5-1-2016

Natural Resources, Conflicts, and Conflict Management

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NATURAL RESOURCES, CONFLICTS, AND CONFLICT MANAGEMENT

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A Dissertation
Submitted in Partial Fulfillment of the Requirement for the
Doctor of Philosophy Degree in Economics

Department of Economics
in the Graduate School
Southern Illinois University Carbondale
May, 2016

DISSERTATION APPROVAL

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March 25, 2016

AN ABSTRACT OF THE DISSERTATION OF

MD. DIDARUL HASAN, for the Doctor of Philosophy degree in ECONOMICS, presented on March 25, 2016, at Southern Illinois University Carbondale.

TITLE: NATURAL RESOURCES, CONFLICTS, AND CONFLICT MANAGEMENT

MAJOR PROFESSOR: Dr. Sajal Lahiri

This dissertation examines, both theoretically and empirically, the effects of international policies, especially of sanctions, on conflicts. In theoretical analysis, we consider conflicts (both civil and inter-state) related to natural resources and examine how sanctions on natural resource exports affect the intensity of conflicts. However, for the empirical analysis, we consider only the civil conflicts and examine how international sanctions affect the duration of civil conflicts.

In chapter 1, we develop a two-period general equilibrium model on the relationship between natural resources and civil conflicts. Contrary to the most of the existing literature, we assume that resource extraction and wage rate are endogenous during the conflict. We find that the effects of current international sanctions on civil conflict depend critically on whether the budget constraints of the warring groups are binding or non-binding, and whether wage rate is exogenous or endogenous. Under both binding and non-binding budgets, the current sanction can be counter-productive. However, a threat of future sanction reduces conflict intensity, when the budget constraint is non-binding. An improvement in agricultural productivity may also limit the conflict. Our results also suggest that the most effective policy for conflict resolution would be bilateral piece-meal reduction in war efforts.

Chapter 2 develops a two-period general equilibrium model linking natural resources to inter-state conflict, treating resource extraction and wage rate are endogenous. First, we characterize the war equilibrium and derive a number of properties of it. Second, we examine the effects of different types of trade sanctions imposed by the international community on war efforts of the two countries. We find that a temporary current sanction on both countries, or even on one of the countries, will be counter-productive, and an anticipated future sanction on both countries will unambiguously reduce war intensity. Whether an anticipated future sanction on one of the countries will reduce war intensity will depend on the level of resource stock; the effect of a permanent sanction on both countries is ambiguous: war intensities will fall only if the resource stocks of the countries are sufficiently high.

Finally, in chapter 3, we examine empirically the effects of international sanctions on the expected duration of civil conflicts. Contrary to the most of the previous findings, we find that international sanctions reduce the expected duration of civil conflicts. Our finding is robust for different controls, different parametric models, and with consideration of endogeneity of sanctions. However, not all types of sanctions are equally successful in shortening conflicts. Total economic embargoes and arms sanctions are effective, but trade sanctions, aid suspension, and other sanctions do not work. We also find that both multi-lateral and unilateral sanctions (mainly U.S. sanctions) can reduce duration of civil wars.

ACKNOWLEDGMENTS

I would like to thank Dr. Sajal Lahiri for his guidance, support, and encouragement throughout my dissertation research. I would also like to thank Dr. Subhash C. Sharma, Dr. Kevin Sylwester, Dr. AKM Mahbub Morshed, and Dr. Dhrubodhi Mukherjee for all of their valuable advices and thoughtful comments. The faculty members, staffs, and fellow students of the Department of Economics at the Southern Illinois University always provided support to me during my doctoral studies. Thanks are due to all of them.

Very special thanks go to my wife, Lata, for her support on my educational endeavors, and my daughter, Disha, for lighting my world with joy and happiness. Finally, I would like express my deep gratitude to my parents for their unconditional love and support throughout my life.

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CHAPTER 1

NATURAL RESOURCES AND CIVIL CONFLICTS: POLICY ANALYSIS UNDER GENERAL EQUILIBRIUM

1.1 INTRODUCTION

Since the end of World War II almost a third of all nations has experienced civil wars, defined as intra-state war with more than 1000 battle death in a single year (Blattman and Miguel, 2010). The number of armed conflict rose steadily through the last half of twentieth century, peaking in the early 1990s, and then has been showing a declining trend (see Figure 1.1 in page 2). Most of these conflicts are intra-state or civil conflicts. Note, the incidence of civil war has been the highest in Africa, the world's poorest continent. During the last 60 years, civil conflicts have been associated with approximately 20 million deaths (Besley and Persson, 2008). Civil wars also destroy physical infrastructure and human capital, weaken the rule of law, displace hundreds of thousands of people, and cause the spread of pandemics (Crost et al., 2014). The internal conflict is not only pervasive, it is also persistent. Almost 70% of all conflicts took place in countries where multiple conflicts were recorded (Collier and Hoeffler, 2004). According to the World Development Report (2011), a civil conflict costs the average developing country roughly 30 years of GDP growth, and countries in protracted crisis can fall over 20 percentage points behind in overcoming poverty. The effects of death, destruction, and delayed development due to conflicts spill over both regionally and globally.

The abundance of natural resources has been blamed for civil conflicts in different parts of the world. Some analysts argue that natural resources are not only the lucrative prize for winner of the conflict, but also are used as source of funding during the conflict. Revenues from natural resource exports allow warring groups to hire soldiers and finance other costs of war (World Bank, 2003; Ross, 2004; Lujala et al., 2005; UN, 2005; Humphreys and Weinstein, 2008). In just the past two decades, seven African countries

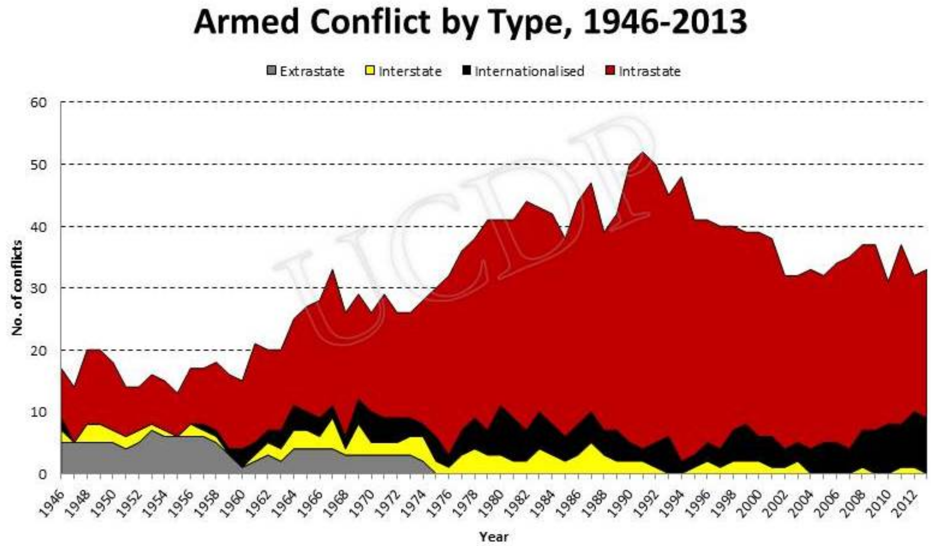

Figure 1.1: Number of Armed Conflict by Year and Type, 1946-2013

Source: UCDP/PRIO armed conflict dataset. An armed conflict is a contested incompatibility that concerns government and/or territory where the use of armed force between two parties, of which at least one is the government of a state, results in at least 25 battle-related deaths in one calendar year.

have endured brutal civil conflicts fueled by diamonds: Sierra Leone, Liberia, Angola, the Republic of Congo, Ivory Coast, the Central African Republic, and the Democratic Republic of Congo. Other examples include: gemstones have been linked to civil wars in Afghanistan, Myanmar (Burma), and Cambodia; drugs like opium and coca have fueled civil wars in Afghanistan, Myanmar, Colombia, and Peru; timber has played a vital role in the civil wars in Cambodia, Liberia, and the Republic of Congo; several oil producing states have experienced civil wars, including Angola, Colombia, Morocco, Nigeria, and Sudan (Le Billon, 2000; World Bank, 2003; Ross, 2004; Fearon, 2005; Humphreys, 2005; Janus, 2012).

Many scholars have studied empirically the relationship between natural resources and civil war since the publication of the seminal paper by Coller & Hoefller (1998).[1] Why resources lead to civil war? Many analysts relied on incentive based theories on resource and war, arguing that the revenues available from resources give the actors a financial

[1]Some of the important studies are Fearon & Latin (2003), Fearon (2004, 2005), Collier & Hoefller (2004), Montalvo & Reynal-Querol (2005), Collier et al. (2009), Estenban et al. (2011).

incentive to initiate conflict. Collier and Hoefler (2004) distinguish between two motives of civil wars: grievance and greed. Grievances usually emerge from inequality in terms of political and economic rights, inequality of income and wealth, and ethnic or religious divisions. These types of grievances may cause civil war between different groups in a society. However, economists and a growing number of social scientists have lately come to analyze civil wars as a competition between warlords for the appropriation of valuable resources (i.e., greed). Using data of civil wars from 1960 to 1999, Collier & Hoeffler (2004) find that greed motives have a greater explanatory power than grievances to explain the onset and intensity of civil war.[2] In our study, we also consider that the motive of conflict is to capture resources.

Contrary to the huge number of empirical literature, only few theoretical literature has been developed on the linkage between natural resources and civil conflicts.[3] Most of these papers focus on how natural resource stocks induce the rent seeking and appropriative activities and hence affect the economy. For example, Torvick (2002) develops a simple model to show how abundance of natural resources increases rent seeking activities and leads to lower welfare for the country. Using a static model of conflict between rulers of urban sector and peasants of rural sector, Olssson and Fors (2004) show how different factors including natural resource abundance affect the intensity of conflict. They use the model to explain the Congolese civil wars. Holder (2006) develops a static model of conflict and demonstrates that the impact of natural resource abundance might differ among countries depending on the degree of fractionalization in population. His

[2]One fundamental question is why the groups fight at all. If they are rational, they should prefer a bargaining solution to destructive conflict. Theories of conflict consider three reasons for a rational war. First, asymmetric information - neither agent knows the military capacity of the other. If both agents are over-optimistic, there may not be a peaceful outcome that both recognize as mutually beneficial. Second, commitment problems - especially the inability of the parties to commit to deals in the absence of third party enforcer. Third, issue indivisibilities - whereby some issues do not admit compromise (Blattman and Miguel, 2010).

[3]However, there are significant number of theoretical literature on the issue of conflict in general e.g., Brito and Intriligator (1985), Hirshleifer (1991), Skaperdas (1992), Hirshleifer (1995), Grossman and Kim (1996), Neary (1997), Skaperdas and Syropoulos (2001, 2002), and Garfnkel, Skaperdas and Syropoulos (2008), Lahiri (2010).

model predicts that natural resources lower income in fractionalized countries, but increase income in homogenous countries. Olsson (2007) uses a two period model of conflict between rulers and rivals to show that natural resource (specifically diamond) abundance negatively affects economic growth of countries with weak institutions. Wick (2008) develops a Stackelberg model of conflict in which rulers move first and the general people move second. She finds that the relationship between conflict intensity and resource rent is non-monotonic, and that the economy's growth rate may be affected by the resource abundance. Instead of using static model, Maxwell and Reuveny (2005) develop a dynamic model to explain continuous conflict over renewable resources between two rival groups. Morelli and Rohner (2015) show that the geographic location of resource deposits also affects conflict. They demonstrate that civil wars are more likely if the resources are relatively abundant in regions of ethnic minorities.

Most of the existing theoretical models treat natural resource stock as exogenous conflict prize in analyzing conflict. But, in reality natural resources can be extracted and sold during the conflict. One hypothesis about rebellion is that rebels may consider rebellion as business and their main motive is to capture or loot resources during the conflict (Collier et al., 2004). Rebel groups often rely upon the plunder of natural resources to sustain conflict financially.[4] Thus, resource extraction may be endogenous during the conflict.[5]

In this chapter, we develop a two-period three-sector general equilibrium model relating natural resources to civil (or *intra-state*) conflicts, and examines how international policies including sanctions on resource exports affect conflicts. Contrary to the most of the existing literature, we assume that resource extraction and wage rate are endogenous during the conflict. We develop a model of non-ethnic civil conflict, where two warlords

[4]Examples include: in Cambodia, Khmer Rouge used revenue from timber and gemstone sale to maintain the military force in the early 1990s (Le Billon, 2000); in Liberia, rebel forces led by Charles Taylor raised money from the sale of timber (Ross, 2004a).

[5]In recent time, Janus (2012), and Ploeg and Rohner (2012) develop models of civil conflicts, where they consider natural resource extraction as endogenous during the conflict.

possess some initial resource stocks and fight with each other to capture more resources. We consider that two warlords fight for some labor-intensive resources.[6] The examples of labor-intensive resources are gemstones, drugs, timber, coffee, forests, fisheries etc. Most of these resources are renewable, geographically spread, and require large amount of labor to extract.[7]

In our model, in the first period two warlords extract resources and fight with each other. If a warlord wins the war, in the second period he/she gets the remaining resource stock. Each warlord hires labor from competitive labor market for two purposes: extraction of resources and fighting. Each warlord also uses the resource revenue to finance the costs of extraction and costs of war. Depending on the revenue and costs, budget constraint of each warlord might me binding or non-binding. In our model, there is also a third sector, which we call agriculture sector and is separate from the war sector. Agriculture sector also hires labor from competitive labor market.

Note, our model is similar to that of Janus (2012), but with important differences. Janus (2012) also develops a two-period three-sector model with endogenous resource extraction. However, there are at least three differences between Janus's model and our one. First, while Janus considers conflict between two social groups, we consider conflict between two warlords.[8] Second, while in his model agricultural sector is directly related to the war sector, in our model agricultural sector is separate from the war sector. Finally, in Janus's model two warring groups use their own labor, but in our model warlords and agricultural sector hire labor from competitive labor market, which makes the wage rate

[6]By labor-intensive resource we mean the resources that can be extracted by labor-intensive method.

[7]In Liberia and Sierra Leone, different types resources (e.g. rubber, timber, diamonds, and iron ore) and their geographical spread have lead to development of warlords and highly fragmented conflicts between a weak government and numerous armed groups controlling resources (Addison et al., 2002). A few studies show that even if gemstones and drugs are not linked to the onset of a conflict, these resources tend to lengthen the pre-existing conflict. Availability of these easily marketable resources also makes it harder to implement peace accord among warring parties (Ross, 2004a).

[8]This framework conforms to the warlord competition in weak African states (Reno, 1998 & 2002). There are many examples of warlords in Africa at different times e.g., Idi Amin & Joseph Kony (Uganda), Milton Blahy & Charles Taylor (Liberia), Sani Abacha (Nigeria), Tomas Lubanga (DRC), Jean-Bedal Bokassa (CAF), Bosco Ntaganda (Rwanda).

endogenous. In general, our model is different from existing models in several ways, which are discussed below.

First, most of the existing models consider civil war between two ethnic groups (one group might be ruler, other group is rebel), who have own labor-force and they use those labors either in war or in productive activities. These models often treat the group as a unitary actor, ignoring the problem of collective action. But, there should be some incentives for the members of a group to participate in the war. Such incentives might include wages, opportunities to loot, promises of future reward, or physical protection from harm (Blattman & Miguel, 2010).[9] To solve the problem of collective action, we consider war between two warlords, each of whom form a group by hiring labor from competitive labor market.[10] The market wage rate is a proxy for reward to join in the group.

Second, most of the existing models consider a *partial equilibrium framework* in analyzing civil conflict. They consider that all agents in the economy engage in war, they do not consider the possibility that there may be some peaceful agents or sectors in the economy that are separate from the war sector. In our model, we consider a separate agriculture sector, which is controlled by a landlord and is not directly related to the war sector.[11] Thus, we consider *a general equilibrium framework* as opposed to partial equilibrium framework of the existing literature.

Third, conflict literature so far ignored the role labor market in conflict. But, in reality most of the conflicts involve large number of labor force, which may be transferred from productive sectors of the economy and affect the wage rate. Thus, wage rate may not be fixed during the war, rather may be endogenously determined in the labor market. In our model, wage rate rate is endogenously determined by war sector and agricultural sector.

The main purpose of this chapter is to examine the policy options for international

[9] Weinstein (2007) also shows that in Mozambique, Sierra Leone, and Peru rebel fighters were remunerated with looting of civilian property and drug sales.

[10] Grossman (1991, 1999) and Gates (2002) also consider this type of micro-economic approach of rebellion in which private gain motivates decisions.

[11] In fact, this can represent any sector other than the war sector, like manufacturing sector.

community to resolve the civil conflicts related to natural resources. On the basis of our comparative static results, we analyze the effects of some important policies on the intensity of civil wars. First, international community frequently imposes sanctions on natural resource exports from conflict zone, which is known as 'blood diamond' policy.[12] Our results suggest that when the budget constraint is non-binding, a temporary current sanction is always counter-productive. However, in this case, a credible threat of future sanction will reduce the conflict intensity. Our results also suggest that a current sanction on resource exports will reduce the conflict intensity, when the budget constraint of each warring group is binding and wage rate is fixed. Note, Janus (2012) also finds the same result for the binding constraint case. However, we show that if wage rate is endogenous and there are limited opportunities of employment in alternative sectors, such as in agricultural sector, the conflict intensity may increase due to sanction, even when the budget constraint is binding. Thus, unlike Janus (2012), we show that sanctions might be counter-productive with binding budget constraint. Second, our results suggest that the most effective policy for conflict resolution would be bilateral piecemeal reduction in war efforts. Regardless of whether budget constraint binds or not, a mutual reduction in war efforts by the warring groups increase their welfare. Thus, if international community can negotiate with the warring groups and can convince them that both will be benefited by reducing the conflict efforts, conflict intensity may diminish. This result supports the conventional wisdom that diplomatic solution is the best to resolve any conflict. Third, we find that an improvement in agricultural productivity may reduce conflict intensity. An increase in productivity will increase the labor demand in agricultural sector, which in turn can increase wage rate and can limit the conflict. A final option would be to destroy the physical resource stocks for which the groups are fighting. But, it is very difficult for international community to apply this policy, and it may decrease the post-conflict welfare.

[12]For example, sanctions have targeted countries experiencing civil war, such as Liberia, Rwanda, Sudan, Lebanon, Cambodia, and Yugoslavia (Escribà-Folch, 2010). Diamond embargo was imposed on warring groups of Ivory Coast, Sierra Leone, Liberia, and Angola to end conflicts related to diamond (Wallensteen et al., 2006).

However, in extreme situations, international community may apply this policy.

The rest of the chapter is organized as follows. Section 1.2 presents a model of natural resource and conflict, and its' solution. Section 1.3 shows and analyses the comparative statics for exogenous shocks or policy changes. Section 1.4 illustrates the effects of piecemeal reduction in war efforts. Section 1.5 concludes the chapter.

1.2 THE MODEL

Suppose, there are two risk-neutral warlords in an economy, who own and control some natural resource stocks, like gemstone, drugs, timber etc. Both warlords are motivated by the greed and so they fight with each other to capture more resources.[13] Each warlord forms a group and hires labor from competitive labor market for two purposes: extraction of resources and fighting. Consider two periods: in the first period, two groups extract resources and fight with each other; and if a group wins the war, in the second period, it gets remaining resource stock. Each warlord uses the resource revenues to finance the costs of extraction and costs of war. Depending on the levels of revenues and costs, the budget constraint of each warlord might be binding or non-binding. We also consider that there is a part of the economy that is not affected directly by the conflict. In particular, there is a landlord in the economy, and she produces agricultural goods by hiring labor from a competitive labor market. Thus, we consider a general equilibrium framework. In the following section we set up the model.

1.2.1 THE BASIC MODEL

Let warlord i, i=1,2, possesses an initial resource stock y_i, and hires l_{ri} amount of labor for extraction and l_{ci} amount of labor for fighting a war. The resource extraction function is for simplicity given by: $r_i = 2l_{ri}^{\frac{1}{2}}$. This function implies that extraction is diminishing with

[13] We implicitly assume that there is no formal government in the economy, who can secure property rights. Due to the absence of governance and enforcement, ownership and control of resources is settled by open conflict or, equivalently by the threat of conflict.

the amount of labor. Group $i's$ winning probability in war is given by the conventional ratio-form contest success function: $q_i = l_{ci}/(l_{ci} + l_{cj}),\ j \neq i$.[14] This function implies that for given amount of conflict labor of group j, the winning probability of group i increases with its' conflict labor and vice versa. The landlord, who produces agricultural goods, hires l_a amount of labor from the labor market. The agricultural production function is given by: $A = 2l_a^{\frac{1}{2}}V^{\frac{1}{2}}$, where V is a fixed amount of land available to the landlord. Labors move freely between sectors and as a result wage rate is same in all sectors.

The net expected return of warlord i in two periods is given by:

$$\begin{aligned} R_i &= p_1 r_i - (wl_{ri} + wl_{ci}) + q_i p_2(y_i + y_j - r_i - r_j) \\ &= p_1(2l_{ri}^{\frac{1}{2}}) - (wl_{ri} + wl_{ci}) + \frac{l_{ci}}{l_{ci} + l_{cj}} p_2(y_i + y_j - 2l_{ri}^{\frac{1}{2}} - 2l_{rj}^{\frac{1}{2}}), i = 1, 2 \text{ and } j \neq i, \end{aligned} \tag{1.1}$$

where p_1 is the current international market price of resources, w is the wage rate, and $p_1 r_i - (wl_{ri} + wl_{ci})$ is the net revenue in period 1. The expected world market price of resources in period 2 is p_2, and $(y_i + y_j - r_i - r_j)$ is the resource stock that group i gets at the beginning of the 2nd period, if it wins the war. For simplicity, we also assume no discounting for period 2. Since q_i is the probability of winning for group i in the conflict, the expected revenue of the group in the 2nd period is $q_i p_2(y_i + y_j - r_i - r_j)$.

The warlord i maximizes expected return subject to the budget constraint. Since we assume that resource revenues are used to finance the costs of war, the budget constraint for each warlord can be written as: $p_1 r_i \geq (wl_{ri} + wl_{ci}),\ i = 1, 2$.

The landlord also maximizes profit and the profit function is given by:

$$R_a = p_a(2l_a^{\frac{1}{2}}V^{\frac{1}{2}}) - wl_a, \tag{1.2}$$

where p_a is the market price of agricultural goods.

Suppose, the economy has a fixed supply of labor, denoted by L. The demand for labor comes from three sectors: resource extraction, conflict, and agricultural sector. Thus,

[14] Many authors use this type of contest success function e.g., Tullock (1980), Hirshleifer (1991), Skaperdas (1996), Ploeg & Rohner(2012).

the labor market equilibrium condition is as follows:

$$l_{r1} + l_{r2} + l_{c1} + l_{c2} + l_a = L. \tag{1.3}$$

Equations (1.1) to (1.3) describe our model. Now we will find the equilibrium conditions of the agents in our model.

1.2.2 EQUILIBRIUM

Consider that two warlords play a simultaneous move game. That is, each warlord i maximizes the following Lagrangian function taking the extraction labor and conflict labor of other warlord as given:

$$\begin{aligned} \max_{l_{ri}, l_{ci}, \gamma_i} \mathcal{L}_i = p_1(2l_{ri}^{\frac{1}{2}}) - (wl_{ri} + wl_{ci}) + \frac{l_{ci}}{l_{ci} + l_{cj}} p_2(y_i + y_j - 2l_{ri}^{\frac{1}{2}} - 2l_{rj}^{\frac{1}{2}}) \\ + \gamma_i[p_1(2l_{ri}^{\frac{1}{2}}) - (wl_{ri} + wl_{ci})], \ i = 1, 2 \text{ and } j \neq i, \end{aligned} \tag{1.4}$$

where γ_i is the Lagrangian multiplier. The constraint above specifies that extraction and conflict is funded by selling extracted resources.

We consider two possible cases regarding the budget constraint: budget constraint is binding, and budget constraint is non-binding. First, assuming binding constraint, the optimality conditions or first order conditions for l_{ri}, l_{ci}, and γ_i $(i = 1, 2)$ are respectively:[15]

$$p_1(1 + \gamma_i)l_{ri}^{-\frac{1}{2}} = w(1 + \gamma_i) + \frac{l_{ci}}{l_{ci} + l_{cj}} p_2 l_{ri}^{-\frac{1}{2}} \tag{1.5}$$

$$\frac{l_{cj}}{(l_{ci} + l_{cj})^2} p_2(y_i + y_j - 2l_{ri}^{\frac{1}{2}} - 2l_{rj}^{\frac{1}{2}}) = w(1 + \gamma_i) \tag{1.6}$$

$$p_1(2l_{ri}^{\frac{1}{2}}) = wl_{ri} + wl_{ci} \tag{1.7}$$

Equation (1.5) implies that marginal benefit of extraction labor (in the left hand side) must equal marginal cost of extraction labor (in the right hand side). Marginal benefit of extraction equals the value of marginal product of extraction labor, while marginal cost equals wage cost of labor plus opportunity cost of extracting now instead of conserve it for

[15]Variation in y_i, $i = 1, 2$, across warlords means generally that we cannot rule out the possibility that one of the two agents will extract all resources in the first period so that $r_i = y_i$. However, to focus on the issue of concern, we assume an interior optimum. Note, for an interior equilibrium to exist any asymmetry between two warlords in initial resource stock y_i needs to be small.

the future. The opportunity cost of extraction is equal to the probability of winning the conflict times the value of marginal product of labor in period 2. Equation (1.6) equates the marginal benefit of labor in conflict, which is the change in the likelihood of winning times the prize of winning the conflict, to the marginal cost of labor in conflict. Note, if budget constraint is binding, the value of resource in period 1 will exceed market price p_1 and will be equal to $p_1(1+\gamma_i)$, where γ_i is the shadow value of increased extraction as it loosens the constraint. Similarly, cost of labor exceeds the market wage rate w and it is equal to $w(1+\gamma_i)$. Equation (1.7) shows the binding budget constraint that total labor costs of extraction and conflict cannot exceed the total revenue from extraction.

For simplicity of the analysis, we assume that two groups are *symmetric* (i.e., $y_1 = y_2$). If two groups are symmetric, the first order conditions for each group become:

$$p_1(1+\gamma)l_r^{-\frac{1}{2}} = w(1+\gamma) + \frac{1}{2}p_2 l_r^{-\frac{1}{2}} \tag{1.8}$$

$$\frac{1}{2l_c}p_2(y - 2l_r^{\frac{1}{2}}) = w(1+\gamma) \tag{1.9}$$

$$p_1(2l_r^{\frac{1}{2}}) = wl_r + wl_c \tag{1.10}$$

Using equations (1.8) to (1.10) we get following two equations:

$$4p_1 l_r^{\frac{1}{2}} - 3wl_r + wyl_r^{\frac{1}{2}} = p_1 y \tag{1.11}$$

$$l_c = \frac{2p_1 l_r^{\frac{1}{2}}}{w} - l_r \tag{1.12}$$

In this case, we don't have explicit solutions for l_r and l_c. However, we have implicit solutions in terms of parameters and wage rate: $l_r(p_1, w, y)$ and $l_c(p_1, w, y)$.

Now consider that the budget constraint is non-binding, i.e., $\gamma_i = 0$. Then, under symmetry the first order conditions become:

$$p_1 l_r^{-\frac{1}{2}} = w + \frac{1}{2}p_2 l_r^{-\frac{1}{2}} \tag{1.13}$$

$$\frac{1}{2l_c}p_2(y - 2l_r^{\frac{1}{2}}) = w \tag{1.14}$$

From equations (1.13) and (1.14), we get the interior optimal (Nash-equilibrium) values of

l_r and l_c as follows:

$$l_r = \frac{(2p_1 - p_2)^2}{4w^2}, \; l_c = \frac{p_2[wy - (2p_1 - p_2)]}{2w^2}$$

Note, $l_r > 0$, if and only if $p_1 > \frac{1}{2}p_2$; and $l_c > 0$, if and only if $y > (2p_1 - p_2)/w$, or $y > r$.[16]

In this economy, the landlord also maximizes her revenue by hiring labor from labor market. From (1.2) we get the first order condition for profit maximization of the landlord as follows:

$$p_a l_a^{-\frac{1}{2}} V^{\frac{1}{2}} = w \tag{1.15}$$

Equation (1.15) implies that in equilibrium marginal benefit of agricultural labor (equal to the value of marginal product of labor) must be equal to marginal cost of labor (equal to wage rate). From (1.15) we get the optimal value of l_a as:

$$l_a = \frac{p_a^2 V}{w^2} > 0$$

If there is *full employment* in the economy, then wage rate is endogenous. The wage rate is determined by the labor market equilibrium condition. With two symmetric warring groups the labor market equilibrium condition is as follows:

$$2l_r + 2l_c + l_a = L \tag{1.16}$$

Equation (1.16) determines the wage rate of labor in this economy.

1.3 COMPARATIVE STATICS: POLICY ANALYSIS

In this section, we shall examine how exogenous shocks or policy changes affect the conflict. One frequently applied international policy instrument to reduce civil conflict is imposing sanctions on resource exports from conflict zone (known as blood diamond policy). For example, in 1992 UN Security Council proposed a ban on timber shipped from Cambodia to Thailand to limit the funding of rebel group Khmer Rouge who was controlling the forests near Thai border (Janus, 2012). The UN Security Council also took measures

[16] In equilibrium $r = 2l_r^{\frac{1}{2}} = 2\sqrt{(2p_1 - p_2)^2/4w^2} = (2p_1 - p_2)/w$.

against the rebel forces in Liberia, the Democratic Republic of Congo, Sierra Leone, and Angola (Ross, 2004). The most prominent example of blood diamond is the Kimberly Process Certification Scheme (took effect in 2003) that targets the trade in rough diamond based on the perception that diamond had fueled civil wars in different parts of the world, especially in Africa. However, most of the empirical literature about the effectiveness of sanctions suggest that sanctions are not generally successful in reducing conflict. Here, we examine theoretically how the sanctions on resource exports affect conflict intensity.

A sanction on resource exports reduces the export price of resource received by the sanctioned country. Thus, we will examine how war efforts of the warring groups change with the change in resource price. We consider different types of sanctions on resource exports: temporary sanction (sanction on period 1 only), sanction threat or expected future sanction (sanction on period 2 only), and permanent sanction (sanction on both periods). We also examine how war efforts change with the change in agricultural price or productivity, and with the exogenous change in resource stock. We shall do these comparative static exercises separately for two cases: when the budget constraint is non-binding, and when the budget constraint is binding. In each case, first we examine how optimal choices of l_r, l_c, and l_a change with exogenous changes in parameters (p_1, p_2, p_a, y), and then we discuss policy implications of the findings.

1.3.1 BUDGET CONSTRAINT NON-BINDING

We consider two sub-scenarios for the economy: 1) when there is unemployment in the economy (the wage rate is fixed), and 2) when there is full employment in the economy (the wage rate is endogenous).

1.3.1.1 UNEMPLOYMENT

In many conflict-prone developing countries unemployment is a common phenomenon. When there is unemployment in the economy, wage rate (w) is fixed. Then the conflict sector and non-conflict sector are not connected with each other. That is, our model can be called *partial equilibrium* one. Now we shall analyze what happens to equilibrium choices of l_r and l_c, when the parameters p_1, p_2, w, and y change exogenously. We derive the following proposition from comparative static analysis.

Proposition 1: *When the budget constraint is not binding and there is unemployment in the economy so that wage rate is fixed, (a) a temporary rise in resource price increases extraction and decreases conflict; (b) an increase in expected future price of resource decreases extraction and increases conflict; (c) a permanent rise in resource price increases extraction, and it increases conflict provided that resource stock is sufficiently high; (d) a rise in physical resource stock does not affect extraction, but it increases conflict; (e) an exogenous increase in wage rate decreases extraction, and it decreases conflict only if resource stock is sufficiently high.*

Proof of proposition 1:

(a) *Change in* p_1: Differentiating optimal values of l_r and l_c with respect to p_1 we get,

$$\frac{\partial l_r}{\partial p_1} = \frac{\overbrace{2p_1 - p_2}^{+}}{w^2} > 0 \tag{1.17}$$

$$\frac{\partial l_c}{\partial p_1} = -\frac{p_2}{w^2} < 0 \tag{1.18}$$

Note, $2p_1 - p_2 > 0$ is necessary condition for $l_r > 0$ (see equation 1.13).

A temporary rise in the resource price in the current period leads to hiring more labor for extraction. This is logical because a rise in resource price increases the marginal benefit of extraction labor. However, a temporary rise in resource price decreases conflict labor. This is because increases in current extraction decreases the future prize of conflict, which causes the reduction of conflict labor.

The proposition 1(a) suggests that when budget constraint of the warring groups are non-binding and there is unemployment in the economy, a temporary sanction on resource exports would be counter-productive. Thus, a temporary sanction intensifies conflict. This is because when budget constraint is not binding, each warring group reduces current extraction of resources facing the lower international price due to sanction. As a result, more resources are left for the future and the warring group increases the fighting efforts to capture that bigger resource stock.

(b) *Change in* p_2: Differentiating optimal values of l_r and l_c with respect to p_2 we get,

$$\frac{\partial l_r}{\partial p_2} = -\frac{\overbrace{(2p_1 - p_2)}^{+}}{2w^2} < 0 \tag{1.19}$$

$$\frac{\partial l_c}{\partial p_2} = \frac{\overbrace{(wy + 2p_2 - 2p_1)}^{+}}{2w^2} > 0, \tag{1.20}$$

Note, $l_c > 0$ implies $wy + p_2 - 2p_1 > 0$, which in turn implies $wy + 2p_2 - 2p_1 > 0$.

A rise in the future price of resource increases the opportunity cost of extraction in the current period, which causes to reduction in extraction. However, an increase in future price of resource increases the conflict both directly and indirectly. First, a rise in future price increases the prize of conflict, which induces more conflict. Second, the fall in extraction raises the conflict prize further and thus causes more hiring of conflict labor.

The proposition 1(b) suggests that a credible sanction threat that implies an expected future sanction (after the conflict ends in our model) reduces the intensity of conflict. An expected future sanction reduces the price of resources in the second period in our model, which reduces the reward of conflict. Facing the reduction of future price, the warring groups also increase resource extraction in the current period, which reduces the conflict prize further. For both reasons the conflict intensity falls.

(c) *Change in* p ($p_1 = p_2 = p$): Differentiating optimal values of l_r and l_c with respect to p we get,

$$\frac{\partial l_r}{\partial p} = \left(\frac{\partial l_r}{\partial p_1} + \frac{\partial l_r}{\partial p_2}\right)\Bigg|_{p_1=p_2=p} = \frac{p}{w^2} - \frac{p}{2w^2} = \frac{p}{2w^2} > 0 \tag{1.21}$$

$$\frac{\partial l_c}{\partial p} = \left(\frac{\partial l_c}{\partial p_1} + \frac{\partial l_c}{\partial p_2}\right)\Bigg|_{p_1=p_2=p} = -\frac{p}{w^2} + \frac{y}{2w} = \frac{wy - 2p}{2w^2} \tag{1.22}$$

From equation (1.22) we see that $\partial l_c/\partial p > 0$, if and only if $y > 2p/w$, or $y > 2r$.[17]

[17] If $p_1 = p_2 = p,\ l_r = p^2/4w^2,\ r = 2l_r^{\frac{1}{2}} = 2\sqrt{p^2/4w^2} = p/w$.

A permanent rise in resource price increases both marginal benefit (in the current period) and marginal cost (in the future) of extraction, but marginal benefit increases more compare to marginal cost.[18] A permanent increase in resource price increases the future conflict prize which increases conflict labor, but a price rise also increases extraction which reduces conflict labor (as more extraction reduces conflict prize). Which effect will dominate depends on the initial level of resource stock relative to current extraction. If the resource stock is high enough that it is greater than twice of current extraction, then the conflict labor increases because lot of resources are left for the future. However, if the resource stock is less than twice of the current level of extraction, then the conflict labor decreases because little amount of resources are left for future.

The proposition 1(c) implies that a permanent sanction on resource exports that reduces both the current and future prices of resources, reduces the conflict intensity only if the resource stock is sufficiently high.

(d) *Change in y*: Differentiating optimal values of l_r and l_c with respect to y we get,

$$\frac{\partial l_r}{\partial y} = 0 \tag{1.23}$$

$$\frac{\partial l_c}{\partial y} = \frac{p_2}{2w} > 0 \tag{1.24}$$

A rise in the physical resource stock does not affect extraction labor, but increases conflict labor. When the budget constraint is not binding, then warlords do not need to change the extraction level even if the resource stock changes. However, a greater resource stock implies greater conflict prize, which induces more conflict. This result is consistent with most of the empirical findings that natural resource rich countries are likely to experience more civil wars, which is particularly true for many African countries.

This proposition suggests that a decrease in physical resource stock reduces the conflict. But, it is very difficult for international community to apply this policy, it will also decrease post-conflict welfare. However, in extreme situation international community

[18]In this case marginal benefit increases by p/w^2, but marginal cost increases by $p/2w^2$ (where 1/2 is winning probability). Thus, net increase in benefit is $p/2w^2$.

may apply this policy. For example, recently a U.S.-led coalition force tried to destroy oil refineries controlled by notorious ISIS group of Iraq and Syria to limit their funding from selling oil in the black market (International Business Times, Sept. 30, 2014).[19]

(e) *Change in* w: Differentiating optimal values of l_r and l_c with respect to w we get,

$$\frac{\partial l_r}{\partial w} = -\frac{(2p_1 - p_2)^2}{2w^3} < 0 \tag{1.25}$$

$$\frac{\partial l_c}{\partial w} = \frac{p_2[2(2p_1 - p_2) - wy]}{2w^3} \tag{1.26}$$

In this case, $\partial l_c/\partial w < 0$, if and only if $y > 2(2p_1 - p_2)/w$, or $y > 2r$.

An increase in wage rate, which increases the marginal cost of extraction labor, decreases the labor in extraction. On the other hand, an increase in wage rate may increase or decrease conflict labor. An increase in wage rate increases the marginal cost of conflict labor, which reduces the demand for conflict labor. However, a reduction in extraction associated with wage increase tend to increase the demand for conflict labor. Which effect will dominate depends on the level of resource stock. If the resource stock is sufficiently high, the negative effect will dominate the positive effect, as a result conflict labor will fall due to rise in wage. The necessary condition for this to happen is that initial resource stock is greater than twice of current extraction in our model. The implication of this result is that even an exogenous increase in wage rate does not guarantee the reduction in conflict intensity.

1.3.1.2 FULL EMPLOYMENT

When there is full employment in the economy, wage rate is endogenous. Now exogenous shocks may affect the wage rate through labor market. Any change in the agricultural sector also affects the decisions of warlords through labor market. Thus, this is a *general equilibrium framework*. The wage rate will be determined by the labor market equilibrium condition. Substituting the optimal values of l_r, l_c, and l_a in to the labor market

[19]Islamic State of Iraq and Syria (ISIS), also known as the Islamic State of Iraq and the Levant (ISIL) is a Sunni, extremist, unrecognized state and self-proclaimed caliphate based in the Middle East. The group currently controls a large area in both Iraq and Syria.

equilibrium condition of (1.16) we get:

$$2p_2wy - 2w^2L + 4p_1^2 + 3p_2^2 - 8p_1p_2 + 2p_a^2V = 0 \tag{1.27}$$

The equation (1.27) determines equilibrium wage rate as a function of exogenous variables. However, we don't have explicit solution for wage rate in this case. From equation (1.27) we get the changes in w with respect to the changes in p_1, p_2, p_a, y, and L as follows: (see appendix A.1 for derivation)

$$\frac{dw}{dp_1} = -\frac{4w(p_1 - p_2)}{\underbrace{\Delta}_{-}}, \; \frac{dw}{dp_2} = -\frac{w(wy + 3p_2 - 4p_1)}{\underbrace{\Delta}_{-}},$$

$$\frac{dw}{dp} = \left(\frac{dw}{dp_1} + \frac{dw}{dp_2}\right)\bigg|_{p_1=p_2=p} = -\frac{w\overbrace{(wy - p)}^{+}}{\underbrace{\Delta}_{-}} > 0, \tag{1.28}$$

$$\frac{dw}{dp_a} = -\frac{2wp_aV}{\underbrace{\Delta}_{-}} > 0, \; \frac{dw}{dy} = -\frac{w^2p_2}{\underbrace{\Delta}_{-}} > 0, \; \frac{dw}{dL} = \frac{2w^3}{\underbrace{\Delta}_{-}} < 0,$$

where $\Delta = (2p_1 - p_2)(3p_2 - 2p_1) - p_2wy - 2p_a^2V < 0$ for the stability of excess demand function of labor. Note, $dw/dp_1 > 0$, if and only if $p_1 > p_2$; and $dw/dp_2 > 0$, if and only if $(wy + 3p_2 - 4p_1) > 0$ (the sufficient condition is $y > 2r$).

An increase in current price increases extraction labor, but reduces conflict labor. If current and expected future prices are same, a temporary change in resource price changes both extraction labor and conflict labor by the same amount, leaving the wage unaffected. If current price is higher than expected future prices, a temporary rise in price causes an increase in extraction labor more compared to reduction in conflict labor, which in turn increases wage rate, and vice versa. An expected increase in future price may increase or decrease the wage rate. An increase in future price decreases extraction labor, but increases conflict labor. If conflict labor increases more compare to reduction in extraction labor, then overall demand for labor increases which in turn increases wage rate. A permanent increase in resource price increases the overall demand for labor, which in turn increases the wage rate. An increase in agricultural productivity as represented by the increase in the price of agricultural goods increases wage rate by increasing the demand for agricultural labor. An increase in the physical resource stock increases wage rate by increasing the demand for conflict labor. Other things remaining fixed, an increase in labor supply reduces the wage rate.

Now we can do the *comparative statics* again in *general equilibrium framework*: how optimal choices for l_r, l_c, & l_a change with exogenous shocks. We derive following proposition from our comparative static analysis.

Proposition 2: *When the budget constraint is not binding and there is full employment in the economy so that wage rate is endogenous, (a) a temporary rise in resource price increases extraction and decreases conflict, the effect on agricultural sector is uncertain; (b) an increase in expected future price of resource decreases extraction and increase conflict, the effect on agricultural sector is uncertain; (c) a permanent rise in resource price increases extraction, increases conflict if resource stock is sufficiently high, and decreases agricultural production; (d) a rise in physical resource stock decreases extraction, increases conflict, and decreases agricultural production; (e) a rise in agricultural productivity/price decreases extraction, decreases conflict provided that resource stock is sufficiently high, and increases agricultural production; (f) an increase in labor supply increases extraction, increases conflict if resource stock is sufficiently high, and increases agricultural production.*

Proof of proposition 2: (see detail derivation in appendix A.2)

(a) *Change in* p_1: Differentiating optimal values of l_r, l_c, and l_a with respect to p_1 we get,

$$\frac{dl_r}{dp_1} = \frac{\partial l_r}{\partial p_1} + \frac{\partial l_r}{\partial w}.\frac{dw}{dp_1} = \frac{\overbrace{2p_1 - p_2}^{+}}{w^2 \underbrace{\Delta}_{-}}[\underbrace{p_2(2p_1 - p_2) - p_2 wy}_{-} - 2p_a^2 V] > 0 \tag{1.29}$$

$$\frac{dl_c}{dp_1} = \frac{\partial l_c}{\partial p_1} + \frac{\partial l_c}{\partial w}.\frac{dw}{dp_1} = \frac{p_2}{w^2 \underbrace{\Delta}_{-}}[\underbrace{(2p_1 - p_2)}_{+}\underbrace{(wy - 2p_1 + p_2)}_{+} + 2p_a^2 V] < 0 \tag{1.30}$$

$$\frac{dl_a}{dp_1} = \frac{\partial l_a}{\partial p_1} + \frac{\partial l_a}{\partial w}.\frac{dw}{dp_1} = \frac{2p_a^2 V(p_1 - p_2)}{w^2 \underbrace{\Delta}_{-}} \tag{1.31}$$

Note, $dl_a/dp_1 < 0$, if and only if $p_1 - p_2 > 0$, or $dw/dp_1 > 0$.

A change in resource price affects demand for extraction labor both directly and indirectly. The indirect effect comes via labor market. As we have shown earlier, a temporary increase in resource price may increase wage rate, or decrease wage rate, or may not affect wage rate (depends on relative prices of resources in two periods). An increase in current resource price increases extraction directly. If wage rate falls, extraction increases further, then the indirect effect reinforces direct effect leading to more increase of extraction labor. If wage rate rises, extraction falls, then indirect effect works against direct effect. But direct effect is dominant here, which results a net increase in extraction labor. If wage rate does not change, then only partial direct effect works. A temporary increase in resource price decreases the conflict labor. Again in this case there are two types of effects. An increase in resource price reduces the conflict, as conflict prize falls because of increased extraction. The indirect effect on conflict labor comes from change in the wage rate associated with the change in resource price, which may reinforce or reduce the overall effect. However, the overall effect of resource price change on conflict labor is negative. Agricultural labor employment may increase or decrease due to the temporary increase in resource price, and it depends on how wage rate changes in response to resource price change. If wage increases due resource price boom, agricultural labor will decrease, and vice versa.

This proposition implies that when budget constraint is non-binding and there is full employment in the economy, a current sanction on resource export increases conflict intensity. Thus, combining propositions 1(a) and 2(a), we can conclude that when budget constraints of the warring groups are non-binding, a temporary current sanction is always counter-productive.

(b) *Change in p_2*: Differentiating optimal values of l_r, l_c, and l_a with respect to p_2 we get,

$$\frac{dl_r}{dp_2} = \frac{\partial l_r}{\partial p_2} + \frac{\partial l_r}{\partial w}.\frac{dw}{dp_2} = \frac{\overbrace{2p_1 - p_2}^{+}}{w^2 \underbrace{\Delta}_{-}}[p_1 \underbrace{(wy - 2p_1 + p_2)}_{+} + p_a^2 V] < 0 \tag{1.32}$$

$$\frac{dl_c}{dp_2} = \frac{\partial l_c}{\partial p_2} + \frac{\partial l_c}{\partial w}.\frac{dw}{dp_2} = \frac{p_1 \overbrace{(p_2 - 2p_1)}^{-}}{w^2 \underbrace{\Delta}_{-}} \underbrace{(wy + p_2 - 2p_1)}_{+} - \frac{p_a^2 V \overbrace{(wy + 2p_2 - 2p_1)}^{+}}{w^2 \underbrace{\Delta}_{-}} > 0 \tag{1.33}$$

$$\frac{dl_a}{dp_2} = \frac{\partial l_a}{\partial p_2} + \frac{\partial l_a}{\partial w}.\frac{dw}{dp_2} = \frac{2p_a^2 V(wy + 3p_2 - 4p_1)}{w^2 \underbrace{\Delta}_{-}} \tag{1.34}$$

Note, $dl_a/dp_2 < 0$, if and only if $(wy + 3p_2 - 4p_1) > 0$, or $dw/dp_2 > 0$ (the sufficient condition is $y > 2r$).

An expected increase in future price of resource has opposite effects on extraction and conflict compared to current price effect, i.e., it decreases the extraction labor and increases the conflict labor. An increase in future price increases the opportunity cost of extraction, but raises the benefit of conflict. The change in wage rate associated with the price change may change the magnitude of the overall effects, but does not reverse them. The effect of future price of resource on agricultural labor again depends on the change in wage rate. If wage rate increases because of expected increase in future price of resource, agricultural labor decreases and vice versa.

The proposition 2(b) suggests that when budget constraint is non-binding and there is full employment in the economy, an anticipated future sanction on resource exports decreases conflict intensity. Combining propositions 1(b) and 2(b), we can conclude that when budget constraints of the warring groups are non-binding, an anticipated future sanction leads to reduction in conflict intensity.

(c) *Change in* p ($p_1 = p_2 = p$): Differentiating optimal values of l_r, l_c, and l_a with respect to p we get,

$$\frac{dl_r}{dp} = \left(\frac{dl_r}{dp_1} + \frac{dl_r}{dp_2}\right)\Bigg|_{p_1=p_2=p} = -\frac{pp_a^2 V}{w^2 \underbrace{\Delta}_{-}} > 0 \tag{1.35}$$

$$\frac{dl_c}{dp} = \left(\frac{dl_c}{dp_1} + \frac{dl_c}{dp_2}\right)\Bigg|_{p_1=p_2=p} = -\frac{p_a^2 V(wy-2p)}{w^2 \underbrace{\Delta}_{-}} \tag{1.36}$$

$$\frac{dl_a}{dp} = \left(\frac{dl_a}{dp_1} + \frac{dl_a}{dp_2}\right)\Bigg|_{p_1=p_2=p} = \frac{2p_a^2 V \overbrace{(wy-p)}^{+}}{w^2 \underbrace{\Delta}_{-}} < 0 \tag{1.37}$$

Note, $dl_c/dp < 0$, if and only if $y > 2p/w$, or $y > 2r$.

A permanent increase in resource price increases extraction labor. Increase in current price increases extraction, but increase in future price reduces extraction. Since the benefit from future price rise is uncertain due to war, landlords will extract more now. However, the effect of a permanent increase in resource price on conflict labor is uncertain. An increase in current price reduces conflict labor, an increase in future price increases conflict labor. Which effect will dominate depends on the size of the resource stock. A permanent increase in resource price increases the conflict intensity only if the resource stock is sufficiently high. A permanent increase in resource price increases the wage rate and thus decreases the employment and production in agricultural sector. Thus, resource price boom is harmful for agricultural sector, which supports the famous 'dutch disease' hypothesis.

This proposition implies that when budget constraint is non-binding and there is full employment in the economy, a permanent sanction on resource export reduces war intensity, if and only if resource stock is sufficiently high.

(d) *Change in y*: Differentiating optimal values of l_r, l_c, and l_a with respect to y we get,

$$\frac{dl_r}{dy} = \frac{\partial l_r}{\partial y} + \frac{\partial l_r}{\partial w}.\frac{dw}{dy} = \frac{p_2(2p_1-p_2)^2}{2w \underbrace{\Delta}_{-}} < 0 \tag{1.38}$$

$$\frac{dl_c}{dy} = \frac{\partial l_c}{\partial y} + \frac{\partial l_c}{\partial w}.\frac{dw}{dy} = \frac{p_2}{2w \underbrace{\Delta}_{-}}[-(2p_1-p_2)^2 - 2p_a^2 V] > 0 \tag{1.39}$$

$$\frac{dl_a}{dy} = \frac{\partial l_a}{\partial y} + \frac{\partial l_a}{\partial w}.\frac{dw}{dy} = \frac{2p_a^2 V p_2}{w \underbrace{\Delta}_{-}} < 0 \tag{1.40}$$

An increase in physical resource stock increases conflict labor directly, because it increases conflict prize. Increase in wage rate associated with increase in conflict labor may reduce some conflict labor. However, net change in conflict labor is positive. An increase in physical resource stock does not affect the extraction directly (as budget constraint in not binding), but it reduces extraction labor by increasing wage rate resulted from increase in conflict labor. A greater resource stock increases wage rate and hence decreases the employment and production in the agricultural sector. This result also supports the 'Dutch disease' hypothesis that the abundance of natural resources diverts resources away from formal sector production and causes to negative growth.

This proposition suggests that a curtail of the resource stock by international community can reduce conflict. However, it should be applied only in extreme situation.

(e) *Change in* p_a: Differentiating optimal values of l_r, l_c,and l_a with respect to p_a we get,

$$\frac{dl_r}{dp_a} = \frac{\partial l_r}{\partial p_a} + \frac{\partial l_r}{\partial w} . \frac{dw}{dp_a} = \frac{p_a V (2p_1 - p_2)^2}{w^2 \underbrace{\Delta}_{-}} < 0 \tag{1.41}$$

$$\frac{dl_c}{dp_a} = \frac{\partial l_c}{\partial p_a} + \frac{\partial l_c}{\partial w} . \frac{dw}{dp_a} = -\frac{p_a p_2 V [2(2p_1 - p_2) - wy]}{w^2 \underbrace{\Delta}_{-}} \tag{1.42}$$

$$\frac{dl_a}{dp_a} = \frac{\partial l_a}{\partial p_a} + \frac{\partial l_a}{\partial w} . \frac{dw}{dp_a} = \frac{2p_a V [(2p_1 - p_2)(3p_2 - 2p_1) - p_2 wy]}{w^2 \Delta} \tag{1.43}$$

If $p_1 = p_2$, then

$$\frac{dl_a}{dp_a} = \frac{2p_a p V \overbrace{(p - wy)}^{-}}{w^2 \underbrace{\Delta}_{-}} > 0$$

Note, $dl_c/dp_a < 0$, if and only if $y > 2(2p_1 - p_2)/w$, or $\partial l_c/\partial w < 0$.

An increase in agricultural productivity represented by increase of the price of agricultural goods increases wage rate in the economy. An increase in wage rate reduces the extraction labor. Conflict labor falls only if increase in wage rate reduces the demand for conflict labor (depends on the level of resource stock). Finally, an increase in agricultural price increases the agricultural labor. A price rise increases the demand for agricultural labor directly, but it also increases the wage rate which in turn reduces the demand for labor in agriculture. The direct effect dominates indirect effect, resulting a net increase of agricultural labor.

This proposition implies that an increase in agricultural productivity that increases the employment in the sector may reduce the conflict intensity. This result is different from Janus (2012) paper, which shows that increasing in agricultural productivity increases conflict.[20]

(f) *Change in L*: Differentiating optimal values of l_r, l_c, and l_a with respect to L we get,

$$\frac{dl_r}{dL} = \frac{\partial l_r}{\partial L} + \frac{\partial l_r}{\partial w}.\frac{dw}{dL} = -\frac{(2p_1 - p_2)^2}{\Delta} > 0 \tag{1.44}$$

$$\frac{dl_c}{dL} = \frac{\partial l_c}{\partial L} + \frac{\partial l_c}{\partial w}.\frac{dw}{dL} = \frac{p_2[2(2p_1 - p_2) - wy]}{\Delta} \tag{1.45}$$

$$\frac{dl_a}{dL} = \frac{\partial l_a}{\partial L} + \frac{\partial l_a}{\partial w}.\frac{dw}{dL} = -\frac{4p_a^2 V}{\Delta} > 0 \tag{1.46}$$

Note, $dl_c/dL > 0$, if and only if $y > 2(2p_1 - p_2)/w$, or $\partial l_c/\partial w < 0$.

An exogenous increase in labor supply reduces wage rate. As a result, employment in both extraction sector and agricultural sector increases. However, the effects on conflict labor is uncertain in this case, because of the uncertainty of the effects of wage rate on conflict labor in our model. A decrease in wage rate increases conflict only if the resource stock is sufficiently high.

1.3.2 BUDGET CONSTRAINT BINDING

Having discussed the effects of exogenous policy changes in the non-binding budget constraint case, we will now discuss the same in binding budget constraint case. In practice, wars are costly and they require lot of resources to finance. Thus, in most cases

[20] In Janus (2012) model, agriculture sector is related to war sector. But, in our model agriculture sector is separate from war sector. This might be the reason for different results.

the budget constraint of the waring groups would be binding. In our model, the budget constraint is more likely to be binding when (1) the resource stock is higher, (2) the current resource price is lower, (3) the future resource price is higher, and (4) agricultural productivity is higher. In this case, the equilibrium conditions of warlords are given by equations (1.11) and (1.12). Totally differentiate (1.11) and (1.12) we get,

$$\Lambda dl_r = (y - 4l_r^{\frac{1}{2}})dp_1 + (p_1 - wl_r^{\frac{1}{2}})dy + (3l_r - yl_r^{\frac{1}{2}})dw \tag{1.47}$$

$$dl_c = \left[\frac{2l_r^{\frac{1}{2}}}{w} + \left(\frac{p_1 l_r^{-\frac{1}{2}} - w}{w}\right)\frac{\partial l_r}{\partial p_1}\right]dp_1 + \left[\left(\frac{p_1 l_r^{-\frac{1}{2}} - w}{w}\right)\frac{\partial l_r}{\partial y}\right]dy + \left[\left(\frac{p_1 l_r^{-\frac{1}{2}} - w}{w}\right)\frac{\partial l_r}{\partial w} - \frac{2p_1 l_r^{\frac{1}{2}}}{w^2}\right]dw, \tag{1.48}$$

where $\Lambda = (2p_1 l_r^{-\frac{1}{2}} - 3w + \frac{1}{2}wyl_r^{-\frac{1}{2}}) > 0$ for the stability of the Nash equilibrium. Again we consider two scenarios for the economy: unemployment and full employment.

1.3.2.1 UNEMPLOYMENT

When there is unemployment in the economy, wage rate is fixed. Now, we can do comparative static analysis for the warlords in partial equilibrium framework. We derive following proposition from comparative statics results.

Proposition 3: *When the budget constraint is binding and there is unemployment in the economy so that wage rate is fixed, (a) a temporary rise in resource price increases both extraction and conflict; (b) an increase in expected future price of resource does not affect extraction and conflict; (c) a rise in physical resource stock increases both extraction and conflict; (d) an exogenous increase in wage rate decreases both the extraction and conflict,.* **Proof of proposition 3:** (see the detail derivation in appendix A.3)

(a) *Change in* p_1: From (1.47) and (1.48) we can derive the effects of change in p_1 on l_r and l_c as follows:

$$\frac{\partial l_r}{\partial p_1} = \frac{\overbrace{(y - 4l_r^{\frac{1}{2}})}^{+}}{\underbrace{\Lambda}_{+}} > 0 \tag{1.49}$$

$$\frac{\partial l_c}{\partial p_1} = \frac{2l_r^{\frac{1}{2}}}{w} + \frac{\overbrace{(p_1 l_r^{-\frac{1}{2}} - w)}^{+}}{w} \cdot \underbrace{\frac{\partial l_r}{\partial p_1}}_{+} = \frac{\overbrace{(p_1 y l_r^{-\frac{1}{2}} - 2wl_r^{\frac{1}{2}})}^{+}}{w \underbrace{\Lambda}_{+}} > 0 \tag{1.50}$$

See the proof of $(y - 4l_r^{\frac{1}{2}}) > 0$ in appendix A.3. Note, we get $(p_1 l_r^{-\frac{1}{2}} - w) > 0$ from first order condition of l_r (equation (8)), and $(p_1 y l_r^{-\frac{1}{2}} - 2wl_r^{\frac{1}{2}}) > 0$, as $p_1 l_r^{-\frac{1}{2}} > w$ and $y > 2l_r^{\frac{1}{2}}$.

A temporary rise in resource price in the current period leads to hiring more labor for extraction. This is logical because a rise in resource price increases the marginal benefit of labor in extraction. As the budget constraint is binding, conflict labor also increases in this case. With more resource revenue (as both price and extraction increase) warlords can employ more labor in conflict. However, the increase in extraction also tends to reduce the conflict labor as prize of conflict falls. The positive effects dominate negative effect, resulting a net increase in conflict.

The proposition 3(a) suggests that when the budget constraints of the warring groups are binding and there is unemployment in the economy, a temporary current sanction reduces war intensity. Note, our finding confirms Janus (2012) finding that under binding budget constraint current sanction is effective.

(b) *Change in* p_2: From (1.47) and (1.48) we can derive the effects of change in p_2 on l_r and l_c as follows:

$$\frac{\partial l_r}{\partial p_2} = \frac{\partial l_c}{\partial p_2} = 0 \tag{1.51}$$

Since budget constraint is binding in the current period, the future price does not affect extraction and conflict in our model. Thus, under binding constraint a sanction threat that reduce the future price of resource will not be effective in reducing conflict.

(c) *Change in* y: From (1.47) and (1.48) we can derive the effects of change in y on l_r and l_c as follows:

$$\frac{\partial l_r}{\partial y} = \frac{\overbrace{p_1 - wl_r^{\frac{1}{2}}}^{+}}{\underbrace{\Lambda}_{+}} > 0 \tag{1.52}$$

$$\frac{\partial l_c}{\partial y} = \frac{\overbrace{(p_1 l_r^{-\frac{1}{2}} - w)}^{+}}{w} . \underbrace{\frac{\partial l_r}{\partial y}}_{+} = \frac{l_r^{-\frac{1}{2}}(p_1 - w l_r^{\frac{1}{2}})^2}{w \underbrace{\Lambda}_{+}} > 0 \tag{1.53}$$

When the budget constraint is binding, an increase in physical resource stock increases extraction. Conflict also increases as prize of conflict increases. Thus, similar to non-binding case, when budget constraint is binding and there is unemployment in the economy, a reduction of resource stock can reduce the conflict.

(d) *Change in* w: From (1.47) and (1.48) we can derive the effects of change in w on l_r and l_c as follows:

$$\frac{\partial l_r}{\partial w} = \frac{3l_r - y l_r^{\frac{1}{2}}}{\Lambda} = -\frac{p_1 \overbrace{(y - 4l_r^{\frac{1}{2}})}^{+}}{w \underbrace{\Lambda}_{+}} < 0 \tag{1.54}$$

$$\frac{\partial l_c}{\partial w} = \frac{\overbrace{(p_1 l_r^{-\frac{1}{2}} - w)}^{+}}{w} . \underbrace{\frac{\partial l_r}{\partial w}}_{-} - \frac{2p_1 l_r^{\frac{1}{2}}}{w^2} = \frac{4p_1 l_r^{\frac{1}{2}} \overbrace{(w - p_1 l_r^{-\frac{1}{2}})}^{-} + p_1 w \overbrace{(l_r^{\frac{1}{2}} - y)}^{-}}{w^2 \underbrace{\Lambda}_{+}} < 0 \tag{1.55}$$

An increase in wage rate, which increases the marginal cost of extraction labor, decreases the labor in extraction. An increase in wage rate decreases conflict labor for two reasons: firstly, an increase in wage rate increases marginal cost of labor; and secondly, a decrease in extraction reduces the resource revenue so that warlord can afford less labor. However, a reduction in extraction associated with wage increase tend to increase the conflict labor. Negative effects dominate positive effect resulting a net decrease in conflict. Thus, under binding budgets an exogenous increase in wage rate can reduce conflict intensity.

1.3.2.2 FULL EMPLOYMENT

When there is full employment in the economy, wage rate is endogenous. Any exogenous policy changes will affect wage rate through labor market. In this case, the labor market equilibrium condition is as follows:

$$2l_r(p_1, w, y) + 2l_c(p_1, w, y) + l_a(p_a, w, V) = L \tag{1.56}$$

Totally differentiate equation (1.56) we get:

$$\left[\frac{\partial l_r}{\partial w} + \frac{\partial l_c}{\partial w} + \frac{1}{2}\frac{\partial l_a}{\partial w}\right] dw = -\left[\frac{\partial l_r}{\partial p_1} + \frac{\partial l_c}{\partial p_1}\right] dp_1 - \left[\frac{\partial l_r}{\partial y} + \frac{\partial l_c}{\partial y}\right] dy - \frac{1}{2}\frac{\partial l_a}{\partial V}dV - \frac{1}{2}\frac{\partial l_a}{\partial p_a}dp_a + \frac{1}{2}dL, \tag{1.57}$$

where

$$\frac{\partial l_r}{\partial w} + \frac{\partial l_c}{\partial w} + \frac{1}{2}\frac{\partial l_a}{\partial w} = \frac{p_1 w l_r^{\frac{1}{2}} - 4p_1^2 - wl_a\Lambda}{w^2\Lambda} = \frac{\Omega}{w^2\Lambda}$$

Note, for stability of equilibrium of the labor market the coefficient of dw must be negative. Thus, $\Omega/w^2\Lambda < 0 \Rightarrow \Omega = p_1 w l_r^{\frac{1}{2}} - 4p_1^2 - wl_a\Lambda < 0$.

From (1.57) we derive the changes in w with respect to changes in p_1, p_a, y, and L as follows: (see appendix A.4 for derivation)

$$\begin{aligned} \frac{dw}{dp_1} &= \frac{w^2\overbrace{(4l_r^{\frac{1}{2}} - y)}^{-} + w\overbrace{(2wl_r^{\frac{1}{2}} - p_1 l_r^{-\frac{1}{2}} y)}^{-}}{\underbrace{\Omega}_{-}} > 0, \ \frac{dw}{dp_a} = -\frac{p_a\Lambda}{\underbrace{\Omega}_{-}} > 0, \\ \frac{dw}{dy} &= -\frac{w^2\overbrace{(p_1 - wl_r^{\frac{1}{2}})}^{+} + wl_r^{-\frac{1}{2}}(p_1 - wl_r^{\frac{1}{2}})^2}{\underbrace{\Omega}_{-}} > 0, \ \frac{dw}{dL} = \frac{w^2\Lambda}{2\underbrace{\Omega}_{-}} < 0. \end{aligned} \tag{1.58}$$

In this case, a temporary rise in resource price increases the demand for both extraction and conflict labors, which cause a rise in wage rate. An increase in agricultural productivity increases the wage rate by increasing the demand for agricultural labor. An increase in physical resource stock increases wage rate by increasing the demand for both extraction and conflict labors. Other things remaining fixed, an exogenous increase in labor supply reduces wage rate.

Now we can do the comparative statics again in *general equilibrium framework*. We derive following proposition from comparative statics.

Proposition 4: *When the budget constraint is binding and there is full employment in the economy so that wage rate is endogenous, (a) a temporary rise in resource price* *increases both extraction and conflict only if agricultural sector is sufficiently large, and decreases agricultural production; (b) a rise in physical resource stock increases extraction, increases conflict only if agricultural sector is sufficiently large, and decreases agricultural production; (c) a rise in agricultural productivity or price decreases both extraction and conflict, and increase agricultural production; (d) an increase in labor supply increases both extraction and conflict, and also increase agricultural production.*

Proof of proposition 4: (see detail derivation in appendix A.4)

(a) *Change in* p_1: Differentiating optimal values of l_r, l_c, and l_a with respect to p_1 we get,

$$\frac{dl_r}{dp_1} = \frac{\partial l_r}{\partial p_1} + \frac{\partial l_r}{\partial w}.\frac{dw}{dp_1} = \frac{w\overbrace{(y - 4l_r^{\frac{1}{2}})}^{+}}{\underbrace{\Omega}_{-}}\left[\frac{2p_1(y-4l_r^{\frac{1}{2}})}{\Lambda} - \frac{p_a^2 V}{w^2}\right] \tag{1.59}$$

$$\frac{dl_c}{dp_1} = \frac{\partial l_c}{\partial p_1} + \frac{\partial l_c}{\partial w}.\frac{dw}{dp_1} = \frac{\overbrace{p_1 y l_r^{-\frac{1}{2}} - 2wl_r^{\frac{1}{2}}}^{+}}{\underbrace{\Omega}_{-}}\left[\frac{2p_1(y-4l_r^{\frac{1}{2}})}{\Lambda} - \frac{p_a^2 V}{w^2}\right] \tag{1.60}$$

$$\frac{dl_a}{dp_1} = \frac{\partial l_a}{\partial p_1} + \frac{\partial l_a}{\partial w}.\frac{dw}{dp_1} = \left(-\frac{2p_a^2 V}{w^3}\right).\underbrace{\frac{dw}{dp_1}}_{+} < 0 \tag{1.61}$$

Note, $dl_r/dp_1 > 0$ and $dl_c/dp_1 > 0$, if V is sufficiently large.

We know that a temporary increase in resource price increases demand for both extraction labor and conflict labor, if other things remain constant. However, an increase in resource price also increases wage rate, which tend to reduce the demand for extraction labor and conflict labor. Which effect will dominate depends on the size of the agricultural sector. If agricultural sector is relatively small (i.e. V is small) so that employment in agricultural sector is low, then a rise in resource price does cause a big increase in wage rate (as less labor available who can shift from agriculture sector to extraction and conflict sectors). A big rise in wage leads to a big fall in the demand for extraction and conflict labor. Thus, net effect on the demand for extraction labor and conflict labor might be negative if wage rate rises enough. On the other hand, if agricultural sector is relatively large, change in wage rate will be small, then an increase in resource price may lead to increase in both extraction and conflict labor. In this case, employment in agricultural sector surely falls due to increase in wage rate.

The proposition 4(a) implies that even if the budget constraint is binding, a current sanction may not reduce the conflict intensity if the wage rate is endogenous (i.e., full employment in the economy). The effects of sanction depends on the alternative employment opportunities, which in turn depends on the size the formal sector (agriculture sector in our model). If the formal sector is small so that employment opportunity is low, a sanction that reduces resource price can increase the conflict. A reduction in resource price due to sanction reduces the demand for both extraction and conflict labors initially, as a result wage rate falls. If alternative employment opportunity is low, the fall in wage will be high. If the fall in wage rate is sufficiently high, the warlords will hire more labor for conflict that may exceed the initial reduction in demand for conflict labor. Thus, sanction on resource exports may be counter-productive under binding budget constraint as well. This finding contradicts Janus (2012) finding that under binding budget constraint a current sanction reduces war intensity.

(b) *Change in y*: Differentiating optimal values of l_r, l_c, and l_a with respect to y we get,

$$\frac{dl_r}{dy} = \frac{\partial l_r}{\partial y} + \frac{\partial l_r}{\partial w}.\frac{dw}{dy} = \frac{\overbrace{p_1 - wl_r^{\frac{1}{2}}}^{+}}{\underbrace{\Omega}_{-}} \left[\frac{p_1 l_r^{-\frac{1}{2}} \overbrace{(wl_r - p_1 y)}^{-}}{\Lambda} - wl_a \right] > 0 \tag{1.62}$$

$$\frac{dl_c}{dy} = \frac{\partial l_c}{\partial y} + \frac{\partial l_c}{\partial w}.\frac{dw}{dy} = \frac{l_r^{-\frac{1}{2}}(p_1 - wl_r^{\frac{1}{2}})}{\underbrace{\Omega}_{-}} \left[\frac{p_1 \overbrace{(p_1 y - wl_r)}^{+}}{\Lambda} - \frac{(p_1 - wl_r^{\frac{1}{2}})p_a^2 V}{w^2} \right] \tag{1.63}$$

$$\frac{dl_a}{dy} = \frac{\partial l_a}{\partial y} + \frac{\partial l_a}{\partial w}.\frac{dw}{dy} = \left(-\frac{2p_a^2 V}{w^3} \right) . \underbrace{\frac{dw}{dy}}_{+} < 0 \tag{1.64}$$

Note, $dl_c/dy > 0$, if V is sufficiently large.

A rise in physical resource stock increases extraction directly, but decreases through rise in wage rate associated with it. In this case, direct effect dominates indirect effect resulting a net increase in extraction. A rise in physical resource stock tends to increase the demand for conflict labor directly, while it tends to reduce the demand for conflict labor via increase in wage rate (as demand for both extraction and conflict labor rise). The magnitude of wage increase depends on the relative size of the agricultural sector. The larger the agricultural sector, the more the labor employed in that sector. Then labors can be easily transferred from agriculture to war sector and the increment of wage will be low. In this case, direct effect dominates indirect effect and there will be net increase in conflict labor. However, if agricultural sector is relatively small, employment level in this sector will be low. In this case, wage increase will be high due to increased demand from war sector. If increase in wage is sufficiently high, the indirect effect may outweigh the direct effect, which results a net decrease in conflict labor. An increase in resource stock decreases the employment in agricultural sector by increasing wage rate.

The proposition 4(b) implies that if the budget constraint is binding, but wage rate is endogenous, a reduction in physical resource stock may not decrease the war intensity. If formal sector is relatively small so that employment opportunity is low, a reduction in resource stock (by international action) may exacerbate conflict.

(c) *Change in* p_a: Differentiating optimal values of l_r, l_c, and l_a with respect to p_a we get,

$$\frac{dl_r}{dp_a} = \frac{\partial l_r}{\partial p_a} + \frac{\partial l_r}{\partial w}.\frac{dw}{dp_a} = \underbrace{\frac{\partial l_r}{\partial w}}_{-} . \underbrace{\frac{dw}{dp_a}}_{+} < 0 \tag{1.65}$$

$$\frac{dl_c}{dp_a} = \frac{\partial l_c}{\partial p_a} + \frac{\partial l_c}{\partial w}.\frac{dw}{dp_a} = \underbrace{\frac{\partial l_c}{\partial w}}_{-} . \underbrace{\frac{dw}{dp_a}}_{+} < 0 \tag{1.66}$$

$$\frac{dl_a}{dp_a} = \frac{\partial l_a}{\partial p_a} + \frac{\partial l_a}{\partial w}.\frac{dw}{dp_a} = \frac{2l_a p_1 \overbrace{(wl_r^{\frac{1}{2}} - 4p_1)}^{-}}{p_a \underbrace{\Omega}_{-}} > 0 \tag{1.67}$$

An increase in agricultural productivity or price increases the demand for agricultural labor directly. As a result wage rate increases. A rise in wage rate reduces both the extraction and conflict. Increase in wage rate reduces the demand for agricultural labor also, but direct effect dominates indirect effect, resulting net increase in agricultural labor.

This proposition suggests that if the budget constraint is binding, an increase in agricultural productivity definitely reduces the conflict intensity. This implies that if alternative opportunities of employment and income increase in the economy, less people will engage in war activities.

(d) *Change in L*: Differentiating optimal values of l_r, l_c, and l_a with respect to L we get,

$$\frac{dl_r}{dL} = \frac{\partial l_r}{\partial L} + \frac{\partial l_r}{\partial w}.\frac{dw}{dL} = \underbrace{\frac{\partial l_r}{\partial w}}_{-} \cdot \underbrace{\frac{dw}{dL}}_{-} > 0 \tag{1.68}$$

$$\frac{dl_c}{dL} = \frac{\partial l_c}{\partial L} + \frac{\partial l_c}{\partial w}.\frac{dw}{dL} = \underbrace{\frac{\partial l_c}{\partial w}}_{-} \cdot \underbrace{\frac{dw}{dL}}_{-} > 0 \tag{1.69}$$

$$\frac{dl_a}{dL} = \frac{\partial l_a}{\partial L} + \frac{\partial l_a}{\partial w}.\frac{dw}{dL} = \underbrace{\frac{\partial l_a}{\partial w}}_{-} \cdot \underbrace{\frac{dw}{dL}}_{-} > 0 \tag{1.70}$$

An exogenous increase in labor supply reduces wage rate and thus increases employment in all sectors. This result explains why countries with more population and low level of income are more likely to experience civil wars.

1.4 PIECEMEAL REDUCTION IN WAR EFFORTS

Now we will examine, starting from war equilibrium, if both warlords agree to reduce the war efforts mutually, whether their expected return increase or decrease. An increase in expected return implies an increase in welfare and vice versa. Again we will consider two cases: budget constraint binding, and budget constraint non-binding. However, now we will not assume that two groups are symmetric.[21]

1.4.1 BUDGET CONSTRAINT NON-BINDING

When budget constraint is non-binding, with optimal values of l_{ri} and l_{ci}, $i = 1, 2$, the maximum expected return of group 1 is:

$$R_1 = p_1(2l_{r1}^{\frac{1}{2}}) - (wl_{r1} + wl_{c1}) + \frac{l_{c1}}{l_{c1} + l_{c2}} p_2(y_1 + y_2 - 2l_{r1}^{\frac{1}{2}} - 2l_{r2}^{\frac{1}{2}}), \tag{1.71}$$

and that of group 2 is:

$$R_2 = p_1(2l_{r2}^{\frac{1}{2}}) - (wl_{r2} + wl_{c2}) + \frac{l_{c2}}{l_{c1} + l_{c2}} p_2(y_1 + y_2 - 2l_{r1}^{\frac{1}{2}} - 2l_{r2}^{\frac{1}{2}}) \tag{1.72}$$

Given these optimum R_1 and R_2, we examine the outcome when warlords negotiate with each other and agree to reduce war efforts mutually. We derive the following proposition in this case.

Proposition 5: *When the budget constraint is not binding, a bilateral piecemeal reduction in war efforts unambiguously increase the welfare of each warring party both in the presence and absence of unemployment.*

Proof of proposition 5: (see appendix A.5 for detail proof)

Unemployment in the economy: We know that when there is unemployment in the economy, wage rate is fixed. Then totally differentiate equation (1.71), and using the first order conditions of group 1 and assuming $dl_{c1} = dl_{c2}$, we get:

$$dR_1 = -\frac{l_{c1}}{(l_{c1} + l_{c2})^2} p_2(y_1 + y_2 - 2l_{r1}^{\frac{1}{2}} - 2l_{r2}^{\frac{1}{2}})dl_{c2} = -wdl_{c2} \tag{1.73}$$

Similarly, totally differentiate (1.72), and using the first order conditions of group 2 and assuming $dl_{c1} = dl_{c2}$, we get:

$$dR_2 = -\frac{l_{c2}}{(l_{c1} + l_{c2})^2} p_2(y_1 + y_2 - 2l_{r1}^{\frac{1}{2}} - 2l_{r2}^{\frac{1}{2}})dl_{c1} = -wdl_{c1} \tag{1.74}$$

Equations (1.73) and (1.74) imply that if the budget constraint is non-binding and wage rate is fixed, a bilateral reduction of war efforts (i.e., $dl_{ci} < 0$) increases the expected return

[21] Even if two groups are non-symmetric, at Nash equilibrium, $l_{r1} = l_{r2}$ and $l_{c1} = l_{c2}$ in this case.

of both warring groups. In this case, the gain of each group comes from decrease in wining probability of the other group due to the reduction of conflict labor by that group. The increase in expected return of group 1 is equal to the change in wining probability of group 2 times the conflict prize times the change in conflict labor of group 2 (i.e., $l_{c1}/(l_{c1}+l_{c2})^2[p_2(y_1+y_2-2l_{r1}^{\frac{1}{2}}-2l_{r2}^{\frac{1}{2}})]dl_{c2}=wdl_{c2}$).

Full employment in the economy: When there is full employment in the economy, wage rate is endogenous. Totally differentiate (1.71), using the first order conditions, and assuming $dl_{c1}=dl_{c2}$ and $p_1=p_2$, we get:

$$dR_1=-\frac{l_{c1}}{l_{c1}+l_{c2}}p_2 l_{r2}^{-\frac{1}{2}}dl_{r2}-wdl_{c2}-(l_{r1}+l_{c1})dw=(l_{r1}-l_{c1})dw-wdl_{c2} \tag{1.75}$$

Similarly, totally differentiate (1.72), using the first order conditions, and assuming $dl_{c1}=dl_{c2}$ and $p_1=p_2$, we get:

$$dR_2=-\frac{l_{c2}}{l_{c1}+l_{c2}}p_2 l_{r1}^{-\frac{1}{2}}dl_{r1}-wdl_{c1}-(l_{r2}+l_{c2})dw=(l_{r2}-l_{c2})dw-wdl_{c1} \tag{1.76}$$

From labor market equilibrium condition we get:

$$dw=\left(\frac{w}{2l_{ri}+l_a}\right)dl_{ci},\ i=1,2$$

Substituting the expression of dw in to (1.75) and (1.76) we get:

$$dR_1=-(\beta w)dl_{c2},\ dR_2=-(\beta w)dl_{c1}, \tag{1.77}$$

where

$$\beta=\left(\frac{l_{r1}+l_{c1}+l_a}{2l_{r1}+l_a}\right)=\left(\frac{l_{r2}+l_{c2}+l_a}{2l_{r2}+l_a}\right)>0$$

Equation (1.77) implies that $dR_i>0$, if $dl_{cj}<0$.

When wage rate is endogenous, a bilateral reduction in war efforts changes the expected revenue of each warlord in different ways. Firstly, a reduction in conflict labor by other warlord (j) decreases the probability of wining of that group, and thus increases the expected revenue of group i (by wdl_{cj}). Secondly, decrease in wage rate due to decrease in conflict labors decreases the costs of extraction and conflict (by$(l_{ri}+l_{ci})dw$) and thus increases return further. However, increases in extraction (due to decreases in wage) by the other group decreases return somewhat (by $2l_{rj}dw$). But overall increases in return is greater than decreases in return, resulting a net increase in return.

Proposition (5) implies that a bilateral piecemeal reduction of war efforts unambiguously increases the welfare of both warring parties, when budget constraints of the parties are non-binding. This peace dividend comes from the fact that if both warlords could negotiate with each other and could reach a bargaining solution to share and use resources peacefully, their expected return would have been higher compared to Nash-equilibrium solution under conflict. War leads to inefficient use of conflict labor. Thus, a reduction in conflict labor increases the efficiency and improves the welfare. This finding suggests that the most effective policy for conflict resolution would be diplomatic negotiation.

One approach of rebellion is rebellion-as-mistake (Collier et al., 2004). Each group overestimates the prospects of victory and thus puts more war efforts. If international community negotiates with the rival groups and can convince them that both groups will be benefited by reducing their war efforts, then they may agree to reduce war efforts. Diplomatic negotiation reduces the information gap and commitment problems between two groups and thus increases the chance of peace. Regan and Aydin (2006) empirically show that diplomatic intervention is successful in reducing the expected duration of war.

1.4.2 BUDGET CONSTRAINT BINDING

When the budget constraint is binding, with optimal values of l_{ri} and l_{ci}, $i = 1, 2$, the maximum expected return of group 1 is:

$$R_1 = \frac{l_{c1}}{l_{c1} + l_{c2}} p_2(y_1 + y_2 - 2l_{r1}^{\frac{1}{2}} - 2l_{r2}^{\frac{1}{2}}), \tag{1.78}$$

and that of group 2 is:

$$R_2 = \frac{l_{c2}}{l_{c1} + l_{c2}} p_2(y_1 + y_2 - 2l_{r1}^{\frac{1}{2}} - 2l_{r2}^{\frac{1}{2}}) \tag{1.79}$$

Now we will examine if warlords negotiate with each other and agrees to reduce war efforts mutually, what happens to their welfare. We derive the following proposition in this case.

Proposition 6: *When the budget constraint is binding, a bilateral piecemeal reduction in war efforts unambiguously increase the welfare of each warring party both in the presence and absence of unemployment*

Proof of proposition 6: (see detail proof in appendix A.6)

Unemployment in the economy: When there is unemployment in the economy, wage rate is fixed. Then, totally differentiate (1.78) and using the first order conditions, we get:

$$dR_1 = -2(1+\gamma_2)wdl_{c2} \tag{1.80}$$

Similarly, totally differentiate (1.79) and using the first order conditions, we get:

$$dR_2 = -2(1+\gamma_1)wdl_{c1} \tag{1.81}$$

Equations (1.80) and (1.81) imply that if the budget constraint is non-binding and wage rate is fixed, a bilateral reduction of war efforts (i.e., $dl_{ci} < 0$) increases the expected return of both warring groups. In this case, gain in return of each warring group comes from two sources. Firstly, reduction in war efforts of group j decreases it's winning probability, and thus increases the return of group i (which is equal to $(1+\gamma_j)w.dl_{cj}$). Secondly, extraction of group j also decreases due to decrease in war as budget constraint is binding, which increases the return of group i further (by $(1+\gamma_j)(p_1 l_{r2}^{-\frac{1}{2}} - w)dl_{r2} = (1+\gamma_j)w.dl_{cj}$).

Full employment in the economy: When there is full employment in the economy, wage rate is endogenous. Then, totally differentiate (1.78) and using first order conditions, we get:

$$dR_1 = -2(1+\gamma_1)(l_{r1}+l_{c1})dw - 2(1+\gamma_2)wdl_{c2} \tag{1.82}$$

Similarly, totally differentiate (1.79) and using first order conditions, we get:

$$dR_2 = -2(1+\gamma_2)(l_{r2}+l_{c2})dw - 2(1+\gamma_1)wdl_{c1} \tag{1.83}$$

From labor market equilibrium condition we get,

$$\Gamma dw = -wp_1 l_{r1}^{-\frac{1}{2}}(dl_{c1} + dl_{c2}), \tag{1.84}$$

where $\Gamma = 2[w(l_{r1} + l_{c1}) - l_a(p_1 l_{r1}^{-\frac{1}{2}} - w)] < 0$, for the stability of excess demand function for labor. Equation (1.84) implies that wage rate decreases when warlords decrease their war efforts (i.e., $dl_{c1} < 0, dl_{c2} < 0$). In this case, equations (1.82) and (1.83) imply that a bilateral reduction of war efforts definitely increase the returns of both warring groups.

When wage rate is endogenous, a bilateral reduction in war efforts increases return of each group by two channels. First, reduction in number of soldiers and associated reduction of extraction by group j increases the return of group i (by $2(1 + \gamma_j)wdl_{cj}$). Second, reduction of conflict labor and extraction labor reduces the wage rate and thus reduces the cost of both extraction and conflict.

Thus, proposition (6) implies that a bilateral piecemeal reduction of war efforts unambiguously increase the welfare of the warring groups, when their budget constraints are binding. It again suggests that diplomatic negotiation can be an effective tool for conflict resolution in the presence of information gap and commitment problem.

1.5 CONCLUSION

Most of the empirical literature on civil conflicts find that the countries that are dependent on natural resources, have large extent of poverty, have more ethnic fictionalization, have large population, have high proportion of mountainous terrain or jungles, lack institutions for conflict resolution tend to experience more civil conflict (e.g., Fearon and Lation, 2003; Collier and Hoeffler, 2004; Fearon, 2005; Blattman and Miguel, 2010). There are no short run solutions to these structural causes of civil war. However, international community can target the immediate causes of conflict by reducing the reward of conflict or by raising the return of peaceful activities. Our paper provides some insights about the potential policies for conflict resolution.

In this chapter, we develop a two-period general equilibrium model of non-ethnic civil conflict, where two warlords fight with each other to capture resources. In our model resource extraction and wage rate are endogenous during the conflict, which is true for many real conflicts. By including a separate agricultural sector we create a general equilibrium framework to analyze the effects of exogenous policy shocks on civil conflict.

The findings of the chapter have important policy implications for conflict resolution. First, one of the most popular policies for conflict resolution is to impose sanctions on exports of natural resources from conflict zone, known as 'blood diamond' policy. Our results suggest that when the budget constraint is not binding, the policy of blood diamond is always counter-productive (i.e., a fall in resource price leads to increase of conflict). However, in this case, a credible sanction threat that decreases the future prize of conflict will reduce the conflict. Our results also suggest that a current sanction will surely limit the conflict, if the budget constraints of warring groups are binding and wage rate is fixed. Note, Janus (2012) also finds the same result for the binding constraint case. However, we find that if wage rate is endogenous and there are limited opportunities of employment in alternative sector, such as in agricultural sector, the conflict intensity may increase even if the budget constraint is binding. Thus, unlike Janus (2012), we show that sanctions might be counter-productive when the budget constraints of the warring groups are binding. Second, our results suggest that the most effective policy for conflict resolution would be bilateral piecemeal reduction in war efforts. Regardless of whether budget constraint binds or not, a mutual reduction in war efforts by the warring groups increase their welfare. Thus, if international community can negotiate with the warring groups and can convince them that both will be benefited by reducing the conflict, then they may agree to reduce conflict efforts. A third option is the productivity improvement in the agricultural sector (or any other sector like manufacturing sector). An increase in productivity will increase the labor demand in agricultural sector, which in turn can increase wage rate and can limit the conflict. Another policy would be to destroy the physical resource stocks for which the groups are fighting. But, it is very difficult for international community to apply this policy, and it may decrease post-conflict welfare. However, in extreme situation international community may apply this policy.

Note, our findings may not be applicable to all types of civil conflicts. They are applied to particular types of conflict, specifically non-ethnic conflicts where resources extraction is endogenous. In fact, there is no panacea for all types of conflicts. The effectiveness of policy depends on the nature and type of conflict.

CHAPTER 2

NATURAL RESOURCES AND INTER-STATE CONFLICTS: EFFECTS OF TRADE SANCTIONS

2.1 INTRODUCTION

Most of the recent theoretical and empirical literature on the relationship between natural resource and conflict focus mainly on civil wars. However, war between independent nations over natural resources are not uncommon. Bakeless (1921) studies the causes of several wars between the years 1878 to 1918 and finds that 14 of the 20 major wars had significant economic motivations, often related to conflicts over resources. In recent history, the most cited examples of the role of natural resources in inter-state wars are the Iran-Iraq war, Iraq's invasion of Kuwait, and the Falklands war. Many other historical examples of militarized inter-state dispute seem to be about natural resources. Examples include Algerian war of independence (with France, oil), Algeria and Morocco (Western Sahara, phosphate and possibly oil), Argentina and Chile (Beagle Channel, fisheries and oil), Argentina and Uruguay (Rio de la Plata, minerals), Bolivia and Paraguay (Chaco War, oil), Bolivia, Chile, and Peru (War of the Pacific, minerals and sea access), China and Vietnam (Paracel Islands, oil), Ecuador and Peru (Cordillera del Condor, oil and other minerals), Nigeria and Cameroon (Bakassi peninsula, oil), and many others.[1]

Klare (2001) argues that, following the end of the Cold War, control of valuable natural resources has become increasingly important, and these resources will become a primary motivation for wars in the future. Like blood diamonds that are believed to fuel African civil wars, many people think blood oil to be a major determinant of international aggression (Kaldor et al., 2007). Some recent and ongoing tensions involving territorial claims are thought to be mineral resource related. Examples of such tensions include Bangladesh-Myanmar, Bangladesh-India, Guyana-Suriname, Nicaragua-Honduras,

[1] See Acemoglu et al., 2012; Caselli et al., 2013; Carter Center, 2010; De Soysa et al., 2011.

Guinea-Gabon, Chad-Libya, Oman-Saudi Arabia, Algeria-Tunisia, Eritrea-Yemen, Guyana-Venezuela, Congo-Gabon, Equatorial Guinea-Gabon, Greece-Turkey, Colombia-Venezuela, Southern and Northern Sudan (Caselli et al., 2013; Carter Center, 2010).[2]

Though there are some case studies about the role of natural resources in inter-state wars, there are very limited theoretical and empirical studies about underlying mechanism of these wars. The literature on inter-state conflicts so far has emphasized the role of trade (e.g., Skaperdas and Syropoulos, 2001; Syropoulos, 2006; Becsi and Lahiri, 2007; Martin et al., 2008; Rohner et al., 2013; Garfinkel et al., 2015), domestic institutions (e.g., Maoz and Russett, 1993; Conconi et al., 2012), development (e.g., Gartzke, 2007; Gartzke and Rohner, 2011), and stocks of weapons (e.g., Chassang and Padró i Miquel, 2010). Surprisingly, natural resources have received little systematic attention in terms of both modeling and empirical investigations.

Many researchers study conflict between two countries in trade-theoretic framework and show how globalization and trade affects conflict efforts. For example, Skaperdas and Syropoulos (2001) develop a simple model with two small countries disputing over a resource used in the production of tradeables. They show that if the international price of the contested resource is lower than a country's autarkic price, the opportunity cost of arming rises, and thus, the introduction of trade softens the intensity of competition for the contested resource, reduces arming, and raises welfare relative to autarky. The opposite can occur, however, when the international price of the contested resource is higher than its autarkic price. Syropoulos (2006) also examines the relationship between trade openness and inter-state conflict for contested resources in a general equilibrium framework. He shows that depending on world prices and their effect on domestic factor prices, it is possible for trade to reduce the opportunity cost of arming and thereby intensify conflict. Becsi and Lahiri (2007) use a three country framework to examine how third country can

[2]Recently a U.N. Tribunal has settled the dispute over maritime boundary between Bangladesh-Myanmar, and Bangladesh-India in the Bay of Bengal.

use policies to influence the conflict between two other countries. Garfinkel et al. (2015) combine a standard trade model with a contest function to study interstate disputes over resources. They show that conflict over resources affects the pattern of comparative advantage, and free trade may intensify conflicts so much that autarky may be preferable to free trade. Acemoglu et al. (2012) study the war between a resource rich and a resource poor countries in a dynamic framework to see under what conditions such war can be prevented. They find that in the case of inelastic resource demand, war incentives increase over time and war may become inevitable; and under monopolistic situations, regulation of prices and quantities by the resource-rich country can prevent war. De Soysa et al. (2011) develop a set of models to study a strategic perspective on petroleum and interstate conflict. In contrast to the popular belief that oil is a catalyst for war, they argue that oil exporters actually experience less wars as powerful petroleum importers protect petrostates. Caselli et al. (2013) study how the geographic location of natural resource endowments affects the likelihood of inter-state wars. They find the the likelihood of war increases if the resources of the warring countries are closer to the border.

Unlike the case of cross-country conflicts, there is sizable theoretical and empirical literature on the role of natural resources in civil conflicts.[3] The main theme of this literature is that natural resource abundance is often the principal cause of civil wars. Our paper is complementary to the existing literature in the sense that we emphasis the role of natural resource in the inter-state war as well. Most of the theoretical work on conflicts assumes the fighting motives as given; the objective is to study the determinants of fighting efforts (Caselli et al., 2013). In our paper, we also do not focus on the causes of conflict, rather we examine the factors that determine the relative war efforts of the two warring countries. At the same time we examine how international sanctions on resource exports affect the intensity of war.

Most of the existing literature use a static one-period framework to study the

[3]Summarized by Ross (2004), Collier and Hoeffler (2007), Blattman & Miguel (2010), Van der Ploeg (2011).

relationship between natural resource and inter-state conflict.[4] Besides, resource stocks are considered exogenous during conflict in the existing literature on inter-state conflict, i.e., it does not consider the possibility that natural resources can be extracted and sold during the conflict. Janus (2012) however develops a two-period model for civil conflict between two social groups and considers the possibility that resource extraction is endogenous. Following Janus (2012), we develop a two-period model for inter-state conflict, where resource extraction is endogenous. However, unlike Janus (2012) who employs a partial equilibrium framework, we treat wage rates as endogenous. In other words, we employ a general equilibrium model where two neighboring countries fight to acquire each other's natural resource stock. In our model in each country labor force is used for three purposes: agricultural production, resource extraction, and war. The two competitive labor markets in the two countries determine equilibrium wage rates in them, which in turn determine their relative war efforts.[5]

Under our framework, first of all, we examine the determinants of relative war efforts in the two asymmetric countries. We find that regardless of the differences in initial ownership of resource stocks, the war efforts of the two countries will be the same, *ceteris paribus*; a country with larger labor force exerts more war efforts; and a country with larger land endowment or higher productivity exerts lower war efforts (i.e., paradox of power). Second, we examine the effects of different types of international sanctions on war efforts of the two countries. We find that a temporary current sanction on both countries, or even on one of the countries, will be counter-productive (i.e., increases the war intensity); an anticipated future sanction on both countries will reduce war intensity; whether an anticipated future sanction on one country will reduce war intensity depends on the level of resource stock; and finally, the effect of a permanent sanction on both countries is in general ambiguous, but war intensity will fall only if the resource stocks of the countries

[4]The only exception is Acemoglu et al. (2012), who consider a dynamic framework.

[5]This framework is also applicable in an intra-state conflict, where labor market is segmented between two regions of a country and two regions fight with each other.

are sufficiently high.

The rest of the chapter is organized as follows. In section 2.2, we describe the basic setup of the model. Section 2.3 analyses the equilibrium conditions and compare the equilibrium war efforts of the two countries. In section 2.4, we discuss the effects of international sanctions on war efforts. In section 2.5, we introduce uncertainty about future sanction. Finally, section 2.6 concludes the chapter.

2.2 THE MODEL

Consider two neighboring countries which are endowed with some initial stock of natural resources. The government of each country is motivated by greed, and fight with each other to capture more resources. There are three sectors in each economy: government sector, resource extraction sector, and agricultural sector.[6] Each country is also endowed with fixed amount of labor force and land. The government of each country recruits labor as soldiers. The extraction sector hires labor to extract natural resources. The agricultural sector uses land and also hires labor to produce agricultural goods. Thus, the aggregate demand for labor is the sum of the labor demands from all three sectors. The model works in two stages: in the first stage the governments decide how many soldier to have; in the second stage extraction sector and agricultural sector decide how much labor to employ. Labors move freely between sectors but not between countries, implying that the wage rate is same in all sectors within a country. We consider two periods: in the first period each country extracts some of the resources it possesses and fight with each other; if a country wins the war, in the second period it gets all the remaining resource stock. Each government finances war costs by imposing lump sum tax on both the extraction and agricultural sectors.[7]

Let, country i (i=1,2) possesses an initial resource stock, y_i, and hires l_{ci} amount of

[6]The third sector could be any other sector not involved directly in the war.

[7]This is done to simplify the analysis. One could in principle assume that revenue for resources finance war efforts as in Lahiri (2010) and Janus (2012).

labor for fighting. Then, the country i's winning probability in war is given by the conventional ratio-form contest success function: $q_i = l_{ci}/(l_{ci} + l_{cj})$, i=1,2, and $j \neq i$. This function implies that for given amount of soldiers of country j, the winning probability of country i increases with it's number of soldiers and vice versa. The extraction sector hires l_{ri} amount of labor for extraction and the resource extraction function is given by $r_i = 2l_{ri}^{\frac{1}{2}},\ (i = 1, 2)$. There is also a private agricultural sector in each country, and it hires l_{ai} amount of labor from the labor market. The agricultural production function is given by: $A_i = 2\lambda_i l_{ai}^{\frac{1}{2}} V_i^{\frac{1}{2}} (i = 1, 2)$, where V_i is the fixed amount of land the economy has and λ_i is the productivity parameter of the agricultural sector.

We consider that each country is a small open economy and exporter of natural resources in the world market. Thus, world market price is given for the country. Let p_1 be the world price of natural resource in period 1, and p_2 is the world price of natural resource in period 2. We shall assume the prices to be the same and denote the common price by p, i.e., $p_1 = p_2 = p$. However, later we shall consider changes in p_1 but not in p_2, and vice versa. Therefore, we shall keep the separate notations for that purpose.

The expected return of the extraction sector of country i is:

$$\begin{aligned} R_{ri} &= p_1 r_i - w_i l_{ri} + q_i p_2 (y_i + y_j - r_i - r_j) \\ &= p_1(2l_{ri}^{\frac{1}{2}}) - w_i l_{ri} + \frac{l_{ci}}{l_{ci} + l_{cj}} p_2 (y_i + y_j - 2l_{ri}^{\frac{1}{2}} - 2l_{rj}^{\frac{1}{2}}),\ i = 1, 2, \text{ and } j \neq i, \end{aligned} \tag{2.1}$$

where w_i is the domestic market wage rate in country i, and $p_1 r_i - w_i l_{ri}$ is the net revenue in period 1. $(y_i + y_j - r_i - r_j)$ is the resource stock that country i get at the beginning of the 2nd period, if it wins the war. For simplicity, we also assume no discounting for period 2. Since q_i is the winning probability of country i in the conflict, the expected value of resource stock in the 2nd period is $q_i p_2 (y_i + y_j - r_i - r_j)$.[8]

The country is an importer of agricultural goods. Let, p_a is the international market price of agricultural goods. Then, the profit of agricultural sector is given by:

$$R_{ai} = p_a(2\lambda_i l_{ai}^{\frac{1}{2}} V_i^{\frac{1}{2}}) - w_i l_{ai},\ i = 1, 2. \tag{2.2}$$

[8] We do not consider second period extraction of resources, because it does not affect our analysis.

The government of each country imposes lump sum tax T_i on both extraction and agricultural sectors to finance its war cost. Then, the budget balance equation of the government is given by:

$$w_i l_{ci} = T_i,\ i = 1, 2, \tag{2.3}$$

and total income of all agents in the country i is given by:[9]

$$I^i = w_i L_i + R_{ri} + R_{ai} - T_i, i = 1, 2, \tag{2.4}$$

where L_i is the fixed supply of labor in country i .

The labor market equilibrium condition in country i is given by:

$$l_{ri} + l_{ai} + l_{ci} = L_i,\ i = 1, 2. \tag{2.5}$$

Equations (2.1) to (2.5) describe the basic structure of the model. In the next section we derive equilibrium conditions of the two countries.

2.3 THE EQUILIBRIUM

We assume that the sequence of decision making is as follows:

Stage 1: The labor market clears,

Stage 2: Two governments simultaneously decide on war efforts to maximize national incomes of the countries,

Stage 3: For given war efforts and winning probability of the government, extraction sector of each country decides how much resource to extract in period 1 and how much to leave for period 2. At the same time, the agricultural sector also decides how much to produce in period 1.

We solve the game by backward induction method. In stage 3, we derive the optimal level of extraction for extraction sector, given the war efforts and winning probability of the government. At the same time, we derive the optimal level of employment in the

[9] We abstract from the possibility that conflict adversely affects the lives, infrastructures, and thus lower the productive capacity of a country.

agricultural sector. Then in stage 2, we derive optimal level of war efforts for the two governments who play a simultaneous move game to maximize national incomes.

From equation (2.1) we derive optimal extraction labor for country i. The first order condition for optimal l_{ri} is:

$$p_1 l_{ri}^{-\frac{1}{2}} = w_i + q_i p_2 l_{ri}^{-\frac{1}{2}},\ i = 1, 2, \tag{2.6}$$

which states that marginal benefit of extraction labor (the left-hand side) must equal marginal cost of extraction labor (the right-hand side). Marginal benefit of extraction equals the value of marginal product of extraction labor in the first period, while marginal cost equals wage cost of labor plus opportunity cost of extracting now instead of conserve it for the future. The opportunity cost of extraction is equal to the probability of winning the conflict (q_i) times the value of marginal product of labor in period 2 ($p_2 l_{ri}^{-\frac{1}{2}}$). From equation (2.6) we get optimal l_{ri} as follows:

$$l_{ri} = \left(\frac{p_1 - q_i p_2}{w_i}\right)^2,\ i = 1, 2.$$

From equation (2.2) we derive optimal agricultural labor for country i. The first order condition for optimal l_{ai} is:

$$p_a \lambda_i l_a^{-\frac{1}{2}} V_i^{\frac{1}{2}} = w_i,\ i = 1, 2. \tag{2.7}$$

Equation (2.7) equates marginal benefit of agricultural labor to the marginal cost, where marginal benefit is the value of marginal product of agricultural labor and marginal cost is just wage cost of labor. From (2.7) we get the optimal l_{ai} as follows:

$$l_{ai} = \frac{p_a^2 \lambda_i^2 V_i}{w_i^2},\ i = 1, 2.$$

Substituting the optimal solution of l_{ri} into equation (2.1), we get optimal expected return for the extraction sector as follows:

$$R_{ri} = w_i l_{ri} + q_i p_2 (y_i + y_j - 2 l_{rj}^{\frac{1}{2}}),\ i = 1, 2, \text{ and } j \neq i. \tag{2.8}$$

Substituting the optimal solution of l_{ai} into equation (2.2), we get optimal return for the agricultural sector as follows:

$$R_{ai} = w_i l_{ai},\ i = 1, 2. \tag{2.9}$$

Substituting (2.8) and (2.9) into equation (2.4), we get total income of the country i as:

$$\begin{aligned} I^i &= w_i L_i + w_i l_{ri} + q_i p_2 (y_i + y_j - 2 l_{rj}^{\frac{1}{2}}) + w_i l_{ai} - w_i l_{ci} + F_i \\ &= w_i L_i + w_i \left(\frac{p_1 - q_i p_2}{w_i} \right)^2 + \frac{l_{ci}}{l_{ci} + l_{cj}} p_2 \left(y_i + y_j - 2 \frac{p_1 - q_j p_2}{w_j} \right) \\ &\quad + w_i \left(\frac{p_a^2 \lambda_i^2 V_i}{w_i^2} \right) - w_i l_{ci} + F_i, \quad (i = 1, 2, \text{and} \ \ j \neq i). \end{aligned} \tag{2.10}$$

At the second stage, each government maximize I^i to choose l_{ci}. From (2.10) we get first-order condition for l_{ci} as (see appendix B.1):

$$\frac{\partial q_i}{\partial l_{ci}} p_2 (y_i + y_j - r_i - r_j) - q_i p_2 \frac{\partial r_j}{\partial l_{ci}} = w_i,$$

which gives

$$\frac{l_{cj}}{(l_{ci} + l_{cj})^2} p_2 (y_i + y_j - 2 l_{ri}^{\frac{1}{2}} - 2 l_{rj}^{\frac{1}{2}}) - \frac{2 p_2^2}{w_j} . \frac{l_{ci} l_{cj}}{(l_{ci} + l_{cj})^3} = w_i,\ (i = 1, 2, \text{ and } j \neq i). \tag{2.11}$$

The left hand side of equation (2.11) is the marginal benefit of conflict labor. The first term of left hand side is the change in the likelihood of winning the conflict $(\partial q_i / \partial l_{ci})$ times the value of resource stock after initial extraction of two countries $(p_2(y_i + y_j - r_i - r_j))$. Note, country j changes the level of extraction in response to change in the conflict efforts of country i. As a result marginal benefit of country i changes by $q_i p_2 (\partial r_j / \partial l_{ci})$, which is the second term of the left hand side. The right hand side of (2.11) is marginal cost of war, which is simply the wage cost of additional soldier.

Equation (2.11) gives us the reaction functions for the two countries. Using these, we derive the following relationship between l_{c1} and l_{c2} (see appendix B.2):

$$w_1 l_{c1} = w_2 l_{c2} \quad \Leftrightarrow \quad l_{c2} = \frac{w_1}{w_2} l_{c1} \tag{2.12}$$

Equation (2.12) implies that relative war efforts of the two countries depends on the relative wage rate, and in equilibrium two countries war costs are same even though the two countries can be asymmetric in many ways.

Using (2.12) we can derive optimal l_{r1} and l_{r2} in terms of wage rates and exogenous parameters as follows:

$$l_{r1} = \left[\frac{p_1}{w_1} - \frac{p_2 w_2}{w_1(w_1+w_2)}\right]^2, \ l_{r2} = \left[\frac{p_1}{w_2} - \frac{p_2 w_1}{w_2(w_1+w_2)}\right]^2$$

Substituting (2.12) in to (2.11) we get optimal values of l_{c1} and l_{c2} as follows:

$$l_{c1} = \frac{w_2}{(w_1+w_2)^2}B, \ l_{c2} = \frac{w_1}{(w_1+w_2)^2}B,$$

where

$$B = p_2\left(y_1 + y_2 - \frac{2p_1}{w_1} + \frac{2p_2 w_2}{w_1(w_1+w_2)} - \frac{2p_1}{w_2} + \frac{2p_2 w_1}{w_2(w_1+w_2)} - \frac{2p_2}{w_1+w_2}\right).$$

Substituting the optimal l_{c1}, l_{r1}, and l_{a1} in to equation (2.5) we get labor market equilibrium condition of country 1 as follows:

$$\frac{w_2}{(w_1+w_2)^2}B + \left[\frac{p_1}{w_1} - \frac{p_2 w_2}{w_1(w_1+w_2)}\right]^2 + \frac{p_a^2\lambda_1^2 V_1}{w_1^2} = L_1 \tag{2.13}$$

Substituting the optimal l_{c2}, l_{r2}, and l_{a2} in to equation (2.5) we get labor market equilibrium condition of country 2 as follows:

$$\frac{w_1}{(w_1+w_2)^2}B + \left[\frac{p_1}{w_2} - \frac{p_2 w_1}{w_2(w_1+w_2)}\right]^2 + \frac{p_a^2\lambda_2^2 V_2}{w_2^2} = L_2 \tag{2.14}$$

Equations (2.13) and (2.14) simultaneously determine optimal w_1 and w_2. Though we don't have explicit solutions for w_1 and w_2, we can determine the relative magnitude of the two. The relative magnitudes of w_1 and w_2 will depend on the relative values of different parameters of the two countries. Relative wage rate determines the relative war efforts of the two countries. Now we will examine the relative war efforts of the two countries if they are non-symmetric in terms of different parameters. With $p_1 = p_2 = p$, the optimal l_{ri} and l_{ci} are as follows:

$$l_{r1} = l_{r2} = \left(\frac{p}{w_1+w_2}\right)^2, \ l_{c1} = \frac{w_2}{w_1}l_{c2} = \frac{w_2}{(w_1+w_2)^2}B$$

where $B = p(y_1 + y_2 - 6p/(w_1+w_2)) > 0$.

Using these results and Combining equations (2.13) and (2.14) we can derive the following equation (see appendix B.3):

$$(L_1 - L_2) + \frac{B}{(w_1 + w_2)^2}(w_1 - w_2) + \left(\frac{a_2}{w_2^2} - \frac{a_1}{w_1^2}\right) = 0, \tag{2.15}$$

where $a_1 = p_a^2\lambda_1^2 V_1,\ a_2 = p_a^2\lambda_2^2 V_2$.

Using equation (2.15) we can compare the Nash equilibrium war efforts of the two countries under different scenarios on the extent on asymmetry between the two countries.

Case 1: *Benchmark case*: Two countries are perfectly symmetric i.e,
$L_1 = L_2, V_1 = V_2, \lambda_1 = \lambda_2, y_1 = y_2$.

In this case from (2.15) we get:[10]

$$\left[\frac{B}{(w_1 + w_2)^2} + \frac{a(w_1 + w_2)}{w_1^2 w_2^2}\right](w_2 - w_1) = 0 \Rightarrow w_1 = w_2$$

As $w_1 = w_2$, we also have $l_{c1} = l_{c2}$. The interpretation is straightforward that if two countries are symmetric in all respects, in equilibrium their wage rate, war efforts and winning probabilities will be same. Now we can compare the war efforts of two countries when they are non-symmetric.

Case 2: Country 1 and country 2 are same in all respects except that the former possesses a bigger resource stock than latter, i.e., $y_1 > y_2$, but $L_1 = L_2, V_1 = V_2, \lambda_1 = \lambda_2$.

In this case from (2.15) we get the same result as of case 1, that is $w_1 = w_2$, and thus $l_{c1} = l_{c2}$. It implies that even if the initial resource endowment is different between two countries their equilibrium war efforts and winning probabilities will be same. In the absence of property rights, insecurity neutralizes the effects of cross-sectional variation in the resource endowment on individual countries' war efforts. Hirshleifer (1991) calls this tendency the *paradox of power*, that the relatively poorer side viewing the marginal return from appropriation to be relatively higher than the marginal product from useful production.

Case 3: Country 1 has a larger labor force than country 2, they are same in all other aspects, i.e., $L_1 > L_2$, but $V_1 = V_2, \lambda_1 = \lambda_2, y_1 = y_2$.

[10]Under symmetry, $a_1 = a_2 = a$.

In this case from (2.15) we get:

$$\left[\frac{B}{(w_1+w_2)^2}+\frac{a(w_1+w_2)}{w_1^2w_2^2}\right](w_2-w_1)=L_1-L_2 \quad\Rightarrow\quad w_1<w_2.$$

As $w_1 < w_2$, $l_{c1} > l_{c2}$. The interpretation of this result is that a country with a relatively larger labor force will have a lower wage rate. A lower wage rate implies lower marginal cost or opportunity cost of conflict. Thus, a country with larger labor force (i.e., population) will exert more war efforts. This prediction is consistent with the empirical findings that the countries with the larger population are more likely to engage in conflict (Collier & Hoeffler 1998, 2004; Fearon, 2005).

Case 4: Country 1 has a larger endowment of land, but they are the same in all other aspects, i.e., $V_1 > V_2$, but $L_1 = L_2, \lambda_1 = \lambda_2, y_1 = y_2$.

In this case from (2.15) we get:

$$\frac{w_2}{(w_1+w_2)^2}B+\frac{p_a^2\lambda^2V_1}{w_1^2}=\frac{w_1}{(w_1+w_2)^2}B+\frac{p_a^2\lambda^2V_2}{w_2^2},$$

which implies

$$\left[\frac{B}{(w_1+w_2)^2}+\frac{p_a^2\lambda^2V_2(w_1+w_2)}{w_1^2w_2^2}\right](w_2-w_1)=\frac{p_a^2\lambda^2(V_2-V_1)}{w_1^2}.$$

Thus, $V_1 > V_2 \iff w_1 > w_2 \iff l_{c1} < l_{c2}$. A country with a large endowment of productive land will have large agricultural sector. The demand for labor and employment in the agricultural sector will be high, as a result wage rate will be high. A high wage rate means higher opportunity cost of conflict and hence leads to lower level of war efforts. This prediction is also supported by empirical findings that countries with low level of per capita income tend to engage in more conflict (Collier & Hoeffler 1998, 2004; Fearon, 2005).

Case 5: Country 1 has higher productivity in agriculture sector than that of country 2, they are same in all other aspects, i.e., $\lambda_1 > \lambda_2$, but $L_1 = L_2, V_1 = V_2 = V, y_1 = y_2$.

This case is very similar to Case 5, and following similar arguments, we can show that $\lambda_1 > \lambda_2 \iff w_1 > w_2 \iff l_{c1} < l_{c2}$.

2.4 EFFECTS OF SANCTIONS

Having discussed the equilibrium war efforts of the two countries, now we will discuss how war efforts change with international sanctions on resource exports. A sanction on resource exports reduces the export price received by the sanctioned country. Thus, we will examine how war efforts change with the change in resource price. We consider different types of sanctions on resource exports (for both countries and for one of the two countries): (i) temporary sanction, (ii) sanction threat or expected future sanction, and (iii) permanent sanction.

In order to simplify our analyses, we assume that two countries are symmetric so that in the initial equilibrium $w_1 = w_2 = w$. Earlier we have also assumed that, at the initial equilibrium, resource prices to be the same in the two periods (i.e, $p_1 = p_2 = p$).

In general, a change in the price of exports affects the war efforts directly for given wage rates, and indirectly through change in wage rates.

We first look at how wage rates are affected by change in resource prices. Totally differentiate equations (2.13) and (2.14) we get (see appendix B.4):

$$\alpha_1 dw_1 + \alpha_2 dw_2 = \beta_1 dp_1 + \gamma_1 dp_2, \tag{2.16}$$

$$\alpha_3 dw_1 + \alpha_4 dw_2 = \beta_2 dp_1 + \gamma_2 dp_2, \tag{2.17}$$

where

$$\begin{aligned} \alpha_1 &= \alpha_4 = \frac{2p(2wy - 3p) - p^2 + 16a}{8w^3}, \\ \alpha_2 &= \alpha_3 = -\frac{p^2}{8w^3}, \\ \beta_1 &= \beta_2 = 0, \\ \gamma_1 &= \gamma_2 = \frac{wy - 2p}{2w^2}. \end{aligned}$$

Equations (2.16) and (2.17) constitute a system of equations, and these give, for any change in the prices in this system, the corresponding changes in w_1 and w_2 .

Totally differentiating optimal l_{c1} and l_{c2} with respect to p_t $(t = 1, 2)$ we get:

$$\frac{dl_{c1}}{dp_t} = \frac{\partial l_{c1}}{\partial p_t} + \frac{\partial l_{c1}}{\partial w_1}\frac{dw_1}{dp_t} + \frac{\partial l_{c1}}{\partial w_2}\frac{dw_2}{dp_t}, \tag{2.18}$$

$$\frac{dl_{c2}}{dp_t} = \frac{\partial l_{c2}}{\partial p_t} + \frac{\partial l_{c2}}{\partial w_1}\frac{dw_1}{dp_t} + \frac{\partial l_{c2}}{\partial w_2}\frac{dw_2}{dp_t}. \tag{2.19}$$

Equations (2.18) and (2.19) state that a change in resource price changes the war efforts of each country via three channels: first, it changes the war efforts directly; second, it changes the wage rate of the country under consideration and thus changes the war efforts; and third, it changes the wage rate of rival country and thus changes the war efforts of the country. Now we examine the effects of sanctions on war efforts of the two countries.

(i) Temporary sanction: A temporary sanction on resource exports reduces the price of resource in period 1, p_1, in the international market. If only p_1 changes, solving the system of equations (2.16) and (2.17) we get the changes in w_1 and w_2 as follows (see appendix B.5):

$$\Delta.\frac{dw_1}{dp_1} = \beta_1\alpha_4 - \beta_2\alpha_2,\ \Delta.\frac{dw_2}{dp_1} = \beta_2\alpha_1 - \beta_1\alpha_3,$$

where $\Delta = \alpha_1\alpha_4 - \alpha_2\alpha_3 > 0$ from the Walrasian stability of the labor market. Under the assumptions of symmetry $(w_1 = w_2 = w)$ and $p_1 = p_2 = p$, we get $\beta_1 = \beta_2 = 0$ (see the expressions after equation (2.17)), and thus $dw/dp_1 = 0$.

Now the change in conflict efforts of each country for a change in p_1 is (see appendix B.6.1):

$$\frac{dl_c}{dp_1} = \frac{\partial l_c}{\partial p_1} + \frac{\partial l_c}{\partial w}\frac{dw}{dp_1} = \frac{\partial l_c}{\partial p_1} = -\frac{p}{w^2} < 0. \tag{2.20}$$

This result implies that a temporary current sanction that reduces the price of resource in period 1 will increase conflict efforts of both countries.[11] In this case, reduction in resource price decreases extraction of resources in the period 1, leaving more prize for conflict. Wage rate may increase or decrease depending on the relative price of resource in two periods. A change in wage rate may increase or decrease the conflict depending on the

[11] This result holds even if two countries are non-symmetric. This is because if $p_1 = p_2$, $\beta_1 = \beta_2 = 0$. In this case, $dw_1/dp_1 = dw_2/dp_1 = 0$ i.e., a temporary change in resource price will not affect wage rate. Then $dl_c/dp_1 = \partial l_c/\partial p_1 < 0$.

resource stocks. However, overall effect of temporary resource price decrease on conflict is positive. Thus, temporary sanction is counter-productive.

Now suppose international community imposes sanction to one country, say country 1. It implies that in period 1 the resource price for country 1, p_{11}, will fall. But, the resource price for country 2, p_{12}, will be unchanged. Now under the assumption of symmetry, from (2.16) and (2.17) we get (see appendix B.6.2):

$$\frac{dw_1}{dp_{11}} = -\frac{dw_2}{dp_{11}} = \frac{2pw}{8a + p\underbrace{(2wy - 3p)}_{+}} > 0,$$

and the change in war efforts of country 1 is:

$$\frac{dl_{c1}}{dp_{11}} = -\frac{p}{2w^2} - \frac{p^2(2wy - 3p)}{2w^2[8a + p(2wy - 3p)]} < 0, \tag{2.21}$$

since $l_c = p(2wy - 3p)/4w^2 > 0 \Rightarrow 2wy - 3p > 0$.

Equation (2.21) implies that temporary sanction on one country is surely counter-productive in the sense that it increases the war efforts of that country. In this case, a reduction of resource price for country 1 decreases extraction of that country and thus induces more conflict efforts. Decrease in resource price for country 1 reduces wage rate in country 1 and increases wage rate in country 2 (as their conflict efforts increases). The combined effects on the changes in two wage rates is negative on the conflict. Thus, overall effect of temporary sanction on one country must be negative on that country.

Now we will examine how the war efforts of the other country changes if a temporary sanction is imposed on one country. In this case the change in war efforts of country 2 as a result of sanction on country 1 is as follows (see appendix B.6.3):

$$\frac{dl_{c2}}{dp_{11}} = \frac{-8ap}{2w^2[8a + p(2wy - 3p)]} < 0, \tag{2.22}$$

since $2wy - 3p > 0$.

Equation (2.22) indicates that a temporary sanction on country 1 increases the war efforts of country 2 as well. This is because a reduction of extraction in country 1 increases conflict prize, thus induces more war efforts by country 2. Decrease in wage rate in country

1 and increase in wage rate in country 2 together reduces the country 2's war efforts somewhat. But, negative effect dominates positive effect, yielding a net increase in war efforts.

Thus, the policy implication is that if resource extraction is endogenous during the conflict, a temporary sanction on resource exports is always counter-productive.

(ii) An anticipated future sanction: Suppose the international community announces a sanction threat to the warring countries that it will impose sanction on resource exports if the resources are acquired by war. If the threat is credible then warring countries would expect resource price in period 2, p_2, to fall. If only p_2 changes then by solving the system of equations (2.16) and (2.17) we get:

$$\Delta.\frac{dw_1}{dp_2} = \gamma_1\alpha_4 - \gamma_2\alpha_2,\ \Delta.\frac{dw_2}{dp_2} = \gamma_2\alpha_1 - \gamma_1\alpha_3$$

If two countries are symmetric and if initially $p_1 = p_2 = p$, we get the change in wage rate with respect to p_2 as follows (see appendix B.6.4):

$$\frac{dw}{dp_2} = \frac{2w(wy - 2p)}{\Lambda},$$

Then the change in war efforts of each country with respect to p_2 would be as follows:

$$\frac{dl_c}{dp_2} = \frac{\partial l_c}{\partial p_2} + \frac{\partial l_c}{\partial w}\frac{dw}{dp_2} = \frac{4a\overbrace{(wy - p)}^{+} + p^2\overbrace{(2wy - 3p)}^{+}}{w^2\Lambda} > 0, \tag{2.23}$$

since $wy - p > 2wy - 3p > 0$, and $\Lambda = p(2wy - 3p) - p^2 + 8a > 0$ (see appendix B.5).

Equation (2.23) implies that an anticipated future sanction on resource exports reduces the conflict efforts of the countries involved in conflict. In this case, an expected reduction of resource price in period 2 reduces expected conflict prize, thus diminishes war efforts. Wage rate may increases or decreases in each country depending on the level of resource stock. War efforts may increase or decrease with the change in wage rate depending on the level of resource stock. But, whatever the effects of wage change on conflict, overall conflict efforts fall due to decrease in resource price in period 2. Thus, an anticipated future sanction is effective in reducing the intensity of conflict in our model.

Now suppose international community declares sanction threat to only one country, say country 1. It implies that in period 2 the resource price for country 1, p_{21}, will fall. But, the resource price for country 2, p_{22}, will be unchanged. Again if two countries are symmetric and initially $p_1 = p_2 = p$, from (2.16) and (2.17) we get (see appendix B.6.5):

$$\begin{aligned} \frac{dw_1}{dp_{21}} &= \frac{w(wy-2p)[2p(2wy-3p)-p^2+16a]}{\Omega}, \\ \frac{dw_2}{dp_{21}} &= \frac{w(wy-2p)3p^2}{\Omega}. \end{aligned}$$

Then the change in war efforts of country 1 with respect to p_{21} is as follows:

$$\frac{dl_{c1}}{dp_{21}} = \frac{4p^2(p(2wy-3p)+8a)\overbrace{(wy-2p)}^{?}+\Theta}{4w^2\Omega}, \tag{2.24}$$

where $\Omega = (p(2wy-3p)+8a)\Lambda > 0$, $\Theta = [p^2(2wy-3p)+16a(wy-p)]\Lambda + 8p^2a(wy-p) > 0$ (as we have shown earlier that $wy - p > 2wy - 3p > 0$, and $\Lambda > 0$).

Note, the sufficient condition for $dl_{c1}/dp_{21} > 0$ is $y > 2p/w$. This condition satisfies if $\partial w_1/\partial p_{21} = \gamma_{11} > 0$ i.e., if wage rate in country 1 falls due to decrease in expected future price of resources. A decrease in p_{21} due to sanction on country 1 reduces conflict efforts of the country, but it also increases extraction in the current period. Whether wage rate will falls, it depends on the relative magnitude of two effects. $\gamma_{11} > 0$ also implies that wage rate in country 2 will increase and thus tend to increase the war efforts of country 1. However, if resource stock is sufficiently high, the overall effect of anticipated future sanction on conflict efforts will be positive (i.e., an anticipated future sanction on one country will reduce its' war efforts). On the other hand, if resource stock is low, there is possibility that an anticipated sanction can be counter productive.

The change in war efforts of country 2 with respect to p_{21} is (see appendix B.6.6):

$$\frac{dl_{c2}}{dp_{21}} = \frac{p^2(p(2wy-3p)+6pwy+48a)\overbrace{(wy-2p)}^{?}}{8w^2\Omega} \tag{2.25}$$

In this case, $dl_{c2}/dp_{21} > 0$ if and only if $y > 2p/w$. In our model, if two countries are symmetric future sanction on country 1 will not affect the conflict efforts of country 2 directly. However, changes in wage rates of country 1 and country 2 will affect the war efforts of country 2. If $y > 2p/w$, wage rate in country 1 falls and wage rate of country 2 increases, and then the war efforts of country 2 falls. Thus, an anticipated future sanction on country 1 will reduce the war efforts of country 2 only if resource stock is sufficiently high. On the other hand, if resource stock is low, then anticipated sanction on country 1 will increase the war efforts of country 2.

(iii) Permanent sanction: Suppose initially $p_1 = p_2 = p$. A permanent sanction implies that price of resource falls in both period 1 and period 2. If two countries are symmetric, the change in wage rate with respect to price will be (see appendix B.6.7):

$$\frac{dw}{dp} = \frac{2w(wy - 2p)}{\Lambda}$$

Then the change in war efforts of each country with respect to price would be as follows:

$$\frac{dl_c}{dp} = \frac{\partial l_c}{\partial p} + \frac{\partial l_c}{\partial w}\frac{dw}{dp} = \frac{4a\overbrace{(wy - 3p)}^{?}}{w^2\Lambda} \tag{2.26}$$

In this case, $dl_c/dp > 0$ iff $y > 3p/w$. Thus, a permanent sanction on resource exports reduces the war efforts of the countries only if the resource stock is sufficiently high. A current sanction increases the war efforts, while a future sanction reduces the war efforts. Which effect will dominate, it depends on the resource stock.

The above analyses imply that whether sanctions on resource exports will be effective in reducing war intensity depends on the types of sanctions. A temporary sanction is not effective, an anticipated future sanction might be effective, and finally the effect of permanent sanction is uncertain.

2.5 UNCERTAIN FUTURE SANCTION

In section 2.3, we derive the equilibrium levels of conflict efforts without considering any possibility of future sanction. In this section the question is: if the warring nations anticipate that international community will impose a sanction, what happens to the levels of conflicts? In particular, we assume that the warring countries are uncertain about possible sanction, they only know the probability of sanction being imposed. For simplicity, we only examine the case when the second period sanction is uncertain and no sanction in the first period. Suppose, the countries consider that probability of future sanction is θ, and expected future price of resources under sanction is p_2' . In this case, the expected total income of country i will be:

$$\begin{aligned} E(I^i) &= \theta \left[w_i L_i + w_i \left(\frac{p_1 - q_i p_2'}{w_i} \right)^2 + \frac{l_{ci}}{l_{ci} + l_{cj}} p_2' \left(y_i + y_j - 2\frac{p_1 - q_j p_2'}{w_j} \right) \right. \\ & \left. + w_i \left(\frac{p_a^2 \lambda_i^2 V_i}{w_i^2} \right) - w_i l_{ci} \right] + (1-\theta) \left[w_i L_i + w_i \left(\frac{p_1 - q_i p_2}{w_i} \right)^2 \right. \\ & \left. + \frac{l_{ci}}{l_{ci} + l_{cj}} p_2 \left(y_i + y_j - 2\frac{p_1 - q_j p_2}{w_j} \right) + w_i \left(\frac{p_a^2 \lambda_i^2 V_i}{w_i^2} \right) - w_i l_{ci} \right], \\ & (i = 1, 2, \text{and} \quad j \neq i). \end{aligned} \tag{2.27}$$

Each government maximizes $E(I^i)$ to choose l_{ci}. Then the first order condition for l_{ci} is:

$$\begin{aligned} & \frac{l_{cj}}{(l_{ci} + l_{cj})^2} \theta p_2' \left[y_i + y_j - 2\frac{p_1 - q_i p_2'}{w_i} - 2\frac{p_1 - q_j p_2'}{w_j} - \frac{2p_2'}{w_j} . \frac{l_{ci}}{(l_{ci} + l_{cj})} \right] \\ & + \frac{l_{cj}}{(l_{ci} + l_{cj})^2} (1-\theta) p_2 \left[y_i + y_j - 2\frac{p_1 - q_i p_2}{w_i} - 2\frac{p_1 - q_j p_2}{w_j} - \frac{2p_2}{w_j} . \frac{l_{ci}}{(l_{ci} + l_{cj})} \right] \\ & = w_i, \ (i = 1, 2, \text{ and } j \neq i). \end{aligned} \tag{2.28}$$

Equation (2.28) gives us the reaction functions for the two countries. Using these, we get the following relationship between l_{c1} and l_{c2} :

$$w_1 l_{c1} = w_2 l_{c2} \quad \Leftrightarrow \quad l_{c2} = \frac{w_1}{w_2} l_{c1} \tag{2.29}$$

Using the above relationship, we can derive optimal l_{c1} and l_{c2} in terms of wage rates and exogenous parameters as follows

$$\widetilde{l}_{c1} = \frac{w_2}{(w_1 + w_2)^2} D, \ \widetilde{l}_{c2} = \frac{w_1}{w_2} \widetilde{l}_{c1} = \frac{w_1}{(w_1 + w_2)^2} D,$$

where

$$\begin{aligned} D = \theta p_2' & \left(y_1 + y_2 - \frac{2p_1}{w_1} + \frac{2p_2' w_2}{w_1(w_1 + w_2)} - \frac{2p_1}{w_2} + \frac{2p_2' w_1}{w_2(w_1 + w_2)} - \frac{2p_2'}{w_1 + w_2} \right) \\ + (1-\theta) p_2 & \left(y_1 + y_2 - \frac{2p_1}{w_1} + \frac{2p_2 w_2}{w_1(w_1 + w_2)} - \frac{2p_1}{w_2} + \frac{2p_2 w_1}{w_2(w_1 + w_2)} - \frac{2p_2}{w_1 + w_2} \right). \end{aligned}$$

Again, if we assume that two countries are symmetric (i.e., $w_1 = w_2 = w$), and at the initial equilibrium $p_1 = p_2 = p$, then the equilibrium war efforts of each country will be (see appendix B.7):

$$\widetilde{l}_c = \frac{p(2wy - 3p) + \theta(p_2' - p_2)(2wy - 3p + p_2')}{4w^2}$$

Note, without any anticipated sanction the equilibrium war effort of each country is:

$$l_c = \frac{p(2wy - 3p)}{4w^2}$$

Since $p_2' < p_2$, and $2wy - 3p > 0$, $\widetilde{l}_c < l_c$. Thus, probability of future sanction on both countries reduces the equilibrium war efforts of each country. The higher the probability of sanction, the lower the equilibrium war efforts. This result is consistent with our comparative static result in the case of certain future sanction on both countries that a future sanction reduces conflict efforts (see equation (2.23)).

2.6 CONCLUSION

In this chapter, we develop a two-country, two-period general equilibrium model linking natural resources to inter-state war. Contrary to the existing literature we consider resource extraction and wage rates to be endogenous. First of all, we examine the relative war efforts of two non-symmetric countries. We find that regardless of initial possession of resource stocks the war efforts of two countries will be same; a country with larger labor force exerts more war efforts; and a country with larger land endowment or higher productivity exerts lower war efforts (i.e., paradox of power). Second, we examine the effects of different types of international sanctions on war efforts of the two countries. We find that a temporary current sanction on both countries or even on one country will be counter-productive (i.e., increases the war intensity); an anticipated future sanction on both countries will reduce war intensity; whether an anticipated future sanction on one country will reduce war intensity depends on the level of resource stock; and finally, the effect of a permanent sanction on both countries is uncertain and war intensity will fall only if the resource stocks of the countries are sufficiently high.

The broad policy prescription of our analysis is that while implementing trade sanction, the international community needs to work out the exact nature of the sanction, and a future sanction may be more effective than a current one. Current sanction can in fact increase war efforts. Furthermore, taking sides in a conflict by imposing sanction on one of the warring countries can increase war intensities.

CHAPTER 3

THE EFFECTS OF INTERNATIONAL SANCTIONS ON THE DURATION OF CIVIL CONFLICTS

3.1 INTRODUCTION

The internal conflicts or civil wars are not only common, they are also persistent. Almost 90% of the last decade's civil wars took place in countries that had already experienced a civil war in the last 30 years (World Development Report, 2011). The average duration of civil wars is quite large compared to that of inter-state wars. For example, while Bennett and Stam (1996) find that international wars last on an average 11 months, Collier et al. (2004) find that average civil war duration is 7 years in their dataset, and Fearon (2004) finds that average civil duration is even longer of about 12 years in their sample.[1] The negative consequences of civil wars are not only limited within the boundary of a country, they also affect the regional and international community. Thus, containment of conflicts is crucial not only for the countries under conflicts, but also for regional and international security and stability (both political and economic). Considering the longevity and adverse consequences of civil wars, international community has been intervening in civil wars in different ways.

The literature so far has pointed out many factors that determine the duration of civil conflicts. These factors include level of income, income inequality, natural resource abundance, geographic characteristics, ethnic fractionalizations, types of conflicts, outside interventions etc. (e.g., Collier et al., 2004; Fearon and Lation, 2003; Fearon, 2004; Regan, 2002; Regan and Aydin, 2006). Not all studies support on the statistical significance and economic significance of each factor, but there is a general consensus on a series of structural factors and outside interventions that influence the expected duration of

[1] The difference in average duration of civil wars in two studies arises from the fact that they define civil war differently and their sample periods are different also. While Collier et al. (2004) define civil war in terms of 1000 deaths per year and cover the period of 1960-99, Fearon (2004) defines civil war in terms of 1000 deaths for entire war and cover the period of 1945-1999.

conflicts. In this study we focus on the role of international sanctions as a determinant of the length of civil wars.

Historically economic sanctions (sticks) are most commonly used instrument by the international community to discourage conflicts. For example, sanctions have targeted countries experiencing civil war, such as Liberia, Rwanda, Sudan, Lebanon, Cambodia, and Yugoslavia (Escribà-Folch, 2010). Though the effectiveness of sanction is debatable, the incidence of sanctions imposed has increased significantly over the last two decades, especially those imposed by UN Security Council. The findings of the papers that examine the effects of sanctions so far are rather mixed and inconclusive, as will be discussed in the next section. Thus, in this chapter we re-examine the effects of sanctions on civil war duration with a new and larger dataset.

In our study we use civil war data for the period of 1960-2008, which include 121 civil war incidences occurring in 67 countries. By using hazard model of duration analysis we examine the effects of international sanctions on the expected duration of civil wars. While Escribà-Folch (2010) also studies the effects of sanctions on the likelihood of ending conflicts, our study is different in several ways. First, we use a new and extended dataset for the study. Escribà-Folch uses the data from 1959 to 1999, whereas we use the data from 1960 to 2008. Note, after the end of cold war, UN and other international organizations increased their policy interventions to terminate the civil conflicts. How this policy shift has helped to settle the wars will be captured by our new data. We also use some relevant control variables that are not used in Escribà-Folch's study. Second, while Escribà-Folch uses logit model for duration analysis, we use hazard model, which is more appropriate for the duration analysis.[2] Finally, previous literature did not consider the endogeneity of sanction variable in determining war duration, we consider the issue in our paper and make an attempt to deal with it.

Contrary to the most of the previous findings, we find that sanctions reduce the

[2]Most of the authors also use duration model to study the effects of interventions on duration of conflicts e.g., Coller et al. (2004), Regan (2002), Regan and Aydin (2006).

expected duration of civil conflicts. Our finding is robust for different controls, different parametric models, and with consideration of endogeneity of sanctions. However, not all types of sanction are equally successful in shortening conflicts. Total economic embargoes and arms sanctions are effective, but trade sanctions, aid suspension, and other sanctions do not work. Both multi-lateral and unilateral sanctions (mainly U.S. sanctions) are found to be associated with shorter civil wars.

The rest of the chapter is organized as follows. Section 3.2 discusses the existing literature on the relationship between sanctions and conflicts. In section 3.3, we define our variables and cite the data sources. Section 3.4 illustrates the model specification. In section 3.5, we present and analyze our findings. Finally, section 3.6 concludes the chapter.

3.2 SANCTIONS AND CONFLICTS

In the context of conflict, sanctions are generally methods of intervention based on coercive measures imposed by a country, or an international organization, or a coalition of countries against a country- the government or any group within a country or both- with the aim of reducing the conflict (Escribà-Folch, 2010). Again, sanctions have different degrees or types, including total economic embargo, partial economic embargo, export/import restrictions, cancellation of foreign aid, blockade, asset freeze, travel ban, and suspension of economic agreement. In the past few decades, the use of economic sanctions has increased substantially and sanctions have become the foreign policy tool of choice for many countries. In 2012, German Institute of Global and Area Studies (GIGA) has listed more than 120 episodes of sanction during 1990 to 2010. In theory, the way sanctions work is simple; sanctioned countries (called targets) suffer costs resulting from actions taken by the sanctioning countries (called senders). In order to avoid the costs, targets modify their behavior in the direction desired by the senders. Now the question is how successful the economic sanctions are to shorten the conflicts in practice. The empirical studies find mixed results as discussed below.

Hafbauer et al., (1990) find very low success of sanctions to achieve intended outcome. Assessing UN sanctions in the 1990s, Cortright and Lopez (2000) also show that most of the sanctions failed to change the behavior of the targets. Pape (1997) argues that sanctions basically do not work, only the use of military forces that accompany sanctions may work. Analyzing 26 conflicts between 1989 and 2006, Le Billon and Nicholas (2007) conclude that military intervention and revenue sharing are more successful than sanctions in ending resource conflicts. However, they also find that sanctions and revenue sharing promote durable peace compared to military interventions. Thyne (2006) finds that sanctions have no significant effect on civil war onset. On the other hand, the existing evidence on the impact of sanctions and or interventions on civil war duration is partial and based on only limited number of cases (Strandow, 2006). Most of the empirical studies suggest that outside interventions tend to extend the expected duration of civil wars. For example, using a hazard model of duration analysis, Regan (2002) finds that third party interventions tend to increase the expected duration of conflicts rather than shorten them. Intervention may exacerbate wars by reducing the cost of rebellion (Elbadawi and Sambian, 2000). Many studies even find that external or third party interventions make it difficult to reach an agreement or a military victory and thus lengthen the conflict. For example, Mason et al., (1999) find that third-party interventions make the negotiated settlement more unlikely. Using Correlates of War (COW) data of civil conflicts and external interventions, Balch-lindsay and Enterline (2000) find that biased interventions increases the duration of war and balanced interventions tend to lengthen the war further. Buhaug et. al., (2002) also find that intervention on the government side increases the duration of civil war.

Many studies find that effectiveness of sanctions depend on different conditions: the initial stability of the target and the cost of the target country (Davis and Radcliff, 1997), the political regime of the target country (Noorunddin, 2002; Lektzian and Souva, 2007), the sender's perception about the importance of the issue (Ang and Peksen, 2007), the types of conflicts and resources involved in case of resource wars (Le Billon and Nicholas, 2007). Regan and Aydin (2006) argue that mediation/diplomacy and timing of intervention are keys to the success of intervention in reducing the expected duration of conflicts. However, some case studies as well as empirical studies find that external interventions or sanctions are associated with the shorter intrastate conflict. For example, the diamond embargo imposed on warring groups of Ivory Coast, Sierra Leone, Liberia, and Angola were effective in shortening the conflict (Escribà-Folch, 2010; Wallensteen et al., 2006). Using data on 55 civil wars between 1960 to 2000, Collier et al., (2004) show that economic sanction has a positive but insignificant effect on the length of war, and only military intervention on the rebel side shorten the war. Another study (using a sample of 213 wars and external interventions covering the period of 1867-1997) by Balch-Lindsay et al., (2008) finds that third party interventions supporting one side reduces the time until that group achieves victory, but it makes negotiated settlement more unlikely. In contrast, according to DeRouen and Sobek (2004), an intervention by UN increases the probability of truce and decrease the likelihood of one-sided victory. The strongest evidence of the effectiveness of sanctions is found by Escribà-Folch (2010). Using a sample of 87 wars between 1959 to 1999, he finds that sanctions and their duration significantly reduce civil war duration. He also shows that total economic embargoes are the most effective type of sanctions, and sanctions imposed by international organizations increase the likelihood of conflict resolution.

Many scholars also debate about what types of sanctions would be more effective: comprehensive sanctions vs. smart sanctions. The comprehensive sanctions target the whole country or use all type of instruments to maximize general costs. On the other hand, smart sanctions target specific group or use specific instrument to avoid suffering of general population. Most of the empirical evidences suggest that more comprehensive sanctions or sanctions that impose higher costs on targets tend to be more successful (Cortright and Lopez, 2002; Nooruddin, 2002; Hufbauer, 2007). On the other hand, Strandow (2006) argue that arms embargoes as they directly target the military capacity of the groups would be more effective, if properly implemented.

Another issue regarding sanctions is what kinds of senders are more effective: multilateral vs. unilateral. International sanctions are imposed either by multilateral institutions (like UN, NATO, EU) or by a state (or a small coalition of them). Some studies suggest that unilateral sanctions are more successful (e.g., Hufbauer et al., 1990; Drezner, 1999), while other studies find that institutional sanctions are more effective (e.g., Bapat and Morgan, 2007; Escribà-Folch, 2010).

Thus, there is no conclusive evidence either in favor of or against the effectiveness of sanctions. That is why we re-examine the effects of sanctions on the duration of civil war with a new and extended dataset. By using civil wars and sanctions data for the period of 1960-2008, we examine how the sanctions aiming to reduce civil conflict or imposed during the civil conflict affect the expected duration of conflict or the likelihood of ending the conflict. In the next section, we define our variables and discuss the sources of data.

3.3 VARIABLES AND DATA

One important aspect of civil war analysis is the definition of civil war, as different datasets code civil war differently. For example, the Correlates of War (COW) definition of civil wars is based on four main characteristics.[3] It requires that there is organized military action and that at least 1,000 battle deaths resulted in a given year. In order to distinguish wars from genocides, massacres and pogroms there has to be effective resistance, at least five percent of the deaths have been inflicted by the weaker party. A further requirement is that the national government at the time was actively involved. On the other hand, the Peace Research Institute Oslo/Uppsala Conflict Data Program at the Department of Peace and Conflict Research, Uppsala University, known as UCDP/PRIO Armed Conflict

[3]The Correlates of War project is an academic study of the history of warfare. It was started in 1963 at the University of Michigan by political scientist J. David Singer. The detail discussion of the dataset can be found in www.correlatesofwar.org.

Dataset (first complied by Nils Petter Gleditsch et al , 2002) define conflict as a contested incompatibility that concerns government and/or territory where the use of armed force between two parties, of which at least one is the government of a state, results in at least 25 battle-related deaths.[4] Their definition has two main dimensions. First, they distinguish four types of violent conflicts according to the participants and location: (1) extra-systemic conflicts (essentially territorial includes both colonial and imperialist wars), (2) interstate wars (between two or more states), (3) intrastate wars (between the government of a state and one or more internal opposition group(s) without intervention from other states) and (4) internationalized intrastate wars (between the government of a state and one or more internal opposition group(s) with intervention from other states (secondary parties) on one or both sides). The second dimension defines the level of violence. Minor conflicts produce between 25 and 999 battle-related deaths in a given year, and wars are conflicts which result at least 1,000 battle related deaths per year. Civil wars are considered as all armed conflicts except interstate wars. For our analysis we use the PRIO/UCDP definition of civil conflicts (i.e., include both minors and wars), as it is used by most of the recent empirical literature on civil war.

To determine the duration of civil war, start date and end date of war as well as choice of death thresholds are important. Different datasets record different start date and end date of civil wars. Even start year and end year are different depending on the definition and death threshold. Higher death threshold reduces the length of civil wars and lower death threshold increases the duration. Furthermore, a higher threshold leads to a higher number of repeat war episodes, while lower threshold may record it as one war episode. For our analysis we use only the yearly information of civil war duration according to UCDP civil war criteria.

We use data on civil conflicts for the period of 1960 to 2008 (see Table 3.1 in

[4]The Uppsala Conflict Data Program (UCDP) is a data collection project on organized violence housed at Uppsala University in Sweden. The first release of the Armed Conflict Dataset was prepared at PRIO in 2002.

appendix C for the list of wars). Civil conflicts data are collected and combined from Escribà-Folch (2010) replication data (up to 1999), the COW dataset, and UCDP dataset. Our data include 121 civil war incidences occurring in 67 countries. For duration analysis our dependent variable consists of two variables: analysis variable and event (failure) variable. Our analysis variable is civil war duration, which is number of years a civil war has survived or is surviving (if the war is ongoing) up to a given year. Our event variable is whether or not war ends in a given year, and we use a dummy variable namely 'war end' which is coded 1 if the war ends and 0 otherwise.

Our main explanatory variables are sanctions. Data on sanctions are collected from Escribà-Folch (2010) replication data, which has data for the period of 1959-1999. These data are compared, amended, and widened using few more datasets: Hufbauer, Schott & Elliott's (2008) dataset, Threat and Imposition of Sanctions (TIES) dataset, and German Institute of Global and Area Studies (GIGA) dataset. We use a dummy variable called 'sanction', coded as 1 if a country under any type(s) of sanction in a given year, 0 otherwise. The TIES dataset classifies sanctions according to the types of measures. We construct five sanction variables as follows: total economic embargo, multilateral arms embargo, trade sanction (imports and exports restrictions), aid suspension, and other measures (e.g., blockade, asset freeze, travel ban, suspension of economic agreement). As mentioned before, sanctions can be multi-lateral or institutional (e.g., imposed by UN, EU, or other multilateral organizations) or it can be unilateral (imposed by a country). To capture whether the effects of these two types of sanction are different, we construct two more sanction variables: one is 'unilateral sanction', which takes the value 0 if no sanction, 1 if a country is under sanctions imposed by a country; and another is 'multi-lateral sanction', which takes 0 if no sanction, 1 if a country is under sanctions imposed by an international institution or group of countries. Some sanctions were jointly imposed by US and UN, or US and EU, or by all three. In this case, we regard it as multi-lateral sanction.

We use a set of country-year control variables that are used in the literature in the studies on civil war onset and duration. Collier et al. (2004) argue that structural characteristics of the economy like level of income and distribution of income affect the duration of civil war. Thus, we use per capita GDP and Gini-coefficient measure of income inequality as control variables. Many studies show that the abundance or dependence of natural resources and primary commodities affect both the onset and duration of civil war (e.g., Collier and Hoeffler, 2002, 2004; Collier et al.,2004; Ross, 2004). We use several alternative measures of resource abundance/dependence: ratio of primary commodity exports to GDP, oil rent as percentage of GDP, mineral exporter (take the value 1 if mineral exports in any year exceeded 50%, 0 otherwise), oil exporter (coded as 1 if oil exports exceeds one-third of total exports, 0 otherwise), oil production per capita (in barrels), diamond production per capita or per square kilometer (in carats). Civil wars tend to be longer if the rebels have the opportunity to finance contraband (Fearon, 2004). Thus, we include a dummy variable labeling 'contraband' for use of contraband in civil war (taking the value 1 if the war is financed by contraband, 0 otherwise). Some researchers argue that ethno-linguistic and religious fractionalizations may affect civil war (Collier et al., 2004; Fearon and Latin, 2003). We use Fearon (2004) measure of ethnic fractionalization, which measures the probability that two randomly selected person from a country will not belong to the same ethnic group. Similarly religious fractionalization is defined as the probability that two randomly selected individuals are from different religious groups. Geographic characteristics like proportion of mountainous terrain and jungles also affect the duration of civil war (Buhaug et al., 2005). So we include two separate variables to capture the geographic characteristics: the proportion of mountainous area in total area, the proportion of forests in total area. Government military capacity definitely affect the duration of civil war. Thus, we include the size of army (per 1,000 inhabitants) to represent the government capability to fight. However, the effects of government capability might be quadratic i.e., civil wars might be short for very week and very strong government. Thus, we also include square of army size as explanatory variable.

Regan (2002) argue that third party or external intervention on either government side or rebel side or both sides affect the duration of civil war. We include a dummy variable called 'external intervention', which is coded as 1 for the year the country is under some sort of external military intervention. Fearon (2004) shows that some categories of civil war tend to last longer than others. We consider two types of civil war variables: 'ethnic war' which takes value 1 if the ongoing war is an ethnic nature and 0 otherwise, and 'sons of soil' conflict (dummy variable tanking 1 or 0) that typically involves land conflict between a peripheral ethnic minority and state-supported migrants of a dominant ethnic group. Other relevant control variables that are used in our paper include: country's population, average battle related death per year, and polity 2 (polity IV project).

The data for our control variables are collected from different sources (see Table 3.2 for the list of variables and data sources). We use data of many control variables from Escribà-Folch (2010) replication dataset, Fearon & Lation (2003) dataset, and Fearon (2004, and 2005) dataset. These variables include primary commodity exports, mineral and oil exporters, oil and diamond productions, ethnic and religious fractionalizations, the use of contraband, mountainous terrain, army size, ethnic war, sons of soil war. We extend these datasets using other sources whenever required. We collect population and per capita GDP data from World Bank and Pen World Table 7.1. Gini-coefficient, oil rents, and forest area data are collected from World Bank's World Development Indicator dataset. Battle related death data are available at PRIO/UCDP dataset and Escribà-Folch (2010) replication dataset, we compare and contrast both datasets. External intervention data are collected and combined from two sources: Cunnigham (2010), and Escribà-Folch (2010). Polity 2 data are collected from Center for Systemic Peace's Polity IV project. Note, for some time varying covariates the data of all years are not available. In those cases, we interpolate the missing years' data using the data of the closest years available.

3.4 MODEL SPECIFICATION

The main objective of the study is to estimate the effects of sanctions on civil war duration and the likelihood of ending the conflict. A useful way to think about the effect of interventions (sanctions) on a conflict duration is as an intervention taking place at a discrete point in time. As a result of an intervention, the conflict either remains at the status quo condition or moves to an alternative state, which we will call the termination of the conflict. The approach to testing such effects is to use a duration, or hazard model (Allison, 1984; Bennett, 1999; Box-Steffensmeier and Jones, 2004). Generally, a hazard model allows us to determine the likelihood of a transition to state t_i , given it is at state t_0, for a series of explanatory variables. For conflict duration analysis, the hazard model estimates the time elapsed up to time t and the risk of conflict termination at t.

We use an event history approach to model the expected duration of civil conflicts. Among the competing parametric models of hazard (or survival) analysis, we have chosen to test the model with a Weibull parameterization.[5] The Weibull model allows us to test for duration dependency in the termination of civil conflict, which is an advantage over other event history analysis methods. Without any covariates, the basic functional form of the hazard rate, $h(t)$, using a Weibull specification is the following:

$$h(t) = \lambda p \left(\lambda t\right)^{p-1} = \lambda^{p} p t^{p-1};\ t > 0, p > 0, \lambda > 0, \tag{3.1}$$

where $h(t)$ is the estimated hazard rate at time t, p is the shape parameter, and λ is the positive scale parameter. The parameter p accounts for duration dependence. When $p = 1$, there is no duration dependence, and the hazard rate $h(t)$ is constant (λ). When $0 < p < 1$, the hazard rate decreases monotonically over time. When $p > 1$, the hazard rate increases monotonically, although not necessarily linearly. Covariates X (independent variables) can

[5] There are alternative specifications of hazard model, e.g., Exponential model, Gompertz model, Log logistic model, Log normal model, Cox proportional hazard model. Each model makes different assumptions about duration dependence. The advantage of Weibull specification is that it does not assume a functional form of the dependence parameter, instead allows one to test for the existence of duration dependence.

be added into the model as influences on the hazard rate by specifying the following:

$$h(t_i) = \lambda_i^p p t^{p-1} = h_0(t)\lambda_i^p, \text{ and } \lambda_i = e^{-\beta X_i}, \tag{3.2}$$

where $h_0(t)$ is called baseline hazard, when all covariates are zero.[6] Positive β implies that hazard decreases and average survival time increases as X increases.

For our cross-sectional time series analysis of war duration, we specify the following proportional hazard model:

$$h(t_i/I_{it}, C_{it}) = pt^{p-1}.exp(\beta I_{it} + \gamma C_{it}) \tag{3.3}$$

In this functional form, $h(.)$ reflects the rate at which a civil conflict terminates at time t given that it has survived until t, p is the duration dependency parameter, I is the vector denoting interventions (sanctions), and C is the vector denoting control variables. β and γ represent the vectors of the coefficients on the variables of interest. Positive duration dependency ($p > 1$) suggests that the conflict is more likely to terminate with the passing of time, whereas negative duration dependency ($0 < p < 1$) suggests the institutionalization of the conflict: as the adversaries continue fighting, their chances of settling the conflict also decrease over time. Note, our explanatory variables include both time invariant and time-varying covariates. Thus, we estimate a hazard model that accounts for the impact of a series of covariates on the expected duration of a conflict. For estimation purpose we use Maximum Likelihood (ML) estimation method.

Previous studies on the effectiveness of sanctions ignore the possibility of endogeneity of the sanction variable. However, we consider this issue in our paper. There might be two possible sources of endegeneity in our sanction variable: 1) selection bias - the threat of sanction might be more effective than imposed sanction, and 2) omitted variable bias - unobserved factors may affect both sanctions and war duration, which are not included as regressors in our model. These unobserved factors include political grievance, culture, institutions, poverty, relationship with other countries, international geo-political situation,

[6]The above model allows for the presence of an intercept term, β_0, within X_i. Thus, the baseline hazard function is actually equal to $h_0(t).exp(\beta_0)$.

international institutions, and the like.

To test for selection bias, we include a dummy variable called 'non-imposed sanction threat' (take the value 1 if a country is threatened but eventually sanctions are not imposed, 0 if no threat or sanction is applied) as a regressor in our model, and test whether non-imposed sanction threat affect the war duration. To test for unobserved heterogeneity, we estimate the the *frailty* model of hazard function, which test for unobserved variation in the hazard rate. A frailty model is a survival model with unobservable heterogeneity, or frailty. At the observation level, frailty is introduced as an unobservable multiplicative effect, α, on the hazard function, such that $h(t/\alpha) = \alpha h(t)$. The frailty, α, is a random positive quantity and, for model identiability, is assumed to have mean 1 and variance θ. We test the presence of unobserved heterogeneity by the likelihood ratio test of $H_0 : \theta = 0$.

According to Masuhara (2013), in case of duration model, only controlling for unobserved heterogeneity is not sufficient to deal with endogeneity. It is important to consider both heterogeneity and endogeneity in duration analysis. One possible source of endogeneity is reverse causality. Sanctions may go to the conflicts that international community perceive would be long-lasting. In this case causation run in opposite direction and we may find a positive association between sanctions and war duration. To deal with endogeneity problem we need to find proper instrument(s).[7] Even if one find an instrument, there is no established or standard methodology for applying instrumental variable technique in case of duration model in particular and nonlinear model in general. Terza et al. (2008), and Atiyat (2011) suggest a two-stage regression method, like *two-stage least squares* (2SLS) technique in case of linear models. In the first-stage, the endogenous variable is regressed on the appropriate instrumental variable(s) and other exogenous regressors in the system. An appropriate non-linear model is used to estimate this first-stage model and residuals are estimated from it. The first-stage residuals are used as a

[7] A good instrument must satisfy the following three conditions: (1) it cannot be correlated with first-stage disturbance term, (2) it must be sufficiently correlated with endogenous regressor for which it is used (i.e. it must not be 'weak'), and (3) it can neither have a direct influence on dependent variable nor be correlated with the error term in second-stage regression.

regressor along with endogenous regressor and other variables in the second-stage regression. This is called *two-stage residual inclusion* (2SRI) method. Terza et al. (2008), and Atiyat (2011) show that 2SRI method produces consistent estimators.[8]

For our sanction variable, we consider two possible instruments: i) post-cold war period, ii) Security Council membership of the conflict affected country. The episodes of sanctions have increased significantly after the end of cold war. This is because the end of cold war has given more freedom to both US and UN Security Council to impose sanctions without opposition from the former USSR. We construct a dummy variable 'post-cold war', which takes the value 1 if the conflict year is 1990 or later, 0 otherwise. Thus, we expect a positive relationship between sanctions and 'post-cold war' variables. We consider temporary membership of a country in the Security Council (SC) is an indicator of good international relationship of the country. We expect that a country will less likely to be under sanction, if it has the membership in the SC during the war years. We generate a variable called 'non-membership in SC', taking the value 1 if the country is not a member of the SC any time during the war, 0 otherwise.[9] Thus, we expect a positive relationship between sanctions and 'non-membership in SC' variables.

As an alternative specification, we also estimate the logit model to test how sanctions affect the likelihood of war termination.[10] However, we think that hazard model is more appropriate for our case. Note, logit model is appropriate for discrete time analysis and if the event is not duration dependent. However, if the duration of time leading up to the event is important, as is the case of civil war, then event history or hazard model is more appropriate. Moreover, event history model performs better than logit model if there

[8] They also show that in this case two-stage predictor substitution (2SPS) method, which is the rote extension to nonlinear models of 2SLS method, does not provide consistent estimators. In the first-stage of 2SPS, auxiliary (reduced form) regressions are estimated, and the results are used to generate predicted values for the endogenous variables. The second-stage regression is then conducted for the outcome equation of interest after replacing the endogenous variables with their predicted values.

[9] Information of Security Council membership is available on UN website

[10] In our case, we specify the following logit model: $Prob.(warend_{it} = 1/I_{it}, C_{it}, \alpha_i) = \Phi(\alpha_0 + \alpha_i + \beta I_{it} + \gamma C_{it})$, where $\Phi(.)$ is logistic cumulative distribution, $warend_{it}$ is a country-year dummy variable taking the value 0 if the war is ongoing and 1 if the war ends.

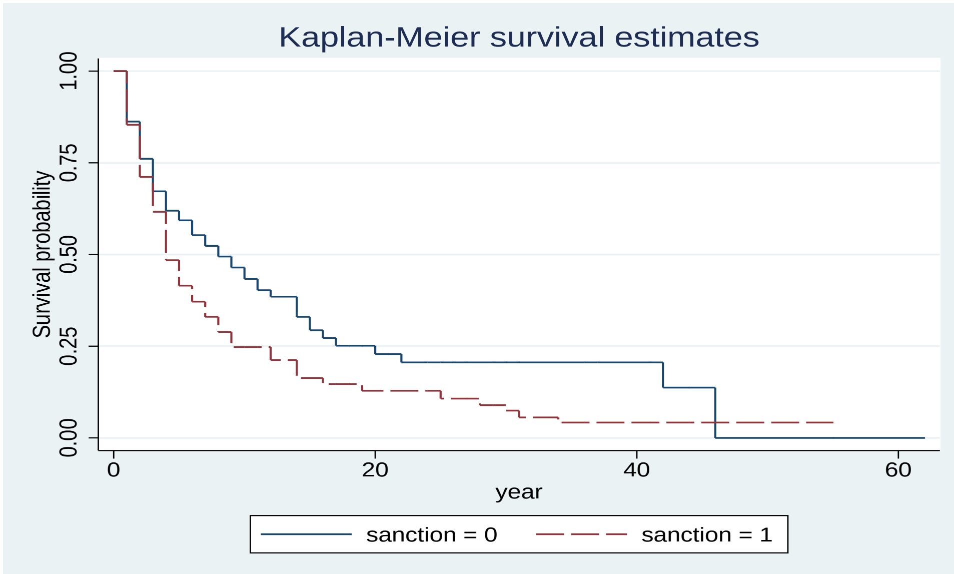

Figure 3.1: Survival Probabilities of Wars Over Time

are time varying covariates in regression. Truncation and censoring can also be better dealt with event history model. Censoring, especially right censoring is important for civil war because some of the wars in the sample might be ongoing even if the sample period ends.[11] Thus, for our study the preferred model is event history model/hazard model. The logit model is used for robustness check of our estimates.

3.5 EMPIRICAL RESULTS

The mean war duration of all civil wars in our sample is 10 years. Thus, as mentioned before, on average civil wars are long-lasting. The non-parametric Kaplan-Meier survival functions of conflicts under sanctions versus conflicts without sanctions are shown in Figure 3.1.[12] In this Figure, the y-axis represent the probability of a conflict ongoing at any given time, and x-axis shows the number of years the conflict is ongoing. The survival curves indicate that the civil wars become slightly less likely to survive with each passing year. Moreover, survival probabilities are lower for the conflicts with sanctions than those

[11] In our study, at the end of 2008, 16 wars were still ongoing. Hazard model takes in to account all these wars in the analysis of duration of wars.

[12] Kaplan-Meier estimator of survival function: $S(t_i) = \Pi(1 - d_i/n_i)$, where n_i is the number of observation at risk, and d_i is the number of event (i.e., d_i/n_i is the hazard rate).

without sanctions, except for very long conflicts. A statistical test - the log rank test for the equality of survivor functions - demonstrates that the difference is statistically significant. But only by this test we can not tell whether there are significant differences in survival probabilities (i.e., expected duration of war) in two cases, because we have not controlled for other determinants of war duration. To determine the causal relationship between sanctions and expected war duration, we have to use regression analysis which controls for other determinants of war duration. The regression results are presented in the following sections.

3.5.1 EFFECTS OF SANCTIONS

At first, we examine the effects of all sanctions in general on the expected duration of civil wars. We estimate the hazard rate of conflict termination using Weibull parameterization, with the unit of analysis being the conflict year. The co-efficients of hazard rate are presented to see whether hazard rate increases or decreases with a covariate.[13]

Table 3.3a reports the estimated coefficients of hazard rate for different regression functions. We see that even without controlling for other covariates, the coefficient of sanction variable is positive and statistically significant (model 1), which implies that sanctions increase the hazard rate of war termination. As we add more and more relevant control variables, the magnitude of sanction coefficient increases and become more significant. Model (8) is our reference model, which we get after a series of iterations, in which insignificant variables are deleted and only statistically significant socio-economic variables are added to the regression.

Our reference model suggests that international sanctions significantly reduce the expected duration of conflict. This result is robust to the inclusions of other control

[13]We can also present the results in proportional hazard (PH) metric and accelerated failure-time (AFT) metric forms. PH metric shows the effects of explanatory variables on the hazard rate, whereas the AFT metric shows the effects of explanatory variables on the expected duration of conflicts. In the PH model the hazard function is $h(tj) = h_0(t)g(X_j) = h_0(t)exp(X_j\beta)$. On the other hand, in the AFT model, the natural logarithm of the survival time, log t, is expressed as a linear function of the covariates, yielding the linear model: log $t_j = X_j\beta + z_j$, where z_j is the error with density $f()$.

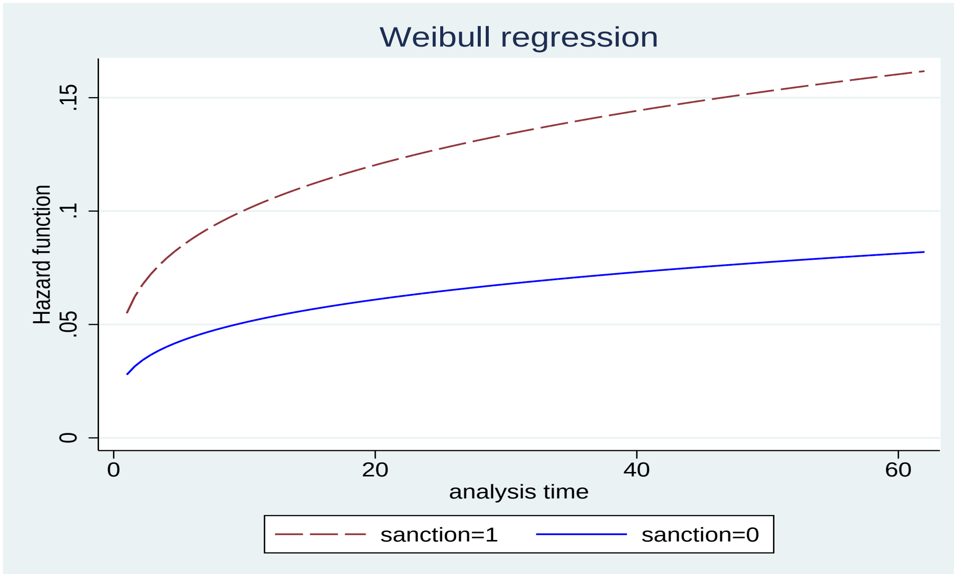

Figure 3.2: Estimated Hazard Rates of Wars Over Time

variables, like Gini-coefficient, external intervention, mountain, forests, ethnic and religious fractionalizations, ethnic war, and polity2 (Table 3.4). The result is also robust to the use of alternative measure of natural resource abundance (Table 3.5). Thus, contrary to the most of the previous literature, our finding suggests that sanctions can reduce the war duration. Note, Table 3.3a shows only the direction of change in hazard rate, it does not show the estimated hazard rates. Table 3.3b reports the estimated hazard rates for the corresponding models of Table 3.3a. The reference model (8) in Table 3.3b shows that sanctions increase the hazard rate of war termination by 97% after controlling for all other relevant variables. Figure 3.2 shows the estimated hazard functions for Wei-bull regression with sanctions and without sanctions. We see that for each year hazard rate is significantly higher under sanction compared to without sanction. From Table 3.3a we also see that the estimate of shape parameter p is greater 1 (as $\log(p)$ is positive) and statistically significant, which implies that hazard rate is increasing over time.

The interpretations for other statistically significant variables are as follows (see Table 3.3a and Table 3.3b). A large population decreases the hazard rate of war termination, implying that more populous countries tend to experience longer civil wars.

Higher per capita income increases the expected duration of wars. One might suspect a reverse causality from war duration to per capita income. To eliminate the possibility of reverse causality, we run separate regression by including the initial level of per capita income of a country for all war years instead of each country-year per capita income. But, we find that the coefficient of per capita income is still negative and statistically significant. This result implies that though lower per capita income is likely to increase risk of conflict onset (e.g., Collier & Hoeffler, 1998, 2002; Fearon, 2005), a relatively higher per capita income tend to lengthen the conflict, once conflict starts. Higher male secondary school enrollment reduces the war duration. This finding is intuitive in the sense that higher male secondary school enrollment decreases the opportunity for rebel recruits, as rebel groups typically recruit fighters from young male. Natural resource abundance measured by both 'oil rent to GDP ratio' and 'diamond production per capita' reduces the war duration. A possible interpretation is that higher resource availability increases the government revenue and thus government can build a strong army, which helps the government to win war within a short time. However, more resource rents might encourage rebel groups to fight harder and longer, thus tend to lengthen the war. In our sample, probably first effect dominates second one, resulting a net reduction of war duration. The opportunity of contraband by rebel groups increase the expected duration of war. The interpretation is straight forward in this case, that if the rebel groups can finance war through selling of natural resources or drugs, they can fight longer wars. The coefficient of 'Son of civil war' is positive and significant, implying that these types of wars are comparatively longer than other types of civil wars. Army size of country has a negative but diminishing effect on hazard rate, implying that larger army size increases the war duration, but a very large army can win war quickly. Higher battle related death tend to lengthen the war, implying that more deaths increase the grievances among groups and lead to a lengthy war. More neighbors with common borders tend to increase the expected duration of war.

Robustness Check: Table 3.4 presents regression equations by adding the other relevant control variables to our reference equation. We find that our estimates are robust in general to the inclusion of others but statistically insignificant control variables. Contrary to the findings of Collier & Hoeffler (2004), and Escribà-Folch (2010), we find that ethnic fractionalization does not affect the war duration. Similarly, the effect of religious fractionalization is not statistically significant. Geographic characteristics, like mountain and forest areas, are not statistically significant as well. Though Balch-lindsay and Enterline (2000), and Regan (2002) find that external or third party intervention tend to increase the war duration, we do not find such evidence in our estimation. Similar to most of the previous findings, we find that regime type indicator variable 'polity2' is not statistically significant for war duration.

We also check the robustness of our estimates by using alternative indicators for resource abundance (Table 3.5). Instead of oil rent to GDP ratio, we use oil production per capita, or oil exporter, or mineral exporter variables. We also use primary commodity export to GDP ratio as an indicator of resource abundance replacing the oil rent to GDP ratio.[14] In all of the above cases, our estimates are found to be robust, except for the 'number of border' variable.

We also estimate some of the other parametric models of hazard function to see which model fits the data best. Table 3.6 shows the estimates of different parametric models: Wei-bull model, Exponential model, Gompertz model, and Cox proportional hazard model. We see that Wei-bull model is the best fitting model with the highest log likelihood value. Wei-bull model is also preferred model with the smallest AIC.[15] We also estimate the logit model to see how the likelihood of war termination is affected by the sanctions (model 5 in Table 3.6). We see that the coefficient of sanction is positive and statistically significant, implying that sanctions increase the probability of war termination. Other variables have the same signs as with the hazard model.

[14] Many authors, including Collier & Hoeffler (1998, 2002, 2004), and Fearon (2005) use the primary commodity export to GDP ratio as the indicator of resource abundance in their estimation.

[15] In this case, AIC = -2(log likelihood) + 2(c + p + 1), where c=number of covariates, p= the number of model-specific ancillary parameters.

Endogeneity of Sanctions: As discussed in section 3.4 our sanction variable may have endogeneity problem. To deal with endogeneity, we do three tests: selection bias test, unobserved heterogeneity test, and use instrumental variable technique. Table 3.7 presents the results of endogeneity tests. To test for selection bias, we include the variable 'non-imposed sanction threat' as a regressor in our model, and we find that the variable is not statistically significant (model 1). Thus, we do not find evidence of selection bias in our estimation. To test for unobserved heterogeneity, we estimate the the frailty model of hazard function, which tests for unobserved variation in the hazard rate (model 2). Using likelihood ratio test we fail to reject the null hypothesis of no unobserved variation. Thus, we can claim that the unobserved heterogeneity is not present in our model.

To deal with endogeneity problem, we use 2SRI method (suggested by Terza et al., 2008; and Atiyat, 2011) as described in section 3.4. First, we use 'post-cold war' variable as a single instrument and find that it significantly affects the likelihood of imposing sanction if we use logit regression (model 3). We estimate the residual from first-stage regression, and then include it as a regressor in the second-stage regression. We find that the coefficient of sanction variable increases significantly after correcting for endogeneity (compare model 5 and model 7 in Table 3.7). This result implies that if we do not consider reverse causality and endogeneity, the true co-efficient of sanctions will be underestimated. Secondly, we use 'non-membership in Security Council' as a second instrument for sanction in the first-stage regression. We find that both instruments significantly predict sanctions (model 4). Again, we estimate residuals from the first-stage, and include it as a regressor in the second-stage (model 6). We find similar results as with first case. Though the coefficient of sanction is slightly lower in the second case, it is still significantly higher than the case without considering endogeneity.

Since instrumental variable technique used in this paper is not standard, we can take this result as indicative, rather than conclusive. However, our main finding does not change in this case. Thus, contrary to the most of the previous finding, we show that international sanctions can reduce the expected duration of civil wars.

3.5.2 DIFFERENT TYPES OF SANCTIONS

In this section, we examine the effects of different types of sanctions: total economic embargo, multilateral arms embargo, trade sanctions, aid end, and other sanctions. Table 3.8 presents the estimated coefficients of hazard rates for these sanctions. We find that the coefficient of total economic sanction or comprehensive sanction is positive, large, and statistically significant. This result implies that comprehensive sanctions that cut the total flow of funds to the conflicting parties are very effective in reducing war duration. Our results also show that arms embargo has positive and significant effect on hazard rate of war termination. This implies that restrictions on the supply of arms to the warring parties can lead to a shorter intra-state war. The coefficients of both trade sanction and aid end are positive, but are not statistically significant. Thus, our results suggest that trade sanctions and aid cancellation as tools for war termination are not effective. Others sanctions such as blockade, asset freeze, travel ban, suspension of economic agreement do not appear to have any significant effect on civil war duration. We also estimate the effects of each category of sanctions individually without controlling for other categories (Table 3.10), and find that the coefficients of total economic embargo and arms sanction are still positive and statistically significant.

We also estimate the effects of sanctions by dividing the sanctions according to the types of senders of sanctions: unilateral and multilateral sanctions. Table 3.9 reports the estimated results and we find that both multilateral and unilateral sanction have positive and significant effects on hazard rate of war termination. Thus, our results suggest that both multilateral and unilateral sanctions can reduce the duration of civil war. Note, in our sample majority of the (89% of total unilateral sanctions) unilateral sanctions were imposed by the United States. Since U.S. is the biggest military and economic power of the world, sanctions imposed by that country has significant effect on civil war termination.

We also run separate regression for these two types of sanctions, and find that the coefficient of multi-lateral sanction is still positive and significant. The coefficient of unilateral sanction though positive, but is not statistically significant.

3.6 CONCLUSION

This chapter examines empirically the effects of international sanctions on the duration of civil conflicts. Using civil wars and sanctions data for the period of 1960 - 2008, we estimate hazard rate of war termination due to sanctions. Contrary to the most of the previous findings, we find that in general sanctions reduce the expected duration of civil wars. However, not all types of sanction are equally successful in shortening conflicts. Total economic embargoes and arms sanctions are effective, but trade sanctions, aid suspension, and other sanctions do not work. Both multi-lateral and unilateral sanctions (mainly U.S. sanctions) are associated with shorter civil wars. Thus, our results suggest that in the current globalized system, sanction could be an effective tool for the international community to reduce the duration of civil war.

Like most studies, our study is not without limitations. Our data on sanctions include all the imposed sanctions during the conflict. We don't have sufficient information about whether these sanctions are imposed because of civil war or for some other reasons (e.g., democracy, human rights issue, violation of international law). Our sanction variables are dummy variables, they measure whether intervention is present or absent in a given war or in a given year, they do not measure the extent of the intervention. But for practical purpose the intensity of intervention might be an important determinant of war duration. Another limitation is the potential endogenity of sanctions. To deal with the endogeneity, we use a instrumental variable technique suggested by Terza et al. (2008), and Atiyat (2011). Since there is no standard methodology to use instrumental variable technique in case of hazard model, our results can be taken as indicative, rather than conclusive.

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APPENDICES

APPENDIX A

A.1 DERIVATION OF (1.28)

The labor market equilibrium condition is as follows:

$$2\frac{(2p_1-p_2)^2}{4w^2}+2\frac{p_2(wy+p_2-2p_1)}{2w^2}+\frac{p_a^2V}{w^2}=L$$

$$2(2p_1-p_2)^2+4p_2(wy+p_2-2p_1)+4p_a^2V=4w^2L \tag{A-1}$$

$$2p_2wy-2w^2L+4p_1^2+3p_2^2-8p_1p_2+2p_a^2V=0$$

Totally differentiating equation (A-1) we get,

$$(p_2y-4wL)dw=-4(p_1-p_2)dp_1-(wy-4p_1+3p_2)dp_2-2p_aVdp_a-p_2wdy+2w^2dL \tag{A-2}$$

Substituting for L and rearranging we get,

$$\Delta dw=-4w(p_1-p_2)dp_1-w(wy-4p_1+3p_2)dp_2-2wp_aVdp_a-p_2w^2dy+2w^3dL, \tag{A-3}$$

where $\Delta=(2p_1-p_2)(3p_2-2p_1)-p_2wy-2p_a^2V$. From equation (A-3) we get the changes in w with respect to the changes in p_1, p_2, p_a, y, and L of (1.28).

A.2 PROOF OF PROPOSITION 2

(a) Change in p_1:

$$\begin{aligned}\frac{dl_r}{dp_1}&=\frac{\partial l_r}{\partial p_1}+\frac{\partial l_r}{\partial w}.\frac{dw}{dp_1}=\frac{2p_1-p_2}{w^2}+\left[-\frac{(2p_1-p_2)^2}{2w^3}.-\frac{4w(p_1-p_2)}{\Delta}\right]\\&=\frac{2p_1-p_2}{w^2}+\left[\frac{(2p_1-p_2)^2}{2w^3}.\frac{4w(p_1-p_2)}{\Delta}\right]=\frac{2p_1-p_2}{w^2}\left[\frac{2w\Delta+4w(2p_1-p_2)(p_1-p_2)}{2w\Delta}\right]\\&=\frac{2p_1-p_2}{2w^3\Delta}[2w((2p_1-p_2)(3p_2-2p_1)-p_2wy-2p_a^2V)+4w(2p_1-p_2)(p_1-p_2)]\\&=\frac{2p_1-p_2}{2w^3\Delta}[(2p_1-p_2)2w(3p_2-2p_1)+4w(p_1-p_2)-2w(p_2wy+2p_a^2V)]\\&=\frac{2p_1-p_2}{2w^3\Delta}[(2p_1-p_2)2wp_2-2w(p_2wy+2p_a^2V)]\\&=\frac{2p_1-p_2}{w^2\Delta}[((2p_1-p_2)p_2-p_2wy)+2p_a^2V)]\end{aligned} \tag{A-4}$$

$$
\begin{aligned}
\frac{dl_c}{dp_1} &= \frac{\partial l_c}{\partial p_1} + \frac{\partial l_c}{\partial w}.\frac{dw}{dp_1} = -\frac{p_2}{w^2} + \left[\frac{p_2[2(2p_1-p_2)-wy]}{2w^3}.-\frac{4w(p_1-p_2)}{\Delta}\right] \\
&= -\frac{p_2}{w^2} - \left[\frac{p_2[2(2p_1-p_2)-wy]}{w^2}.\frac{2(p_1-p_2)}{\Delta}\right] \\
&= \frac{p_2}{w^2\Delta}[-\Delta - 2(p_1-p_2)(2(2p_1-p_2)-wy)] \\
&= \frac{p_2}{w^2\Delta}[-((2p_1-p_2)(3p_2-2p_1)-p_2wy-2p_a^2V)-4(p_1-p_2)(2p_1-p_2)+2wy(p_1-p_2)] \\
&= \frac{p_2}{w^2\Delta}[(2p_1-p_2)(p_2-2p_1)-p_2wy+2p_a^2V+2p_1wy] \\
&= \frac{p_2}{w^2\Delta}[-(2p_1-p_2)^2+(2p_1-p_2)wy+2p_a^2V] \\
&= \frac{p_2}{w^2\Delta}[(2p_1-p_2)(wy-(2p_1-p_2))+2p_a^2V]
\end{aligned}
\tag{A-5}
$$

(b) Change in p_2:

$$
\begin{aligned}
\frac{dl_r}{dp_2} &= \frac{\partial l_r}{\partial p_2} + \frac{\partial l_r}{\partial w}.\frac{dw}{dp_2} = -\frac{2p_1-p_2}{2w^2} + \left[-\frac{(2p_1-p_2)^2}{2w^3}.-\frac{w(wy+3p_2-4p_1)}{\Delta}\right] \\
&= \frac{2p_1-p_2}{2w^2\Delta}[-((2p_1-p_2)(3p_2-2p_1)-p_2wy-2p_a^2V)+(2p_1-p_2)(wy+3p_2-4p_1)] \\
&= \frac{2p_1-p_2}{2w^2\Delta}[-(2p_1-p_2)(3p_2-2p_1)+p_2wy+2p_a^2V+(2p_1-p_2)(wy+3p_2-4p_1)] \\
&= \frac{2p_1-p_2}{2w^2\Delta}[(2p_1-p_2)(wy-2p_1)+p_2wy+2p_a^2V] \\
&= \frac{2p_1-p_2}{w^2\Delta}[p_1(wy-(2p_1-p_2)+p_a^2V]
\end{aligned}
\tag{A-6}
$$

$$
\begin{aligned}
\frac{dl_c}{dp_2} &= \frac{\partial l_c}{\partial p_2} + \frac{\partial l_c}{\partial w}.\frac{dw}{dp_2} = \frac{(wy+2p_2-2p_1)}{2w^2} + \left[\frac{p_2[2(2p_1-p_2)-wy]}{2w^3}.-\frac{w(wy+3p_2-4p_1)}{\Delta}\right] \\
&= \frac{(wy-2(p_1-p_2))}{2w^2} + \left[\frac{p_2[2(p_1-p_2)-wy)+2p_1p_2][(2(p_1-p_2)-wy)+(2p_1-p_2)]}{2w^2\Delta}\right] \\
&= \frac{(wy-2(p_1-p_2))}{2w^2\Delta}[\Delta + p_2(wy-2(p_1-p_2))-2p_1p_2-p_2(2p_1-p_2)] + \frac{p_1p_2(2p_1-p_2)}{w^2\Delta} \\
&= \frac{(wy-2(p_1-p_2))}{2w^2\Delta}[(2p_1-p_2)(3p_2-2p_1)-2p_a^2V-2p_1p_2-p_2(2p_1-p_2)] + \frac{p_1p_2(2p_1-p_2)}{w^2\Delta} \\
&= \frac{(wy-2(p_1-p_2))}{w^2\Delta}[p_1(p_2-2p_1)-p_a^2V] + \frac{p_1p_2(2p_1-p_2)}{w^2\Delta} \\
&= \frac{p_1(p_2-2p_1)}{w^2\Delta}[wy-(2p_1-p_2)] + \frac{(wy-2(p_1-p_2))p_a^2V}{w^2\Delta}
\end{aligned}
\tag{A-7}
$$

(d) Change in y:

$$\frac{dl_c}{dy} = \frac{\partial l_c}{\partial y} + \frac{\partial l_c}{\partial w}.\frac{dw}{dy} = \frac{p_2}{2w} + \left[\frac{p_2[2(2p_1 - p_2) - wy]}{2w^3}. - \frac{w^2 p_2}{\Delta}\right]$$

$$= \frac{p_2}{2w\Delta}[\Delta - p_2(2(2p_1 - p_2) - wy)] \tag{A-8}$$

$$= \frac{p_2}{2w\Delta}[(2p_1 - p_2)(3p_2 - 2p_1) - p_2wy - 2p_a^2V - 2p_2(2p_1 - p_2) + p_2wy]$$

$$= \frac{p_2}{2w\Delta}[-(2p_1 - p_2)^2 - 2p_a^2V]$$

(e) Change in p_a:

$$\frac{dl_a}{dp_a} = \frac{\partial l_a}{\partial p_a} + \frac{\partial l_a}{\partial w}.\frac{dw}{dp_a} = \frac{2p_aV}{w^2} + [-\frac{2p_a^2V}{w^3}. - \frac{2wp_a}{\Delta}]$$

$$= \frac{2p_a}{w^2\Delta}[\Delta + 2p_a^2V] \tag{A-9}$$

$$= \frac{2p_aV[(2p_1 - p_2)(3p_2 - 2p_1) - p_2wy]}{w^2\Delta}$$

A.3 PROOF OF PROPOSITION 3

Proof of $(y - 4l_r^{\frac{1}{2}}) > 0$:

From (1.14) we get,

$$p_1y - 4p_1l_r^{\frac{1}{2}} = wyl_r^{\frac{1}{2}} - 3wl_r \Rightarrow p_1(y - 4l_r^{\frac{1}{2}}) = wl_r^{\frac{1}{2}}(y - 4l_r^{\frac{1}{2}}) + wl_r \Rightarrow (p_1 - wl_r^{\frac{1}{2}})(y - 4l_r^{\frac{1}{2}}) = wl_r$$

$$\Rightarrow (y - 4l_r^{\frac{1}{2}}) = \frac{wl_r}{\underbrace{(p_1 - wl_r^{\frac{1}{2}})}_{+}} > 0$$

Note, from FOC of equation (1.8) we get $(p_1 - wl_r^{\frac{1}{2}}) = \frac{p_2}{2(1+\gamma)} > 0$

Derivation of $\partial l_c/\partial p_1$:

$$\frac{\partial l_c}{\partial p_1} = \frac{2l_r^{\frac{1}{2}}}{w} + \left(\frac{p_1l_r^{-\frac{1}{2}} - w}{w}\right)\frac{\partial l_r}{\partial p_1} = \frac{2l_r^{\frac{1}{2}}}{w} + \left(\frac{p_1l_r^{-\frac{1}{2}} - w}{w}\right)\frac{y - 4l_r^{\frac{1}{2}}}{\Lambda}$$

$$= \frac{2l_r^{\frac{1}{2}}(2p_1l_r^{-\frac{1}{2}} - 3w + \frac{1}{2}wyl_r^{-\frac{1}{2}}) + p_1l_r^{-\frac{1}{2}}y - wy - 4p_1 + 4wl_r^{\frac{1}{2}}}{w^2\Lambda} \tag{A-10}$$

$$= \frac{p_1yl_r^{-\frac{1}{2}} - 2wl_r^{\frac{1}{2}}}{w\Lambda}$$

Derivation of $\partial l_c/\partial w$:

$$\frac{\partial l_c}{\partial w} = \left(\frac{p_1 l_r^{-\frac{1}{2}} - w}{w}\right)\frac{\partial l_r}{\partial w} - \frac{2p_1 l_r^{\frac{1}{2}}}{w^2} = \left(\frac{p_1 l_r^{-\frac{1}{2}} - w}{w}\right)\frac{3l_r - y l_r^{\frac{1}{2}}}{\Lambda} - \frac{2p_1 l_r^{\frac{1}{2}}}{w^2}$$

$$= \frac{w(p_1 l_r^{-\frac{1}{2}} - w)(3l_r - y l_r^{\frac{1}{2}}) - 2p_1 l_r^{\frac{1}{2}}(2p_1 l_r^{-\frac{1}{2}} - 3w + \frac{1}{2} w y l_r^{-\frac{1}{2}})}{w^2\Lambda}$$

$$= \frac{9p_1 w l_r^{\frac{1}{2}} + w^2 y l_r^{\frac{1}{2}} - 2p_1 w y - 3w^2 l_r - 4p_1^2}{w^2\Lambda} \tag{A-11}$$

$$= \frac{w(4p_1 l_r^{\frac{1}{2}} + w^2 y l_r^{\frac{1}{2}} - 3w l_r) + 5p_1 w l_r^{\frac{1}{2}} - 2p_1 w y - 4p_1^2}{w^2\Lambda}$$

$$= \frac{p_1 w y + 5p_1 w l_r^{\frac{1}{2}} - 2p_1 w y - 4p_1^2}{w^2\Lambda}$$

$$= \frac{5p_1 w l_r^{\frac{1}{2}} - p_1 w y - 4p_1^2}{w^2\Lambda} = \frac{4p_1 l_r^{\frac{1}{2}}(w - p_1 l_r^{-\frac{1}{2}}) + p_1 w(l_r^{\frac{1}{2}} - y)}{w^2\Lambda}$$

A.4 PROOF OF PROPOSITION 4

Derivation of the changes in w with respect to changes in p_1, y, p_a, and L:

$$\frac{dw}{dp_1} = -\frac{\frac{\partial l_r}{\partial p_1} + \frac{\partial l_c}{\partial p_1}}{\frac{\partial l_r}{\partial w} + \frac{\partial l_c}{\partial w} + \frac{1}{2}\frac{\partial l_a}{\partial w}}$$

$$= -\frac{\frac{y - 4l_r^{\frac{1}{2}}}{\Lambda} + \frac{p_1 y l_r^{-\frac{1}{2}} - 2w l_r^{\frac{1}{2}}}{w\Lambda}}{-\frac{p_1(y - 4l_r^{\frac{1}{2}})}{w\Lambda} + \frac{4p_1 l_r^{\frac{1}{2}}(w - p_1 l_r^{-\frac{1}{2}}) + p_1 w(l_r^{\frac{1}{2}} - y)}{w^2\Lambda} - \frac{l_a}{w}}$$

$$= -\frac{\frac{wy + p_1 y l_r^{-\frac{1}{2}} - 6w l_r^{\frac{1}{2}}}{w\Lambda}}{\frac{p_1 w l_r^{\frac{1}{2}} - 4p_1^2 - w l_a \Lambda}{w^2\Lambda}} \tag{A-12}$$

$$= \frac{w(6w l_r^{\frac{1}{2}} - wy - p_1 y l_r^{-\frac{1}{2}})}{p_1 w l_r^{\frac{1}{2}} - 4p_1^2 - w l_a \Lambda}$$

$$= \frac{w^2(4l_r^{\frac{1}{2}} - y) + w(2w l_r^{\frac{1}{2}} - p_1 y l_r^{-\frac{1}{2}})}{\Omega}$$

$$\frac{dw}{dp_a} = -\frac{\frac{1}{2}\frac{\partial l_a}{\partial p_a}}{\frac{\partial l_r}{\partial w} + \frac{\partial l_c}{\partial w} + \frac{1}{2}\frac{\partial l_a}{\partial w}}$$

$$= -\frac{\frac{1}{2}\frac{2p_a V}{w^2}}{-\frac{p_1(y-4l_r^{\frac{1}{2}})}{w\Lambda} + \frac{4p_1 l_r^{\frac{1}{2}}(w-p_1 l_r^{-\frac{1}{2}})+p_1 w(l_r^{\frac{1}{2}}-y)}{w^2\Lambda} - \frac{l_a}{w}} \tag{A-13}$$

$$= -\frac{p_a\Lambda}{p_1 w l_r^{\frac{1}{2}} - 4p_1^2 - w l_a \Lambda}$$

$$= -\frac{p_a\Lambda}{\Omega}$$

$$\frac{dw}{dy} = -\frac{\frac{\partial l_r}{\partial y} + \frac{\partial l_c}{\partial y}}{\frac{\partial l_r}{\partial w} + \frac{\partial l_c}{\partial w} + \frac{1}{2}\frac{\partial l_a}{\partial w}}$$

$$= -\frac{\frac{p_1 - w l_r^{\frac{1}{2}}}{\Lambda} + \frac{l_r^{-\frac{1}{2}}(p_1 - w l_r^{\frac{1}{2}})^2}{w\Lambda}}{-\frac{p_1(y-4l_r^{\frac{1}{2}})}{w\Lambda} + \frac{4p_1 l_r^{\frac{1}{2}}(w-p_1 l_r^{-\frac{1}{2}})+p_1 w(l_r^{\frac{1}{2}}-y)}{w^2\Lambda} - \frac{l_a}{w}} \tag{A-14}$$

$$= -\frac{w^2(p_1 - w l_r^{\frac{1}{2}}) + w l_r^{-\frac{1}{2}}(p_1 - w l_r^{\frac{1}{2}})^2}{p_1 w l_r^{\frac{1}{2}} - 4p_1^2 - w l_a\Lambda}$$

$$= -\frac{w^2(p_1 - w l_r^{\frac{1}{2}}) + w l_r^{-\frac{1}{2}}(p_1 - w l_r^{\frac{1}{2}})^2}{\Omega}$$

$$\frac{dw}{dL} = \frac{\frac{1}{2}}{\frac{\partial l_r}{\partial w} + \frac{\partial l_c}{\partial w} + \frac{1}{2}\frac{\partial l_a}{\partial w}}$$

$$= \frac{\frac{1}{2}}{-\frac{p_1(y-4l_r^{\frac{1}{2}})}{w\Lambda} + \frac{4p_1 l_r^{\frac{1}{2}}(w-p_1 l_r^{-\frac{1}{2}})+p_1 w(l_r^{\frac{1}{2}}-y)}{w^2\Lambda} - \frac{l_a}{w}} \tag{A-15}$$

$$= \frac{w^2\Lambda}{p_1 w l_r^{\frac{1}{2}} - 4p_1^2 - w l_a\Lambda}$$

$$= \frac{w^2\Lambda}{\Omega}$$

(a) Change in p_1:

$$
\begin{aligned}
\frac{dl_r}{dp_1} &= \frac{\partial l_r}{\partial p_1} + \frac{\partial l_r}{\partial w}.\frac{dw}{dp_1} = \frac{y-4l_r^{\frac{1}{2}}}{\Lambda} + \frac{p_1(4l_r^{\frac{1}{2}}-y)}{w\Lambda}.\frac{w^2(4l_r^{\frac{1}{2}}-y)+w(2wl_r^{\frac{1}{2}}-p_1l_r^{-\frac{1}{2}}y)}{\Omega} \\
&= \frac{y-4l_r^{\frac{1}{2}}}{\Lambda} + \frac{p_1w(y-4l_r^{\frac{1}{2}})^2+p_1(4l_r^{\frac{1}{2}}-y)(2wl_r^{\frac{1}{2}}-p_1l_r^{-\frac{1}{2}}y)}{\Lambda\Omega} \\
&= \frac{y-4l_r^{\frac{1}{2}}}{\Lambda\Omega}[\Omega+p_1w(y-4l_r^{\frac{1}{2}})-p_1(2wl_r^{\frac{1}{2}}-p_1l_r^{-\frac{1}{2}}y)] \\
&= \frac{y-4l_r^{\frac{1}{2}}}{\Lambda\Omega}[p_1wl_r^{\frac{1}{2}}-4p_1^2-wl_a\Lambda+p_1wy-6p_1wl_r^{\frac{1}{2}}-p_1^2l_r^{-\frac{1}{2}}y] \\
&= \frac{y-4l_r^{\frac{1}{2}}}{\Lambda\Omega}[p_1wy-4p_1^2-wl_a\Lambda-5p_1wl_r^{\frac{1}{2}}-p_1l_r^{-\frac{1}{2}}(4p_1l_r^{\frac{1}{2}}-3wl_r+wyl_r^{\frac{1}{2}})] \\
&= \frac{y-4l_r^{\frac{1}{2}}}{\Lambda\Omega}[2p_1wy-wl_a\Lambda-8p_1wl_r^{\frac{1}{2}}] \\
&= \frac{w(y-4l_r^{\frac{1}{2}})}{\Lambda\Omega}[2p_1(y-4l_r^{\frac{1}{2}})-l_a\Lambda] \\
&= \frac{w(y-4l_r^{\frac{1}{2}})}{\Omega}[\frac{2p_1(y-4l_r^{\frac{1}{2}})}{\Lambda}-l_a]
\end{aligned} \tag{A-16}
$$

$$
\begin{aligned}
\frac{dl_c}{dp_1} &= \frac{\partial l_c}{\partial p_1} + \frac{\partial l_c}{\partial w}.\frac{dw}{dp_1} \\
&= \frac{p_1 y l_r^{-\frac{1}{2}} - 2wl_r^{\frac{1}{2}}}{w\Lambda} + \frac{4p_1 l_r^{\frac{1}{2}}(w - p_1 l_r^{-\frac{1}{2}}) + p_1 w(l_r^{\frac{1}{2}} - y)}{w^2\Lambda}.\frac{w^2(4l_r^{\frac{1}{2}} - y) + w(2wl_r^{\frac{1}{2}} - p_1 l_r^{-\frac{1}{2}} y)}{\Omega} \\
&= \frac{p_1 y l_r^{-\frac{1}{2}} - 2wl_r^{\frac{1}{2}}}{w\Lambda} + \frac{p_1 w(4l_r^{\frac{1}{2}} - y) + (p_1 w l_r^{\frac{1}{2}} - 4p_1^2)}{w^2\Lambda}.\frac{w^2(4l_r^{\frac{1}{2}} - y) + w(2wl_r^{\frac{1}{2}} - p_1 l_r^{-\frac{1}{2}} y)}{\Omega} \\
&= \frac{1}{w^2\Lambda\Omega}[(p_1 y l_r^{-\frac{1}{2}} - 2wl_r^{\frac{1}{2}})\Omega + p_1 w^3(4l_r^{\frac{1}{2}} - y)^2 + w^2(4l_r^{\frac{1}{2}} - y)(p_1 w l_r^{\frac{1}{2}} - 4p_1^2) \\
&+ p_1 w^2(4l_r^{\frac{1}{2}} - y)(2wl_r^{\frac{1}{2}} - p_1 l_r^{-\frac{1}{2}} y) + w(p_1 w l_r^{\frac{1}{2}} - 4p_1^2)(2wl_r^{\frac{1}{2}} - p_1 l_r^{-\frac{1}{2}} y)] \\
&= \frac{(y - 4l_r^{\frac{1}{2}})}{w^2\Lambda\Omega}[p_1 w^3(y - 4l_r^{\frac{1}{2}}) - w^2(p_1 w l_r^{\frac{1}{2}} - 4p_1^2) - p_1 w^2(2wl_r^{\frac{1}{2}} - p_1 l_r^{-\frac{1}{2}} y)] \\
&+ \frac{1}{w^2\Lambda\Omega}[(p_1 y l_r^{-\frac{1}{2}} - 2wl_r^{\frac{1}{2}})(p_1 w l_r^{\frac{1}{2}} - 4p_1^2 - wl_a\Lambda) + w(p_1 w l_r^{\frac{1}{2}} - 4p_1^2)(2wl_r^{\frac{1}{2}} - p_1 l_r^{-\frac{1}{2}} y)] \\
&= \frac{(y - 4l_r^{\frac{1}{2}})}{\Lambda\Omega}[p_1 wy - 7p_1 w l_r^{\frac{1}{2}} + p_1^2 l_r^{-\frac{1}{2}} y + 4p_1^2] + \frac{1}{w^2\Lambda\Omega}[-w^2 l_a\Lambda(p_1 y l_r^{-\frac{1}{2}} - 2wl_r^{\frac{1}{2}})] \\
&= \frac{p_1(y - 4l_r^{\frac{1}{2}})}{\Lambda\Omega}[4p_1 + wy - 7wl_r^{\frac{1}{2}} + p_1 l_r^{-\frac{1}{2}} y] - \frac{l_a}{\Omega}(p_1 y l_r^{-\frac{1}{2}} - 2wl_r^{\frac{1}{2}}) \\
&= \frac{p_1(y - 4l_r^{\frac{1}{2}})}{\Lambda\Omega}[p_1 l_r^{-\frac{1}{2}} y + 3wl_r^{\frac{1}{2}} - 7wl_r^{\frac{1}{2}} + p_1 l_r^{-\frac{1}{2}} y] - \frac{l_a}{\Omega}(p_1 y l_r^{-\frac{1}{2}} - 2wl_r^{\frac{1}{2}}) \\
&= \frac{2p_1(y - 4l_r^{\frac{1}{2}})}{\Lambda\Omega}(p_1 l_r^{-\frac{1}{2}} y - 2wl_r^{\frac{1}{2}}) - \frac{l_a}{\Omega}(p_1 y l_r^{-\frac{1}{2}} - 2wl_r^{\frac{1}{2}}) \\
&= \frac{(p_1 l_r^{-\frac{1}{2}} y - 2wl_r^{\frac{1}{2}})}{\Lambda\Omega}[2p_1(y - 4l_r^{\frac{1}{2}}) - l_a\Lambda] \\
&= \frac{(p_1 l_r^{-\frac{1}{2}} y - 2wl_r^{\frac{1}{2}})}{\Omega}[\frac{2p_1(y - 4l_r^{\frac{1}{2}})}{\Lambda} - l_a]
\end{aligned}
\tag{A-17}
$$

(b) Change in y:

$$\frac{dl_r}{dy} = \frac{\partial l_r}{\partial y} + \frac{\partial l_r}{\partial w}.\frac{dw}{dy} = \frac{p_1 - wl_r^{\frac{1}{2}}}{\Lambda} + \frac{3l_r - yl_r^{\frac{1}{2}}}{\Lambda}. - \frac{w^2(p_1 - wl_r^{\frac{1}{2}}) + wl_r^{-\frac{1}{2}}(p_1 - wl_r^{\frac{1}{2}})^2}{\Omega}$$
$$= \frac{p_1 - wl_r^{\frac{1}{2}}}{\Lambda\Omega}[\Omega - w^2(3l_r - yl_r^{\frac{1}{2}}) - wl_r^{-\frac{1}{2}}(p_1 - wl_r^{\frac{1}{2}})(3l_r - yl_r^{\frac{1}{2}})]$$
$$= \frac{p_1 - wl_r^{\frac{1}{2}}}{\Lambda\Omega}[p_1wl_r^{\frac{1}{2}} - 4p_1^2 - wl_a\Lambda - w(3l_r - yl_r^{\frac{1}{2}})(-p_1l_r^{-\frac{1}{2}})] \quad \text{(A-18)}$$
$$= \frac{p_1 - wl_r^{\frac{1}{2}}}{\Lambda\Omega}[p_1wl_r^{\frac{1}{2}} - 4p_1^2 - wl_a\Lambda + (4p_1l_r^{\frac{1}{2}} - p_1y)p_1l_r^{-\frac{1}{2}}]$$
$$= \frac{p_1 - wl_r^{\frac{1}{2}}}{\Lambda\Omega}[p_1l_r^{\frac{1}{2}}(wl_r - p_1y) - wl_a\Lambda] = \frac{p_1 - wl_r^{\frac{1}{2}}}{\Omega}[\frac{p_1l_r^{\frac{1}{2}}(wl_r - p_1y)}{\Lambda} - wl_a]$$
$$= \frac{p_1 - wl_r^{\frac{1}{2}}}{\Omega}[\frac{p_1l_r^{\frac{1}{2}}(wl_r - p_1y)}{\Lambda} - wl_a]$$

$$\frac{dl_c}{dy} = \frac{\partial l_c}{\partial y} + \frac{\partial l_c}{\partial w}.\frac{dw}{dy}$$
$$= \frac{l_r^{-\frac{1}{2}}(p_1 - wl_r^{\frac{1}{2}})^2}{w\Lambda} - \frac{p_1w(4l_r^{\frac{1}{2}} - y) + (p_1wl_r^{\frac{1}{2}} - 4p_1^2)}{w^2\Lambda}.\frac{w^2(p_1 - wl_r^{\frac{1}{2}}) + wl_r^{-\frac{1}{2}}(p_1 - wl_r^{\frac{1}{2}})^2}{\Omega}$$
$$= \frac{(p_1 - wl_r^{\frac{1}{2}})}{w\Lambda\Omega}[l_r^{-\frac{1}{2}}(p_1 - wl_r^{\frac{1}{2}})\Omega - p_1w^2(4l_r^{\frac{1}{2}} - y) - w(p_1wl_r^{\frac{1}{2}} - 4p_1^2) - p_1w(4l_r^{\frac{1}{2}} - y)l_r^{-\frac{1}{2}}$$
$$(p_1 - wl_r^{\frac{1}{2}}) - (p_1wl_r^{\frac{1}{2}} - 4p_1^2)l_r^{-\frac{1}{2}}(p_1 - wl_r^{\frac{1}{2}})] = \frac{(p_1 - wl_r^{\frac{1}{2}})}{w\Lambda\Omega}[l_r^{-\frac{1}{2}}(p_1 - wl_r^{\frac{1}{2}})(p_1wl_r^{\frac{1}{2}} - 4p_1^2 - wl_a\Lambda)$$
$$- p_1w^2(4l_r^{\frac{1}{2}} - y) - w(p_1wl_r^{\frac{1}{2}} - 4p_1^2) - p_1w(4l_r^{\frac{1}{2}} - y)l_r^{-\frac{1}{2}}(p_1 - wl_r^{\frac{1}{2}}) - (p_1wl_r^{\frac{1}{2}} - 4p_1^2)l_r^{-\frac{1}{2}}$$
$$(p_1 - wl_r^{\frac{1}{2}})] = \frac{(p_1 - wl_r^{\frac{1}{2}})}{w\Lambda\Omega}[-wl_r^{-\frac{1}{2}}(p_1 - wl_r^{\frac{1}{2}})l_a\Lambda - p_1w^2(4l_r^{\frac{1}{2}} - y) - w(p_1wl_r^{\frac{1}{2}} - 4p_1^2)$$
$$- p_1w(4l_r^{\frac{1}{2}} - y)l_r^{-\frac{1}{2}}(p_1 - wl_r^{\frac{1}{2}})] = \frac{(p_1 - wl_r^{\frac{1}{2}})}{\Lambda\Omega}[-l_r^{-\frac{1}{2}}(p_1 - wl_r^{\frac{1}{2}})l_a\Lambda + p_1w(y - 4l_r^{\frac{1}{2}})p_1l_r^{-\frac{1}{2}}$$
$$- p_1wl_r^{\frac{1}{2}} + 4p_1^2] = \frac{(p_1 - wl_r^{\frac{1}{2}})}{\Lambda\Omega}[-l_r^{-\frac{1}{2}}(p_1 - wl_r^{\frac{1}{2}})l_a\Lambda + p_1l_r^{-\frac{1}{2}}(p_1y - wl_r)]$$
$$= \frac{l_r^{-\frac{1}{2}}(p_1 - wl_r^{\frac{1}{2}})}{\Omega}[\frac{p_1(p_1y - wl_r)}{\Lambda} - (p_1 - wl_r^{\frac{1}{2}})l_a] \quad \text{(A-19)}$$

(c) Change in p_a:

$$\frac{dl_a}{dp_a} = \frac{\partial l_a}{\partial p_a} + \frac{\partial l_a}{\partial w}.\frac{dw}{dp_a} = \frac{2l_a}{p_a} + \left[-\frac{2l_a}{w}.-\frac{w^2 l_a \Lambda}{p_a \Omega}\right] = \frac{2l_a}{p_a} + \frac{2wl_a^2\Lambda}{p_a\Omega} = \frac{2l_a}{p_a\Omega}[\Omega + wl_a\Lambda]$$

$$= \frac{2l_a}{p_a\Omega}[p_1 w l_r^{\frac{1}{2}} - 4p_1^2 - wl_a\Lambda + wl_a\Lambda] \quad \text{(A-20)}$$

$$= \frac{2p_1 l_a}{p_a\Omega}(wl_r^{\frac{1}{2}} - 4p_1)$$

A.5 PROOF OF PROPOSITION 5

When w is fixed: Totally differentiate (1.71) we get:

$$\begin{aligned}
dR_1 &= p_1 l_{r1}^{-\frac{1}{2}} dl_{r1} - wdl_{r1} - wdl_{c1} + \frac{l_{c1}}{l_{c1}+l_{c2}} p_2(-l_{r1}^{-\frac{1}{2}} dl_{r1} - l_{r2}^{-\frac{1}{2}} dl_{r2}) \\
&+ \frac{l_{c2}}{(l_{c1}+l_{c2})^2} p_2(y_1 + y_2 - 2l_{r1}^{\frac{1}{2}} - 2l_{r2}^{\frac{1}{2}}) dl_{c1} - \frac{l_{c1}}{(l_{c1}+l_{c2})^2} p_2(y_1 + y_2 - 2l_{r1}^{\frac{1}{2}} - 2l_{r2}^{\frac{1}{2}}) dl_{c2} \\
&= [p_1 l_{r1}^{-\frac{1}{2}} - w - \frac{l_{c1}}{l_{c1}+l_{c2}} p_2 l_{r1}^{-\frac{1}{2}}] dl_{r1} + \left[\frac{l_{c2}}{(l_{c1}+l_{c2})^2} p_2(y_1 + y_2 - 2l_{r1}^{\frac{1}{2}} - 2l_{r2}^{\frac{1}{2}}) - w\right] dl_{c1} \\
&- \frac{l_{c1}}{l_{c1}+l_{c2}} p_2 l_{r2}^{-\frac{1}{2}} dl_{r2} - \frac{l_{c1}}{(l_{c1}+l_{c2})^2} p_2(y_1 + y_2 - 2l_{r1}^{\frac{1}{2}} - 2l_{r2}^{\frac{1}{2}}) dl_{c2}
\end{aligned} \quad \text{(A-21)}$$

Using first order conditions of warlord 1, from (A-21) we get,

$$dR_1 = -\frac{l_{c1}}{l_{c1}+l_{c2}} p_2 l_{r2}^{-\frac{1}{2}} dl_{r2} - wdl_{c2} \quad \text{(A-22)}$$

Totally differentiate FOC of l_{r2} we get:

$$\frac{1}{2l_{r2}}\left(\frac{l_{c2}}{l_{c1}+l_{c2}} p_2 l_{r2}^{-\frac{1}{2}} - p_1 l_{r2}^{-\frac{1}{2}}\right) dl_{r2} = \frac{l_{c1}}{(l_{c1}+l_{c2})^2} p_2 l_{r2}^{-\frac{1}{2}} dl_{c2} - \frac{l_{c2}}{(l_{c1}+l_{c2})^2} p_2 l_{r2}^{-\frac{1}{2}} dl_{c1} \quad \text{(A-23)}$$

Using Nash equilibrium of $l_{c1} = l_{c2}$, and assuming $dl_{c1} = dl_{c2}$, from (A-23) we get, $dl_{r2} = 0$. Then, from (A-22) we get, $dR_1 = -wdl_{c2}$. Similarly, we can derive that $dR_2 = -wdl_{c1}$

When w is endogenous: Totally differentiate (1.71) we get:

$$\begin{aligned}
dR_1 &= p_1 l_{r1}^{-\frac{1}{2}} dl_{r1} - l_{r1}dw - wdl_{r1} - l_{c1}dw - wdl_{c1} + \frac{l_{c1}}{l_{c1}+l_{c2}} p_2(-l_{r1}^{-\frac{1}{2}} dl_{r1} - l_{r2}^{-\frac{1}{2}} dl_{r2}) + \\
&\frac{l_{c2}}{(l_{c1}+l_{c2})^2} p_2(y_1+y_2-2l_{r1}^{\frac{1}{2}}-2l_{r2}^{\frac{1}{2}})dl_{c1} - \frac{l_{c1}}{(l_{c1}+l_{c2})^2} p_2(y_1+y_2-2l_{r1}^{\frac{1}{2}}-2l_{r2}^{\frac{1}{2}})dl_{c2} \\
&= [p_1 l_{r1}^{-\frac{1}{2}} - w - \frac{l_{c1}}{l_{c1}+l_{c2}} p_2 l_{r1}^{-\frac{1}{2}}]dl_{r1} + \left[\frac{l_{c2}}{(l_{c1}+l_{c2})^2} p_2(y_1+y_2-2l_{r1}^{\frac{1}{2}}-2l_{r2}^{\frac{1}{2}}) - w\right] dl_{c1} \\
&- \frac{l_{c1}}{l_{c1}+l_{c2}} p_2 l_{r2}^{-\frac{1}{2}} dl_{r2} - \frac{l_{c1}}{(l_{c1}+l_{c2})^2} p_2(y_1+y_2-2l_{r1}^{\frac{1}{2}}-2l_{r2}^{\frac{1}{2}})dl_{c2} - (l_{r1}+l_{c1})dw \\
&= -\frac{l_{c1}}{l_{c1}+l_{c2}} p_2 l_{r2}^{-\frac{1}{2}} dl_{r2} - wdl_{c2} - (l_{r1}+l_{c1})dw
\end{aligned} \tag{A-24}$$

Totally differentiate FOC of l_{r2} we get:

$$\begin{aligned}
\frac{1}{2l_{r2}}(\frac{l_{c2}}{l_{c1}+l_{c2}} p_2 l_{r2}^{-\frac{1}{2}} - p_1 l_{r2}^{-\frac{1}{2}})dl_{r2} &= \frac{l_{c1}}{(l_{c1}+l_{c2})^2} p_2 l_{r2}^{-\frac{1}{2}} dl_{c2} - \frac{l_{c2}}{(l_{c1}+l_{c2})^2} p_2 l_{r2}^{-\frac{1}{2}} dl_{c1} + dw \\
\frac{w}{2l_{r2}} dl_{r2} &= \frac{l_{c1}}{(l_{c1}+l_{c2})^2} p_2 l_{r2}^{-\frac{1}{2}} (dl_{c1} - dl_{c2}) - dw
\end{aligned} \tag{A-25}$$

If $dl_{c1} = dl_{c2}$, then from (A-25) we get:

$$dl_{r2} = -\frac{2l_{r2}}{w} dw \tag{A-26}$$

Similarly, totally differentiate FOC of l_{r1} we get:

$$dl_{r1} = -\frac{2l_{r1}}{w} dw \tag{A-27}$$

Substituting (A-26) in to (A-24) we get:

$$dR_1 = \left[\frac{l_{c1}}{l_{c1}+l_{c2}} \frac{2p_2 l_{r2}^{\frac{1}{2}}}{w} - (l_{r1}+l_{c1})\right] dw - wdl_{c2} \tag{A-28}$$

If we assume $p_1 = p_2$ and use Nash equilibrium condition of $l_{r1} = l_{r2}$, from (A-28) we get:

$$dR_1 = (l_{r1} - l_{c1)} dw - wdl_{c2} \tag{A-29}$$

Similarly, totally differentiate (1.72) and using the same procedure we can get:

$$dR_2 = (l_{r2} - l_{c2)} dw - wdl_{c1} \tag{A-30}$$

Totally differentiate labor market equilibrium condition we get:

$$dl_{r1} + dl_{r2} + dl_{c1} + dl_{c2} + dl_a = 0 \tag{A-31}$$

Substituting the values of dl_{r1}, dl_{r2}, and dl_a in to (A-31) we get:

$$\frac{4l_{ri}+2l_a}{w}dw = dl_{c1}+dl_{c2} \Rightarrow dw = \frac{w}{2l_{ri}+l_a}dl_{ci},\ i=1,2 \tag{A-32}$$

Substituting (A-32) in to (A-29) and (A-30) we get respectively:

$$dR_1 = -\left(\frac{l_{r1}+l_{c1}+l_a}{2l_{r1}+l_a}\right)wdl_{c2},\ dR_2 = -\left(\frac{l_{r2}+l_{c2}+l_a}{2l_{r2}+l_a}\right)wdl_{c1}$$

A.6 PROOF OF PROPOSITION 6

When w is fixed: Totally differentiate (1.78) we get:

$$\begin{aligned} dR_1 = {} & \frac{l_{c1}}{l_{c1}+l_{c2}}p_2(-l_{r1}^{-\frac{1}{2}}dl_{r1}-l_{r2}^{-\frac{1}{2}}dl_{r2}) + \frac{l_{c2}}{(l_{c1}+l_{c2})^2}p_2(y_1+y_2-2l_{r1}^{\frac{1}{2}}-2l_{r2}^{\frac{1}{2}})dl_{c1} \\ & - \frac{l_{c1}}{(l_{c1}+l_{c2})^2}p_2(y_1+y_2-2l_{r1}^{\frac{1}{2}}-2l_{r2}^{\frac{1}{2}})dl_{c2} \end{aligned} \tag{A-33}$$

Applying first order conditions of warlord 1 in to (A-33) we get:

$$dR_1 = -(1+\gamma_1)(p_1l_{r1}^{-\frac{1}{2}}-w)dl_{r1}-(1+\gamma_2)(p_1l_{r2}^{-\frac{1}{2}}-w)dl_{r2}+(1+\gamma_1)wdl_{c1}-(1+\gamma_2)wdl_{c2} \tag{A-34}$$

Totally differentiate two budget constraints we get:

$$(p_1l_{r1}^{-\frac{1}{2}}-w)dl_{r1} = wdl_{c1},\ (p_1l_{r2}^{-\frac{1}{2}}-w)dl_{r2} = wdl_{c2} \tag{A-35}$$

Then, substituting (A-35) in to (A-34) we get:

$$\begin{aligned} dR_1 &= -(1+\gamma_1)wdl_{c1}-(1+\gamma_2)wdl_{c2}+(1+\gamma_1)wdl_{c1}-(1+\gamma_2)wdl_{c2} \\ &= -2(1+\gamma_2)wdl_{c2} \end{aligned} \tag{A-36}$$

When w is endogenous: Totally differentiate two budget constraints we get:

$$(p_1l_{r1}^{-\frac{1}{2}}-w)dl_{r1} = (l_{r1}+l_{c1})dw+wdl_{c1},\ (p_1l_{r2}^{-\frac{1}{2}}-w)dl_{r2} = (l_{r2}+l_{c2})dw+wdl_{c2} \tag{A-37}$$

Then, substituting (A-37) in to (A-34) we get:

$$\begin{aligned} dR_1 = {} & -(1+\gamma_1)[(l_{r1}+l_{c1})dw+wdl_{c1}]-(1+\gamma_2)[(l_{r2}+l_{c2})dw+wdl_{c2}]+(1+\gamma_1)wdl_{c1} \\ & -(1+\gamma_2)wdl_{c2} = -2(1+\gamma_1)(l_{r1}+l_{c1})dw-2(1+\gamma_2)wdl_{c2} \end{aligned} \tag{A-38}$$

Totally differentiate labor market equilibrium condition we get:

$$dl_{r1}+dl_{r2}+dl_{c1}+dl_{c2}+dl_a = 0 \tag{A-39}$$

Substituting (A-37) and value of dl_a in to (A-39) we get:

$$(dl_{c1} + dl_{c2}) + \frac{2(l_{r1} + l_{c1})}{p_1 l_{r1}^{-\frac{1}{2}} - w} dw + \frac{w}{p_1 l_{r1}^{-\frac{1}{2}} - w}(dl_{c1} + dl_{c2}) - \frac{2l_a}{w} dw = 0$$

$$\left[\frac{2(l_{r1} + l_{c1})}{p_1 l_{r1}^{-\frac{1}{2}} - w} - \frac{2l_a}{w}\right] dw = -\frac{p_1 l_{r1}^{-\frac{1}{2}}}{p_1 l_{r1}^{-\frac{1}{2}} - w}(dl_{c1} + dl_{c2}) \tag{A-40}$$

$$2[w(l_{r1} + l_{c1}) - l_a(p_1 l_{r1}^{-\frac{1}{2}} - w)]dw = -wp_1 l_{r1}^{-\frac{1}{2}}(dl_{c1} + dl_{c2})$$

$$\Gamma dw = -wp_1 l_{r1}^{-\frac{1}{2}}(dl_{c1} + dl_{c2}),$$

where $\Gamma = 2[w(l_{r1} + l_{c1}) - l_a(p_1 l_{r1}^{-\frac{1}{2}} - w)] < 0$, for stability of excess demand function for labor.

APPENDIX B

B.1 DERIVATION OF $\partial I^i/\partial l_{ci}$:

$$\frac{\partial I^i}{\partial l_{ci}} = w_i.2l_{ri}^{\frac{1}{2}}\left[-\frac{p_2}{w_i}.\frac{l_{cj}}{(l_{ci}+l_{cj})^2}\right] + \frac{l_{cj}}{(l_{ci}+l_{cj})^2}p_2(y_i+y_j-2l_{rj}^{\frac{1}{2}}) + \frac{l_{cj}}{l_{ci}+l_{cj}}p_2\left[-\frac{2p_2}{w_j}.\frac{l_{cj}}{(l_{ci}+l_{cj})^2}\right] - w_i$$

$$= -\frac{l_{cj}p_2}{(l_{ci}+l_{cj})^2}2l_{ri}^{\frac{1}{2}} + \frac{l_{cj}}{(l_{ci}+l_{cj})^2}p_2(y_i+y_j-2l_{rj}^{\frac{1}{2}}) - \frac{2p_2^2}{w_j}.\frac{l_{ci}l_{cj}}{(l_{ci}+l_{cj})^3} - w_i$$

$$= \frac{l_{cj}}{(l_{ci}+l_{cj})^2}p_2(y_i+y_j-2l_{ri}^{\frac{1}{2}}-2l_{rj}^{\frac{1}{2}}) - \frac{2p_2^2}{w_j}.\frac{l_{ci}l_{cj}}{(l_{ci}+l_{cj})^3} - w_i \tag{B-1}$$

B.2 DERIVATION OF (2.12):

From (2.11) we get two reaction functions of the two countries as follows:

$$\frac{l_{c2}}{(l_{c1}+l_{c2})^2}p_2(y_1+y_2-2l_{r1}^{\frac{1}{2}}-2l_{r2}^{\frac{1}{2}}) - \frac{2p_2^2}{w_2}.\frac{l_{c1}l_{c2}}{(l_{c1}+l_{c2})^3} = w_1 \tag{B-2}$$

$$\frac{l_{c1}}{(l_{c1}+l_{c2})^2}p_2(y_1+y_2-2l_{r1}^{\frac{1}{2}}-2l_{r2}^{\frac{1}{2}}) - \frac{2p_2^2}{w_1}.\frac{l_{c1}l_{c2}}{(l_{c1}+l_{c2})^3} = w_2 \tag{B-3}$$

From (B-2) and (B-3) we can derive the followings:

$$\begin{aligned}
&\frac{2p_2^2}{w_2}.\frac{l_{c1}}{(l_{c1}+l_{c2})^3} + \frac{w_1}{l_{c2}} = \frac{2p_2^2}{w_1}.\frac{l_{c2}}{(l_{c1}+l_{c2})^3} + \frac{w_2}{l_{c1}} \\
&\Rightarrow \frac{2p_2^2}{(l_{c1}+l_{c2})^3}\left(\frac{l_{c1}}{w_2} - \frac{l_{c2}}{w_1}\right) = \left(\frac{w_2}{l_{c1}} - \frac{w_1}{l_{c2}}\right) \\
&\Rightarrow \frac{2p_2^2}{(l_{c1}+l_{c2})^3}\left(\frac{w_1l_{c1}-w_2l_{c2}}{w_1w_2}\right) = \frac{w_2l_{c2}-w_1l_{c1}}{l_{c1}l_{c2}} \\
&\Rightarrow (w_1l_{c1}-w_2l_{c2})\left[\frac{2p_2^2}{(l_{c1}+l_{c2})^3w_1w_2} + \frac{1}{l_{c1}l_{c2}}\right] = 0 \\
&\Rightarrow w_1l_{c1}-w_2l_{c2} = 0 \Rightarrow l_{c2} = \frac{w_1}{w_2}l_{c1}
\end{aligned} \tag{B-4}$$

B.3 DERIVATION OF (2.14):

If $p_1 = p_2 = p$,

$$l_{r1} = l_{r2} = \left(\frac{p}{w_1+w_2}\right)^2,\ l_{c1} = \frac{w_2}{w_1}l_{c2} = \frac{w_2}{(w_1+w_2)^2}B$$

where $B = p(y_1 + y_2 - 6p/(w_1 + w_2))$.

Then from (2.13) and (2.14) we get:

$$\frac{w_2}{(w_1+w_2)^2}B + \left(\frac{p}{w_1+w_2}\right)^2 + \frac{p_a^2\lambda_1^2 V_1}{w_1^2} - L_1 = \frac{w_1}{(w_1+w_2)^2}B + \left(\frac{p}{w_1+w_2}\right)^2 + \frac{p_a^2\lambda_2^2 V_2}{w_2^2} - L_2$$
$$\Rightarrow L_1 - \frac{w_2}{(w_1+w_2)^2}B - \frac{a_1}{w_1^2} = L_2 - \frac{w_1}{(w_1+w_2)^2}B - \frac{a_2}{w_2^2}$$
$$\Rightarrow (L_1 - L_2) + \frac{B}{(w_1+w_2)^2}(w_1 - w_2) + \left(\frac{a_2}{w_2^2} - \frac{a_1}{w_1^2}\right) = 0, \tag{B-5}$$

where $a_1 = p_a^2\lambda_1^2 V_1$, and $a_2 = p_a^2\lambda_2^2 V_2$

B.4 DERIVATION OF (2.16) AND (2.17):

Totally differentiate (2.13) and using the symmetry (i.e. $w_1 = w_2 = w$, and $p_1 = p_2 = p$) we get:

$$\frac{B}{4w^2}dw_2 - \frac{B}{4w^2}dw_1 - \frac{B}{4w^2}dw_2 + \frac{dB}{4w} + \frac{p}{w^2}dp_1 - \frac{p}{w^3}dw_1 - \frac{p^2}{2w^2}dp_2 - \frac{p^2}{w^3}dw_2 + \frac{p^2}{w^3}dw_1 + \frac{p^2}{4w^3}dw_1$$
$$+ \frac{p^2}{4w^3}dw_2 - \frac{2a}{w^3}dw_1 = 0 \Rightarrow \frac{p}{w^2}dp_1 - \frac{p}{2w^2}dp_2 - \left(\frac{B}{4w^2} + \frac{p^2}{4w^2} + \frac{2a}{w^3}\right)dw_1 - \frac{p^2}{4w^3}dw_2 = 0 \tag{B-6}$$

where

$$dB = -\frac{4p}{w}dp_1 + \frac{Bw + p^2}{wp}dp_2 + \frac{3p^2}{2w^2}dw_1 + \frac{3p^2}{2w^2}dw_2$$

Substituting dB in to (B-6) and rearranging we get:

$$\alpha_1 dw_1 + \alpha_2 dw_2 = \beta_1 dp_1 + \gamma_1 dp_2, \tag{B-7}$$

where

$$\alpha_1 = \frac{B}{4w^2} + \frac{p^2}{4w^3} + \frac{2a}{w^3} - \frac{3p^2}{8w^3} = \frac{p(2wy - 3p)}{4w^3} - \frac{p^2}{8w^3} + \frac{2a}{w^3} = \frac{2p(2wy-3p) - p^2 + 16a}{8w^3}$$

$$\alpha_2 = \frac{p^2}{4w^3} - \frac{3p^2}{8w^3} = -\frac{p^2}{8w^3}$$

$$\beta_1 = \frac{p}{w^2} - \frac{p}{w^2} = 0$$

$$\gamma_1 = \frac{Bw + p^2}{4w^2 p} - \frac{p}{2w^2} = \frac{p(2wy - 3p) + p^2 - 2p^2}{4w^2 p} = \frac{wy - 2p}{2w^2}$$

Similarly, totally differentiate (2.14) we can get:

$$\alpha_3 dw_1 + \alpha_4 dw_2 = \beta_2 dp_1 + \gamma_2 dp_2, \tag{B-8}$$

where $\alpha_3 = \alpha_2,\ \alpha_4 = \alpha_1,\ \beta_2 = \beta_1$ and $\gamma_2 = \gamma_1$ (because of symmetry).

B.5 DERIVATION OF dw_i/dp_1 and dw_i/dp_2 $(i = 1, 2)$:

From (2.16) and (2.17) we get:

$$\begin{pmatrix} \alpha_1 & \alpha_2 \\ \alpha_3 & \alpha_4 \end{pmatrix} \begin{pmatrix} dw_1 \\ dw_2 \end{pmatrix} = \begin{pmatrix} \beta_1 \\ \beta_2 \end{pmatrix} dp_1 + \begin{pmatrix} \gamma_1 \\ \gamma_2 \end{pmatrix} dp_2 \tag{B-9}$$

Now applying Cramer's rule from (B-9) we get:

$$\Delta \frac{dw_1}{dp_1} = (\beta_1\alpha_4 - \beta_2\alpha_2)$$
$$\Delta \frac{dw_2}{dp_1} = (\beta_2\alpha_1 - \beta_1\alpha_3)$$
$$\Delta \frac{dw_1}{dp_2} = (\gamma_1\alpha_4 - \gamma_2\alpha_2)$$
$$\Delta \frac{dw_2}{dp_2} = (\gamma_2\alpha_1 - \gamma_1\alpha_3)$$

Note, $\Delta = \alpha_1\alpha_4 - \alpha_2\alpha_3 = \alpha_1^2 - \alpha_2^2 = (\alpha_1 + \alpha_2)(\alpha_1 - \alpha_2) = \Lambda(p(2wy - 3p) + 8a)/16w^6 > 0$ (for Walrasian stability of the labor market), where $\Lambda = p(2wy - 3p) - p^2 + 8a > 0$ (as $\Delta > 0$, and $(2wy - 3p) > 0$ which follows from $l_c = p(2wy - 3p)/4w^2 > 0$).

B.6 EFFECTS OF SANCTIONS:

B.6.1 Derivation of dl_c/dp_1:

Under symmetry (i.e., $w_1 = w_2 = w$) and $p_1 = p_2 = p$ the change in wage rate with respect to p_1 is:

$$\Delta \frac{dw}{dp_1} = 0$$

Under symmetry the conflict efforts of each country is given by:

$$l_c = \frac{p_2}{4w}(2y - \frac{4p_1}{w} + \frac{p_2}{w}) = \frac{p_2(2wy - 4p_1 + p_2)}{4w^2}$$

Then,

$$\frac{dl_c}{dp_1} = \frac{\partial l_c}{\partial p_1} + \frac{\partial l_c}{\partial w}\frac{dw}{dp_1} = \frac{\partial l_c}{\partial p_1} = -\frac{p}{w^2} \tag{B-10}$$

B.6.2 Derivation of dl_{c1}/dp_{11}:

If the price of period 1 in country 1 (p_{11}) changes only, then from (2.16) we get:

$$\beta_{11} = \frac{2p_1}{w_1^2} - \frac{2p_2w_2}{w_1^2(w_1+w_2)} - \frac{2p_2w_2}{w_1(w_1+w_2)^2} = \frac{2p}{w^2} - \frac{p}{w^2} - \frac{p}{2w^2} = \frac{p}{2w^2},$$

and from (2.17) we get:

$$\beta_{12} = -\frac{2p_2}{(w_1+w_2)^2} = -\frac{p}{2w^2},$$

Then,

$$\frac{dw_1}{dp_{11}} = -\frac{dw_2}{dp_{11}} = \frac{\beta_{11}(\alpha_1+\alpha_2)}{\Delta} = \frac{\beta_{11}}{(\alpha_1-\alpha_2)}$$

where

$$\alpha_1 - \alpha_2 = \frac{2p(2wy-3p) - p^2 + 16a}{8w^3} - \frac{p^2}{8w^3} = \frac{p(2wy-3p)+8a}{4w^3} > 0.$$

Note, $(2wy - 3p) > 0$ as $l_c = p(2wy - 3p)/4w^2 > 0$.

Then,

$$\frac{dw_1}{dp_{11}} = -\frac{dw_2}{dp_{11}} = \frac{2pw}{p(2wy-3p)+8a}.$$

From (2.18) we can write,

$$\frac{dl_{c1}}{dp_{11}} = \frac{\partial l_{c1}}{\partial p_{11}} + \frac{\partial l_{c1}}{\partial w_1}\frac{dw_1}{dp_{11}} + \frac{\partial l_{c1}}{\partial w_2}\frac{dw_2}{dp_{11}}, \tag{B-11}$$

where

$$\frac{\partial l_{c1}}{\partial p_{11}} = -\frac{2p_2}{w_1(w_1+w_2)} = -\frac{p}{2w^2}$$

$$\frac{\partial l_{c1}}{\partial w_1} = -\frac{2Bw_2}{(w_1+w_2)^3} + \frac{p_2w_2}{(w_1+w_2)^2}\left[\frac{2(p_1-p_2)(w_1^2+2w_1w_2)+2p_1w_1^2}{w_1^2(w_1+w_2)^2} + \frac{4p_2}{(w_1+w_2)^2}\right]$$

$$= -\frac{p(2wy-3p)}{4w^3} + \frac{3p^2}{8w^3} = \frac{9p^2-4pwy}{8w^3},$$

and

$$\frac{\partial l_{c1}}{\partial w_2} = \frac{B(w_1-w_2)}{(w_1+w_2)^3} + \frac{p_2w_2}{(w_1+w_2)^2}\left[\frac{(p_1-p_2)(w_1^2+2w_1w_2)+2p_1w_2^2}{w_1^2(w_1+w_2)^2} + \frac{4p_2}{(w_1+w_2)^2}\right]$$

$$= \frac{3p^2}{8w^3}.$$

Then,

$$\begin{aligned}
\frac{dl_{c1}}{dp_{11}} &= \frac{\partial l_{c1}}{\partial p_{11}} + \frac{dw_1}{dp_{11}}\left(\frac{\partial l_{c1}}{\partial w_1} - \frac{\partial l_{c1}}{\partial w_2}\right) \\
&= -\frac{p}{2w^2} + \frac{2pw}{8a + p(2wy - 3p)}\left(\frac{9p^2 - 4pwy}{8w^3} - \frac{3p^2}{8w^3}\right) \qquad \text{(B-12)} \\
&= -\frac{p}{2w^2} - \frac{p^2(2wy - 3p)}{2w^2[8a + p(2wy - 3p)]} < 0
\end{aligned}$$

B.6.3 Derivation of dl_{c2}/dp_{11}:

From (2.19) we can write,

$$\frac{dl_{c2}}{dp_{11}} = \frac{\partial l_{c2}}{\partial p_{11}} + \frac{\partial l_{c2}}{\partial w_1}\frac{dw_1}{dp_{11}} + \frac{\partial l_{c2}}{\partial w_2}\frac{dw_2}{dp_{11}} \qquad \text{(B-13)}$$

Using the above derivations we can write (B-13) as follows:

$$\begin{aligned}
\frac{dl_{c2}}{dp_{11}} &= \frac{\partial l_{c2}}{\partial p_{11}} + \frac{dw_1}{dp_{11}}\left(\frac{\partial l_{c2}}{\partial w_1} - \frac{\partial l_{c2}}{\partial w_2}\right) \\
&= -\frac{p}{2w^2} + \frac{2pw}{8a + p(2wy - 3p)}\left(\frac{3p^2}{8w^3} - \frac{9p^2 - 4pwy}{8w^3}\right) \qquad \text{(B-14)} \\
&= -\frac{p}{2w^2} + \frac{p^2(2wy - 3p)}{2w^2[8a + p(2wy - 3p)]} = \frac{-8ap}{2w^2[8a + p(2wy - 3p)]} < 0
\end{aligned}$$

B.6.4 Derivation of dl_c/dp_2:

Under symmetry the change in wage rate with respect to p_2 is:

$$\frac{dw}{dp_2} = \frac{\gamma_1(\alpha_1 - \alpha_2)}{\Delta} = \frac{\gamma_1}{\alpha_1 + \alpha_2},$$

where

$$\gamma_1 = \frac{wy - 2p}{2w^2},\ \alpha_1 + \alpha_2 = \frac{p(2wy - 3p) - p^2 + 8a}{4w^3} = \frac{\Lambda}{4w^3} > 0$$

Thus,

$$\frac{dw}{dp_2} = \frac{2w(wy - 2p)}{\Lambda}$$

Then,

$$\frac{dl_c}{dp_2} = \frac{\partial l_c}{\partial p_2} + \frac{\partial l_c}{\partial w}\frac{dw}{dp_2} = \frac{wy-p}{2w^2} + \frac{p(3p-wy)}{2w^3}.\frac{2w(wy-2p)}{\Lambda}$$
$$= \frac{wy-p}{2w^2} + \frac{p(3p-wy)(wy-p)+p^2(wy-p)-2p^3}{w^2\Lambda}$$
$$= \frac{wy-p}{2w^2\Lambda}[\Lambda + 2p(3p-wy)+2p^2] - \frac{2p^3}{w^2\Lambda}$$
$$= \frac{wy-p}{2w^2\Lambda}[p(2wy-3p)-p^2+8a+2p(3p-wy)+2p^2] - \frac{2p^3}{w^2\Lambda} \quad \text{(B-15)}$$
$$= \frac{wy-p}{2w^2\Lambda}[8a+4p^2] - \frac{2p^3}{w^2\Lambda}$$
$$= \frac{(wy-p)(8a+4p^2)-4p^3}{2w^2\Lambda}$$
$$= \frac{4a(wy-p)+p^2(2wy-3p)}{w^2\Lambda} > 0$$

B.6.5 Derivation of dl_{c1}/dp_{21}:

If the price of period 2 in country 1 (p_{21}) changes only, then from (2.16) we get:

$$\gamma_{11} = \frac{w_2B}{p_2(w_1+w_2)^2} + \frac{2p_2w_2^2}{w_1(w_1+w_2)^3} - \frac{2w_2}{w_1(w_1+w_2)}\left(\frac{p_1}{w_1} - \frac{w_2p_2}{w_1(w_1+w_2)}\right)$$
$$= \frac{B}{4pw} + \frac{p}{4w^2} - \frac{p}{2w^2} = \frac{2wy-3p}{4w^2} - \frac{p}{4w^2} = \frac{wy-2p}{2w^2},$$

and from (2.17) we get:

$$\gamma_{12} = \frac{2p_2w_2}{(w_1+w_2)^3} - \frac{2p_2w_1}{(w_1+w_2)^3} = \frac{p}{4w^2} - \frac{p}{4w^2} = 0$$

Then,

$$\frac{dw_1}{dp_{21}} = \frac{\gamma_{11}\alpha_4}{\Delta} = \frac{w(wy-2p)[2p(2wy-3p)-p^2+16a]}{\Omega},$$

$$\frac{dw_2}{dp_{21}} = -\frac{\gamma_{11}\alpha_3}{\Delta} = \frac{w(wy-2p)3p^2}{\Omega}$$

where $\Omega = \Lambda(p(2wy-3p)+8a) > 0$.

From (2.18) we get,

$$\frac{dl_{c1}}{dp_{21}} = \frac{\partial l_{c1}}{\partial p_{21}} + \frac{\partial l_{c1}}{\partial w_1}\frac{dw_1}{dp_{21}} + \frac{\partial l_{c1}}{\partial w_2}\frac{dw_2}{dp_{21}}, \quad \text{(B-16)}$$

where

$$\frac{\partial l_{c1}}{\partial p_{21}} = \frac{w_2B}{(w_1+w_2)^2p_2} + \frac{2p_{21}w_2^2}{(w_1+w_2)^3w_1} = \frac{wy-p}{2w^2}$$

Then,

$$\frac{dl_{c1}}{dp_{21}} = \frac{\partial l_{c1}}{\partial p_{21}} + \frac{\gamma_{11}}{\Delta}\left(\alpha_4 \frac{\partial l_{c1}}{\partial w_1} - \alpha_3 \frac{\partial l_{c1}}{\partial w_2}\right)$$
$$= \frac{wy-p}{2w^2} + \frac{8w^4(wy-2p)}{\Omega}[\frac{2p(2wy-3p)-p^2+16a}{8w^3}.\frac{p(9p-4wy)}{8w^3} + \frac{p^2}{8w^3}.\frac{3p^2}{8w^3}]$$
$$= \frac{wy-p}{2w^2} + \frac{p(wy-2p)}{\Omega}\frac{[(2p(2wy-3p)-p^2+16a)(9p-4wy)+3p^3]}{8w^2}$$
$$= \frac{wy-p}{8w^2\Omega}[4\Omega + (2p(2wy-3p)-p^2+16a)(9p-4wy)+3p^4]$$
$$- \frac{p^2}{8w^2\Omega}[(2p(2wy-3p)-p^2+16a)(9p-4wy)+3p^3]$$
$$= \frac{wy-p}{2w^2\Omega}[(p^3(2wy-3p)+12p^2a+8a(p(2wy-3p)-p^2+8a)]$$
$$+ \frac{p^2}{4w^2\Omega}[(2p(2wy-3p)-p^2+16a)-3p(p(2wy-3p)-p^2+8a)]$$
$$= \frac{p^2}{2w^2\Omega}(p(2wy-3p)+8a)(wy-2p) + \frac{p^2(2wy-3p)+16a(wy-p)}{4w^2\Omega}(p(2wy-3p)-p^2+8a)$$
$$+ \frac{8p^2a(wy-p)}{4w^2\Omega} = \frac{4p^2(p(2wy-3p)+8a)(wy-2p)+\Theta}{4w^2\Omega}, \tag{B-17}$$

where $\Omega = (p(2wy-3p)+8a)\Lambda > 0$,

$\Theta = [p^2(2wy-3p)+16a(wy-p)](p(2wy-3p)-p^2+8a)+8p^2a(wy-p) =$

$[p^2(2wy-3p)+16a(wy-p)]\Lambda + 8p^2a(wy-p) > 0.$

B.6.6 Derivation of dl_{c2}/dp_{21}:

From (2.19) we get,

$$\frac{dl_{c2}}{dp_{21}} = \frac{\partial l_{c2}}{\partial p_{21}} + \frac{\partial l_{c2}}{\partial w_1}\frac{dw_1}{dp_{21}} + \frac{\partial l_{c2}}{\partial w_2}\frac{dw_2}{dp_{21}}, \tag{B-18}$$

where

$$\frac{\partial l_{c2}}{\partial p_{21}} = \frac{2p_{22}(w_2-w_1)}{(w_1+w_2)^3} = 0.$$

Then,

$$
\begin{aligned}
\frac{dl_{c2}}{dp_{21}} &= 0 + \frac{\gamma_{11}}{\Delta}(\alpha_4 \frac{\partial l_{c2}}{\partial w_1} - \alpha_3 \frac{\partial l_{c2}}{\partial w_2}) \\
&= \frac{8w^4(wy-2p)}{\Omega}[\frac{2p(2wy-3p)-p^2+16a}{8w^3}.\frac{3p^2}{8w^3} + \frac{p^2}{8w^3}.\frac{p(9p-4wy)}{8w^3}] \\
&= \frac{p^2(wy-2p)(8pwy-3p^2+48a)}{8w^2\Omega} \\
&= \frac{p^2(p(2wy-3p)+6pwy+48a)(wy-2p)}{8w^2\Omega}
\end{aligned}
\tag{B-19}
$$

B.6.7 Derivation of dl_c/dp:

Under symmetry the change in wage rate with respect to permanent change in resource price will be:

$$
\frac{dw}{dp} = \frac{\gamma_1}{\alpha_1+\alpha_2} = \frac{2w(wy-2p)}{\Lambda}
$$

In this case,

$$
l_c = \frac{p(2wy-3p)}{4w^2},\ \frac{\partial l_c}{\partial p} = \frac{wy-3p}{2w^2},\ \frac{\partial l_c}{\partial w} = \frac{p(3p-wy)}{2w^3}
$$

Then,

$$
\begin{aligned}
\frac{dl_c}{dp} &= \frac{\partial l_c}{\partial p} + \frac{\partial l_c}{\partial w}\frac{dw}{dp} = \frac{wy-3p}{2w^2} + \frac{p(3p-wy)}{2w^3}.\frac{2w(wy-2p)}{\Lambda} \\
&= \frac{wy-3p}{2w^2\Lambda}[\Lambda - 2p(wy-2p)] \\
&= \frac{wy-3p}{2w^2\Lambda}[p(2wy-3p)-p^2+8a-2pwy+4p^2)] \\
&= \frac{4a(wy-3p)}{w^2\Lambda}
\end{aligned}
\tag{B-20}
$$

B.7 UNCERTAIN FUTURE SANCTION

When two countries are symmetric so that $w_1 = w_2 = w$, then

$$
\begin{aligned}
D &= (\theta p_2' + (1-\theta)p_2)\frac{2wy-4p_1}{w} + \frac{\theta(p_2')^2 + (1-\theta)p_2^2}{w} \\
&= (p_2 + \theta(p_2' - p_2))\frac{2wy-4p_1}{w} + \frac{p_2^2 + \theta((p_2')^2 - p_2^2)}{w} \\
&= (p_2 + \theta(p_2' - p_2))\frac{2wy-3p_1}{w} + \frac{p_2^2 + \theta((p_2')^2 - p_2^2)}{w} - \frac{(p_2 + \theta(p_2' - p_2))p_1)}{w}
\end{aligned}
$$

If in initial equilibrium $p_1 = p_2$, then

$$\begin{aligned}
D &= (p_2 + \theta(p_2' - p_2))\frac{2wy - 3p_1}{w} + \frac{\theta(p_2' - p_2)(p_2' + p_2)}{w} - \frac{\theta(p_2' - p_2)p_1}{w} \\
&= (p_2 + \theta(p_2' - p_2))\frac{2wy - 3p_1}{w} + \frac{\theta(p_2' - p_2)p_2'}{w} \\
&= \frac{p_2(2wy - 3p_1)}{w} + \frac{\theta(p_2' - p_2)(2wy - 3p_1 + p_2')}{w}
\end{aligned}$$

Then the equilibrium war efforts of each country is:

$$\widetilde{l_c} = \frac{p(2wy - 3p_1) + \theta(p_2' - p_2)(2wy - 3p_1 + p_2')}{4w^2}$$

APPENDIX C

Table 3.1: List of Civil Wars: 1960-2008

Country	War years	Country	War years	Country	War years
AFGHANISTAN	1978-89	HAITI	1991-95	PHILIPPINES	1972-
AFGHANISTAN	1990-02	HAITI	2004-04	ROMANIA	1989-89
AFGHANISTAN	2003-	INDIA*	1960-	RUSSIA	1994-96
ALGERIA	1962-62	INDIA	1965-	RUSSIA	1999-05
ALGERIA	1991-00	INDIA	1984-88	RWANDA	1962-65
ANGOLA	1975-02	INDIA	1989-	RWANDA	1990-94
ANGOLA	1992-02	INDONESIA*	1960-60	RWANDA	1997-02
ARGENTINA	1974-77	INDONESIA	1975-98	SENEGAL	1989-03
AZERBAIJAN	1991-94	INDONESIA	1999-05	SIERRA LEONE	1991-02
BANGLADESH	1976-97	IRAN	1978-79	SIERRA LEONE	1997-02
BOSNIA	1992-95	IRAN	1980-93	SOMALIA	1982-91
BURUNDI	1972-73	IRAQ	1961-74	SOMALIA	1991-97
BURUNDI	1988-88	IRAQ	1994-96	SOMALIA	2001-02
BURUNDI	1993-08	IVORYCOST	2002-04	SOMALIA	2006-08
CAMBODIA	1970-75	JEORGIA	1992-94	SOUTH AFRICA	1983-94
CAMBODIA	1978-91	JORDAN	1970-70	SRI LANKA	1971-71
CAF	1996-97	LAOS	1960-73	SRI LANKA	1983-
CAF	2001-	LEBANON	1975-90	SUDAN	1963-72
CHAD	1965-79	LIBERIA	1989-96	SUDAN	1983-
CHAD	1980-88	LIBERIA	2000-03	SYRIA	1979-81
CHAD	1997-02	MALI	1989-95	TAJIKISTAN	1992-97
CHAD	2005-06	MOLDOVA	1992-92	THAILAND	1974-81
CHINA	1991-99	MOROCCO	1975-88	THAILAND	2003-05
COLOMBIA	1963-	MOZAMBIQUE	1976-92	TURKEY	1977-80
CONGO	1998-99	MYANMAR	1968-	TURKEY	1984-
CONGO	2002-03	MYANMAR	1983-	UGANDA	1980-88
CROATIA	1992-95	MYANMAR	1988-	UGANDA	1993-
CYPRUS	1974-74	NEPAL	1960-62	UK	1969-98
DJIBOUTI	1991-94	NEPAL	1996-06	VIETNAM, S.	1960-64
DOMINICAN REP.	1965-65	NICARAGUA	1978-79	YEMEN ARAB REP.	1962-69
DRC	1960-65	NICARAGUA	1981-89	YEMEN	1986-86
DRC	1977-78	NIGERIA	1966-70	YEMEN	1994-94
DRC	1996-97	NIGERIA	1980-80	YEMEN	2004-05
DRC	1998-01	NIGERIA	2004-04	YEMEN	2007-07
EL SALVADOR	1979-92	PAKISTAN	1971-71	YUGOSLAVIA	1991-91
ETHIOPIA	1974-92	PAKISTAN	1973-77	YUGOSLAVIA	1998-99
ETHIOPIA	1994-	PAKISTAN	1993-99	ZIMBABWE	1967-68
GEORGIA	1992-94	PAKISTAN	2004-06	ZIMBABWE	1972-79
GUATEMALA	1965-95	P. N.G.	1988-98	ZIMBABWE	1983-87
GUINEA	2000-02	PERU	1980-99		
GUINEA BISSAU	1998-99	PHILIPPINES	1968-		

Note: DRC- Democratic Republic of Congo, CAF-Central African Republic. * Wars started before 1960.

Table 3.2: List of Variables and Data Sources

Variable	Data Source
War duration (in year)	COW, UCPD, Escriba`-Folch (2010)
War end (dummy)	COW, UCPD, Escriba`-Folch (2010)
Sanction (dummy)	Escriba`-Folch (2010), Hufbauer, Schott & Elliott's (2008), TIES, GIGA
Total economic embargo (dummy)	Escriba`-Folch (2010), Hufbauer, Schott & Elliott's (2008), TIES, GIGA
Aid end (dummy)	Escriba`-Folch (2010), Hufbauer, Schott & Elliott's (2008), TIES, GIGA
Trade sanction (dummy)	Escriba`-Folch (2010), Hufbauer, Schott & Elliott's (2008), TIES, GIGA
Other sanctions (dummy)	Escriba`-Folch (2010), Hufbauer, Schott & Elliott's (2008), TIES, GIGA
Arms embargo (dummy)	Escriba`-Folch (2010), Hufbauer, Schott & Elliott's (2008), TIES, GIGA
Multi-lateral sanction (dummy)	Escriba`-Folch (2010), Hufbauer, Schott & Elliott's (2008), TIES, GIGA
Unilateral sanction (dummy)	Escriba`-Folch (2010), Hufbauer, Schott & Elliott's (2008), TIES, GIGA
Population (in thousands)	WB, Pen World Table 7.1
Per capita GDP (2005 constant $)*	WB, Pen World Table 7.1
Per capita GDP in PPP(international $)*	WB, Pen World Table 7.1
Gini-efficient (index, 0-100)*	WB
Male secondary school enrollment ratio*	WB
Army size (per 1000 population)	Escriba`-Folch (2010)
Battle death per year	Escriba`-Folch (2010), UCPD
polity2 (index, -10 to +10)	Polity IV project, CSP
Mountainous area (% of total land)	Escriba`-Folch (2010), Fearon (2004)
Forest area (% of total land)*	WB
Ethnic fractionalization (index, 0-1)	Escriba`-Folch (2010), Fearon (2003)
Religious fractionalization (index, 0-1)	Escriba`-Folch (2010), Fearon (2003)
Number of border	Escriba`-Folch (2010)
Primary commodity exports (% of GDP)*	Escriba`-Folch (2010), Fearon (2005)
Oil rent (% of GDP, interpolated)*	WB
Mineral exporter (dummy)	Escriba`-Folch (2010), Fearon (2005)
Oil exporter (dummy)	Escriba`-Folch (2010), Fearon (2005)
Oil production per capita (in barrels)*	Escriba`-Folch (2010)
Diamond production per capita (in carats)*	Escriba`-Folch (2010)
Diamond production per square kilometer (in carats)*	Olsson (2007), Geology.com
Contraband (dummy)	Escriba`-Folch (2010)
Military intervention (dummy)	Escriba`-Folch (2010)
External intervention (dummy)	Cunningham (2010)
Ethnic war (dummy)	Escriba`-Folch (2010), Fearon (2004)
Sons of civil war (dummy)	Escriba`-Folch (2010), Fearon (2004)
Post-cold war (dummy)	= 0 if the year is before 1990, =1 if 1990 and after
Non-member of UNSC	= 0 if member of SC during the war, 1 = otherwise

Notes: * interpolated for missing values, COW-Correlates of War, UCPD-Uppsala Conflict Data Program, TIES-Threat and Imposition of Sanctions, GIGA-German Institute of Global and Area Studies, WB-World Bank, UNSC-United Nation Security Council.

Table 3.3a: Effects of Sanctions on Civil War Duration

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sanction	0.384*	0.341*	0.339*	0.493**	0.513**	0.560**	0.681***	0.679***
	(0.05)	(0.09)	(0.10)	(0.02)	(0.02)	(0.01)	(0.00)	(0.00)
Log of population		-0.319***	-0.383***	-0.391***	-0.250***	-0.309***	-0.380***	-0.303***
		(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.01)
Log of GDP per capita		0.025	-0.215*	-0.343***	-0.391***	-0.349***	-0.417***	-0.425***
		(0.79)	(0.06)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
Male secondary school enrolment			0.017***	0.016***	0.015***	0.015***	0.017***	0.016***
			(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Oil rent to GDP				0.026***	0.028***	0.030***	0.035***	0.042***
				(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Diamond production per capita				2.829***	2.555***	2.196**	2.454***	3.052***
				(0.00)	(0.00)	(0.02)	(0.01)	(0.00)
Contraband				-1.336***	-1.206***	-1.316***	-1.322***	-1.376***
				(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Son of civil war					-1.284***	-1.283***	-1.404***	-1.655***
					(0.00)	(0.00)	(0.00)	(0.00)
Army size						-0.038	-0.048**	-0.054**
						(0.11)	(0.05)	(0.03)
Army size sq.						0.0003	0.0003	0.0005*
						(0.24)	(0.12)	(0.08)
Log of battle death per year							-0.196**	-0.189**
							(0.01)	(0.02)
Number of border								-0.100*
								(0.10)
Constant	-2.275***	0.452	2.029**	2.812***	1.786*	2.359**	4.820***	4.582***
	(0.00)	(0.61)	(0.03)	(0.01)	(0.08)	(0.03)	(0.00)	(0.00)
Ln (p)	-0.137*	-0.019	-0.019	0.080	0.152*	0.185**	0.235***	0.232***
	(0.07)	(0.81)	(0.82)	(0.30)	(0.06)	(0.03)	(0.01)	(0.01)
N	1013	1013	943	940	927	927	927	927
LL	-193.3	-183.4	-165.0	-145.6	-136.2	-134.5	-131.4	-130.0
AIC	392.6	376.7	342.0	309.3	292.5	292.9	288.9	288.0

p values in parentheses: *p<.10, **p<.05, ***p<.01

Table 3.3b: Effects of Sanctions on Civil War Duration: Hazard Rates

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sanction	1.468*	1.407*	1.403*	1.636**	1.670**	1.751**	1.975***	1.973***
	(0.05)	(0.09)	(0.10)	(0.02)	(0.02)	(0.01)	(0.00)	(0.00)
Log of population		0.727***	0.682***	0.676***	0.779***	0.734***	0.684***	0.738***
		(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.01)
Log of GDP per capita		1.025	0.807*	0.709***	0.676***	0.706***	0.659***	0.654***
		(0.79)	(0.06)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
Male secondary school enrolment			1.017***	1.016***	1.015***	1.015***	1.017***	1.016***
			(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Oil rent to GDP				1.027***	1.028***	1.030***	1.035***	1.043***
				(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Diamond production per capita				16.935***	12.866***	8.989**	11.632***	21.152***
				(0.00)	(0.00)	(0.02)	(0.01)	(0.00)
Contraband				0.263***	0.299***	0.268***	0.267***	0.253***
				(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Son of civil war					0.277***	0.277***	0.246***	0.191***
					(0.00)	(0.00)	(0.00)	(0.00)
Army size						0.963	0.953**	0.948**
						(0.11)	(0.05)	(0.03)
Army size sq.						1.000	1.000	1.000*
						(0.24)	(0.12)	(0.08)
Log of battle death per year							0.822**	0.828**
							(0.01)	(0.02)
Number of border								0.905*
N	1013	1013	943	940	927	927	927	927
LL	-193.3	-183.4	-165.0	-145.6	-136.2	-134.5	-131.4	-130.0
AIC	392.6	376.7	342.0	309.3	292.5	292.9	288.9	288.0

p values in parentheses: *p<.10, **p<.05, ***p<.01

Table 3.4: Robustness Check: Other Controls

Variable	(1)		(2)		(3)		(4)		(5)		(6)	
Sanction	0.682***	(0.005)	0.683***	(0.005)	0.698***	(0.004)	0.690***	(0.005)	0.688***	(0.005)	0.703***	(0.007)
Log of population	-0.333***	(0.006)	-0.338***	(0.005)	-0.341***	(0.005)	-0.289**	(0.025)	-0.317**	(0.020)	-0.357**	(0.014)
Log of GDP per capita	-0.354**	(0.012)	-0.340**	(0.021)	-0.351**	(0.021)	-0.444**	(0.010)	-0.422**	(0.016)	-0.401**	(0.027)
Male secondary school enrolment	0.0140**	(0.017)	0.0143**	(0.015)	0.0146**	(0.016)	0.0153**	(0.012)	0.0147**	(0.018)	0.0139**	(0.036)
Oil rent to GDP	0.0409***	(0.000)	0.0401***	(0.000)	0.0409***	(0.000)	0.0427***	(0.000)	0.0423***	(0.000)	0.0408***	(0.000)
Diamond production per capita	3.073***	(0.002)	2.657**	(0.027)	2.702**	(0.025)	2.941**	(0.023)	2.769**	(0.034)	2.562**	(0.049)
Contraband	-1.341***	(0.000)	-1.422***	(0.000)	-1.479***	(0.000)	-1.476***	(0.000)	-1.516***	(0.000)	-1.447***	(0.000)
Son of civil war	-1.574***	(0.000)	-1.570***	(0.000)	-1.561***	(0.000)	-1.733***	(0.000)	-1.645***	(0.000)	-1.540***	(0.001)
Army size	-0.0533**	(0.028)	-0.0566**	(0.021)	-0.0587**	(0.018)	-0.0529**	(0.038)	-0.0527**	(0.041)	-0.0447*	(0.098)
Army size sq.	0.000468	(0.107)	0.000510*	(0.081)	0.000528*	(0.074)	0.000416	(0.184)	0.000409	(0.195)	0.000347	(0.290)
Log of battle death per year	-0.180**	(0.025)	-0.169**	(0.041)	-0.172**	(0.040)	-0.155*	(0.069)	-0.150*	(0.082)	-0.198**	(0.028)
Number of border	-0.0894	(0.138)	-0.0949	(0.120)	-0.0982	(0.111)	-0.114*	(0.073)	-0.0982	(0.129)	-0.0465	(0.525)
Gini index	-0.00963	(0.509)	-0.00796	(0.595)	-0.0105	(0.494)	-0.00997	(0.527)	-0.0118	(0.467)	-0.0114	(0.513)
Ethnic fractionalization			-0.0865	(0.969)	-0.130	(0.954)	1.133	(0.651)	0.850	(0.734)	-0.105	(0.967)
Ethnic fractionalization sq.			0.501	(0.826)	0.623	(0.787)	-0.634	(0.806)	-0.342	(0.894)	0.414	(0.874)
Religious fractionalization					-1.096	(0.848)	-1.867	(0.760)	-1.979	(0.747)	-3.655	(0.562)
Religious fractionalization sq.					0.238	(0.977)	1.078	(0.903)	1.305	(0.883)	5.264	(0.572)
Mountain							-0.00707	(0.228)	-0.00650	(0.269)	-0.00653	(0.275)
Forests							-0.00420	(0.487)	-0.00363	(0.554)	-0.00497	(0.455)
External intervention									-0.156	(0.625)	-0.166	(0.614)
Ethnic war											-0.324	(0.290)
Polity2											-0.00387	(0.874)
Constant	4.717***	(0.002)	4.442***	(0.006)	5.089**	(0.016)	5.280**	(0.017)	5.443**	(0.014)	6.038***	(0.009)
Log(p)	0.252***	(0.003)	0.256***	(0.003)	0.256***	(0.003)	0.261***	(0.002)	0.260***	(0.002)	0.296***	(0.001)
N	857		857		857		857		850		838	
Log likelihood	-121.7		-121.4		-121.2		-120.4		-120.4		-113.9	
AIC	273.4		276.8		280.4		282.8		284.7		275.8	

p values in parentheses: *p<.10, **p<.05, ***p<.01.

Table 3.5: Robustness Check: Alternative Definitions of Resource Abundance

Variable	(1)	(2)	(3)	(4)	(5)
Sanction	0.679***	0.708***	0.597***	0.557**	0.618***
	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)
Log of population	-0.303***	-0.433***	-0.345***	-0.309***	-0.296**
	(0.01)	(0.00)	(0.00)	(0.01)	(0.02)
Log of GDP per capita	-0.425***	-0.399***	-0.382***	-0.326***	-0.390***
	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)
Male secondary school enrolment	0.016***	0.017***	0.017***	0.017***	0.022***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Diamond production per capita	3.052***	2.822***	2.877***	2.483***	1.968**
	(0.00)	(0.00)	(0.00)	(0.01)	(0.04)
Contraband	-1.376***	-1.331***	-1.219***	-1.315***	-1.556***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Son of civil war	-1.655***	-1.158***	-1.409***	-1.399***	-1.372***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Army size	-0.054**	-0.056**	-0.047*	-0.055**	-0.053**
	(0.03)	(0.03)	(0.05)	(0.02)	(0.03)
Army size sq.	0.000*	0.000	0.000	0.001**	0.001*
	(0.08)	(0.28)	(0.12)	(0.03)	(0.07)
Log of battle death per year	-0.189**	-0.168**	-0.186**	-0.157*	-0.143*
	(0.02)	(0.04)	(0.02)	(0.05)	(0.07)
Number of border	-0.100*	-0.019	-0.036	-0.009	0.006
	(0.10)	(0.80)	(0.55)	(0.87)	(0.92)
Oil rent to GDP	0.042***				
	(0.00)				
Oil production per capita		13.519**			
		(0.02)			
Oil exporter			0.872***		
			(0.01)		
Mineral exporter				0.688**	
				(0.02)	
Primary exports to GDP ratio					3.450***
					(0.00)
Constant	4.582***	5.077***	4.414***	3.539**	3.251**
	(0.00)	(0.00)	(0.00)	(0.01)	(0.03)
Log (p)	0.232***	0.245***	0.212**	0.193**	0.195**
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
N	927	863	927	927	912
LL	-130.0	-123.0	-135.8	-136.6	-131.3
AIC	288.0	274.0	299.6	301.2	290.6

p values in parentheses: *p<.10, **p<.05, ***p<.01

Table 3.6: Different Parametric Models and Logit Model

Variable	Wei-bull	Exponential	Gompertz	Cox proportional	Logit
Sanction	0.679***	0.652***	0.666***	0.620***	0.732***
	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)
Log of population	-0.303***	-0.225**	-0.283**	-0.244**	-0.221*
	(0.01)	(0.04)	(0.02)	(0.04)	(0.07)
Log of GDP per capita	-0.425***	-0.360***	-0.410***	-0.376***	-0.413***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Male secondary school enrolment	0.016***	0.014***	0.015***	0.013**	0.015**
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
Oil rent to GDP	0.042***	0.037***	0.040***	0.036***	0.047***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Diamond production per capita	3.052***	2.750***	2.919***	2.865***	3.201***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
Contraband	-1.376***	-1.233***	-1.362***	-1.295***	-1.237***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Son of civil war	-1.655***	-1.413***	-1.624***	-1.389***	-1.418***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Army size	-0.054**	-0.044*	-0.051**	-0.044*	-0.048*
	(0.03)	(0.06)	(0.03)	(0.06)	(0.06)
Army size sq.	0.000*	0.000	0.000*	0.000	0.000
	(0.08)	(0.12)	(0.09)	(0.15)	(0.12)
Log of battle death per year	-0.189**	-0.135*	-0.159**	-0.128*	-0.123
	(0.02)	(0.06)	(0.04)	(0.09)	(0.13)
Number of border	-0.100*	-0.101*	-0.096	-0.097	-0.123*
	(0.10)	(0.09)	(0.11)	(0.11)	(0.06)
Constant	4.582***	3.589**	4.484***		4.047***
	(0.00)	(0.01)	(0.00)		(0.01)
Log (p)	0.232***				
	(0.01)				
Gamma			0.027		
			(0.10)		
N	927	927	927	927	934
LL	-130.0	-133.5	-132.2	-332.3	-267.8
AIC	288.0	293.0	292.5	688.5	561.5

p values in parentheses: *p<.10, **p<.05, ***p<.01

Table 3.7: Endogeneity of Sanctions

Variable	(1)		(2)		(3)		(4)		(5)		(6)		(7)	
					Sanction		Sanction							
Sanction	0.687***	(0.003)	0.679***	(0.003)					1.361**	(0.037)	1.295**	(0.050)	0.730***	(0.002)
Log of population	-0.307***	(0.009)	-0.303***	(0.010)	0.381***	(0.000)	0.502***	(0.000)	-0.385***	(0.003)	-0.383***	(0.003)	-0.358***	(0.005)
Log of GDP per capita	-0.424***	(0.001)	-0.425***	(0.001)										
Log of initial GDP per capita					0.538***	(0.000)	0.478***	(0.000)	-0.443***	(0.004)	-0.440***	(0.005)	-0.407***	(0.007)
Male secondary school enrolment	0.0159***	(0.003)	0.0160***	(0.002)	-0.0207***	(0.000)	-0.0194***	(0.000)	0.0165***	(0.006)	0.0164***	(0.006)	0.0157***	(0.009)
Oil rent to GDP	0.0425***	(0.000)	0.0423***	(0.000)	-0.0376***	(0.000)	-0.0346***	(0.000)	0.0417***	(0.000)	0.0414***	(0.000)	0.0394***	(0.000)
Diamond production per capita	3.073***	(0.001)	3.052***	(0.002)	2.974**	(0.025)	2.556*	(0.052)	1.980	(0.123)	2.104*	(0.096)	2.389*	(0.050)
Contraband	-1.381***	(0.000)	-1.376***	(0.000)	0.810***	(0.000)	0.923***	(0.000)	-1.569***	(0.000)	-1.561***	(0.000)	-1.446***	(0.000)
Son of civil war	-1.673***	(0.000)	-1.655***	(0.000)	0.407*	(0.081)	0.325	(0.166)	-1.740***	(0.000)	-1.731***	(0.000)	-1.689***	(0.000)
Army size	-0.0539**	(0.025)	-0.0539**	(0.025)	0.119***	(0.000)	0.130***	(0.000)	-0.0598**	(0.024)	-0.0597**	(0.027)	-0.0509**	(0.045)
Army size sq.	0.000494*	(0.082)	0.000494*	(0.083)	-0.00126***	(0.000)	-0.00136***	(0.000)	0.000522	(0.107)	0.000518	(0.114)	0.000419	(0.177)
Log of battle death per year	-0.191**	(0.015)	-0.189**	(0.017)	0.351***	(0.000)	0.329***	(0.000)	-0.210**	(0.021)	-0.204**	(0.025)	-0.176**	(0.039)
Number of border	-0.103*	(0.091)	-0.100*	(0.096)	0.156***	(0.000)	0.144***	(0.001)	-0.0820	(0.215)	-0.0806	(0.223)	-0.0691	(0.292)
Non-imposed sanction threat	0.404	(0.701)												
Ethnic fractionalization					2.490	(0.136)	2.603	(0.120)	-0.598	(0.789)	-0.470	(0.833)	-0.391	(0.861)
Ethnic fractionalization sq.					-2.675	(0.107)	-2.865*	(0.084)	0.841	(0.714)	0.707	(0.758)	0.636	(0.782)
Mountain					0.394**	(0.033)	0.405**	(0.030)	-0.306	(0.234)	-0.284	(0.265)	-0.260	(0.304)
Ethnic war					-0.00547	(0.167)	-0.00773*	(0.056)	-0.00622	(0.232)	-0.00613	(0.239)	-0.00632	(0.224)
Polity2					-0.0535***	(0.001)	-0.0477***	(0.003)	0.0143	(0.545)	0.0140	(0.555)	0.0108	(0.644)
Post-cold war					1.669***	(0.000)	1.577***	(0.000)						
Non-member of SC							0.687***	(0.001)						
Residual 1									-0.287	(0.307)				
Residual 2											-0.262	(0.364)		
Constant	4.634***	(0.002)	4.582***	(0.002)	-13.21***	(0.000)	-14.31***	(0.000)	5.764***	(0.002)	5.658***	(0.002)	5.001***	(0.003)
Log (p)	0.233***	(0.005)	0.232***	(0.006)					0.233***	(0.006)	0.235***	(0.005)	0.242***	(0.004)
Log (θ)			-14.29	(0.980)										
N	927		927		922		922		915		915		915	
LL	-129.9		-130.0		-505.6		-500.3		-123.5		-123.7		-124.1	
AIC	289.9		290.0		1047.2		1038.5		287.1		287.3		286.2	

p values in parentheses: *p<.10, **p<.05, ***p<.01. Likelihood-ratio test of theta=0: chibar2(01) = 0.00 Prob.>=chibar2 = 1.000

Table 3.8: Effects of Different Types of Sanctions on Civil War Duration

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Total economic embargo	0.834**	0.568	0.381	0.536	0.701	0.647	0.921*	0.968**
	(0.03)	(0.15)	(0.37)	(0.22)	(0.12)	(0.15)	(0.05)	(0.04)
Aid suspension	0.188	0.075	0.264	0.230	0.104	0.179	0.362	0.318
	(0.55)	(0.81)	(0.42)	(0.48)	(0.75)	(0.60)	(0.29)	(0.36)
Trade sanction	-0.074	0.003	0.026	0.560	0.500	0.506	0.362	0.390
	(0.87)	(1.00)	(0.96)	(0.26)	(0.32)	(0.32)	(0.48)	(0.45)
Other sanctions	-0.291	-0.157	-0.005	-0.151	-0.117	-0.100	0.090	0.156
	(0.50)	(0.72)	(0.99)	(0.74)	(0.80)	(0.83)	(0.85)	(0.74)
Arms embargo	0.759***	0.649**	0.474*	0.610**	0.686**	0.638**	0.619**	0.583**
	(0.00)	(0.01)	(0.09)	(0.03)	(0.02)	(0.03)	(0.03)	(0.04)
Log of population		-0.282***	-0.343***	-0.352***	-0.194*	-0.254**	-0.331***	-0.266**
		(0.00)	(0.00)	(0.00)	(0.06)	(0.02)	(0.00)	(0.03)
Log of GDP per capita		0.022	-0.189	-0.318**	-0.349***	-0.317**	-0.402***	-0.416***
		(0.83)	(0.13)	(0.02)	(0.01)	(0.02)	(0.01)	(0.00)
Male secondary school enrolment			0.015***	0.013***	0.011**	0.012**	0.014**	0.013**
			(0.00)	(0.01)	(0.04)	(0.04)	(0.02)	(0.02)
Oil rent to GDP				0.027***	0.028***	0.030***	0.035***	0.042***
				(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Diamond production per capita				2.780***	2.494***	2.217**	2.537***	2.995***
				(0.00)	(0.01)	(0.02)	(0.01)	(0.00)
Contraband				-1.354***	-1.227***	-1.295***	-1.244***	-1.281***
				(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Son of civil war					-1.295***	-1.286***	-1.419***	-1.644***
					(0.00)	(0.00)	(0.00)	(0.00)
Army size						-0.031	-0.042*	-0.047*
						(0.20)	(0.09)	(0.06)
Army size sq.						0.000	0.000	0.000
						(0.38)	(0.20)	(0.17)
Log of battle death per year							-0.209**	-0.200**
							(0.01)	(0.02)
Number of border								-0.085
								(0.17)
Constant	-2.403***	0.050	1.509	2.361**	1.104	1.696	4.363***	4.196***
	(0.00)	(0.96)	(0.15)	(0.04)	(0.34)	(0.18)	(0.01)	(0.01)
Log (p)	-0.082	0.003	-0.002	0.090	0.167**	0.196**	0.255***	0.251***
	(0.29)	(0.97)	(0.98)	(0.26)	(0.04)	(0.02)	(0.00)	(0.00)
N	997	997	930	928	915	915	915	915
LL	-183.8	-176.7	-160.7	-141.9	-132.8	-131.5	-128.4	-127.5
AIC	381.6	371.3	341.4	309.8	293.7	295.1	290.8	290.9

p values in parentheses: *p<.10, **p<.05, ***p<.01.

Table 3.9: Effects of Sanctions: Multi-lateral vs. Unilateral

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Multi-lateral sanctions	0.619**	0.524**	0.407	0.474*	0.555**	0.560**	0.614**	0.618**
	(0.01)	(0.03)	(0.10)	(0.07)	(0.03)	(0.03)	(0.02)	(0.02)
Unilateral sanctions	0.070	0.078	0.176	0.445	0.374	0.485	0.667**	0.616**
	(0.78)	(0.77)	(0.52)	(0.12)	(0.19)	(0.11)	(0.03)	(0.05)
Log of population		-0.316***	-0.377***	-0.394***	-0.247**	-0.310***	-0.388***	-0.314***
		(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.01)
Log of GDP per capita		0.035	-0.200*	-0.350***	-0.386***	-0.353***	-0.434***	-0.439***
		(0.71)	(0.08)	(0.01)	(0.00)	(0.01)	(0.00)	(0.00)
Male secondary school enrolment			0.016***	0.016***	0.015***	0.015***	0.017***	0.016***
			(0.00)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)
Oil rent to GDP				0.027***	0.028***	0.030***	0.035***	0.042***
				(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Diamond production per capita				2.831***	2.472***	2.181**	2.500***	3.026***
				(0.00)	(0.01)	(0.02)	(0.01)	(0.00)
Contraband				-1.326***	-1.199***	-1.306***	-1.313***	-1.358***
				(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Son of civil war					-1.294***	-1.283***	-1.387***	-1.620***
					(0.00)	(0.00)	(0.00)	(0.00)
Army size						-0.037	-0.049**	-0.054**
						(0.12)	(0.05)	(0.03)
Army size sq.						0.000	0.000	0.000*
						(0.26)	(0.12)	(0.09)
Log of battle death per year							-0.189**	-0.178**
							(0.02)	(0.02)
Number of border								-0.092
								(0.12)
Constant	-2.282***	0.348	1.918**	2.883***	1.747*	2.401**	4.958***	4.673***
	(0.00)	(0.69)	(0.05)	(0.01)	(0.09)	(0.03)	(0.00)	(0.00)
Log (p)	-0.125	-0.013	-0.015	0.081	0.157*	0.187**	0.234***	0.232***
	(0.10)	(0.87)	(0.85)	(0.29)	(0.05)	(0.02)	(0.01)	(0.01)
N	1013	1013	943	940	927	927	927	927
LL	-192.1	-182.6	-165.0	-146.0	-136.5	-134.8	-132.1	-130.8
AIC	392.2	377.3	344.1	311.9	295.1	295.7	292.1	291.7

p values in parentheses: *p<.10, **p<.05, ***p<.01.

Table 3.10: Effects of Different Types of Sanctions Separately

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Total economic embargo	0.956**						
	(0.04)						
Aid suspension		0.284					
		(0.40)					
Trade sanction			0.296				
			(0.53)				
Other sanctions				0.402			
				(0.34)			
Arms embargo					0.649**		
					(0.02)		
Multilateral sanction						0.478*	
						(0.06)	
Unilateral sanction							0.428
							(0.15)
Log of population	-0.270**	-0.331***	-0.316***	-0.326***	-0.283**	-0.276**	-0.332***
	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)
Log of GDP per capita	-0.423***	-0.387***	-0.387***	-0.387***	-0.319**	-0.374***	-0.437***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
Male secondary school enrolment	0.015***	0.018***	0.016***	0.016***	0.014**	0.014***	0.018***
	(0.01)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)
Oil rent to GDP	0.041***	0.038***	0.039***	0.039***	0.038***	0.041***	0.041***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Diamond production per capita	3.203***	3.074***	2.995***	2.901***	2.952***	2.899***	3.226***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Contraband	-1.121***	-1.158***	-1.168***	-1.170***	-1.286***	-1.259***	-1.218***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Son of civil war	-1.680***	-1.578***	-1.608***	-1.595***	-1.650***	-1.662***	-1.627***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Army size	-0.046*	-0.053**	-0.048**	-0.047*	-0.048*	-0.042*	-0.050**
	(0.06)	(0.04)	(0.05)	(0.06)	(0.05)	(0.08)	(0.04)
Army size sq.	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0.17)	(0.11)	(0.15)	(0.17)	(0.15)	(0.21)	(0.13)
Log of battle death per year	-0.176**	-0.163**	-0.143*	-0.152**	-0.162**	-0.141*	-0.163**
	(0.02)	(0.04)	(0.06)	(0.05)	(0.04)	(0.06)	(0.04)
Number of border	-0.097	-0.086	-0.094	-0.091	-0.084	-0.102*	-0.092
	(0.11)	(0.15)	(0.12)	(0.13)	(0.15)	(0.09)	(0.12)
Constant	4.275***	4.464***	4.273***	4.359***	3.582**	3.769**	4.769***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.02)	(0.01)	(0.00)
Log (p)	0.241***	0.234***	0.226***	0.235***	0.245***	0.228***	0.226***
	(0.00)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)
N	921	921	921	915	926	927	927
LL	-130.7	-132.3	-132.4	-132.0	-130.2	-132.7	-133.4
AIC	289.5	292.6	292.8	292.1	288.5	293.4	294.7

p values in parentheses: *p<.10, **p<.05, ***p<.01.

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