“Head for the Hills!” or This Hard Land? The Direct and Indirect Effects of Rough Terrain on Civil Conflict Onset

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Abstract:

Most studies of the impact of geography on civil conflict emphasize its direct effect on the tactical considerations of insurgents and the proximity of conflict to valuable natural resources. A growing literature in development economics suggests, however, that geography may play a large indirect role as well, affecting the economic and political circumstances of the states against which the insurgents rebel. I estimate the impact of rough terrain on the likelihood of civil conflict by modeling both its direct and indirect effects. I find that several plausible definitions of rough terrain, including tropical rainforest and desert, exert no direct effect. Mountainous terrain, however, remains a significant predictor. I capture the indirect effects, however, through the impact of rough terrain on three attributes of the state associated with the onset on civil conflict: per capita income, reliance on oil exports, and measures of regime consolidation. I find that rough terrain is associated with lower per capita income, increased reliance on oil exports, and less well consolidated political institutions, all circumstances that predict an increased likelihood of conflict. This leads me to conclude that in most cases, rough terrain is significant more for its effects on state capacity rather than the tactical considerations of insurgents.

Keywords:
Civil war, rough terrain, conflict, economic development, geography

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1. Introduction

“Guerrilla fighting will not always take place in country most favorable to the employment of its tactics; but when it does, that is, when the guerrilla band is located in zones difficult to reach, either because of dense forests, steep mountains, impassable deserts or marshes, the general tactics, based on the fundamental postulates of guerrilla warfare, must always be the same.”

--Ernesto Che Guevara, Guerrilla Warfare

The preceding quote is representative of the dominant thinking regarding the relationship between rough terrain and civil conflict. The causal mechanism is simple to grasp: especially at the outset, the insurgent must above all else avoid capture, as government forces are almost certainly better armed and more numerous than the rebels. In order to survive, therefore, the rebels must be able to hide. Remote and difficult terrain, it is argued, provides good hiding places.

Intuitively, there must be something to this, as astute students of insurgency, to say nothing of its direct practitioners, argue that rough terrain approaches a necessary condition for sustaining conflict (Guevara 1968, US Army 1992, Buhaug and Gates 2002, Fearon and Laitin 2003, Fearon 2004). In emphasizing the role of rough terrain in the tactical considerations of insurgents, however, I argue that we are not casting our nets sufficiently widely. Though it is plausible that rough terrain conditions the tactical considerations of insurgents, I contend that the effects of geography on national wealth, the strength of political institutions and natural resource dependence play a larger indirect role in the onset of conflict.

I offer two extensions of the existing literature. First, I expand the definition of rough terrain and develop hypotheses regarding the direct effect of other types of rough terrain, specifically deserts and rainforests, on civil conflict. Second, I investigate the impact of rough terrain on the factors that affect the ability of the state to deter potential challengers. Specifically, I argue that the same qualities that make rough terrain ideal for sustaining insurgency make centralizing political authority difficult in the first place. Therefore, the effect of rough terrain should be exaggerated by its effect on the strength of political institutions. Finally, I argue that rough terrain places limitations on the types of large-scale economic activity that can be sustained, thereby increasing dependence on mined commodities.

I estimate the impact of rough terrain on the likelihood of civil conflict by modeling both its direct and indirect effects. I find that several plausible definitions of rough terrain, including tropical rainforest and desert, exert no direct effect. Mountainous terrain, however, remains a significant predictor. Furthermore, I capture the indirect effects through the impact of rough terrain on three attributes of the state associated with the onset of civil conflict: per capita income, reliance on oil exports, and measures of regime consolidation. I find that rough terrain is associated with less well consolidated political institutions and increased reliance on oil exports, circumstances that predict an increased likelihood of conflict. This leads me to conclude that in most cases, rough terrain is significant more for its effect on attributes of the state than the tactical considerations of insurgents.

These findings point to two main conclusions. The first is that our understanding of the effects of rough terrain on conflict is bound to be incomplete without an expanded notion of what
constitutes rough terrain and addressing issues of endogeneity. In previous studies, countries with such vastly dissimilar geographies as the Netherlands, the Republic of Congo and Kuwait have been treated as equivalent (all more or less flat) with respect to rough terrain. Moreover, in constructing counterfactuals on the role of geography in conflict, the question “what if Rwanda were geographically more like the Netherlands?” would have missed the fact that in addition to exhibiting differences in climate and topography, Rwanda would also be more wealthy, more politically consolidated, and less dependent on natural resources.

The second conclusion is that the effects of geography on conflict are apparent even when aggregate measures are used. Much of the most recent work linking geography and conflict has been aimed at disaggregating the unit of analysis. Disaggregated data may, therefore, allow us to test directly the role of rough terrain as it pertains to this specific mechanism. However, this emphasis would overlook the fact that regardless of whether or not the fighting took place in remote areas, the state against which the insurgents rebel would be poorer, less politically consolidated and more reliant on the export of natural resources—all in all less able to repel challenges—than it would have been were it not for its challenging geography.

The organization of this paper is as follows. The next section briefly summarizes the current state of the literature linking geography and civil conflict. Section three develops the argument that rough terrain implies combinations of geography and ecology that significantly constrain the prospects for the economic and political development of states, and derives hypotheses regarding these effects. Section four then tests these hypotheses. Section five concludes with a summary of the significant findings and suggestions for an ecological perspective on geography and conflict.

2. Literature Review

There is a large literature developing around opportunity models of civil conflict, which seek to predict conflicts based on the economic incentives and deterrents facing potential rebels, rather than objective societal grievances (Grossman 1991, 1999; Collier and Hoeffler 2002, 2004; Elbadawi and Sambanis 2002, Fearon 2002, Fearon and Laitin 2003, Hegre and Sambanis 2004). Across these various studies, three explanatory variables have proven robust to a variety of model specifications: economic development, the strength of political institutions, and dependence on primary commodity exports, especially oil and other “lootable” resources, for revenue. The consensus positions are that a) more wealthy countries are less likely to experience civil wars, b) countries with more stable political institutions are less likely to experience civil wars, and finally c) countries that are less dependent on primary commodity exports are less likely to experience civil wars.

Despite less consensus on its explanatory power, geography has begun nevertheless to play a large role in this debate, in terms of access to valuable natural resources (Buhaug and Lujala 2004), the diffusion of conflicts across borders (Salehyan and Gleditsch 2004), and the presence or absence of terrain conducive to insurgency (Collier and Hoeffler 2001, Fearon and Laitin 2003, Raleigh 2004). In this paper, I will be focusing on this final mechanism.

1 Though not democratic quality thereof; levels of political democracy (operationalized as the POLITY score on the -10 to 10 scale) have consistently failed to attain significance when included along with measures of regime consolidation.
The standard argument is that rough terrain confers tactical advantages on insurgents that mitigate the advantages enjoyed by state armies. Insurgents are typically outnumbered and outgunned (especially at early stages of rebellion), and as such they must be able to both avoid direct engagement and have access to safe havens in which to rest, recruit and replenish supplies. Rough terrain, it is argued, facilitates both. Collier and Hoeffler (2002) test two alternate operationalizations, percentage of mountainous terrain and percentage of forested terrain, and find mountainous terrain to be significant and positive under several model specifications, but forest terrain fails to achieve significance. Using the log-transformed percentage of mountainous terrain as their preferred operationalization, Fearon and Laitin find a significant positive relationship between rough terrain and conflict onset. Cederman (2004) argues also for the importance of terrain but posits a different causal mechanism: because peripheral ethnic groups are more likely to inhabit peripheral territory, mountainous terrain may serve as a proxy for mechanisms of nationalist identity formation. Using agent-based modeling techniques, Cederman finds that violent separatist movements are much more likely to occur in mountainous territories.

This perspective has been criticized on at least three counts. The first is that applying aggregate measures of rough terrain says little about whether or not conflicts are located in these areas, a point made by Buhaug and Gates (2002). Moreover, Herbst (2000) and Raleigh (2004) have argued that modern insurgencies are as likely to be based in urban areas as rural ones. This criticism attacks the use of mountainous terrain on the basis of construct validity, as the variable may not accurately proxy the existence of safe havens. Second, the possibilities of finding safe havens in neighboring states and porous borders combine to lessen the importance of rough terrain; if hiding places are available in neighboring counties, rough terrain may be irrelevant (see Saleyhan 2004 and Raleigh 2004 for more on this mechanism). Finally, there is the argument that economic and political factors trump geographic variables. Raleigh argues that weak states, defined as those with low GDP per capita and weak political institutions, are limited in their ability to project political authority within their national boundaries, regardless of terrain, a perspective shared by Hegre et al. (2001). Controlling for these foreign safe havens and economic and political development, Raleigh finds that rough terrain, as defined by Fearon and Laitin (2003), is not a significant covariate of conflict onset, although it does appear to affect conflict duration.

Discussions of endogeneity and indirect causation have been largely absent from this debate. Figure one (last page of document) is a visual representation of the various causal relationships posited in the literature. To the extent that the conflict onset literature has addressed geographic variables, these variables are typically included on the right hand side of the equation along with various measures of economic development, strength and democratic quality of political institutions, and dependence on valuable natural resources. That is, causal mechanism one (the direct effect of geography on conflict onset) is pitted against causal mechanisms five (the direct effect of economic development on conflict onset), six (resource dependence) and seven (political institutions). This design is common to Collier and Hoeffler, Fearon and Laitin, and Raleigh, although differences in model specification lead them to differing conclusions.

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2 Fearon and Laitin defend this operationalization on the grounds that because mountainous terrain is not normally distributed a log transformation is necessary to fulfill the standard Gauss-Markov assumptions.
Setting aside the various and well-documented problems of endogeneity that arise from the interplay of political institutions, patterns of economic development and resource dependence (mechanisms 8-13), the criticisms of the rough terrain hypothesis beg the question of whether rough terrain may exert an indirect effect through these other mechanisms. In order to address this, we must ask the question of whether these other factors are endogenous to rough terrain. If rough terrain exerts an indirect effect through these endogenous variables, then its effect has been both significantly underestimated empirically and not adequately accounted for theoretically.

There is mounting evidence to suggest that rough terrain may play a large indirect role. Diamond (1997) has argued that the timing of the transition from hunter-gatherer societies to sedentary, agricultural societies has had an immense impact on present-day levels of economic development. He argues that the human populations of Eurasia benefited from a large expanse of territory lying along the east-west axis, thereby positioning Eurasian peoples to benefit from agglomeration effects and technological diffusion. Olsson and Hibbs (2004) use pre-historical data on initial biological endowments and the timing of transition to agriculture to estimate present day levels of wealth, finding that areas with appropriate endowments of domesticable plant and animal life are indeed more wealthy than those with less accommodating biological endowments, even in the presence of controls for institutional quality (mechanism two). Moreover, Gallup, Sachs and Mellinger (1998) have demonstrated that geography affects long-run economic growth by influencing agricultural productivity, access to markets and human capital formation.

Regarding mechanism four, Engerman and Sokoloff (1994) have emphasized the negative consequences for institutional development of certain geographically determined factor endowments that engender extremely unequal resource distribution. Specifically, they argue that the suitability of the Caribbean region to plantation-based cultivation of valuable luxury crops such as sugar and coffee led to the massive importation of slaves and the development of institutions that facilitated the concentration of wealth and political influence. More recently, Acemoglu, Johnson and Robinson (2001) and Rodrik, Subramanian and Trebbi (2004) have affirmed this position, arguing that geography has a strong indirect effect on economic growth by influencing the quality of political institutions (mechanism four). Their argument hinges on the effects of settler mortality rates on the types of political and legal institutions that developed. Where geographic conditions approximated those in continental Europe, colonizers were more likely to establish European-like institutions, with protections on private property and checks and balances against government expropriation. Where geographic conditions did not sustain large settler populations or large-scale agriculture, extractive (and therefore non-capital forming) institutions were likely to be put in place. Interestingly, this perspective has set aside the question of whether geography has been a determinant of whether European powers were successful in their attempts to subjugate foreign populations.

The connection between oil dependence and geography is seemingly the most straightforward. An obvious precondition for oil dependence is the presence of petroleum deposits within the national territory or proximate to its coastline. Beyond the existence of oil to exploit, a second necessary condition for oil dependence is a relative incapacity to sustain other types of large-scale economic activity. This may be due to a variety of factors. Some are political. Oil production is less dependent on dense complex networks of information and transactions than either manufacturing or services, and therefore production is less likely to suffer from political
and economic instability (Collier 1999). Oil production may succeed in contexts where many other types of economically productive activity cannot. Moreover, mineral wealth typically raises the value of the national currency, making manufactured goods and services less competitive in international markets (the dreaded “Dutch Disease”). Others may be ecological. As Diamond and others have argued, some climates are more hostile than others to the development of large-scale agriculture and the attendant benefits of technological diffusion. If this were the case, we would expect countries with climates hostile to large-scale agriculture to be more dependent on petroleum (contingent on its existence). The United States is a massive oil producer, with average daily production equaled or surpassed only by the Soviet Union and Saudi Arabia in several country-year observations, and yet could not accurately be described as an oil-dependent economy, with fuel exports as a percentage of merchandise exports averaging 3.2 percent in the sample.4

In the next section, I develop a broader definition of the concept of rough terrain that encompasses both issues of penetrability (the focus of the extant conflict literature) and environmental constraints on political, economic and social development (the focus of the extant development literature). I then develop hypotheses regarding its direct effect on conflict onset as well as its indirect effects, mediated through a variety of significant correlates of conflict onset: level of economic development, oil dependence, and the strength of state institutions.

3. The Argument and Hypotheses

3.1. Rough Terrain as Closed Terrain: Direct Effects

In geographic terms, rough terrain affects the ability of states to project authority and insurgents to hide and regroup. Fearon and Laitin (2003) argue that mountainous terrain increases the feasibility of insurgency because it endows insurgents with places to hide safely, thereby diminishing the power asymmetry between state forces and insurgents. To the extent that environment exerts an impact on civil conflict onset, this line of thinking is representative of opportunity models (Grossman 1999, Collier and Hoeffler 2002).

In these studies, rough terrain is conceptualized entirely in terms of penetrability: the degree to which terrain impedes the surveillance capacity and mobility of state forces. Surveillance capacity refers to the ability of forces to observe the actions of opposition forces and local populations. If being able to hide is crucial in the early stages of insurgency, terrain must offer good hiding places. In military terminology, mobility refers to the degree to which forces retain their ability to fulfill their primary mission while in motion. Mobility is therefore a function of the composition of fighting forces and the terrain in which they operate. A mechanized, heavily armored force such as the US Army’s “Iron Horse” Fourth Division might be highly mobile across open, rolling country, but virtually immobile in mountainous or jungle terrain. The preceding are examples of what is called closed terrain, an environment of poor visibility and trafficability. These types of terrain facilitate insurgency by diminishing the advantages conferred by superior firepower, as state forces operating in these areas are necessarily much more like insurgent bands: small and lightly armed.

3 The present situations in Iraq and Russia suggest that this contention is not airtight.
4 I will of course grant that descriptions such as oil consumption-dependent state are warranted.
Mountainous terrain fits clearly this definition. Rapid changes in elevation, weather, and reduced visibility and mobility make traversing mountains an arduous process. Routing options are limited, and in most cases local knowledge of safe passages is necessary. However, it is not clear that these qualities are particular to mountainous terrain alone. Having thus defined rough terrain, the logical question becomes whether other climates or terrain fit this definition. If it is judged to be similar to mountainous terrain in these respects, it should lead to the same hypothesized effect on the likelihood of conflict.

Using Guevara’s comments as a starting point, tropical rainforests and deserts might be good choices. Tropical rainforest turns out to be the better candidate. Marked by dense foliage and an abundance of streams and rivers, rainforests are similarly impenetrable to those without accurate, detailed knowledge of local geography and mechanized forces. The potential for aerial surveillance is clearly curtailed by the presence of the canopy layer. Moreover, rainforests are inhospitable climates for those not familiar with local flora and fauna. Therefore, we would expect that tropical rainforest climate would be associated with a higher likelihood of conflict.

The expected effect of another type of harsh climate, desert terrain, is the opposite. Deserts are undoubtedly inhospitable places, but there are reasons to believe that this inhostableness confers an advantage on state rather than insurgent forces. The desert is a relatively healthy place for large numbers of troops to live. Visibility is generally good, and there are few natural barriers such as rivers to slow the advancement of mechanized forces, as the fabled tank battles of the North African campaign in Word War II and more recent invasions of Kuwait and Iraq have demonstrated. Moreover, deserts are usually devoid of local populations, making the identification of insurgents, a constant problem for state forces, a much easier task. As such, it does not meet the criteria that hinge on impediments to mobility and surveillance. Rather, I expect desert terrain to be associated with a diminished likelihood of conflict onset.

\( \text{H}_1: \) There is a positive relationship between mountainous terrain and the likelihood of civil conflict, ceterus paribus.

\( \text{H}_2: \) There is a positive relationship between tropical rainforest terrain and the likelihood of civil conflict, ceterus paribus.

\( \text{H}_3: \) There is no relationship between desert terrain and the likelihood of civil conflict, ceterus paribus.

3.2. Rough Terrain and Human Ecology: Indirect Effects

An alternate perspective on the link between rough terrain and conflict is to understand rough terrain in ecological terms. As used here, human ecology is the study of the relationships between human groups and their physical environments. Humans have proven remarkably adaptable to widely disparate geographic realities. The nature of this adaptation has been overwhelmingly technological relative to the minor physical differences between groups inhabiting different environments. Diamond has developed this line of reasoning most synthetically. Without committing too much violence to Diamond, who is wary of the fallacy of viewing all human advancements as the result of conscious planning, the vast differences in

\(5\) US hesitancy to deploy armored divisions in South Vietnam was the direct result of these types of tactical considerations; see Starry (1978).
levels of technological sophistication among civilizations\textsuperscript{6} were largely a function of differences in the utility of investment in technology: first for agriculture and subsequently the development of writing, centralized bureaucracies, and large armies. These differences arose because of differences in biological endowments: relatively flat areas with dry summers and wet winters, so-called temperate climates, were (and continue to be) favorable to the staple cereal grains that fueled the rise of agriculture in the Fertile Crescent and later across the Eurasian continent, while in areas with climates unsuitable for these types of activities, such as most tropical zones, societies either did not develop agriculture based on the Eurasian bundle or reverted to hunter-gathering rather than face the certain starvation that would attend a reliance on farming in inhospitable climates.

Physical geography may be thought of as a highly differentiated system of incentives and constraints. In this sense, the argument is analogous to those common to institutional perspectives on political behavior.

3.2.1. Economic Development

Higher levels of development are linked to decreased incidence of conflict (Collier and Hoeffler 2002, Fearon and Laitin 2003). Though the mechanisms proffered to explain this relationship (economic development as a proxy for state strength, fewer grievances) may vary, it represents the single most robust empirical relationship in the civil conflict literature (for a thorough empirical defense of this claim, see Hegre and Sambanis 2004).

In addition to the argument elaborated by Diamond, Gallup, Sachs and Mellinger (1999) demonstrate convincingly that differences in climate and terrain have a dramatic impact on economic development. Their argument centers on two mechanisms: remote areas\textsuperscript{7} have much higher shipping costs and therefore lower productivity, and tropical areas suffer lower output because of the unsuitability of the soil to large-scale agriculture and increased burden of disease.\textsuperscript{8}

According to this logic, economic development will be greater in nations with more temperate, fertile climates, and lesser in tropical and subtropical climates where large-scale cultivation is more difficult. Due to water scarcity and a lack of nutrient rich soil, desert territory is a poor candidate for the development of large-scale agriculture as well. While suffering from no shortage of water, tropical rainforests have proven difficult to convert to agriculture, as clear-cutting and burning promote massive soil erosion and nutrient depletion.

What about mountainous terrain? Building on the logic of Gallup, Sachs and Mellinger (1999), mountainous terrain should be associated with lower levels of economic development. The argument hinges on the costs of shipping and agglomeration effects. Productivity is likely to be lower in mountainous areas because transshipment and access to markets are hindered by the aforementioned difficulties of navigation. Moreover, these areas are less likely to enjoy the agglomeration effects and economies of scale that arise in more linked markets.

\textsuperscript{6} To be sure, his argument pertains to the differences apparent at the dawn of the age of sail and European military conquest. Diamond’s argument, therefore, is not so much in opposition to that offered by Acemoglu \textit{et al}. (2001) but logically prior: Acemoglu \textit{et al}. do not concern themselves with the question of why Eurasian civilizations were so successful in conquering other civilizations.

\textsuperscript{7} This is operationalized as areas situated more than 100 kilometers away from coastline or navigable rivers.

\textsuperscript{8} I will return to the subject of disease in my discussion of the impact of climate on the strength of political institutions.
There is a negative relationship between tropical rainforest climate and the level of economic development of a nation, ceterus paribus.

There is a negative relationship between desert climate and the level of economic development of a nation, ceterus paribus.

There is a positive relationship between temperate climates and the level of economic development of a nation, ceterus paribus.

There is a negative relationship between mountainous terrain and the level of economic development of a nation, ceterus paribus.

3.2.2. Natural Resource Dependence: Oil and other Fossil Fuels

Arguments about natural resource dependence have been central to the development of the opportunity literature. Up to this point, empirical analysis has focused almost exclusively on the impact of lootable (high-value, low-weight) resources such as oil (Sørli 2002, Fearon and Laitin 2003, Humphreys 2003) and diamonds (de Soysa 2002, Humphreys 2003, Lujala, Gleditsch and Gilmore 2003, Snyder and Bhavnani 2003). While these commodities have been at the heart of several of the most prominent recent conflicts (Sierra Leone, Angola, and Algeria, to name a few), they constitute a small number of cases and are restricted largely to the Middle East and sub-Saharan Africa. Here, I will restrict my analysis to oil and fossil fuels, as their effects on conflict have been the subjects of much debate.

Generally, the arguments focus on two possible mechanisms. The first is that lootable resource dependence increases the overall “prize” of capturing the state. This approach finds its most clear expression in the work of Grossman (1991, 1999) and Fearon and Laitin (2003). The second approach emanates from the rentier states literature, which suggests that states that are highly dependent on oil revenue will have comparatively less well developed state institutions and be less democratic than their level of economic development would otherwise suggest (Karl 1997, Ross 2001, Sørli 2002). On the other hand, there are those who contend that the direct effect of the increased economic development of these oil-rich states is enough to offset any institutional weakness, and that access to oil revenue and suppression of democracy allow these states to overspend comparatively on defense, thereby deterring violent challenge (Smith 2004).

Oil dependence is operationalized generally as fuel exports as a percentage of merchandise exports. While this variable is a good indicator of the centrality of fuel exports to the economic profile of a country, it is a good indicator also of the relative centrality of other forms of economic activity. For reasons analogous to those discussed in the section on economic development, countries with climates relatively hostile to large-scale agriculture will be comparatively more reliant on oil as a percentage of exports for two reasons. The first, as discussed in the section on economic development, is that terrain and climate are reasonable proxies for the absence or presence of economic alternatives. The second is geological: countries located in tropical rainforests and deserts are characterized by the higher ground temperatures necessary for the formation of petroleum deposits. Regarding mountainous terrain, the expectation is null.

There is a positive relationship between tropical rainforest climate and oil dependence, ceterus paribus.

The logic of this argument is contingent on petroleum reserves being subsoil rather than offshore.
There is a negative relationship between desert climate and oil dependence, ceterus paribus.

There is a negative relationship between temperate climates and oil dependence, ceterus paribus.

There is no relationship between mountainous terrain and oil dependence, ceterus paribus.

3.2.3. Strength of Political Institutions

Various empirical studies (Ellingsen and Gleditsch 1997, Hegre et al. 2001, Fearon and Laitin 2003, Smith 2004) have demonstrated that consolidated authoritarian states and institutionalized democracies experience fewer civil wars than regimes falling between these extremes, the “inverted U-curve” hypothesis. Explanations for this phenomenon are varied. Hegre et al. argue that so-called “semidemocracies” are more prone to conflict because of the inherent contradictions of partially open societies commingling with repressive, authoritarian regimes. These contradictions express themselves in the forms of state repression and mass mobilization.

Here, state capacity to repress is defined as the degree to which democratic and non-democratic features are intermingled in the political system and the degree of political instability within the system (Hegre et al. 2001, Fearon and Laitin 2003). Where instability and intermingling are high, state capacity is lowest; where intermingling is low and stability is high (i.e. strong democracies or non-democracies, stable political systems), state capacity is high. Fearon and Laitin operationalize intermingled systems as “anocracies,” countries with Polity IV values between -5 and 5, all others being strong democracies or non-democracies. Hegre et al. use a different operationalization, a quadratic transformation of the -10 to 10 POLITY scale, in order to measure the same underlying phenomenon. Both find that coherent non-anocracies, or states with higher squared POLITY values, have a lower likelihood of experiencing civil war. Most of these studies have failed to find a significant effect for political democracy (operationalized as the POLITY score on the -10 to 10 scale).

My contention is that standard measures of political democracy conflate the concepts of state consolidation and the institutionalization of inclusive channels of political competition. The problem is one of construct validity: extant operationalizations of political democracy capture levels of state consolidation as well, thereby making a test of the democracy hypothesis impossible. This critique is consistent with Fearon and Laitin’s interpretations of their findings regarding the inverted U-curve hypothesis:

We suspect that the answer is often that “anocracies” are weak regimes, lacking the resources to be successful autocrats or containing an unstable mix of political forces that makes them unable to move to crush nascent rebel groups (85).

That is, intermediate regimes are not more prone to violence because of a commingling of democratic and non-democratic institutions, but for the incomplete nature of state consolidation in these regimes, which in turn makes it more difficult for states to deter challengers. Measures of political democracy are taken as a proxy for state consolidation, which is an empirically and theoretically distinct concept.
POLITY conflates democracy and state consolidation by introducing the concept of anocracy, which encompasses values around 0 on the -10 to 10 POLITY scale. Logically, one would expect the median values on a linear scale of authoritarianism and democracy to be those cases in which democratic and authoritarian political institutions are mixed. However, the definition of anocracy developed by Gurr says no such thing: the essential, defining characteristic of anocracy is the lack of centralized political power and institutionalization (1974, 1487), which seems to be capturing a different vector of variance: level of political consolidation.

The causes for the development of centralized, consolidated state structures are some of the most studied questions in political science, and a more thorough investigation of this subject is beyond the scope of my analysis here. However, there is some agreement that geopolitical competition was one of the more significant determinants of the functional form of the modern state (Tilly 1975, Poggi 1990), which suggests that centralized states are most likely to develop in locations that facilitate the projection of political power.

I contend that the regions in which state consolidation is most likely to take place are those in which local geography and climate confer advantages on larger, more organized fighting forces —that is, terrain that is highly penetrable. Therefore, the hypothesized relationships between the strength of political institutions and climate are virtually identical to those identified as tactical effects, as both concern the degree to which local climate and geography favor the projection of political power. States where geography and climate provide significant natural impediments to the projection of authority will be less fully consolidated than others.

HA12: There is a negative relationship between mountainous terrain and the consolidation of political institutions, ceterus paribus.
HA13: There is a negative relationship between tropical rainforest terrain and consolidation of political institutions, ceterus paribus.
HA14: There is a positive relationship between desert terrain and the consolidation of political institutions, ceterus paribus.
HA15: There is a positive relationship between temperate climate and the consolidation of political institutions, ceterus paribus.

Figure 1: Possible Causal Mechanisms

4. Data, Methodology and Models

The analyses presented here focus on the effects of rough terrain and climate on levels of economic development, dependence on fossil fuel exports, and the strength of political institutions, and ultimately armed domestic conflict. Following descriptions of the relevant dependent and independent variables, the tests will be presented in the following order: first, I present the models designed to capture indirect effects of rough terrain and climate, as mediated by its effect on economic development, oil dependence, and the strength of political institutions. Then, I present a full model of onset designed to capture both direct and indirect effects. In order to demonstrate the magnitude of indirect effects, I then generate predicted probabilities in order to demonstrate the relative magnitude of these effects.

The data used herein is an extension of the Fearon and Laitin (2003) dataset, which covers 161 countries between 1945 and 2003, for a total of 7246 country-year observations. Due to issues of data availability, not all analyses will make use of all observations. Descriptive statistics for all variables discussed herein are available in Appendix A.
4.1. Dependent Variables

4.1.1. Economic Development

The dependent variable in this analysis will be GDP _per capita_ in constant 1990 dollars. The data are taken from Fearon and Laitin’s dataset.

4.1.2. Oil Dependence

The issue of coding oil dependence is nearly as contested as the causal mechanisms offered to explain its impact (see Humphreys 2003). I will be examining the coding used by Fearon and Laitin, which is a dummy variable using a threshold of 33 percent of fuel exports as a share of GDP for coding a country as dependent in a given year. The variable takes on a value of one if this threshold is reached, zero otherwise.

4.1.3. Strength of Political Institutions

Two operationalizations of the strength of political institutions will be used. The first is Fearon and Laitin’s anocracy variable, which is coded with a value of 1 for country-year where \(-5 \leq \text{POLITY} \leq 5\), and 0 for all others, thereby encompassing values clustered around 0 on the -10 to 10 POLITY scale.

4.1.4. Conflict Onset

The main dependent variable is the onset of civil war. Two codings of this variable will be used: that used by Fearon and Laitin (2003), and that developed by the Uppsala Conflict Data Project (UCDP). Fearon and Laitin define insurgency as:

1. The presence of groups who sought either to take control of a government, take power in a region, or use violence to bring about a change in government policies.
2. A conflict that killed or has killed at least 1000 over its course, with a yearly average of at least 100.
3. At least 100 of the dead are on the side of the government (including civilians attacked by rebels).

The UCDP defines conflict as a violent incompatibility that concerns government and/or territory where the use of armed force between two parties, of which at least one is the government of a state, results in at least 25 battle-related deaths. In both cases, the variable is coded as “1” only for the year of onset and zero for all years thereafter. Largely due to the lower casualty threshold, the UCDP includes many more conflicts, with onsets representing 1.7 percent of observations is Fearon and Laitin’s data, but 3.75 using the UCDP coding. Both operationalizations will be used in order to check the robustness of the model.

4.2. Independent Variables

4.2.1. Rough Terrain
As follows from the discussion in section three, the operationalization of rough terrain used here expands on the conventional operationalization of rough terrain as the natural log of the percentage of mountainous terrain. To this definition, I add percentage of territory encompassed by tropical rainforest and desert. The data come from Harvard’s Center for International Development data project, which was coded using the well known Köppen-Geiger climate classification system. In this system, terrain and climate are differentiated according to two main factors: precipitation and temperature. Tropical rainforests (K-G zones Af and Am) are humid and warm throughout the year, with average rainfall capable of exceeding 20 centimeters per month. Deserts (K-G zone Bw), on the other hand, are dry and warm throughout the year, with average rainfall as little as two centimeters per year. For each country, the independent variable will be the percentage of land area encompassed by these climate zones.

While these classifications are based on temperature and precipitation, their use as operationalizations for the direct effects of rough terrain has little to do with rainfall and temperature per se, but rather with the types of terrain they entail: thick, canopy jungle in the case of rainforest, and sparsely populated, barren territory in the case of desert.

4.2.2. Climatic Constraints

In addition to the tropical rainforest and desert climate zones already identified, I also will be testing the effects of terrain using different levels of aggregation. I follow Gallup, Sachs and Mellinger (1999) in dividing climates into two main groupings: temperate and tropical/subtropical. The category temperate climates includes the following (examples in parentheses): Mediterranean dry summer (Greece, southern and western Spain), humid temperate (southern Norway, the British Isles), snowy forest moist winter (eastern Canada, eastern Sweden) and snowy forest dry winter (boreal forests of Siberia). Tropical/subtropical climates include tropical rainforest (Malay Peninsula, the Philippines), tropical savannah (Caribbean, Cote D’Ivoire, eastern Brazil), and mild humid dry winter (India’s Gangetic valley). The grouping non-temperate adds to the tropical/subtropical grouping desert (the Sahara, the Arabian Peninsula), steppe (western Great Plains, Botswana), and highland (the Himalayas, Andes and Rockies). In each case, the variable used will be the percentage of land area covered by the relevant climate zone.

4.3. Tests

4.3.1. Economic Development

The independent variables of interest are percentage of total area in rainforest climate, percentage of total area in desert climate, percentage of area in temperate zones, and the natural log of percent mountainous territory. Also included are interaction terms between the three climate variables (rainforest, desert, and temperate) and the mountainous variable, which addresses topography.

Table One: OLS Estimates of GDP per capita, 1945-2000

11 A persistent critique of this approach argues that it is not geographic features in the aggregate, but rather local geographic features (for example, whether an ethnic minority has access to rough terrain) that affect the likelihood of conflict. Regarding the hypotheses for the direct effects, this point is well taken. For insurgents, local economies and opportunity structures may be paramount. Regarding the indirect effects, which are mediated through state-level attributes, state-level analysis of the territory is appropriate.
The results are presented in table one. Counter to expectations, tropical rainforest climates were associated with higher levels of economic development, *ceterus paribus*. However, the effect of rainforest is small when compared to the effect of temperate climate, which also exerts a positive effect on GDP *per capita*: this model predicts a net loss of GDP *per capita* of $1,500 when moving from an entirely temperate climate to an entirely rainforest climate. Desert terrain is significant and counter to the hypothesized direction, although that may be attributable to the high correlation between desert terrain and oil dependence.

### 4.3.2. Oil Dependence

The dependent variable is a dummy coding for oil dependence, which takes on a value of one if the threshold (33.33%) is met, zero otherwise. Since the variable of interest shows a high degree of serial autocorrelation (r=.9382), two specifications include the lagged dependent variable in models 2 and 3. Finally, in order to control for the possibility that oil dependence is simply a function of overall levels of production, I include average daily output in millions of barrels, a measure on loan from Macartan Humphreys, in model three.
Taken together, the three models show strong support for the hypothesized relationship between rainforest and desert terrain and oil dependence, with the coefficients both positive and highly significant. Moreover, the findings were robust to the inclusion of interaction effects. The relationship between temperate climate and oil dependence is weakly supported, attaining significance at the 0.1 level in the presence of the lagged DV but not when overall levels of production are taken into account. This may, however, be an artifact of missing data: the sample is significantly smaller and completely excludes several large petroleum exporters.\footnote{Angola, Azerbaijan, Bahrain, Congo, Iran, Iraq, Nigeria, Russia.}

Logit analysis indicates significance, direction and magnitude, but because effects are non-linear and contingent on values of other independent variables, I use CLARIFY 2.1 (King, Tomz and Wittenberg 2003) in order to generate predicted probabilities, which allows for a more intuitive assessment of the marginal effect of a change in variable of interest on the likelihood of conflict. According to model one, Algeria is a prime candidate for oil dependency, being 87.4 percent desert, only 6.2 percent temperate, and above the mean in mountainous terrain. The probability of Algeria being oil dependent in any year, given these values, is estimated at 0.509, more than two standard deviations (0.152) greater than the baseline probability for all observations ($p=0.13$). Halving the value for desert terrain (0.435, roughly equal to that of Iran) reduces the probability of oil dependence to 0.226, a change of -55.6 percent. Setting these variables to the values for Morocco (10.3 percent desert, 39.1 percent temperate, 75 percentile mountainous) yields a predicted probability of being oil dependent of 0.061, an 88 percent decrease.

### 4.3.3. Political Institutions: Anocracy

As before, the models include interaction terms (two and four) as well as a lagged dependent variable.

<table>
<thead>
<tr>
<th>Anocracy (t-1)</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainforest</td>
<td>0.716375 (0.1206582)</td>
<td>0.2994761 (0.1856484)</td>
<td>0.291519 (0.236295)</td>
<td>0.1744915 (0.3596894)</td>
</tr>
<tr>
<td>Desert</td>
<td>-0.5623198 (0.1172964)</td>
<td>-1.457604 (0.2301926)</td>
<td>-0.36812 (0.216127)</td>
<td>-0.8785973 (0.4010103)</td>
</tr>
<tr>
<td>Temperate</td>
<td>-1.533935 (0.1002101)</td>
<td>-2.496381 (0.2190431)</td>
<td>-0.94637 (0.16848)</td>
<td>-1.595924 (0.3363056)</td>
</tr>
<tr>
<td>Mountainous</td>
<td>0.1840592 (0.0216222)</td>
<td>0.0347756 (0.0327354)</td>
<td>0.090761 (0.040206)</td>
<td>-0.0001548 (0.0620931)</td>
</tr>
<tr>
<td>Rainforest-Mountains</td>
<td>0.2357373 (0.0810157)</td>
<td>0.2357373 (0.0810157)</td>
<td>0.2357373 (0.0810157)</td>
<td>0.2357373 (0.0810157)</td>
</tr>
<tr>
<td>Desert-Mountainous</td>
<td>0.4782208</td>
<td>0.4782208</td>
<td>0.4782208</td>
<td>0.4782208</td>
</tr>
</tbody>
</table>

**Table 3: Logit Estimates of Anocracy, 1945-2003**
The effect of rainforest is in the hypothesized direction but only achieves significance in models one and two, which suggests the finding is not particularly robust. Desert terrain seems to favor the development of strong political institutions under all specifications. The signs on the coefficients for mountainous terrain are in the hypothesized (+) direction and significant even in the presence of interaction terms, which are also highly significant. This finding does not survive the inclusion of a lagged dependent variable, however. The effect of temperate climate is striking: temperate zones were associated with a significantly diminished likelihood of being categorized as anocracies under all specifications.

4.3.4. The Onset Model

I follow Fearon and Laitin (2003) in including measures of noncontiguous territory, whether or not the country had experienced a distinct ongoing civil war in the previous year, population, oil dependence, and measures of ethnic and religious fractionalization. Moreover, I include their measure of the strength of political institutions, anocracy, as well as the rainforest, desert and temperate climates, mountainous terrain and economic development as measured as lagged GDP per capita. While the indirect effects of terrain and climate on the political and economic attributes of the state have been identified, these variables are included here to test for the presence of direct or tactical effects on the decisions of potential insurgents (referring back to figure one).

| Table Four: Logit Estimates of Civil Conflict Onset, 1945-2000 |
|---------------------------------|----------------|----------------|
| COW Coding                     | UPDC Coding    |
| Lagged War                     | -0.93783       | 0.837012       |
|                                | 0.323368       | 0.16278        |
| Lagged GDP                     | -0.21385       | -0.09551       |
|                                | 0.062094       | 0.033026       |
| Lagged InPop                   | 0.28831        | 0.195793       |
|                                | 0.078469       | 0.054584       |
| New State                      | 1.449293       | 1.198822       |
|                                | 0.440253       | 0.363684       |
| Ethnic Frac.                   | 0.059848       | 0.651998       |
|                                | 0.415987       | 0.296911       |
| Rel. Frac                      | 0.268865       | 0.241041       |
|                                | 0.556356       | 0.378769       |
| Oil Dependent                  | 0.575326       | 0.620177       |
|                                | 0.31219        | 0.203978       |
| POLITY lagged                  | 0.019645       | 0.016021       |
|                                | 0.018889       | 0.01263        |
| Anocracy lagged                | 0.535126       | 0.554185       |
|                                | 0.22473        | 0.149874       |
| Mountainous Terrain            | 0.166326       | 0.092088       |
|                                | 0.087894       | 0.058614       |
| Noncontig. Territory           | 0.514674       | 0.182624       |
|                                | 0.330061       | 0.219481       |
| Rainforest Climate             | -0.22556       | -0.37317       |
|                                | 0.503822       | 0.329802       |

Bold denotes p<.05, italics p<.1
The results of this analysis are presented in table four. Of the three operationalizations of rough terrain included, only mountainous terrain attains significance. However, the coefficients on lagged GDP per capita and oil dependence remain highly significant, as does the coefficient on strength of political institutions in the hypothesized direction (+).

That percentage temperate climate is significant when included in the onset model needs mentioning. Temperate climates are not incompatible with dense forests, and therefore their tactical effect should at the very least be indeterminate. However, a glance at the data suggests an alternate interpretation. Of the 45 countries in the sample that are more than 50 percent temperate, 36 are located in Europe. Of the remaining nine countries, two more (United States and Canada) are located in North America and three (Japan and the Koreas) are located in East Asia. Only four countries (Lesotho, Swaziland, Lebanon and Uruguay) are located in at higher latitudes (relative to their proximity to the pole). This suggests that this variable captures otherwise unmodeled differences in state capacity that arise out of climates favorable for the development of large-scale agriculture, centralized political institutions, and diversified economies. This is the position taken by Olsson and Hibbs (2004).

The argument of this paper complicates the construction of counterfactuals by introducing the question of indirect causation. It would be inappropriate, therefore, to estimate the marginal effect of a change in the percentage of mountainous terrain without accounting for its impact on endogenous variables as well. In order to demonstrate these effects, I present the counterfactual regarding the Democratic Republic of Congo in 1997. The baseline model predicts a 0.062 probability of conflict onset for that country-year, which is in the 95 percentile of all predicted probabilities for conflict onsets. Moving from a mixture of rainforest and savannah climate to a fully temperate climate predicts a 75 percent decrease in the probability of conflict just capturing the direct effect. However, such a counterfactual must take into account also the predicted changes in wealth, commodity dependence and political centralization. A fully temperate DRC would be much wealthier and predicted also to not be anocratic. Accounting for these changes as well, the predicted probability of onset diminishes to 0.002, a full 96 percent decrease from the baseline probability.

The Battle of Hürtgen Forest in western Germany is an instructful example; see Whiting, The Battle of Hurtgen Forest (2000).

<table>
<thead>
<tr>
<th>Desert Climate</th>
<th>-0.27271</th>
<th>-0.09808</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.49268</td>
<td>0.318406</td>
</tr>
<tr>
<td>Temperate Climate</td>
<td>-1.05437</td>
<td>-0.61811</td>
</tr>
<tr>
<td></td>
<td>0.495753</td>
<td>0.32576</td>
</tr>
<tr>
<td>n</td>
<td>6134</td>
<td>6134</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table Five: Presenting A Counterfactual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pr(onset) DRC, 1997</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>Lagged War</td>
</tr>
<tr>
<td>Lagged GDP (1000s)</td>
</tr>
<tr>
<td>Lagged In(Pop)</td>
</tr>
<tr>
<td>New State</td>
</tr>
<tr>
<td>Ethnic Frac.</td>
</tr>
<tr>
<td>Rel. Frac.</td>
</tr>
<tr>
<td>Oil Dependent</td>
</tr>
</tbody>
</table>

13 The Battle of Hürtgen Forest in western Germany is an instructful example; see Whiting, The Battle of Hurtgen Forest (2000).
5. Discussion

These findings suggest two general conclusions. The first is that measures of state capacity, though indirect, remain the strongest correlates of the onset of civil conflict; as such, these findings are consistent with the bulk of the conclusions drawn by those working in the opportunity literature (Collier and Hoeffler (2002), Fearon and Laitin (2003), Sørli 2002, etc.). The second is that more attention should be paid to disaggregating the causal mechanisms through which these correlations operate. Here, I have demonstrated that two plausible operationalizations of rough terrain, rainforest and desert, respectively, increase the likelihood of conflict. However, unlike mountainous terrain, which appears to exert a direct effect, the effects of these other types of rough terrain are mediated by their impact on measures of state capacity, suggesting a more nuanced understanding of what constitutes “rough.”

Much current work on geography and conflict is focused on disaggregating the country-level data in order to investigate the impact of the explanatory variables on conflict. Regarding terrain, this critique is posed typically in the following way: that a country both has rough terrain and experiences conflict does not tell us whether the conflict actually occurred in the rough terrain. This reflects an a priori assumption about the mechanism (tactical considerations of insurgents, grievances of marginalized locals) through which rough terrain leads to conflict. Disaggregated data may, therefore, allow us to test directly the role of rough terrain as it pertains to this specific mechanism. However, this emphasis would cause us to ignore the fact that regardless of whether or not the fighting took place in remote areas, the state against which the insurgents would be rebelling would be poorer, less politically consolidated and more reliant on the export of natural resources—all in all less able to repel challenges—than it would have been were it not for its challenging geography.

This line of analysis suggests at least two fruitful areas for further research. The first concerns the spatial distribution of conflicts. The onset of civil war shows a high degree of spatial clustering—that is, some regions of the world, specifically Western Africa and Southeast Asia, are significantly more violent than others. Two alternate interpretations of this finding are prevalent. The first, the diffusion hypothesis, is that the dynamics of conflict in one country may destabilize or spill over into neighboring countries. The second, the common constraints hypothesis, is that conflicts cluster because neighboring states tend to face similar underlying circumstances that make conflict more likely.

It may be that these explanations create a false dichotomy, in that the underlying circumstances that make a state more conflict prone, in isolation, also are related to those factors that create conflict-prone neighbors. Specifically, geographical and ecological constraints affect the development of economies and state institutions by impeding growth, encouraging reliance on
non-renewable resources and discouraging investment in strong, centralized bureaucracies. Thus, conflicts may be likely to occur in states characterized by the common constraints of hostile geography and ecology. Because these common constraints tend to be spatially clustered, conflicts will appear to be spatially clustered as well, regardless of whether the observations are instances of diffused conflicts.

Otherwise, my tests of indirect effects suggest that conceptualizing rough terrain in terms of the constraints it places on economic and political development is plausible. This suggests that perhaps more research needs to be devoted to understanding the economic and political constraints facing rulers and the strategies they pursue as they attempt to deter violent challenge.
References


Figure 1: Causal Mechanisms and Endogeneity. Arrows indicate hypothesized directions of causality.