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Natural Resources
and Armed Civil Conflict

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Introduction and Summary

INTRODUCTION

This thesis explores the relationship between natural resource endowment and armed civil conflict. In particular, it concentrates on unraveling whether or not natural resources have an effect on conflict through the incentives and opportunities they provide for rebel movements. The thesis departs from the standard approach to statistical conflict analysis in which natural resources are considered at the country level without controlling for rebels' access to the resource base. Because of the lack of suitable data on natural resource localities, a substantial part of the thesis is devoted to the collection of such data.

My project was inspired by Collier and Hoeffler's (2004) seminal work on the role of natural resources in civil war. Instead of considering resource abundance as detrimental to peace in the traditional economic sense through Dutch disease, which can increase the vulnerability of a country to conflict, they propose that natural resources provide opportunities, occasionally even motivation, for cash-strapped rebel movements to emerge and survive.

Despite their intriguing insight, the Collier & Hoeffler work, especially the statistical analysis they conduct, has been attacked on various grounds. Clearly, their measure of resource revenues available to the rebel movement – primary product exports to GDP ratio – is not ideal. The ratio does not distinguish between different resource types. It includes many resources, such as oil, that are not readily available for rebel exploitation during a conflict, and it partially excludes revenues from some of the most lootable resources such as smuggled gemstones and drugs. The ratio also makes the analysis susceptible to reverse causality even though Collier & Hoeffler's research design does limit the problem. Crucially, the analysis is not able to control whether the rebels in reality have access to resources, which is a central element in the Collier & Hoeffler proposition. For example, is it plausible to think that diamonds in Siberia, Russia, are linked to the Chechen conflict in the North Caucasus?

Other researchers have contested the robustness of the Collier & Hoeffler results and the correctness of their interpretations. Fearon (2005) shows that the Collier & Hoeffler results are not necessarily robust in relation to other model specifications and Sambanis (2004) and Hegre & Sambanis (2006) find that natural resources are not always robustly related to conflict. Fearon & Laitin (2003), Humphreys (2005), and de Soysa & Neumayer (2007) among others challenge the accuracy of the underlying causal mechanism proposed by Collier & Hoeffler. They argue that resource-dependent

countries are more prone to conflict because of resources adversely affecting the state, its institutions, and its (military) capacity. These studies also tend to find that dependence on oil production is the main cause of the perceived link between natural resources and conflict.

Are these weaknesses in the analysis, conflicting results, and other plausible explanations enough to discredit the Collier & Hoeffler proposition altogether? Their argument is intuitively appealing and there is case study evidence supporting their assertion that natural resources can play an important role in rebel group financing (Ross 2004a, b). By using more appropriate data and analysis methods, can N-large statistical studies support their argument? This is the central theme in my thesis.

From the very beginning of this project I was aware that I needed to address two crucial issues if I wanted to explore statistically the plausibility of the Collier & Hoeffler argument. First, I needed to disaggregate the resource variable and concentrate on a few, likely, causes. Second, I needed to collect data on resource localities to be able to control for whether or not rebels in reality had access to natural resources. Therefore, collecting location data on a few, highly relevant natural resources became one of the top priorities for my project. By using such data this thesis seeks to shed light on the following research question:

- Do natural resources have a detrimental impact on peace through their effects on rebel groups?

In addition to answering this fundamental question, my thesis seeks to investigate and provide a more nuanced picture of the link between natural resources and armed civil conflict with the following broad research questions as a guide:

- How do natural resources affect different aspects – onset, duration, and severity – of armed civil conflict?
- Is it necessary to control for the location of natural resources, or can we rely on country-level aggregates?
- Do the types of natural resources matter? Are rebel movements motivated and sustained only by resources that can be looted during a conflict or can a promise of future resource revenues have a similar impact?

Summary of the articles

This thesis consists of six independent yet related articles. Four have been published in international peer-reviewed journals, while the remaining two are under review. Two are single authored. Chapter 2 demonstrates the need to collect data and conduct analysis at the subnational level. Chapters 3 and 4 describe and document two natural resource datasets – diamond deposits and hydrocarbon reserves, respectively – that can be used in disaggregated analysis of armed civil conflict. The remaining three chapters use these data and analyze various aspects of armed civil conflict.

Chapter 2: Accounting for scale: Measuring geography in quantitative studies of civil war

This article was jointly written with Halvard Buhaug and was published in *Political Geography* (Buhaug & Lujala, 2005). In this article, we demonstrate the possibility of incorrectly conducting statistical analysis on armed civil conflict at the country level when the independent variables have a considerable subnational variation. Several theoretical arguments refer to local conditions relevant in shaping civil conflicts, yet the subsequent testing commonly uses country-level measures. For example, rough terrain and natural resource endowment are commonly linked to civil conflict, but as forests or mountains only rarely span entire countries and many natural resources are location specific, using country-level aggregates is questionable. In this article, we show how Geographical Information Systems (GIS) can be used to generate conflict-specific measures and how these can be used in conventional statistical analysis. We find that conflict zones are not representative of the host country and that several covariates change their performance when we move from country-level analysis to conflict level.

Chapter 3: Conflict diamonds: A new dataset

This article was written jointly with Elisabeth Gilmore, Nils Petter Gleditsch and Jan Ketil Rød and was published in *Conflict Management and Peace Science* (Gilmore et al., 2005). It introduces and describes a new dataset, DIADATA, which provides a comprehensive list of diamond deposits throughout the world. The dataset has several useful features. First, it concentrates on a single resource and thus avoids aggregating resources that may have different, even opposite, impacts on armed civil conflict. It concentrates on a high-value low-weight resource that has frequently been mentioned in conflict literature as a conflict-generating and -sustaining factor yet it has rarely been included in the statistical analysis of conflict. Second, the dataset includes information

on the geological type of the deposit: whether it is secondary, which generally are relatively easily accessible for mining, or primary, which often require more sophisticated extraction methods. Third, in contrast to other diamond datasets, the base unit for the dataset is not the country but the diamond deposit. DIADATA includes spatial information in the form of latitudinal and longitudinal coordinates for each deposit. Finally, DIADATA includes information on when the specific diamond deposit was discovered and, where relevant, the first year the site produced diamonds. This makes it possible to use the diamond data in time-series analysis. In total, the dataset includes 1,175 entries divided into more than 200 primary and almost 900 secondary deposits. DIADATA, a detailed codebook, and country profiles are publicly available. DIADATA comes also as a compact dataset that aggregates sites in the same region.

Chapter 4: Fighting over oil: Introducing a new dataset
This article was coauthored with Jan Ketil Rød and Nadja Thieme and was published in *Conflict Management and Peace Science* (Lujala, Rød & Thieme, 2007). This article presents PETRODATA, a dataset of oil and gas reserve locations throughout the world. It includes information on discovery year and, where relevant, the first production year, for 890 onshore and 383 offshore regions. This enables the user to ensure spatial and temporal overlap with conflict data. To demonstrate the usefulness of the dataset in subnational analysis, we run a simple duration analysis in which we use both the temporal and the spatial features of the dataset. We find that oil and gas production in the conflict zone makes governmental conflicts longer while having no effect on the length of territorial conflicts. Although we use the dataset in the context of armed civil conflict, this dataset could also be used in other studies, for example to analyze international relations and disputes. The dataset is publicly available.

Chapter 5: A diamond curse? Civil war and a lootable resource
This article was written jointly with Nils Petter Gleditsch and Elisabeth Gilmore and was published in *Journal of Conflict Resolution* (Lujala, Gleditsch & Gilmore, 2005). In this article, we concentrate on the role of diamonds as one key resource in the conflict literature. We use the DIADATA dataset on diamond production to study onset and prevalence of major civil war. The article demonstrates the importance of disaggregating diamond deposits according to their geological form. Primary diamonds, which generally cannot be considered lootable, and the more lootable secondary diamonds affect civil war differently. We find that generally diamonds are not related to

the onset of civil war for the post-World War 2 period. However, secondary diamonds tend to promote the onset and incidence of ethnic conflict. Analysis restricted to the post-Cold war period shows that secondary diamond production strongly and significantly increases the risk of conflict onset and is positively related to conflict prevalence. Production of primary diamonds, on the other hand, is related to lower risk of conflict.

Chapter 6: The spoils of nature: Armed civil conflict and rebel access to natural resources

This article analyzes the effect of natural resources on the duration and onset of conflict. In addition to using the location data on oil and gas and diamond deposits described in Chapters 3 and 4, it also includes newly collected data on other gemstones such as rubies, sapphires, and jade (Flöter, Lujala & Rød, 2005). The duration analysis fully integrates the advantage of the spatial and temporal aspects of these datasets. The article shows that valuable resources located in the conflict zone are associated with the doubling of the length of conflict. Strikingly, when I measure resource endowment at the country level, the resources are seemingly unrelated to the duration. The role of location is further illustrated by the onset analysis: oil and gas production located in the offshore areas is not related to the onset even though onshore production increases the risk of onset. The results in this article provide strong evidence that natural resources play a central role in civil wars because of the incentives and opportunities they present for rebel groups. Interestingly and importantly, the onset analysis shows that secondary diamond production considerably increases the risk of conflict onset. This stands in contrast to other statistical studies, which have not found such a link.

Chapter 7: Deadly combat over natural resources: Gems, petroleum, drugs, and the severity of armed civil conflict

This article studies how natural resources are related to two aspects of conflict severity: the number of combat-related deaths and the intensity of conflict. Based on the insights provided by the previous chapters, I expect that location of natural resource extraction crucially determines the range of possible effects. I also expect that the type of resource influences the direction and size of the impact. In addition, I suspect that oil and gas production outside the conflict zone and in offshore areas may be related to conflict. The results confirm that it is essential to control for the location of natural resources. Oil and gas production is a prime example of this. Production substantially increases the

severity when located inside the conflict zone. When located outside the conflict zone and offshore areas, production has the opposite effect: these conflicts accumulate fewer combat deaths and are less intensive. Furthermore, when I use country-level aggregates, I find no relationship between oil and gas production and conflict severity. I also find evidence that the resource type matters. Drug cultivation in a conflict zone is associated with less severe conflicts. Gemstone mining increases the number of combat deaths but is not necessarily related to more intensive conflicts. The most violent of all conflicts are secessionist conflicts in regions with oil and gas production. Results in this article imply that natural resources affect conflict severity by altering incentives for both the rebel group and the state.

Concluding remarks and some future research agendas

This thesis has sought to investigate the role of natural resources in armed civil conflicts after the Second World War. The principal research question has been whether rebel movements can be motivated and sustained by natural resource exploitation. The thesis consists of several empirical articles that analyze various aspects of conflict – onset, duration, and severity – at the country and conflict levels. Data collection on drug cultivation, oil and gas, diamond, and gemstone localities throughout the world has been an essential part of the project.

In my opinion, one of my most important conclusions in the thesis is the proposition that natural resources have a direct effect on rebel movement. If natural resources affected conflict only through their adverse effect on the state, we would expect all resource revenue sources to have the same effect on conflict. Contrary to this, I find that natural resources tend to have an effect on conflict only when the resource sites are located in the conflict region. For example, oil and gemstone production make conflicts longer and more violent, but only when they are located in the conflict zone. Moreover, offshore oil and gas production, which is less likely to have a direct effect on rebel groups, has no effect on conflict onset, although onshore production positively predicts the risk of conflict. This, of course, is not to say that natural resources cannot have a negative impact on peace through their effect on the state. In fact, I find that conflicts in which the state and rebels contest access to resources that are highly valuable for both sides are prolonged and the most severe. This indicates that the state is prepared to use more force when its economic interests are threatened.[1]

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[1] Furthermore, resource curse in the form of slow or negative growth, deteriorating institutions, and weak-state capacity is a very real and challenging issue for many resource-rich countries and a potential source of conflict-generating grievances and opportunities.

That location of natural resources matters has a clear and important implication for empirical conflict research in general: it is imperative to control for local conditions if we want to explain rebel behavior in conflict. In this thesis, relying on country-level aggregates would have led to wrong conclusions about the role of natural resources in armed civil conflict. I find that country-level aggregates are rarely related to conflict duration or severity. However, these nonresults tend to evaporate as soon as I replace them by conflict-level measures. An illustrating example is the effect of oil and gas production on conflict severity: at the country level, production does not have any effect on severity, but disaggregated measures show that production inside the conflict zone makes conflict more severe while production outside the conflict region and in offshore areas actually tends to make conflict less severe.

Yet another important conclusion provided by this project is that natural resources should be considered individually and not lumped together. Oil and gas, gemstones, and drug cultivation in the conflict zone affect conflict severity very differently: drug cultivation is related to fewer combat deaths and lower conflict intensity, gemstone mining to more deaths but not necessarily to more intensive conflicts, and oil and gas production to a higher number of deaths and more intensive conflicts. Diamonds provide another illustrative example: the geological form of the diamond deposit is related to its effect on conflict. Secondary diamonds – the more lootable form of the two deposit types – makes conflict more likely, longer, and more severe. Primary diamonds, on the other hand, are generally not related to conflict.

Finally, future revenue flows are related to conflict via the rebel channel. Revenues from oil and gas production are rarely available to rebel groups during a conflict and rebels can access these revenues only through successful state capture or secession, or by increasing their negotiation power in how resource revenues originating from the region are shared. However, production of oil and gas makes conflicts longer and more severe, indicating that rebels tend to value the promise of future revenues highly. Moreover, I find that production is not always necessary for this effect: the mere presence of oil and gas reserves in the conflict region is sufficient to lengthen the conflict substantially.

This thesis has documented the need to collect resource data at the subnational level. As a part of this project we have collected data on diamonds, other gemstones, hydrocarbons, and drug localities throughout the world. Future research on resource-induced conflicts should seek to collect similar data on other natural resources. Priority should be given to resources that are rare, have a high value-to-weight ratio, and can be easily smuggled. These include natural resources such as gold, chromite, and tantalite.

This thesis demonstrates the necessity of conducting conflict studies at the subnational level. Since the start of this project, the research on armed civil conflict has moved more and more in this direction and the first truly disaggregated conflict studies have been recently published (Buhaug & Rød, 2006; Raleigh & Urdal, 2007). As more detailed data on conflict zones and rebel-held areas become available, it will be possible to study the resource–conflict nexus in more detail. Do conflicts start near the extraction sites, or is it only later that the conflict zone encompasses the resource areas? Does the fighting concentrate at or near the exploitation sites, or are these areas relatively free of fighting? Answers to these and other questions would give valuable insight into what extent resource looting is used to finance the start-up costs of rebellion and to what extent it is used to finance fighting after the conflict outbreak. They could also shed light on the question of the extent that rebels are motivated by personal enrichment rather than other, more 'noble' objectives such as economic and political equality.

For policy purposes it is necessary that we have a better understanding of causal mechanisms of how natural resources shape rebel movements and their behavior. We need to know under which circumstances individuals join rebel movements that are motivated by resource looting and personal enrichment. Are these different for participants that join rebellions seeking autonomy for a region with oil production? Are rebel movements originating from regions with valuable natural resources generally different from other rebel organizations? How and why do groups that begin as justice-seeking movements sometimes end up as looting bandits that indiscriminately use violence toward civilians? Do natural resources affect which form the rebellion takes: factional warlordism, guerilla war, terrorism, etc? Weinstein (2007) provides valuable insight into how natural resources can shape rebel organization, but further research – statistical and theoretical, as well as case studies – is required before we can fully conceptualize the many possible mechanisms that operate between natural resources and rebel group formation and conflict, and how these complement and interact with mechanisms that work through the state.

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Accounting for Scale:

Measuring Geography in Quantitative Studies of Civil War

Accounting for scale: Measuring geography in quantitative studies of civil war

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Abstract

The empirical evidence from studies linking geographic factors like terrain and natural resources to civil war is generally weak and not robust to varying samples or coding procedures. We argue that these investigations suffer from a major weakness: although most civil wars are geographically limited to small parts of the host countries, the analyses rely almost exclusively on country-level data. We demonstrate how Geographical Information Systems (GIS) can be used to generate precise measures of space-varying factors at the scale of the conflict. A comparison of several relevant variables measured both at the scale of the country and the conflict demonstrates that country statistics are poor approximations of the conflict zones. An analysis of duration of civil war further shows that certain findings are indeed dependent upon the scale of measurement. We conclude by discussing how GIS and spatial analysis may be applied in future research to increase our understanding of location, duration, and risk of armed civil conflict.
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Introduction

The link between geography and war has deep roots. From Sun's (500 BC/1963) classic treatise *Art of War*, via early-modern theoretical works on geopolitics and imperialism, to contemporary conflict studies, scholars of international relations have repeatedly asserted that geographical factors are vital aspects of the origin and conduct of war (see Diehl, 1991 for an overview). Features of terrain, subsoil assets, population distribution, and ethnic diversity are aspects of geography that have received particular attention. Typically, the risk and duration of civil war are thought to be high in remote, rural districts, populated by an ethnic or religious minority, with rough mountainous or forested terrain, and containing valuable natural resource deposits. So far, however, empirical studies have been less than successful in establishing a clear link between the geographic distribution of physical and human factors and civil war.

The theoretical framework for empirical studies on civil war and geography is often motivated by how local factors such as rebels' access to easily exploitable natural resources and sanctuaries in rough terrain increase the viability of insurgency. However, our review of the empirical literature shows that most studies ignore local conditions and instead use country aggregates in analysis. We argue that while it may be appropriate to focus on the national scale and use state-level geographical variables when exploring the risk of conflict, this research strategy is less suitable when the conflict is the unit of observation. This is particularly true for conflicts that are spatially limited and in cases with several simultaneous conflicts within the same country. We demonstrate that Geographical Information Systems (GIS) can be used to generate measures of geography that are unique to each conflict zone. To explore the effect of scale of measurement, we compare sample means for several indicators of terrain and natural resources. The *t*-test shows that all conflict-specific variables differ significantly from the corresponding variables measured at the habitual country level. We then conduct an analysis of duration of civil war, which reveals that some findings are indeed dependent on the scale of measurement. In particular, presence of gemstones and coca cultivation in the conflict zone increases the length of conflict considerably, while they are found to have diminutive effects when measured at the country level. In addition, the use of precise conflict location data allows us to add a new variable to the duration analysis that measures the conflict–capital distance. The relative location of conflict matters: the further the conflict is from the capital, the longer it lasts. This is a powerful effect that substantially alters the estimates for country size, type of incompatibility, and rainy season. The results show that local conditions and the relative location of the battle zones should be accounted for in conflict studies, and that future research on civil conflict could greatly benefit from the use of GIS and spatial methodology.

Previous studies of geography and civil war

Inspired by the likes of Alfred T. Mahan and Harold J. Mackinder, the 19th- and early 20th-century classic geopolitical literature deals solely with international wars.

This is reflected in the quantitative conflict literature, which has until recently almost exclusively studied militarized interstate disputes and wars. Yet, civil war is by far the dominant form of conflict. Since the Congress of Vienna (1814–1815), only two decades have produced as many interstate wars as civil wars, and in every 10-year period since the Second World War the rate of civil war onsets has exceeded that of international wars (Sarkees, Wayman, & Singer, 2003). In fact, the war between India and Pakistan over Kashmir was the sole international conflict among the 34 active conflicts in 2001 (Gleditsch, Wallensteen, Eriksson, Sollenberg, & Strand, 2002). As the World Bank Policy Research Report (Collier et al., 2003) argues, researchers should pay more attention to civil wars.

Traditionally, quantitative IR and conflict studies define geography in a very narrow sense, merely permitting the concept to include measures of contiguity and distance. This is, of course, mainly due to the general focus on interaction between states, where other factors, including economic issues, regime attributes, alliance patterns, and balance of power, are presumed to be more salient and influential. Yet, with the recent shift in the academic interest from international wars towards civil wars, other aspects of geography are now considered as part of the equation. Natural resource dependence, in particular, has received substantial attention. Among others, Addison, Le Billon, and Murshed (2002), Auty (2004), Collier and Hoeffler (1998, 2002, 2004), and Ross (2004a,b) have promoted the view that valuable and easily exploitable natural resources constitute opportunities for rebellion by providing finance for arms purchase and rebel recruitment. In fact, Addison et al. (2002) claim that since a civil war may provide all fighting groups economic opportunities that are not present during peacetime, the parties may prefer continued fighting to peace. In this way, natural resources may increase the risk of internal armed struggle and at the same time decrease the likelihood of peaceful resolution once the conflict gets going. Some also emphasize the negative impact of resource abundance on regime stability and economic growth, thus suggesting a more indirect path of causation (see Auty, 2001; Sachs & Warner, 1995, 2001).[2]

The empirical evidence for a causal connection from resource abundance to conflict is less consistent than the theory, although several case studies suggest that such a link exists (Fairhead, 2000; Le Billon, 2001; Renner, 2002; Smillie, 2002). In a study of 78 civil war onsets since 1960, Collier and Hoeffler (2004) report a significant parabolic relationship between natural resource dependence and risk of civil war. However, this finding is not particularly robust, as shown by Fearon and Laitin (2003) and Elbadawi and Sambanis (2002). Using more disaggregated

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[2] In seeming contrast to the resource abundance perspective, some scholars argue that environmental scarcity – that is, scarcity of renewable resources – is a major threat to domestic and interstate stability (see Hauge & Ellingsen, 1998; Homer-Dixon, 1999). The two literatures are not as opposed as it seems, though, since they generally pertain to different types of resources. Advocates of the scarcity perspective concentrate on issues related to regional/global depletion of renewable resources (fresh water, soil, crops, forest), whereas the abundance literature mainly focuses on non-renewable resources (gems, minerals, fuels, drugs). While not dismissing the arguments for scarcity-based conflicts, we limit the discussion and empirical testing in this article to availability of valuable and easily extractable resources.

measures of resources, both de Soysa's (2002) and Fearon and Laitin's analyses suggest that oil-exporting countries have substantially higher risks of internal conflict. de Soysa and Neumayer's (2004) work on natural resource rents further suggests that revenues from non-fuel minerals are generally unrelated to the risk of civil conflict. In one of the few studies that analyze the duration of civil war, Collier, Hoeffler, and Söderbom (2004) find only a weak and statistically insignificant effect of primary commodity exports. In contrast, Fearon (2004) makes a case for how extraction of certain contrabands (gems and drugs) has enabled ethnic groups to conduct protracted warfare. In sum, the empirical evidence for direct connection between natural resource abundance and civil war is far from impressive, and findings seem to vary with the operationalization of the resource proxy.

Several studies have pointed out that rebel movements prefer to operate from peripheral bases in mountainous or densely forested regions, which presumably provide safe havens out of reach of government forces. Collier and Hoeffler (2004), Collier et al. (2004), DeRouen and Sobek (2004), and Fearon and Laitin (2003) all include a measure of mountainous terrain, and some additional control for forest cover. These terrain measures have so far failed to produce consistent and robust results. In Collier and Hoeffler's study of civil war onset, neither terrain indicator produced a significant effect. Fearon and Laitin (2003: 85) reach the opposite conclusion, stating that 'mountainous terrain is significantly related to higher rates of civil war'. The two analyses apply fairly similar operationalizations of civil war, but the Fearon and Laitin study covers a larger temporal span (1945—1999 versus 1960—1999), includes more civil war onsets (127 versus 78), and employs annual data compared to Collier and Hoeffler's five-year pooled time series. Nevertheless, the discrepancy is disturbing. In a study of the duration of 55 civil wars since 1960, Collier et al. find that extensive forest cover and mountainous terrain are not significantly associated with longer wars. In contrast, DeRouen and Sobek's analysis of civil war outcomes shows that forest cover increases the likelihood of prolonged conflict. Mountainous terrain, on the other hand, reduces duration by increasing the likelihood of rebel victory and ceasefire.

In addition to natural resources and rough terrain, the distribution and ethnic and religious composition of the population have been tested in relation to civil war. Collier and Hoeffler (2004) demonstrate that countries with a large but dispersed population face a higher risk of intrastate conflict, as do countries dominated by one ethnic group. Further, they find evidence that social fractionalization decreases the risk of conflict onset. These results are supported by Fearon and Laitin (2003), who find a very strong positive effect of population size, while ethnic and religious diversity have positive but insignificant effects on conflict proneness. The Collier et al. (2004) study on conflict duration finds that large population size tends to prolong conflicts, although this might be an artifact of how civil wars are coded in their dataset. Neither Elbadawi and Sambanis (2002) nor Fearon (2004) manages to produce evidence that population size affects duration. Fearon's analysis further fails to support the alleged links between ethnic fractionalization or ethnic war and duration of civil war, though the influential sons-of-the-soil dummy is likely to

capture any potential effect of ethnicity.[3] On the other hand, both Collier et al. and Elbadawi and Sambanis suggest a parabolic effect of ethnic fractionalization on conflict duration.

Few empirical studies have explicitly considered the role of distance in civil wars. Buhaug and Gates (2002) find that secessionist and identity-based wars tend to be located further away from the capital than other types of conflict. Their analysis also shows that conflicts that cover a larger area generally last longer, although the size of the conflict zone may be endogenous to the conflict duration. Others have found that separatist conflicts, which presumably are located in remote regions, last longer (Balch-Lindsay & Enterline, 2000). In addition, Fearon and Laitin (2003) and Fearon (2004) include an indicator of 'non-contiguous territory' for countries that have populated (over 10,000 inhabitants) enclaves or territories that are separated from the capital city by over 100 km of water. The dummy fails to make an impact except in the model that also includes colonial wars.

Finally, some studies have found evidence of spatial autocorrelation and spillover effects of civil conflicts, strongly suggesting that border length, interstate contiguity, and proximate conflict arenas play a role in shaping intrastate behavior (Anselin & O'Loughlin, 1992; Murdoch & Sandler, 2002; Ward & Gleditsch, 2002).

Unit of analysis: country or conflict?

Despite the evident upsurge in quantitative research on geographical aspects of civil war, we argue that several of these studies suffer from serious weaknesses regarding the data that are used. This may potentially have a big impact on the validity of the inferences. Above all, our concern relates to the scale of measurement of the various indicators of geography.

The interaction between geography and civil war is characterized by two facts that most empirical studies fail to account for: civil conflicts are by definition sub-national events, and the fighting rarely spans entire countries. For example, the ongoing secessionist conflicts in the Basque Provinces (Spain), Cabinda (Angola), and Chechnya (Russia) cover only a fraction of the countries' territories. If we are to estimate spatial spillover effects to neighboring countries (such as the risk of conflict or the impact on the economy), ignoring the relative location of the conflict may lead to biased conclusions. According to Murdoch and Sandler (2002) neighboring conflict has a negative impact on economic growth, and the effect increases with the length of the common border. While this finding sounds reasonable, it makes little sense to argue that Finland, due to its 1200 km border with Russia, is more affected by the civil war in Chechnya than Azerbaijan, with a 270 km-long common border. When operating with country-level aggregates, the effect of distance from the actual conflict area to neighboring countries is totally ignored.

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[3] First used by Weiner (1978), the term 'sons of the soil' denotes peripheral ethnic minorities.

Second, many frequently proposed conflict-promoting factors, such as terrain, natural resources, population distribution, and ethnic composition, have substantial sub-national variation. Contemporary studies of civil war have so far failed to take account of this. As previously mentioned, valuable natural resources can be a major source of finance for rebel groups. Yet, in order to acquire resource revenues, the rebels must control resource extraction areas or transport channels. If the rebels do not have access to the resources, there is less reason to expect conflicts in resource-abundant countries to be substantially different from civil wars in countries with lower resource endowment. It is highly unlikely that diamond and other mineral deposits in Siberia have much impact on rebel activities in Chechnya, in contrast to the gas and oil reserves in the Caucasus region. Likewise, the rough terrain argument posits that mountainous and forested terrain is favorable to rebel forces, providing shelter out of reach of government forces. However, unless the rebels operate from such terrain, it really should not matter whether 20% or 80% of the country is mountainous. Thus, the rough terrain proposition may be perfectly valid without there being a general, probabilistic relationship between country-level statistics of topography and risk or duration of intrastate conflict.

The essence of the problem is that the proxies for geography are generated at the wrong level of measurement: the nation state.[4] For example, the most popular measure for resource dependence is the ratio of primary commodities exports to GDP. Likewise, indicators of rough terrain are based on country statistics. Such aggregated measures really only make sense if we can assume that the conflict area constitutes a representative sample of the conflict-ridden country on all explanatory factors, and in cases in which the conflict spans the entire country. However, such an assumption is rarely valid. Consider the case of India. According to the Armed Conflict dataset (Gleditsch et al., 2002), India has experienced seven territorial intrastate conflicts since 1990 (Fig. 1). None of these conflicts covered more than 5% of India's territory. We cannot explain differences between these conflicts (in terms of type, severity, duration, or outcome) if we rely exclusively on country-level regressors. Clearly, we need to control for sub-national variations since there may be huge deviations between nation-level statistics and conflict-specific characteristics. This, we argue, is where GIS will prove useful.

GIS and studies of civil war

Recent developments in GIS have made spatial methodology increasingly available to users of conventional mapping software. Tools that facilitate exploratory spatial data analysis (Anselin, 1995) include global and local indicators of spatial association, variance pattern exploration, and distance analysis. In the social sciences, spatial analysis has been around for a few decades; O'Loughlin (2003)

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[4] See Agnew (1994) for a related critique of how theories of international relations implicitly and exclusively treat states as fixed territorial entities.
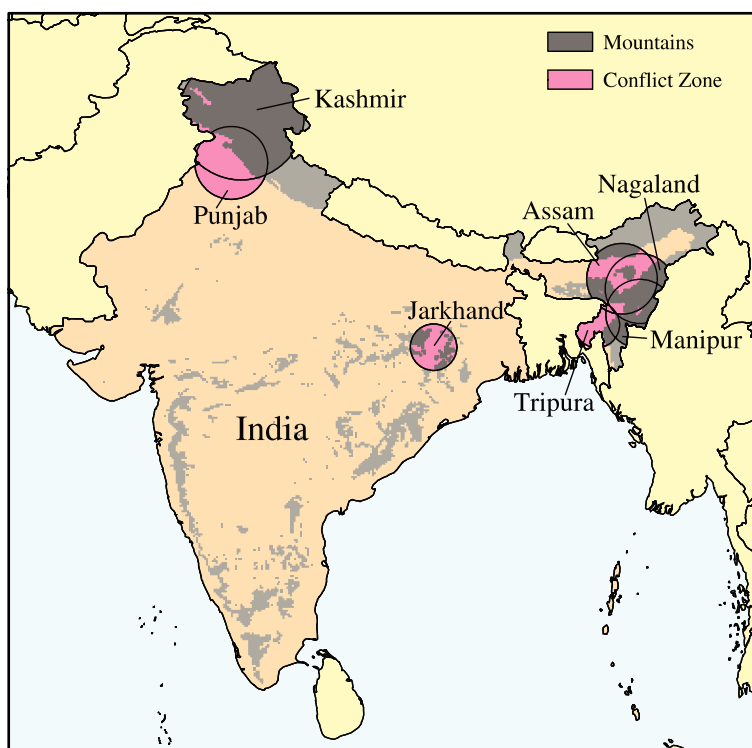
Fig. 1. Territorial intrastate conflicts in India in the 1990s. Conflict data from Gleditsch et al. (2002), mountain data from UNEP (2002).

credits McCarty's (1954) study of geographical voting patterns in Wisconsin to be the first spatial analysis of political data. Since then, almost all space-oriented quantitative analyses of political data have focused on voting behavior (O'Loughlin, 2004). In studies of international relations and peace research, spatial analyses are still quite rare, and GIS is largely an undiscovered tool. Exceptions include Anselin and O'Loughlin's (1992) exploration of the contextual effects on conflict and cooperation in Africa, and Starr (2002), who uses GIS to generate indicators of interaction opportunities and salience of border zones for the case of Israel. Further, Ward and Gleditsch (2002) develop an autologistic model that estimates the likelihood of war as a function of recent war involvement of proximate states. Studying civil conflict, Buhaug and Gates (2002) construct a relative location indicator by using GIS to measure the distance from the conflict zones to the capital cities, while O'Loughlin (2004) uses the same conflict location data to illustrate the spatial overlap between conflicts and lack of development. In addition, some recent studies on diffusion patterns employ spatial econometrics (e.g. Gleditsch, 2002; Gleditsch & Ward, 2000; O'Loughlin et al., 1998; O'Loughlin, 2001).

Civil wars are rarely spatially contiguous. When contiguity is determined by shared borders, a sample of civil wars will necessarily consist mostly of 'islands',

rendering it impossible to compute connectivity matrices and spatial weights. Although other contiguity measures can be used, such as distance or transport networks, the exclusion of relevant null-cases (non-conflict areas) limits the use of spatial regression models whenever the civil conflict is the unit of observation. Instead, we shall demonstrate how GIS may enhance conflict studies by following Gleditsch and Ward (2001), Buhaug and Gates (2002), and Starr (2002) in using GIS software to generate more precise and valid data. However, in contrast to these contributions, we will not limit our task to the measurement of distance. A major reason for introducing GIS to the study of conflict is that it facilitates data generation on a truly sub-national level, as opposed to relying on national statistics. Such measures will undoubtedly improve the validity of traditional regression models where the conflict is (or should be) the unit of observation.

Empirical analysis

Our central hypothesis concerns the suitability of using country-level aggregates and averages instead of data collected for the actual conflict zone in empirical conflict studies. In fact, if the level of measurement (country versus conflict) does not matter for the results, the time-consuming effort to collect data on sub-national level can be spared, and the data and results obtained by using country-level aggregates can be regarded as representative. Before presenting the results, we first describe how we used GIS to collect conflict-level data on geographical factors linked to civil war.

Data generation

A first step towards conducting conflict-specific analyses is to acquire data on the location of conflicts within states. The Armed Conflict dataset (Gleditsch et al., 2002) provides reasonably accurate geographical data on all interstate and internal conflicts since 1946. Here, each conflict is assigned a circular conflict zone, defined by a conflict center point (latitude and longitude coordinates) and a radius variable, as illustrated in Fig. 1. This dataset is currently the only source of systematic information on the sub-national location of armed conflicts. Yet, the circular shape of the conflict zones is a crude approximation. For example, a civil war may take place mainly along the borders of a country (the Democratic Republic of the Congo), or the conflict zone may be a long but disproportionately narrow area (Peru). In such cases, the circular operationalization by design exaggerates the real zone of conflict by covering vast areas of unaffected land. Even so, it seems fair to assume that any irregularities in the accuracy of the location data are not correlated with the explanatory variables.

A valuable byproduct of the location data in the Armed Conflict dataset is that it allows measuring the location of the conflict zones relative to other factors of interest, such as the capital city or neighboring countries. We include one such measure in the analysis: the conflict–capital distance. The relative location of conflict may affect the length of conflict at least for two reasons. First, the farther the conflict is from the capital, the more difficult and expensive it is for the government

to project power to reach the opposition force. Second, a government may view remote incidents as less pressing than proximate ones and consequently dedicate less resources to tackle them.

Several geographical variables that are frequently regarded as affecting war propensity are available in GIS format. The World Conservation Monitoring Centre of the United Nations Environment Programme (UNEP-WCMC) recently released a gridded mountain dataset with global coverage (UNEP, 2002). In this dataset, the surface of the earth is divided into grid cells of approximately 10×10 km where each cell is assigned a value of 1 (mountain) or 0 (no mountain). The gray shades in Fig. 1 represent mountainous terrain based on UNEP data. Evidently, rough terrain is not evenly distributed throughout India. The northwestern and northeastern corners are substantially more mountainous than the central regions. Incidentally, India's internal conflicts appear to be located in these parts of the country. Whereas approximately 19% of India's two-dimensional land mass is characterized as mountains, the seven conflict zones have a joint mean score of 49% mountainous territory, with Kashmir obviously having the highest score. The proportion of rough terrain in these conflict regions is clearly above the average for the whole country, and using country-level statistics would thus lead to biased estimates for the effects of rugged topography. In order to assess the degree of similarity between country- and conflict-level measures of terrain, we have computed the share of mountainous terrain for all countries and all civil conflicts since 1946.

The Food and Agriculture Organization of the United Nations (FAO) has collected comparable forest data (FAO, 1999). The released forest map consists of 1 km^2 grids, where each grid is categorized as (1) closed forest, (2) open and fragmented forest, (3) other wooded land, or (4) other land. From this, we created a forest dummy where the first two categories represent forested terrain. Following the same procedure as for the mountain data, we then generated a conflict-specific forest variable that gives the percentage of each conflict zone covered by forested terrain. Both rough terrain measures are logged to avoid outlier bias.

Several recent civil conflicts are dominated by the presence of precious natural resources, such as in Angola, the Democratic Republic of the Congo, Liberia, Sierra Leone (alluvial diamonds), Indonesia, Nigeria, Sudan (oil), Afghanistan, Burma, and Colombia (drugs). Yet, there is a remarkable lack of available systematic information on the global distribution and significance of natural resource deposits. The World Bank (1997, 2002) has estimated the rents for some renewable and non-renewable resource production, but these data are aggregated to the country-level and contain no information on the location of the commodities.

During a conflict, some natural resources are more easily exploited by rebels than others (Ross, 2004b). For example, alluvial diamonds are easy to mine and smuggle, and can therefore be considered lootable. Such resources constitute a potential source of finance for rebel groups. Other resources, such as bauxite mines, are more difficult for rebels to exploit and can be considered as non-lootable. Gilmore and Lujala (2003) describe an ongoing project that aims to map the location of selected types of natural resources. The resulting database will contain information on location and type, as well as time of discovery and initial extraction. In the analysis

presented below, we use a preliminary version of the database to get data on four types of lootable resources: gemstones, coca, cannabis, and opium poppy. Based on these records, we generated two sets of dummies: one set of country-level variables, indicating presence of the given commodity in the country at the time of conflict (coded '1' if present and '0' if not), and a conflict-specific set of variables, indicating the availability of the commodity within the conflict area during the conflict. Fig. 2 illustrates the distribution of alluvial diamond deposits and the conflict zone in Liberia in 2000. Evidently, the conflict and the diamonds overlap. Hence, we can assume that LURD (Liberians United for Reconciliation and Democracy), the primary rebel force in Liberia, had access to the highly valuable commodity.

By accounting for the location of conflicts relative to the natural resources, and by considering the temporal component, the research design largely avoids the problem of endogeneity. In contrast to the common proxy for resource dependence − the ratio of primary commodity exports to GDP (Collier & Hoeffler, 2004; Sachs & Warner, 1995) − the location of a gemstone deposit is truly exogenous to the model.[5] Whereas the total output from a diamond mine might be affected by a nearby conflict, the resource cannot relocate in the face of a civil war. Illicit crops, on the other hand, can be introduced in new areas and act as a source of finance, as has been the case in several contemporary conflicts, including Afghanistan. Even so, by controlling the timing of the conflict relative to the introduction of the drug, we can exclude cases where there was no production (and hence no causal link) at the outbreak of hostilities.

Population density and ethnic composition are other geographical features that could be measured at the conflict level. The Center for International Earth Science Information Network at Columbia University has released gridded population density data with global coverage for the 1990s (CIESIN, 2000). UNEP (2003) has comparable population data for previous decades for Africa and Latin America. The main problem with these databases is the lack of temporal data with global coverage.

Data for other aspects of human geography are even less available. To our knowledge, the spatial distribution of ethnicity, religion, and culture have so far not been mapped at a satisfactory level of detail, even for the contemporary world, and therein lays a huge challenge. Development indicators such as economic growth, infant mortality rates, and unemployment statistics are other aspects that should be measured at a sub-national level, as they are likely to influence the risk and location of civil unrest. For example, Murshed and Gates (2005) show that the death toll due

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[5] The habitual resource dependence/financial opportunities indicator has been criticized on several grounds. First, the proxy merges all natural resources together, assuming that they all influence the likelihood of conflict. Second, for the same reasons that some natural resources are valuable to rebels (e.g. they are easy to smuggle), some resource exports may be under-reported in the national export statistics due to extensive illicit trade. The measure is also possibly endogenous since the level of GDP varies in response to political instability, which often predates civil war. The level and growth of GDP may further be affected by external factors, including neighboring conflict and regional economic shocks, which are generally not related to the looting opportunities for rebels. Finally, the resource dependence measure suffers severely from non-random missing data.
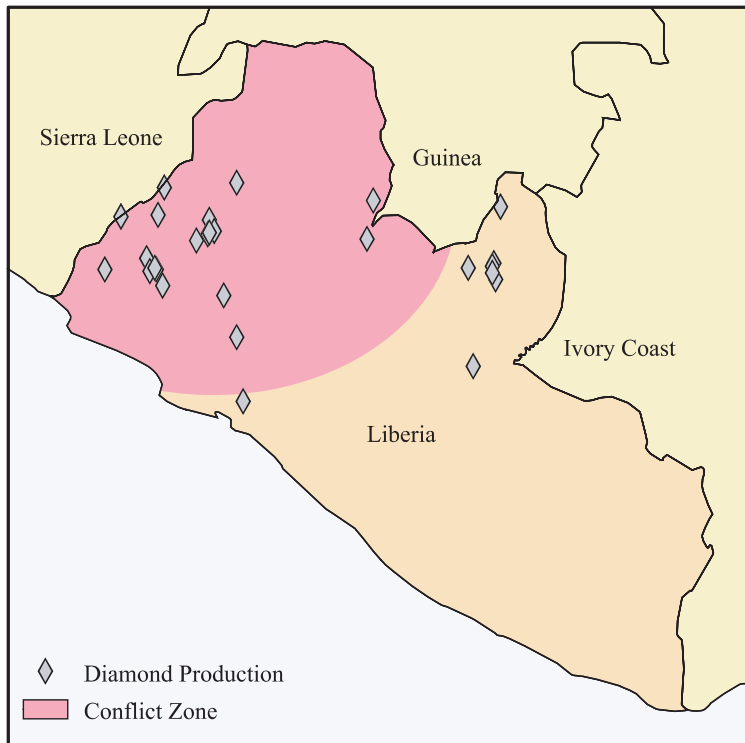
Fig. 2. Conflict zone and diamond production in Liberia, 2000. Conflict data from Gleditsch et al. (2002), diamond data from Gilmore and Lujala (2003).

to the Maoist insurgency in Nepal has been highest in the less developed Nepalese districts. Although there appears to be some development and human security data available at the administrative level, they tend to reflect the current situation only and are generally not available for regions with armed conflict. A possible solution would be to identify and use appropriate instrumental variables. A promising example is the work by Miguel, Satyanath, and Sergenti (2004), who use rainfall variation as an instrumental variable for income shock in Africa. Because the agricultural sector in sub-Saharan Africa is dominant, changes in rainfall have a large impact on growth, and thus indirectly on conflict. However, rainfall is a poor indicator of growth in other, more developed parts of the world, so it will not work as a global proxy for economic development.

Rainfall data can be relevant, however, to the study of conflict in a more straightforward manner. Several regions throughout the world experience rainy seasons that effectively hinder road transportation. Consequently, fighting becomes less intensive and often stops altogether for several months. This provides opportunities for the fighting parties to regroup, rearm, train, and recruit forces, as well as time to raise funds for warfare. Based on precipitation data from the

Global Precipitation Climatology Project (GPCP),[6] we have generated dummy indicators for rainy seasons at both levels of measurement. Areas that experience at least one month with average daily precipitation in excess of 8 mm are considered as having rainy seasons.

Empirical test: comparison of sample means

The following two sections compare operationalizations of geography at the country level with corresponding conflict-specific measures. A paired *t*-test of sample means serves as the initial analysis. We run the *t*-test for two samples. The full sample consists of 252 civil conflicts between 1946 and 2001, taken from the Armed Conflict dataset.[7] In addition, we run a test for a restricted sample of relatively small conflicts, where the deviation to the country aggregates is presumably most evident. In this context, a conflict is considered relatively small if the spatial extent of the war is less than 10% of the country in which it is located. About 40% of the sample (97 conflicts) is below this arbitrary cut-off point. The null hypothesis of the *t*-test is that the mean values of the country variables are equal to the means of the corresponding conflict variables. For the terrain measures, the significance test is two-tailed, since we have no a priori expectation of deviation in a particular direction. The mean values of the resource variables can vary in only one direction (the conflict-level variables cannot have higher means than the country statistics), hence a one-tailed test. The results are presented in Table 1.

Looking at the full sample first, we find very strong evidence that most conflict zones do not simply mirror the geographical characteristics of the host countries. The mean value of every single geographical feature differs significantly between the levels of measurement. More specifically, the conflict zones are − contrary to general belief − *less* mountainous and forested than the countries in which they occur, and most are not located in resource-rich areas. Even in countries that possess easily exploitable resources, nearly half of the conflicts do not overlap with the lootable resources. Moving our attention to the restricted sample, we note that the mean differences have increased for all but one variable. This implies that relatively smaller conflicts − that is, conflicts that affect only a fraction of the country − are particularly likely to have characteristics that differ from the average figures of the countries. For these conflicts, the reliance on country statistics is particularly problematic.

Empirical analysis: duration of civil war

The paired *t*-tests demonstrated that the alternative measures yielded different results, but how substantial are the discrepancies? We can better answer this question

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[6] See http://cics.umd.edu/∼yin/GPCP/main.html.
[7] We follow Buhaug and Gates (2002) in treating contests over the same issue between the same parties as separate conflicts if the incidents are separated by at least two calendar years without recorded conflict.

Table 1
Paired *t*-test of sample means

	All conflicts (N = 252)					Small conflicts (N = 97)				
	Mean country	Mean conflict	Δ Mean	S.E.	*p*	Mean country	Mean conflict	Δ Mean	S.E.	*p*
Mountain (log)	3.16	2.91	0.26	0.07	<0.001	3.16	2.71	0.46	0.15	<0.001
Forest (log)	2.83	2.60	0.23	0.06	<0.001	2.97	2.55	0.42	0.12	<0.001
Rainy season	0.40	0.37	0.04	0.01	<0.001	0.41	0.36	0.05	0.02	0.012
Gemstones	0.42	0.21	0.21	0.03	<0.001	0.49	0.07	0.42	0.05	<0.001
Coca	0.02	0.01	0.01	0.01	0.042	0.02	0	0.02	0.01	0.079
Cannabis	0.04	0.03	0.02	0.01	0.023	0.03	0.03	0	0	—
Opium	0.23	0.10	0.13	0.02	<0.001	0.35	0.10	0.25	0.05	<0.001

Note: Small conflicts are defined as covering less than 10% of the country area.

by conducting a comparative multivariate regression analysis. Table 2 shows the output for three models of civil war duration. The table reports the accelerated failure-time coefficients. A negative estimate implies that the hazard of failure − that is, the likelihood of the conflict ending − is higher than the reference. Hence, negative coefficients are associated with shorter conflicts. We include four control variables that might create omitted variable bias if excluded: country size (logged), population size (logged), issue of incompatibility (dummy, 1 if territory), and a binary indicator of initial intensity (1 if at least 1000 battle-deaths were reported during the first year of the conflict).[8]

The first two models include country-level measures of geography and differ only with respect to choice of resource proxies. Model 1 includes Sachs and Warner's (1995) well-known measure of primary commodity exports to GDP, whereas the second model uses dummies for specific types of commodities. Because of missing export data, Model 1 loses about one-third of the conflicts. Model 3 relies on conflict-specific variables of terrain, climate, and resources, and additionally includes the relative location measure, the conflict−capital distance.

By comparing the first two models, we see that the resource dependence proxy and most of the various resource dummies fail to make an impact on the duration of civil war. Still, there are notable differences between the models. Whereas the coefficient for the ratio of commodity exports to GDP hints at a negative association, three of the four resource dummies produce estimates in the expected positive direction. In fact, Model 2 offers some evidence that countries with gemstone deposits experience somewhat longer civil wars. Moreover, the aim of the opposition − territorial versus governmental control − only makes an impact on the second country-level model. This is not due to the increased sample size but rather because the territorial dummy is negatively correlated with coca ($r = -0.22$) and cannabis ($r = -0.16$). The other

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[8] The population data are taken from COW's National Material Capability dataset, v.3.0 (Singer, Bremer, & Stuckey, 1972). The country size variable is based on the World Bank's (2002) World Development Indicators. The incompatibility and intensity dummies are from the Armed Conflict dataset (Gleditsch et al., 2002).

Table 2
Weibull regression of duration of civil war

	Model 1 Country level	Model 2 Country level	Model 3 Conflict level
Country size (log)	0.108(0.166)	−0.013(0.139)	−0.365**(0.153)
Population (log)	0.047(0.148)	0.109(0.123)	0.215(0.131)
Territorial conflict	0.565(0.362)	0.977***(0.300)	0.551*(0.334)
Initial intensity	0.744*(0.388)	0.682**(0.292)	0.689**(0.299)
Mountain (log)	0.291*(0.164)	0.258*(0.152)	−0.022(0.102)
Forest (log)	−0.323**(0.133)	−0.376***(0.119)	−0.242***(0.088)
Rainy season	1.257***(0.453)	1.107**(0.428)	0.590(0.385)
Commodity exports/GDP	−0.245(0.146)		
Gemstones		0.648*(0.352)	0.885***(0.336)
Coca		0.999(1.164)	2.901*(1.523)
Cannabis		0.385(0.403)	0.151(0.509)
Opium		−0.153(0.459)	−0.192(0.472)
Conflict−capital distance (log)			0.573***(0.115)
Intercept	−0.768(1.459)	−0.957(1.233)	−1.919*(1.146)
N	1006	1482	1482
# Conflicts	178	252	252
Wald Chi^2	26.37	41.94	85.54

Note: The table reports accelerated failure-time coefficients with standard errors (adjusted for clustering on country) in parenthesis. *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

regressors are fairly robust across the two models. The amount of mountainous terrain in the country is positively associated with the duration of conflict, whereas densely forested countries tend to have shorter conflicts, *ceteris paribus*. Conflicts in countries with distinct rainy seasons are longer on average, supporting our notion that seasonal pauses are exploited to gather strength and prepare for renewed hostilities. Conflicts that immediately reach a high level of violence are also harder to resolve. Finally, the size of the conflict-ridden country appears to be irrelevant.

Model 3 presents the results of the conflict-specific regression analysis. Several findings deserve attention. First, the weakly significant effect of gemstones found in the second model is considerably larger and stronger when measured at the conflict level. Evidently, civil wars that occur in regions with gemstones are substantially harder to bring to an end. We also see that coca, another highly valuable commodity, has a significant impact in the expected direction. However, we must be cautious about making overly general statements from this finding since only three countries in our sample, Colombia, Peru, and Bolivia, are coded as coca producers. Third, the positive and statistically significant estimates of the mountain variable in the country-level models are misleading; there is no link between the degree to which a conflict occurs in the mountainous terrain and its expected duration. The unexpected negative effect of forest prevails, though. The most influential factor in the conflict-specific model is the relative location. Civil wars that occur at a distance from the capital − the presumed center of state power − are much more likely to turn into protracted contests than relatively proximate ones. The inclusion of the conflict−capital distance further removed most of the explanatory power of the

territorial conflict and rainy season dummies, whereas country size now has a significant, negative effect. The estimates for the remaining variables do not differ substantively from the country-level models.

Summing up, Table 2 demonstrates that the scale of measurement affects not only standard errors and significance levels but even the substantive impact of some regressors. In particular, the shifting behaviors of mountains, gemstones, and coca imply that using country-level aggregates as proxies for geographical characteristics of civil wars is indeed a dubious procedure. The analysis also uncovered the importance of controlling for the relative location of the conflict, which in addition to affecting the expected duration of conflict also influences the estimated impact of other variables, such as country size and type of incompatibility.[9]

Future research

As we have demonstrated, GIS-generated geographical data measured for each conflict zone – undoubtedly being more accurate and representative that country-level statistics – can easily be included in conventional statistical models of civil war. The analyses above illustrate the potential problem with analyses of civil conflict conducted at the country level. Yet, more work is required to fully gauge the impact on various aspects of civil war, including use of more advanced methods that account for spatial autocorrelation and interaction, such as spatial regression and multilevel analysis, even at the country-level analysis (see, for example, Raleigh, 2004). However, by using data on conflict location, diffusion and neighborhood effects of civil wars can be studied at the correct regional level. For example, a test of spillover effects on neighboring countries could be restricted to a sample of countries near the conflict, or the neighbors could be weighted according to their inverse distance from the conflict zone. This enables the exclusion or downgrading of irrelevant neighbor countries like Finland and China when exploring the neighborhood effects from the Chechen conflict. When more data becomes available, such as annual death rates and refugee flows, we will be able to analyze other aspects of a conflict's destructiveness besides duration.

One of the challenges is the choice of the unit of observation. The conflict zone can be used as the base unit in cases when we analyze duration of conflict, type of conflict, conflict termination, and location of conflict. However, analysis of risk of conflict requires a unit of observation that includes null cases (cases without conflict), which renders conflict-specific variables inappropriate. One alternative strategy is to use first-order administrative units as the focal point of data generation and analysis. Subject to data availability, such a research design facilitates more precise testing of several prevailing theories on causes of civil war, such as whether

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[9] This finding implies that some measure of relative location should be included in any study of duration of civil war. Although only the Armed Conflict dataset (Gleditsch et al., 2002) currently includes data on location of conflict zones, users of other conflict data could quite easily code a simple, binary indicator that distinguishes between proximate and distant conflicts.

conflicts tend to break out in sparsely populated hinterlands with extremely rugged terrain, and near state borders. Unfortunately, the size and number of the units differ greatly from country to country. For example, most of Niger's *departments* (first-order sub-national units) are larger than Rwanda and Burundi combined. Hence, it may not be meaningful to divide all countries into smaller units, in particular if the sub-national units do not vary with respect to the dependent variable and the geographical covariates. Moreover, sub-national administrative units are subject to frequent changes.

A second possible strategy is to define a geometric unit, like a 100 km × 100 km grid, as the basis for measurement, and assign values for conflict and the explanatory variables to each pixel. This solves the problem of huge variations in unit size while simultaneously permitting the same detailed level of analysis as the administrative unit approach. Unfortunately, sub-national data for income level, infant mortality rate, and other space-varying factors are typically given only for administrative units — if available at all — and must be converted to the crude grid format. Although this could be done by calculating average weighted values based on the relative share of the administrative entities within each grid cell, we still have the problem of huge missing data on the sub-national level. Besides, the grid approach is less intuitive than the administrative level, and policy implications will necessarily be less apparent.

Yet another alternative is to employ point pattern analysis (PPA). PPA does not allow studying of risk of conflict per se, but facilitates exploring patterns of conflict onset without including null cases explicitly in the model. By using the centroid of the conflict polygon or the location of rebel headquarters as the unit, one can, for example, measure the distances from any conflict to nearby conflicts and assess whether the spatial distribution of conflicts differs significantly from a random distribution. Ideally, the analysis should also incorporate the time dimension since conflicts in a region may also cluster temporally. In fact, there are good reasons to assume that conflicts do cluster in both space and time (Anselin & O'Loughlin, 1992; Ward & Gleditsch, 2002). First, the underlying causes of conflict, such as level of economic development, type of political institutional arrangements, and aspects of physical geography, also tend to cluster spatially and temporally. Second, a civil conflict is likely to increase the risk of additional conflicts in the region by means of destabilizing the economy, creating refugee flows, facilitating smuggling, and increasing availability of arms. Therefore, more rigorous point pattern models should be used. They should either incorporate the underlying variables in the model or compare the conflict surface to the distribution of relevant conflict-promoting variables. For example, one could explore whether conflicts follow the distribution of rough terrain, and if so, whether there is any unexplained clustering of conflict left once the terrain is controlled for.

PPA can be used to verify that conflicts tend to cluster, to obtain more nuanced analysis of conflict clustering, and to distinguish between the two forces driving clustering: clustering of underlying causes of conflict and spatial interaction between conflicts. However, conflicts are by nature events that cover considerable areas, and they can hardly be described as points even on a small-scale map. Moreover, the

amount of terrain covered by the conflict also varies from case to case. This raises some difficult methodological issues concerning how the various exogenous surfaces should be generated and how they can be compared to the conflict distribution. An additional methodological problem arises from the fact that the study of conflict tends to cover the entire globe. Hence, the researcher must resolve the issue of how to deal with non-contingent regions, separated by big lakes, seas, and oceans.

Final remarks

A large obstacle to testing the relationship between geography and civil conflict lies in the shortcomings of the available data. One of the most acute problems is the lack of relevant data at the sub-national level. This is true both for conflicts and for factors that may explain conflict propensity and conflict characteristics. Nevertheless, this article has shown that with relatively simple methods, the researcher can generate richer and more accurate data for large-scale statistical analyses. A paired *t*-test of sample means demonstrated that the seven geographic variables all differed significantly between the scales of measurement, and the deviation was particularly apparent in the sub-sample of relatively small conflicts. An analysis of duration of civil war further showed that changing from the national to the sub-national scale did have noticeable consequences. The shifting behavior of gemstones, coca cultivation, and mountain variables were particularly striking. Evidently, country-level measures are not always representative for the circumstances in the conflict areas. The analysis also demonstrated the importance of conflict location in relation to capital. Besides having the largest individual impact on duration, the conflict–capital distance measure also affected the estimated effects of country size, type of incompatibility, and rainy season. Therefore, researchers of civil war should strive to generate more precise proxies for the theoretical concepts related to geography, and always control for the relative location of the conflicts. This work, we believe, is facilitated by the use of GIS.

This article has demonstrated the data-generating capability of GIS. However, the potential contribution of GIS to conflict research goes well beyond overlays and area calculations. By selecting an appropriate unit of analysis, GIS and spatial econometrics will provide much better instruments for assessing the true spatial relationship between geography and civil war.

Acknowledgements

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3

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A New Dataset

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Fighting over Oil:

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A Diamond Curse?

Civil War and a Lootable Resource

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