Artisanal Gold Mining and Civil Conflict: A Time-Series, Cross-Country Analysis

by

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A Thesis Submitted in Partial Fulfillment of the Requirements for the
Degree of Bachelor of Sciences, Honours
in the Department of Economics
University of Victoria
April 2017

Supervised by Dr. Merwan Engineer & Dr. Nilanjana Roy

for

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Abstract

In this paper I study the causal relationship between artisanal and small-scale gold mining and civil conflict, as the existing research literature has either largely focused on other resources such as diamonds and oil, or on these links more generally. I use empirical methods from the existing literature to examine whether these links exist when considering artisanal gold production. My results indicate that artisanal gold production has no effect on the risk of civil conflict, and that primary gold production consistently serves to lessen that risk. I conclude that, while there exists anecdotal evidence on the links between artisanal gold mining and civil conflict, such a link is not systemic for the timeframe I consider in this paper.

Acknowledgements

I would like to acknowledge the unceded territories of the WS'ANEC' (Saanich) and Lkwungen (Songhees) people of the Coast Salish nation on whose land I work and live as a visitor. I would like to thank my supervisors Dr. Merwan Engineer and Dr. Nilanjana Roy, whose support was invaluable in the pursuit of successful completion of my Honour’s thesis. I would also like to recognize Alistair Campbell, whose work on estimating artisanal gold production motivated a large part of this thesis.

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1. Introduction

Artisanal and small-scale gold mining accounts for the employment of an estimated fifteen million people around the world (Gibb & O'Leary, 2014), and is characterised by rudimentary and dangerous labour-intensive processes. Most artisanal gold mining activity occurs in low to middle-income countries, which generally tend to be more prone to civil conflict (Auvinen & Nafziger, 1999). Indeed, a vast amount of research has been devoted to the causal relationships between various types of natural resources and civil conflict . However, despite the ubiquity of gold in general, there has been little research conducted into the links between gold production and civil conflict. The existing research literature on so-called conflict resources suggests that there may be such a link.

There are numerous anecdotes suggesting this link. In the Democratic Republic of the Congo artisanal gold mining activities have been funding rebel groups for years (Bafilemba & Lezhnev, 2015); between 2013 and 2014, it was reported that 57% of artisanal miners there were operating in the presence of armed groups (IPIS, 2015). For such reasons, gold is recognised as a "conflict mineral" in Section 1502 of the 2010 Dodd-Frank Act. To lessen this perceived risk, the Conflict-Free Gold Standard has been introduced by the World Gold Council, a market development organization for the gold industry, to mitigate the effects of informal and illegal gold mining and smuggling on civil conflict worldwide (World Gold Council, 2012). Surprisingly, these major policy initiatives are not based on research that evaluates whether there exist systematic causal relationships between gold mining activity and civil conflict.

In this paper, I examine whether the presence of an artisanal gold mining sector has a causal effect on both the onset and incidence of civil conflict (that is, on the likelihood of it beginning and of it being prolonged). To do this I adopt a methodology similar to that used in the study of the relationship between diamond production and civil conflict (Lujala, Gleditsch, & Gilmore, 2005), in which distinctions between primary and secondary minerals (and conflict onset and incidence) are made. This is important as the production of different types of resource can result in effects of different directions. Primary minerals are those which often require capital-intensive processes and are thus usually extracted by large corporations, while secondary minerals (such as alluvial gold) necessitate labour-intensive processes and are thus targeted by artisanal miners. Lujala et al. (2005) find that primary diamond production is negatively correlated with civil conflict, while secondary diamond production serves to exacerbate civil conflict. Their methodology provides a set of baseline models we can use to estimate the effects of primary and artisanal gold production on the likelihood of civil conflict.

While primary gold production data can be found easily (United States Geological Survey, 2016), a comprehensive artisanal gold production dataset does not currently exist. However, it is known that the use of mercury is a key ingredient in artisanal gold mining. It provides a cheap (albeit hazardous) way to convert gold ore into an amalgam, which can then be heated to leave only the unrefined gold. Aided by this knowledge, I am able to form a proxy variable for artisanal gold production through using data on net imports of mercury, obtained from the United Nations Comtrade Database (UN Comtrade, n.d.). It then becomes possible to isolate the effects of primary and artisanal gold production on the onset and incidence of civil conflict, which is a method not present in the current literature.

Contrary to certain findings in the literature, I find that primary gold production has a significant negative effect on conflict onset and incidence, while artisanal gold production is insignificant in explaining both conflict onset and incidence. In including resource variables which have been adopted by other researchers, I come to some surprising conclusions. Particularly, I find that primary diamond production has a positive, statistically significant effect on conflict onset and an insignificant effect on incidence, while secondary diamond production remains consistently statistically insignificant. It is important to qualify my findings, however; the disparities between my results on diamond production and those of Lujala et al. (2005) may be due to differences in the time period and sample size used. The authors find that the effect of secondary diamonds on civil conflict has increased dramatically following the end of the Cold War; my more recent dataset may reflect similar effects of primary diamonds on civil conflict. Additionally, this may take into account the effects of the Kimberley process, which was introduced in the mid-2000s to combat the effects of so-called "blood diamonds" on financing civil conflict. These results remain robust when using a so-called rare events logistic regression to take into account the sparseness of observations in my onset models. Overall, my results indicate that that, over the countries and time period tested, gold production generally does not have a positive effect on the likelihood that a state experiences new or prolonged civil conflict.

2. Literature Review

a. Greed and grievance

The question of whether civil conflict is motivated by economic forces was first studied by Collier and Hoeffler (1998). In this paper, they provided evidence for the notion that rebels engaged in insurgent activities if they predicted the post-conflict payoffs to be greater than the costs incurred during conflict. However, in Collier and Hoeffler (2004), the authors recognized that this was a flawed conclusion as they fused the notions of conflict onset and incidence (that is, the beginning of a conflict and its duration). Indeed, they realized that quite often rebels would more than cover the cost of their activities over the course of the conflict, thus rendering their initial hypothesis moot. In this later work, the authors focused on what we refer to in this paper as conflict onset, that is, the start of new civil conflicts.

Collier and Hoeffler (2004) departed from the view prevalent in the political science literature that civil conflict came as a result of grievances held by the people. Instead, they reasoned that conflict was caused by “atypical circumstances that generate profitable opportunities,” (Collier & Hoeffler, 2004, p. 564) or in other words, greed. To this end they used proxies for greed and grievance in two non-nested econometric models to examine which set of regressors better explained the likelihood of civil conflict. The categorization of these variables seems to have informed subsequent works in this field.

The authors reported that explanatory variables modelling “grievances” were largely insignificant in models tested, while proxies for “greed” tended to be significant and thus had a larger explanatory effect on the likelihood of civil war. One drawback of this methodology is in the dual personality of certain variables, such as the natural resource variable they use. This variable proxies natural resource dependence with a ratio of primary commodity exports to GDP, which has a positive and strongly significant effect on the risk of civil war. This is used as a "greed" variable, due to the possibility of profits from looting. However, the authors also note that it may act as a "grievance" variable – it marks country-years in which primary commodity exports make up more than one third of GDP, thus signalling resource dependence, which may also lead to weak institutions and governance, thus potentially increasing the risk of conflict through this alternative avenue.

b. Natural resources

The aforementioned natural resource variable is problematic for a number of further reasons. Humphreys (2005) highlights that while Collier and Hoeffler (2004) cite numerous studies linking diamonds and cocaine to the financing of insurgent activities, it is unlikely that these resources are captured in primary commodity export estimates. Furthermore, Lujala et al. (2005) note that this measure does not account for separate types of natural resources and the degrees to which they affect the likelihood that a country will experience civil conflict. They instead propose that such a measure be disaggregated, as different natural resources may affect the likelihood of civil conflict to varying degrees, and additionally, the types of resource that potentially play a role in financing rebel groups may fail to show up entirely in primary commodity exports data.

Furthermore, Lujala et al. (2005) note that because the natural resource variable in Collier and Hoeffler (2004) represents resource dependence, it may also pose endogeneity problems. A country facing civil conflict may as a result appear more dependent on natural resources as other industries wither away, while companies engaging in extractive activities are often unable to and thus may become more persistent, particularly in the case of small civil conflicts (my dataset records conflicts in which at least 25 deaths have occurred; certain small conflicts are surely included). Lujala et al. (2005) therefore assert that natural resource production is the more appropriate measure to use. Additionally, the Collier and Hoeffler (2004) resource variable includes re-exports, which may result in misleading conclusions.

c. Diamonds

In this paper I extend the work of Lujala et al. (2005) to include primary and artisanal gold production in explaining the causal links between natural resource extraction and the likelihood that a state experiences civil conflict. The authors use the DIADATA set compiled by Gilmore et al. (2005), which extensively documents primary and secondary diamond production and deposits around the world. For the purposes of this paper I only use diamond production data, as Lujala et al. (2005) find diamond deposits to be consistently insignificant in their models.

The authors use this dataset as they claim it to be more reliable than others concerning diamond production. A drawback is that it does not take annual production into account. This dataset codes a production variable as 1 for the first year diamonds are produced in a given country and for every subsequent year. This fails to take into account shifts in local employment. It is not unreasonable to expect secondary diamond sectors to wax and wane; for example, locals may choose to forgo hazardous artisanal mining for safer and more lucrative employment opportunities as they arise in their region, in more prosperous times (which may also see a lessened occurrence of conflict). This distinction would help to explain the role of secondary diamond production in determining the risk of conflict, and this methodology ignores this possibility. However, this variable distinguishes between primary and secondary diamond production, unlike that of Humphreys (2005), whose diamond production variable is continuous, but does not distinguish between the two types of production.

The authors find that primary and secondary diamond production has no effect on conflict onset, while only primary diamond production has a negative, significant effect on incidence. Additionally, Lujala et al. (2005) find an interaction term between secondary diamond production and ethnic fractionalisation to be positive and significant, indicating that secondary diamond production affects the likelihood of conflict to a higher degree in ethnically heterogenous countries. I explore a similar methodology below. However, some disparities between their results and mine are to be expected because of the different time-frame my dataset assumes, as well as the number of observations involved (1998-2014 instead of 1946-1999).

d. Temporal dependence

Beck, Katz and Tucker (1998) note the increasing frequency with which "time-series, cross-section data with a binary dependent variable (BTSCS)" (Beck, Katz, & Tucker, 1998) are studied, particularly in the field of international relations and conflict. The authors note that data of this kind are likely to face issues of temporal dependence, and thus violate the independence assumptions necessary in logit regressions. A remedy is thus proposed: the authors note that so-called BTSCS data are identical to grouped duration data, and thus methods in event history analysis can be employed to what the authors refer to as international relations data. The authors suggested adding an additional variable to count the number of years between conflicts, which is not included in the

UCDP/PRIO Armed Conflict Dataset. This so-called peace year variable can be paired with cubic splines to control for temporal dependence. I employ this method to control for temporal dependence in the models for which the dependent variable is conflict incidence; as using it in onset models would not be appropriate as the data would not indicate how long it would have been since the conflict began.

3. Data

a. Civil conflict

In this paper I focus on civil conflict, as opposed to interstate wars. Incidents of civil conflict have occurred more frequently, and have resulted in an estimated five times more deaths than interstate wars over the latter half of the twentieth century (Fearon & Laitin, 2003). There are numerous datasets available for quantitative analysis of conflict, with varying standards and levels of (dis)aggregation. While the Correlates of War (COW) Project (Sarkees & Wayman, 2010) set the standards for subsequent research, the UCDP/PRIO Armed Conflict Dataset (Gleditsch, Wallensteen, Eriksson, Sollenberg, & Strand, 2002; Themner & Wallensteen, 2014) is regarded as having enlarged the scope of conflict under study (Sousa, 2014). This is partially a result of the battle death thresholds considered by either dataset; the former focusing on wars with greater than a thousand deaths, the latter focusing on both wars and smaller conflicts with a threshold of 25 deaths. This lower threshold allows us to consider a wider range of civil conflict episodes, and serves as my primary motivation in using the UCDP/PRIO Armed Conflict Dataset (Gleditsch et al., 2014).

There are, however, other considerations taken in my choice of dataset. The COW dataset spans from 1816-2007 while the UCDP/PRIO dataset is shorter but more recent, spanning 1946-2014. Due to other data considerations (as discussed below), I examine conflict between 1998 and 2014, making the UCDP/PRIO dataset the obvious choice. Additionally, this dataset, while perhaps lacking in certain details such as the identity of different sides in a particular conflict, distinguishes between active conflict country-years and country-years in which new conflicts begin. This is an important distinction, as

Lujala, et al. (2005) study the effects of primary and secondary diamonds both on the incidence and onset of conflict, as natural resources can affect the two aspects in different ways. The sample I use in this paper comprises 153 countries between 1998 and 2014. While the UCDP/PRIO dataset covers more countries, I am forced to restrict my analysis because of the control variables included in the Fearon & Laitin (2003) models (and subsequently, the Lujala et al., 2005 models), which I include in my models.

b. Determinants of conflict

To capture the effects of other factors on the likelihood that a country will experience conflict in a given year, I use the explanatory variables employed by Fearon & Laitin (2003) (and subsequently by Lujala et al., 2005). I use a prior war variable, which measures whether a conflict occurred in the previous year. Additionally, I use GDP per capita, measured in thousands of 2011 PPP dollars, and the log of population. This data was sourced from the World Bank. There exist possible endogeneity problems with including GDP per capita as an explanatory variable, but I include it to prevent omitted variable bias (Sambanis, 2001, p. 269). An instrumental variable may be employed to address this issue, which is left to future work.

To motivate the use of population as an explanatory variable, Fearon and Laitin (2003) hypothesize that countries which have larger populations tend to see a higher risk of civil conflict due to the increased difficulty of a central government to observe organizing at the local level, and due to the increased pool of fresh recruits insurgents may have. I include the log of population in this regard, using data from the World Bank.

I use a dummy variable for oil dependence, which measures instances in which a country's fuel exports are greater than or equal to a third of a country's GDP. This figure comes from the understanding that the risk of conflict reaches its height when primary commodity exports make up roughly a third of GDP (Collier & Hoeffler, 2004, p. 574). Additionally, it is understood that countries which were heavily reliant on oil and gas between 1990 and 2000 tended to see a higher risk of experiencing civil conflict over that time period (Ross, 2003, p. 50). It would thus make sense to include this variable in our model as a control variable (but not as a resource variable per se).

Additionally, Fearon and Laitin (2003) hypothesize that a state which is non-contiguous, that is, with parts of the country separated from the centre of the state, is more likely to experience conflict due to this factor. This is possible because of the added difficulty for a central government in monitoring activities at a country's periphery, demonstrated in such cases as pre-separation Pakistan and Indonesia. I include a non-contiguity dummy variable to reflect this. The authors also speculate that the degree to which a state is mountainous influences the likelihood of conflict, in that countries with rougher terrain are more likely to experience it, through the added difficulty of a central government to seek out insurgents. Fearon and Laitin (2003) use the "rough terrain" measure provided by A.J. Gerard, and I include this continuous variable in my dataset.

A large contribution of Fearon and Laitin's (2003) work surrounded exploring the links between ethnicity and conflict. The authors use ethnic and religious fractionalisation data to capture these effects, and I use the same data. The variable presents itself as a fixed effect, and this remains a shortfall in the data available for use in this field. It nonetheless acts as a reasonable approximation for my purposes.

c. Natural resources

I include data on primary and secondary diamond production from DIADATA, using the same specifications as Lujala et al. (2005), in that they are coded 1 from the first year production began, and remain the same for every subsequent year. I use data on primary gold production from the United States Geological Survey (USGS), which reports annual estimates of gold production. In some cases these include estimates of artisanal gold mining, but I assume these figures to be relatively small. The figures reported by the USGS are estimates at best, and are subject to disparities in the quality of reported data between countries. To remedy this, I use a primary gold production dummy variable to ignore issues of magnitude, which measures whether or not primary gold production occurs in a given country-year.

Artisanal gold mining often occurs informally, and in many cases illegally, making estimation notoriously difficult. However, using the information that much of this type of mining uses mercury in the production process, I am able to form a proxy variable for the presence of artisanal gold production. I use a dataset on annual net mercury imports across country-years created by Campbell (2016), which omits countries with prominent industries (such as the chlor-alkali industry) which use mercury in their production processes. The resulting data indicates which countries (excluding those omitted for this reason) have positive net mercury imports in any given year. This method is predicated on the assumption that countries with positive net mercury imports which do not have prominent mercury-intensive industries likely have an artisanal gold mining sector.

However, knowledge of annual net mercury imports does not indicate how large artisanal mining sectors are. I remedy this using a similar method to the primary gold production variable, by using dummy variables instead of continuous variables. In doing this I come to a reasonable conclusion regarding the presence of primary and artisanal gold mining sectors despite not being able to make any inferences regarding the size of these sectors. As new methodologies come into existence to estimate both the presence and the size of artisanal gold mining sectors, future work is left to determining how these factors affect the risk of civil conflict.

In table 5 of the Appendix I report the summary statistics associated with these variables. While only approximately 11 percent of country-years experienced primary diamond production and 16 percent of country-years experienced secondary diamond production, more than 50 percent of country-years saw primary or artisanal gold production by my estimation. Gold therefore tends to be a more commonly-found resource in the dataset considered in this paper, and this has ramifications for its economic importance relative to that of diamonds, which I discuss below.

4. Methodology

a. Objectives

My primary objective in this paper is to determine whether a causal link between artisanal gold production and civil conflict exists. The literature surrounding the determinants of conflict is vast, and much work has been dedicated to determining the mechanisms through which various explanatory variables affect the likelihood that a state will experience conflict in a given year. As mentioned above, this takes the form of hypotheses constructed through theoretical frameworks which inform our understanding of the determinants of conflict. In this paper, however, determining the mechanisms through which gold production is linked to conflict is secondary to the question of whether such links exist.

Furthermore, in attempting to explain the links between artisanal gold production and civil conflict, it is necessary that I include both primary and secondary diamonds (the effects of which have been studied in the past), in addition to primary gold. In exploring these links, I am able to make inferences regarding the effects of other types of resources on the likelihood of conflict onset and incidence.

b. Model

I estimate the effects of natural resources on the likelihood of civil war onset and incidence using the following logit model:

$$\Pr\left(y_{i,t} = 1\right) = \frac{\exp(\beta' x_{i,t})}{1 + \exp(\beta' x_{i,t})},$$

$$\beta' x_{i,t} = \beta_0 + \beta_1 n_{i,t} + \beta_2 c_{i,t} + \beta_3 \delta_{i,t}$$

Where $n_{i,t}$ is a matrix of natural resource variables, including primary and secondary diamond production and primary and artisanal gold production; $c_{i,t}$ refers to the various control variables includes; and $\delta_{i,t}$ refers to the peace-years and cubic spline included in the incidence models to handle issues of temporal dependence as discussed above.

5. Results

Lujala et al. (2005) report the coefficients associated with their models, and not the marginal effects. Reporting the marginal effects would provide information on the magnitude of the effects of explanatory variables, while coefficients only provide an indication regarding the signs and significance of the effects. Nevertheless, I report the coefficients associated with my models, which are reported in table 1 below, to compare my results with that of Lujala et al. (2005). To form a baseline from which I can do this, I construct a series of baseline models using the same specifications (including only primary and secondary diamond production as the natural resource variables), and report the results below. Model 1a is the baseline model using conflict onset as a dependent variable, and model 1b extends this to include primary and artisanal gold production dummies.

Model 1c estimates this model using a so-called rare events logit method of estimation. Conflict data more generally can be referred to as rare events data, in which the binary dependent variable contains many more ones than zeroes. Using standard logit regression can result in vastly underestimated probabilities of such events occurring (King & Zeng, 2001). Such a problem is present when considering the probability of conflict onset in the dataset I use; out of more than 2,000 observations, only 25 separate conflicts began in the timeframe I consider. I therefore use this method, which is a penalized maximum likelihood logit regression, as a robustness check.

Model 2a is the baseline model using conflict incidence as the dependent variable. Model 2b extends this to include an interaction term between secondary diamonds and ethnic fractionalisation. Model 2c extends the baseline model (without the interaction term) to include the gold dummies, in addition to the Beck, Katz and Tucker corrections, the effects of which are not reported. (2003)

Table 1: Main results (coefficients)

Variable	*Model 1a*	*Model 1b*	*Model 1c*	*Model 2a*	*Model 2b*	*Model 2c*
Prior War	-1.503	-2.052	-1.789	4.779***	1.661	1.549
	(1.155)	(1.707)	(1.060)	(0.442)	(1.078)	(1.133)
Per capita income	-0.0442	-0.0386	-0.0225	-0.0212	-0.0166	-0.0204
	(0.0327)	(0.0275)	(0.0334)	(0.0192)	(0.0187)	(0.0176)
Population (log)	0.532**	0.823***	0.733***	0.429***	0.470***	0.456***
	(0.188)	(0.249)	(0.219)	(0.0893)	(0.0926)	(0.0879)
Mountainous (log)	-0.258	-0.229	-0.168	0.115	0.137	0.241**
	(0.144)	(0.137)	(0.195)	(0.0906)	(0.0870)	(0.0829)
Noncontiguous	1.131	-0.0668	-0.109	0.364	0.169	0.146
	(0.860)	(0.879)	(0.976)	(0.362)	(0.350)	(0.389)
Oil exporting	0.531	1.074	1.039	0.490	0.488	0.550
	(0.613)	(0.587)	(0.758)	(0.328)	(0.321)	(0.330)
Instability	1.200	1.216	1.382	0.875	0.718	0.858
	(0.707)	(0.745)	(0.739)	(0.542)	(0.526)	(0.548)
Democracy	0.0255	0.0720	0.0573	-0.00696	-0.0102	0.00615
	(0.0564)	(0.0651)	(0.0645)	(0.0207)	(0.0197)	(0.0219)
Ethnic fractionalisation	0.555	1.793*	1.665	0.992*	0.548	1.226*
	(0.875)	(0.827)	(1.330)	(0.489)	(0.463)	(0.502)
Religious fractionalisation	-0.660	-2.092	-1.971	-0.0789	0.0883	-0.0672
	(2.021)	(1.773)	(1.755)	(0.565)	(0.558)	(0.599)
Primary diamond production	1.962*	3.125**	2.624*	0.174	0.0434	0.570
	(0.956)	(1.093)	(1.138)	(0.589)	(0.618)	(0.526)
Secondary diamond production	-0.279	-0.0468	0.134	-0.446	-2.014*	-0.668
	(0.781)	(0.768)	(0.982)	(0.549)	(0.920)	(0.529)
Primary gold production		-2.162**	-1.913*			-0.681*
		(0.833)	(0.929)			(0.287)
Artisanal gold production		-1.130	-1.000			-0.214
		(0.688)	(0.557)			(0.307)
Secondary diamond production × Ethnic fractionalisation					2.601*	
					(1.174)	
N	1946	1836	1836	1946	1946	1836

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In the baseline model that Lujala et al. (2005) report, both primary and secondary diamond production variables are insignificant in explaining both conflict onset and incidence. While these coefficients are insignificant in explaining conflict incidence in my dataset (model 2a), primary diamond production has a positive and significant effect on conflict onset (model 1a). My results depart from those of Lujala et al. (2005) for several possible reasons. The authors included a statistically significant 'new state' variable, which I omit due to the timeframe my dataset uses, in which only one new state was formed (South Sudan). This would not therefore not be a relevant variable for the timeframe considered in this paper.

Lujala et al. (2005) also test a model which includes an interaction term between secondary diamond production and ethnic fractionalisation, which is positive and significant in explaining conflict incidence. I come to the same conclusion in model 2b. This indicates that the presence of secondary diamond production has some effect on the risk of conflict incidence in ethnically heterogeneous countries (the sign will only be known when reporting the marginal effects). I discuss this result further below, and I test a model containing an interaction term between artisanal gold production and ethnic fractionalisation.

Adding gold production variables, I find that primary gold production has a negative and statistically significant effect on both conflict onset and incidence, and that artisanal gold production is insignificant. The results for the conflict onset model including both diamond and gold variables remain robust to the rare events logit specification used in model 1c.

Reporting the coefficients corresponding to a logit model, as per Lujala et al. (2005), only indicate the signs of the marginal effects and the significance of the explanatory variables included, but give no indication of the magnitude of the effects. Obtaining the marginal effects is important as this allows one to evaluate the economic significance of the explanatory variables included in a model. I report the marginal effects of these models (except that of model 1c, the rare events logit model) in table 2 below.

Table 2: Main results (marginal effects)

Variable	*Model 1a*	*Model 1b*	*Model 2a*	*Model 2b*	*Model 2c*
Prior war	-0.0110	-0.0143	0.173***	0.0593	0.0528
	(0.00876)	(0.0115)	(0.0129)	(0.0372)	(0.0371)
Per capita income	-0.000323	-0.000269	-0.000767	-0.000593	-0.000696
	(0.000244)	(0.000198)	(0.000709)	(0.000674)	(0.000608)
Population (log)	0.00389**	0.00575***	0.0155***	0.0168***	0.0155***
	(0.00145)	(0.00165)	(0.00376)	(0.00401)	(0.00351)
Mountainous	-0.00189	-0.00160	0.00416	0.00490	0.00821**
	(0.00106)	(0.000895)	(0.00340)	(0.00326)	(0.00304)
Noncontiguous	0.00827	-0.000466	0.0132	0.00604	0.00497
	(0.00644)	(0.00615)	(0.0132)	(0.0125)	(0.0132)
Oil exporting	0.00459	0.0105	0.0188	0.0184	0.0199
	(0.00617)	(0.00780)	(0.0131)	(0.0125)	(0.0121)
Instability	0.00878	0.00849	0.0316	0.0256	0.0293
	(0.00523)	(0.00520)	(0.0191)	(0.0184)	(0.0185)
Democracy	0.000186	0.000502	-0.000251	-0.000365	0.000209
	(0.000412)	(0.000447)	(0.000751)	(0.000706)	(0.000747)
Ethnic fractionalisation	0.00406	0.0125	0.0358	0.0338	0.0418*
	(0.00668)	(0.00644)	(0.0189)	(0.0176)	(0.0184)
Religious fractionalisation	-0.00483	-0.0146	-0.00285	0.00315	-0.00229
	(0.0148)	(0.0124)	(0.0204)	(0.0199)	(0.0204)
Primary diamond production	0.0236	0.0552	0.00641	0.00155	0.0208
	(0.0186)	(0.0389)	(0.0221)	(0.0222)	(0.0206)
Secondary diamond production	-0.00205	-0.000326	-0.0157	-0.0270	-0.0221
	(0.00581)	(0.00537)	(0.0188)	(0.0196)	(0.0172)
Primary gold production		-0.0240*			-0.0234*
		(0.0122)			(0.00945)
Artisanal gold production		-0.00875			-0.00732
		(0.00537)			(0.0104)
N	1946	1836	1946	1946	1836

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The average marginal effect of the primary gold production variable remains negative and significant in explaining both conflict onset and incidence. This indicates that, for the timeframe considered, primary gold production reduces the likelihood of conflict onset and incidence by roughly 2.4 percentage points. Note that I do not report the marginal effects associated with model 1c, the rare events logit model. I include model 2b, which includes the interaction term between secondary diamond production and ethnic fractionalisation, but I omit reporting the marginal effect of this term as it is not meaningful. Including this interaction term increases the average marginal effect of secondary diamond production to -2.7 percentage points (from -1.57 percentage points in the model without the interaction term). I discuss this further below.

For the resource variables employed in these models, marginal effects are interpreted as the percentage points by which the expected probability of conflict onset or incidence changes with the presence of natural resource production. This allows me to comment on the economic significance of these effects, instead of merely commenting on the direction of the effect and its statistical significance. These results indicate that, for the dataset used, the presence of primary gold production reduced the likelihood of conflict occurring by more than 2 percentage points. Furthermore, under no specification is artisanal gold production related to the risk of conflict. The ramifications of these results are discussed below.

6. Sensitivity Analysis

In this section I attempt to explain the mechanisms through which natural resources affect the risk of conflict, based on both empirical and theoretical hypotheses present in the research literature (Humphreys, 2005; Lujala et al., 2005).

a. Ethnicity

Lujala et al. (2005) constructed an interaction term between secondary diamond production and ethnic fractionalisation in their incidence model, and found it to be positive and significant. In model 2b (reported above and below), I find such an interaction term to be positive and significant as well. This leads me to a conclusion similar to that of Lujala et al. (2005), that secondary diamond production increases the likelihood of conflict in countries with a high degree of ethnic fractionalisation to a greater degree than those which are less ethnically heterogeneous. More precisely, I find that the presence of secondary diamond production increases the impact of ethnic fractionalisation on the probability of conflict incidence by roughly 8 percentage points, which is the cross partial effect (not reported in the table below)[1].

I then test the hypothesis that this can be applied to artisanal gold production, by adding an interaction term between artisanal gold production and ethnic fractionalisation. I find this term to be statistically insignificant. This allows me to conclude that it is not always the case that secondary resources exacerbate conflict in ethnically heterogeneous countries. Note that the marginal effect of the primary gold production variable remains

[1] This is calculated by taking the difference of the average marginal effect evaluated at both levels of secondary diamond production (that is, between 1 and 0).

statistically and economically significant in model 2d, reported in table 3 below. This result is robust to different specifications, as is the statistical insignificance of artisanal gold production.

Table 3: Effects of ethnic heterogeneity and secondary resources on conflict risk

Variable	*Model 1c (Coefficient)*	*Model 1c (Marginal effect)*	*Model 2d (Coefficient)*	*Model 2d (Marginal effect)*
Prior war	1.661	0.0593	1.549	0.0528
	(1.078)	(0.0372)	(1.131)	(0.0370)
Per capita income	-0.0166	-0.000593	-0.0201	-0.000685
	(0.0187)	(0.000674)	(0.0175)	(0.000605)
Population (log)	0.470***	0.0168***	0.457***	0.0156***
	(0.0926)	(0.00401)	(0.0876)	(0.00348)
Mountainous (log)	0.137	0.00490	0.247**	0.00841**
	(0.0870)	(0.00326)	(0.0845)	(0.00310)
Noncontiguous	0.169	0.00604	0.151	0.00514
	(0.350)	(0.0125)	(0.386)	(0.0131)
Oil exporting	0.488	0.0184	0.531	0.0191
	(0.321)	(0.0125)	(0.325)	(0.0119)
Instability	0.718	0.0256	0.863	0.0294
	(0.526)	(0.0184)	(0.546)	(0.0184)
Democracy	-0.0102	-0.000365	0.00548	0.000187
	(0.0197)	(0.000706)	(0.0220)	(0.000748)
Ethnic fractionalization	0.548	0.0338	1.690	0.0435*
	(0.463)	(0.0176)	(0.877)	(0.0185)
Religious fractionalization	0.0883	0.00315	-0.0272	-0.000926
	(0.558)	(0.0199)	(0.608)	(0.0207)
Primary diamond production	0.0434	0.00155	0.532	0.0193
	(0.618)	(0.0222)	(0.535)	(0.0207)
Secondary diamond production	-2.014*	-0.0270	-0.657	-0.0217
	(0.920)	(0.0196)	(0.532)	(0.0172)
Secondary diamond production × Ethnic fractionalization	2.601*			
	(1.174)			
Primary gold production			-0.681*	-0.0234*
			(0.288)	(0.00946)
Artisanal gold production			0.0489	-0.00787
			(0.541)	(0.0103)
Artisanal gold production × Ethnic fractionalization			-0.626	
			(1.057)	
N	1946	1946	1836	1836

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

b. Agricultural dependence

Humphreys (2005) finds that higher levels of agricultural dependence increase the likelihood that a state experiences civil conflict. The author uses this variable as a proxy for the "sparse networks" mechanisms, which hypothesize that countries facing lower levels of industrialization (and thus, a higher proportion of the population working in the agricultural sector), which can sometimes occur due to natural resource dependence more generally, see a higher risk of civil conflict. This is due to lower levels of internal trade which form "independent enclaves of production," which can accordingly have adverse effects on national social cohesion (Humphreys, 2005, p. 513). Conversely, the author also argues that such a mechanism can result in lengthened conflicts, as the absence of "dense [economic] linkages" removes the incentives associated with ending and preventing conflict between close trading partners (Humphreys, 2005, pp. 518–519). This is an example of a variable which can motivate both "greed" and "grievance" mechanisms.

I therefore test two hypotheses: that higher levels of agricultural dependence serve to both heighten the risk of conflict onset and exacerbate existing conflict through having a positive effect on conflict incidence. I test for conflict onset in model 1d (taking into account the rare events logit method as discussed above) and for incidence in model 2e, and I find agricultural dependence to be insignificant under either specification. These results are reported in table 4 below. I report both the coefficients and the marginal effects associated with these models, as these provide different types of information. Reporting the coefficients associated with model 1d, both primary gold and diamond production are significant, with diamond production having a positive effect and primary gold having a negative effect on conflict. Under model 2e, none of the resource variables are significant. Additionally, the agricultural dependence variable remains insignificant in both cases. I conclude that, for the dataset considered in this paper, agricultural dependence is unrelated to the risk of civil conflict onset and incidence.

Table 4: Effects of agricultural dependence on conflict risk

Variable	*Model 1d (Coefficient)*	*Model 1d (Marginal effects)*	*Model 2e (Coefficient)*	*Model 2e (Marginal effects)*
Prior war	-2.109	-0.0154	1.908	0.0616
	(1.172)	(0.00917)	(1.246)	(0.0384)
Per capita income	-0.0422	-0.000309	-0.0407	-0.00131
	(0.0434)	(0.000324)	(0.0229)	(0.000748)
Population (log)	0.864^{***}	0.00633^{**}	0.531^{***}	0.0171^{***}
	(0.253)	(0.00230)	(0.0979)	(0.00349)
Mountainous (log)	-0.235	-0.00172	0.328^{***}	0.0106^{***}
	(0.221)	(0.00165)	(0.0818)	(0.00280)
Noncontiguous	-0.239	-0.00175	0.514	0.0166
	(1.109)	(0.00814)	(0.441)	(0.0142)
Oil exporting	1.019	0.0102	0.680	0.0236
	(0.859)	(0.0115)	(0.380)	(0.0137)
Instability	1.256	0.00919	0.998	0.0322^{*}
	(0.853)	(0.00655)	(0.513)	(0.0164)
Democracy	0.0619	0.000453	0.00968	0.000313
	(0.0727)	(0.000540)	(0.0261)	(0.000840)
Ethnic fractionalization	2.452	0.0180	1.464^{**}	0.0473^{*}
	(1.755)	(0.0134)	(0.563)	(0.0194)
Religious fractionalization	-2.234	-0.0164	-0.403	-0.0130
	(1.928)	(0.0146)	(0.819)	(0.0265)
Primary diamond production	3.258^{*}	0.0636	0.849	0.0303
	(1.276)	(0.0544)	(0.652)	(0.0262)
Secondary diamond production	-0.301	-0.00222	-0.825	-0.0261
	(1.076)	(0.00800)	(0.683)	(0.0215)
Primary gold production	-2.258^{*}	-0.0269	-0.317	-0.0103
	(1.052)	(0.0178)	(0.378)	(0.0121)
Artisanal gold production	-1.117	-0.00906	-0.451	-0.0148
	(0.601)	(0.00546)	(0.343)	(0.0109)
Agricultural dependence (%)	-0.0250	-0.000183	0.0119	0.000384
	(0.0481)	(0.000354)	(0.0151)	(0.000491)
N	1748	1748	1748	1748

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

7. Conclusion

My results indicate that first, primary gold has a statistically and economically significant negative effect on the likelihood of conflict. For the timeframe considered, primary gold production reduced the expected probability of conflict onset and incidence by more than 2 percentage points, which is robust across different specifications of the models considered. This result is consistent with the literature surrounding conflict resources. Second, my results indicate that artisanal gold production is systemically unrelated to the likelihood that a country will experience civil conflict in a given year. This is an interesting result as it serves to call into question the efficacy of efforts such as the Dodd-Frank Act and the Conflict-Free Gold Standard in mitigating civil conflict outbreak through targeting conflict resources. More than half of the country-years considered in this dataset exhibit some degree of likely artisanal gold production; as such, its economic importance to communities worldwide cannot be understated. Efforts to stymie the outflow of artisanal gold product will likely result in adverse economic effects to low-income communities in the Global South. If it is to be believed that members of such communities engage in risky artisanal mining because of the relative economic benefits (over other activities such as agriculture) associated with it, harming this economic sector may incentivise members of low-income communities to engage in rebel activities to make up for the economic losses incurred with increased regulation of artisanal gold mining sectors. It is not unreasonable to suggest that this may in fact increase the risk of conflict outbreak. While a link between artisanal gold mining and civil conflict is not systemic, anecdotal evidence exists which indicate that such activities have been exploited to support rebel insurgencies. Future work is left to determining whether the benefits of policies aimed at controlling the flow of artisanal gold outweigh the potential costs of doing so.

Furthermore, artisanal gold mining activity exhibits a different kind of adverse effect on communities not reflected in the data, largely through the widespread use of mercury in the production process, discussed above. Instead of positing a "resource curse" linking artisanal gold production to conflict, international regulations would likely see more impact in foreign aid directed at lessening the use of mercury in artisanal gold mining communities.

These results must be qualified, however, regarding the use of net mercury imports as a proxy for artisanal gold production. While industries with chlor-alkali industries are excluded, the data includes developed countries with positive net mercury imports. Of course, mercury has other commercial uses, and artisanal gold mining likely does not have a significant presence in most (if not all) developed countries. Future work is left to refining this problematic measure of artisanal gold production in the pursuit of a more sophisticated understanding of the effects of artisanal gold mining on the likelihood of civil conflict.

8. Appendix

Table 5: Summary statistics

Variable	*No. of observations*	*Mean*	*Standard deviation*	*Min*	*Max*
Per capita income	2480	9.483	13.796	0.130	69.095
Population (log)	2584	16.280	1.445	13.187	21.034
Mountainous (log)	2601	1.925	1.601	-2.660	4.546
Noncontiguous*	2601	0.157	0.364	0	1
Oil exporting*	2126	0.184	0.388	0	1
Instability*	2550	0.049	0.216	0	1
Democracy*	2556	3.489	6.415	-10	10
Ethnic fractionalisation	2601	0.413	0.278	0.001	0.925
Religious fractionalisation	2601	0.383	0.216	0	0.783
Primary diamond production*	2601	0.111	0.314	0	1
Secondary diamond production*	2601	0.163	0.370	0	1
Primary gold production*	2558	0.559	0.497	0	1
Artisanal gold production*	2499	0.594	0.491	0	1
Agricultural dependence (%)	2355	14.762	13.406	0.035	62.383

* denotes a categorical variable; all other variables are continuous

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