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# Natural Disasters and the Size of Nations

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**ABSTRACT**
What is the relationship between natural disasters and country size? Is an increasing likelihood of environmental shocks linked to political integration or secessionism? We argue that natural disasters are associated with a decline in country size. This relationship arises because costs generated by disasters are higher for citizens located farther away from the political center of a country, and costs are amplified as disasters affect a larger area in a country, which in turn makes it less desirable for citizens in remote regions to remain part of a larger country. Our empirical results show that greater risks of environmental shocks are indeed associated with smaller countries, as well as smaller administrative units.

**KEYWORDS**
Country size; natural disasters

The size of nations has long attracted scholarly attention due to the numerous profound political and economic consequences of this key country characteristic. Studies of domestic politics suggest that country size, broadly defined,[1] affects democracy and in particular, the quality of governance, levels of political participation, democratic representation, and political efficacy (Alesina and La Ferrara 2000; Dahl and Tufte 1973; Olsson and Hansson 2011; Remmer 2010; Weldon 2006). Similarly, size is an important determinant of national economic performance (Alesina and Wacziarg 1998; Easterly and Kraay 2000; Katzenstein 1985; Wittman 2000). Finally, country size shapes foreign policies and, hence, has ramifications for international conflict and cooperation (Dorussen, Kirchner, and Sperling 2009; Finke 2013).

Despite the well-documented importance of country size, less is known about its determinants, especially when it comes to territorial size. A small number of studies have investigated political (dis)integration by utilizing models that incorporate the trade-off between the heterogeneity of individuals' preferences over policies adopted and implemented by a state and lower per capita costs of providing public goods in larger countries. Specifically, Bolton and Roland (1997) show that redistributive conflicts motivate disintegration of countries,

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[1]Research on the effect of country size examines various aspects of this concept, such as territory, population size or density, electorate size, etc. This study mainly focuses on territorial size.

and Alesina and Spolaore (2003) study the optimal size and number of countries under different regimes. Another line of research focuses on the predatory nature of the state: The state is assumed to exist to extract resources from the population on the territory the state controls, with the goal of defending against internal and external threats and ensuring the state's survival (Levi 1981; North 1981; Olson 1993; Tilly 1985, 1992). This implies, then, that states should seek to increase their territory as much as possible, all else being equal. Subsequent studies identified limits on such territorial expansion. For instance, Herbst (2000) points out demographic and geographic limits on country size: Low population density and "inhospitable territories" tend to hamper territorial increases. International institutions appear to exert a similar restraining influence on territorial expansion: Herbst (1990) and Buzan and Waever (2003) suggest that regional institutions, such as the Organization of African Unity and the norm against territorial revisionism upheld by the institution, helped to maintain the territorial status quo in Africa.

These studies provide a general and parsimonious baseline for explaining country size. However, they do not help us understand how country size may be related to long-term susceptibility to shocks that change the availability and distribution of resources, such as natural disasters. Therefore, key theoretical questions that motivate our research are: How do such risks affect preferences of population groups that live in different locations? What are the long-term implications of susceptibility to shocks for interstate border change and country formation?

The complexity of historical processes influencing country formation, territorial adjustments, and border changes presents a significant challenge for developing and testing causal claims in order to answer these theoretical questions. Therefore, our approach in this article pursues a more modest goal: We introduce an explicative model of country size and natural disasters, which offers one plausible pathway linking disaster susceptibility and territorial size. At the same time, our model offers one of the first theoretically driven attempts to test the argument that preference heterogeneity is a key determinant of state formation, as well as a constraint on territorial expansion. In addition, this article contributes to the research on country size by explicitly examining the interaction between physical forces (in the form of environmental hazards) and social forces in the process of border formation —a fundamental political institution in international relations. Focusing on the risks of natural disasters provides us with empirical leverage in the research area that is generally not amenable to alternative approaches: Unlike other forces that shape country size, we can be confident that disaster risks are not subject to strategic manipulation.

Our empirical tests yield results that demonstrate associations consistent with this theoretical story. Based on our model, we argue that greater disaster risks are associated with declining country size because costs generated by disasters are on average higher for citizens located farther away from the political center of a country, and costs are amplified as disasters affect a larger area in the country, which, in turn, makes it less desirable for citizens in remote regions to remain part of a larger country. The model suggests that disaster proneness is a relevant factor for country size, which works alongside other processes shaping country size and boundaries. To explain the proposed relationship between environmental shocks and country size, we first briefly describe the setup of our model, which compares the scenario without environmental shocks with the case when such shocks are possible. Equilibrium and comparative statics analyses allow us to state our expectation regarding the association between our dependent variable, the size of countries, and the key explanatory variable, anticipated resource shocks. We then test the expectation using data on natural disasters and country boundaries.

We believe that this combination of methodological approaches in our study has several advantages. The formal modeling approach allows us to engage in a discussion of the research question that has already been partly addressed in several existing studies. We build on this existing research and show what effects we expect to see when natural disasters are allowed in the model. One particular advantage of constructing a formal model in this case is the transparency of our assumptions and findings. We then proceed to test observable implications using statistical analyses and illustrate the causal link proposed in our model using case studies. Together, these methodological tools are useful in probing the robustness of our conclusions.

This combination of methods also requires us to align theoretical concepts with empirical measures. The model we propose emphasizes individuals' expectations about future disasters and their costs, rather than focusing on individual responses to actual disaster events. Therefore, to evaluate our theoretical expectations empirically, we look at the susceptibility to disasters instead of actual disasters as the key variable of interest. In addition to our main models, we consider implications of our argument for territorial size at the subnational level and use the territorial size of administrative units as an alternative measure of size in our empirical tests. Compared to interstate border formation, we expect administrative unit sizes to be less affected by confounding factors, as in many cases they are determined by a single government, unlike interstate borders that are usually drawn through interstate bargaining and conflict.[2] Overall, our empirical results are consistent with the proposed negative relationship between anticipated natural disasters

[2]Our model allows for a variety of ways in which borders can be drawn—that is, through conflict, peaceful secession, bargaining, etc. We do not explicitly focus on any one of these processes; instead, our theoretical model takes a macro approach and does not make any predictions as to how country size will change. The expectation is that in the long run separatist or unification pressures due to differing levels of disaster susceptibility will lead to an equilibrium through border changes.

and country size. In our concluding remarks we highlight implications of our findings for the study of territorial size as well as contributions of this research to understanding the likely consequences of major environmental issues confronting the world today, such as global climate change.

## Country size and its determinants in perspective

Territory is an integral part of the concept of state, the key actor in world politics; hence, country size is commonly used as an explanatory variable in IR research. At the same time, determinants of size are still not well understood.[3] The following discussion of the literature on country size suggests that one factor in particular—sudden resource shocks and the anticipation of such shocks in the future—has been completely overlooked. Our article seeks to address this gap in the extant research.

Existing studies identify several political and economic factors that help to explain country size. Lake and O'Mahony (2006:138) argue that "a combination of technological change and federation … explain[s] the increase in territorial size in the nineteenth century, and a combination of economic openness and democratization in unitary states … explain[s] the decrease in the twentieth century." Alesina and Spolaore (2003) develop a series of general models to investigate the determinants of the optimal size and number of countries in the international system. Based on their model, which centers on a trade-off between the heterogeneity of preferences within larger populations and efficiency gains on a per capita basis from providing public goods in larger countries, Alesina and Spolaore conclude that the spread of democratization and deeper economic integration should result in smaller countries because people will choose to live in more homogeneous countries, and economies of scale in the provision of public goods become irrelevant in a globalized world. In sum, country size is shaped by the gradual transformation of international relations, in which technological innovations, globalization, and democratization are main driving forces.

A closely related body of research examines borders and border adjustments—political (dis)integration processes that shape country size cannot leave international borders unaffected. While realist approaches focus primarily on the military and political value of borders and hence explain border formation as a result of states' efforts to enhance their security by drawing more defensible borders (Goemans 2006; Mearsheimer 2001; Sahlins 1990), institutionalist approaches offer a nuanced understanding of the significance of international borders, as well as factors shaping border (in) stability. From this perspective, interstate borders are institutions that help

[3]See Lake and O'Mahony (2004) for an overview of the literature on state size and the shortcomings of this research.

to resolve coordination problems among domestic and international actors (Carter and Goemans 2011; Gavrilis 2008; Simmons 2005). Consequently, border redrawing gives rise to the same problems that accompany any major institutional changes, such as concerns about uncertainty due to potential unexpected consequences of new institutional arrangements (Koremenos 2001, 2005; Rosendorff and Milner 2001).

To help alleviate this uncertainty, parties negotiating over new interstate borders rely on a prominent focal point—that is, a set of existing administrative borders (Carter and Goemans 2011). Hence, administrative boundaries assume an important role in determining national borders and country size. Gavrilis (2008:14) underscores the importance of domestic actors in border formation by arguing that "borders are institutions all the way down to the local level" because they are defined not only by the central government and its relations with other countries, but also by local processes. Therefore, determining country size constitutes a creation of a new institution that is shaped by local and national actors. For the purposes of our study, subnational borders are important. This is due to the expectation that some of the effects driving country size should also be reflected at the administrative level, since these boundaries can be redrawn more easily and with less cost than national borders.[4] Moreover, subnational borders should be less affected by confounding international factors, such as strategic considerations and interstate conflict, and hence should be more likely to reflect the objective of maximizing citizens' utility than national-level borders.

## A model of country size and disasters

We begin by presenting a general theoretical framework to explain country size, which allows us to compare scenarios with and without natural disasters. In our model, we investigate how the equilibrium number of countries and equilibrium country size change when we take into account varying susceptibility to natural disasters. We show that equilibrium territorial size will decrease as the likelihood of anticipated environmental shocks increases.[5] The basic setup follows that of Alesina and Spolaore's (2003) model, in which the world consists of a unit interval [0,1], where individuals making up the population are points that are uniformly distributed on the interval. Countries are modeled as a continuous interval [a,b] placed on the

[4]Administrative borders themselves can experience adjustments under the influence of local and national actors' preferences (Grossman and Lewis 2014; Malesky 2009).

[5]In the Web appendix, we also focus on a social planner's solution to the problem, which represents the most efficient distribution of countries on the globe that aims to maximize the total utility of the world population. If we talk about country borders, this solution represents how a benevolent global dictator would have drawn borders, considering the possibility of future disasters. If we focus on administrative borders in a country, the solution again creates borders to maximize the aggregate well-being of the citizens of that country.

world and their size is $b - a$. The utility for each individual $i$ on the [0,1] interval is defined as follows:

$$u_i = y_i - t_i + g - al_i, \tag{1}$$

where $y_i$ is an individual's income (assumed to be homogeneous on the [0,1] interval), and $g > 0$ is the utility from a variety of public goods provided by the state, such as infrastructure, security, public health care, various types of institutions, etc. The cost of the public goods, $k > 0$, is paid for by imposing a tax $t_i$ on each individual $i$. We assume that the tax rate must satisfy the following equality: $\int_i t_i = k \cdot l_i \geq 0$ is the distance of each individual to the center of the nation. $a > 0$ is the heterogeneity penalty, which reduces an individual's utility as his distance from the state center increases. The heterogeneity penalty arises as a result of different policy preferences of various social (such as ethnic, cultural, or religious) groups: As population size increases, more individuals will find that state policies are more distant from their preferences.

Derived in Alesina and Spolaore's (2003) analysis, the following proposition establishes our theoretical expectations in the absence of environmental shocks and serves as a baseline for comparison when we introduce natural disasters to our model:[6]

> Proposition 1: *When borders are determined through democratic processes, $N_D$ equally sized nations are formed. $N_D = \frac{1}{s_D}$ where $s_D = \sqrt{\frac{2k}{a}}$ provided that $\frac{1}{s_D}$ is an integer. Otherwise, $N_D$ is either the largest integer smaller than $\frac{1}{s_D}$ or the smallest integer larger than $\frac{1}{s_D}$.*[7]

This result satisfies the following criteria. First, in each nation, the location of the public good is determined through a simple majority rule, which ensures that the government will be located at the center due to the median voter theorem. Second, the solution assumes that each individual located on the border between two countries can choose which country to join. Third, new borders need to be approved by a majority of citizens in the affected countries. Finally, the solution is stable to unilateral secessions from a given country by a connected group of individuals (Alesina and Spolaore 2003). With these conditions, the solution coincides with a Rawlsian social planner's approach, in which the utility of the worst-off individual is maximized in each country.

[6]The Web appendix contains proofs of the formal results presented in the article.

[7]More specically, suppose that $N_D^-$ and $N_D^+$ represent the largest integer smaller than $\frac{1}{s_D}$ and the smallest integer larger than $\frac{1}{s_D}$ respectively. If $\frac{1}{s_D}$ is not an integer, then the equilibrium solution is $N_D^-$ if $N_D^-(N_D^- + 1) > \frac{1}{s_D}$, $N_D^+$ if $N_D^-(N_D^- + 1) < \frac{1}{s_D}$, and both $N_D^-$ and $N_D^+$ if $N_D^-(N_D^+ + 1) = \frac{1}{s_D}$.

### *Introducing disasters*

After this brief overview of the key results from the model without natural disasters, we consider a model in which disasters are possible. Suppose that, after national borders are drawn and the location of the public good is determined, Nature leaves the pool of resources undisturbed with probability $1 - p$ and sends a disaster to a fraction of the unit interval with probability $p$. For a given disaster size $\sigma \in [0, 1]$ (that is, the share of the unit interval that is affected by the disaster), we assume that the location of the disaster, or the point on the unit interval where Nature strikes, is drawn from a probability distribution. In particular, the "center" of the disaster is defined as $\alpha \in [0, 1]$ and is uniformly distributed. The interval $[\alpha - \sigma/2, \alpha + \sigma/2]$ represents areas affected by the disaster. We assume that the two end points of the unit interval are "connected": That is, when $\alpha < \sigma/2$ or $\alpha > 1 - \sigma/2$, the part of the disaster that exceeds one end point of the unit interval will be transferred to the opposite end of the interval. A disaster can hit more than one nation depending on the size of the disaster and the number and size of nations populating the world. We denote the portion of the disaster $\sigma$ that affects nation $n$ as $\sigma_n$.

When no disasters occur, each individual's utility remains the same as specified in Equation 1. If they do occur, disasters affect individual utilities in two ways: When a disaster hits part of a nation, every individual in the nation pays a cost whether his location is directly affected by the disaster or not. We represent this cost by $-b\sigma_n$ added to the utility function in Equation 1, where $\sigma_n$ is the total area affected in country $n$, and $b > 0$, which captures the relative weight of the cost in individuals' utilities. Substantively, $-b\sigma_n$ represents economic, political, or other repercussions of the shock that are felt across the country.[8] The costs increase as the area of the country affected by the disaster increases. When there are $N$ equally sized nations of size $s$, the probability that a given country will be affected by a shock (that is, $\sigma_n > 0$) equals $1 - \max(0, 1 - \sigma - s)$. In other words, for large enough nations and shocks, it is guaranteed that the disaster will affect a part of a given nation. As shocks or nations get smaller, the probability reduces to $\sigma + s < 1$.

The second cost parameter only applies to individuals directly affected by the shock. The probability that an individual will be in the area of a given disaster is $\sigma$. When a disaster strikes, it destroys a fraction of public goods $g$ in the area it hits, and only the individuals in the affected region will experience this reduction in utility. We parameterize this cost as $-gcl_i$ added to such individuals' utility function, where $c \in (0, 1]$. $c$ captures varying rates of damage to public goods as a function of individuals' distance from the political center. In other words, we assume that the extent of

[8]As an example, an "earthquake solidarity tax" was introduced in Turkey following the massive earthquake that hit the heavily industrialized and populated part of the country in 1999.

damage to public goods is increasing in $l_i$, or the distance of each individual to the political center of the nation.[9] This assumption may represent, for instance, physical barriers to relief efforts that increase with geographical distance from the center, or political differences between the central government and remote areas of the country, which may result in the government prioritizing politically favored areas for relief efforts while leaving distant areas with little or no assistance. Some of the recent examples of such unequal distribution of disaster assistance include the Indian government's response to the 2004 Indian Ocean tsunami, which was described as discriminatory: "everyone who was eligible to receive supplies and cash assistance did not do so, especially among peripheral groups" (Aldrich 2010). Similarly, Muslim communities in the distant Eastern Province of Sri Lanka found the government's tsunami response to be entirely inadequate: They "suffered massive losses but state assistance has been minimal" (Uyangoda 2005). Geography is often closely intertwined with political closeness to the government. Consequently, peripheral populations may not have the same access to communication and transportation networks due to the government's past underinvestment in these areas, which naturally impedes relief efforts: "in other communities, particularly remote ones, the distribution of aid seemed to be quite slow and limited" (Rodríguez, Wachtendorf, James, and Trainor 2006).

In sum, with these assumptions, each individual will have the following expected utility:

$$eu_i = y_i - t_i - al_i - pE[b\sigma_n] + g(1 - p\sigma cl_i). \quad (2)$$

This expected utility takes into account all three scenarios that might apply to an individual: First, no disaster occurs anywhere with probability $1 - p$; second, a disaster occurs but may or may not directly affect an individual. The expected cost in the second scenario is $pE[b\sigma_n]$, where random variable $\sigma_n$ ranges from 0 to $\sigma$ depending on the total affected area of the country. Finally, an individual can be directly affected by a disaster with probability $p\sigma$ and with an associated cost of $cl_i g$.

### The democratic solution with disasters

The following proposition presents our main result regarding the equilibrium size of countries, in the case when natural disasters are possible:

Proposition 2: *When disasters are possible, the democratic solution will result in $N_D^H$ equally sized nations. $N_D^H = \frac{1}{S_D^H}$ where $s_D^H = \sqrt{\frac{2k}{a + 2bp\sigma + p\sigma cg}}$ provided that $\frac{1}{S_D^H}$ is an*

[9]Later in this section and in our empirical analyses, we also consider the possibility that $c \leq 0$, that is, the economies of scale and insurance benefits from living in a larger country outweigh the heterogeneity cost in certain types of countries, such as democracies.

*integer. Otherwise, $N_D^H$ is either the largest integer smaller than $\frac{1}{S_D^H}$ or the smallest integer larger than $\frac{1}{S_D^H}$.*

Lemma 1: *The democratic solution for the optimal size of nations results in a larger number of countries in the case when disasters are possible than in the scenario without disasters, or $N^H{}_D \geq N_D$. Equivalently, the size of countries under the democratic solution should decline, or $\frac{1}{N_D^H} \leq \frac{1}{N_D}$.*

Thus, according to the model, the possibility of disasters decreases the democratic equilibrium size of countries. Moreover, $s^H{}_D$ reduces to $s_D$ if disasters are not possible or are insignificant, that is, $p = 0$ or $\sigma = 0$. Similarly, the equilibrium number of nations increases as disasters become more likely, their expected size grows, or individuals value public goods more.[10]

These results can also be extended to consider the possibility that benefits from economies of scale that accrue from a territory being part of a larger country may in fact outweigh heterogeneity costs in certain types of countries. Our model already assumes the existence of such benefits—that is, individuals' costs of providing public goods decrease when these costs are shared by a larger population. At the same time, one may argue that fairness and effectiveness of larger countries' disaster relief and insurance programs could also depend on the level of corruption, the quality of bureaucracy, level of democracy, economic development, quality of roads, or disaster management capabilities. Existing research suggests that the effect of democracy could be particularly prominent. One of the key characteristics of democratic political regimes is their responsiveness to a larger share of the population than in autocratic countries. Democratic institutions are found to offer greater inclusion and participation opportunities, which in turn "increases satisfaction and political efficacy of citizens, [and] reduces their grievances" (Li 2005:294). This increases the likelihood that the government's policy preferences will be closer, on average, to those living farther away from the center and makes it more likely that the government will respond to the disaster-generated needs of more distant areas. Previous studies report that greater inclusion in democratic countries mitigates grievances of ethnic groups: Cederman, Wimmer, and Min (2010:88) suggest that democratic systems facilitate greater inclusion of ethnic groups in governance structures, which increases ethnic groups' access to public goods, and this, in turn, reduces the likelihood of conflict with the government. Given that democracies favor responding to grievances peacefully, rather than with

[10]In the supplementary files, we consider two extensions: (1) a social planner's solution when disasters are possible; and (2) the case in which the effects of two costs on individual utilities are interactive. Specifically, we allow for the possibility that costs to citizens due to the total area affected in a country and costs from being directly affected by disasters and being distant from the political center amplify each other. We find that our substantive results hold. The possibility of shocks means a larger number of states in the international system, and as the expected size of shocks grows, countries tend to become smaller.

discrimination and repression, which is particularly important in the context of ethnopolitical frictions, democracies provide incentives for peaceful protest and disincentives for violence and secessionist rebellions (Fearon and Laitin 2003; Gurr 2000). This implies that democracies may also have weaker secessionist pressures in disaster-prone areas populated with ethnic, cultural, religious, or other groups whose preferences are distant from the government. This expected mitigating effect of democracy with respect to disasters is interactive, in the sense that democracy will alleviate the negative effects of disasters, and hence we would expect that democratic countries in disaster-prone areas will tend to be larger in size compared to less-democratic countries in similar areas. At the same time, the literature also suggests an alternative, negative effect on country size, which is additive. Some scholars point out that democratic political regimes make it easier for ethnic and other types of societal groups to organize politically and mobilize, if they do choose to seek self-determination (see, for instance, Sambanis 2006). In this case, democracy would increase the likelihood of secession, thereby reducing country size. This negative additive effect, if it exists, is independent from the effect of disasters. In our empirical tests, we will differentiate these two opposing effects.

In sum, when countries become more democratic and improve in other areas relevant for public goods provision and access, the weight of the postdisaster heterogeneity penalty in individuals' utilities could decrease ($c_i \rightarrow 0$) as the expected level of discrimination decreases. As a result, insurance and efficiency benefits from national disaster response programs in some cases could cancel out or outweigh heterogeneity costs ($c < 0$). Thus, for such countries, the anticipated negative effect of disasters could be weaker, or absent, compared to countries that lack such characteristics.[11]

What are the implications of this model, and how does it inform our subsequent empirical analysis? First, assumptions of our model, such as single dimensional characterization of preference space and lack of bargaining, war, or alliances in determining country size, are certainly simplifications and are not meant to be tested. Clarke and Primo (2007:745) argue that empirical tests do not have much utility in testing assumptions of political science models because "political scientists are well aware that almost all assumptions are false." With our simplifying assumptions, abstracting away from these microlevel factors, our model aims to provide a macrolevel story linking disaster susceptibility and country size. Second, we primarily view our model as serving an explicative function, which Clarke and Primo (2007:744) define as "models to explore the putative causal mechanisms underlying phenomena of interest." In the context of disasters, we propose

[11]More specifically, when $c \leq \frac{-2b}{g}$, larger countries are formed in equilibrium in the case when disasters are possible than in the scenario without disasters, or $N_D^H \leq N_D$.

our model as one plausible pathway that accounts for the negative relationship between the likelihood of environmental shocks and country size.

Therefore, the main hypothesis derived from our model is that an increasing likelihood of natural disasters should be associated with smaller countries. We also state two auxiliary expectations. First, disaster risks should exert the same pressure on territorial size at the subnational level with respect to the size of administrative units.[12] Second, for certain countries where preference heterogeneity and discrimination are not expected to be severe, such as democracies, the effect should be weaker or absent: Greater disaster proneness will increase the population's reliance on insurance and other public goods that benefit from economies of scale, and in democratic countries such disaster relief and mitigation advantages come with a lower preference heterogeneity cost.[13] Consistently with the focus of our model on macro trends, the following hypothesis and auxiliary expectations reflect an anticipated long-term equilibrium state, rather than an immediate response to any given natural disaster:

**H1:** *Territorial country size is negatively related to the likelihood of natural disasters.*

**Auxiliary Expectation 1:** *Territorial administrative unit size is negatively related to the likelihood of natural disasters.*

**Auxiliary Expectation 2:** *The negative relationship between the likelihood of natural disasters and country size is weaker or absent for established democracies, richer countries, or countries with higher-quality bureaucracies, disaster management programs, or roads, or countries with lower levels of corruption.*

## Illustrative cases

Before we test our theoretical predictions empirically, we discuss two case studies illustrating the link between environmental hazards and political disintegration: Bangladesh's split from Pakistan in 1971 and Eritrea's split from Ethiopia in 1991. In a nutshell, while we do not claim that natural disasters played the main role in secessionism in these cases, we argue that disaster proneness contributed to existing societal grievances and the dissatisfaction with government policies and, hence, increased these regions' preference for political separation. Government policies of unequal resource distribution among the privileged central regions and more distant, or peripheral, regions likely magnified the negative economic impact of

[12]This expectation is based on the social planner's solution extension that is presented in the Web appendix. If a central social planner that aims to maximize the aggregate well-being of a given population determines borders, a similar implication linking disaster proneness to territorial size emerges. Compared to national borders, subnational administrative unit borders are more likely to satisfy the social planner assumption and are therefore included in the empirical analyses as an auxiliary test.

[13]While this expectation is not directly derived from the theoretical model, it represents an extension of the logic of our argument.

recurrent disasters. The unequal treatment, in turn, contributed to the periphery's belief that secession was preferable to remaining part of the larger country because resource allocation policies in a newly formed country would be more favorable to these peripheral regions than existing policies.

### *Bangladesh and Pakistan*

Bangladesh is one of the most disaster-prone areas in the world: UNDP statistics show that between 1980 and 2008, it experienced 219 natural disasters, one of the largest numbers in the world. Similarly, Columbia University's Center for Hazards and Risk Research suggests that cyclones and floods are the two greatest environmental hazards for this country, while Bangladesh's northern and eastern areas also experience earthquakes, and the southeast is susceptible to droughts and landslides.[14] Pakistan has a lower risk of disasters, with floods presenting the main hazard for the country.

At Pakistan's formation in 1947, West Pakistan (present-day Pakistan) and East Pakistan (present-day Bangladesh) were roughly equal in terms of population size; however, the central government located in West Pakistan pursued policies that favored this region at the expense of East Pakistan. For instance, political power and economic resources were concentrated in West Pakistan, while the choice of the country's common language (Urdu) was rejected by the majority Bengali-speaking population of East Pakistan.

The inequitable distribution of resources became particularly evident when the 1970 Bhola cyclone struck East Pakistan. The central government's response to this enormous natural disaster that killed hundreds of thousands of people and left large numbers of survivors in dire need of assistance was perceived to be grossly inadequate, inefficient, and at times deliberately slow. For instance, the government did not provide more helicopters to deliver aid to affected areas, and the president was perceived as downplaying the scale of damage.

East Pakistan's politicians responded to the government's failed relief efforts by declaring that "if concrete steps were not taken to correct interregional inequities and to protect Bengal against the destructive vagaries of nature, East Pakistan would be forced to separate" (Sisson and Rose 1991). Despite this warning, the government did not make any noticeable improvements in its relief programs and continued its ongoing military action against the secessionist movement in the region. The conflict between the two parts of the country escalated into a civil war and led to the declaration of Bangladesh's independence in March of 1971. While the military conflict was not over with the formation of a new country, the de facto secession was complete.

[14] http://www.ldeo.columbia.edu/chrr/research/profiles/bangladesh.html

## Eritrea and Ethiopia

Ethiopia and Eritrea are primarily vulnerable to the same environmental hazard that affects the rest of the region—droughts—while floods are the second most important type of natural disaster to affect the area. Whereas floods appear to be more frequent (during the period between 1980 and 2010, Ethiopia experienced 45 floods and 10 droughts), droughts affect larger areas and hence cause more damage in economic terms as well as in terms of the number of affected people.[15] Historically, the region has experienced at least seven major droughts each century, but their frequency appears to be increasing due to climate change (Pankhurst 1985).

Political and economic relations in Ethiopia prior to Eritrea's secession were equally challenging. The country was composed of a number of ethnic groups that were dominated by the ruling elites of the Amhara group. The Amhara traditionally held top political and military positions in the country, and even the capital of the country—Addis Ababa—is located in the central region, populated by the Amhara people. The northern periphery is inhabited by the Tigre ethnic group; the east by the Affar tribes; the south by the Oromo group; and the west by seminomadic tribes of Nilotic background (Comenetz and Caviedes 2002). This historical political and economic inequality was exacerbated by the regime change in 1974 when Marxists deposed Emperor Haile Selassie, whose rule was marked by "cultural chauvinism, as well as ethnic and regional inequalities" (Keller 1992) and formed a new government, the Derg, led by Mengistu Haile Mariam. Despite the Mengistu government's declared goals of eradicating injustice and inequality in the Ethiopian society, grievances of groups populating the peripheral regions of the country remained unaddressed; instead, the government resorted to repression.

These political and environmental factors combined in the drought of 1983–1986, with a subsequent wave of drought in 1987 and resulting famine. The Derg failed to address the needs of the starving populations, especially on the periphery, which caused a significant increase in the popular discontent with the government in these areas (Tareke 2002). When repressive measures proved to be ineffective, the government resorted to reorganizing administrative borders to split up areas of resistance. These changes, especially in border regions, were also used to benefit ethnic minorities supportive of the central government (Adhana 1991). Similarly, the government relocated people from restive regions to other parts of the country: "resettlements were located in areas troubled by insurgent activities" (Gebre 2002). Finally, the Derg appeared to disrupt famine-relief efforts of international organizations operating in

[15] http://www.preventionweb.net/english/countries/statistics/?cid=59

rebellious regions, such as Tigre and Eritrea, and attempted to divert food aid toward supportive groups and the military (Keller 1992). In fact, some relief agencies attempted to bypass the central government by moving famine assistance across borders, thereby undermining the Derg's efforts to control food aid and deny it to rebels (Ottaway 1988). The intensifying conflict between the central government and separatist forces was brought to an end by the 1991 fall of the Mengistu government, the success of the Eritrean People's Liberation Front in taking control over Eritrea, and the 1993 referendum on Eritrea's independence, followed by formal secession and international recognition of a new country.

## Empirical analysis

In this section, we conduct statistical tests of the hypothesized relationship between environmental hazards, on the one hand, and territorial size at different levels of analysis, on the other. After describing the data and methods utilized in this section, we present and discuss our results, which lend significant support to our main theoretical expectation. Namely, we find that countries, as well as subnational administrative units, that are more disaster prone tend to be smaller.

### *Data and methods*

For our empirical analyses, we collected territorial size data on all countries in the world in existence in 1998, subnational administrative units and their size for the year 2012, and information on different types of natural disasters and their relative likelihood. In our country size analyses, we treat a given year as an equilibrium state and make comparisons across countries based on their susceptibility to disasters.[16] We describe our data and sources of the data in detail in this section. We then conduct empirical tests at different levels of analysis, ranging from the country level to more localized analysis down to 12-minute grid cells to match the level of detail available in the disaster hazards data set as much as possible.

### *Independent variables*

The data on environmental hazards are from the Socioeconomic Data and Applications Center (SEDAC).[17] We focus on six major natural hazards recorded by SEDAC: droughts, cyclones, floods, earthquakes, volcanoes, and landslides. The data sets focus on the relative likelihood and distribution

[16]We replicated our models for different years (specifically, 1875, 1913, 1950, 1975, and 1998), and the results were substantively the same. Here, we report and discuss results for 1998 because this year has the best data coverage for our dependent and independent variables. Moreover, compared to earlier years, borders change less frequently in more recent years, making our equilibrium state assumption more likely to hold.

[17]http://sedac.ciesin.columbia.edu/

of these hazards (Dilley, Chen, Deichmann, Lerner-Lam, and Arnold 2005). For each hazard, the data sets provide a frequency scale ranging from 0 to 10 for each 2.5-minute grid cell, with higher values representing areas that are at a higher risk for that specific hazard.

We focus on disaster hazards, or likelihoods, rather than actual disaster events because our theoretical model emphasizes expectations. An actual disaster makes a difference only if it causes individuals to revise their beliefs about disaster susceptibility and government response. For instance, if an area receives frequent moderate earthquakes, and the government is usually responsive in providing relief, an average earthquake and a usual government response will not result in changes in expectations. However, an event like the Bhola cyclone likely resulted in different expectations—not about the frequency of such events but about the government's likely future behavior because the government's response was clearly inadequate, given the affected population's expectations.

Globally, the most widespread environmental hazards are floods and droughts: Approximately 33% and 38% of the world's land area is exposed to these natural disasters, respectively. The most spatially concentrated hazard is volcanic eruptions, which affect less than 1% of the global land surface. Less than 10% of the world's land area is subject to each of the remaining three hazards: earthquakes (7.5%), cyclones (6.7%), and landslides (5%). For our analyses that use a 12-minute grid, we calculate the average risk of each one of these six hazards for each grid cell by taking the average hazard scores of the 2.5-minute grid cells that fall within that cell. In addition to environmental hazards, SEDAC provides information on levels of exposure to these hazards. In particular, we use a population density measure, which captures the distribution of population for the year 2000, and a road density measure, gauging the length of major roads and railroads for the year 1993.

### *Dependent variables*

For our main analyses, we rely on measures of territorial size based on interstate border maps from Zhukov and Stewart (2013). First, we use a country-level measure of logged territorial size in square kilometers (*lnarea1998*), for the year of 1998. In addition, we use a variable that captures the logged size of administrative units (*lnadminarea*), based on the information from the Sub-National Political Boundaries Map 2012 Dataset collected by ISciences.[18] This data set codes information for nearly 3,000 unique subnational administrative entities. In most cases subnational boundaries are first-level administrative units, such as provinces and states.

[18]http://geoserver.isciences.com:8080/geonetwork/srv/en/metadata.show?id=333

## Methods

Since we work with geospatial data, we need to address the methodological challenge that may arise as a result of unobserved location-related effects: Events in closely located geographical points may not occur independently of each other. In our model, since a given individual at the border between two neighboring countries decides which one to join, this implies that the size of a given country is negatively related to its neighbor. If not accounted for, such spatial dependencies threaten the validity of standard estimation techniques. One way we control for spatial dependence is by estimating a spatial autoregressive (SAR) model.[19]

With this model, we allow the outcome (that is, country size) variable in a given observation to be dependent on a weighted average of the outcomes in the other units and estimate the form of the dependence. The model we estimate is

$$y = \lambda Wy + X\beta + \in, \tag{3}$$

where $y$ is a 1x$n$ vector for the observations on the dependent variable, $X$ is a matrix containing the set of independent variables, $\beta$ is the vector of coefficients for the independent variables, $W$ is the spatial weight matrix, $Wy$ is the spatial lag vector, and $\lambda$ is the spatial autoregressive coefficient. When $\lambda = 0$, the SAR model reduces to the standard linear regression model. In our regressions, we use inverse distance weighting matrix, which assumes that geographically closer observations receive a larger weight than more distant ones in the spatially weighted average term.

## Results and discussion

Tables 1– 3 display our main estimation results. First, we test the hypothesis that links country size and environmental hazards in specifications without and with control variables; second, we estimate territorial size models using administrative unit-level data; finally, we turn to grid-level data to evaluate the effect of disaster proneness on the process of border formation. In addition, we conduct a series of robustness checks provided in the supplementary files. The first set of empirical analyses offers a direct assessment of the association between the likelihood of natural disasters and territorial size. We expect to find a negative relationship between the two variables, and our empirical evidence is supportive of this expectation. Table 1 reports results of territorial size models at the country level. For these analyses, we calculated the average likelihood of each hazard for each country in 1998, using the SEDAC hazard grid files and country border shape files. We located the geometric center of each country in calculating geographic distance between them and estimated a spatial autoregressive model described in Equation 3 to

[19]We estimated this model using the spreg command in STATA, using the generalized spatial two-stage least squares (GS2SLS) method. See Drukker, Prucha, and Raciborski (2013).

**Table 1.** Spatial Regression of Country Size on Different Hazard Types (Country Level).

| | c | D | E | F | L | v | All |
|---|---|---|---|---|---|---|---|
| Cyclone | −0.341** | | | | | | −0.261** |
| | (0.065) | | | | | | (0.063) |
| Drought | | 0.063 | | | | | 0.011 |
| | | (0.057) | | | | | (0.050) |
| Earthq. | | | −0.292** | | | | 0.140 |
| | | | (0.084) | | | | (0.130) |
| Flood | | | | −0.152** | | | −0.047 |
| | | | | (0.047) | | | (0.045) |
| Landslide | | | | | −0.333** | | −0.297** |
| | | | | | (0.065) | | (0.107) |
| Volcano | | | | | | −0.958** | −0.457 |
| | | | | | | (0.305) | (0.302) |
| Constant | 14.826** | 13.340** | 14.072** | 14.284** | 14.340** | 14.068** | 15.276** |
| | (0.463) | (0.460) | (0.442) | (0.457) | (0.433) | (0.489) | (0.473) |
| Lambda | −0.050** | −0.028** | −0.034** | −0.035** | −0.037** | −0.038** | −0.052** |
| | (0.009) | (0.008) | (0.008) | (0.008) | (0.008) | (0.010) | (0.008) |
| Obs. | 165 | 165 | 165 | 165 | 165 | 165 | 165 |

*Note*. Spatial regression with inverse distance weighting matrix, standard errors in parentheses. Dependent variable: log of country area in 1998.
Level of significance: *$p < .10$, **$p < .05$.

**Table 2.** Spatial Regression of Country Size on Different Hazard Types with Political and Economic Controls (Country Level).

| | c | D | E | F | L | v | All |
|---|---|---|---|---|---|---|---|
| St. Year | −0.010** | −0.013** | −0.013** | −0.014** | −0.013** | −0.012** | −0.012** |
| | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) |
| Ln(GDPpc) | −0.070 | −0.085 | −0.095 | −0.139 | −0.101 | −0.101 | −0.181* |
| | (0.094) | (0.106) | (0.093) | (0.094) | (0.092) | (0.091) | (0.093) |
| Rel Pol *C.* | 0.431 | 0.377 | 0.229 | 0.780 | 0.220 | 0.374 | 0.493 |
| | (0.488) | (0.517) | (0.482) | (0.487) | (0.478) | (0.473) | (0.463) |
| Polity | −0.046* | −0.066** | −0.050** | −0.038 | −0.045* | −0.053** | −0.015 |
| | (0.024) | (0.024) | (0.023) | (0.024) | (0.023) | (0.023) | (0.023) |
| Cyclone | −0.262** | | | | | | −0.211** |
| | (0.085) | | | | | | (0.077) |
| Drought | | −0.015 | | | | | −0.060 |
| | | (0.065) | | | | | (0.059) |
| Earthq. | | | −0.346** | | | | −0.036 |
| | | | (0.093) | | | | (0.152) |
| Flood | | | | −0.206** | | | −0.143** |
| | | | | (0.052) | | | (0.050) |
| Landslide | | | | | −0.299** | | −0.101 |
| | | | | | (0.074) | | (0.125) |
| Volcano | | | | | | −1.099** | −0.666** |
| | | | | | | (0.257) | (0.291) |
| Constant | 33.431** | 38.517** | 39.935** | 42.256** | 39.458** | 38.719** | 38.885** |
| | (5.927) | (6.009) | (5.640) | (5.678) | (5.585) | (5.536) | (5.425) |
| Lambda | −0.050** | −0.036** | −0.038** | −0.038** | −0.039** | −0.043** | −0.056** |
| | (0.011) | (0.011) | (0.010) | (0.010) | (0.010) | (0.010) | (0.010) |
| Obs. | 126 | 126 | 126 | 126 | 126 | 126 | 126 |

*Note*. Spatial regression with inverse distance weighting matrix, standard errors in parentheses. Dependent variable: log of country area in 1998.
Level of significance: *$p < .10$, **$p < .05$

**Table 3.** Spatial Regression of Country Size on Different Hazard Types (Administrative Unit Level).

| | All | c | D | E | F | L | v |
|---|---|---|---|---|---|---|---|
| Cyclone | −0.107** | −0.128** | | | | | |
| | (0.011) | (0.010) | | | | | |
| Drought | −0.046** | | −0.045** | | | | |
| | (0.007) | | (0.008) | | | | |
| Earthq. | −0.028* | | | −0.092** | | | |
| | (0.014) | | | (0.011) | | | |
| Flood | −0.062** | | | | −0.088** | | |
| | (0.007) | | | | (0.007) | | |
| Landslide | −0.029** | | | | | −0.091** | |
| | (0.012) | | | | | (0.010) | |
| Volcano | −0.055 | | | | | | −0.180** |
| | (0.037) | | | | | | (0.036) |
| Ln(C.Area) | 0.561** | 0.585** | 0.641** | 0.611** | 0.606** | 0.603** | 0.624** |
| | (0.015) | (0.015) | (0.015) | (0.015) | (0.014) | (0.015) | (0.015) |
| Constant | 3.431** | 2.645** | 1.653** | 2.039** | 2.360** | 2.181** | 1.804** |
| | (0.236) | (0.236) | (0.223) | (0.229) | (0.225) | (0.231) | (0.226) |
| Lambda | −0.002** | −0.002** | −0.001** | −0.001** | −0.002** | −0.001** | −0.002** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Obs. | 2,830 | 2,830 | 2,830 | 2,830 | 2,830 | 2,830 | 2,830 |

*Note*. Spatial regression with inverse distance weighting matrix, standard errors in parentheses. Dependent variable: log of administrative unit area in 2012.
Level of significance: **p* < .10, ***p* < .05

control for spatial dependence. We first estimated a model for each hazard separately. In the table, each coefficient that represents a direct relationship between the hazard variables and country size is negative and significant, supporting our hypothesis. One exception is the drought coefficient, which fails to reach statistical significance. We also estimate a statistically significant λ coefficient, which is an indication of spatial dependency. In line with our expectations, the negative λ indicates that country size is dependent on the sizes of neighboring countries negatively: As neighboring countries expand, a given country tends to become smaller. This is not surprising because fixed geographical space means that a country can only expand at the expense of its neighbors. In the last column of Table 1, we also report a model with all hazards included. Even though coefficients on four hazards are in the expected direction, only results for cyclones and landslides are significant. This is very likely due to a small sample size of this regression and high collinearity between the hazard variables.[20] Finally, we estimate models that restrict our analyses to observations with positive disaster risks. Our findings remain unaffected as Table A1 in the supplementary files shows.[21]

[20]For instance, the correlation between earthquakes and landslides is more than .8 in this sample. Similarly, volcanic and landslide hazards are moderately correlated at around .5.

[21]Although not reported here, we also generated two additional measures capturing each country's average and aggregate susceptibility to all six disasters by taking the mean and the sum of the six 10-scale hazard variables, respectively. When we use either of these measures in our spatial regressions of country size, it has a significant negative coefficient as in most of our existing results. For the average hazard measure, the coefficient is −.64 with a standard error of .12. For the aggregate measure, the coefficient is −.11 with a standard error of .02. For both regressions, the spatial lag parameter is negative and significant.

In our regressions, even though the relationship between environmental hazards and country size is predominantly negative and significant for almost all hazard types, because of the spatial lag, these estimated coefficients do not have the same straightforward substantive interpretation as coefficients in a linear regression. Due to spatial dependency across observations, all observations are determined simultaneously. In other words, a unit change in the value of an independent variable in an observation not only changes the dependent variable in that observation but affects the dependent variable in other observations in the sample as well. Therefore, to assess the substantive magnitude of these effects, we pick actual cases from our sample, hypothetically change their hazard proneness, and calculate the resulting change in the predicted country size for these cases.[22] We also calculate confidence intervals (CI) for the direct predicted effects. For the models reported in Table 1, we focus on Russia, Canada, and Australia—countries that are relatively large and less hazard prone than the average of the sample—and hypothetically increase their hazard proneness toward the sample mean across different hazard types.

Before we proceed, two cautionary remarks are in order. First, these simulation exercises do not assume that the hazard variables are the sole determinants of country size; instead, we report results of these simulations mainly to illustrate the substantive size of the estimated relationships. Second, the correct way to interpret these calculations is not to conclude that an increase in environmental hazards would immediately result in political disintegration of an existing country. Rather, our results suggest that, had the areas these countries currently occupy been more hazard prone historically, smaller countries would have emerged through long-term historical processes because some parts of these countries' populations would become more willing either to secede and form independent countries or join neighboring countries.

With these caveats in mind, our results indicate a 19% decrease in the sizes of Canada and Australia, with the confidence intervals for the direct effects given as (−13.75, −30.15) and (−13.56, −29.74) respectively, and a 20% reduction (CI: −14.01, −30.74) in Russia's size if the level of these three countries' cyclone vulnerability increased from their actual (low) levels to that of the United States. An increase in the risk of earthquakes up to the mean of the sample (that is, around Mexico's hazard level) would similarly imply that Canada would occupy territory that is 21% less (CI: −14.15, −31.68) than its actual current land area, and both Russia and Australia 20% less, with the CIs of (−13.77, −30.84) and (−14.02, −31.40) respectively. Setting the risk of floods at the sample mean (that is, close to Argentina's level) would again mean a decrease in Canada's size by 32% (CI: −15.27, −

[22]These predictions are based on the reduced form predictor, $(I - \lambda W)^{-1} X\beta$.

62.23), Russia's by 29% (CI: −13.49, −55.01), and Australia's by 28% (CI: −13.17, −53.70). Substantive effects of the landslides hazard variable are the largest (when evaluated with respect to the sample mean), based on our results: If landslides had been as prevalent in these three countries as they are in Romania, whose level is just above the sample mean, both Canada and Russia would be smaller by 34%, with the CIs of (−25.90, −58.01) and (−25.54, −57.18) respectively, and Australia by 35% (CI: −26.33, −58.96). Finally, had the level of volcano hazard been as high as that of Italy (that is, approximately the mean of the sample), the expected historical decline in territorial size would be 10% for all three countries, with the CIs of (−3.79, −16.36) for Russia, (−3.82, −16.51) for Canada, and (−3.82, −16.51) for Australia.

Even though the likelihood of many natural hazards such as earthquakes or volcanoes could be regarded as exogenous to political processes, we also control for several historical, political, and economic factors that could be related to country size. All of these control variables are lagged by one year. First, more affluent countries may be more efficient in public goods provision during times of disasters, in which case such countries would experience less severe secessionist tensions, according to our model. To account for this possibility, we include GDP per capita as a control variable. We also include a measure of democracy (we rely on the polity score) to control for the effect of more inclusive and responsive political institutions on country size. In addition, we control for a more direct measure of government capacity—relative political performance.[23] Table 2 shows that the relationships between the state capacity variable and GDP per capita on the one hand and country size on the other are not significant.[24] At the same time, democracy has a negative association with territorial size, and the result is statistically significant in most models. This result is consistent with our expectation of a negative additive effect of democracy on country size and suggests that, all else being equal, democratic regimes make it easier to secede. More importantly, after controlling for all these factors, the effects of disaster proneness remain largely unchanged in their substantive and statistical significance as covariates of country size.

[23]The RPR (or relative political reach) measure gauges the capacity of governments to mobilize populations under their control (Kugler and Tammen 2012). The data and manual are available at: Marina Arbetman-Rabinowitz; Ali Fisunoglu, Jacek Kugler, Mark Abdollahian, Kristin Johnson, Kyungkook Kang, Zining Yang. (2013) Replication Data for Relative Political Capacity Dataset. http://hdl.handle.net/1902.1/16845 Transresearch Consortium [Distributor] V4 [Version] http://thedata.harvard.edu/dvn/dv/rpc/faces/study/StudyPage.xhtml?globalId=hdl:1902.1/16845.

[24]Although not reported here, we also controlled for bureaucratic quality and corruption levels and found that they were not significantly related to country size. Note that Table 2 has a smaller sample size than Table 1: This is due to missing data in the control variables—GDP per capita, relative political capacity, and the Polity score. Based on two-sample *t*-tests, the missing countries in Table 2 do not appear to differ significantly from the remaining countries in most of the key variables, with the exception of cyclones and landslides hazards. The missing countries are slightly more prone to these disasters (with *t*-test *p* values of .01 and .04 respectively).

The period during which a country is formed could be another important determinant of its size. The acceptability and the difficulty of territorial expansion or secession could vary over time. Also, older countries have more time to develop their state capacity, which could be instrumental in preventing secessionist movements from succeeding in their struggle for independence. Thus, we expect the year of state formation to be negatively related to country size: That is, older states should be larger on average. We also consider an interactive effect: Older states might be able to deal with secessionist pressures more effectively due to their more developed state capacity, which could alleviate the impact of susceptibility to disasters. Table A5 of the supplementary files confirms both of these expectations: All hazards, except droughts, have significant coefficients in the expected direction, and the interaction terms (that is, the year of state formation interacted with each of the six hazards), except cyclones, are negative and significant, as expected. Moreover, to establish the relationships more clearly for countries that emerged most recently, we restricted the sample to countries that were created after 1945 in the analyses presented in Table A6. The effects of the hazards remain negative and significant, except for earthquakes and droughts.

We then test the robustness of the hypothesized relationship between environmental hazards and country size in the context of postcolonial African countries. Since many African country borders at independence coincided with colonial boundaries, the arbitrary nature of these postcolonial borders—coupled with weak central governments—could spur more frequent and successful border redrawing attempts, including secessionist movements. If this argument is correct, one would expect the effect of disaster proneness to be more prominent on the African continent. Beyond confirming the expected effects of individual hazards, our results presented in Table A7 indeed show that the effects are amplified for some hazards: When we interact an Africa dummy variable with each hazard, we find that the coefficient on the interaction term is in the expected direction and significant for landslides and volcanoes and only slightly below conventional levels of significance for earthquakes and droughts.[25]

Finally, we run additional tests to identify the existence of potential benefits from economies of scale that populations may receive when they live in a larger country and establish whether such benefits outweigh heterogeneity costs in certain types of countries. To conduct these tests, we rely on several variables. First, we add a dummy variable for durable democracies (that is, democratic regimes that have persisted since at least 1960) and

[25]While we do not have a prior theoretical explanation for the lack of significance for four out of six interaction terms, one possibility is that since these countries were only formed relatively recently as a result of decolonization, and territorial changes in our model are long-term processes, it is possible that the expected amplified effects of disaster proneness have not reached an equilibrium in this region yet.

interact this dummy with hazard variables. We find that the coefficients on the hazard variables remain negative and significant, except the coefficient on the droughts variable. The coefficient on the durable democracy variable remains negative, suggesting that durable democracy has a negative additive effect on country size when environmental hazards are not present. However, the coefficients fail to reach statistical significance. At the same time, the interaction terms have positive coefficients for all hazards, except floods, which indicates that democracy may indeed alleviate heterogeneity costs in disaster-prone countries, consistently with our expectation of a positive interactive effect of democracy and hazards on country size. Yet none of the coefficients on interaction terms are significant. The lack of statistical significance is likely due to the small number of stable democracies in the sample—just 22. Indeed, when we drop the stability requirement and make the comparison between all democracies and other regimes, coefficients on two of the interaction terms (for cyclones and droughts) become positive and significant, which lends some support for the expectation of a positive interactive effect of democracy on country size in disaster-prone areas. A similar test for durable dictatorships shows that interactive terms are negative for all hazards except volcanoes, and the interaction coefficient is significant for droughts. This result suggests that for these regimes, discrimination concerns are higher, and negative effects of hazards are amplified. If we compare all dictatorships (stable or more recent) and other regimes, all six hazard interaction terms are negative, and the interaction for droughts is again significant. Next, we rerun these interactive tests after replacing the democracy dummy with GDP per capita, a measure of bureaucratic quality, corruption, the level of democratic accountability, a measure of road quality, and an indicator of disaster risk management. As earlier, we expect to see that improvements on any of these political and economic dimensions would alleviate peripheral populations' concerns with respect to environmental hazards. In a majority of these specifications, interaction terms are positive, as expected, but fail to reach statistical significance. We provide data sources and all the results in the supplementary files (Tables A10–A19).

Next, we run similar tests at the administrative unit level. For each administrative unit in the year 2012, we calculate the average proneness to the six hazard types as well as the total area of each unit and estimate a SAR model using inverse distance weighting based on the distance between the geographical centers of different administrative units. Besides the hazard variables, we include the country size variable to allow for the possibility that larger countries could have larger administrative units on average. These results, reported in Table 3, once again confirm our hypothesis: Higher hazard levels have a statistically significant negative relationship with territorial size. We also find evidence of negative spatial dependence: As neighboring administrative units increase, a given unit tends to become smaller.

Table A2 in the supplementary files reports additional models that restrict our administrative-level analyses to observations with positive hazards; our findings remain unchanged.

## Conclusions

This article has argued and empirically demonstrated that susceptibility to natural disasters is an important factor for country size. The key mechanism that we proposed for this relationship is a combination of biased distribution of resources and deprivation resulting from sudden and severe environmental shocks. Costs generated by disasters are, on average, expected to be higher for citizens who are more distant from the political center of a country, and more frequent disasters increase such costs for the affected areas, making it less desirable for citizens in these areas to remain part of a larger country. Our empirical results show that a greater likelihood of environmental hazards is, in fact, negatively related to territorial size, as a result of expectations about the risk of future disasters and deprivations brought about by environmental shocks, as well as a deepening dissatisfaction with the central government.

The findings reported in this study contribute to our understanding of the process of country formation. While previous research examines socioeconomic and political determinants of country size, this study draws attention to the factor that is external to this process—that is, environmental shocks. This allows us to explore how forces of nature combine with social and political factors in restraining state expansion.

One of the key implications of this research is linked to the increasing number of adverse natural events as a result of climate change. The Emergency Events Database points to an increase in the frequency of disasters, in particular hydro-meteorological events, such as floods and droughts (Guha-Sapir, Below, and Hoyois 2015). Even if some of this increase is due to greater attention to this problem and better record keeping, there is a clear pattern suggesting that the number of disasters has significantly increased over time (see Figure A1 in the supplementary files).[26] At the same time, different regions of the world are not equally affected by environmental shocks: For instance, in 2012, Asia experienced more frequent disasters than any other region of the world (40.6% of all disasters).[27] Given this disaster frequency pattern, it is possible that people in the affected areas increase their expectations of the likelihood of future environmental shocks. The findings reported in our article suggest that, if such changes in expectations occur, they could contribute to pressures for border changes and could, in the long run, result in

[26] This map is based on EM-DAT information and is available at http://www.emdat.be/disaster_trends/index.html.
[27] See Guha-Sapir et al. (2015).

even smaller countries in the areas that are most vulnerable to such environmental hazards.

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