

## Did natural resource wealth motivate fighting in the Bosnian War?

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**Abstract.** The 1992 to 1995 Bosnian War was not a war begun over a conflict for natural resources. Instead, this study hypothesizes that the intensity of fighting during the War was positively influenced by the presence of high levels of natural resource wealth distributed throughout Bosnia. Drawing upon self-coded data for myriad measures of the intensity of fighting and natural resources in a given area of the country, we use multiple regression techniques as well as factor analysis to support the hypothesis and conclude that natural resource wealth was an important factor in influencing the course of the War. Natural resources both strategically deprived the opposing army from adequate land and water during the War and also ensured that high quality natural resource infrastructure and forest resources were available after the War ended. This research is unique in that it examines the importance of natural resources where fighting takes place.

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### INTRODUCTION

Was the Bosnian War motivated by natural resource wealth? The answer is pretty clearly no. Instead, the desire to create separate countries for each ethnic group in the former Yugoslavia was a clear driving factor. However, creating a separate country involved fighting over who acquired different quantities of land, and the Serbs and the Croats obsessed over fighting to extract as much land from the Bosnians as possible. Was this desire for land simply because more land equaled more power or did this land contain something more than such a psychological advantage? That is, were the attempted land grabs and the fiercest battles during the Bosnian War taking place in areas that also happened to have a wealth of various natural resources? It is this question that this research is trying to address. In no way will I argue that the chief cause of the Bosnian War was natural resource wealth, nor will I argue that the simple desire for land demonstrates fighting a War over natural resources. Rather, I hypothesize that there is a positive correlation between intense fighting during the War and natural resource wealth. If this is indeed the case, we can assert that natural resource wealth may have played a role in shaping the structure and flow of the Bosnian War. The War would have occurred

regardless of the placement of natural resources throughout Bosnia and Herzegovina, but specific, targeted attacks may have been influenced by natural resource wealth.

The broadest sense of the question being addressed is, "Do natural resources impact the progress of a war?" It is extremely important to define "natural resources" and the way that "progress of a war" is measured. Instead of specifying a precise research question based on limiting the independent and dependent variables, this study will keep them intentionally broad in order to find some measure of natural resource wealth that really does impact the progress of a war, particularly the Bosnian War.

This broad research question has already been successfully answered "yes" for many other conflicts that were clearly about natural resources. It has also been answered "yes" for if natural resource wealth helps promote the beginnings of conflict and even if it extends the duration of conflict. However, studies of whether the physical movements of forces in the war that result in more fighting and confrontation in certain regions of the country at war correlate to high concentrations of natural resource wealth are virtually non-existent. Thus, the specific research question can be phrased as, "Are the concentrations of violence within Bosnia during the Bosnian War correlated to high levels of natural resource wealth?" Of course, it is natural to desire causation, but this research question will mostly focus on finding correlations and simply describe possible evidence to suggest where causation might be present.

## LITERATURE REVIEW

The Bosnia and Herzegovina natural resource wealth question has four essential components: Were there natural resources that were seen as valuable in Bosnia? Does the presence of these resources encourage the conflict? Do conflicts occur that involve natural resource distribution? And, if a natural resource wealth model for conflicts is indeed possible, how should such a linear regression model be constructed?

Many studies confirm the necessity of some of the natural resource variables in our regression. Andreas (2004) states that oil smuggling and other types of natural resource smuggling activities occurred in Bosnia and that oil smuggling in particular was significant enough to provide funding to rebel groups. Illegal timber harvest throughout the War and after its conclusion provided additional funding to rebel groups (Herman *et al.*, 2005; Meško *et al.*, 2010). Herman *et al.* (2005) especially highlights that other natural resources were not as much of a vehicle of financial support as were illegal timber harvests. Further, Pugh (2002) concludes that those wishing to extract natural resources had to be at least somewhat skilled as entrepreneurs in order to profit adequately when the War concluded. Regardless, natural resource issues were seen as significant enough in Bosnia to play some role in the course of the War. The extent to which the locations of natural resources in Bosnia were significant is unclear and became one of the major purposes of this study.

There are two different schools of thought regarding the impact natural resources have on civil conflicts. Ross (2004b) provides a good summary of recent studies of natural resource conflicts. Global Witness (2002) and Ballentine and Nitzschke (2005) emphasize the prevalence of such conflicts, while Bannon and Collier (2003) provide a description of possible actions to address and mitigate them. Costalli and Moro (2010) address micro-level conflict analysis in a quantitative manner during the Bosnian War by categorizing violence in each canton, then aggregating that information into a single regression for the entire state. They manage to find a measure of the total number of victims as a percentage of the population of each of 109 municipalities in Bosnia and Herzegovina (Costalli and Moro, 2010, p. 7-8). To distinguish differences in municipalities, Costalli and Moro measure the terrain free from dense vegetation and the amount of urbanized territory (2010, p. 11). They also account for the possibility of intervention from Serbia and Croatia using a dummy variable to indicate if the municipality was on the border of one of those states or if the mu-

nicipality was on the yet-to-be-determined dividing line between the Federation of Bosnia and Herzegovina and Republika Srpska (Costalli and Moro, 2010, p. 11-12). The study finds that the presence of "open terrain" is generally not significant in the aggregated model, but that location of municipalities, especially near borders, does correlate to more violence (Costalli and Moro, 2010, p. 22). The results section concludes that urban areas are not particularly important; yet only three regression models were tested with urban areas where one regression contained a significant correlation (Costalli and Moro, 2010, p. 18, 22). Military balance does in fact lead to additional violence, and income does not affect the levels of violence (none of the 24 regression models found it significant) (Costalli and Moro, 2010, p. 23). Population of a municipality is, however, always important (all 24 regression models found it significant) (Costalli and Moro, 2010, p. 18).

The debate over whether natural resources calm or exacerbate civil conflict is extensive and contentious. Collier and Hoeffler (1998) were essentially the first to produce a paper on the subject when they stated that civil conflicts have definite economic consequences and that such consequences could be measured in losses of natural resource wealth; this is widely known as the "natural resource curse" (see van der Ploeg, 2011 for an overview). Many other researchers have followed Collier's lead in investigating the effect natural resource wealth has on civil conflicts. Weinstein (2005) believes the natural resource curse works with rebel groups as well, destabilizing them and leading less dedicated recruits to join the cause. Ron (2005) dedicated an entire section of the *Journal of Conflict Resolution* to clarifying and articulating arguments for and against natural resource wealth encouraging the onset or duration of civil war. In 2003, Collier provided explanations and case studies to back-up his 1998 paper. The primary measure Collier and Hoeffler (2004) used to represent natural resources was the primary commodity exports of a nation divided by that nation's Gross Domestic Product. Most of his studies then found a positive correlation between natural resource wealth as measured by this formula and longer civil wars (Collier and Hoeffler, 2004). Humphreys (2005) expands this assertion to include agricultural resources such as the presence and quality of farmland and continues to find that agriculture and natural resources both drive civil wars to take place. Echoing these messages, Le Billon (2001; 2003) draws even broader conclusions by stating that the presence of natural resources brings civil war into those regions and helps finance war. Christia (2008) analyzed micro-level interactions of Bosnians during the Bosnian War and found that areas with high natural resource concentrations can help support rebels. De Soysa (2002), Doyle and Sambanis (2000), Renner (2002), Lujala (2008), Casilli *et al.* (2014), Collier and Hoeffler (2005), Collier *et al.* (2004), Englebert and Ron (2004), Ide (2015), and Collier *et al.* (2006) hold similar views based on both quantitative and qualitative research. Hegre and Sambanis (2006) are a little warier about the robustness of the natural resource results, but agree they exist to some extent while Sambanis (2004) wants to focus more on the micro-level aggressions in civil war rather than natural resource wealth.

Ross (2003; 2004a; 2004b) breaks down the concept of natural resources into more precisely defined categories in order to isolate those categories that have a greater impact on the outbreak of civil conflict. He asserts that oil, non-fuel minerals, and drugs are causally linked to civil war breakout, though this is a link that comes via a variety of mechanisms (Ross, 2004a). Gemstones, for example, are linked to promoting a longer duration to civil conflict, while oil reserves only contribute to promoting the onset of war (Ross, 2004b). Lujala *et al.* (2005) identifies diamonds as a prominent factor aside from oil that can encourage the onset of civil war (also see Snyder and Bhavnani, 2005). Ross (2003) does make sure to emphasize that there are possibly spurious factors that promote natural resource wealth as being the true cause of civil wars. Among these, he identifies poor economic performance associated with large quantities of natural resource extraction and the separatist divides incited by pockets of a country rich in natural resources (Ross, 2003). Fearon and Laitin (2003) confirm Ross' (2004a) conclusions about the influence of oil exports.

Buhaug and Gates (2002) and Casilli *et al.* (2014) specifically identify the geographic location of natural resources as an important predictor of future civil conflict. This was the reason to add a distance measure to the regression to account for the increased likelihood of an attack when oil reserves or fields are located near the border of a country or, in this case, of an ethnic majority. In a more specific study, Lujala (2008) states that the duration of a conflict is doubled if oil or natural resources are located in significant quantities within the conflict zone.

Collier and Hoeffler's (1998) positive connection between natural resources and civil war stimulated a number of researchers to show the opposite result. Fearon (2005) directly attacks Collier and Hoeffler (2004) by stating that their conclusion about the correlation between natural resources and civil war was fragile and showed no indication of causation. Brunnschweiler and Bulte (2008) and Humphreys (2005) emphatically declare that a larger presence of natural resources shortens the length of the civil conflict. In fact, the concept that natural resource levels then promote or dissuade civil conflict may, Brunnschweiler and Bulte (2008) say, be an example of reverse causality. Mitchell and Thies (2012) agree, concluding that war lowers resource production. Thies (2010) continues this argument using a statistical analysis to find that primary commodity exports indirectly affect state capacity, but state capacity is unrelated to civil war onset. Taking a slightly different angle, Stoett (2005) admits that the Bosnian War especially caused a lot of ecological damage, but that the War provided a respite from rampant deregulation in Bosnia that was leading to massive exploitation of natural resources. De Soysa concluded differently in 2002, but now with Neumayer (2007), De Soysa finds that neither oil nor energy wealth predict civil war onset, though, with a small threshold of twenty-five battle deaths, energy wealth becomes a significant factor. Still, De Soysa remains more skeptical than the rest of this group at the precise conclusion to draw. The econometric model used in this study was informed by: Alexander and Harding's (2006) emphasis on poverty and income, De Soysa and Neumayer's (2007) focus on disaggregated mineral and energy wealth, Morelli and Rohner's (2014) oil resources model, and Ross' (2004b) caution about spurious and misspecified natural resources wealth models in conflict situations.

## THEORY AND HYPOTHESIS

I hypothesize that there is a positive correlation between the intensity of fighting during the Bosnian War and natural resource wealth. If this is indeed the case, we can assert that natural resource wealth may have played a role in shaping the structure and flow of the Bosnian War. The War would have occurred regardless of the location of natural resources throughout Bosnia and Herzegovina, but specific, targeted attacks may have been influenced by natural resource wealth.

## DATA AND UNIT OF ANALYSIS

This research has many challenges, not the least of which is defining what is meant by "natural resource wealth" and "fiercest battles." Before addressing these measures and the various ways I have found to account for the independent variables and controls, a few words about the availability of data, the quality of data, and the unit of analysis are in order. Quite simply put, the National and University Library of Bosnia and Herzegovina was shelled during the Bosnian War in 1992 and burned to the ground. From 1992 until 1996, no national library existed. Eventually, the library was reconstructed and re-opened in 2014, but virtually all records about the former Yugoslavia and those that would be relevant for study during the Bosnian War were lost or not recorded. Further, statistical records for Bosnia and Herzegovina did not exist from the fall

of Yugoslavia in 1989 until the Dayton Agreement in 1995. Eventually, in 2004, the Agency for Statistics of Bosnia and Herzegovina was created and statistics were compiled as far back as 1996. Adding to the complicated mess, the Federation of Bosnia and Herzegovina has its own statistical agency, the Institute for Statistics of the Federation of Bosnia and Herzegovina, while Republika Srpska maintains its own separate agency, the Institute for Statistics of the Republika Srpska. These agencies do not necessarily collect the same information in the same way. Therefore, even finding data about the period from 1992 to 1996 in Bosnia and Herzegovina especially for a topic such as natural resources, is exceedingly difficult.

This challenge is compounded by the choice of a unit of analysis. Statistics for the aggregate Bosnia and Herzegovina are useless for this project. Instead, the study needed some smaller political division to measure fighting intensity and natural resource wealth. I quickly determined that collecting information about individual cities was impractical because there are so few cities in Bosnia and Herzegovina and pinpointing a city on an unlabeled map (the form most of the data came in) was difficult. Thus, the unit of analysis moved to the Bosnian corollary to a county. In Bosnia and Herzegovina, these areas are called cantons, they are well established, and whatever statistics exist are usually broken down by canton. However, such easy divisions really are unnamed in Republika Srpska, so this presented a further problem. Ultimately, we use the ten cantons in the Federation of Bosnia and Herzegovina, the independent district of Brčko, and the seven county-like divisions in the Republika Srpska.

Quality of data varied wildly. Much of the data was gleaned from maps of varied quality and granularity. These maps typically did not have the political divisions like cantons marked on them. In some cases, precise statistics were available about a political division. These statistics were often from a time period different from 1992 to 1995 simply because a lot of natural resource data was not available during that time. It was generally assumed that natural resources consumed from 1992 until the year in which the statistic was measured either did not change significantly or changed relatively constantly over all the political divisions (which will herein be called “cantons” for simplicity).

There are a number of possible dependent variables from which to choose. The first is what we will call the number of “Conflict Points,” or instances of troop movements, that occurred in a particular canton during the entirety of the War. The following sources were used to count the number of Conflict Points: Burg and Shoup, 1999; Bildt, 1998; Holbrooke, 1998; Izetbegović, 2003; Kadrijević, 1993; Marković, 1996; Owen, 1995; Yelesiyevich, 2006; and Yelesiyevich, 2014. These sources were comprehensive enough to provide a listing of cities where troops moved during the War. A second measure of the amount of conflict that occurred in a given canton is the number of “Peacekeeping Events” that took place during the period of 1992 to 1995. This number was generated from the official United Nations Protection Force reported events as part of a map created by the London School of Economics and Political Science. Also from the London School, the measure “Victims/Population” is a measure of the percentage of people in a given canton who died during the War. A similar measure, the number of “Dead or Missing” represents those who were reported as casualties or missing during the War. This measure was generated by the University of Colorado, Boulder. Finally, the measure “Mined” represents the percentage of the canton that was mined during the War (some of these mines are still active), as reported by the Bosnia and Herzegovina Mine Action Center, a government agency.

As previously mentioned, there are myriad ways to measure natural resource wealth in a particular area, and it seems logical that a combination of these measures will provide the best overall representation of the true natural resource wealth. The number of major rivers running through a canton was recorded off of a standard map of Bosnia and Herzegovina produced by the Maps of the World company. The net change in forest land in each canton, measured in hectares, was calculated based off of maps from the group Global Forest Watch. The number of dams, major industries (hydro, thermal, mineral deposits, mining operations),

and the hydro or thermal capacity in Megawatts are all from officially published sources. The amount of wind energy is measured in meters per second and averaged throughout the canton as is the amount of solar radiation in a canton in kWh/square meter. These numbers are all derived off of maps. The annual coal production and reserves are all officially published values measured in millions of tons per canton. Additionally, the land was broken up into forest, pasture/valley, or mixed use and each was reported as a percentage of the total area of the canton as read off of several maps. Elevation of the largest city in a given canton in meters was also recorded from official government sources.

Finally, there were many controls added to the analysis. First were controls for the size and population distribution of the canton. These included the number of cities and towns as marked on official government maps, the total area of the canton as measured in hectares by computer drawing, the total area of the canton as reported by official government statistics in square kilometers (these do not exist for Republika Srpska), the population of the canton in the 2013 census, and the population density of the canton as calculated by the census. Additional controls focused on ethnic and economic differences between cantons including the ethnic distribution (Muslim, Serb, Croat, Yugoslav/other) of the canton in percentages in 1991, the Gross Domestic Product per capita in 2013 in Bosnian Convertible Marks (estimated if necessary based on population), the absolute child poverty rate as reported by Yekaterina Chzhen for UNICEF and the University of York, the percentage of people in the canton at risk for poverty or who were extremely poor in 1997 as reported by Marcelo Bisogno and Alberto Chong, the Gini index of income inequality in 1997, the number of rail lines crossing the canton, the calculated distance in kilometers from Sarajevo to the largest city in the canton (a measure of accessibility), and the calculated distance in kilometers from the Serbian boarder or Banja-Luka (whichever was shorter) to the largest city in the canton.

## ANALYSIS

This analysis begins by computing bivariate correlations between all variables and looking for instances where these correlations are significant. The goal is to reduce the number of possible independent variables for each given dependent variable in order to perform some sort of meaningful analysis on each dependent variable.

Listed below are the significant correlations between given dependent variables and all independent variables:

- Conflict Points: Rail Lines, RS Distance, GDP per capita
- Peacekeeping Events: Dead or Missing\*, InDead\*, Dams
- Victims/Population: Forest, Poverty Risk (Poor)
- Dead or Missing: InPopulation, Towns, Rivers, Total Area, Peacekeeping Events\*, InDead\*, Population<sup>x</sup>, Dams, Forest Gain
- InDead: InPopulation, Towns, Rivera, Area\*, Total Area, Major Industries, Forest, Dead or Missing\*, Peacekeeping Events\*, Population<sup>x</sup>, Dams, Forest Gain
- Mined: GDP per capita, Other, Density<sup>1</sup>

<sup>1</sup> Where:

\* refers to an indicator that is also another dependent variable. These variables are not used as explanatory variables because they measure roughly the same concept as the given dependent variable.

<sup>x</sup> indicates that the Population and InPopulation variables were both significant; thus, InPopulation was chosen because the natural log is often more resistant to heteroskedasticity.

<sup>+</sup> indicates that the Area and Total Area variables were both significant. Total Area was chosen because this variable is more complete across the cantons.

For each dependent variable, we run regressions with combinations of the significantly correlated independent variables until we find the model that is both highly explanatory and passes the most specification tests for the given dependent variable. The  $\ln\text{Dead}$  dependent variable produces best overall regression model that explains the most variation in the data and passes all specification tests, *Equation 1*.

$$\ln\text{Dead}(y) = 6.094 + 0.165\ln\text{Population}(x) + 0.075\text{Towns}(x) + 0.801\text{Forest}(x)$$

$$t = (9.531) \quad (2.669) \quad (2.659) \quad (2.262) \quad R^2=0.766 \quad DW=2.347$$

**Equation 1.  $\ln\text{Dead}$  Regression Model**

Source: Own work.

*Equation 1* has an adjusted  $R^2$  of 0.716, which means that seventy-one percent of the variation in the percentage of individuals who were dead or missing within a particular canton can be explained by the independent variables. For every additional town in a given canton, we can expect to see a  $e^{0.075}=1.078$ , so a 7.8% increase in the number of dead or missing in that canton. Similarly, for a one percent increase in the forest cover in a canton, we can expect to see a 123% increase in the number of dead or missing in that canton. This is an important result. Recall that a one percent increase in forest cover necessitates a one percent decrease in mixed use land and pastures/valley within the canton. It is unclear, therefore, if the forests themselves cause the correlation or if the decrease in mixed use and pastures/valley causes the correlation. Finally, for a 10 percent increase in the population of a canton, we can expect to see a 1.65% increase in the number of dead or missing in that canton. The F test and individual t-tests are clearly significant. Additionally, the Variance Inflation Factor is below ten for each independent variable, so there is no notable multicollinearity.

We wish to verify if there are no problems or general misspecification issues with this model. The Durbin-Watson of 2.347 looks promising for failing to reject the null hypothesis that there is no autocorrelation ( $p>.05$ ). We perform a White's test find no evidence of heteroskedasticity in the model ( $p>.05$ ). Lastly, both versions of the Ramsey RESET test for generic misspecification are easily passed, ( $p>>.05$ ). Together, we can identify no statistical problem or misspecification of our regression model, *Equation 1*.

I also calculate robust standard errors to be sure that all independent variables remain statistically significant if there is some unidentified violation to the classical regression assumptions. All the t-tests hold up to these robust standard errors, so we can be yet more confident that the importance of these variables is not some statistical fluke.

## COMPARISON OF MODELS

*Table 1* compares the "best" models from each dependent variable and includes two models for the  $\ln\text{Dead}$  dependent variable. In *Table 1*, 'IV' refers to the number of independent variables in the given model, 'R<sup>2</sup>' is the adjusted R<sup>2</sup> value, 'F' denotes the overall F test, 'T' denotes the individual t-tests, 'VIF' refers to the Variance Inflation Factor which measures multicollinearity, 'D-W' is the Durbin-Watson test for autocorrelation, 'VCE' means robust standard errors, 'White' refers to the White's test for heteroskedasticity, 'Ramsey' refers to both versions of the RESET test for general model misspecification, 'Resid.' examines the residual plot for patterns, and 'Causal Logic' describes whether there is a logical argument to support the independent variables affecting the dependent variable. In all cases, 'Pass' means that a particular model showed no signs of the model problems that the test was examining.

Table 1

Independent Variable Models with Specification Tests

Model Name	IV	R <sup>2</sup>	F	T	VIF	D-W	VCE	White	Ramsey	Resid.	Causal Logic
InDead	3	0.716	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Plausible
InDead w/Dams	4	0.769	Pass	Pass at 0.1	Pass	Pass	Fail	Pass	Pass	Pass	Plausible
Dead	2	0.746	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Less Plausible
Victims	1	0.370	Pass	Pass	N/A	Pass	Fail	Fail	Pass	Fail	Not Plausible
Peacekeeping	1	0.248	Pass	Pass	N/A	Pass	Fail	Fail	Fail	Fail	Vaguely Plausible
Conflict Points	1	0.242	Pass	Pass	N/A	Pass	Fail	Pass	Pass	Fail	Not Plausible
Mined	1	0.802	Pass	Pass	N/A	Pass	Pass	Pass	Pass	Fail	Vaguely Plausible

Source: Own work.

The InDead model passes all tests with three independent variables and an R<sup>2</sup> of 0.716. This is our most plausible model.

The InDead with Dams included as an independent variable fails the t-test for Dams at an alpha of 0.05. However, it passes at 0.10, so this is not a huge issue. More concerning is that the robust standard errors are not all significant, so now Towns could not be significant. Removing Towns then results in a three independent variable regression with a lower R<sup>2</sup>, so there is no obvious advantage to this model over the previous InDead model. If we had been able to keep all four independent variables in the regression, we could have claimed that we had added some information to the regression, but because the significance of two independent variables is suspect, this is not a fair representation of these data.

The Dead model passes all specification tests and can be considered an adequate model. The R<sup>2</sup> of 0.746 is about the same as with the previous two regressions. As we will see, the limited number of independent variables may be concerning.

Relying only on Poverty Risk, the Victims model fails many specification tests. First, the standard errors are not even robust. This means that there really is no purpose in analyzing this regression further because the single independent variable is not significant. Additionally, White’s test and the residual plot show that there is heteroskedasticity in the model. The R<sup>2</sup> of 0.37 is unsurprisingly low.

Like Victims, the single independent variable of Dams in the Peacekeeping model was not robust. This was the single model that also failed the Ramsey RESET test that indicates variables are omitted. Additionally, White’s test and the residual plot show that there is heteroskedasticity in the model. The R<sup>2</sup> of 0.248 is likely random chance.

If there were to be a very random perceived correlation, it might be this poor one between Conflict Points and the number of Rail Lines. Again, the independent variable is not robust. The presence of heteroskedasticity is a bit more mixed in this situation since the model passes White’s test, but fails the residual plot.



That the Mined model could achieve an  $R^2$  of 0.802 with only population Density as an independent variable is evidence enough that the standard errors are skewed and the regression is heteroskedastic. The residual plot also shows this. Somewhat surprisingly, White's test comes out okay.

## CAUSATION AND SUPPORTING EVIDENCE

In the lnDead model, the independent variables are: the logarithm of the population, the forest cover in the canton (in percent), and the number of towns. Are these variables likely to cause increases in the percentage of dead or missing in a canton when they are increased? There is definitely causal evidence to back these variables up.

Population and Towns go hand-in-hand. More of both indicates that the canton is likely of more importance because it holds many towns and many larger towns. Such areas concentrate population so that killing higher percentages of people in a canton is easier with much of the population of the canton residing in a town. Large population towns likely have infrastructure that will help whichever side captures the most area in the canton have a strategic advantage in fighting in neighboring cantons. Additionally, each town captured can be declared a victory by the side that captured the town. This adds to a narrative of propaganda that a particular side is winning and seems more convincing than just taking territory without towns or population. Population centers are also likely to have more ethnic diversity or at least more population from each ethnic group. Thus, the attacking side could use this as a strategic reason to attack a particular town in order to "rescue" people of the same ethnicity.

The Forest variable represents a natural resource, but it could also be a confounding variable in the regression. It can be used to argue that natural resource wealth was a significant factor in the locations chosen for attacks, but this can take on two major meanings. The first is that forest cover provided hiding places for attackers. It is much harder to track mass movements of forces when these movements are conducted in heavy brush and forest cover. Forest cover generally favors small bands of guerillas that know the land well. Mladić was infamous for his knowledge of military strategy and of the terrain of Bosnia. We might easily conclude that since the Republika Srpska army was attacking a Bosnian held area, the Serbs were unfamiliar with the territory. However, recall that Serbs and Bosnian Muslims were living together in every city in Bosnia before the War started. Thus, both sides were familiar with terrain, but the attacking force definitely gains a strong advantage by selecting a place with more forest cover in order to provide an element of surprise.

Additionally, we are using the percentage of dead or missing in a canton as an indication of the level of violence in that canton. I think this is a reasonable proxy variable; however, I would note that the data does not specify whether the definition of someone dying in a canton reflects any person from any canton physically dying in a given location or whether it represents a person with a permanent address in that canton dying during the War. We therefore conclude that there is significant causal logic to support this regression model.

In the lnDead with Dams model, we need only to determine whether the number of Dams variable is likely to cause more dead or missing in a given canton. There are several ways to interpret the number of dams. One is as an indication of infrastructure where infrastructure implies populated areas, which would mean that Dams is another way to represent the number of towns or the population of a given canton. A second interpretation is that a dam represents a significant water source, a natural resource, which is valuable. Lastly, a dam could represent an infrastructure investment where infrastructure is a valuable component to secure in a war effort. In any of these cases, adding the number of dams to the previous regression analysis makes sufficient causal sense.

The same possible interpretations of Towns and Dams are possible with the Dead model; however, it is harder to convincingly see that these two factors alone will be enough to cause more significant numbers of dead in a given canton. Under the assumption that Dams represents a population indicator, we are simply saying that population centers are conducive to higher levels of violence. This is a somewhat obvious, but seemingly incomplete solution. Under the assumption that Dams represents an infrastructure component, we are explaining a variable significantly related to actual population since high levels of infrastructure are unlikely to occur in a canton with little population unless water is trucked or piped very long distances to population centers outside of the canton. Thus, only when Dams represent true water resources does a regression with Towns add more than a simple analysis of population concentrations.

It is much harder to create causal logic that links poverty risk with an escalation of violence in a particular canton in the Victims model. Individuals who have less income are not necessarily more likely to be attacked. In fact, this does not really make sense, as the richer areas would be more likely to be attacked. One possible explanation is that poverty risk is really a variable that masks population or towns because those places will be likely to have more lower income residents. However, this is an extremely tenuous connection.

The ability of Dams to solely be able to predict an escalation of violence through Peacekeeping operations within a canton is vaguely plausible, but not very. If Dams encapsulates both population and infrastructure as well as water resources, this is a plausible situation. There is some evidence that Bosnia has poor water transportation infrastructure, thus making dams valuable resources. However, it is hard to say that dams alone can encapsulate all the variation in the number of peacekeeping events in a canton.

Rail Lines are definitely not indications of natural resources in the Conflict Points model. More rail lines may correlate with population centers, but the variability present in this variable is not enough to constitute using it to explain the number of conflict points in a given canton.

Population density is a vaguely plausible measure of the percentage of a canton that has been Mined. More population density indicates a city or town, which in turn indicates a more valuable target that may have enemy military supplies contained within it. However, again, that the percentage of a canton that was mined could be explained merely by the population density is unlikely.

## AN EXPLORATION OF FACTOR ANALYSIS

Factor analysis is a branch of econometrics designed to isolate “principal components” within a number of related variables in order to reduce the number of variables within a regression. This increases the number of degrees of freedom within a regression and, even more importantly in this case, lets us clump natural resource variables together in order to find if the aggregate of natural resource variables is significant within the regression. The set-up involves grouping variables into three categories: natural resources, dependent variables, and other. We run a separate factor analyses for each of these categories in order to minimize the number of significant variables within the regression.

First, the Natural Resource variables were: Rivers, Forest Gain, Forest Loss, Forest Net, Dams, Wind, Solar, Coal Annual, Coal Reserves, Hydro/Thermal, Forest, Pastures/Valley, Mixed, Elevation, and InElevation.

The Other variables were: Towns, Total Area, Area, Major Industries, Rail Lines, Muslim, Serb, Croat, Other, Population, InPopulation, Density, GDP per Capita, InGDP, Child Poverty, Poverty Risk Extreme, Poverty Risk, Gini Index, BIH Distance, and RS Distance.

The Dependent variables were: Conflict Points, Peacekeeping Events, Victims/Population, Dead or Missing, InDead, and Mined.

A factor analysis requires that the determinant of the correlation matrix between all the possible factors to be non-zero. If the determinant is zero or extremely close to zero, the factor analysis will likely be misspecified.

Additionally, there are two tests that validate the significance of a given factor analysis. The first, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) represents the level of variation accounted for in the factor analysis model. A result for the KMO test over 0.5 is generally considered adequate.

Bartlett's Test of Sphericity is a  $\chi^2$  test that determines whether the correlation matrix is different from the identity matrix. Both of these tests should be validated before the factor analysis is deemed adequate. In order to generate this appropriate matrix for the variables, some of each of the Natural Resource, Other, or Dependent variables had to be eliminated to get a non-zero correlation matrix that passes each of the tests.

## NATURAL RESOURCE VARIABLES

In *Table 2* we see that the determinant is above zero. Additionally, the KMO test is above 0.5 and the Bartlett Test demonstrates that the matrix is different from the identity (which is the null hypothesis). Thus, we are free to proceed with the analysis.

The Communalities table shows the percentage of each variable encapsulated in the factor analysis. Generally, values of extraction should be over 0.5 in order for the factor analysis to encapsulate all the variables. That is the case for this model.

The Rotated Component Matrix normalizes and iterates the Component Matrix to produce a final representation of each initial variable as it splits into components.

Table 2

Natural Resource Components  
KMO= 0.536, Bartlett's Test=0.019, Determinant=0.005

Rotated Component Matrix			
	Component		
	1	2	3
Rivers	0.578		0.532
Wind		0.610	
Solar		-0.769	
Forest	0.578		
Major_Industries			0.882
Hydro_Thermal			0.845
Dams	0.552		
Forest_Net	0.905		
Elevation		0.899	
Pastures_Valley	-0.718	0.542	

Source: Own work.

From here, we save the three new components that encapsulate adequate information about all ten natural resource variables with the following names: NR\_1, NR\_2, and NR\_3 and repeat this analysis for the other and dependent variables.

**OTHER VARIABLES**

In *Table 3* the three components were saved as: O\_1, O\_2, and O\_3.

Table 3

Other Variables Component Matrix  
 KMO=0.518, Bartlett's Test=0.002, Determinant=0.007

Rotated Component Matrix			
	Component		
	1	2	3
Towns	0.898		
Total_Area	0.820		
Rail_Lines	0.505	0.601	
Major_Industries	0.749		
Muslim			-0.562
Serb			0.737
Population	0.874		
BIH_Distance		-0.831	
lnGDP		0.590	0.610

Source: Own work.

**DEPENDENT VARIABLES**

In *Table 4* the purpose is to find a principal dependent variable to encapsulate all the different ways I attempted to measure high levels of violence and fighting within a given canton. Although Bartlett's Test of Sphericity is not passed at either a 0.05 or 0.1 level of significance, this was the best combination of the possible dependent variables. I saved these components as: D\_1 and D\_2.

Table 4

Dependent Variables Component Matrix  
 KMO=0.508, Bartlett's Test=0.118, Determinant=0.504

Rotated Component Matrix		
	Component	
	1	2
Conflict_Points		0.790
Mined		0.800
Peacekeeping_Events	0.880	
Dead_Missing	0.902	

Source: Own work.

**REGRESSION ANALYSIS OF THE FACTOR ANALYZED COMPONENTS**

We have now reduced the number of variables in the regression model to three natural resource variables, three other variables, and two additional combined dependent variables. The remaining analysis seeks to examine the combined and original dependent variables in order to see which dependent variables may have significant independent variables in them. First, we run a bivariate correlation with the three natural resource and three other variables and all the possible dependent variables as shown in *Table 5*.

Table 5

Significant Independent Variables for Given Dependent Variables

DV	D_1	D_2	Conflict Points	Peacekeeping Events	Victims Population	Dead Missing	InDead	Mined
Significant IV	NR_1*, O_1*	O_2**	O_2**, NR_3*	None	None	NR_1**, O_1****	NR_1*, NR_3**, O_1****	O_2*

Significance: \*at 0.1, \*\*at 0.05, \*\*\*at 0.01

Source: Own work.

Now, we isolate the significant variables (*Table 5*) with each dependent variable in a separate regression and see if any regression provides a significant and well-specified model. The only model without specification issues is using Dead or Missing as the dependent variable (*Equation 2*).

Though the residuals in the Dead or Missing model do initially look concerning, we note that there is really just one outlier. The other points are fairly evenly distributed around the origin. The model also passes all basic tests, so we consider it later for further analysis.

$$\begin{aligned}
 \text{Dead\_Missing}(y) &= 8.527.778 + 2369.512\text{NR}_1(x) + 3957.125\text{O}_1(x) \\
 t &= (8.384) \quad (2.154) \quad (3.597) \quad R^2=0.622 \quad DW=2.044
 \end{aligned}$$

**Equation 2. Dead or Missing Regression Model**

Source: Own work.

The standard errors in the two independent variables remain robust. We fail to reject the null hypothesis in White's test. The Bruesch-Pagan/Cook-Weisberg test is a more general test for heteroskedasticity. The null hypothesis is homoscedasticity, and we fail to reject the null hypothesis. The model also passes all omitted variables tests.

We now seek to actually interpret what the regression coefficients in the Dead or Missing model mean. Obviously, the addition of one NR\_1 unit increases the number of dead or missing in a given canton by 2369 and the addition of one O\_1 unit increases the number of dead or missing by 3957. Note that the signs on both of these variables are positive, which follow our intuition. Let us try to break down exactly which original independent variables are most important in these factors.

Recall the Rotated Component Matrix for Natural Resources from earlier. First, we will cluster the most important variables in each component. This results for NR\_1 in: Rivers, Forest, Dams, Forest\_Net, and Pastures\_Valley. For NR\_2: Wind, Solar, and Elevation. For NR\_3: Major\_Industries and Hydro\_Thermal.

All factors can be expressed as proportions of their loading variables. For NR\_1 that is  $NR_1(y) = 0.578Rivers(x) + 0.578Forest(x) + 0.552Dams(x) + 0.905Forest\_Net(x) - 0.718Pastures\_Valley(x)$  where  $x$  is a given canton. The absolute value sum of the variables in the component is 3.331. We then divide the high loadings of each variable by the sum of the high loadings to find the percentage each initial variable influences the component. Rivers and Forest are both 17.4%, Dams is 16.6%, Forest\_Net is 27.2%, and Pastures\_Valley is 21.6%. These percentages are fairly close to each other. We say that Forest\_Net (a measure of the recent forest activity in a given canton) is the most influential, with Pastures\_Valley slightly less influential, followed by Rivers, Forest, and Dams all at about the same level.

In some sense, we validate the best regression model found earlier without the benefit of factor analysis. Forest cover and Dams remain important variables in the regression. Measures of water resources and non-developed land (that is not mixed use land) are the most critical variables in predicting violence in a given canton.

## DISCUSSION

The Bosnian War clearly started because of ethnic tensions and attempts to grab land to create ethnically homogenous states. However, the ethnic factor did not direct where opposing sides attacked during the course of the War. Instead, the Republika Srpska and Bosnian (including Croatia for most of the War) armies focused on population rich locations with natural resource based industry and specific land uses. Of course, war activity in a particular canton was, in part, dictated by the size of that canton. Population centers were likely to be the centers of resistance movements and represent the more valuable land areas within a canton. While taking empty land was of some importance, there was little to be gained strategically by taking such land. Land with lots of population could put up a more coordinated defense, but this land was also likely to have a more mixed ethnic population, so there were likely ethnic groups within the population center that would defect from protecting the city and aid the army trying to take it over. Plus, capturing populated territory was a recruitment tool and propaganda device. Dams and Major Industries represented the desire of armies to take strategically important natural resource infrastructure locations. In the case of Major Industries, the natural resources themselves were not critical to the armies; rather, they gained an advantage by preventing the other side from having these resources and earned a major symbolic victory. Additionally, control over electricity and water resources in a canton that an army had invaded allowed them to shut-off access to these resources to the opposing forces while the army stayed supplied. This became a further strategic advantage in attacking major industrial sites. Dams were also important for their connection to water resources. As rivers were also a significant factor in this regression analysis, water resources, though they were not scarce in most parts of Bosnia, were hard to transport. Water resource infrastructure was (and remains) some of the worst in the world. For this reason, easy access to rivers or dams gave an advantage to the invading army and access to dams prevented opposing forces from having access to this water. Because the water transportation infrastructure was so poor in Bosnia, controlling the rivers and dams gave an army a major advantage, so armies were likely to focus attacks on areas with these features. Finally, the type of land mattered. Forests provided natural resources that can be used for hiding troops from detection of the opposing army. Additionally, however, forests and pastures and valleys significance indicated that good quality land was important for these armies. Recall that each army wanted to claim as much land as possible for their ethnically homogenous country. We now know that the quality of the land mattered a good amount. Mixed-use land was the land already occupied by some structure or already developed. Both sides were seeking land that they could use to be profitable later. Whereas the importance of forests could be a military tac-

tic as well as a natural resource concern, pastures and valleys could only be associated with natural resource importance. Thus, we conclude that armies prioritized fighting over land that was high quality in order to try to secure future natural resource benefits. This narrative fits with wanting natural resource industries for future production purposes instead of actually valuing the mineral resources specifically available at the time the industry was captured. Water was used as both a military tool and a future natural resource benefit.

We do initially seem to challenge one of Costalli and Moro's (2010) claims. Though our conclusions about the importance of income and population completely agree and urban areas mostly agrees with their research, their conclusion that open areas were not important in determining violence in municipalities in the War contrasts with our conclusion about the importance of Forests increasing violence. Several possible reasons exist to explain these differences. First, we should caution that there were only 18 in this regression model, compared to Costalli and Moro's (2010) 109 municipalities. Our research compared dependent variables to measure the level of violence in a canton and found that Costalli and Moro's (2010) measure of victims as a percentage of the population did not produce the most statistically robust results. We also note that the facts that forests were particularly important in our analysis and open areas particularly unimportant in Costalli and Moro's (2010) analysis are not necessarily contradictory. This analysis did find that pastures/valley were sometimes correlated to the level of violence in a canton, but that mixed use land was not. Costalli and Moro (2010) did not study the presence of forests or other natural resources, so their conclusion about open areas does actually disagree with our conclusions. Thus, the validation of a study with much more data does provide some additional robustness to our analysis.

## CONCLUSIONS

This multiple regression analysis has provided plausible support for the importance of natural resources in influencing the course of the Bosnian War. Natural resources both strategically deprived the opposing army from adequate land and water during the War, but also ensured that high quality natural resource infrastructure and forest resources were available after the War ended. We also provide support for the obvious connection of population and cities with higher levels of violence in the War.

Our hypothesis that there would be a positive correlation between the intensity of fighting in a given canton and natural resource wealth in that canton found support. Natural resources industry, high quality land (forests and pastures), and water resources as critical components that helped direct the course of fighting throughout the Bosnian War. Though we cannot prove that these factors *caused* the course of the Bosnian War to change or the intensity of fighting to concentrate in areas with these factors (this is impossible without a controlled experiment), we can say that there is a plausible causal logic that connects these factors and increased violence in a canton. That is, our empirical analysis corroborates the hypothesis that there is a positive relationship between the intensity of fighting during the Bosnian War and natural resource wealth.

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