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Resource Curse in Reverse: How Civil Wars Influence Natural Resource Production

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Conflict scholars have argued that natural resources, such as oil, diamonds, and gemstones, may increase the chances for civil wars because rebels can sustain their organizations by looting resources and because certain types of resources, such as oil, create weaker state governments that are less capable of putting down insurgencies. Natural resources like oil also raise the value of capturing the state through war. However, empirical studies typically treat natural resources as exogenous variables, failing to consider the possibility that war alters the production levels of various natural resources. This endogenous relationship may help to explain the inconsistent empirical results linking natural resources and civil war onset. This article examines the two-way relationship between natural resources and civil war, focusing on oil, diamonds, and fisheries. The empirical findings suggest that most of the relationships run in the direction from war to resources, with no significant effects of resources on the onset of civil war. States with civil wars experience lower oil and diamond production, while marine fisheries production recovers in civil war–torn states.

KEYWORDS *civil war, diamonds, fisheries, oil, resource curse*

Empirical studies have identified many relationships between natural resources and conflict (Gleditsch 1998). Interstate conflict is more likely

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between states that share river borders, especially where freshwater is scarce (Brochmann and Hensel 2009; Gleditsch, Furlong, Hegre, Lacina, and Owen 2006; Lonergan 1997). Conflicts also erupt between states competing for scarce fishery resources, as illustrated by the Cod Wars between Iceland and Great Britain (Bailey 1996; Hensel, Mitchell, Sowers, and Thyne 2008). The scarcity of environmental resources has been positively linked to interstate conflict, including fresh water, fisheries, soil degradation, and population density and growth (Stalley 2003; Tir and Diehl 1998). In the civil war literature, oil resources have been shown to increase the chances for domestic conflict (Fearon and Laitin 2003), while lootable resources, such as alluvial diamonds increase the onset (Lujala, Gleditsch, and Gilmore 2005) and duration (Buhaug, Gates, and Lujala 2009; Ross 2004) of civil wars. Environmental degradation, such as deforestation, land degradation, and scarcity of freshwater supply, may also increase the risk for civil war (Theisen 2008). Gemstones have been linked to civil wars in Afghanistan, Cambodia, and Myanmar; several oil-producing states have experienced civil wars, including Angola, Colombia, Morocco, and Sudan; diamond-producing countries, such as the Democratic Republic of Congo, Sierra Leone, and Liberia, have also experienced intrastate wars (Ross 2003). In short, there are many examples of countries with sizable natural resources experiencing civil war.

However, most of this research treats natural resources as exogenous, independent variables to help explain the variance in conflict onset, duration, or intensity. We highlight the reverse relationship by examining the effect of intrastate conflict on natural resource production, with specific focus on the production of oil, diamonds, and marine fish. Once we control for the endogenous relationship between natural resources and civil conflict, we find that these resources have little effect on civil war onset, consistent with Ross's (2004) case study analyses. On the other hand, civil wars have differential effects on natural resources, significantly reducing oil and diamond production, while at the same time significantly increasing marine fish production.

This article is part of a broader project that seeks to understand how natural resources, economic growth/income, environmental degradation, state strength, and civil war are interrelated (see Figure 1). A focus on the endogenous relationship between conflict and natural resources will give us better purchase for integrating the greed (Collier and Hoeffler 2004) and state strength (Fearon and Laitin 2003) explanations for civil war onset. Natural resource dependency tends to reduce economic growth, in what economists have termed the "resource curse" (Auty 1993).[1] Reduced economic growth also puts states at much greater risk for civil war (Collier and Hoeffler 2004). Increased economic growth has an inverted U relationship with environmental degradation, a process known as the "Kuznets curve" (Gleditsch et al. 2006). As environmental degradation increases, this process may also

[1]For a more skeptical view of the resource curse, see Haber and Menaldo (2011).

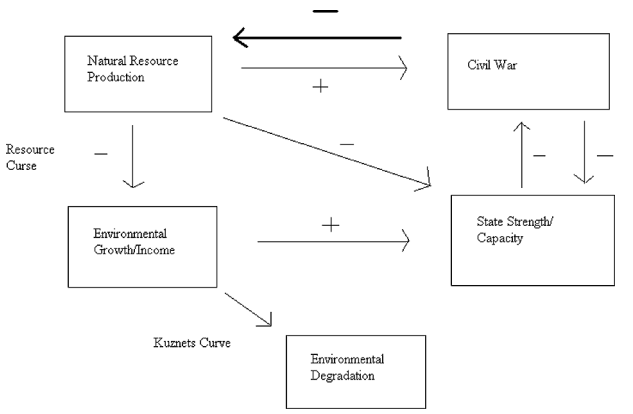

FIGURE 1 Literature Overview.

increase the risk for civil war onset. Certain resources, such as oil production, may also weaken the strength of the state (Fearon and Laitin 2003; Thies 2010), which reduces the government's ability to combat insurgencies (although see Fjelde 2009). Natural resource dependency also prohibits the development of institutions needed to overcome the resource curse, such as the rule of law, property rights, and democracy. The civil war literature also points to the instabilities caused by incoherent political regimes (Hegre, Ellingsen, Gates, and Gleditsch 2001). In short, natural resources have important effects on economic productivity, state strength, and the development of democratic institutions. Learning more about the "resource curse in reverse" will help us devise better policies for states seeking to prosper peacefully.

LITERATURE REVIEW

The seminal civil war studies by Collier and Hoeffler (2004) and Fearon and Laitin (2003) establish two general lines of thinking about how natural resources influence the behavior of rebel groups and governments. The first is the idea that lootable natural resources reduce the opportunity costs for rebellion. The second is that resource dependency reduces the strength of the state by limiting its dependence on citizens for revenue, which in turn reduces its ability to put down insurgencies. The state's extraction of oil also raises the value of center-seeking civil wars whose goal is the capture of the state or the value of peripheral areas for secessionists. Natural resources have also been linked to civil war onset more indirectly through reduced economic growth, increased poverty, reduced education, and the creation of more corrupt, authoritarian regimes.[2]

[2]For reviews of this literature, see Ross (2003a, 2003b, 2004). Our article focuses on the two primary explanations related to lootability and state strength, but we hope to expand this in future work. For a

Collier and Hoeffler (2004) emphasize the opportunity costs for rebellion, focusing on productive economic activities individuals forego in order to join a rebel group. Their primary finding is that states with higher average income levels experience significantly reduced risk for civil wars. They also consider how natural resource dependency, measured by primary commodity exports/GDP, alters the opportunity costs for rebellion. They include this measure and a squared term in their models, finding an inverted U relationship between primary commodity exports and civil war onset. "At peak danger (primary commodity exports being 33% of GDP), the risk of civil war is about 22%, while a country with no such exports has a risk of only 1%" (Collier and Hoeffler 2004:580).[3] They also disaggregate resources into specific types (food, nonfood agriculture, oil, etc.) and find that the only significant difference in civil war risk occurs between oil and non-oil producing states.

The emphasis on oil is further articulated in Fearon and Laitin's (2003) study of civil war onset. They emphasize the importance of state strength, which influences the government's ability to handle insurgencies. Fearon and Laitin (2003:81) also find that wealthier states have significantly lower risks for civil war. Theoretically, they argue that:

> The political and military technology of insurgency will be favored . . . when potential rebels . . . have . . . land that supports the production of high value, low-weight goods such as coca, opium, diamonds, and other contraband, which can be used to finance an insurgency [and] a state whose revenues derive primarily from oil exports. Oil producers tend to have weaker state apparatuses than one would expect given their level of income because the rulers have less need for a socially intrusive and elaborate bureaucratic system to raise revenues . . . At the same time, oil revenues raise the value of the "prize" of controlling state power.

The correlation between oil production and weak states is documented in research on the "Dutch" disease (Ebrahim-Zadeh 2003; Karl 1997). In the 1970s, the discovery of oil in the North Sea provided a new source of income for the Netherlands. However, as the Dutch state began extracting oil, their manufacturing sector declined dramatically. Economists attribute this decline to an appreciation of Dutch currency following increased oil exports, which increased incentives for labor and capital to move from manufacturing into oil production (Corden and Neary 1982).

More broadly, oil dependency is thought to create a variety of problems for states. Oil producers often borrow in bad economic times, leading

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more detailed discussion of possible causal mechanisms relating resources and civil war, see Humphreys (2005).

[3]de Soysa (2002) also finds evidence for a curvilinear relationship between natural resources and civil conflict including timber, pasture, and agricultural assets.

to debt problems. These recessionary cycles exist largely due to inherent price instabilities of natural resources on the world market. There is also considerable variability in extraction rates and the timing of payments from multinational corporations (Humphreys, Sachs, and Stiglitz 2007:6). The reduction in manufacturing leads to less funding for education because there is a reduced demand for skilled workers[4]; this lack of education can further increase the risk for civil war (Lai and Thyne 2007). As noted above, weaker states will have a harder time dealing with internal threats to the regime because they lack the administrative structures for combating rebels. Oil states typically have less democratic regimes than non-oil states (Ross 2001) and they are more likely to experience state failure (Chauvet and Collier 2008).

Natural resources can also raise the overall prize of capturing the state or parts of the state through secessionism (Fearon and Laitin 2003). In this regard, natural resources create a "honey pot" that increases the desirability of ruling a state (de Soysa 2002). For example, both of Sudan's civil wars were fueled by the location of oil resources in the southern region of the country. The discovery of natural gas in 1971 and the subsequent political, economic, and demographic changes served as a catalyst for the Aceh rebellion in Indonesia (Aspinall 2007; Ross 2003b). The importance of offshore oil to the Congo-Brazzaville government raised the value of capturing the state, encouraging the rebels to seize the capital city and key port of Pointe Noire during the 1997 civil war (Addison, Le Billon, and Murshed 2003). The RUF in Sierra Leone funded its operations through the capture of alluvial diamond mining areas. Illegal cash crops, such as cocaine and opium, have also funded rebel movements in places like Colombia and Afghanistan (Collier, Elliott, Hegre, Hoeffler, Reynal-Querol, and Sambanis 2003).

However, not all primary commodities will increase the value of capturing the state. As Fearon (2005) notes, the broader measure of primary commodities (*sxp*) advocated by Collier and Hoeffler (2004) is not likely to be much of a prize, since rebels typically lack the distribution system necessary to reap revenues from those resources. In this sense, resources that are lootable by ease of extraction, transport, and sale should increase the chances for civil war more than other resources like agricultural products. On the other hand, some studies that disaggregate measures of primary commodity exports question the robustness of the lootability connection to civil war, as most individual resources (for example, oil, mineral rents, energy rents) do not have a significant effect on civil war onset (De Soysa and Neumayer 2007; Theisen 2008). Using geo-coded data on resources and civil conflict, Lujala (2009, 2010) finds that the presence of resources (gemstones,

[4]Oil, gas, and minerals are nonrenewable resources, which makes them more like assets rather than sources of income. They are extracted rather than produced, which separates them from most of the labor force and the manufacturing market in the economy (Humphreys, Sachs, and Stiglitz 2007:4).

drugs, and hydrocarbons) in a conflict zone significantly increases the number of battle deaths in the area and the duration of the civil conflict. She also finds (2010) that countries with secondary diamond and oil production face higher risks for civil war onset.

Thies (2010) examined the role that natural resources play in the relationship between state capacity and civil war onset. While much of the literature has focused on the opportunities that natural resources provide to rebels, he also highlights their importance as a source of state revenue. He argues that revenues from primary commodities will primarily benefit the state even as internal rivals seek to obtain them for rebellion. While Thies does not find evidence that states with higher fiscal capacity deter civil war onsets, he does find evidence that most types of natural resource revenue strengthen state capacity. Most types of natural resources do not significantly increase the risk of civil war onset, with the exception of the Fearon and Laitin (2003) oil exporter dummy. These findings further support the conclusions of Smith (2004) and Morrison (2009) that oil and nontax revenues may not necessarily be detrimental to state capacity and may even strengthen it. Even among the set of oil producing states, those that are more corrupt may be better equipped to buy off rivals and the military (Fjelde 2009).

The debate about the instability of oil regimes points to a broader issue. There are many countries with significant natural resource exports that are able to avoid civil wars. Even though Botswana had a similar GDP per capita to Sierra Leone in the early 1960s and sizable diamond production, it was able to utilize that production positively to create economic growth and increase its mean income per capita. This difference may be attributable to the fact that most of Botswana's diamonds are from kimberlite mines, which are easier for the government to control, in comparison to the alluvial diamonds in Sierra Leone found in riverbeds (Collier et al. 2003:127). This example shows that conflict risk may be based on characteristics of the natural resources, such as the government's ability to control them and whether they are located in a few or many sites. Whether natural resources fuel civil conflict may also depend on their interaction with other factors that increase a state's risk for conflict. As noted above, Fjelde's (2009) study suggests that corrupt oil producing states can avoid civil war while non-corrupt oil producers face a higher risk for war. In this instance, natural resources increase civil war risk only when triggered by some other factor.

THE EFFECT OF CIVIL WARS ON NATURAL RESOURCES

Our general expectation is that civil war harms the production of natural resources. War can influence the production of natural resources through several mechanisms. As stated by Maxwell and Reuveny (2000:302): "First, it may divert labor away from normal economic activities into conflict

activities. Second, it may increase the death rate. Third, it may reduce the resource growth rate." Destruction of the environment may be a strategy employed by combatants, either directly by the targeting of resources that the opponent uses to fund its war efforts, or indirectly through the degradation and pollution of areas that troops occupy. Certain resources may be extracted at higher rates to fund wartime activities, such as higher rates of deforestation or extraction of coal. Refugees may also put stress on the environment by degrading the areas around their camps, as the cases of Afghanistan, Malawi, and Sudan illustrate (Reuveny, Mihalache-O'Keef, and Li 2010:750).

Wars also divert citizens from regular economic activities, which could increase or decrease natural resource production depending on the nature of the conflict.[5] For example, fishery stocks might rebound if fishermen are diverted from fishing activities into war-fighting activities, something that occurred in the Atlantic during World War II (Reuveny et al. 2010). On the other hand, pollution of sea areas could harm fish stocks, something that happened after the Persian Gulf War. In an analysis of armed conflicts from 1961–1997, Reuveny et al. (2010) illustrate these differential effects of conflict on resources. They find that conflict has harmful effects on timber (increasing deforestation rates) and increases overall stress on the environment in terms of extraction of resources like coal, fertilizers, and industrial pollutants. On the other hand, armed conflict reduces the production of CO_2 and NO_X emissions, especially if the fighting takes place on home territory. Their results demonstrate, however, the endogenous relationship between armed conflict and natural resources.

Kelly (1991–1992:922–923) provides historical examples of environmental destruction caused by war including the poisoning of wells and destruction of farmland in the Punic Wars of the third century B.C.; destruction of dikes by the Dutch in the Franco-Dutch war of 1672–1678; destruction of dams during the Sino-Japanese war of 1937–1945; in the Ruhr Valley in Germany in world war; and in the Vietnam war; as well as the use of "herbicides and defoliants to clear the jungle and reduce food supplies" in Vietnam. During the Persian Gulf War in 1991, Iraq created an environmental disaster by setting fire to over 600 oil wells and refineries in Kuwait. There were also oil spills on the order of three million barrels in the Persian Gulf, which killed thousands of marine animal species (Kelly 1991–1992:926). Some wildlife species are targeted in wars, such as American bombing of elephants in the Vietnam War to prevent their use for transportation of military supplies (Dudley, Ginsberg, Plumptre, Hart, and Campos 2002). The use of war machinery, such as heavy tanks, ammunition, and mines, also

[5]This fits into a larger pattern of behavior whereby civil wars have destructive short-term effects on economic growth (Collier 1999).

damages the soil, leading to erosion, compaction, loss of forage and shrubs, habitat destruction, and loss of insect fauna (Brauer 2000:4).

Many recent cases illustrate the devastating effects civil wars can have on natural resources and wildlife populations. A decade of civil war in Uganda significantly reduced elephant populations and degraded wildlife reserves. The conflict in Bosnia-Herzegovina led to massive deforestation. Forest areas of the Republic of Congo were burned to displace rebel forces (Dudley et al. 2002:321). Rebel groups often target oil and gas facilities, which can reduce the state's oil production capacity, as the recent cases of Sudan and Colombia illustrate. Civil war battles can also intrude on economic activities, such as fishing, as laborers flee violent areas or become recruited to join rebel or government forces (for example, Sri Lanka and Lebanon).

Just as the effect of natural resources on civil war is likely to depend on the characteristics of the resources and the context within which they are produced, the reverse relationship is also likely to be conditioned by these same factors. Ross (2003a:54) points to three critical features of resources: (1) lootability: "the ease with which [a resource] . . . can be extracted and transported by individuals or small teams of unskilled workers, (2) obstructability: whether "transportation can be easily blocked by a small number of individuals with a few weapons"; and (3) whether the good is legally traded. The manner in which goods are produced is likely to matter as well, as explained by Le Billon (2001:568): "The nature of violence may change whether resources involve production or extraction. With extracted resources (for example, minerals), violence is most likely to take a physical form to achieve territorial or state control, as was the case of Congo Brazzaville over oil rents in 1997. With produced resources (for example, crops), violence usually takes a more structural form, such as coercive forms of labour or controls over trade."

The importance of lootability has been examined in detail in the work relating diamonds to civil war onset. Lujala et al. (2005) argue that secondary or alluvial diamonds are more likely to be associated with the onset of civil wars due to the ease with which rebels can access and extract these resources. Secondary diamonds are also more likely to be located farther from the center, which makes government control more difficult. They find that secondary diamonds increase the risk for civil war onset, especially in the post–Cold War era. Humphreys (2005) also finds that diamond production per capita is positively and significantly related to civil war onset.

Location from center clearly matters, with proximate resources being easier for governments to control than distant ones (Le Billon 2001:570). Resources close to the capital are less likely to be captured by rebels than those located in peripheral regions, as the cases of Aceh, Sierra Leone, and Sudan illustrate. Point resources like kimberlite diamond mines, oil wells, and gemstone mines are easier for the state to control, while diffuse

resources like alluvial diamonds, agriculture, timber, and fisheries are more difficult to control and monitor. Le Billon (2001) argues that point/proximate resources are most likely to be associated with center-seeking civil wars, while point/distance resources will be associated with secessionist wars. Warlords are likely to operate in countries where there are diffuse resources that are distant from the capital, in such countries as Afghanistan (opium), Angola (diamonds), Burma (opium, timber), Cambodia (gems, timber), Colombia (cocaine), Peru (cocaine), and the Philippines (marijuana, timber) (Le Billon 2001:573). Civil wars could wreak havoc on point or diffuse resources, but their effects should be more pronounced for diffuse resources, such as marine fisheries production. However, point resources could be at risk for destruction in the context of civil wars, especially if they are located far away from the capital.

The effect of civil war on natural resource production may also vary depending on whether the resources are renewable or not. Homer-Dixon (1994:8) explains: "Resources can be roughly divided into two groups: nonrenewables, like oil and iron ore, and renewables, like fresh water, forests, fertile soils, and the earth's ozone layer. The latter category includes renewable 'goods' such as fisheries and timber, and renewable 'services' such as regional hydrological cycles and a benign climate." In this article, we examine the effect of civil war on two nonrenewable resources, oil and diamonds, and one renewable resource, fisheries. Homer-Dixon (1994) asserts that states will fight more often over nonrenewable resources because they can be converted into state power more easily. If nonrenewable resources trigger civil wars frequently, the reverse causal relationship might be one whereby the production of resources like oil and diamonds is harmed more acutely than the production of renewable resources like timber or fisheries. However, we believe this effect will depend on the location of the resource and the ease of lootability. As seen in Angola and Sierra Leone, secondary diamond production could increase in war zones due to the diffuse nature of the resource and the ease with each these resources can be looted and transported. While oil resources could also be looted, as the case of Nigeria suggests (Lujala 2010), production facilities are typically more centralized and controlled by the state. This increases the incentives for rebel groups to target oil facilities as a wartime strategy to reduce oil revenues available to the state.

Diffuse resources such as agriculture, timber, and fisheries may also suffer disproportionately in civil war environments because these resources are fairly labor-intensive. As farmers and fishermen are drafted or recruited into the fighting efforts, they will have less time to devote to productive economic activities. For example, there was a decline in fishing catches in the North Atlantic during World War I, a loss of 25% marine fish catches during the Sri Lankan civil war, and a 50% reduction in marine fish catches during the Lebanese civil war (Hendrix and Glaser 2011). Beyond the redeployment

of labor, diffuse natural resources like fisheries may also suffer declining production in civil war due to the displacement of the local population fleeing war zones (Hendrix and Glaser, 2011). The perils of civil war make it more difficult for citizens to engage in normal economic activities, reducing the overall production and extraction of natural resources.

In sum, we expect states experiencing civil wars to experience lower levels of natural resources production. However, the effects of war may vary depending on the characteristics and location of the resources. We expect oil production to decline during civil wars because these facilities are typically controlled by the state, which increases incentives for rebels to target them to weaken the state's strength. Oil companies are also likely to withdraw investments in areas with high risks for their employees; Chevron reduced its operations in Sudan in the 1980s in light of increased civil violence. We have mixed expectations for fisheries during a civil war. If fighting occurs in fishing villages, which leads to population displacement, fishermen may choose to divert their regular economic activity into war fighting. This could lead to an improvement in fisheries stocks, but a decline in the production of extracted fisheries. Alternatively, fisheries production may also increase as agricultural crops on land are destroyed during the conflict, leading the population to seek alternative food sources. The effect of civil war on diamonds is also mixed. On one hand, civil war might prompt increases in production, especially for countries with large supplies of secondary, diffuse diamonds. As seen in Sierra Leone, these can be used to fund rebel group activities and the ease of extraction may increase diamond companies' willingness to remain in these areas. On the other hand, countries with primary, mined diamonds could see a decline in production if violence threatens mining areas.

Modeling Endogeneity

Most empirical studies have focused on the effect of natural resources on civil war onset without considering the potential feedback effect of civil war occurrence on natural resource production. Brunnschweiler and Bulte's (2009) exceptional study looks at the two-way relationship between resource extraction and civil war. Once they control for the two-way relationship, they find that war-torn societies become more natural resource dependent, which increases their civil war risk. Natural resources in peaceful environments are actually boons for economic development. This is similar to discussions of the conflict trap, whereby countries that experience civil wars experience further declines in economic growth, education, health care, and infrastructure, which puts them at additional risk for recurrent conflicts (Collier et al. 2003).

We believe it is important to control for the potential endogeneity in the natural resource-civil war relationship. If two variables are endogenously

related and the relationship is modeled in only one direction, the estimator is not consistent; parameter estimates are not near their true values in large samples (King, Keohane, and Verba 1994). If endogeneity is present, the relationship posited in a single equation analysis is biased because the covariance between the explanatory variable (for example, oil production) and the residuals will be nonzero.

King et al. (1994:188) explain: "If we have endogeneity bias, we are estimating the correct inference plus a bias factor. Endogeneity is a problem because we are generally unaware of the size or direction of the bias. This bias factor will be large or small, negative or positive, depending on the specific empirical example." Thus, if the parameters are biased, we have no way of knowing in what direction. The effects of natural resources on civil war could be greater or smaller than we think. The disconnect between the findings of large-*N* empirical studies and qualitative case studies of resources and civil war could be explained by the failure of many large-N studies to account for endogeneity.

There are suggestive parallels in other areas of conflict studies regarding the importance of modeling endogenous relationships. The literature on trade and conflict shows that investors are forward looking, thus they avoid trading in dangerous areas. In this sense, only unexpected conflicts are likely to have a significant effect on future trade or foreign direct investment (Li and Sacko 2002).[6] Democratic peace scholars have asserted that peace may be the "cart before the horse" (Maoz 1997; Thompson 1996), whereby democratic regimes are more likely to flourish in peaceful regions. At the global level, systemic war may promote democratization in the international system (Mitchell, Gates, and Hegre 1999). Gibler's (2007) work suggests that the resolution of border disputes may be a key part of this process as well, as democratic regimes are more likely to emerge once violent territorial disputes have been settled.

While endogeneity has not been the subject of a great deal of focus in civil war studies, initial examinations have shown why this omission may be problematic. Fearon and Laitin (2003) assert that strong states are able to avoid civil war by having greater capabilities for combating insurgency. Yet, once we consider the endogenous relationship between state capacity and civil war, a different conclusion emerges. Thies (2010) finds that state capacity has no effect on civil war onset. On the other hand, civil wars significantly reduce the strength of the state. A similar debate has emerged in the literature seeking to understand why some oil-producing states are stable while others are at a high risk for civil war. Oil production could be a boon for corrupt states as they could use the revenues to pay off potential threats to the regime (Fjelde 2009). Yet the experience of civil war could reduce oil

[6]For examples, see Kesch, Pollins, and Reuveny (2004); Li and Sacko (2002); Long (2008); Morrow (1999); Morrow, Siverson, and Tabaras (1998); Reuveny (2001); and Reuveny and Kang (1996, 1998).

production, making it harder for regimes to survive. In order to understand these complexities, we think it is important to consider endogeneity in civil war studies.

In our own data, single equation bivariate analyses between civil war onset and measures of natural resources show little in the way of significant relationships.[7] Only the measure of marine fish catch (Hendrix and Glaser 2011) has a significant, negative effect on civil war onset in a simple probit analysis. Humphreys' (2005) measures of oil production and diamond production have nonsignificant effects on civil war onset. The signs on all of these parameters are negative. Turning the table, single equation bivariate analyses reveal that onset also fails to exert any statistically significant effect on any of the aforementioned measures of natural resources. The signs are positive on oil production and marine fish catch, and negative on diamond production. All of these results are quite surprising given the statistical literature's findings on the relationship between natural resources and civil war onset.[8] A straightforward Durbin-Wu-Hausman test reveals endogeneity in each of these simple models (Davidson and McKinnon 1993). This test is conducted by including the residuals of each suspected endogenous variable in a regression of the original model, then testing for the significance of those residuals. In all of these cases, we find that the relationship posited in the single equation analysis is biased because the covariance between the explanatory variable and the residuals is nonzero. It is therefore difficult to know even in these simple bivariate analyses if we have identified the correct direction and significance of the variables. We turn now to a description of the research design we use to deal with the presence of endogeneity.

RESEARCH DESIGN

Since we know that OLS produces biased and inefficient results in the presence of endogeneity, we turn to other methods to properly identify the relationships of interest in this paper. Instrumental variables (IV) techniques have been developed to allow researchers to either find or create a variable that is highly correlated with the endogenous variable, yet uncorrelated with the error term. Finding an instrument that meets these conditions is quite difficult and always subject to controversy. We pursue the option of creating an instrument through the use of a two-stage least squares estimation technique. This technique separates the endogenous variable into a part that is

[7]The analyses of civil war onset were conducted with probit and those for the measures of natural resources were conducted with OLS.

[8]Most studies fail to report the bivariate relationship between their natural resource variable of interest and civil war onset. For example, Humphreys' (2005) article reports the effects of oil and diamond production only in the context of a replication of the Fearon and Laitin (2003) multivariate model. Fearon's (2005) analyses of *sxp* are similarly conducted within multivariate models.

correlated with the error term and a part that is not. The latter is then used as the instrument to estimate the model. We produce instruments for civil war onset and each of the measures of natural resources in our attempt to model rather than ignore the endogeneity present in these relationships.

The technique we use to analyze this system of equations was originally developed by Maddala (1983) and more practically implemented by Keshk (2003). This method is designed for simultaneous equation models where one of the endogenous variables is continuous (natural resources) and the other is dichotomous (civil war onset). This two-stage estimation technique creates instruments for the endogenous variables in the first stage and then substitutes them for their endogenous counterparts in the structural equations to complete the analysis in the second stage.[9] This technique has previously been applied to studies of trade and conflict (Keshk, Pollins, and Reuveny 2004), democracy and conflict (Reuveny and Li 2003), and state capacity and civil war onset (Thies 2010). There are 157 countries included in the data set with a maximum number of 5269 observations during the years 1960–1999.[10]

The Civil War Equation

The civil war equation starts with the Fearon and Laitin (2003:76) model, which is often used as a baseline for studies that have offered innovations (Cederman and Girardin 2007; Humphreys 2005; Lujala et al. 2005; Thies 2010; Thyne 2006). The variables used in this equation are identical to their basic model, with one exception. We replace the oil exporter variable with a series of natural resource production measures generated for the second equation (described below).

Civil war onset is coded dichotomously according to whether violent civil conflicts meet the following criteria (Fearon and Laitin 2003:76):

> (1) They involved fighting between agents of (or claimants to) a state and organized nonstate groups who sought either to take control of a government, to take power in a region, or to use violence to change government policies. (2) The conflict killed at least 1,000 over its course, with a yearly average of at least 100. (3) At least 100 were killed on both sides (including civilians attacked by rebels). The last condition is intended to rule out massacres where there is no organized or effective opposition.

[9]In the first stage of the estimation process, the endogenous variables are regressed on all of the exogenous variables to produce predicted values. In the second stage, the predicted values become the instruments to replace the original endogenous variables in order to complete the estimation (Keshk 2003). The continuous variable is estimated with OLS and the dichotomous variable with probit.

[10]This data set is based on Fearon and Laitin (2003) for the post-1960 observations.

Prior war is a dichotomous variable that indicates whether a civil war was ongoing in the previous year. *GDP per capita* is measured in thousands of 1985 U.S. dollars and lagged one year. *Population* is the logged population size, lagged one year. *Mountainous terrain* is measured as the logged share of a state's terrain covered by mountains. *Noncontiguous state* is a dichotomous variable that captures the effect of having territory like islands or enclaves. *New state* is a dichotomous variable marking the first and second years of a state's independence. *Instability* is a dummy variable indicating whether the state had a change of three or greater in the Polity IV regime index in any of the prior three years. *Polity2* is a lagged Polity IV value derived from the polity2 score that varies between −10 (most autocratic) and +10 (most democratic). *Ethnic fractionalization* is represented by the commonly used ELF index, which ranges from 0 (complete ethnic homogeneity) to 100 (complete ethnic heterogeneity) by measuring the probability that two randomly chosen individuals belong to different ethnolinguistic groups. *Religious fractionalization* is an analogous measure that Fearon and Laitin (2003) construct to represent religious diversity.

The models are identified by the exclusion condition (Gujarati 2003). There are seven variables that are unique to the civil war equations, including prior war, polity2, mountainous terrain, noncontiguous state, ethnic and religious fractionalization, and new state. We also employ the technique developed by Beck, Katz, and Tucker (1998) to address the problem of serial correlation with a counter for peace years and three cubic splines to account for the effect of autocorrelation.

Natural Resource Production Equation(s)

We use three different measures of natural resource production. We employ Humphreys' (2005) measure of *oil production* in millions of barrels per capita per day. Oil production is expected to be positively related to civil war onset according to conventional wisdom, though we hypothesize that accounting for endogeneity may negate this effect. Civil war may actually reduce oil production due to the destruction of oil facilities and distributional difficulties during civil war.

We use Humphreys' (2005) measure of *diamond production* in carats per capita, which he demonstrates is positively related to civil war onset in a multivariate replication of Fearon and Laitin (2003). Alluvial diamonds are lootable, thus civil conflict may increase diamond production. Kimberlite-mined diamonds are state controlled, but their value means rebels may force a shutdown. Ideally, we would have a measure of the production of primary and secondary diamonds, but no such data exists. The data we use is biased in favor of primary, mined diamonds since their production, distribution, and sale is more regulated by the state.

Finally, we include a measure of the log of *marine fish catch* in metric tons provided by Hendrix and Glaser (2011), and based on the FAO Fisheries and Aquaculture Statistics Collection Global Production Tables. While Hendrix and Glaser are interested in the effects of civil war on marine fish catch growth, our interest is in the production of marine fish catch as another type of natural resource. Hendrix and Glaser find that civil war onset reduces the growth of marine fish catch, though they do not directly test its effects on the level of production.

We predict variation in these measures of natural resource production using a set of independent variables based on the models found in Reuveny et al. (2010). Reuveny et al. (2010:750–751) draw on the same theoretical literature reviewed in this paper to discuss the effect of war on natural resource production, including specific discussions of oil and fisheries. While their dependent variables include some factors that are not directly related to our interests, such as CO_2 and NO_X emissions, they also look at forests. Forests, much like fisheries, are renewable natural resources. The same types of structural variables that would affect forests are likely to affect fisheries. Given that the variables they use are basic structural features of a state's political economy, we think they should also affect oil and diamond production. The fact that the structural variables are also significant predictors in their models increases our confidence that they offer the best baseline model of natural resource production in the current literature. Following their lead, we include *GDP per capita* and *GDP per capita*^{2} to account for the Economic Kuznets Curve, which posits that natural resource (over)use will increase to a certain threshold when it begins to decline because wealthier people demand a higher quality environment. We include the aforementioned *population* measure, as well as a measure of *population growth* to account for the effect of size and stress of population pressure on natural resource production. *Trade openness* (imports + exports divided by GDP) may also affect natural resource production if countries are producing such goods for export. Finally, we include the *polity2* measure of regime type described above even though regime type's role in environmental processes is debated (Reuveny et al. 2010).[11] The natural resource production equations are identified by the exclusion criterion (Gujarati 2003): the GDP per capita^2, trade openness, and population growth measures are unique to this equation.

[11]We do not include a lagged dependent variable (LDV) in the natural resource models. The correlation between the LDV and contemporaneous measures of natural resources is very high—over .90 for all variables, As both Achen (2000) and Keele and Kelly (2006) note, OLS with a LDV produces biased and inefficient estimates in the presence of such high correlation. Differencing the data to deal with this issue would have the unfortunate effect of eliminating many of the slower moving or time invariant variables (for example, polity2, mountainous terrain, noncontiguous, etc.) and would transform the natural resource measure into a change variable. Since the civil war literature has focused exclusively on the level, rather than changes in production, we prefer to retain our measures of natural resource levels so the findings are consistent with the rest of the literature.

EMPIRICAL ANALYSES

The use of the two-stage estimation technique generates some provocative results. The instrumented variables produced in the first-stage estimation exhibit relatively good fit as indicated by reasonable R^2 values and relatively high correlations with their endogenous counterparts. There is also little difference between the standard errors produced by the Maddala (1983) procedure in the second stage of estimation or if we obtain White (1980)/Newey and West (1987) robust standard errors at the conclusion of the first stage.[12] We present the results from the Maddala (1983) procedure produced in the second stage of the estimation in the tables below.

Oil Production

Table 1 presents the results from the simultaneous equation models of civil war onset and oil production. The top half of Table 1 shows the first part of this model by demonstrating the effect of oil production on civil war onset. We can see that oil production does not significantly affect civil war onset, even though the sign on the variable is positive as much of the literature would expect. This finding replicates the results in Thies (2010). The variables from the original Fearon and Laitin (2003) model perform as expected with prior war and GDP per capita significantly reducing civil war onset, and population, mountainous terrain, new state, and instability increasing the likelihood of civil war onset.

The bottom half of Table 1 demonstrates that civil war onset significantly reduces oil production. Substantively, the onset of a civil war reduces oil production on average by approximately 42,000 barrels per day. With oil often returning $75 to $100 per barrel, this represents a substantial hit to what is already likely to be a resource-dependent economy and government. The EKC is U-shaped, rather than inverted U-shaped, according to the GDP per capita measures in our model. This suggests that lower income societies look to increase oil production, perhaps as a way of industrializing, then richer societies reduce domestic oil production. This result does not fit with the stylized account of the EKC, but the literature is full of inconsistent findings in this regard (Reuveny et al. 2010). States with larger populations produce less oil per capita than smaller countries. Population growth, on the other hand, spurs oil production. Trade openness reduces domestic oil production, perhaps because less expensive international imports substitute for more expensively produced domestic oil. More democratic states are also less likely to produce oil. These results show the importance of controlling

[12]CDSIMEQ does not allow the generation of robust standards errors at the conclusion of the second stage of the estimation procedure. Keshk et al. (2004:1169–1170) similarly find little difference between the two techniques.

TABLE 1 The Simultaneous Effects of Civil War Onset and Oil Production

Variable	Coefficient	Std. Error
Civil War Onset		
Oil Production (barrels/pc)	0.198	0.727
Prior War	−0.380***	0.152
GDP per capita	−0.133***	0.043
Population	0.125***	0.040
Polity2	0.013	0.011
Mountainous Terrain	0.066*	0.039
Noncontiguous	0.206	0.161
Ethnic Fractionalization	0.244	0.201
Religious Fractionalization	−0.039	0.257
New State	0.667**	0.298
Instability	0.313***	0.115
Peace Years	0.022	0.053
Spline 1	0.001	0.001
Spline 2	−0.001	0.001
Spline 3	0.000	0.000
Constant	−3.298***	0.409
First Stage Pseudo-$R^2 = 0.10$		
LR $\chi^2 = 78.07$***		
Oil Production		
Civil War Onset	−0.042***	0.015
GDP per capita	−0.132***	0.014
GDP per capita^2	0.167***	0.012
Trade openness	−0.059***	0.011
Population	−0.018***	0.003
Population growth	4.188***	0.208
Polity2	−0.008***	0.001
Constant	−0.075	0.048
First Stage Adj. $R^2 = 0.63$		
$F = 474.62$***		

$N = 4690$. Two-tailed test, *$p < .10$, **$p < .05$, ***$p < .01$.

for endogeneity, as oil production has no discernable impact on civil war onset once we control for the two-way relationship, whereas civil war onset significantly reduces oil production.

The destruction of oil production in civil war makes sense in light of the historical case studies discussed earlier, such as the Persian Gulf War. Rebels often sabotage oil wells and refineries as part of their war fighting strategy. For example, in August 2001, rebels attacked the facilities at the Heglig oil fields in southern Sudan (Washington Post August 16, 2001). In January 1991, members of the Colombian National Liberation Army (ELN) kidnapped four French oil workers and destroyed $2.5 million worth of equipment on an oil pipeline (Miami Herald January 19, 1991). Multinational corporations may also temporarily cease drilling operations as the risks to their personnel in war zones increase as we know from our previous discussion of Chevron in Sudan.

Diamond Production

Table 2 shows that diamond production does not significantly affect the onset of civil war in the top half of the table. These findings are fairly consistent with the Lujala et al (2005) study, which found a positive relationship between (secondary) diamonds and civil war onset to be sensitive to model specification and temporal period. While diamonds might be a prize for rebels, given the probability that these data reflect largely mined diamonds, they are a prize that may be beyond their reach and even aspiration given the level of state control of this industry. The prior war, GDP per capita, population, and instability variables retain their significance in these models.

TABLE 2 The Simultaneous Effects of Civil War Onset and Diamond Production

	Civil War Onset	
Variable	Coefficient	Std. Error
Civil War Onset		
Diamond (carats/pc)	−0.820	0.967
Prior War	−0.395***	0.152
GDP per capita	−0.142***	0.036
Population	0.094*	0.049
Polity2	0.023	0.016
Mountainous Terrain	0.027	0.061
Noncontiguous	0.171	0.158
Ethnic Fractionalization	0.342	0.224
Religious Fractionalization	0.112	0.321
New State	0.521	0.356
Instability	0.268**	0.131
Peace Years	0.025	0.054
Spline 1	0.001	0.001
Spline 2	−0.001	0.001
Spline 3	0.000	0.000
Constant	−2.900***	0.600
First Stage Pseudo-$R^2 = 0.10$		
LR $\chi^2 = 78.07$***		
Diamond Production		
Civil War Onset	−0.105*	0.057
GDP per capita	−0.074	0.049
GDP per capita^2	0.047	0.045
Trade openness	0.030	0.039
Population	−0.033***	0.011
Population growth	3.283***	0.755
Polity2	0.016***	0.002
Constant	0.143***	0.181
First Stage Adj. $R^2 = 0.06$		
$F = 14.75$***		

$N = 4690$. Two-tailed test, *$p < .10$, **$p < .05$, ***$p < .01$.

The bottom half of Table 2 demonstrates that civil war onset reduces diamond production. Substantively, the onset of civil war reduces diamond production by a little over a tenth of a carat per capita. For example, this would translate into a decline of roughly 456,000 carats per year for a state the size of Sierra Leone at the outbreak of its civil war in 1991. The finding for decreased diamond production is consistent with the characteristics of primary diamonds. Even if the presence of mined diamonds is not enough to motivate rebels to start a civil war, once the war begins, they clearly become a target. The onset of a civil war is therefore likely to result in diminished diamond production.[13] However, diamond production may still recover during the course of a civil war. For example, during the Angola civil war, the Canadian-based company DiamondWorks Ltd. more than doubled its diamond production from 74,600 carats in 1998 to 150,000–200,000 carats in 1999 (National Post [Canada] May 28, 1999).[14] While the EKC drops out altogether in this model, population and population growth retain their significance, and more democratic states produce more diamonds per capita.

The negative consequences of civil war on these measures of natural resource exports show the largely negative effects of war on states' economic production. This creates a resource curse trap because countries that experience civil wars may become increasingly dependent on higher levels of natural resource production (Brunnschweiler and Bulte 2009), which in turn is problematic due to the destruction of those resources during war and the potential risks for future conflicts, especially if the resources in contention are located far from the center and are relatively easy to extract.

Marine Fishery Catches

Increases in marine fish catches do not significantly reduce the likelihood of civil war onset, despite the negative sign on the variable as shown in Table 3. On the other hand, the onset of civil war significantly increases the levels of marine fishery catches. On average, countries experiencing a civil war see a 233% increase in marine fishery catches.[15] Our general expectation was that since fishing is more of a distant, diffuse resource that it is more likely to be directly affected by war due to population displacement from

[13]It is also possible that some of the decline in diamond production may be a function of the shift to illegal mining (especially with alluvial diamonds) at the start of a civil war, which could lead to underreporting the true amount of production. This logic could also theoretically apply to fish production, and to a lesser extent oil production.

[14]We should also point out that the Kimberley Process has made it more difficult for diamond producers to extract diamonds from conflict zones, although the process has been criticized for ineffectiveness (Collier et al. 2003).

[15]We use Kennedy's (1981) calculation for the effect of a dummy variable on a logged dependent variable, which corrects for bias with the following formula: $100*[\exp\{b - \frac{1}{2}\,\mathrm{var}(b)\} - 1]$, where b is the estimated coefficient for the dummy variable and var(b) is the variance of the standard error.

TABLE 3 The Simultaneous Effects of Civil War Onset and Marine Fish Catch

	Civil War Onset	
Variable	Coefficient	Std. Error
Civil War Onset		
Marine Fish Catch (log)	−0.022	0.573
Prior War	−0.414	1.217
GDP per capita	−0.123	0.089
Population	0.134	0.332
Polity2	0.009	0.044
Mountainous Terrain	0.069	0.079
Noncontiguous	0.171	0.623
Ethnic Fractionalization	0.209	1.222
Religious Fractionalization	−0.012	1.028
New State	0.679**	0.309
Instability	0.329	0.291
Peace Years	0.019	0.074
Spline 1	0.001	0.001
Spline 2	−0.000	0.001
Spline 3	0.000	0.000
Constant	−3.221**	1.595
First Stage Pseudo-$R^2 = 0.10$		
LR $\chi^2 = 78.07$***		
Marine Fish Catch		
Civil War Onset	1.319***	0.480
GDP per capita	1.252***	0.445
GDP per capita^2	−0.875**	0.406
Trade openness	0.112	0.356
Population	0.192**	0.093
Population growth	3.378	6.576
Polity2	−0.101***	0.017
Constant	−7.908***	1.519
First Stage Adj. $R^2 = 0.08$		
$F = 24.22$***		

$N = 4690$. Two-tailed test, *$p < .10$, **$p < .05$, ***$p < .01$.

fighting, which leads to a reduction of labor in the local fishing industry. Yet, destruction of agricultural production or even distribution networks for imported food may force those with the ability to turn toward marine fish as basic foodstuff. Civil war may also lead to a rebounding of marine fish stocks over time, which could improve future production levels. Given that our observations are aggregated on a yearly basis, we might have instances where a civil war initially depressed fish catch, only to have it rebound within the course of the year. This finding is consistent with Reuveny et al. (2010), who demonstrate that war can have beneficial consequences for some aspects of the environment. However, we should be rather cautious in interpreting the results of the marine fish catch model, since it is the poorest fitting model in the group as we can see from Table 3.

Finally, we have separately analyzed the simultaneous effects of civil war onset on changes in the production of these various natural resources,

rather than levels. Given the slowly changing or time invariant nature of most of the structural variables in civil war models (that is, population, polity, mountainous terrain, noncontiguous territory, ethnic and religious fractionalization, new state, and a lag for prior civil war) it should not be surprising that civil war onset is not generally related to changes in natural resource production. Future studies may attempt to model both the level and change in natural resource production in connection with civil war onset.

CONCLUSION

In this article, we examine the endogenous relationship between the production of natural resources and civil war. We focus on several prominent resources that have received a great deal of attention in the civil war literature including oil, diamonds, and marine fishery catches. Once we control for the two-way relationship between these factors, we show that most of the relationship runs from civil war to natural resource production. Civil wars tend to wreak havoc on the production of natural resources, reducing oil production and diamond production. This occurs because such resources are explicitly targeted by rebel and government forces and because businesses may pull out their investments as the risks to their employees increase. However, we also show that the effect of civil war on resources may depend on the characteristics of the resources and nature of the conflicts. Some resources, such as marine fisheries, may actually see an improvement as laborers in the industry are forced to flee an area or join the fighting of a war and as demands on other agricultural resources increases. Our findings suggest that civil war might not only fuel a development trap, but that these countries may also find themselves in a natural resource trap, as civil war moves more economic activity into this arena. At the same time, the occurrence of civil war reduces the resources that are available for production or extraction, which further disadvantages the state.

We have taken only a small step toward understanding the broader relationship between natural resources, civil war, state strength, economic growth/income, environmental degradation, and regime type. In future research, we hope to examine the pathways by which resources and conflict are linked more indirectly. We also seek to determine if civil wars have conditional effects on natural resource production depending on their duration, intensity, history of prior conflicts, and the overall level of economic development a state has achieved.

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