Marking Territory: Modeling the Spread of Ethnic Conflict in Bosnia and Herzegovina, 1992-1995

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Abstract: This paper seeks to understand how civil war develops and spreads, focusing on Bosnia and Herzegovina (BiH). To do this, we explore the variation in nature, severity, and incidence of conflict during the 1992-1995 war. The conflict narrative is coded by type and date of an incident; these data are then related to indicators of pre- and post-conflict population composition, and presence of industrial, transportation, or military infrastructure. We then use OLS and IV regressions to attempt to identify the community determinants of where and when fighting occurred. We find that ethnic composition is the primary initial determinant of conflict type and intensity, with more diverse communities suffering more conflict and greater intensity of fighting. We conclude that analysis of post-conflict economic development needs to control for the variation in pre-war ethnic diversity and differences in pre- and post-conflict ethnic composition.

Acknowledgements: We are exceptionally grateful for insightful and creative research assistance on this project from Sabina Nogo, Jordan Rahal, and Gracia Sierra, and to US Army Lt. Daniel Schaffer for an external review of our conflict modeling. Kathryn Anderson, Pawel Charasz, Gregory Price, Mieke Meurs, Ed Tower, along with participants at a seminar at Sophia University and the Southern Economic Association meetings have provided insightful, critical comments from which we have benefited. Remaining errors and inconsistencies are our own.

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I. INTRODUCTION

There is nothing profound in the claim that war is harmful. Nor can it be any surprise that the consequences of war do not end once the violent conflict ceases. Societies must be rebuilt, the maimed and traumatized must be cared for, and even thereafter they likely will be less productive than they would have been otherwise. Distrust among former combatant nations lingers; trade links are disrupted; the most productive members of society – who also tend to be the most mobile – are likely to leave, thereby diminishing productive capacity of the war-torn region; government may be seized by populists or plunderers as civil society falters and once-stable institutions dissolve.

Even for those with only a cursory grasp of history, it is evident that patterns of recovery are not uniform. This is true both for wars between nation states and for civil wars. This observation begs the questions as to why and to what extent the spread and aftermath of wars differ from place to place. Presumably, much of the difference reflects the resilience of civil institutions and initial social conditions.[1] However, the varying nature of recovery – or, put differently, of the long-run consequences of war – must depend on the nature of conflict itself, and that in turn invites case-study analysis. the concept of "war" is not a simple one: war can vary in intensity, duration, and type. Yet, most analysis tends to either treat war as a bivariate event ("presence of war" = 1; "absence of war" = 0) or a unidimensional event ("war intensity" = casualty count, generally of combatants).[2] This strikes us as too simplistic.

Many of the consequences of conflict are obvious: people are maimed and killed; productive assets are destroyed; communications and trade infrastructure are damaged or disrupted. The persistence of these types of consequences across generations has been modeled in the context of high AIDS mortality using an overlapping generations' model of human capital acquisition (Bell *et al.*, 2006). Loss of parents and widespread orphanhood result in reduced schooling and intergenerational transmission of skills and knowledge. Refugee populations impose significant costs – a particularly

[1] For a discussion of cross-country patterns of post-conflict recovery, see Collier and Hoeffler (2004).

[2] Examples include Montalvo and Reynal-Querol (2002); Kouibi, *et al.* (2012); Collier and Sambanis (2002); Polachek and Sevastianova (2012); and Miguel *et al* (2004).

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critical issue in the Bosnian context.[3] Recent work even suggests changes in personality as a result of conflict by reducing risk tolerance in a community (Callen *et al.*, 2014).

Among the various types of conflict and damage, landmines have been singled out for potential lasting damage, in large part because they remain live ordnance unless disarmed, which is an arduous and expensive task. It is estimated that the laying of landmines reduced Bosnian agricultural potential by 11%, and that food security and intra-family relationships also declined sharply among affected households.[4] These large effects appear even though the average lethality of blasts in Bosnia, where the average blast killed 0.54 persons and injured 1.40, was lower than in some of the comparator countries, such as Afghanistan, Cambodia, and Mozambique.

The onset of civil war is complex: the literature suggests that while there is no single precipitating cause, settings need to be divided between "marginalized developing countries" that are in fact failing to develop, and others that are caught in a "conflict trap."[5] Bosnia falls into the latter group that has experienced economic growth, but still has unresolved, smoldering conflicts from the past that have not been completely overshadowed by rising prosperity.

While we ultimately seek to determine the differential impacts on social outcomes of various types of conflict, as well as the effects of duration of conflict exposure, as a first step we must develop a more robust model of the conflict. Thus, this paper develops a quantitative model to describe conflict and explain its spread and evolution. To our knowledge, there have been few attempts to project the spread of civil warfare over time and by type, as the literature is primarily concerned with analysis of onset or end of conflict.[6] This is likely due to the fact that detailed, coded data on intra-war dynamics appear to be nonexistent. Consequently, the literature involves either impressionistic

[3] We use with "Bosnia" and "BiH" interchangeably with the cumbersome but correct designation "Bosnia and Herzegovina."

[4] The consequences in the immediate post-conflict period for a group of countries, including Bosnia, are presented in Andersson *et al.* (1995).

[5] See Blattman and Miguel (2010); Collier *et al.* (2003)

[6] See for example Hegre and Sambanis (2006); Jakobsen *et al* (2013); Yair and Miodownik (2016); Tang (2015); Regan and Frank (2014); Wegenast and Basedau (2014); and Pilster and Bohmelt (2014). There also are occasional predictive articles within countries, such as Schutte (2017), and across countries, such as Danneman and Ritter (2014).

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patterns of the evolution of war gleaned from descriptive case studies, or quantitative assessments based on single measures – usually recorded deaths – of war intensity.

The Bosnia and Herzegovina conflict of 1992-1995 conflict enables researchers to explore the onset and evolution of civil war in a multi-dimensional, causal framework that is missing in prior studies. Key to this is a unique, rich dataset.

Unlike most societies affected by catastrophic civil war, Bosnia was a middle-income country (MIC) that was well-documented, even by MIC standards, at the outset of conflict. Census, school enrollment, and economic data are available for the years prior to the war. They are detailed at the municipal (*opština*) level and tend to record populations by nationality/ethnicity (*nacionalnost*). Furthermore, after the war, Bosnia became a *de facto* UN protectorate for an indefinite period. Consequently, standard data collection returned, albeit in a cumbersome and divided fashion. The first post-war census did not occur until 2013, and publication of its results has been fraught with methodological disagreements. Nevertheless, a series of geocoded panel household Living Standards Measurement Surveys (LSMS) were conducted during 2001-04 under the auspices of the World Bank. Still more remarkable were the efforts of the Survey Action Center (http://www.sac-na.org/surveys.html) to identify and geocode landmines throughout Bosnia, while the Uppsala Conflict Data Program (https://ucdp.uu.se/) has geocoded mortality estimates. For our purposes, the most important data source is the US Central Intelligence Agency's three-volume detailed history of the Yugoslav civil war that includes a dedicated segment on the conduct of the conflict in Bosnia. This history enables us to quantify the history of the war for each municipality, for each of 12 quarters of the conflict, and for each of nine conflict types, plus an indicator of which party to the conflict was on the offense. This information enables us to shine light into the black box of war, and ultimately will enable us to address the impact of different types of conflict as well as conflict duration on disruption to schooling, family formation, fertility, and internal and external migration.

II. RELATED LITERATURE

A paper close to ours in many respects is Weidmann and Ward (2010). They use the Armed Conflict Location and Event Data Project (ACLED) database (https://acleddata.com/#/dashboard) to

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predict both the onset and the spread of civil war in Bosnia. Their paper differs in its more detailed temporal modeling but lesser detail in terms of type of conflict. They delineate conflict events into regions and months, as do we, but simply record events in binary fashion, a limitation we focus on below. Their explanatory variables for predicting conflict include population, ethnic composition, border location, and elevation. Townships with greater population, ethnic heterogeneity, near borders, and in mountainous terrain faced increased risk of initial conflict. Raleigh *et al.* (2010) also provide an overview of ACLED and, along with Raleigh *et al.* (2010a) and O'Loughlin and Raleigh (2008), also provide spatial-temporal analyses of the spread of the Bosnian war. Finally, Perry (2013) uses ACLED data to explore machine-learning techniques as a mechanism for predicting the spread of conflict in African countries: given the idiosyncracies of virtually all regions and periods in BiH, we did not follow this approach below.

Alesina *et al.* (2016) use nighttime luminosity data to show an inverse relationship between ethnic inequality and joint development. Nogo (2012) extends this by conclusively demonstrating that the onset of conflict was linked to ethnic heterogeneity. Consequently, conflict outcomes cannot simply be related to various types of conflict exposure and duration.[7] Rather, we first model the onset of conflict at the local level at a function of plausibly exogenous explanatory variables. Conflict in subsequent periods then depends on both exogenous forces, conflict in neighboring regions, and conflict in prior periods in both own and neighboring *opštine*.

The formal study of warfare goes back to at least the writings of Sun Tsu in the 5th century BCE, making it one of the oldest academic disciplines. However, despite its tradition and longevity, there remains a surprising divorce between professional military study of optimal tactics and strategy, and academic research of instigating causes and bad outcomes. Some of this is likely due to the changing nature of warfare as humanity has developed. Professional armies during the enlightenment

[7] The importance of ethnic heterogeneity in regions of conflict is documented below, and is also found by Nogo (2012). This is distinct from and not necessarily inconsistent with the findings of Fearon and Laitin (2003). They argue that conditions that favor insurgency (weak states, poverty, political instability, rough terrains, and large populations) determine whether outbreaks of civil war but that religious or ethnic diversity do not. However, their paper does no address where fighting will take place once conflict has broken out. Note, too, that while Easterly and Levine (1997) find that ethnic diversity contributes to low growth and to the conditions that favor the outbreak of civil conflict, they do not explore where it will take place, in particular within countries where income levels and growth are lowest.

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gave rise to beliefs about outmaneuvering an opposing force, which lead to new thought by von Clausewitz and others on how to win wars.

Academically, the entire field of game theory grew out of the need to model strategic and nuclear competition. Esteban and Ray (2008) offer a simple game theoretic model of ethnic civil wars; a broad summary of both empirical and theoretical literature is provided by Blattman and Miguel (2010). Since its inception, game theorists developed many different solution concepts to identify stable outcomes and identified paths to reach them. Jackson and Morelli (2011) outline the main theories of how conflict breaks out and spreads, why they occur, and the many paths they take. They analyze the commonalities of conflict and networks of states including incentive structures and cost functions. This justifies the use of rational actors and many different bargaining models and types of bargaining failures resulting in conflict and networks of alliances that factor into these models and decision making. Jackson and Nei (2014) extend the use of game theory to study conflict by linking actors in network architecture. With these theoretical foundations, König *et al.* (2017) develop a model of ethnic conflict and study empirical groupings of actors and introducing a measurement of conflict intensity. These are valuable contributions, pointing further research to understand how conflict, especially ethnic conflict, develops over time.

In addition to game theorists there are now entire graduate warfare colleges that teach strategy to field grade officers. Their objective is to standardize the tactics to reach strategic success, essentially developing agent-based optimal decision making. Chief among these schools in the United States is the development of unified and standardized procedures known as *Joint Publications*, which become a handbook for every tactical, strategic, and logistic process to impose on each problem faced. *Joint Publication 3-0* (1995) establishes the desired phases of combat for American military officers to plan for and achieve. While this directly outlines how combat changes over time, importantly, it only prescribes how combat ***should change*** rather than how combat ***does change***.

Both the ideal and the actual evolutions are, as game theorists answered before, questions of optimization. However, these professional strategists have extended the game theoretic equilibrium to the practical frictions of war. Paret's *New Military History* (1991) broadens the study from pure strategic choice between two commanders to account for economic, social, and cultural determinants in driving wars and developing a more general optimized tactic. Furthermore, in their book *Conflict*

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Dynamics, Cook and Lounsbery (2017) disaggregate civil conflict across time and capacity to develop a more wholistic understanding of conflict. Their efforts allow for dynamic strengths of competitive units, changing over time. Our analysis takes this a step further in treating conflict itself as heterogeneous.

The rise of international organizations and multilateral treaties has given rise to new academic departments focusing on how to prevent war and keep the peace, particularly within ethnic conflicts. The academic literature of wars is particularly robust in looking at ethnic factors. Montalvo and Reynal-Querol (2005) look directly at these factors, empirically correlating ethnic fractionalization to conflict. Nicholas Sambanis (2001) compares ethnic to non-ethnic wars in their leading indicators. War begets war, ethnic violence in neighboring countries have strong tendencies to spill over. His paper focuses its study on the indicators of impending war and the aftereffects, however, understanding the war itself is left for us. Collier's (2007) work on ethnic civil war aims to understand the fundamentals of a stable post-war peace and preventing a new ignition. Similarly, Downes (2006) looks at active sectionalization and its success in stopping ethnic conflict. Bercovitch and DeRouen (2007) broaden the question to look at the determining factors in successful mediation to stop ongoing ethnic civil wars.

Detailed studies on the Bosnian civil war include Beger's (2012) doctoral dissertation on intensity and location of fighting, and Weidmann and Ward's (2008), Weidmann's (2011), Novta's (2016) and Klašnja and Novta's (2016) work on ethnic diversity and the spread of civil war. Alacevic and Zejcirovic (2020) focus on a consequence of importance for our empirical work below – how violence against civilians affects subsequent voter turnout. Empirical studies in other settings that focus on ethnic tensions and ensuing civil wars include Miodownik and Bhavani (2011), who use a cross-country dataset, as do Collier et al. (2009).

Within this rich literature there is a gaping hole between the academic and military literature that fails to answer the positive, rather than normative, question of how ethnic civil wars actually progress beyond consideration of aggregated measures of conflict. In doing so we introduce a novel approach by treating fighting styles, rather than just fighting agents, as heterogenous, and so open up a new field of research into their asymmetric effects.

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We find that Bosnia's patterns of conflict were non-random and that warring parties' objectives can be determined from patterns of fighting. Conventional warfare doctrine dictates that after seizing initiative in a conflict, the first military objective is to gain access to theater infrastructure, such as transport and power grids, airfields, and ports. Attention then turns to dominating the enemy's capacity to resist, and ultimately in the end stabilizing and establishing an alternative civil authority over the territory and population.

However, in a civil war like Bosnia's, the first objective appears to be to secure territory and unite one's supporters into a cohesive geographic entity. This is followed by claiming strategic assets in a second phase, and ultimately either building defensible perimeters or pursuing the destruction of the opponent in a third and final phase, depending on whether the strategic objective is outright victory or a negotiated settlement.

To the extent that the Bosnian experience can be generalized, understanding the geographic patterns and warfare nature of civil conflict, and how these events will spread, is valuable to bodies seeking to counter or stop violence and minimize the associated human suffering. It may also prove useful to the UN and international coalitions seeking to anticipate where conflict might occur and how a civil war might evolve. While a single observation does not offer conclusive evidence, the methodology may hold promise and ultimately lead to deeper understanding of how violent civil conflict disseminates.

We observe distinct patterns of objectives among the parties, and these patterns help us devise a multi-period causal model. Since initial moves in a civil war likely are based largely on territorial rather than economic/ strategic objectives, the onset of conflict to some degree may have occurred in locations that were not distinct in terms of economic characteristics. While the conflict ultimately shifts to strategic and hence more prosperous locations, these were not central at the war's outset. Having identified determinants of initial conflict, evolving objectives together with subsequent period effects from earlier fighting can then be used to map the war's spread.

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III. THE BOSNIAN SETTING

Bosnia is a mountainous country in the Western Balkans: as Figure 1 shows, a large majority of the country is mountainous, with the exceptions being the northern strip near the Sava river and, to a lesser extent, a southern enclave centered around Zenica. At about 51,000 km^2 and with a 1991 population of some 4.2 million it is a small country, reasonably comparable in size and topography, to West Virginia (63,000 km^2 with 1.9 million people) in the USA, and Sinaloa (57,000 km^2 and 2.8 million people) or Puebla (34,000 km^2 and 5.7 million people) states in Mexico.[8] The combination of poor infrastructure and difficult terrain led to significant regionalization that manifests itself through strong dialects and intense regional and sub-regional rivalries. The levels of urban concentration are low; the largest city (Sarajevo) had a 1991 population of only 450,000. The four other major regional centers (Banja Luka, Mostar, Tuzla, Zenica) have populations in the 100,000-200,000 range and, together with Sarajevo, comprise less than a quarter of the population. The overall level of urbanization in Bosnia hovered at around 40% (Bosnia and Herzegovina Statistics Agency). This major city urbanization is low when compared to other small European countries like Austria, Denmark and Croatia, where the capital cities of Vienna, Copenhagen and Zagreb represent 20-25% of the population on their own and usually an even higher portion of the GDP.

[8] Civilian gun ownership rates in West Virginia and Bosnia also appear to be similar today, though it is not clear whether this was the case in the early 1990s. See https://www.gunpolicy.org/firearms/region/bosnia-and-herzegovina.

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FIGURE 1
TOPOGRAPHIC MAP OF BOSNIA AND HERZEGOVINA WITH MAJOR URBAN AREAS AND TRANSPORTATION COMMUNICATIONS

(source: University of Texas online map collection)

The political economy of BiH has been determined by three major factors – external rule, internal diversity and their interaction. Having gradually gained independence from the Hungarian Kingdom, Bosnia's independent medieval state fell to the Ottoman Empire in 1463; henceforth, Bosnia never enjoyed full and unified sovereignty. It was an autonomous *vilayet* of the Ottoman Empire until it was handed to the Austro-Hungarian Empire (AHE) for administration in 1878. After the AHE's collapse after the First World War, Bosnia became a part of the Kingdom of Serbs, Croats and Slovenes which was established by the Versailles Conference in 1919. This composite kingdom was renamed Yugoslavia in 1929. Following World War II, Yugoslavia reemerged as the Socialist Federal Republic of Jugoslavija (SFRJ) – a communist state, within which Bosnia was one of six constituent republics, the others being Serbia, Croatia, Montenegro, Slovenia and Macedonia. At the same time, the Bosnian population was traditionally diverse and divided between Muslim Bosniaks, Orthodox Christian Serbs, Catholic Croats, and a broad combination of others that included

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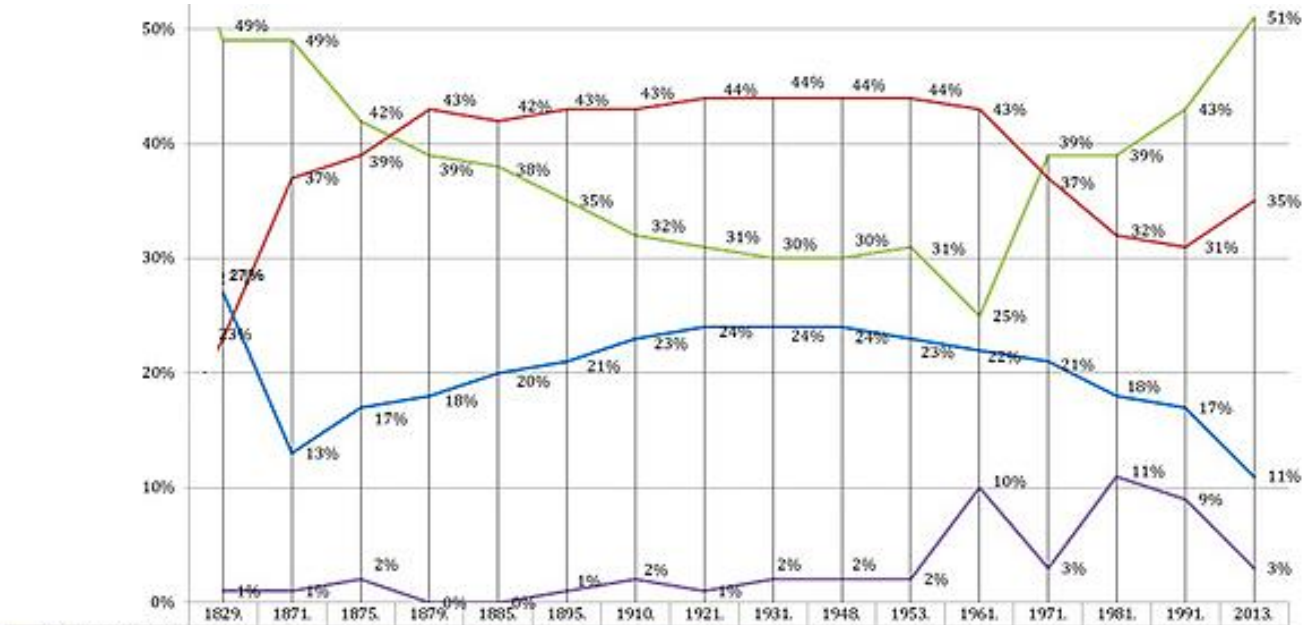
substantial Jewish and Romani groups. Figure 2 shows the population composition of these groups according to census data from 1829 through 2013.

FIGURE 2
BIH POPULATION CENSUSES OVER TIME 1829-2013



	1829.	1871.	1875.	1879.	1885.	1895.	1910.	1921.	1931.	1948.	1953.	1961.	1971.	1981.	1991.	2013.
Muslimani/Bošnjaci	49%	49%	42%	39%	38%	35%	32%	31%	30%	30%	31%	25%	39%	39%	43%	51%
Srbi	23%	37%	39%	43%	42%	43%	43%	44%	44%	44%	44%	43%	37%	32%	31%	35%
Hrvati	27%	13%	17%	18%	20%	21%	23%	24%	24%	24%	23%	22%	21%	18%	17%	11%
Ostali/Jugosloveni	1%	1%	2%	0%	0%	1%	2%	1%	2%	2%	2%	10%	3%	11%	9%	3%

(source: Federation of Bosnia and Herzegovina Statistical Institute)

The political and economic relationships among these groups varied under the various rulers of Bosnia. Under the Ottomans, Muslim Bosniaks represented the bulk of the urban population, all of the feudal landholders, and a smaller fragment of the rural population, whether serf or free. The Serb population was predominately rural, as were the Croats, though both groups were represented in urban communities as well. Under the Ottoman Empire, Muslims paid a lower tax rate (though they had to serve in the military) which provided an incentive for Islamization, and it is not surprising that Muslims were largely clustered in urban areas where trade and direct influence of the Turkish occupiers was more strongly felt. As the Ottoman feudal reform did not begin until the mid-19th century, these relationships were largely still in place when Austria took over Bosnia in 1878, thereby setting up a drive for land reform in the subsequent decades.

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Following the Catholic AHE occupation there was simultaneously a migration of Muslims to the Ottoman Empire, a migration of Serbs and Croats into urban areas, and an inflow of Catholic populations (notably skilled engineers and administrators) from the other parts of the Empire. Austria's defeat in World War I brought Bosnia under the Serb rule from Belgrade which resulted in another wave of Muslim emigration and, more importantly, significant land reform. Feudal landholdings, largely still held by the Muslim landed gentry, were divided up among their former Serb tenants. Following a bloody civil war during World War II that had both class and ethnic components, Bosnia became a communist state.[9] The subsequent nationalization of private enterprise and other assets hit the nascent urban bourgeoisie particularly hard, and communism-driven urbanization brought another wave of rural migration to urban areas. This wave made Bosnia's cities even more mixed; the communist era also involved transferring the ownership of land and capital to the state. The ethno-spatial picture of Bosnia's population in the 1991 census is shown in Figure 3.

Prior to the 1991 census, communist rule in Yugoslavia collapsed in 1989, and free elections were held in all the republics including Bosnia in 1990. Ethnically determined parties (Bosniak SDA, Serb SDS and Croat HDZ) won a clear majority and formed a coalition government, a strange echo of the last election under Austria-Hungary when ethnically-based parties also dominated the Bosnian parliament set up to govern the "*corpus separatum*" (Table 1). Both the 1990 and 1910 parliaments suffered from the same level of ineffectiveness, though in 1990, unlike in 1910, parliamentary decisions mattered. The broader forces contributing to the breakup of Yugoslavia drove Bosnia toward the historic choice of independence or continued union with Serbia, while at the same time the political leaders were forced to contemplate how to transition the economy from a government-directed to a free market system.

[9] The Second World War resulted in huge population losses in Yugoslavia – up to one million dead out of a population of 15 million. The communist Partisan forces drew from the population at large; they generally fought the Germans and the Croatian fascist Ustaše, who also fought the Serb royalist Četniks, who in turn often collaborated with the Germans. Much of the fighting occurred in mountainous Bosnia and Herzegovina. Ethnic cleansing massacres by the Germans, Ustaše, and Četniks were common, both against populations from major opponents and against relatively powerless minorities (Roma, Bosniaks, Jews, Hungarians). While ethnic hostilities were suppressed in the SFRJ under communist rule, virtually all nationalities emerged with grievances and a latent sense of nationalism that appeared after the collapse of the SFRJ.

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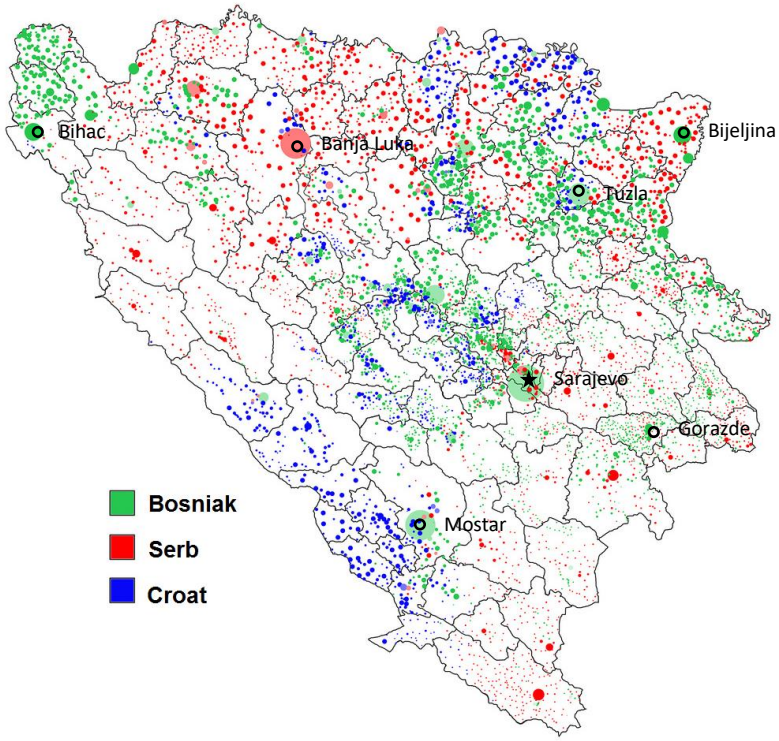
FIGURE 3

ETHNIC AND SPATIAL DISTRIBUTION OF THE POPULATION – 1990 CENSUS



(Source: Federation of Bosnia and Herzegovina Statistical Institute)

Table 1

ETHNIC PARTIES IN FREE BOSNIAN ELECTIONS - 1910 AND 1990

Party in 1910	Seats in 1910 Assembly (unicameral)	Party in 1990	Seats in the 1990 Assembly (upper chamber
Serbian National Organization	41	Serb Democratic Party	38
Muslim National Organization	24	Party of Democratic Action (Bosniak- Muslim)	43
Croat People's Union	16	Croat Democratic Union	23
Others	0	Others	6
Total	71	Total	110

Source: Nolen and Stover, 2011

These transitions set up an opportunity to renegotiate the relative power arrangement among the groups as essentially the entire economy stood to be privatized or, if kept as a state-owned enterprise, placed under the control of politically appointed governing boards and managers. Whether the decisions were made in Sarajevo, Belgrade or Zagreb mattered significantly for the welfare and

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influence of not just the elites in the three groups but also for the general populations. Further complicating the incentives were questions of restitution of nationalized property. These included the significant holdings of the three religious communities, in particular the large land, real estate and enterprise holdings that had been endowed to the Muslim charitable foundations (*vakuf)* throughout the Ottoman rule. These had been either nationalized or redistributed in several waves under the Austrian, Serbian or Communist rule (Halilovic, 2008).

Finally, the two world wars of the 20th century manifested themselves as civil and ethnic conflicts in the Balkans, with significant and brutal atrocities committed against civilians and soldiers by all three groups. These conflicts resulted in deep mistrust among the ethnic groups, who rightfully felt trapped in a repeated game of conflict over land and power that placed a premium on acting first.

Given these incentives, it is not surprising that the Serbs, advantaged by the fact that their ethnic kinsmen in Belgrade controlled the federal army of Yugoslavia (JNA), sought to retain Bosnia within the confines of a collapsing Yugoslavia, even at the cost of war. In contrast, Bosniaks sought the independence of Bosnia, from which they stood to benefit as the largest ethnic group. Finally, the Croats, as the smallest group of the three, hedged their bets between making an alliance within Bosnia and seeking to break off a portion of the country and join with Croatia. In 1991 Bosnia was at the precipice of war, which had already engulfed the neighboring republics of Slovenia and Croatia. Triggered by the vote for independence at a referendum in 1992 (which was largely boycotted by the Serb side), the war in Bosnia would prove to be long and bloody, and would be fought in the environment of an international arms embargo, which had the effect of freezing the distribution of military power at the outset. There are many excellent narratives of the war itself: we refer readers to Woodward (1995), Burg and Shoup (1999), Weidemann and Ward (2008), and O'Ballance (2016); see also Bellamy (1998) for a closer-to-the-ground account.

IV. DATA AND VARIABLES

This paper seeks to explain how conflict starts and spreads. As distinct from conventional models of conflict, we emphasize the importance of measuring an array of heterogeneous conflict attributes and exploring their evolution. As distinct from military histories, we develop a multiperiod model that begins by looking for exogenous explanatory factors, and then models conflict evolution

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as being dependent on both temporal and spatial autocorrelation, as well as shifting incentives. This modeling process has large data requirements that merit detailed explanation.

In order to develop a quantitative model for the war it is necessary to assemble a dataset that integrates a wide range of data sources. With the unit of analysis set at the *opština* (municipality) level, the completed dataset describes the various layers of information – a topographic layer that includes geo-location, urbanization, presence of critical infrastructure; a social layer that includes population size and composition both before (census data) and after (proxied by ethnic party voting) the war, and a conflict layer that includes various proxies for the intensity, nature and timing of the fighting, the number of dead by period and type (civilian *vs.* military), control of the municipality by a given warring party in a particular time period, quantified indicators for the type of conflict that occurred in a given period, and placement of landmines as of the end of the war. The following paragraphs discuss sources and limitations of the various dataset components. Since the conflict layer is of particular interest, we focus on its generation.

Topographic layer – Movement of armies, tactics, military strategy, and conflict outcome depend upon battlefield geography and terrain. To place each municipality in space we geocode the seat of the municipal government in each of Bosnia's 110 municipalities, as identified via their online presence cross-referenced to Google Maps to obtain coordinates of the most densely populated area. After locating the municipalities, the next step is to measure their levels of infrastructure development and economic importance. To capture these effects we create infrastructure variables indicating the presence of power plants, armories, ore mines, major highways, and highway junctions.

We assume that highways are important as major lines of communication and that movement is critical for sustaining protracted military efforts. Due to the poor post-war governance environment in Bosnia, fewer than 100 kilometers of four-lane highway were built in the country since the end of the war in 1995 (Bosnia Systematic Country Diagnostic, The World Bank Group, in draft). This slow pace of increase and improvement in infrastructure allows us to use recent government road maps to closely approximate the highways available during the conflict. In coding highways, we use the 10 major thoroughfares including the "E" designated highways (part of the European corridor network) and the major "M" national highways running through the country. We code for the presence of such roads in a municipality and track municipalities where multiple highways intersected as junctions.

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In addition to highways, we expect the presence of power plants (mostly hydro-electric dams), existing armories, and ore mines to be important for a war of conquest, and we include them as explanatory variables as, given that they augment military capacity, they are likely to provoke initial fighting. Armories and ore mines' measures are dummy variables indicating the presence of one or a cluster of facilities of military significance in a municipality. Due to Yugoslav military doctrine of territorial defense, the armories often contained equipment that was easy to employ with minimal training. The idea was to deter a potential aggressor by forcing it to face an armed and dug-in population in a protracted insurgency rather than a massed army. Furthermore, due to Bosnia's regional location in the former Yugoslavia, much of Yugoslavia's defense industry and key military infrastructure were pre-staged in the region, and so these indicators are also included in a composite variable. The power plant dummy variable indicates the presence of a major power plant in a municipality and is included under the assumption that supply of electricity and control over hydrological resources would be important military objectives. Data on power plants, ore mines, and armories are obtained from the Central Intelligence Agency's (2002) detailed narrative of the war. The strategic importance of these assets in a broader context is explored by Hammond (2018).

A few issues merit mention. We include a measure of terrain unevenness provided by the World Bank database, but cannot be certain that the impact of hilliness is linear. A second concern is with missing observations. There could be small armories that we do not know about or ore mines that were abandoned and not mentioned in the CIA narrative. However, given the carefulness of the underlying studies and data collection, it is likely that we have most of the observable independent variables that were broadly known to all parties and affected their military decisions.

Social layer – In order to study the impact of conflict on human well-being, we need to assess population composition at the war's outbreak. Fortunately, in 1991 there was a comprehensive census conducted to international standards. These data were recorded and preserved during the war, and give us a clear snapshot of prewar demographic structure. Unfortunately, the same cannot be said for post-war and intra-war data. There was no precise census taken at the immediate conclusion of the conflict. In order to get an accurate endpoint on the demographic shifts caused by the conflict we need to find proxy measures closely related to the true population distribution. While no census was conducted between 1991 and 2013, carefully monitored elections were held in 1996 and 1997. We assume that the election results form an accurate substitute for the ethnic composition of post-war BiH. Political scientists have found that in times of crisis or significant political change, political voting

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patterns tend to mirror ethno-nationalist lines – in effect a "rallying around the flag" effect (Baker and Oneal, 2001). In the case of Bosnia, as was observed in 1910 and 1990, the core divisions within the country are along ethnic and religious lines. Because of this effect, along with high post-war voter turnout (around 80% in the immediate aftermath of the war, compared to a long-term turnout average in subsequent elections of about 60%), election results closely approximate the post-war demographics of each municipality (van Willigen, 2013). Furthermore, the proportion of absentee ballots and for whom they were cast, when compared to the local ballots, serve as an indicator as to which groups were displaced and in what proportions. These data give us important insight into the types of conflict that contributed most strongly to an ethnic group's displacement

In sum, the social layer contains two key data sets. These are the prewar census, which was conducted at developed country standards, along with detailed information from the internationally-supervised post-war election. The bridge between these two data points is, first, the ability to estimate adult population based on ethnic voting patterns and, second, a description of the war provided by a neutral authority (see below).

Conflict layer - This layer contains five sets of variables that we use to define the "black box" of the war which changed BiH's economic and demographic conditions. These sets, for each period and municipality, include: the number of deaths by type of casualty (civilian *vs.* military), which of the warring ethnic groups had military control of each municipality, indicators of the type of conflict that occurred, a measure of conflict intensity, and placement of landmines as of the end of the war. Unfortunately, date-specific landmine placement information is unavailable. We turn first to the two most complex parts of the conflict layer: the types of conflict and relative intensity of conflict by municipality. Discussions of fatality deaths, municipal control, and landmines follow.

Classification of the many different types of conflict that occurred in Bosnia and Herzegovina is required to understand the post-war recovery patterns. It involves a two-fold exercise: identification of the types of conflict that occurred and development of a metric for the severity of a particular conflict. This codification of the war is a key contribution of this paper and, we believe, is the first time that a war has been dissected in such a manner. Our codification is based in part on a reading of the literature on the Bosnian and other civil wars; in addition, it reflects the military experience of two of the authors (Harun Đogo, Bosnian Air Force; Lt. Peter Devine, US Navy) and one external reviewer (Lt. Daniel Schaffer, US Army).

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Combat intensity traditionally has been quantified as a series of iso-intensity curves approximately equal to the square root of troop size interacted with the percentage of casualties per day. While this is a valuable metric, it was created to analyze the intensity of conventional wars fought between two large-scale armies (Dupuy, 1985). Many of the battles during the Bosnian civil war involved much fewer personnel and often were not conventionally fought. Our ultimate concern is the conflict intensity experienced by the population living where fighting occurred; therefore, we emphasize battle duration and the number of battles occurring in the same space over the course of the war. With the many different styles of combat from sieges to raids and trench warfare to urban fighting, we anticipate that the effect on a community may be significant even if few troops were involved. An example is a 'war crimes' scenario (defined below) in which a few troops over a single night attempt to ethnically cleanse a municipality. We believe that such war crimes could have a devastating effect on a community, likely causing most surviving citizens to flee. While these war crimes and ethnic cleansing consequently would affect both subsequent military responses and long-run civilian behaviors, they would not be accounted for in Dupuy's (1985) large-force-centric model. In essence, we are not looking for a scale to measure epic battles but a metric of the impact of warfare on a local municipality that for some time was a battlefield.

We classify each type of conflict that occurred (for example, a large force engagement in the surrounding fields, or, conversely, a house-to-house engagement between smaller fighting forces). Then, to measure the intensity of each conflict type, we sum up the instances of each type in each municipality within a given time period. One consequence of this unweighted summation is that each type counts equally for intensity: *e.g.*, war crimes count as much as sieges, and sieges that had war crimes associated with them are effectively double-counted. In the absence of clear evidence of diminishing or increasing costs of further conflict, summation is as reasonable an assumption as any alternative, while multiple counting in the event of multiple effects also has intuitive appeal. From the perspective of a person living in a town, a siege is bad; a siege with associated war crimes is worse. We extend this reasoning to argue that any time conflict occurs it has a negative impact on the community, and the more it occurs over the course of the war the worse the impact is on that community. What we do not address in this paper is whether the impact accumulates linearly or whether there are diminishing or, alternatively, increasing costs.[10]

[10] We are grateful to Kathryn Anderson for this point, and ultimately hope to explore the issue in a separate paper on scale effects.

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In the absence of objective reasoning to say that one type of conflict was universally worse than another, we did not differentiate among the types of conflict in our measure of conflict intensity. However, categorizing different types of battles does add dimensionality to the analysis. By binning and labeling the types of conflict it is possible to describe the flow of conflict (how the fighting tactics and strategy change over time), where each type occurs, which factors are associated with different types of conflict, and the distinct effects each conflict type has on the post-war population. Moreover, by separating conflicts into different types, it is possible to assess the relative impact of various types and assign weights; these weights may vary during the course of the war.

The primary source for conflict data is the three-volume CIA (2002) military history of the war. While this source provides a detailed narrative of the broader Balkan conflict, we focus on the fighting within Bosnia and Herzegovina. The document's authors depended on the best available information, which often consisted of secondary sources, published news from press agencies, memoirs, and International Criminal Tribunal for the former Yugoslavia (ICTY) testimony. Within this structure, the work goes into considerable depth in some areas while leaving salient but unknown details unmentioned. It is also apparent that there are gaps in the dataset: events in certain municipalities that are known from other sources to have occurred are unmentioned in the narrative. A likely explanation is that these gaps are the result of omission in the volumes of cases where conflict in one municipality was a side-effect of a larger campaign in a neighboring area.

Our choices for categorizing conflict type are dictated both by what we could identify and differentiate in the data, and which at the same time appear to be potentially economically or/or socially significant. From these restrictions we identified nine different conflict characteristics (Captured, Recaptured, Trenches, War Crimes, Sieges, Pockets, Internal Fighting, Threatened, and Contested) and built a codebook defining them.

> **Captured:** A municipality was coded as captured if it transitioned from control from one ethnic group to a different ethnic group in the same time period. In order to estimate this in time period 1 (initial conflict period), we determined who had initial control prior to fighting. We define initial control as the pre-war election result, which

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shows which ethnic group held political control of the police force. Police force control meant *de facto* military control of the municipalities at the outset of hostilities.

Recaptured: A municipality was coded as Recaptured if two separate groups captured the municipality within a unit time period.

Trenches: Battles in municipalities were coded as Trenches if the literature specifically mentioned dugout or prepared positions forming a front line. The literature most often refers to these positions specifically as trenches. Note that trenches are different from sieges, as a siege requires an encircling component. While some sieges also had trenches (and were coded as such) others did not, and conversely some conflicts with trenches were not sieges.

War Crimes: A battle was coded as having War Crimes if the literature mentioned widespread or organized rape, targeting or killing of civilians (including ethnic cleansing), or organized killing of prisoners of war. War crimes can occur in battles with other components or by themselves.

Sieges: A battle was coded as having a siege component if a municipality, town, or garrison of troops was surrounded by comparatively fixed lines of enemy forces. Sieges also must have an attempt to capture the besieged municipality; *i.e.*, a prolonged attack against a fortified area for the purpose of isolating and weakening defenses, and aimed at capitulation or invasion. A siege is different from a surrounded pocket in that pockets are not fortified but rather constitute larger areas and with loosely-defined "breathing" front lines.

Surrounded Pocket: A municipality was coded as being a pocket if loose adapting lines of opposing forces and natural boundaries encircled a large area of troops or civilians. A pocket differs from a siege in that the former does not have to be fortified with strong static frontlines. Pockets are less likely to have heavy shelling from field artillery and generally involve larger areas than a besieged town.

Internal fighting: A municipality was coded as having internal fighting if two or more opposing groups were based within the same municipality and engaged in fighting with each other. An example would be organized fighting between neighborhoods within

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the same municipality. Internal fighting is different from 'contested' because the combatants have no external force with a rear guard or reserve force outside of the municipality.

Threatened: A municipality was coded as Threatened if it was within shelling range of an enemy position or under un-countered air bombardment, but at the same time there was no ability to launch a ground assault on the municipality. An example of a threatened region would occur when a hill held by opposing forces is within artillery range of the municipality. A threatened municipality is different from a 'contested' location in that the enemy is not able or attempting to seize ground. When a municipality was coded as threatened and captured in the same time period, it implies that after being captured and held, there was fighting nearby from a larger operation. However, a municipality not in danger of being immediately retaken still might receive light bombardments. Bosanski Šamac in northeastern BiH (and also a war crimes site) provides an example of a city that was captured and then threatened.

Contested: A municipality was coded as contested if two or more armies engaged in a conventional engagement in an attempt to degrade enemy forces and capture territory. These involved established frontlines and adaptive supply routes as armies maneuvered. A contested municipality may or may not result in the capture of that municipality. Conversely, a municipality may be captured without a conventional engagement and so would not be coded as 'contested'. A contested municipality is different from a threatened municipality in that one or more armies is immediately able to take ground and attempts to do so. A contested municipality is different from internal fighting because forces have elements external to the actual battlefield and have established frontlines.

A difficulty in coding the conflict is that no two conflicts are identical. Consequently, we have to identify characteristics of each battle to describe what was occurring. In most cases, more than one characteristic is used to define a single battle in order to accurately portray as much of the actual battle as possible. These multiple descriptors also are useful for determining an aggregate measure of conflict: the sum of total conflict variables is an indicator of how much fighting occurred in a municipality and can be used as a separate regressor. Aggregating across all of conflict variables and

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then using multiple characteristics to describe one conflict leads to effective double counting of some battles. However, condensing measures via principle components analysis and then regressing both subsequent conflict and social impacts on these aggregate conflict types rather than simply on unadjusted characteristics mitigates the multicollinearity and double counting effects.

The *Bosnian Book of the Dead* (hereafter, BBD; described by http://www.documenta.hr/hr/bosanska-knjiga-mrtvih.html) is a collection of data on casualties both military and civilian during the Bosnian conflict in the early 1990's. It categorizes human losses from 1991-1995 and breaks down the dead and missing by regions and municipalities then panels the dead and missing by month and year from 1992 to 1995. The BBD further categorizes the dead and missing by status (civilian or military) and, if military, how they died – fighting, after capture, or in some other manner. Deaths are also broken down by military allegiance and nationality. Importantly, the data set distinguishes losses by gender and age, giving us a casualty population of fighting-aged males. Unfortunately, a cross-tabulation of military casualty data by both municipality and quarter is missing. Since we only have separate measures of deaths by period, or by municipality, our ability to measure intensity of conflict is blunted.

The dataset we compiled tabulates total deaths, both military and civilian, and by municipality and quarter. Since the majority of deaths in each region were due to conflict (for example, in the Sarajevo region only 4.4% of the deaths were not directly related to combat), and even civilian noncombatant deaths were likely related to the effects of combat, using an aggregate number involves little loss of accuracy in assessing fighting intensity. Given its near perfect correlation with the conflict measure, total deaths effectively serve as a measure of conflict intensity.

Available landmine data are of varying precision and usefulness. The source of information is the Bosnia and Herzegovina Mine Action Center (http://www.bhmac.org). We are primarily interested in specific data point categories. The observations divide each municipality into many sub-communities, label the approximate population and victims (no time stamp), and provide an impact score corresponding to an impact descriptor (high, medium, or low). The data also specify when the last landmine in a group was planted and when the mines began to affect the civilian population, effectively denoting the start if not the intensity of conflict involving mines.

We choose to use a single landmine impact score. Since observations are broken down into municipalities rather than sub-communities, we create a population-weighted average of the sub-

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communities' scores for each municipal observation. A placement timestamp would have been useful, but the dataset only lists the time the last mine was laid, which in most cases is at or near the end of the war. This deprives us of an estimate of landmine placement distribution over time, which would have helped determining what caused them to be placed and the specific effects they may have had on conflict.

V. METHODOLOGY

Our analytic tools and underlying data can be used in three ways. First, aggregation via principal components makes it possible to describe key facets of the war – in essence, it serves as a guide to writing military history. However, instead of simply asserting how different aspects of conflict fit together, the use of principal components analysis (PCA) provides statistical aggregation. The data aggregation also makes it possible to compute a simple transition probability matrix, with no causal inference. This procedure effectively describes how the war progressed "on average" without making any connections to nearby events or causal forces. Second, regression analysis links conflict events both to the surrounding environment and to past conflict in a formal, non-speculative manner. This analysis also enables us to assign relative importance to specific initial conditions and causal forces. It is also possible to assess the success of the regression analysis in predicting conflict. Finally, the regression analysis generates residuals that identify specific municipalities and periods in which the model predicts poorly. Exploring residuals enables us to focus on forces that are missing from the analysis – and, as the discussion below indicates, in many if not most cases, there are fairly obvious events that disrupted the anticipated course of fighting.

The Bosnian conflict dataset is complex with multiple layers, indicators, and time dimensions. The conflict layer is particularly multifaceted, with nine separate but non-mutually exclusive characteristics in 109 municipalities across 12 three-month-long seasons. Consequently, a first step is to reduce data complexity with little loss of information while generating more easily interpreted patterns. We begin with a standard measurement of the ethnic tensions that characterize the conflict. Following Nogo (2012), we assume that this can be measured through ethnic fractionalization (*Frac*) values defined as:

$$FRAC_j = 1 - \sum_{i=1}^{N} s^2{}_{ij} \,, \tag{1}$$

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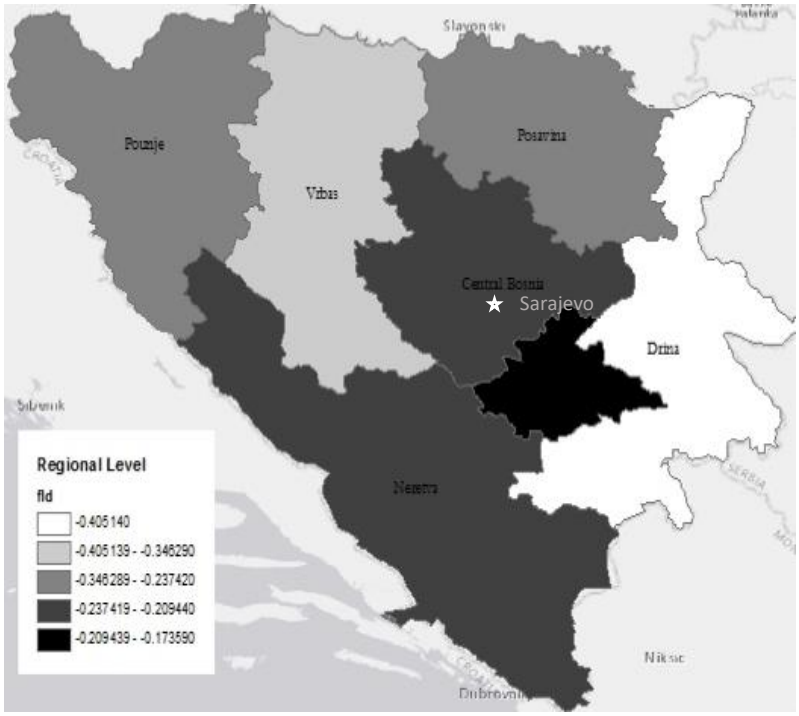
where s_{ij} is the population share of group i ($i = 1 \ldots N$) in municipality j and $FRAC_j \in [0,1)$. Broadly speaking, a high ethnic fractionalization score indicates a pluralistic society. A low fractionalization number indicates one ethnic group is in the majority. Note that both theory (Esteban and Ray, 1999) and prior empirical work (Esteban, Mayoral, and Ray, 2012) suggest that the effect of fractionalization should be nonlinear.

This measure allows comparison of pre- and post-war fractionalization, using data from the 1991 census and 1995 elections. These election figures make it possible to estimate the ethnic shifts across the municipalities, absent a more recent census. By looking at changes in local fractionalization, it is possible to determine the extent to which the war resulted in segregated ethnic groups that consolidated for mutual security. It is apparent from Figure 4 (aggregated into higher level regions for easier visualization) that ethnic separation happened throughout the country, especially near the Serbian border, and to the least extent near Sarajevo. Substantially increased ethnic segregation occurred across the country, with modest increases occurring mainly in areas that were already relatively segregated – and which were adjacent to similarly segregated communities.

FIGURE 4
DIFFERENCE BETWEEN POST-WAR FRACTIONALIZATION OF THE LOCAL VOTES AND PRE-WAR CENSUS FRACTIONALIZATION AT THE REGIONAL LEVEL



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The next step is to reduce data dimensionality by using PCA over conflict characteristics, where the latent characteristic is conflict type, and by reducing the number of periods to correspond to distinct phases of the war. The latter aggregation is endogenously determined and reflects the pattern of the war: there was an initial "land-grab" (and ethnic cleansing) phase), followed by a period of protracted warfare in which the pace slowed and final alliances were cemented, and then a final phase that involved posturing and land grabs in anticipation of a cease fire. It also reflects the fact that, at a level of high frequency and geographic disaggregation, most cells experienced no conflict "innovations" (new conflicts or conflict types). For the different types of fighting identified we then compute four separate sets of principal components: one set for each time period, and another set across all three periods that disregards time.

Mathematically, PCA identifies common elements of support underlying each observed type of fighting. These common support vectors have no inherent definition: it is up to the researcher to examine the set of conflict variables that are highly correlated with a given principal component and use that information to determine what these vectors represent. We identify and categorize different types of conflict based on the component levels of characteristics contained, limiting our significant components to only those that had Eigenvalues greater than 1. We then take those components and determine, based on their Eigenvectors, assess which "type" of conflict they represent, given the conflict characteristics they had. This process leads us to identify five separate types of conflict:

> **Siege type conflicts** are characterized by high component values of 'Captured', 'Recaptured', 'Trenches', 'War Crimes', and 'Sieges' during a given time period. These battle types occur throughout the war, though with a lower component of captures toward the end of the war.
> **Hybrid type conflicts a**re characterized by high component values of 'Captured', 'War crimes', 'Pocket' and 'Threatened'. These battle types had less-defined front lines, occurred early in the war, and likely represent the role of external paramilitaries in opening stages of the war.
> **Civil war type conflicts** are characterized by high component values of 'infighting', 'contested', 'threatened', 'captured', and 'recaptured'. These battles occurred prominently in period 2, capturing the intra-municipal fighting between Bosniaks and Croats, and the intra-Bosniak conflict.
> **Conventional type conflicts a**re characterized by high component values of 'captured', 'recaptured', 'contested', 'threatened', and 'pocket'. These battles represent

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what one can think of as traditional large force maneuver warfare, and only appear during period 3.

Dirty conventional type conflicts are characterized by high component values of 'recaptured', 'war crimes', and 'threatened'. These conflicts were for the most part conventional maneuver battles but had significant associated incidents of war crimes, which becomes significant in social and geopolitical analysis, and primarily occurred in period 1 and to a lesser extent period 2.

While these are hardly the only warfare delineations that one could create, they also are recognizably distinctive, and a military analyst should not have difficulty assigning events to a particular type. PCA results are summarized in Table 2.

TABLE 2:
PRINCIPAL COMPONENTS COMPOSITION AND PROPORTIONS

	T1PC1 Siege	**T1PC2 Hybrid**	**T1PC3 Dirty Conventional**	**T2PC1 Siege**	**T2PC2 Dirty Conventional**	**T2PC3 Civil War**	**T3PC1 Siege**	**T3PC2 Conventional**	**T3PC3 Hybrid**
Eigenvalue	2.027	1.687	1.354	2.701	1.520	1.270	2.091	1.867	1.294
Proportion of Variance	.23	.19	.15	.30	.17	.14	.2614	.2334	.1617
Variable Components									
Captured		.6191			.5969			.5890	
Recaptured		.5322		.5274				.5305	
Trenches	.6604			.5311			.6339		
War Crimes			.6138		.5756		.3556		.3144
Sieges	.6574			.5497			.6383		
Pockets		.3304				.5621			.5214
Threatened			.5926			.4009			.6379
Contested					.4346	.4193		.4724	
Infighting			.1866			.5211			

Having labeled types of conflicts, we then run two sets of regressions over these five conflict types *j* for each of three periods *t*. The goal of the first set of regressions is to provide an evolutionary narrative of the conflict that looks to the previous period's PCAs, as well as to any pre-war exogenous variable to the conflict. This set of regressions allows for evolution over time by including predicted values of observed endogenous variables from the initial phase (t=1) as explanatory variables in

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subsequent phase (t=2) regressions, and predicted values from phases 1 and 2 in the 3rd stage regression. After evaluating temporal autocorrelation, a Moran's I statistic is determined for each component to determine spatial autocorrelation[11].

A second set of regressions uses both pre- and post-war exogenous variables to try and create a narrative that incorporates both the goals and the effects of the conflict. These regressions use deaths and landmine data that are not dated. The cost of adding these terms is that the principal components cannot be regressed on predicted values of previous periods, so that the time dimensionality of the analysis is lost: since land mine and municipality deaths' data lack a time dimension, it is not possible to explore their evolution. These can be run both with and without principal component terms (and, if included, either with period specific or single, time-invariant principal components) as explanatory variables.

The results discussed below are based on simple OLS regressions. These, along with a variety of robustness checks, are presented in supplemental Appendices. Alternative specifications use Probit forms, correct for spatial autocorrelation, add nonlinearities in explanatory variables, and correct for correlated errors among the dependent variables in any given time period by using a SUR (seemingly unrelated regression) system.

Before turning to empirical results, two issues merit further discussion. First, once distance and spatial autocorrelation are incorporated, it is necessary to choose a method to address the impact of nearby events in a parsimonious manner. We choose to do this by taking a weighted average of values (in particular, of lagged principal components) of neighboring *opštine* as additional regressors, restricting neighbors to contiguous municipalities, and using the main town as the *opština* centroid. We have no *a priori* best weighting scheme and use, alternately, (a) distance, (b) *ln* distance, (c) *ln* distance * *ln* population; (d) *ln* distance * *ln* average hilliness; and (e) *ln* distance * *ln* average hilliness * *ln* population. We regard this last specification, which assumes diminishing returns to distance and

[11] Moran's I measures spatial autocorrelation on observation location and observation value, returning a z-score and p-value with an index which evaluates if the value data across observations are expressed in a spatial pattern, and what type of pattern (clustered, dispersed, or random).

$$I = \frac{n}{S_0} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{i,j} z_i z_j}{\sum_{i=1}^{n} z_i^2}$$

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corrects for both terrain difficulty and neighbor importance (as proxied for by population), as the most plausible.

Second, we also face the issue of temporal autocorrelation. In essence, a particular *opština* may have idiosyncratic, time-invariant conditions that make for more or less conflict of a particular type. As there are multiple types of conflict, and we do not know *a priori* whether a PC's own lagged values or lagged values of other PCs will matter, we include lagged values of own and other principal component measures. Since the model already includes predicted values of lagged principal components, the error terms from previous models are added separately to capture idiosyncratic autocorrelation. From the perspective of predicting the spread and duration of conflict, this practice allows us to distinguish **deterministic paths** (in which predicted conflict today of type *k*, $PC_{t,k}$, depends of predicted values of all kinds of conflict *j* in previous periods as well as on current exogenous variables), **idiosyncratic paths** (in which predicted conflict today of type *k* depends on lagged error terms of various kinds of conflict $\varepsilon_{t-1,j}$), and **unpredicted outbursts** of $PC_{t,k}$ that depend neither on predicted past conflict of various types, nor on unpredicted conflict, nor on current exogenous variables.

$$\begin{aligned} Conflict\ Type_{t,i} = \alpha + \beta' \overrightarrow{dist}_i + \beta' \overrightarrow{pop}_i + \beta' \overrightarrow{frac}_i + \beta' \overrightarrow{geog}_i + \beta' \overrightarrow{assets}_i + \\ \beta' \overrightarrow{Conflict\ Types}_{t-1,i,j} + \beta' \overrightarrow{Conflict\ Types}_{t-2,i,j} + \\ \beta\ \epsilon_{t-1,i,j} + \beta\ \epsilon_{t-2,i,j} + \epsilon_{t,i} \end{aligned} \tag{2}$$

With this delineation as a guide, it is then possible to track the Bosnian Civil War. The difficulty that arises is with presentation. Even ignoring deaths and landmines, we have a vast number of alternative specifications once we begin to address spatial autocorrelation and temporal autocorrelation with, in turn, its deterministic and idiosyncratic paths. The commentary that follows provides an informed sketch of the war, but the vast majority of maps, figures, and tables must be relegated to an online Appendix. As noted above, we begin with the most parsimonious and simplest regressions, and then gradually add complexity.

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VI. QUANTITATIVE DESCRIPTION OF CONFLICT

The following subsections provide a statistical description of the BiH civil war, and links events both to the environment and to past or nearby events. Residuals are discussed separately in Section VII. It is important to note that the principal components for different periods are not identical. In effect, the war contained different phases with distinct objectives and strategies, and hence there were different linkages among different types of conflict (as well as different causal forces).

6.1. Siege type conflicts

TABLE 3:
OLS REGRESSION COEFFICIENTS: PREDICTING SIEGE-TYPE CONFLICTS

Regressors	Period 1 Siege Type	Period 2 Siege Type	Period 3 Siege Type
Distance to the Northern Boarder	.463	-.268	-.271
Distance to the Eastern Boarder	-.134	.098	-.452
Distance to the Southern Boarder	-	-	-
Demographic Majority	.535	-.609	.117
Bosniak Majority	.094	.441	.241
Serb Majority	-.010	.362	-
Croat Majority	-	-	.485
Ethnic Fractionalization	-1.541	-.097	1.527
Percent Bosniak	-20.637	-	-
Percent Serb	-21.205	-	1.082
Percent Croat	-21.346	.675	1.083
Percent Yugoslavian	-1.437	-	-
ln Total Population	.304	-.144	-.198
Urban/Suburban Ethnic Split	-.637	.131	.106
Power Plant	-.356	.499	-.261
Armory	-.741	.640	-.398
Extractive Mine	-.333	-.280	.173
Major Road	-.008	-.103	.035
Highway Junction	.326	-.391	.136
ln Mountainous Terrain	.285	.148	-
Period 1 Siege Type	-	1.134	-
Period 1 Hybrid Type	-	.252	-
Period 1 Dirty Conventional Type	-	.381	-
Period 2 Siege Type	-	-	.988
Period 2 Dirty Conventional Type	-	-	-.314
Period 2 Civil War Type	-	-	.030

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The onset of sieges is strongly correlated with ethnic heterogeneity (Table 3). This is unsurprising in that urban areas, which are more likely to be besieged, are typically less ethnically homogenous than rural areas, though this also raises a question of causality. Our conflict data set largely relies on media reporting, and Sarajevo and its siege received the lion's share of media coverage. Therefore, there may be reporting bias leading to an overrepresentation of the siege of Sarajevo in both siege types and the conflict layer overall. However, this result conveys the larger reality that sieges need a fortified town or city to besiege, and thus a city is the most likely siege site. While ethnic heterogeneity was significant across all time periods, the presence of a siege in a given municipality in the preceding period was the most significant indicator of sieges in later periods.

There is one aspect of conflict in Bosnia that our dataset does not cover: UN intervention and aid. It is likely that the amount of UN protection and/or aid especially affected the level of siege conflicts. The siege of Sarajevo may have been prolonged by UN intervention because of the perception by the defenders that the international community would not allow Sarajevo to fall. Therefore, the defensive side could easily move its resources away from Sarajevo to other fronts, relying on the UN to pick up the slack. This shifting of personnel and equipment could have increased not only the duration of the siege of Sarajevo, but also the may have increased fighting in other municipalities around the region and country. However, since the regression analysis is cross-municipality, an effect like this with national implications would not be picked up in the empirical work.

6.2 Hybrid type conflicts

Looking across all time periods in hybrid type conflicts, demographics play the largest factor (Table 4). When considering determinants of conflict, a majority Serb population is almost perfectly negatively correlated with the use of hybrid warfare. This finding reaffirms widely accepted narratives that the purpose of hybrid actions was to ethnically cleanse certain areas. This is also reflected in the post-conflict correlations. Positive absentee values indicate that when a hybrid type of conflict broke out, people tended to flee after initial fighting occurred, though it is not possible to say conclusively whether this was because of the nature of the fighting, or because of the ethnic cleansing that followed.

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TABLE 4:
OLS REGRESSION COEFFICIENTS: PREDICTING HYBRID-TYPE CONFLICTS

Regressors	Period 1 Hybrid Type	Period 3 Hybrid Type
Distance to the Northern Boarder	.227	-.142
Distance to the Eastern Boarder	.074	-.141
Distance to the Southern Boarder	-	-
Demographic Majority	-.175	.634
Bosniak Majority	-.060	-.671
Serb Majority	-1.950	-1.207
Croat Majority	-	-
Ethnic Fractionalization	.980	-.345
Percent Bosniak	-2.545	-3.371
Percent Serb	.489	-2.413
Percent Croat	-2.332	-4.375
Percent Yugoslavian	-3.766	-.445
ln Total Population	.076	-.091
Urban/Suburban Ethnic Split	.465	.214
Power Plant	-.033	.397
Armory	.048	.448
Extractive Mine	.189	.042
Major Road	.053	.131
Highway Junction	-.353	-.452
ln Mountainous Terrain	-.222	-
Period 1 Siege Type	-	-
Period 1 Hybrid Type	-	-
Period 1 Dirty Conventional Type	-	-
Period 2 Siege Type	-	.062
Period 2 Dirty Conventional Type	-	-.066
Period 2 Civil War Type	-	.136

In period 2, power plants become negatively correlated with hybrid conflicts. Most of the power plants were hydroelectric dams on the Drina and hybrid conflicts would have been boxed in by the natural boundary, perhaps making it a less effective tactic. Furthermore, fighting in the Drina valley would most likely be characterized by infighting in period 2, with hybrid conflicts appearing elsewhere.

Finally, there is a strong negative correlation between the presence of major road junctions and the use of hybrid conflict. This likely speaks to the larger goals behind the deployment of these

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hybrid forces. First, hybrid actions mainly occurred in situations where traditional military forces could not operate effectively. A lack of road junctions indicates relative inaccessibility for large-scale troop movements. Second, the lack of road junctions reinforces the fact that these hybrid forces were more concerned with the ethnic composition of a municipality than its conventional strategic value.

6.3 Civil War

After the initial push for control in period 1, civil war conflict dominated the second period. Once these conflicts ended, positioning for the end game of the long war began. We see that post-war absentee vote distribution relative to 1991 Census population, our proxy measure for ethnic cleansing (since "cleansed" residents would have had to vote absentee), is negatively correlated with conflict for all ethnic groups, when evaluated outside a given time period (Table 5). In non-civil wars these values would be positive. This negative correlation seems to indicate that defenders were focused on staying; *i.e.*, that they invested heavily in holding their territory.

TABLE 5:
OLS REGRESSION COEFFICIENTS: PREDICTING CIVIL WAR, CONVENTIONAL, AND DIRTY CONVENTIONAL-TYPE CONFLICTS

Regressors	Period 1 Dirty Conventional Type	Period 2 Dirty Conventional Type	Civil War Type (period 2)	Conventional War Type (period 3)
Distance to the Northern Boarder	.338	-.932	-.054	.011
Distance to the Eastern Boarder	.468	-.537	-.050	.643
Distance to the Southern Boarder	-	-	-	-
Demographic Majority	-.008	-.454	.479	.403
Bosniak Majority	-1.326	1.664	-.174	-.674
Serb Majority	-.790	1.881	-.430	-.886
Croat Majority	-	-	-	-
Ethnic Fractionalization	-.693	1.761	1.027	-2.045
Percent Bosniak	-3.788	-	-	-8.337
Percent Serb	-5.472	-	-	-10.009
Percent Croat	-6.669	3.779	.106	-11.770
Percent Yugoslavian	-3.967	-	-	-6.636
ln Total Population	.284	-.867	.252	.072
Urban/Suburban Ethnic Split	.184	-.615	.221	-.007
Power Plant	-.351	1.001	.538	-.058
Armory	-.361	.716	.825	-.071
Extractive Mine	-.140	.207	-.505	.459
Major Road	-.009	-.383	.078	.082
Highway Junction	.216	-.117	.028	-.116

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ln Mountainous Terrain	.127	-.069	.289	-
Period 1 Siege Type	-	.143	-.331	-
Period 1 Hybrid Type	-	.349	-.410	-
Period 1 Dirty Conventional Type	-	1.054	.105	-
Period 2 Siege Type	-	-	-	.134
Period 2 Dirty Conventional Type	-	-	-	-.430
Period 2 Civil War Type	-	-	-	-.064

Outside of ethnic fault lines, another story appears related to the importance of armories. Civil wars were fought for immediate control of a municipality, making armories and power plants strategically key. Whoever controlled the power plants had the ability to keep the lights on or turn them off. Second, when civil war split the Croats and the Bosniaks, the Bosniak fighters lost their supply of smuggled arms from the Croatian coastline. This made the pre-staged armories critically important. These two factors, more so than any other, were the most strongly correlated with the outbreak of civil war type conflict.

6.3.1 **Dirty conventional conflict**

The primary difference between a conventional conflict and a dirty conventional conflict is the presence of war crimes. It is interesting then that we see "dirty" conventional battles fought only in periods 1 and 2, with war crimes becoming statistically insignificant in period 3. The most significant determinant of dirty conventional conflict in a given municipality is a low initial fractionalization score, implying that ethnic homogeneity was positively correlated with war crimes against a nearly defenseless minority.

We also see that roads have a negative effect during period 2. Logically, if a group was going to commit war crimes in an otherwise straightforward battle, it would prefer to be unobserved, making the presence of major roads a deterrent. Power plants have a broader positive effect on likelihood of dirty conventional battles. This suggests that power plants are a valuable military asset in controlling a region for reasons similar to their importance in civil war type conflicts. Additionally, municipalities with power plants were larger and more strategically important regardless of power producing facilities.

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There is one glaring exception to our analysis, namely the battle at Srebrenica. It was the largest incident of war crimes and mass killings of civilians, over eight thousand, in a declared UN "safe zone." However, it occurred at the very end of the war. This is a significant outlier that is neither well measured nor explained in our analysis. A weakness of counting conflict week by week is that the massacre occurred over the course of only a couple of days and was given relatively little weight because of its short duration. Thus, it ended up being given equal weight to the shelling of a civilian market in Sarajevo. One option to correct this drawback would be to weight war crimes by casualties (or their natural logarithm); we have not done so here.

6.3.2 Conventional Conflict

Conventional conflict occurred only in the final period of the war. The regressions suggest that in most cases the conventional conflict seen in period 3 was simply an extension of the dirty conventional conflict seen in periods 1 and 2. As the end game of the war became apparent, armies worked to avoided negative press that could sway international opinion and forfeit bargaining chips at the peace table. Also notable is the consistently positive impact of ore mines on conventional conflict. Assuming that "possession is 9/10 of the law," the warring nationalities could have focused on ore mines, trying to control as much valuable territory as possible while not causing an international wave of disapproval.

6.3.3 Intensity of Conflict

There are two additional measures of conflict intensity: deaths and landmine concentration. These two were evaluated outside any given period due to the indeterminate nature of their timing (Table 6). While we know final concentrations of landmines and final death tolls, we know neither when the mines were placed nor when soldiers (or civilians) died. These two variables instead are regressed against pre-war exogenous variables and predicted principal components from the first period. Period 1 principal components were included because a simple reliance on pre-war exogenous variables would remove these regressions from the context in which they occur. While death rates unsurprisingly were correlated with population size and fractionalization, there was a significant negative correlation with sieges. The concentration of landmines also was strongly correlated with the use of hybrid warfare in the first period. There also is a strong negative landmine correlation with whether a municipality was majority Serb.

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TABLE 6:
OLS REGRESSION COEFFICIENTS:
PREDICTING CIVILIAN AND MILITARY DEATHS, AND LANDMINE CONCENTRATION

Regressors	ln Deaths	Land Mines
Distance to the Northern Boarder	-.276	-1.506
Distance to the Eastern Boarder	-.229	-1.027
Distance to the Southern Boarder	-	-
Demographic Majority	.470	2.063
Bosniak Majority	-.271	3.999
Serb Majority	-.421	2.867
Croat Majority	-	-
Ethnic Fractionalization	1.524	7.749
Percent Bosniak	-	-
Percent Serb	-	-
Percent Croat	-1.858	4.585
Percent Yugoslavian	-	-
ln Total Population	.740	-1.731
Urban/Suburban Ethnic Split	.051	-2.422
Power Plant	.123	1.453
Armory	.250	.815
Extractive Mine	-.088	-.013
Major Road	.038	-.352
Highway Junction	.028	-.295
ln Mountainous Terrain	.253	-.292
Period 1 Siege Type	-.183	-.101
Period 1 Hybrid Type	.246	2.299
Period 1 Dirty Conventional Type	.063	3.185

6.3.4 Conflict Transition: an a-theoretical matrix plus forecasting accuracy

Appendix 2 provides a lengthy matrix of transition probabilities from one state of conflict to another, aggregating over all 109 municipalities. These are summarized in Figure 5 below.

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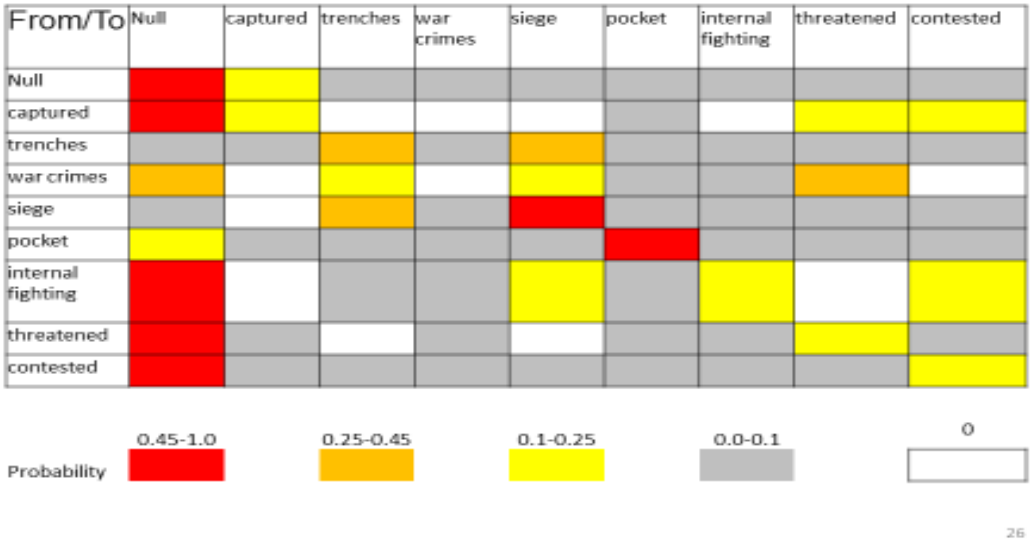
FIGURE 5
MULTI-PERIOD CONFLICT TRANSITION MATRIX SUMMARY



Several conclusions can be drawn from Figure 5. First, municipalities that did not experience conflict in the initial period were not likely to be affected thereafter, unless they were captured. However, captured regions faced large risk – greater than 10% in each case—of being threatened or contested thereafter, so that captured status did not guarantee stability, especially as many captured regions were subsequently re-captured – a quintessential feature of civil war.

The most stable types of conflict included sieges and trenches (prepared front lines), which were largely a precursor to sieges. Trenches generally remained unchanged or evolved into sieges. Similarly, sieges were likely to continue, or, if broken, were replaced by established front lines. Municipalities that were threatened or contested either continued to be so, or generally became quiet; the same is true for pockets. Again, this pattern reflects the intermittent nature of civil war among parties with limited resources.

The least stable pattern occurs following war crimes. War crimes themselves were not repeated in subsequent periods, but their presence was followed by a range of other types of fighting. Of course, the causality is unclear from the available information: war crimes could have been a precursor to

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offensives that were already planned, or they may have invited a response from forces siding with the victims.

Table 7 provides an overview of the model's general predictive power as measured by R^2 value, and also of the sources of predictive ability. Underlying regression results with coefficients for specific variables are reported in Appendix 3.

Table 7
FORECASTING CONFLICT:
ACCURACY AND IMPORTANCE OF CONTRIBUTING FACTORS AS MEASURED BY R^2 VALUES

Period	Conflict type	Exogenous factors: topographic conditions, baseline population, baseline economic structure	Additional exogenous factors: weighted neighbor exogenous factors included	Additional exogenous factors: lagged PCA dependent variables (all types)	Additional exogenous factors: neighbor lagged PCA dependent variables (all types)	Unpredicted outbursts (current residual share, or 1 – R^2)
1	Siege	.4661	.1979	_____	_____	.3360
1	Hybrid	.2216	.2412	_____	_____	.5372
1	Dirty Conventional	.2604	.1850	_____	_____	.5546
2	Siege	.4250	.1274	.3100	.0066	.1310
2	Dirty Conventional	.2126	.2268	.0258	.0091	.5257
2	Civil War	.3498	.1332	.0309	.0131	.4730
3	Siege	.4774	.1402	.2383	.0018	.1423
3	Conventional	.3535	.1206	.0034	.0743	.4482
3	Hybrid	.1038	.1128	.2115	.0025	.5694
All	Landmines	.2594	.0939	_____	_____	.6467
All	Deaths	.8162	.0658	_____	_____	.1180

There are a large number of lessons. First, pre-conflict values of exogenous factors (topographic, economic, and demographic) explain an overwhelming share of variation in war deaths

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– nearly 81.6 percent from own-*opština* effects alone, with another 6.6 percent explained by conditions in neighboring regions. While the exceptionally tight link – the clearest measure of the devastation of war can be clearly predicted by the setting – may be surprising, at the same time, the result may reflect the fact that from the outset the conflict was directed by military officers. These officers would have been trained in strategy and tactics based on an area's perceived relative value and vulnerability. In this case, the moves and outcomes would be highly predictable, and likely far more so than for civil conflicts not initially directed by experienced officers.

Second, landmine placement is not nearly as predictable: barely more than one-quarter of the variance can be explained by initial conditions. We believe this to be the case because landmines were so ubiquitous, and also were placed for heterogeneous reasons. However, since we do not have information on timing of landmine placement, it is not feasible to disentangle multiple reasons.

Third, some types of conflict are far more predictable than others, though none is nearly as predictable as total deaths. Sieges are the most readily predicted based on past characteristics (which explain just under half of the variance in each of the three periods) and neighboring regions characteristics (which explain 13 to nearly 20 percent). Lagged factors in periods 2 and 3 account for under 1 percent of variance.

Following sieges, conventional civil war in period 2 is relatively predictable: more than one-third of variance is explained by initial conditions; another 3 percent is explained by lagged PCA values; and 13 percent is explained by neighboring regions' exogenous variables. Our ability to model conventional warfare in period 3 is fairly similar. Where we do particularly poorly in explaining variance in warfare given the baseline information and lagged values is with hybrid warfare (the sort least completely controlled by professional officers). The information available to us does not account for more than one-half of the variance in any cases, and for period 3 hybrid warfare, even with lagged PCA values we can account for barely more than 20 percent of regional variance.

Dirty conventional warfare is largely driven by war crimes; the other contributing factors differ in periods 1 and 2. The relatively poor explanatory power of own-township variables in both periods suggests that there is an apparently irrational spontaneity to this type of conflict. As it would not have been taught in JNA operations handbooks, it is unsurprising that dirty warfare has a much more

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limited relationship to conventional motivating factors – including ethnic heterogeneity, economic factors, and strategic objectives. Given the importance of neighbors' terms, it would appear that "prairie fire" spreading (in the sense of Kuran's (1989) tipping model of revolution) is an important factor, as is the case with hybrid warfare.

A final point to emerge from Table 6 is that near-neighbor effects appear to be only modestly important for conventional warfare, civil war, landmines, and deaths, and to a lesser extent for sieges and conventional warfare after the initial period. This seems likely to be a peculiar feature of (broadly defined) civil war. In some respects, civil war – especially when not centrally controlled – is an amalgamation of many local wars (analogous to the way in which US presidential campaigns are an amalgam of semi-independent state campaigns). In a conventional war with large armies acting in a coordinated fashion, one would expect very high spatial autocorrelation. Civil wars appear to be far less coordinated, at least in BiH; we conjecture that guerrilla warfare would be the least spatially coordinated of all

7 LIMITATIONS OF THE MODEL

To evaluate the model, we map the residual values obtained from regressions of the conflict principal components on exogenous variables, lagged conflict variables, and neighbor conflict variables. High positive residuals indicate an *underestimation* of conflict in a given region, while negative values indicate *overestimation*. Close examination of residuals (Appendix 3) reveals three major limitations.

The first, unsurprising limitation appears when attempting to predict sieges. The conflict models systematically overpredict the existence of sieges in urban, industrial centers of Bosnia other than Sarajevo – Tuzla, Banja Luka, and Zenica. This behavior is likely driven by Sarajevo with its capital city effect. Given that the dataset is based on open-source reporting, it is unsurprising that siege of Sarajevo dominated the narrative more than any other event, likely resulting in considerable over-reporting. Also skewing the data is the division of the city into several small municipalities, all of which were besieged and thus all reported sieges at once, although in reality a single urban agglomeration was under siege. This can be addressed by aggregating the Sarajevo municipalities or re-running the model without these municipalities, though we did not elect to do so here. A key reason for not

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excluding these municipalities is the possibility that the Sarajevo siege was fundamentally more severe than any other. While the tactical operations and sustained urban combat only occurred for a short period in Mostar during the Bosniak-Croat conflict, Sarajevo was besieged for over 1,000 days with World War I-style entrenchments and tunneling. This level of intensity for this long did not occur anywhere else.

The second finding is the decline in the performance of exogenous variables over the course of the war. "Exogenous" or fundamental variables, such as population, terrain, and infrastructure, do a reasonable job of predicting non-siege type conflicts in the first period of the war, both in the case of dirty conventional and hybrid type conflicts. The errors in period 1 likely are related to strategic decisions rather than fundamentals, including the desire of the Serbs to connect pockets of control of predominately Serbian territories within Bosnia with Serb-controlled territories in Croatia. However, in subsequent periods the predictive value of these fundamentals declines: as Kathryn Anderson has noted, conflict already has adjusted to these characteristics, and so would be embedded in lagged values. In period 2 their predictive power also wanes as a result of the emergence of Bosniak-Croat and Bosniak-Bosniak conflict. By period 3, they have essentially lost all predictive value, once conflict becomes driven by "off board" factors rather than the pre-war population or terrain/infrastructure.

Finally, a model such as this one cannot explain changes in conflict driven by political shifts. While regressions on conflict variables appear to perform better than the regressions on fundamentals in periods 2 and 3, the lack of fit is largely driven by the changing nature of the conflict. In particular, in period 2 the conflict-based regressions fail to anticipate the Bosniak-Croat conflict in Central Bosnia and the Neretva valley of Herzegovina. In period 3, the conflict based regressions fail to anticipate the Bosniak-Croat offensive in the West, following the Croat Operation Storm in Croatia and the NATO airstrikes on Serbs in Bosnia. The reappearance of the hybrid type conflict is representative of the Serb offensives against the enclaves – Srebrenica, Žepa, Bihać, and Goražde. However, since this type of conflict did not occur in period 2, regressing on period 2 variables where it is not present fails to predict it.

8 DISCUSSION

While the model relies on three layers of data, the conflict layer is both the most central to our analysis as well as being the most subjective. To make our results more robust, we compare our

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unique coded conflict data with the Uppsala Conflict Data Program (UCDP) published annually in the *Journal of Peace Research*. The UCDP gathers data from over 30,000 print and electronic media sources including Reuters, the AP, and the BBC that report on conflict events. Each event is geocoded with coordinates for the smallest administrative division reported.

For our analysis we took each instance of conflict in the UCDP data within Bosnia during the war and coded it as a single, binary "occurrence" variable as the UCDP does not distinguish between types of conflict. The geocoordinates of each event correlate strongly with our native data set, except for within Sarajevo. We divide the city of Sarajevo into its component administrative municipalities for finer detail, while the UCDP data lumps them together under "Sarajevo". To compare the two data sets, we create an analogue of our unique data set that matched the UCDP dimensionality by lumping all the Sarajevo municipalities together into one region and then collapse all of the types of conflict into a single measure of occurrences across Sarajevo and all municipalities.

Comparing the two data sets, we find that they are highly correlated (Figure 6). The UCDP data scale up the conflict data, especially in major regional hubs. This is likely due to its primary sources. While our conflict data draw its geocoding from intelligence sources available to the CIA, the UCDP draws its locations from the international reporting corps who were more likely to use better known municipalities as reference points. While it is unsurprising that intelligence and media sources are imperfectly correlated, the generally high correlation of our conflict data with the UCDP data strengthens our results.

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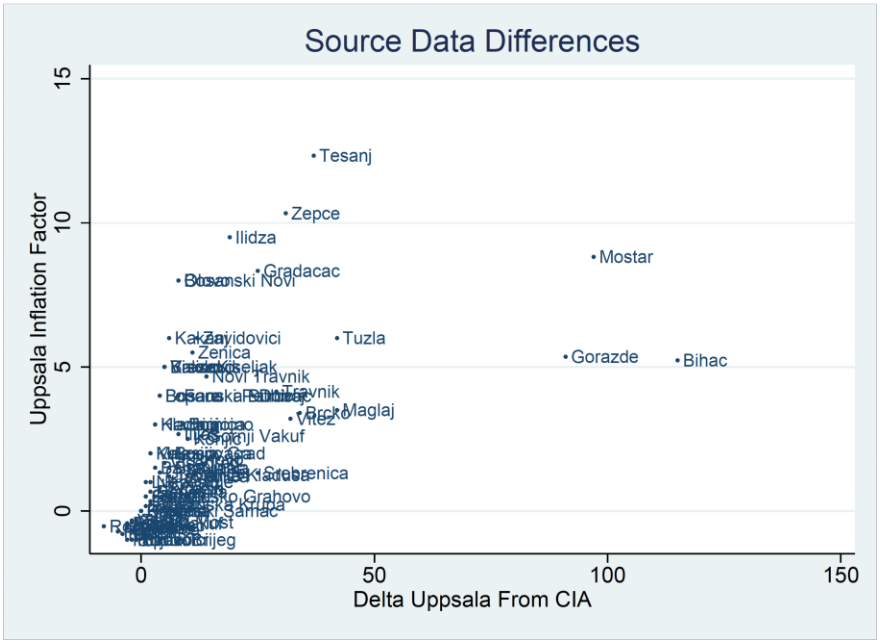
FIGURE 6
VARIATION IN UCDP AND CIA HISTORY OF REPORTED CONFLICTS IN THE BIH CIVIL WAR



Two interesting points arise from using UCDP data. First, kitchen sink regressions on conflict as a binary variable yield statistically unreliable results. While the kitchen sink regression on UCDP conflict data across all time has a reasonable R^2 value of .64 (Adjusted R^2 of .55) nearly all of the time-invariant coefficients have standard errors too large to make meaningful inferences. This weak signal-to-noise ratio when using only generalized conflict, as the UCDP does, shows the critical importance of classifying conflict data into types, as we have done using the CIA data set. Each type of conflict is better predicted than when an aggregate measure is used. Second, by comparing the two conflict data sets, the observed difference can be taken as an indicator of international attention, which is an important factor in understanding NATO intervention, protective areas, and strikes and therefore the shifting effect it had on conflict.

Also of note is are the two townships with the largest divergence in outcomes, Žepče and Tešanj. Žepče was a substantially though not majority Croatian town far from the Croatian border, and hence one marked by unusual levels of fighting (Croat-Bosniak). Tešanj also was an outlying town that had a small Croatian community that was defended by Croatian forces from attacking Bosniak forces (Shrader, 2003).

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From an assessment of the contributing conflict factors underlying the time-specific principal components, and from an analysis of the exogenous and lagged determinants of their values, we can begin to construct a narrative of the conflict as it developed. In the first period, sieges were established in ethnically heterogeneous, urban areas. Substantial spatial autocorrelation indicates that these sieges were not random, while other conflict forms exhibited weaker spatial links. These patterns hold true throughout the conflict, since sieges stayed constant as opposed to increasing or decreasing. The first period also witnesses hybrid forces moving into areas that are not Serb-majority, but that the military is unable to get to. It is this lack of traditional military power that explains the correlation with landmines. Landmines provide a cheap, simple form of defense, especially when the defenders are outnumbered, as the hybrid forces were. Finally, dirty conventional conflicts emerge at the onset of the war rather than later.

As the conflict progresses, the sieges and the dirty conventional conflict stay more or less constant. The major change is a shift toward more conventional conflict with fewer war crimes, possibly to maneuver for a negotiated peace by minimizing negative international press coverage. More interesting is the evolution from hybrid conflict to civil war. After the initial period in which hybrid warfare is used to push out certain ethnic groups, it takes a much less prominent role in the conflict and is instead replaced by conventional civil war.

Widely accepted military doctrine establishes that in a conventional war the objectives are to: (1) destroy the opponents' military might (position for peace settlement); (2) secure key logistic connection and productive assets; and (3) seize and control territory. However, the evolution established by our data indicates that the military doctrine practiced, especially by Serb forces, appeared to be reversed from those in conventional objectives: (1a) seize and cleanse territory; (2a) secure key logistic connections and productive assets; and (3a) pursue the destruction of opponents' military might (position for peace settlement). This is because the Balkan war in Bosnia and Herzegovina was a conflict driven by demographics. It was, at its core, an ethnic civil war. Strategy was decided by geopolitical exigencies while tactics were determined by capabilities and exogenous parameters on the ground.

These findings help us to identify uncorrelated instruments for analysis of the effects of conflict on a society, as well as to develop models for predicting the presence, type, and progression

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of ethnic conflict. However, there are limitations for which we need to account. As discussed above, the overweighting of the siege of Sarajevo due to heightened press coverage, as well as the underrepresentation of the war crimes at Srebrenica may be of particular importance.

Furthermore, we do not address the role of external players, such as the UN and NATO, in the conflict. By providing food, supplies, and safe zones throughout the war, especially in enclaves, they essentially guaranteed the survival of those enclaves and potentially shifted conflict elsewhere. Most notably, in Sarajevo the international community essentially prevented the city from falling – but did not weigh in enough to lift the siege. This perpetuated the status quo in the city and removed the incentives of combatant forces to push for a local victory. However, the warring parties did have the ability to shift a certain amount of resources and effort away from Sarajevo, and the international community's implicit guarantee could have contributed to more fighting farther afield. Additionally, NATO supplied ongoing no-fly zones and bombing sorties in the summer of 1995. These created tactical cover for the Bosnian-Croat western maneuver offensives in the later part of the war. While this policy may be reflected in the period 3 results, we do not address it in our analysis. In effect, these various interventions represent structural changes that cannot be captured adequately with data for a war a brief and limited in scope as in Bosnia and Herzegovina. At this point, we can only hypothesize that measures of the interventions mattered, especially in period 3. Specifically, we anticipate that the presence of international bodies increased fighting outside of Sarajevo and may have both prolonged the war and mitigated its effects to some degree. This could be evaluated by comparing UCDP data to the CIA data, but more dimensionality is needed in the UCDP data to break out types of conflict preventing any inference at this point.

9 NEXT STEPS

This paper is an initial attempt to quantify a civil war both in terms of autocorrelation – in both temporal and spatial terms – and multiple types of conflict. To our knowledge, formal analysis based on a detailed typology has not been conducted before, and a major objective of the paper is to demonstrate that detailed knowledge of the type of conflict can enhance understanding of the nature and spread of a conflict. Ideally, some of the patterns uncovered in our analysis of Bosnia will be more generally applicable, but until further studies have been conducted, this is merely a speculative

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hypothesis. Indeed, Bosnia may be highly idiosyncratic, starting with the fact that there were three major warring parties whose alliances shifted during the course of the war.

This multi-phase analysis also enables us to assign direct and indirect effects to exogenous variables, in effect identifying a multi-dimensional causal path. Subsequent work can incorporate clearer measures of displaced persons, and distinguish temporary and permanent displacements, based on the 2013 Census. As we turn to an analysis of longer-term consequences, once again it will be possible to determine whether estimations that account for multiple dimensions of conflict and the spatial interrelatedness of the war yield superior results to simpler regressions that do not incorporate these factors.

This future work will then set the stage for subsequent analysis that explores the impact of conflict type and duration on social outcomes. These include estimates of social change (to schooling, marriage, births, and relocation for teenagers and young adults; to relocation, family intactness, and health for older adults). More comprehensive data from the 2013 Census on relocation and several other measures also can be exploited. The disadvantage of the Census, relative to World Bank Living Standard Measurement Survey (LSMS) data, is that the latter occurred soon after the war and, being a panel, allowing us to (imperfectly) assess recovery. On the other hand, the Census is of course far larger in terms of sample size.

What neither Census nor LSMS data directly estimate is the effect of emigration. To some degree, this can be inferred, if one makes assumptions about mortality, by comparing the 1991 and 2013 Censuses. School enrollment data and election data provide alternative sources for estimating the emigrant population residually.

Having identified important social outcomes, we hope to relate them to conflict measures – three conflict types in Phase I of the war, three types in Phase II, and five types (including land mines and fatalities) in Phase III. Even if different types, distinct phases, conflict duration, and spatial and temporal autocorrelation prove unimportant for predicting military outcomes, they may be important in understanding social consequences.

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As emphasized above, pre-conflict events unrelated to social outcomes but that are related to conflict measures will be valid instrumental variables for conflict measures. In particular, we are optimistic that base year ethnic heterogeneity will prove to be a good instrument. It is also possible that dirty conventional war (or war crimes) will prove to be a valid instrument, precisely because they are so poorly correlated with rational military objectives that in turn are related to economic conditions. For nearly converse reasons, landmine density also may prove to be a valid instrument: they are useful in nearly all types of conflict, so that variation in their intensity may be effectively random.

The project sketched here is vast. Our hope is that the tragedy of Bosnia will enable us eventually to understand how war affects survivors – what sorts of conflict are especially pernicious, whether exposure duration is important, and which sorts of effects are most sensitive. That knowledge in turn may affect agreements on war practices, and post-war intervention strategies. In the interim, this analysis will assist in predicting how and where conflict is likely to mutate.

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Appendix 1: Mapping the BiH Civil War

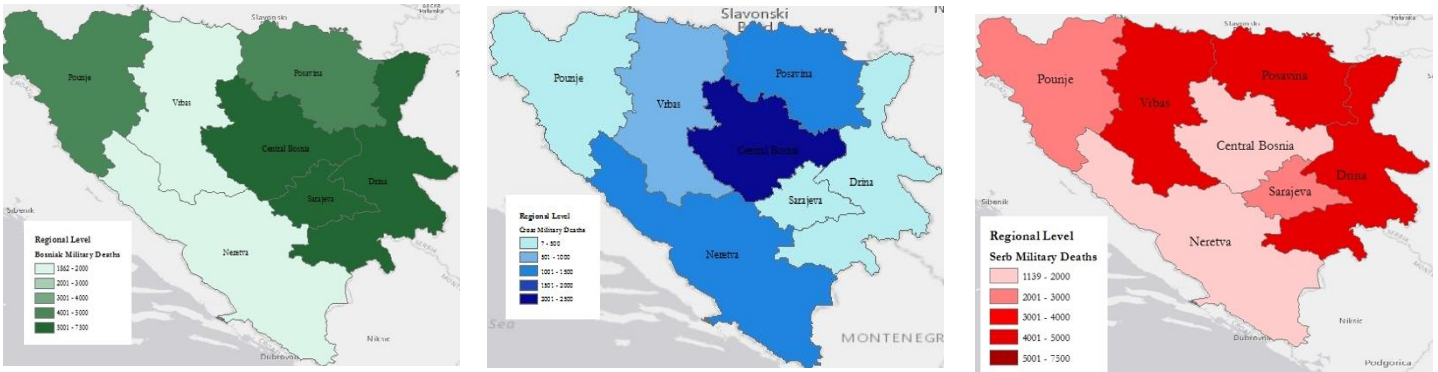

FIGURE 11: MILITARY DEATHS BY REGION BY ETHNICITY
SOURCE: Bosnian Book of the Dead

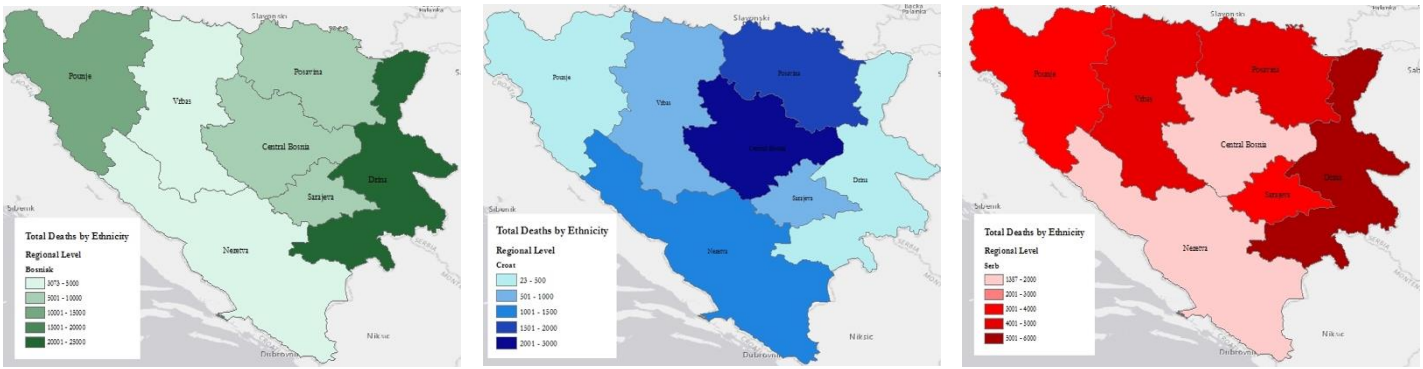

FIGURE 5: TOTAL DEATHS BY REGION BY ETHNICITY

SOURCE: Bosnian Book of the Dead

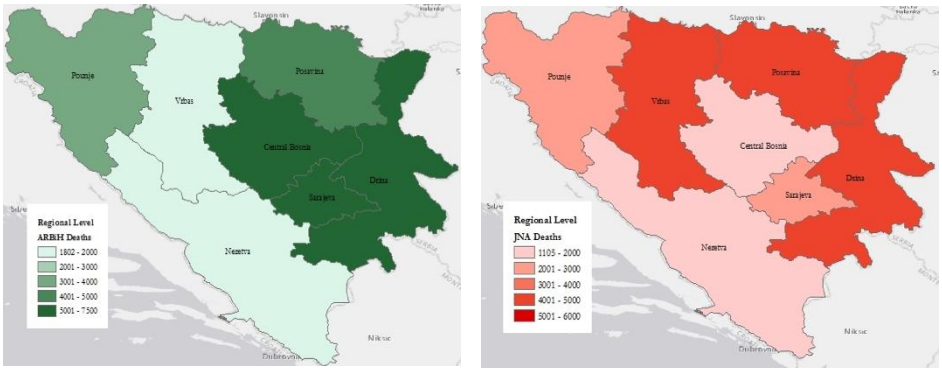

FIGURE 6: ARBIH AND JNA DEATHS BY REGION
SOURCE: Bosnian Book of the Dead

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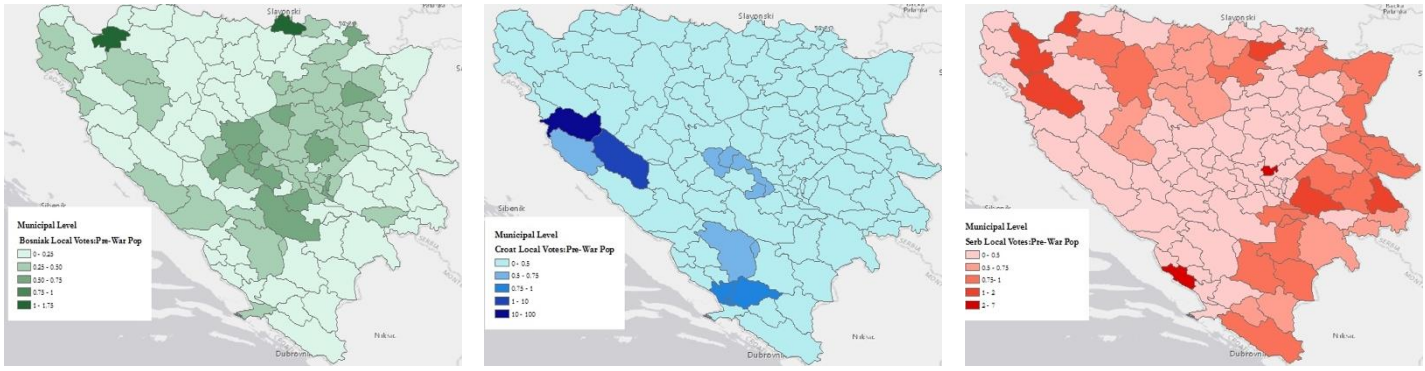

Figure 7: Post-War Local Votes for Ethnic Parties compared to Pre-War Ethnic Populations
Source:

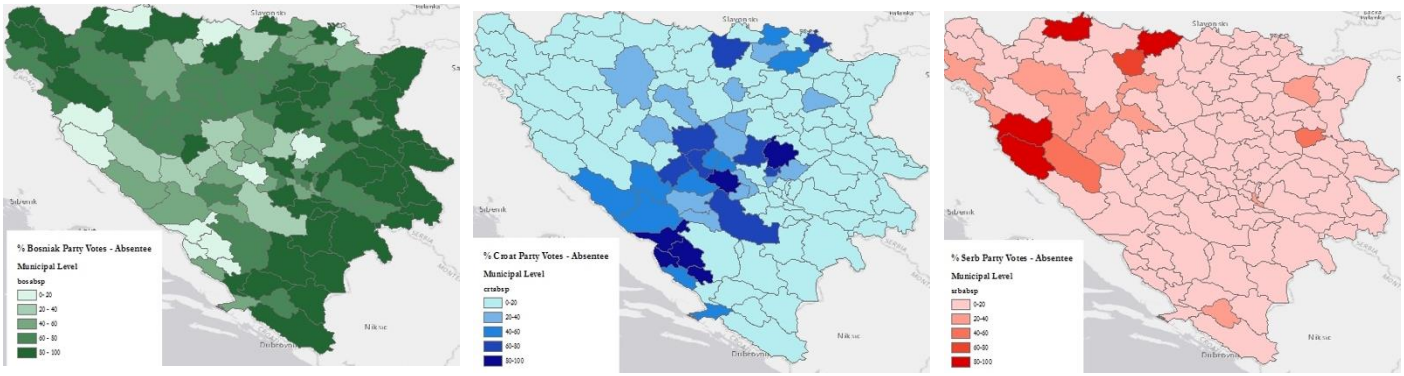

Figure 8: Percent Absentee Ballots for Ethnic Parties by Municipality
Source:

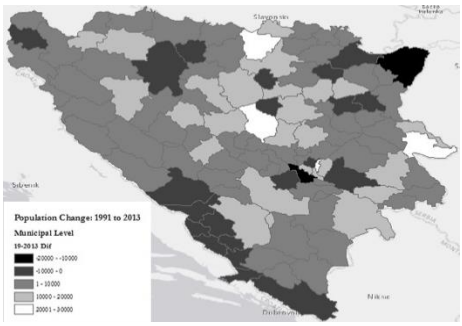

Figure 9: Population Change 1991 to 2013 by Municipality
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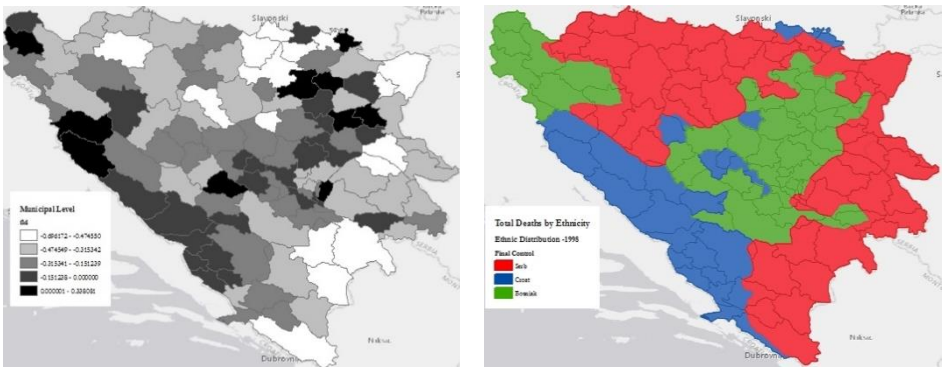

Figure 10: Difference between Post-War Fractionalization of the Local Votes and Pre-War Census Fractionalization compared to Post-War Ethnic distribution

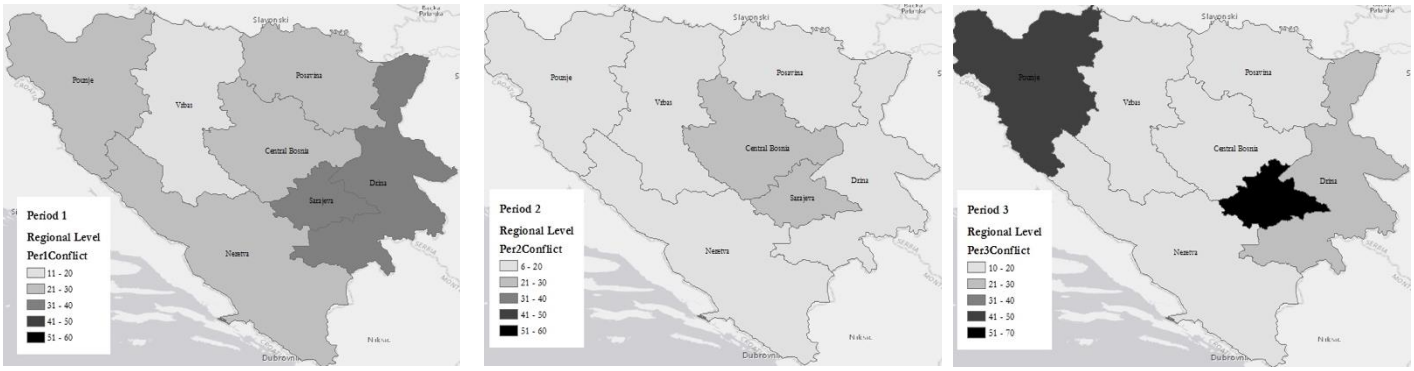

Figure 11: Incidences of Conflict across Time Periods
Source:

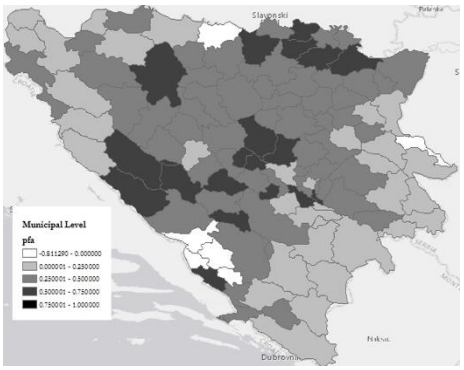

Figure 12: Polarization of Post-War Absentee Votes by Municipality

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Source:

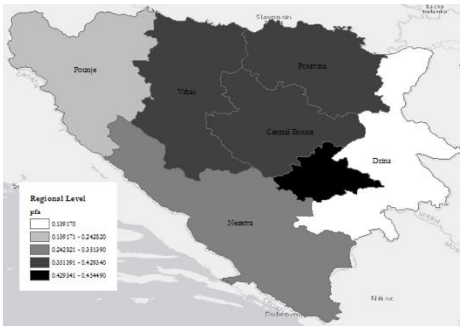

Figure 13: Polarization of Post-War Absentee Votes by Region
Source:

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Appendix 2: Conflict transition matrices

Period 1 Transition Matrix

REG	Captured	Recaptured	Trenches	War Crimes	Siege	Pocket	Infighting	Threatened	Contested
Central Bosnia	0	0	0	1	0	3	9	2	8
Drina	7	2	0	0	2	9	2	6	5
Neretva	4	0	0	0	1	1	5	5	5
Posavina	9	2	0	0	0	7	2	2	7
Pounje	4	0	0	3	0	4	2	10	0
Sarajevo	1	0	8	0	20	0	1	0	1
Vrbas	2	1	1	0	0	2	4	1	0
Total	27	5	9	4	23	26	25	26	26
Mean	3.86	0.71	1.29	0.57	3.29	3.71	3.57	3.71	3.71
Std Deviation	3.24	0.95	2.98	1.13	7.41	3.25	2.76	3.50	3.35
Min	0	0	0	0	0	0	1	0	0
Max	9	2	8	3	20	9	9	10	8

REG	Captured	Recaptured	Trenches	War Crimes	Siege	Pocket	Infighting	Threatened	Contested
Central Bosnia	1	1	0	1	4	3	9	1	4
Drina	0	0	0	0	0	9	0	2	0
Neretva	0	0	0	1	3	1	6	1	3

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Posavina	2	0	0	0	2	0	1	0	1
Pounje	0	0	4	0	4	3	1	0	0
Sarajevo	1	4	8	0	12	0	4	0	0
Vrbas	1	0	1	0	1	2	0	0	4
Total	5	5	13	2	26	18	21	4	12
Mean	0.71	0.71	1.86	0.29	3.71	2.57	3.00	0.57	1.71
Std Deviation	0.76	1.50	3.08	0.49	3.95	3.10	3.46	0.79	1.89
Min	0	0	0	0	0	0	0	0	0
Max	2	4	8	1	12	9	9	2	4

Period 2 Transition Matrix

Period 3 Transition Matrix

REG	Captured	Recaptured	Trenches	War Crimes	Siege	Pocket	Infighting	Threatened	Contested
Central Bosnia	0	0	1	0	6	0	0	3	6
Drina	3	0	0	3	1	19	0	2	1
Neretva	3	0	0	0	0	0	0	2	5
Posavina	0	0	0	1	0	2	0	8	9
Pounje	7	1	2	0	1	6	0	8	17
Sarajevo	0	0	28	2	28	0	0	6	6
Vrbas	5	0	2	0	0	0	0	3	5
Total	18	1	33	6	36	27	0	32	49

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Mean	2.57	0.14	4.71	0.86	5.14	3.86	0.00	4.57	7.00
Std Deviation	2.76	0.38	10.31	1.21	10.30	7.03	0.00	2.70	5.00
Min	0	0	0	0	0	0	0	2	1
Max	7	1	28	3	28	19	0	8	17

Total Transition Probability Matrix

	null	captured	trenches	war crimes	siege	pocket	internal fighting	threatened	contested
Null	0.8890	0.0130	0.0049	0.0024	0.0073	0.0081	0.0106	0.0227	0.0422
captured	0.5682	0.1364	0	0	0	0.0682	0	0.1364	0.0909
trenches	0.0543	0.0109	0.3913	0.0217	0.4348	0.0217	0.0109	0.0217	0.0326
war crimes	0.3125	0	0.125	0	0.1875	0.0625	0.0625	0.25	0
siege	0.0657	0	0.3211	0.0146	0.4891	0.0146	0.0584	0.0146	0.0219
pocket	0.1828	0.0645	0.0215	0.0215	0.03226	0.5161	0.0538	0.0538	0.05381
internal fighting	0.4844	0	0.0625	0.0156	0.125	0.0625	0.1563	0	0.0938
threatened	0.6032	0.0476	0	0.0317	0	0.0794	0.0317	0.1429	0.0635
contested	0.5789	0.0439	0.0439	0.0088	0.0351	0.0614	0.0440	0.0526	0.1316

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Appendix 3: Model prediction and major residuals, periods 1, 2, and 3

Name	Conflict Type	Regression Variables	Residuals' Conclusions
T1pc1 (period 1, PC_1 siege type conflicts)	Siege	All exogenous (population, infrastructure, urban/suburban, terrain)	The model based on non-political variables has a mixed performance in this period. It significantly underpredicts the incidence of the siege of Sarajevo and overpredicts it for a few other major urban areas – *e.g.*, Tuzla and the surrounding environs, Zenica and Banja Luka. There are two possible explanations for the Sarajevo result – one is that the full onset of the siege was not entirely expected on the ground, given the population composition and terrain and that the fact it was besieged as the result of events exogenous to the model; *i.e.*, political and tactical maneuvering. The historical record shows that indeed the Yugoslav Army, in the months leading up to the beginning of hostilities, deployed heavy weapons on the mountains surrounding the city and deployed arms to the local Serb population in the villages and suburbs surrounding the city, thus changing the facts on the ground. The other potential explanation for Sarajevo, and one which is of consistent concern, is the reporting bias of the capital city. As the capital city of the country, and a former Olympic host city, the conflict in Sarajevo is potentially overrepresented in the dataset, which is largely based on open-source information and thus dependent on journalistic reporting. The underprediction in Banja Luka, Zenica and Tuzla is likely in contrast, as these significant urban and industrial centers were not besieged – Banja Luka was quickly occupied by the Serbs who were the majority while Tuzla and Zenica avoided such fates – as there was less preparation (compared to Sarajevo) and less of a friendly population for the Yugoslav Army to arm in the surrounding areas.
T1pc2 (period 1, PC_2 hybrid type conflicts)	Hybrid	All exogenous (population, infrastructure, urban/suburban, terrain)	Exogenous variables seem to perform relatively good at predicting the potential for such conflict in Eastern Bosnia, though they underpredict it in the Northern lowlands of Derventa and Modrica, which were less fractionalized, but found themselves on the critical path of building up the corridor between Eastern and Western areas of Serb dominance. There is a systematic underprediction in Western Bosnia for reasons that are not immediately clear, but could have to do with the desire of the Serbs to consolidate these large but heavily Bosniak areas that presented an obstacle between the Serb controlled areas in Croatia and Bosnia. However, the battles for the corridor in the north of the country likely pulled away the bulk of the armored force from Banja Luka, meaning that the conflict was largely militia-driven.

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T1pc3 (period 1, PC_3 dirty conventional conflicts)	Dirty Conventional	All exogenous (population, infrastructure, urban/suburban, terrain)	The model generally performs well with this type of conflict but underpredicts the incidence in municipalities surrounding Banja Luka. This is an area with significant war crimes – *e.g.* Prijedor and Sanski Most, which were non-majority Serb before the war, and which were fairly thoroughly cleansed in the opening stages of the war – *e.g.*, the concentration camps of Omarska and Keraterm, as well as the largest single mass grave in Bosnia at Tomasica. These probably were more overt and industrial-scale then elsewhere in the country, showing up eventually on BBC in the fall of 1992. The presence of significant armored and mechanized forces in the neighboring city of Banja Luka (armored training center) could have lent heavier than expected firepower in these areas.
T2pc1_con predicted values (period 2, siege conflict, only lagged PCs)	Siege	Period one conflict PCs (presence of siege, hybrid, and dirty conventional)	The period 2 siege regression on T1 conflict PC shows a relatively good performance throughout the country except in three key areas – the first being Sarajevo, which continues to be underpredicted despite having been sieged in the previous period, and which, as discussed previously, may reflect capital city/ reporting bias; the second being the overperformance in the major urban/industrial areas – Banja Luka, Zenica, and Tuzla basin municipalities which were not besieged at this time; and finally, the third being the brutal siege of Mostar which is heavily underpredicted. In this period the Bosniak/Croat conflict occurs with Mostar as ground zero, and which was not indicated by the conflict variables in the previous period.
T2pc2_con predicted values (period 2, dirty conventional, only lagged PCs)	Dirty Conventional	Period one conflict PCs (presence of siege, hybrid, and dirty conventional)	This model performs relatively well across the country. However, it underperforms (and overpredicts) in Eastern Bosnia and Bihać where there is less conflict than anticipated, and overperforms (and underpredicts) in central Bosnia and in Herzegovina where more conflict occurs than expected. This is actually an interesting artifact, as conflict in period 2 is defined by the Bosniak-Croat conflict in central Bosnia and in the Neretva valley of Herzegovina proper. The model underperforms in areas where we would expect Bosniak-Serb conflict (*i.e.*, where the enclaves are located) and overperforms in areas where Bosnia experienced Bosniak-Croat conflict – still, apart from Sarajevo this residual map is very indicative of where conflict occurred in this period. **This likely indicates that the conflict changed type to something not seen in period 1.**
T2pc3_con predicted values	Civil War	Only period one conflict PCs (presence of siege, hybrid, and dirty conventional)	This model generally underpredicts areas where civil conflict occurred in this period – both between Bosniaks themselves (*e.g.*, Bihać, though there is likely a somewhat inaccurate coding of that conflict given that the municipalities in that area are collectively known as Bihaćka Krajina) and between Bosniaks and Croats. **This implies that there is something systematically different about this conflict type than that observed in**

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(period 3, civil war, only lagged PCs)			**the previous period – a fairly obvious point especially in areas of intra-Bosniak fighting, but also reflective of changes in alliances and main warring parties in different parts of the region.**
T2pc1	Siege	All exogenous (population, infrastructure, urban/suburban, terrain) + conflict variable	The model here continues to have similar performance to the first period siege PC in the same specification – it is underpredicting Sarajevo, which continues to be under siege, and overpredicts other industrial areas. However, it is also underpredicting Mostar and the areas in central (*e.g.*, Maglaj) and northern Bosnia (*e.g.*, Orasje) that ended up under siege due to military operations in the previous period rather than any intrinsic strategic importance.
T2pc2	Dirty Conventional	All exogenous (population, infrastructure, urban/suburban, terrain) + conflict variables	The model overpredicts this type of conflict in several municipalities and underpredicts conflict in several others largely in central Bosnia where such conflict occurred. The pattern once again overpredicts in areas of Bosniak-Serb conflict and underpredicts in many areas of Bosniak-Croat conflict – though not all, as there is a wide band in the area of Lasva valley where the model underpredicts.
T2pc3	Civil War	All exogenous (population, infrastructure, urban/suburban, terrain) + conflict variables	This model underpredicts the Bosniak-Croat conflict in Central Bosnia and in the Neretva Valley of Herzegovina. Not surprisingly, it also misses the Bosniak-Bosniak conflict in Western Bosnia. The underprediction in Eastern Bosnia does not fit with the description of the civil war principal component.
T3pc1_con-residuals (period 3, siege, only lagged PCs)	Siege	Only period two conflict PCs (presence of siege, dirty conventional, and civil)	This model once again underpredicts the siege of Sarajevo. It continues to overpredict sieges of major urban/industrial areas across the country.

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T3pc2_con-residuals (period 3, conventional, only lagged PCs)	Conventional	Only period two conflict PCs (presence of siege, dirty conventional, and civil)	This model underpredicts conventional conflict in the west of the country. The combined Bosniak-Croat offensive in the summer/fall of 1995 is not correlated with the occurrence of conflict in the prior periods. This is likely due to the fact that the offensive is enabled by the success of Operation Storm in Croatia which reconquered the Serb-controlled areas of Croatia. **However, this operation is completely exogenous to what had occurred previously and that was recorded in the dataset, so there is no reason to expect it to be predicted.**
T3pc3_con-residuals (period 3, hybrid, only lagged PCs)	Hybrid	Only period two conflict PCs (presence of siege, dirty conventional, and civil)	**The residuals here are concentrated in the areas of Bihać, and in Eastern Bosnia, particularly Srebrenica, Žepa and Goražde. What we are seeing is Serb operations to mop up enclaves in the East with support from paramilitary militias which resulted in the genocide of Srebrenica and the attacks on other enclaves.** Bihać could represent the interaction of Serbia's paramilitary forces' support for the renegade Bosniaks whose rebellion was finally ended in the context of the Operation Storm.
T3pc1	Siege	All exogenous (population, infrastructure, urban/suburban, terrain) + conflict	The model continues to underpredict the siege of Sarajevo for previously stated reasons. It is also continuing to overpredict the siege of other major urban areas.
T3pc2	Conventional	All exogenous (population, infrastructure, urban/suburban, terrain) + conflict	**The model underpredicts conflict essentially everywhere where it occurred in the country.**
T3pc3	Hybrid	All exogenous (population, infrastructure, urban/suburban, terrain) + conflict	**The model systematically underpredicts the most of the conflict in this period** except in Sarajevo where it overpredicts the conflict.

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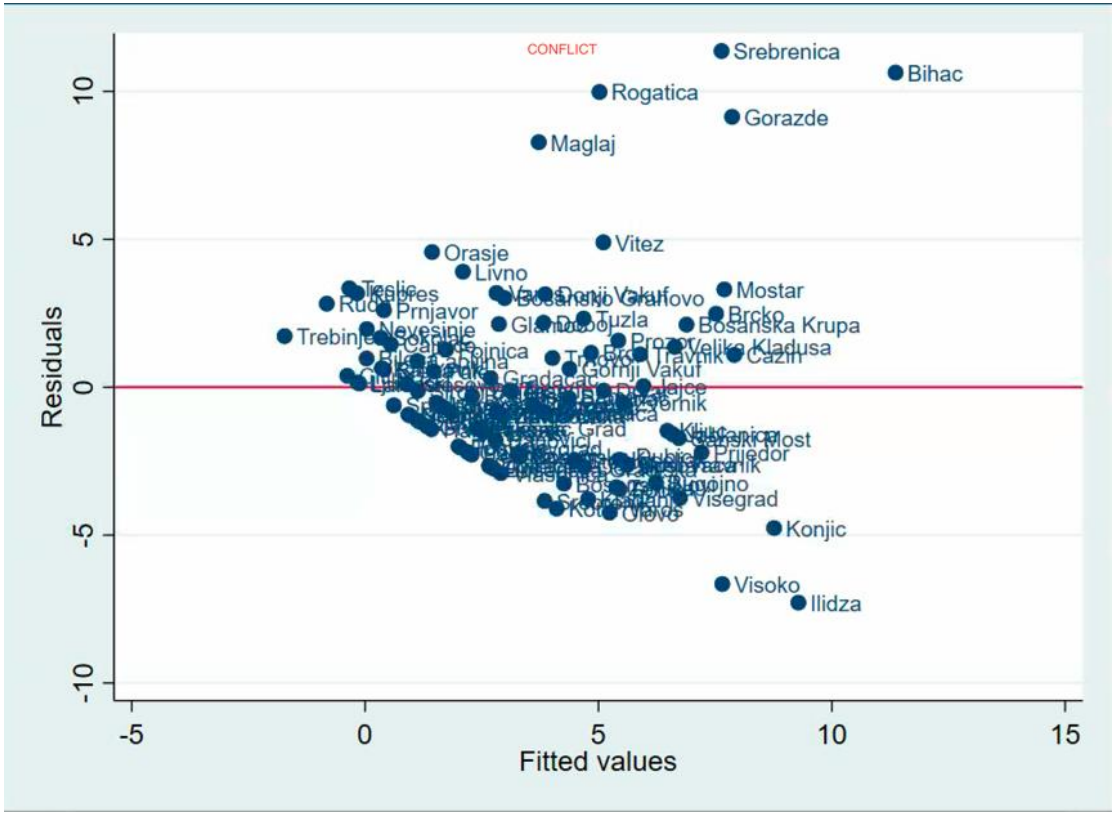
Appendix 4: UCDP data analysis comparisons



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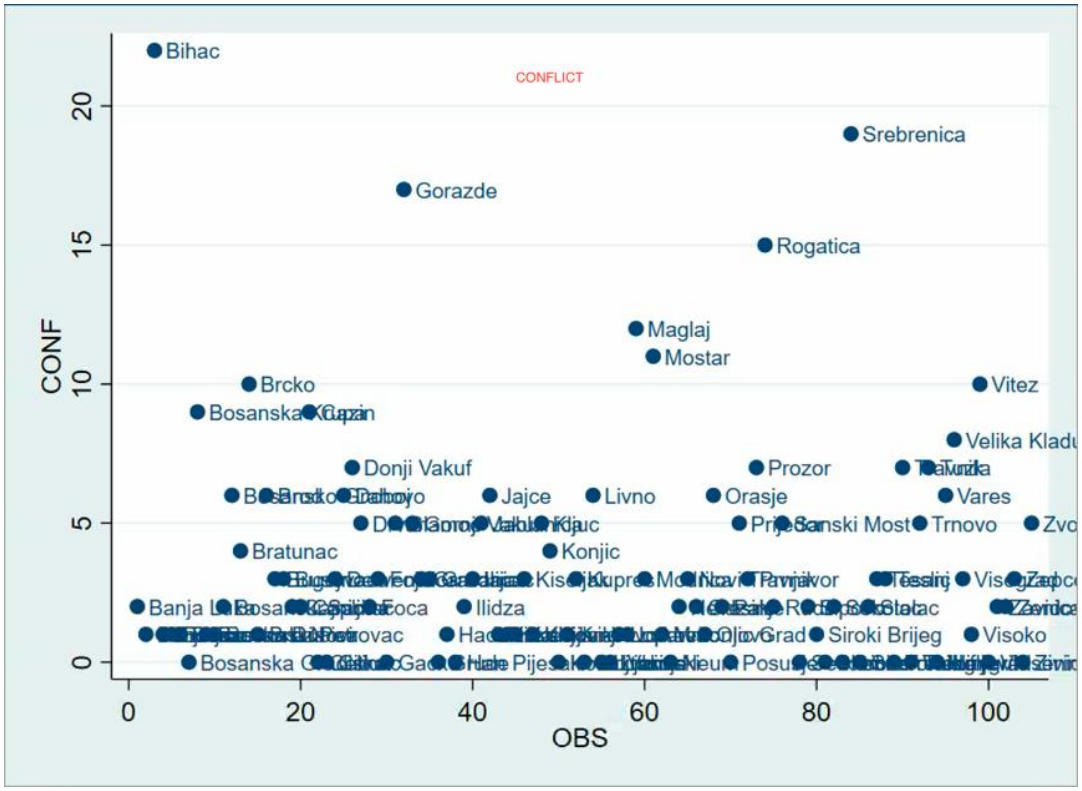

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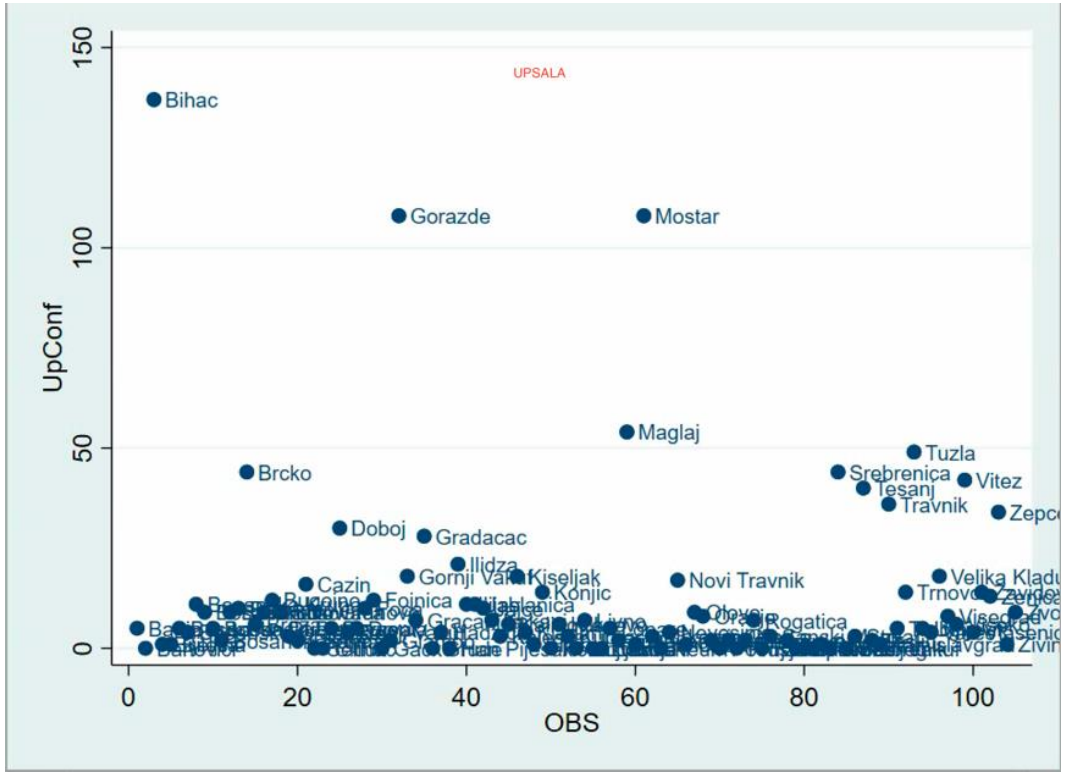

Appendix 5: Selected Regression Tables

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