inferential challenges discussed above, I develop a research design that endogenizes agreement strength and relaxes the assumption of a time-constant effect of agreement strength. The first problem is addressed by constructing a full-information maximum likelihood estimator that jointly estimates agreement strength and peace duration. The second problem is addressed by including an interaction term between time and the strength of agreement, thus allowing the effect of agreement strength to vary over time. In what follows, I present a statistical model that I have developed to estimate the effect of agreement strength on peace duration in the presence of the endogeneity problem.

Statistical Model

The statistical model is an extension of the procedures utilized to address endogenous treatment, and shares similar features with other multivariate statistical models that control for endogeneity (c.f., Angrist & Pischke 2009, Ch.4). The approach is to estimate agreement strength and postwar peace duration jointly, while controlling for the correlation between the two processes. I begin by characterizing the disputants' latent propensity to reach stronger agreements at war's end, and then the duration of postwar peace. I then show how a separate estimation of each can lead to bias, and derive a statistical model that corrects for it.

Let s^* denote the belligerents' unobserved propensity to reach stronger agreements. I assume it takes the following form:

$$S^* = z\gamma + \mu \tag{4.1}$$

where μ follows a Poisson distribution, z is the vector of independent variables, and γ is the vector of coefficients. We do not observe S^*. Instead, we observe s, which takes integer numbers greater than or equal to zero. s has a univariate distribution function denoted as $F_s(\cdot)$ Then, let T denote the random variable that describes the duration of postwar peace. We assume that it is a function of agreement strength, s, and other covariates. It thus takes the following form:

$$\log(T) = s\beta + x\alpha + \epsilon \tag{4.2}$$

where ϵ follows a log-Normal distribution, β is the effect of agreement strength, x is the vector of independent variables, and α is the vector of coefficients.

As discussed above, I suspect that belligerents may want to sign stronger agreements when they have a more fragile prospect for peace. This means that the part of the agreement strength that is unaccounted for by independent variables, μ, will be negatively correlated with the duration of postwar peace. Suppose, for example, the disputants have an unusually fragile prospect for peace. Then, μ in equation (4.1) will take an unusually high value, whereas ϵ in equation (4.2) will take an unusually low value. This means that, unless we account for this correlation between the two error terms, we will underestimate β in equation (4.2), the effect of agreement strength, because part of the effect of ϵ on T will be picked up by β. In other words, we will incorrectly attribute to β the effect of any part of ϵ that is correlated with μ.

To correct for such dependence between two processes, I construct a unified model that jointly estimates equations (4.1) and (4.2). The joint model has the following likelihood function:

$$\mathcal{L} = \prod_{i=1}^{n} \prod_{S_i^*=0}^{S_i^*=s_i} \Pr(S_i^* = s_i \cap T_i > t_i^0)^{A_i} \Pr(S_i^* = s_i \cap T_i = t_i)^{(1-A_i)}, \tag{4.3}$$

where A_i is the right-censoring indicator that takes the value of 1 when the observation is right-censored and 0 otherwise. To specify this likelihood function, we must be able to characterize two joint distributions that appear in equation (4.3). The challenge here is that it is not straightforward to write down a joint distribution of two random variates that are of different distribution families (in our case, Poisson and log-Normal). This is done by utilizing a copula function. A copula is a function that parameterizes the dependence between univariate marginal distributions to form a joint distribution function (Trivedi & Zimmer 2005). Consider two random variables x and y with associated univariate distribution functions $F_x(\cdot)$ and $F_y(\cdot)$. Sklar's (1959) theorem establishes that there exists a copula $C(\cdot,\cdot,;\theta)$ such that a bivariate joint distribution is defined for all x and y in the extended real line as

$$F_{xy}(x, y) \equiv \Pr(x < x^* \cap y < y^*) = C\left\{F_x(x^*), F_y(y^*); \theta\right\} \tag{4.4}$$

where the association between the two marginal distributions is represented by the association parameter, θ. This result is remarkable because it shows we can construct a new bivariate distribution based on univariate marginal distributions of known form. As long as the univariate marginal distributions are known, an appropriate choice of copula function C in (4.4) enables one to represent the unknown joint distribution.

Then, the first component of the likelihood function, the probability that disputants reach an agreement with strength s_i and then peace has not lasted until the right-censoring point, t_i^0, is obtained as

$$\begin{aligned}\Pr(S_i^* = s_i \cap T_i > t_i^0) &= \Pr(S_i^* < s_i \cap T_i > t_i^0) - \Pr(S_i^* < s_i - 1 \cap T_i > t_i^0) \\ &= \Pr(S_i^* < s_i) - \Pr(S_i^* < s_i \cap T_i < t_i^0) \\ &\quad - \left[\Pr(S_i^* < s_i - 1) - \Pr(S_i^* < s_i - 1 \cap T_i < t_i^0)\right] \\ &= F_s(s_i) - F_s(s_i - 1) - C\left\{F_s(s_i), F_t(t_i^0); \theta\right\} + C\left\{F_s(s_i - 1), F_t(t_i^0); \theta\right\}\end{aligned}$$

where F_s is the Poisson distribution function that characterizes agreement strength, and F_t is the distribution function that characterize postwar peace duration. Note that, as the agreement strength is measured as integer values, $\Pr(S^* = s_i)$ is obtained as $\Pr(S^* < s_i) - \Pr(S^* < s_i - 1)$.

The second component of (4.3), the probability that disputants reach an agreement with strength s_i and then a next war recurs at t_i is obtained by applying the Bayes' rule and taking derivatives of the joint distributions, as

$$\begin{aligned}\Pr(S_i^* = s_i \cap T_i = t_i) &= \Pr(S < s_i \cap T_i = t_i) - \Pr(S < s_i - 1 \cap T_i = t_i) \\ &= \Pr(S < s_i | T_i = t_i) \times f_t(t_i) - \Pr(S < s_i - 1 | T_i = t_i) \times f_t(t_i) \\ &= \left[\frac{\partial C\left\{F_s(s_i), F_t(t_i); \theta\right\}}{\partial F_t(t_i)} - \frac{\partial C\left\{F_s(s_i - 1), F_t(t_i); \theta\right\}}{\partial F_t(t_i)}\right] \times f_t(t_i)\end{aligned}$$

where f_t is the density function for peace duration.

The last step to complete the derivation of the likelihood function (4.3) is to choose a particular copula function, $C(,;\theta)$. There exist a number of different copula functions that we can use to characterize a multivariate distribution (Trivedi &

Zimmer 2005), but some copulas are simpler and easier to handle than others, while simpler copulas tend to be less flexible. For example, perhaps the simplest copula function is the product copula that takes the following form: $C(F(x), G(y); \theta) = F(x) * G(y)$. This copula simply multiplies two marginal distribution functions to generate a joint distribution, assuming that the two marginal distributions are independent ($\theta = 0$). For another example, some copulas, such as the Clayton copula, only allow positive correlation between the marginal distributions. In this paper, I use the Gaussian copula function. This copula is one of the most flexible copula functions that allow for both positive and negative dependency to the maximum extent. It takes the following form

$$C(u, v; \theta) = \int_{-\infty}^{\Phi^{-1}(u)} \int_{-\infty}^{\Phi^{-1}(v)} \frac{1}{2\pi(1-\theta^2)^{1/2}} \exp\left[\frac{-(s^2 - 2\theta st + t^2)}{2(1-\theta^2)}\right] dsdt$$

where $\Phi^{-1}()$ is the Gaussian quantile function, $-1 < \theta < 1$ is the association parameter, and $u = F_x(x)$ and $v = F_y(y)$ are the marginal distributions for random variables x and y. I chose the Gaussian copula for a number of reasons. Although taking a relatively simple form, the Gaussian copula is *comprehensive*, meaning that it can fully accommodate perfect negative dependence ($\theta = -1$) and perfect positive dependence ($\theta = 1$). Relatedly, the association parameter allows for independence as a special case ($\theta = 0$). This allows us to test the existence of endogeneity by testing whether θ is statistically distinguishable from 0.

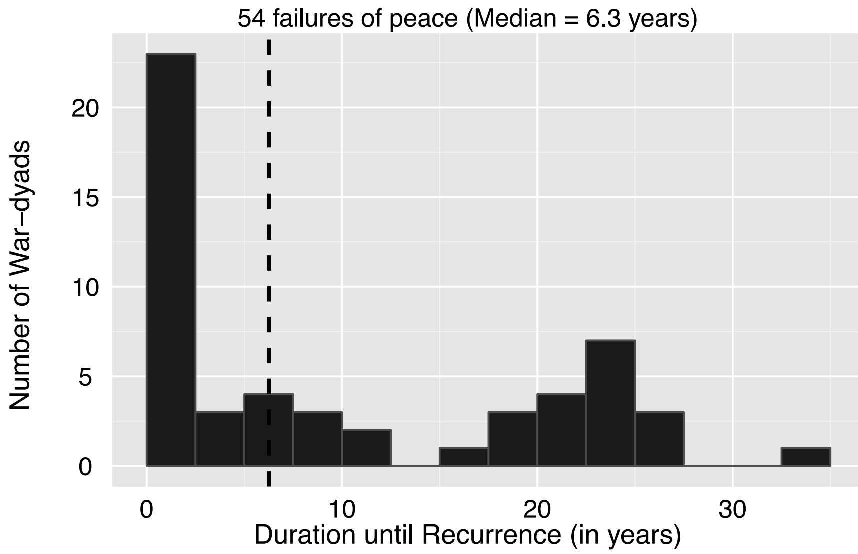

Figure 4.2 : Duration of post-war peace

(*Notes.* This figure shows the histogram of observed (i.e., non-censored) duration of peace following interstate wars, 1914–2001. The horizontal axis shows the duration of peace until war recurrence measured in years, and the height of the bars shows the number of war-dyads that have a given duration.)

The Data

To estimate the likelihood function (4.3), this paper utilizes the dataset on post-war peace duration and the strength of peace agreements originally developed by Fortna (2003, 2004) and supplemented by Lo, Hashimoto & Reiter (2008). The unit of observation in the dataset is a war-dyad, a pair of countries that fought an interstate war against each other. The outcome variable measures the duration of peace following wars that began from 1914 to 2001. There are 52 wars in the dataset, involving 186 war-dyads. Among the 186 war-dayds, 54 "failures" of peace are observed. For the remaining 132 observations, post-war peace has not broken down yet as of the end of 2001 and thus they are treated as right-censored. Figure 4.2 shows the distribution of observed duration of post-war peace for the 54 non-right-censored cases. The vertical dashed line is drawn at the median (6.3 years). We can see that more than a half of the "failures" (recurrence) occurred in less than 5 years, whereas some cases, mainly from the first world war, have recurred after more than 20 years.

Table 4.1 : Agreement strength: Constituent variables and their measurements

Variable Name	**Measurement**
Formalism	0 = no declared cease-fire, or tacit or informal acceptance of cease-fire 1 = formal acceptance of cease-fire proposal or agreement
Withdrawal of Forces	0 = none 1 = partial, to status quo ante, or beyond
Demilitarized Zones	0 = none 1 = demilitarized zone
Arms Control	0 = none 1 = arms embargo, limits near cease-fire line, specific weapons prohibited
Peacekeeping	0 = none .5 = monitoring (unarmed military observers) 1 = peacekeeping forces (armed)
External Involvement	0 = none .5 = mediate cease-fire, restraint, patron, etc 1 = explicit or well-understood guarantee of peace
Paragraph Count	0 = 0 paragraph 1/3 = 1–20 paragraphs 2/3 = 21–80 paragraphs 1 = over 80 paragraphs
Internal Control	0 = none .5 = stated responsibility for actions from own territory 1 = concrete measures to ensure control
Confidence Building Measures	0 = none 1 = military info exchanged, hot line, onsite or aerial verification
Dipute Resolution	0 = none .5 = ongoing third-party mediation 1 = joint commission of belliegerents

Source: Fortna (2003, 2004).
Index of agreement strength is constructed by summing all these ten variables.

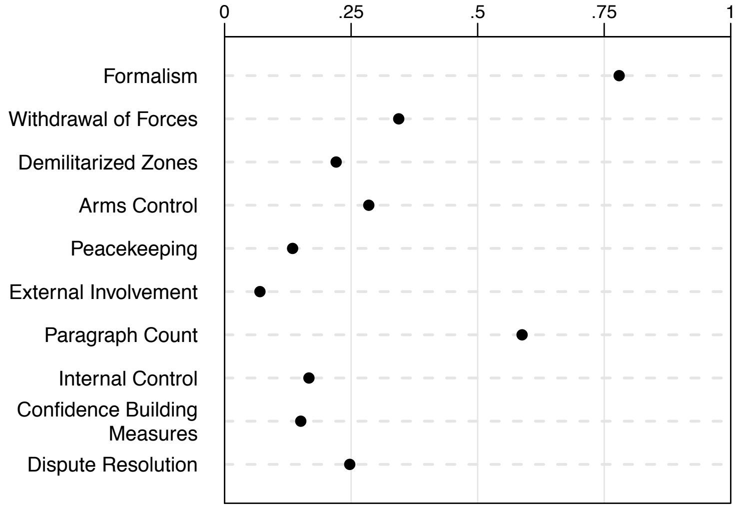

Figure 4.3 : Agreement strength: Mean values of each constituent variable (*Notes.* This figure shows the mean values of ten variables that comprise the index of agreement strength.)

The key explanatory variable of this study is the strength of peace agreements reached by war-dyads. Fortna (2003, 2004) operationalizes this variable as an index of various mechanisms implemented, such as demilitarized zone, arms control measures, peacekeeping force, etc., for a period of 1945–1998. In a subsequent study, Lo, Hashimoto & Reiter (2008) expanded the time frame of the dataset for a period of 1919–2001 by using the same codebook developed by Fortna (2003, 2004). Overall, the dataset contains information about 136 peace agreements, including cease-fire agreements and follow-up agreements. Table 4.1 describes the measurement of the ten mechanisms that comprise this index. Figure 4.3 presents mean values of each variable. As there are ten constitutive variables, each of which varies from 0 to 1, the agreement index varies from 0 to 10. [1] Figure 4.6 in the Appendix shows the histogram of agreement index.

Estimation of the likelihood function (4.3) requires two sets of independent variables, as shown in equations (4.1) and (4.2). The first set of independent variables, z in equation (4.1), explain agreement strength. For this equation, I draw on Fortna's (2004) analysis of agreement strength and use the same independent variables in her analysis. The second set of independent variables, x in equation (4.2), explain the duration of postwar peace. For this equation, I use the same sets of independent variables used in Lo, Hashimoto & Reiter's (2008) analysis of peace duration in order to make the results comparable with past studies.

Estimation Results

Table 4.2 reports the maximum likelihood estimates of coefficient parameters. It shows five sets of coefficients from four different models. Estimates under the first column are for the equation (4.1) explaining agreement strength as a Poisson process, and those under the second to the fifth columns represent the parameter estimates for the equation (4.2) explaining postwar peace duration as a Weibull process. As the coefficients for the duration process are shown in the accelerated failure time metric, positive estimates are associated with longer durations. Models 1 and 2 (under the second and the third columns) do not account for the endogeneity of agreement strength by ignoring the equation (4.1), whereas models 3 and 4 (under the fourth and the fifth columns) correct for the endogeneity by jointly estimating

[1] In the actual estimation, the index is multiplied by 6 so that it takes only integer values. This involves no loss of generality.

equations (4.1) and (4.2). We can see that the estimated correlation between the error terms in agreement strength and peace duration is negative in both models 3 and 4, suggesting that, all else equal, the disputants sign stronger agreements when they face a fragile prospect for peace. This is consistent with my argument that agreement strength is endogenous to the fragile prospect for peace.

Among the four models shown in Table 4.2, the main focus of this study is model 4, as this is the one that truthfully captures my theoretical argument. I report the results from the other models to facilitate a comparison between my results and those from the past studies. The result reported in the second column (Model 1) is essentially a replication of Lo, Hashimoto & Reiter (2008) using a Weibull duration model. [2] The result under this column shows that agreement strength does not matter if we ignore the endogeneity and assume that the effect of agreement strength is time constant. The second model includes an interaction term between agreement strength and time, which allows the effect of agreement strength to vary over time. Nevertheless, the estimated effect of agreement strength and its time interaction are both statistically indistinguishable from zero. The third model corrects the endogeneity, but forces the effect to be constant over time.

[2] Lo, Hashimoto & Reiter (2008) use a Cox semi-parametric model, which does not require assumptions about the shape of the hazard. Although Cox model is more flexible, parametric duration models, such as Weibull model, are more efficient when the distributional assumptions are correct. I chose Weibull model based on specification tests. That said, specification choice does not make much of a difference in this particular application: the result shown in the second column is substantively identical with the result from the Cox model reported in the first column of Table 4.1 in Lo, Hashimoto & Reiter (2008).

Table 4.2 : Models of agreement strength (Poisson) and postwar peace duration (Weibull)

	Agreement Strength	**Postwar Peace Duration**			
		Separate Estimation		Joint Estimation	
		Model 1	Model 2	Model 3	Model 4
Agreement Strength		0.01	−0.03	−0.48	−0.45**
		(0.01)	(0.09)	(0.37)	(0.04)
Agreement Strength × log(time)			0.01		0.03**
			(0.01)		(0.00)
Foreign-Imposed Regime Change	−0.54**	115.96	117.34**	14.32**	6.60**
	(0.12)	(77.77)	(56.88)	(6.32)	(3.12)
FIRC × log(time)		−11.85	−11.99**	−1.87**	−0.84**
		(7.83)	(5.80)	(0.68)	(0.33)
Change in Capabilities		−0.35	−0.32	2.43**	1.85**
		(0.29)	(0.28)	(1.17)	(0.59)
Battle Consistency		0.68	0.68	1.00**	0.20
		(0.43)	(0.46)	(0.50)	(0.18)
Interrupted War		−0.04	−0.02	−0.84	−0.01
		(0.39)	(0.35)	(0.76)	(0.28)
One Democracy		−0.06	−0.07	1.85**	0.38**
		(0.33)	(0.35)	(0.52)	(0.19)
Joint Democracy		−7.22**	−6.61**	−11.84**	−1.40
		(2.92)	(2.26)	(2.68)	(1.09)
Joint Democracy × log(time)		1.55**	1.43**	1.39**	0.19
		(0.70)	(0.47)	(0.29)	(0.12)
Tie	−0.28**	−0.70*	−0.63	2.62**	1.14**
	(0.07)	(0.42)	(0.47)	(0.72)	(0.29)
War Deaths	0.54**	0.22**	0.21*	0.69**	0.17**
	(0.04)	(0.09)	(0.11)	(0.14)	(0.05)
Conflict History	0.81**	−0.35	−0.34	−0.64	−0.32
	(0.05)	(0.45)	(0.40)	(0.76)	(0.29)
Stakes	−0.27**	−0.87**	−0.81*	−2.30**	−0.80**
	(0.06)	(0.36)	(0.49)	(0.52)	(0.20)
Contiguity	0.01	−7.15**	−6.30*	−8.30**	0.30
	(0.02)	(1.08)	(3.46)	(1.52)	(0.79)
Contiguity × log(time)		0.71**	0.62	0.96**	−0.01
		(0.14)	(0.40)	(0.16)	(0.08)
Multilateral War	−15.15				
	(1304.10)				
Balance of Power	0.26**				
	(0.04)				
U.S. Belligerent	−0.04				
	(0.07)				
Constant	−2.65**	9.35**	9.16**	20.53**	13.65**
	(0.44)	(0.90)	(1.35)	(2.08)	(0.89)
log(p)		−0.00	0.06	−1.32**	−0.47**
		(0.20)	(0.28)	(0.14)	(0.14)
athrho		0	0	−0.72**	−0.82**
		(assumed)	(assumed)	(0.03)	(0.02)
Log likelihood		−18504.22	−18503.86	−18188.45	−18141.76
AIC		37042.45	37043.72	36412.90	36321.51

Robust standard errors in parentheses. 186 subjects, 6368 observations. * $p < 0.10$, ** $p < 0.05$

Since agreement strength is interacted with the natural log of analysis time in the main model (model 4), the *implied* coefficient for agreement strength can vary over time. More specifically, the implied coefficient for agreement strength at time t is the sum of its linear coefficient (-0.45) and the product of the natural log of time t and the coefficient (0.03) for the interaction term. This means that, at time 0 (immediately after the war ends), the implied coefficient for agreement strength is equal to the linear coefficient, but as time passes, the implied coefficient grows larger. It is important to note, however, that, in multi-equation, non-linear statistical models such as this model, a coefficient is not necessarily equal to the substantive effect of the variable on the outcome variable of interest. In fact, when the correlation between multiple equations is not zero and an independent variable appears in more than one equation, it is often the case that the magnitude, sign, and statistical significance of the substantive effect of the variable are different from its coefficient (Greene 2003, 783). Therefore, to illustrate the estimated impact of agreement strength on postwar peace duration, I calculate the change in probabilities of continued peace corresponding to a small change in agreement strength.

Figure 4.4 presents the estimated effect of agreement strength on peace duration over time obtained from Model 4. The horizontal axis shows time, measured in years, and the vertical axis represents the increase in conditional probabilities of continued peace at time t when we change the value of agreement strength from 2 to 3. The solid curve shows the point estimate, and the gray shade around the curve shows the 95 % confidence intervals of the estimate. [3] As we can see, the confidence intervals

[3] To obtain confidence intervals, I follow the approach proposed by King, Tomz & Wittenberg

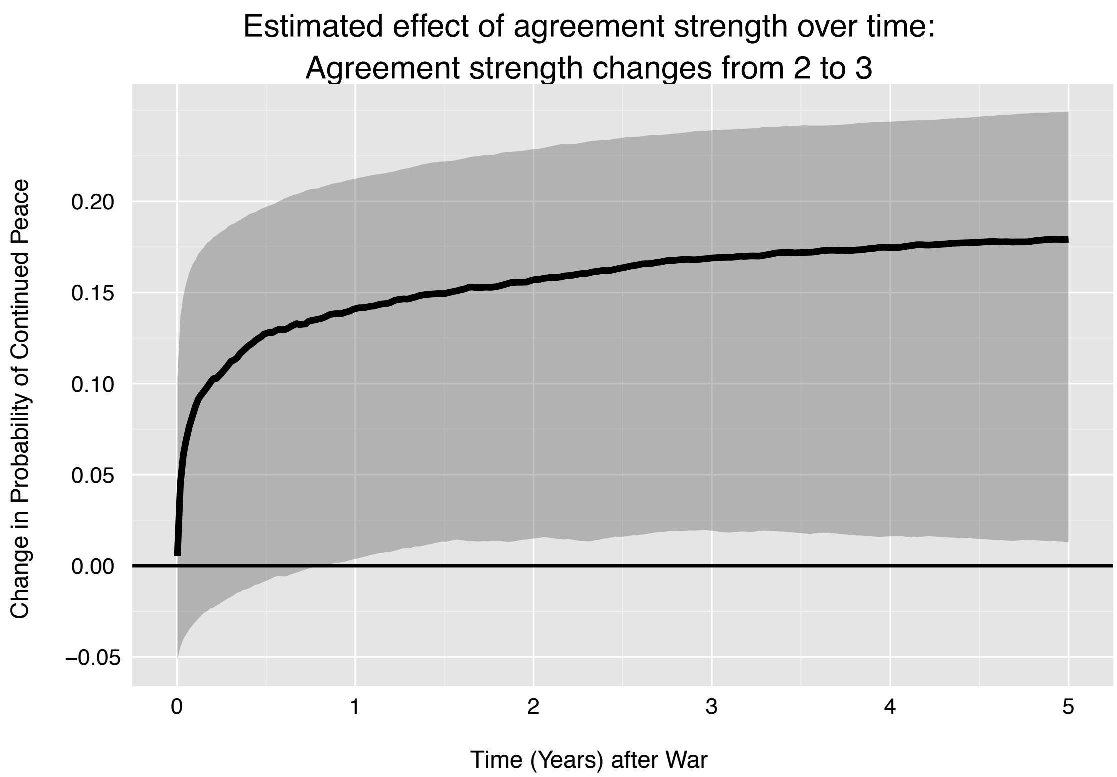

Figure 4.4 : Substantive effect of agreement strength

(*Notes.* This figure shows the estimated impact of agreement strength on postwar peace duration from Model 4. The horizontal axis shows time after war, and the vertical axis shows the increase in conditional probabilities of continued peace at time t corresponding to an increase in the value of agreement strength from 2 to 3. The solid curve shows the point estimate, and the gray shade around the curve shows the 95% confidence interval of the estimate.)

contain zero immediately after a war ends. This means that, immediately after a

(2000). Specifically, I first generate 1,000 sets of model parameters by randomly drawing from a multivariate Normal distribution characterized by the estimated parameter and the variance-covariance matrix. I then calculate the conditional probabilities of peace survival for a given agreement strength at a given time using the simulated parameters. The values of the control variables are held constant at their median values. The 50th percentile values are the point estimates, and the 2.5th and 97.5th percentile values are the lower and the upper bounds of the 95% confidence interval.

war ends, agreement strength has no statistically discernible effect on postwar peace duration. In less than a year after war, however, the effect becomes statistically significant. The improvement in the prospect for peace is substantively significant as well. For example, a one unit increase in agreement strength (from 2 to 3) leads to about 15 percentage point increase in the probability of continued peace one year after war. This improvement translates into about 7-year longer peace after one year.

Figure 4.5 displays the results of the same calculation from four different models shown in Table 4.2. The top two panels show the results for models that correct for endogeneity, and the left two panels show the results for models where agreement strength is allowed to have time-varying effect. That is, the top-left panel corresponds to Model 4, the top-right panel to Model 3, the bottom-left to Model 2, and the bottom-right to Model 1. We can see that the effect of agreement strength is estimated positive only in Model 4 that addresses both of the two inferential problems I identified.

4.5 Conclusion

This paper provides a reassessment of the relationship between the strength of ceasefire agreements and the duration of postwar peace. While past studies have provided mixed support for the theoretical argument, this study identifies conditions under which stronger agreements are likely to promote more durable peace. Specifically, I theorize that agreement strength will have the anticipated positive effect on the prospect for peace only after a certain period of time has passed and the underlying conditions have changed. The statistical results confirm this expectation: ex-

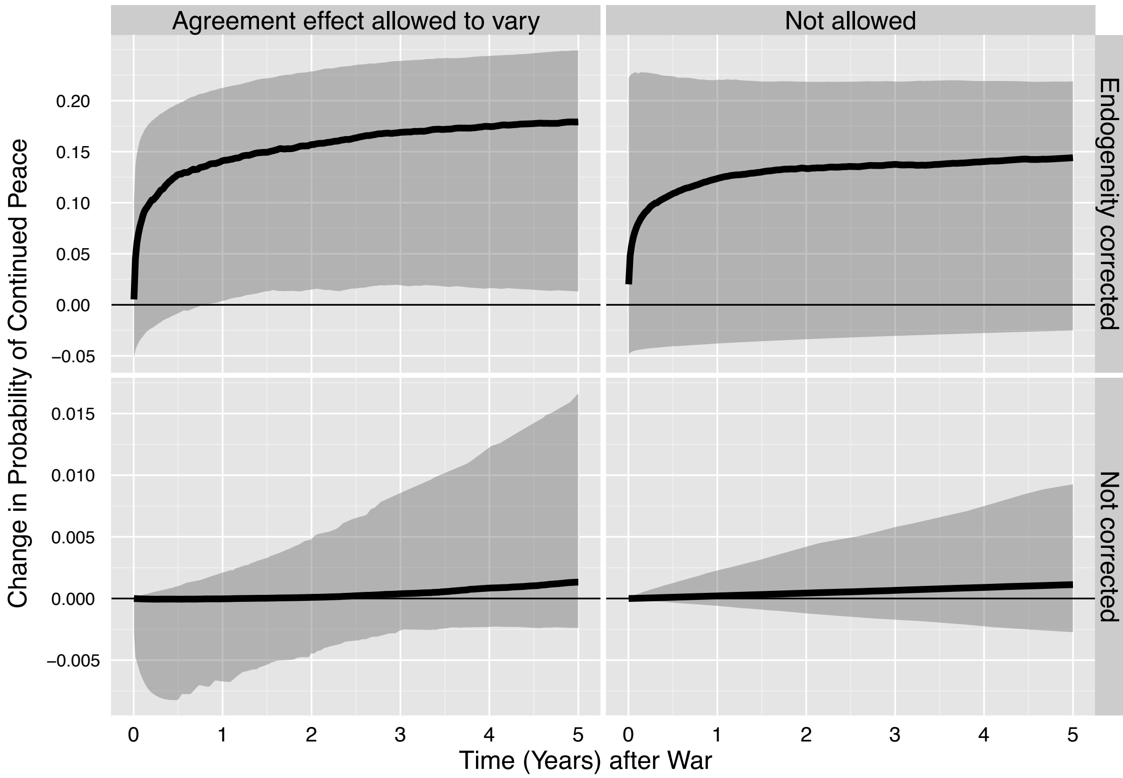

Figure 4.5 : Comparison of results from four different models

(*Notes.* This figure shows the estimated effects of agreement strength obtained from Models 1 to 4 in Table 4.2. The top two panels show the results from joint estimation that corrects endogeneity, and the left two panels show the results from estimation where the effect of agreement strength is allowed to vary. The top-left panel replicates Figure 4.4, which is based on Model 4; the top-right panel corresponds to Model 3, the bottom-left to Model 2, and the bottom-right to Model 1.)

belligerents who are able to reach stronger cease-fire agreements will nevertheless experience precarious peace for up to a few years, but after this period is passed, they will be able to maintain more durable peace than if they reach weaker agreements. I have also shown evidence that agreement strength is endogenous to the baseline prospect for peace. The negative and statistically significant estimate of the correlation parameter clearly indicates that the disputants tend to sign stronger agreements when *unobservable* factors suggest to them that they will experience shorter durations of peace. This finding is not only consistent with Fortna's (2004) argument but also provides additional support for her finding that *observable* correlates of peace duration are associated with agreement strength. More importantly, once we correct for the endogeneity appropriately, stronger cease-fire agreements are indeed found to keep peace longer, but only after certain length of time.

The finding about the increasing effect of agreement strength presents an interesting contrast with the findings from conflict mediation research. Specifically, scholars of conflict mediation have reported that the effect of mediation tends to be short-lived (Beardsley 2008, Gartner & Bercovitch 2006). That is, mediated conflicts are less likely to recur in the short run, but *more* likely to recur in the long run. Beardsley (2008) argues that this is because third-party intermediaries sometimes pressure the disputants to reach a cease-fire agreement even when the disputants have not fully resolved the bargaining problem that had caused the outbreak of conflict in the first place. Such "unnatural" cease-fire agreements may maintain peace as long as the intermediaries are willing to enforce them, but third-parties often lose interests soon after immediate violence is ceased. Future research on conflict management should investigate the possibility that conflict mediation and well designed cease-fire agreements can function in a complementary fashion.

The findings of this study have important implications for policy makers. First, my results suggest that signing a stronger cease-fire agreement provides ex-belligerents with a powerful tool to increase the prospect for peace after war. Second, the results also point to a limitation in such measures. Specifically, although stronger agreements lead to more stable peace in the long run, the first several months after war will actually see a greater risk of war recurrence in the presence of such agreements. This means that the international community should pay a particularly strong attention to the ex-belligerents that have managed to craft a promising cease-fire agreement.

4.6 Appendix: Descriptive Statistics

The main explanatory variable

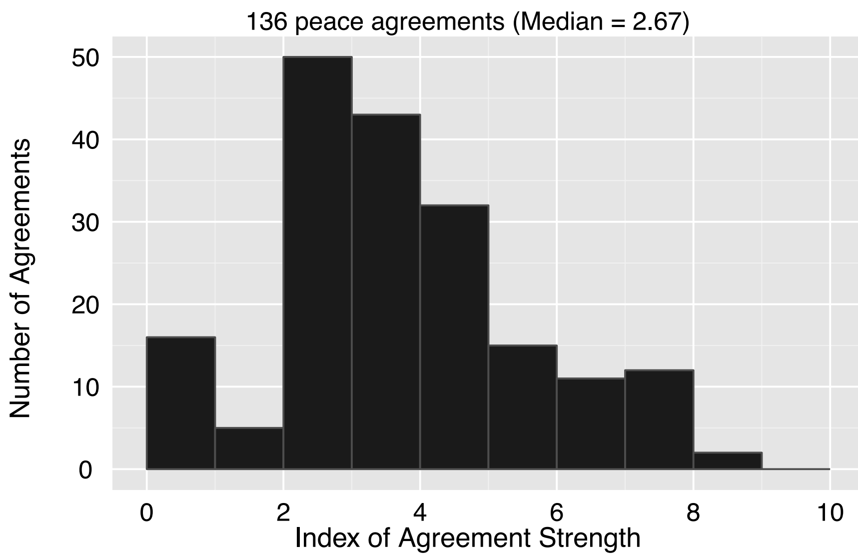

Figure 4.6 : Histogram of agreement strength index

(*Notes.* This figure shows the histogram of agreement strength index. The horizontal axis shows the value of the composite index of agreement strength, and the vertical axis shows the number of peace agreements that have a given strength.)

The main explanatory variable of this study is the strength of cease-fire agreements. This variable is originally coded by Fortna for the period between 1946 to 1997, and then later expanded by Lo, Hashimoto & Reiter (2008) using the same codebook. The data set contains information on the contents of 136 peace agreements signed by the members of the war-dyads. The agreement strength varies from 0 to 10, with 10 being the strongest agreement, and the median is 2.67. Figure 4.6

shows the histogram of agreement strength index.

Control variables

Table 4.3 below shows the descriptive statistics of the control variables shown in Table 4.2.

Table 4.3 : Descriptive statistics of control variables

Variable	Mean	Std. Dev.	Min.	Max.	N
Foreign-Imposed Regime Change	0.165	0.371	0	1	6368
Change in Capabilities	0.1	0.226	0	4.463	6368
Battle Consistency	0.385	0.417	0	1	6368
Interrupted War	0.081	0.273	0	1	6368
One Democracy	0.703	0.457	0	1	6368
Joint Democracy	0.256	0.436	0	1	6368
Tie	0.084	0.278	0	1	6368
War Deaths	10.706	2.353	5.288	16.2	6368
Conflict History	0.156	0.235	0	1.6	6368
Stakes	0.589	0.492	0	1	6368
Contiguity	0.482	0.5	0	1	6368
Multilateral War	0.903	0.296	0	1	6368
Balance of Power	0.77	0.149	0.5	0.998	6368
U.S. Belligerent	0.07	0.254	0	1	6368

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