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Roads to Rule, Roads to Rebel: Relational State Capacity and Conflict in Africa

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Abstract

Weak state capacity is one of the most important explanations of civil conflict. Yet, current conceptualizations of state capacity typically focus only on the state while ignoring the relational nature of armed conflict. We argue that opportunities for conflict arise where relational state capacity is low, that is, where the state has less control over its subjects than its potential challengers. This occurs in ethnic groups that are poorly accessible from the state capital, but are internally highly interconnected. To test this argument, we digitize detailed African road maps and convert them into a road atlas akin to Google Maps. We measure the accessibility and internal connectedness of groups via travel times obtained from this atlas and simulate road networks for an instrumental variable design. Our findings suggest that low relational state capacity increases the risk of armed conflict in Africa.

Keywords

civil wars, state capacity, Africa, ethnic groups

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Introduction

Weak state capacity is a leading explanation of civil war. Scholars and policy-makers frequently argue that rebels fight where governments are too poor, incompetent, and distant to uphold their monopoly of violence (Fearon and Laitin 2003). Yet, despite its relevance in the literature, the empirical link between state capacity and conflict remains elusive. For one, existing studies often argue that conflict occurs in areas where states are weak. This perspective neglects that conflict is inherently relational. Whether the state can uphold its monopoly of violence also depends on whether local conditions facilitate non-state mobilization. Second, measuring subnational state capacity consistently across countries remains challenging. Third, state capacity may be endogenous to conflict, complicating statistical inference.

This paper addresses these points. We introduce a relational concept of state capacity and employ road network data to measure how well states can access their subjects, and how well subjects are interconnected among themselves. Focusing on opportunities for rebellion among ethnic groups in Africa, we show that state access reduces the risk of conflict, while groups' internal connectedness increases it. An instrumental variable analysis based on simulated road networks supports this result.

Our theoretical argument focuses on violent competition between the state and non-state actors over controlling local populations. We argue that opportunities for conflict arise where states are weak compared to potential challengers. Because physical access is a precondition for political control (e.g. Buhaug and Rød 2006; Raleigh and Hegre 2009; Tollefsen and Buhaug 2015), we operationalize this concept of "relational state capacity" with accessibility metrics computed from road network data. Following Herbst (2000), we argue that states' control is strongest in areas accessible from their capitals. However, roads can also help armed groups to mobilize and control local populations, increasing their ability to rebel. Combining these two arguments, we approximate relational state capacity as the difference between areas' accessibility from the capital and their internal connectedness. Because violent challengers of African states' often mobilize along ethnic lines, we assess the effect of relational state capacity on conflict within the settlement areas of ethnic groups.

We compute our road-based proxy of relational state capacity using historical road maps from Michelin, which we collect using an innovative and fully automatic machine learning algorithm. In particular, we train a fully convolutional neural network that classifies pixels of map scans and translate them into digital road network data in a replicable and efficient manner. We use these data to create a road atlas for Africa akin to Google Maps and measure ethnic groups' accessibility from the capital and their internal connectedness via traveling times. We then test the effect of relational state capacity on the number of armed non-state actors, and battles involving the state, rebel groups, and militias since 1997 (Raleigh et al. 2010).

Supporting our expectations, we observe more rebel groups and militias, more violence among these armed groups, and more violence between armed groups and the state in ethnic settlement areas with low relational state capacity. Our results suggest that decreasing states' access to ethnic groups by 10 percent, or increasing groups' internal connectedness by the same amount increases the number of armed groups and battles between them by 1.8 and 1.4 percent, respectively. The same change in relational state capacity is associated with an increase in the number of battles between government forces and armed groups by 1.3 percent. These results are robust to an extensive set of robustness checks, including accounts of alternative mechanisms such as economic market access or local economic development.

We use simulated road networks to implement a complementary instrumental variable strategy that addresses the potential endogeneity of road networks. Our simulated road networks are designed to maximize the connectivity between any two inhabitants of a country in back-projected data on population distributions. We derive our instrument as the accessibility metrics on the simulated networks and assume conditional exogeneity of the instrument after controlling for the endogenous simulation inputs. The resulting estimates support our baseline results.

In sum, the data support our argument that opportunities for challenges to state rule arise not just where states are weak, but where they are at risk of being outgoverned. Our findings thus highlight the dual role of road networks as tools for political mobilization and control. For states, building roads is literally a two-way street. It extends their ability to govern, but also provides their challengers with an infrastructure for mobilization.

Literature

Much of the contemporary discussion on state capacity and conflict is inspired by Fearon and Laitin (2003), who assert that civil wars are a consequence of weak statehood. Following their seminal contribution, scholars have refined the concept and measurement of state capacity. A first wave of research argues that conflict erupts where states lack the military and financial resources to uphold their monopoly of violence. While intuitive, the argument received mixed support from country-level evidence (Buhaug 2010; Walter 2006; Fjelde and De Soysa 2009; Hendrix 2010).

A second approach focuses on *social control*, states' ability to control their subjects through targeted incentives (Migdal 1988) and the state's *infrastructural power* to extend its rule to the entire populated territory (Mann 1984). Capable states can administer such incentives through, for example, a professionalized police force, bureaucracy, and a judicial system. Social control can prevent rebellion because it undermines mobilization. Individuals who believe that the state scrutinizes their behavior are less likely to join and more likely to denounce organizations that challenge state rule.

A widely used proxy of social control is the fraction of national economic output that states capture through taxation (Thies 2007, 2010; Fjelde and De Soysa 2009; Hendrix 2010; Buhaug 2010). Empirically, however, the relationship between states' tax ratios and civil war is inconclusive (Thies 2010; Fjelde and De Soysa 2009; Buhaug 2010). One likely reason is endogeneity (Thies 2010). The fear of rebellion may deter taxation, which would bias its estimated effects. Another drawback is that most tax data is measured at the country-level, while social control is inherently local: States may be strong in some parts of their territory, but weak in others (Buhaug and Rød 2006; Buhaug 2010; Tollefsen and Buhaug 2015).[1]

Adopting a spatially explicit logic, recent contributions advance new measures of local state capacity. Lee and Zhang (2017) construct a census-based measure of local "legibility," and Wig and Tollefsen (2016) derive the quality of local state institutions from survey data. However, the survey and census data they rely on are often not available for weak states. In a different approach, Koren and Sarbahi (2018) use nightlight luminosity to proxy state capacity but have difficulties to distinguish local state capacity from development.

Substituting for a direct measure, some studies proxy social control with physical *accessibility*. They find that areas that are difficult for states to reach—those far removed from the national capital or covered by mountains—are particularly prone to civil conflict (Buhaug and Rød 2006; Raleigh and Hegre 2009; Tollefsen and Buhaug 2015). Following this logic, the use of road network data to measure social control has gained traction with Herbst's (2000) pioneering work on the impact of transport infrastructure on state power. Analyses of the relation between local road densities and conflict in Africa yields mixed results. While Buhaug and Rød (2006) find that high densities come with less conflicts, Raleigh and Hegre (2009) report a positive association. Most recently, Rogall (forthcoming) finds that rainfall-induced inaccessibility of Rwandan villages curtailed Hutu militias' efforts to mobilize genocidaires. This finding that mirrors Zhukov's (2016) results on the positive association of local road networks with one-sided violence.

Despite considerable progress over the past decade, the literature on the effect of social control on political violence remains incomplete for at least three reasons. First and with the exception of Rogall (forthcoming), most accessibility measures do not appropriately account for the structure of transport networks.[2] While country-level aggregates obfuscate local variation, local road densities do not capture the costs of *reaching* an area. Reflecting these costs, we measure local accessibility as travel times on observed road networks.

Second, endogeneity afflicts estimates of the effects of road networks on conflict if past or anticipated violence affects road infrastructure. Rogall (forthcoming) relies on exogenous short-term variation in roads' quality, a strategy that disregards long-term effects of accessibility. We address endogeneity concerns and capture such long-term effects by using simulated road networks for our instrumental variable strategy.

Finally, recent studies overlook the relational nature of social control and accessibility.[3] Many scholars argue that rebellion erupts where low accessibility causes state weakness. In contrast, we argue that opportunities for conflict arise where actors that compete with the state have more social control than the state. Hence, conflict is likely in areas that are more accessible to such challengers than they are to the central government.

Theoretical Framework

In the following, we argue that opportunities for conflict arise in areas with low levels of relational state capacity (RSC) and motivate our accessibility-based measurement strategy. For the sake of conceptual clarity, we focus solely on the effect of RSC on *opportunities* for violent challenges to state rule while leaving potential interactions with challengers' *motivations* such as greed or grievances for future research to explore. Our use of the term "challenger" denotes armed actors that infringe on a government's monopoly of violence, in particular rebel groups and militias that compete for local power with the government and among themselves.

Social Control and the State's Monopoly of Violence

To enforce their nominal monopoly of violence, states need to be able to monitor their population and steer its behavior through targeted incentives. Both dimensions define the concept of social control. States with strong social control can enforce policies in the broadest sense and change the behavior of their subjects (Migdal 1988). States do so by gathering information about citizens' behavior and by using sticks and carrots that punish non-compliance and reward cooperation.[4]

Some states have amassed significant monitoring capacity and individual leverage. They have done so by building mechanisms of direct rule that deeply penetrate their societies, including official police forces, professionalized bureaucracies, and the monopolization of local public goods provision (Mann 1984; Tilly 1992; Weber 1977). By embedding their agents into local communities, strong states can monitor and steer individual behavior directly. By providing public services, they create dependencies that affect individuals' actions indirectly: citizens are hesitant to disobey if they receive government welfare, are employed in the public sector, or rely on public schools.

Such direct rule and the resulting social control allow states to avoid conflict and monopolize violence. Individuals that are monitored and can be punished by their state are more likelty to be deterred from joining or financing rebel organizations. In addition, even radical and undeterrable ideologues are unlikely to escape state forces and mobilize support. Civilians, including those who share insurgents' grievances, have to weigh the risk to their livelihoods against the greater cause with uncertain outcome (Lichbach 1994). Long highlighted by counterinsurgency strategists, there are few opportunities to challenge state rule where governments wield effective social control (Galula 1967; Kilcullen 2010).

Consequently, many scholars argue that African states' lack of social control causes their "security predicament" (Ayoob 1995, see also Migdal 1988; Herbst 2000). Most contemporary African states emerged from the European colonization of the continent, which often left administrations with very weak social control. Backed by imperial armies, colonial administrations were not designed to maximize control over their subjects, but to operate at minimal cost (Mamdani 1996). Many post-independence leaders thus inherited states that exercised social control around the capital, but not in their peripheries (Herbst 2000). Still today, many African governments exert little social control over remote areas, leaving opportunities for rebels to mobilize against state rule.

States' social control in general, and that of African states in particular, is closely affected by their ability to physically access their population. As highlighted by Herbst (2000), Buhaug and Rød (2006), and Raleigh and Hegre (2009), we can therefore use transport networks to derive empirical proxies for social control. Two arguments underpin this approach. First and in the long run, accessibility is a prerequisite for building and maintaining the institutions that exercise social control over distance (Herbst 2000). Political organizations that seek to monitor and steer the behavior of individuals must embed agents into local communities. High transport costs prohibit regular interaction with and control over these agents. Moreover, accessibility increases individual costs of disobedience by facilitating economic integration and the provision of public services. The parallel historical development of transport infrastructure and state institutions reflects this link between accessibility and effective state rule (Mann 1984; Tilly 1992; Weber 1977).

Second, accessibility affects social control in the short run because it determines governments' ability to militarily defend its rule. If local state rule is contested, maintaining social control requires deploying repressive and punitive resources. Their cost-effectiveness increases with physical accessibility.

Fragmented Social Control and Mobilization

We have so far argued that challenges to states' rule arise where they have little control over their population. This logic assumes that conflict emerges from a vacuum of social control left by a weak state. This view is incomplete, because state weakness does not necessarily imply an absence of social control. Instead and as highlighted by Migdal (1988), social control is frequently fragmented, residing with formal and informal institutions in communities that speak the same language, trade at the same markets, and follow the same customs. In other words, where states are weak, social control is often organized along ethnic lines. In difference to ideal-type direct state rule discussed above, ethnic groups rarely feature elites that preside over "proto-states" and sit atop neatly structured hierarchical organizations. Rather, they are oftentimes characterized by patronage networks of personal allegiance and protection.

Acknowledging that ethnic governance structures often coexist, compete with, or replace the state has important implications for our understanding of political violence. For one, the emergence of armed groups is more likely where ethnic governance institutions trump state control and allow successful challengers to govern their realm (e.g. Weinstein 2007; Mampilly 2011; Arjona 2014). If local ethnic leaders decide to defend or expand their power by force, their networks can secure civilian cooperation, a key requirement for successful insurgencies. Civilians will tend to cooperate with whatever party is able to credibly threaten to punish defection (Kalyvas 2006). Thus, dense and hierarchical social networks help challengers mobilize funds and fighters (Humphreys and Weinstein 2008; Larson and Lewis 2018; Parkinson 2013). As a result, opportunities to challenge state rule arise where the state has less social control than a potential challenger.

However, the emergence of an armed organization does not only raise the prospect of conflict with the state, but also that of conflict with other armed groups. Because formal and informal ethnic institutions are often decentralized and overlapping, multiple leaders can mobilize subsets of their co-ethnics in parallel. Absent a state capable of locally enforcing the peace, competition among local elites can quickly lead to violence between the groups they mobilize and command (Bates, Greif, and Singh 2002; Seymour 2014; Skaperdas 2002). Indeed, violence among armed groups is a common characteristic of many civil wars (Fjelde and Nilsson 2012).

Recent African history suggests not only that states have low levels of social control, but that social control has frequently been and still is fragmented. Upon European colonization, the continent featured a diverse set of political structures that ranged from complex empires to acephalous groups (Murdock 1959). With varying strategies of rule, colonial governments often invented or co-opted local notables as intermediaries in ethnically delimited constituencies (Mamdani 1996; Crowder 1964; Herbst 2000). Many "traditional," (pre)colonial governance institutions survived well into the postcolonial period: Baldwin and Holzinger (2019) indicate that about 83 percent of the population in Sub-Saharan Africa belongs to ethnic groups with some form of traditional institutions, as compared to a global average of 36 percent.

Postcolonial governments oftentimes followed strategies of cooptation and indirect rule to mitigate their lack of centralized power. To varying degrees, ethnic institutions and elites thus feature in constitutions (Holzinger et al. 2019), are relied upon by states to govern and provide public services (Baldwin 2016; Boone 2003), secure politician's electoral survival (Baldwin 2013; Koter 2013), and are co-opted into broad, clientelistic ruling coalitions (Arriola 2009; Francois, Rainer, and Trebbi 2015). These patterns of co-optation show the strength of ethnic institutions in weak states and highlight the fragmentation of social control. The latter has been an important driver of conflict because it creates *opportunities* for ethnic elites to violently defend or expand their power against local rivals and the state (Reno 1999). Co-optation of ethnic elites and institutions can mitigate conflict risks by addressing some *motives* of taking up arms (e.g., Cederman, Gleditsch, and Buhaug 2013; Mustasilta 2019). It does, however, not eradicate the structural opportunities for violent challenges to state rule where weak states confront strong ethnic elites.

Because social control is often fragmented, the link between social control and conflict hinges on not only the control exerted by the state but also that exerted by its potential challengers. What determines opportunities for rebellion is *relational state capacity* (RSC), the degree to which the state's control over its subjects outweighs that of ethnic governance institutions. Where RSC is low, local elites can mobilize against the state and each other, frequently taking up arms in the process.

This relational perspective has direct implications for the accessibility-based measurement of social control. Because the link between accessibility and social control is not restricted to the state but extends to any political and territorial organization, we argue that local ethnic elites are better able to control and mobilize their co-ethnics in areas with high levels of internal accessibility. Again, the underlying logic is two-fold. Over the long run, infrastructure that permits accessing members of an ethnic group facilitates the maintenance of effective non-state governance structures. In the short run, accessibility facilitates upholding control in times of conflict by coercive means, i.e. when competing over civilian cooperation against the state or other challengers (Zhukov 2012). In sum, these arguments suggest a relational measure: RSC is low in areas that are difficult to access for the state, but easy to access for local power holders, and vice-versa.

Observable Implications

Building on our theoretical argument, we derive three hypotheses on the effects of RSC on armed conflict in African states. Our first hypothesis concerns the general presence of armed non-state actors that challenge local state rule in the settlement areas of ethnic groups. As we have argued, where the state exercises little control over an ethnic group that is internally well connected, one or multiple challengers can mobilize recruits and resources with relative ease and violently compete for local power with the state and other armed groups.

> **Hypothesis 1:** More challengers to local state rule are active in ethnic settlement areas with low RSC.

In the following, we break up this hypothesis according to the challengers' main competitors with which they clash violently. As outlined above, ethnic groups that are internally well connected rarely feature a single, all-powerful node of social control. Instead, patronage structures will often allow multiple power centers to exert social control in parallel. Aiming to build, defend, and extend their realm, competition between these actors often takes a violent turn where the state is incapable of enforcing the peace (Fjelde and Nilsson 2012; Seymour 2014).

Hypothesis 2: Ethnic settlement areas with low RSC are more likely to experience conflict among challengers to local state rule.

While states are often unable to deter or repress the mobilization of local challengers in areas of low RSC, we do not expect states to withdraw from such regions without resistance. Instead, we expect that challengers who realize their opportunity for rebellion will violently clash with the state. This is for two reasons. First, while a low level of RSC implies state weakness, it may not come with the wholesale *absence* of local state institutions. The feeble tentacles of the state, for example district offices or military garrisons, will be prime targets of challengers who aim to expand their sphere of influence. Second and in response, the state will attempt to defend what is left of its integrity and contain the rebellion by sending military support. But, as we argue above, effective military intervention in areas of low RSC is hampered by logistical problems, suffers from a lack of local knowledge on rebel mobilization and support networks, and cannot draw on institutions with long-term leverage over the population (see also Fearon and Laitin 2003). Interventions are therefore unlikely to quell the rebellion, instead resulting in protracted conflict.

Hypothesis 3: Ethnic settlement areas with low RSC are more likely to experience conflict between local challengers and the state.

Data and Operationalization

As argued above, physical accessibility is a crucial determinant of the social control held by the state and its challengers. We therefore operationalize RSC using accessibility-based metrics computed via road networks for the settlement areas of ethnic groups. In particular, `state access` denotes the ability of the state to access an ethnic group, while groups' `internal connectedness` captures the degree to which transport networks allow for challenger mobilization by interconnecting group members. We operationalize `RSC` as the ratio between state access and internal connectedness. Hence, groups that are difficult to reach by the state but internally highly interconnected exhibit low RSC. We explain each metric in the following.

Because in Africa state power and resources are typically concentrated in the capital (Herbst 2000), we define `state access` as the ease of travel from a country's capital[5] to any given member of an ethnic group. This is computed as the inverse average travel time from the state's capital to ethnic group members:

$$\texttt{state access}_g = \left(\frac{1}{I_g}\sum_{i=1}^{I_g} 1 + time_{C,i}\right)^{-1}, \tag{1}$$

where I_g enumerates the members of group g and $time_{C,i}$ is the shortest-path traveling time from the capital C to the location of individual i. The inversion ensures that increases in travel times to the capital have a negative impact on the value of state access. Furthermore, the inversion mirrors the logic that the impact of one additional travel hour on governments' social control is decreasing in the absolute distance to the capital. All travel times start at a constant of 1 hour to avoid division-by-zero errors for groups with small territories centered in the capital.

Ethnic groups' `internal connectedness` captures the degree to which transport networks interconnect the members of a given group. Because ethnic governance institutions are often internally fragmented, we remain agnostic about the location of political leadership within an ethnic group and do not define a single ethnic power center. We thus compute internal connectedness as the inverse average travel time between any two group members:

$$\texttt{internal connectedness}_g = \left(\frac{1}{I_g^2} \sum_{i=1}^{I_g} \sum_{j=1}^{I_g} 1 + time_{i,j} \right)^{-1}. \tag{2}$$

Finally, we operationalize `RSC` by computing the ratio of state access to internal connectedness,

$$\texttt{RSC}_g = \frac{\texttt{state access}_g}{\texttt{internal connectedness}_g}. \tag{3}$$

To compute expressions 1 to 3 for the African continent[6] we require three types of data, namely ethnic settlement patterns, spatial population distributions, and information on road networks, the primary type of transport infrastructure in Africa (Herbst 2000, ch. 5). We obtain data on ethno-linguistic settlement areas from the Ethnologue dataset (Global Mapping International and SIL International 2015). Our analysis uses the Ethnologue data over alternative sources like the Atlas Narodov Mira (Weidmann, Rød, and Cederman 2010) and Murdock's (1967) Ethnographic Atlas because of its extensive coverage.[7] For demographic information we rely on the HYDE 3.1 dataset produced by Klein Goldewijk, Beusen, and Janssen (2010), who provide historical and contemporary gridded population data at high spatial resolution. The intersection of the spatial population grids with the ethnic polygons gives us the approximate location of individual group members I_g.

Finally, existing geo-coded road network data (CIESIN and ITOS 2013) are ill-suited for our purposes. The available cross-national road datasets focus on contemporary roads and are inconsistent across countries. Both complicates cross-country analyses of past outcomes. To circumvent these issues, we compile a new historical African road dataset by digitizing the Michelin map corpus. This collection of maps covers the entire African road network at a resolution of 1:4,000,000 and has been updated repeatedly since 1966. In our baseline analysis, we rely on the 1966 road data to maximize the temporal distance between the road-network "treatments" and conflict outcomes. This limits the potential for reverse causality bias. We furthermore use road network data from 1990 as a robustness test (online Appendix A4.3).[8]

To ensure replicability at low cost, we develop software that extracts road networks from scanned map sheets. More specifically, we refine and implement a fully convolutional neural network (FCNN), a deep-learning model designed for object detection in photographs (Shelhamer, Long, and Darrell 2017). Described in online Appendix A1, our custom FCNN serves as a road-recognition model that detects the presence and type of roads on the pixels of the map scans. We first train our FCNN on 2000 artificial and automatically generated maps. In a transfer-learning approach, we then refine this pre-trained model by training it on hand labeled parts of the original Michelin scans. A set of post-processing algorithms derives road network data from the classified maps by thinning and tracing pixel lines, filling small holes in the network that result from visual noise on the map scans (e.g., text labels), and smoothing road-quality information on each road segment to correct small classification errors by the FCNN.

In combination, the digitization procedure extracts Michelin's road-network information with human-level accuracy at a fraction of the cost. Over 98.8% of all extracted roads are present within a five kilometer radius on the Michelin maps, and 98.6% of all Michelin roads are extracted. The corresponding figures are somewhat lower if we account for road categories, but still 88.8 and 96.4, respectively. We note, however, that in those cases where the model misclassifies the road type, the error is typically small since roads of similar quality follow a similar symbology. Furthermore, most misclassified roads are very short stretches of roads that only marginally affect estimates of travel times.

Equipped with these new data, we build a digital road atlas akin to Google Maps and compute travel times between any two points on the African continent in 1966 and 1990. Underlying this atlas is a gridded, eight-connected network with a resolution of $.1667 \times .1667$ decimal degrees (ca. 18.5 km at the equator) onto which we superimpose the road network data as additional edges. Each road is assigned a travel speed estimate that is based on its quality indicated on the map.[9] For the eight-connected base network we assign a travel speed corresponding to travel on foot. Accordingly, we call these baseline edges "footpaths." Online Appendix A2 further describes the construction of road networks.

With these data, we compute all groups' state access, internal connectivity, and relational state capacity in 1966 and 1990.[10] Figure 1 illustrates the resulting estimates for the Democratic Republic of the Congo in 1966. Figure 1a shows that the road network is the densest in the country's eastern and western parts. However, the sparse roads in the center curb the capital Kinshasa's access to ethnic groups in the east and the north (Figure 1b). In contrast, the local road networks in the east result in high internal connectedness of ethnic groups (Figure 1c). RSC is therefore high in the west, intermediate in the north, and very low in the east (Figure 1d). Our traveling-time based operationalization of RSC thus accounts for the structure of the entire road network.

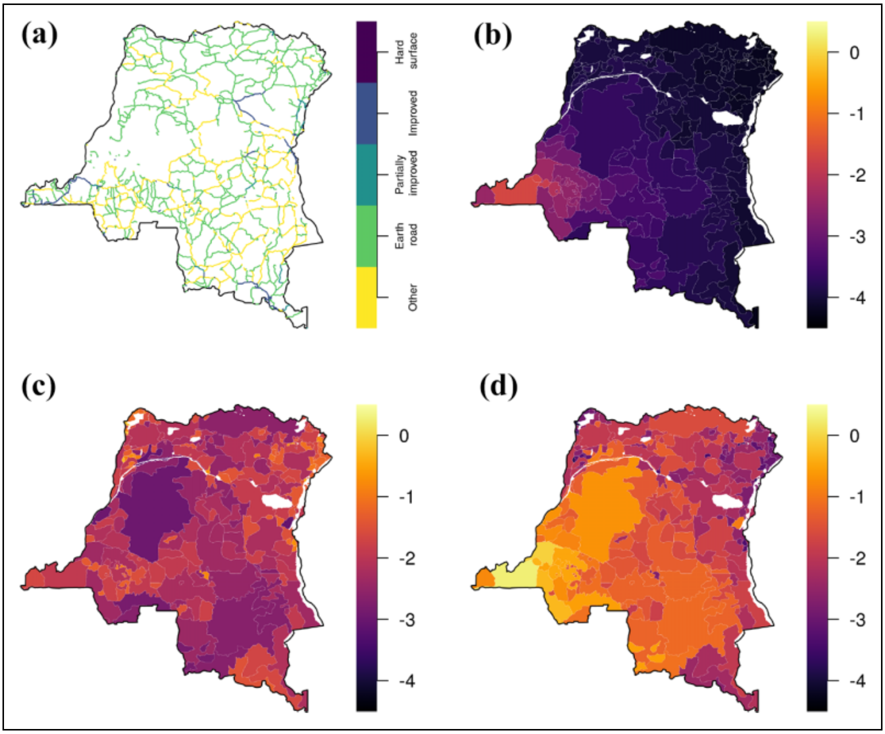

Figure 1. Measuring state access, internal connectedness, and relative state capacity in the Democratic Republic of the Congo 1966. Figures (b) to (d) are based on Equations 1 to 3; plotted values are logged. (a) Road network. (b) State access. (c) Internal connectedness. (d) Relational state capacity.

Throughout our empirical analyses, we employ a panel setup with group-years as units of analysis to account for moving borders and capitals.[11] To measure the three main outcomes of interest we employ the ACLED dataset (1997-2016; Raleigh et al. 2010), which provides the most extensive collection of geo-coded event data for Africa. To reflect Hypotheses 1-3, we encode for each group-year the number of:

1. *challengers*, defined as active rebel groups and ethnic or political militias,
2. *challenger events*, conflict events in which challengers fight against other challengers, and
3. *state events*, which denote conflict events in which the state fights directly with challengers.

We geographically encode these variables by counting unique armed actors and violent events in ethnic groups' settlement areas.[12] This geographic coding our dependent variables allows us to analyze the full set of African ethnic groups.

However, it comes at the risk of attributing armed actors and the violence they commit to ethnic groups from which they did not originate. This blurs our measures, especially where armed groups expand their radius.

We log-transform ($ln(y+1)$) our three outcome variables to account for their skewed distribution. In a robustness check in online Appendix A4.1, we separately analyze rebels groups and militias to account for militias allied with the state.[13] We also consider other functional forms, types of political violence, and data sources.

Empirical Strategy

In a first set of analyses, we test our hypotheses by estimating the impact of RSC measured in 1966 on conflict-related outcomes in the 1997-2016 period. This long temporal lag between treatment and outcome is used to minimize the risk of reverse causality, i.e, the risk of road networks reflecting anticipated future conflict.

We estimate linear models with country-year fixed effects. This setup effectively controls for all phenomena that are constant within country-years. To mitigate the risk of omitted variables at the group-level, we add two sets of controls. First, we control for $\texttt{state access}_g^{foot}$ and $\texttt{internal connectedness}_g^{foot}$. These variables are analogous to the ones defined in expressions 1 and 2, but calculated exclusively on the "footpath" network. Because travel speed on the foot network is fixed at 6km/h, these measures only reflect geodesic distances and do not contain any road network information. They thus capture the main non-road related determinants of state access and internal connectedness, in particular the population distribution in and shape of ethnic groups' settlement areas and their geodesic distance to the state's capital. These might have effects on conflict that are independent of the road networks. Including the two controls ensures that the measure of RSC calculated on the road network only captures the *increase* in state access and ethnic groups' internal connectedness caused by the road network.

Second, we include geographic controls that plausibly affect the presence of roads and conflict risk: groups' distance to the closest border, coastline, and navigable river, a dummy indicating whether a group's settlement area includes the capital, local resource wealth measured as a mineral deposit dummy (Schulz and Briskey 2005) as well as soils' suitability for general agriculture (Ramankutty et al. 2002) and cash crop production,[14] the local climate (mean temperature, precipitation, evapotranspiration), and the altitude and roughness of a group's settlement area (FAO 2015). We also control for groups' contemporary total population and urban population (CIESIN and ITOS 2013), as well as the size of their settlement area.[15] We add and subtract control variables in a robustness check (online Appendix A4.4). To account for error dependence, we cluster standard errors at the ethnic group and country-year levels.

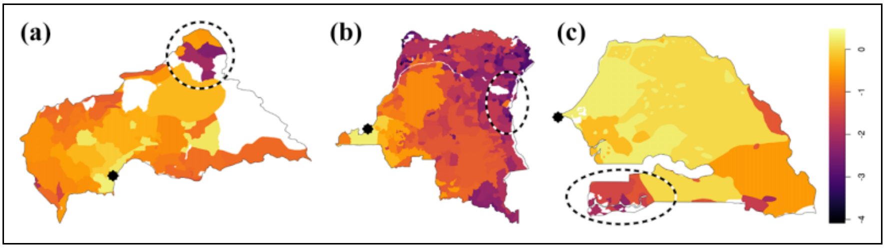

Figure 2. RSC (logged) in three African countries, based on expression 3. Highlighted regions are discussed in the text. (a) Central African Republic. (b) Democratic Republic of the Congo. (c) Senegal.

Results

Before turning to the quantitative results, we briefly highlight three cases that, while certainly more complex than depicted here, underline the face validity of our argument: the Central African Republic, the Democratic Republic of the Congo, and Senegal. Figure 2 depicts the distribution of RSC within these countries. Dark shades indicate ethnic groups with low levels of RSC, many of which experienced violent challenges to state power in the recent past.

In the Central African Republic, RSC is lowest in the northern region Vakaga from where the Seleka rebels toppled the government in 2013. Cut off from the capital during the rainy season but internally interconnected, Vakaga is outside the government's reach, and its inhabitants rarely use the national language and currency (International Crisis Group 2007, 2015). In the DRC, we find that RSC is up to 350% higher among groups located in the west of the country compared to those in the Eastern Kivu region. In line with our argument, civil wars have raged in the Kivus for years. Many areas are ruled and competed over by militias and rebel groups rather than the state (Sanchez de la Sierra 2020). In the nominally much stronger Senegal, the Casamance constitutes another area that features low levels of RSC and long-lasting conflict. As in the eastern part of the DRC, rebel groups in the Casamance have established governance structures that compete with the state and tax the local population—activities facilitated by their comparatively high levels of social control (Humphreys and ag Mohamed 2005; Evans 2004).

Turning to the statistical analysis, Table 1 presents estimates of the effects of ethnic groups' state access and internal connectedness on the three main outcomes.[16] In line with our hypotheses, higher levels of `state access` are associated with fewer challengers (Model 1), less violence among them (Model 2), and less fighting between them and government forces (Model 3). Conversely, `internal connectedness` is associated with more challengers and conflict events. Across the three models, the two coefficients are precisely estimated and

Table 1. Effect of the Components of RSC, OLS.

	Dependent variable (logged)		
	Challengers (1)	Challenger Events (2)	State Events (3)
β_1: State access '66 (log)	−0.157***	−0.111**	−0.138***
	(0.038)	(0.044)	(0.046)
β_2: Internal connectedness '66 (log)	0.186***	0.161***	0.133***
	(0.036)	(0.041)	(0.035)
State access; foot '66 (log)	0.036	−0.006	0.011
	(0.029)	(0.035)	(0.033)
Internal connectedness '66; foot (log)	−0.130***	−0.117***	−0.103***
	(0.030)	(0.034)	(0.030)
$\beta_1 + \beta_2$	0.03	0.05	0
	(0.04)	(0.05)	(0.04)
Country-year FE:	yes	yes	yes
Controls:	yes	yes	yes
Mean DV	0.21	0.17	0.15
F-Stat:	22.83	20.33	15.99
Observations	31,760	31,760	31,760
Adjusted R^2	0.399	0.370	0.313

Note: OLS models. Control variables consist of the total and urban population (log), groups' area (log), the mean annual temperature, precipitation, evaporation, the ratio of precipitation and evaporation, the mean altitude and slope of a group's settlement area, its cash crop and agricultural suitability, a mineral deposit dummy, as well as groups' logged distance to the closest coast, navigable river, and border. Two-way clustered standard errors in parentheses (ethnic group and country-year clusters). Significance codes: *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

have opposite effects. Because the difference between the estimates' absolute values is not significantly different from zero, we can substitute them with logged RSC (see Expression 3) without much loss of information.[17]

Table 2 summarizes the results based on the combined RSC metric. Consistent with the previous results, higher levels of RSC are associated with fewer challengers, less conflict among them, and less fighting between challengers and the state. In substantive terms, the coefficients of RSC are sizable, precisely estimated, and similar across the three outcomes. The models associate a 10% decrease of RSC with an increase in the number of violent challengers and events by between 1.4 and 1.8 percent.[18] Returning to DR Congo, the estimates suggest that the 350% increase in RSC when traveling from the Kivus in the east to Kinshasa in the west comes with a decrease in the number of challengers by 60 percent. Along the same route, the predicted number of violent events drops by 50 percent.

Table 2. Relational State Capacity and Violence in Africa 1997 to 2016: Main Results, OLS.

	Dependent variable (logged)		
	Challengers (1)	Challenger Events (2)	State Events (3)
RSC 1966 (log)	−0.174***	−0.141***	−0.135***
	(0.032)	(0.036)	(0.033)
State access 1966; foot (log)	0.048*	0.015	0.009
	(0.026)	(0.031)	(0.027)
Internal connectedness 1966; foot (log)	−0.122***	−0.103***	−0.104***
	(0.029)	(0.032)	(0.030)
Country-year FE:	yes	yes	yes
Controls:	yes	yes	yes
Mean DV	0.21	0.17	0.15
F-Stat:	22.84	20.33	16.01
Observations	31,760	31,760	31,760
Adjusted R^2	0.398	0.370	0.313

Note: OLS models. Control variables as described in Table 1. Two-way clustered standard errors in parentheses (ethnic group and country-year clusters). Significance codes: *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

Robustness Checks

We implement a series of robustness checks, discussed in full detail in online Appendix A4. We first alter our dependent variables and the functional form of the estimated models. A disaggregation of the composite of "challengers" into rebel groups and militias shows that RSC has a similar effect on the number and violence committed by both actor types (online Appendix A4.1). Taking event dummies and fatalities instead of counts as outcomes, and using UCDP GED (Sundberg and Melander 2013) and SCAD (Salehyan et al. 2012) as alternative data sets yields substantively equivalent estimates (online Appendix A4.1). The same applies when we estimate logistic or negative binomial instead of linear models (online Appendix A4.2).

Additionally, the baseline results hold when we employ the 1990 road network data (online Appendix A4.3). They are also robust to either dropping all control variables or expanding them, including precolonial and geographic characteristics of ethnic settlement areas (online Appendix A4.4). Adding fixed effects for 10'000 "bins" of ethnic groups of the same country and a similar geographic distance to the capital, distance between inhabitants, and population size produces equally consistent results (online Appendix A4.4). Dropping groups that are very small or cross national borders (online Appendix A4.5), using different ethnic settlement data (online Appendix A4.6), and conducting a country-by-country jackknife does not significantly change the results either (online Appendix A4.7). Finally, cross-sectional analyses show that the results are not due to our panel setup or potentially endogenous movements of borders and capitals since independence (online Appendix A4.8).

Beyond the caveats addressed above, a mechanism other than states' and challengers' social control may explain the relationship between our road-based proxy of RSC and conflict. First, roads connect markets, foster growth and economic development, and may thereby bring peace and stability. We capture this mechanism by controlling for nightlight emissions and the quality-weighted density of roads in ethnic groups' settlement areas. Second, roads to the capital may capture generally higher levels of connectedness of an ethnic group with the entirety of its country. The resulting strength of inter-ethnic ties might curb the risk of rebellion. We address this alternative explanation by controlling for the average population-weighted travel time between an ethnic group and the rest of the country. Controlling for these two alternative mechanisms barely reduces the size of the estimated effect of RSC (online Appendix A4.9).

Instrumental Variable Approach

We complement our robustness checks with an instrumental variable (IV) strategy that addresses potential omitted variable biases not captured by the previous tests. In particular, there might be hitherto unmeasured group-level characteristics that have affected colonial road building and recent conflict. To address such endogeneity as well as potential systematic measurement bias in the Michelin maps, our IV approach exploits variation from road networks simulated on the basis of countries' population distribution. Our IV approach improves identification by isolating the component of RSC that is due to the spatial population distribution within a country. While population distributions are less malleable than road networks, populations are not randomly distributed. We must therefore rely on the assumption that the population distributions that produce our simulated road networks are conditionally exogenous to conflict. We address potential violations of this assumption below.

Simulating an Instrument for Road Networks

We simulate "optimal" road networks that minimize the average traveling time between the inhabitants of every country in our sample. We then recompute the state access and internal connectedness metrics on the simulated networks and use these variables as instruments for the observed measure of RSC. Focused on the spatial structure of road networks, our approach differs from previous IV-strategies that simulate the location of roads based on least-cost-paths between a fixed set of nodes in a network (Faber 2014; Voigtländer and Voth 2014; Jedwab, Kerby, and Moradi 2017). While these strategies identify variation in the precise location of roads, their reliance on observed network nodes condition on the presence of a road

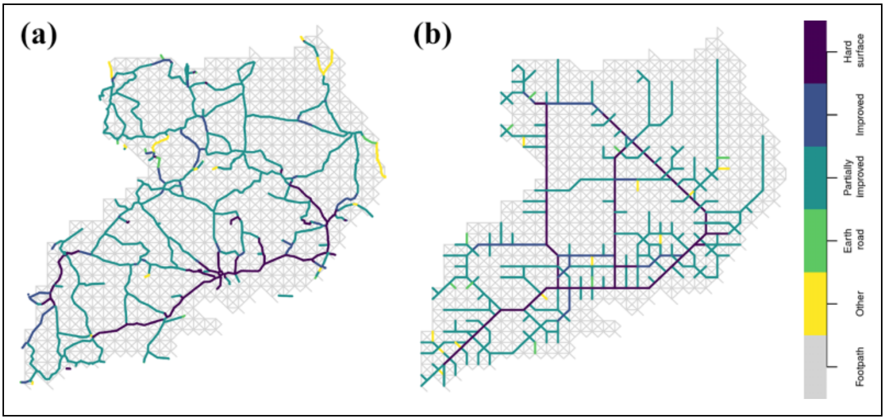

Figure 3. Observed and simulated road network in Uganda, 1966. (a) Observed network. (b) Simulated network.

between nodes, which leaves the overall structure of networks fixed and makes them unsuited for instrumenting RSC.

Our road-building algorithm is based on a country's total type-specific (highways, dirt roads, etc.) road mileage in 1966[19] and its spatial population distribution as estimated for the year 1880 from the HYDE 3.1 database (Klein Goldewijk, Beusen, and Janssen 2010). Substituting for ideally used but non-existent historical data, these population data are estimated based on time-varying subnational census data coupled with national-level projections and other geospatial measures, in particular local soil productivity, distance to water, as well as land cover and population count data from 2000. For 42 percent of our sample used in a robustness check, HYDE estimates are based on pre-1960 subnational census data, before we observe the first Michelin map. Below, we discuss our strategies to address implications of the HYDE data for the exclusion restriction.

The simulation algorithm described in online Appendix A5 heuristically places road segments such that they minimize inter-citizen travel times, for example by placing better-quality roads between population hotspots. To limit computational costs, the spatial coarseness of simulated road networks' resolution increases with countries' size. While real-world road building is more complex than minimizing inter-citizen traveling times, our simulated networks are fairly realistic. As demonstrated for Uganda in Figure 3, the algorithm places the highest-quality roads between the most populated areas in the southwest, center, and southeast of the country. As in the observed network, the algorithm also produces trunk- and feeder-roads of main roads.

Empirical Strategy

Because we base the simulation of our instrument on the back-projected HYDE population estimates, we have to assume that the observed spatial population distribution is, conditional on covariates, exogenous to post-1990 conflict and thus satisfies the exclusion restriction. We account for four potential violations of this assumption. First, we directly control for the estimated 1880 population count of ethnic groups, thus capturing that long-term peace may have increased groups' population and their internal connectedness. Second, we control for the footpath-based versions of `state access` and `internal connectedness` based on the 1880 population distribution. These variables account for groups' internal population distribution and distance to the capital. Both characteristics may bias our instrument if the HYDE data picks up conflicts' effects on population distributions. Third, we add the geographic controls from the baseline analysis to account for factors that affect local population density as well as conflict in the long run. Fourth, we estimate robustness checks comparing (1) observations for which the HYDE data draws on pre-1960 subnational census data with those for which it does not and (2) between countries for which we simulate roads at different levels of spatial coarseness. Samples with early input data to HYDE or a coarser network simulation likely exhibit less reverse causality bias from the HYDE data. Providing evidence against the existence of strong biases, results in these subsamples are consistent with the main results (online Appendix A6.2 and A6.3).

Together, our empirical strategy intends to ensure that our instrument isolates variation in road networks that is caused by non-local effects of countries' population distribution. For example, the instrument leverages the difference in RSC between two ethnic groups with a similar population size and distance to the capital, one crossed by an "optimal" road that connects two population clusters elsewhere in the country while the other is located off that road. We implement this matching-like logic in a robustness check by constructing 10'000 "bins" of ethnic groups in the same country-year with a similar (1) estimated 1880 population size, (2) geodesic distance to the capital, and (3) geodesic distance between 1880 inhabitants. Exploiting only variation in instrumented RSC within these bins of similar ethnic groups produces consistent results (online Appendix A4.4).

Our IV strategy thus leverages variation in ethnic groups' connectedness that is caused by groups' positioning vis-à-vis the spatial population distribution. The latter determines the overall structure of the road network and thereby affects groups' RSC. Our interpretation of the estimates assumes that, once we account for the controls discussed above and country-year fixed effects, simulated RSC is conditionally exogenous to conflict and only affects conflict through variation in observed RSC. Inherently unable to empirically confirm these two assumptions, we note that our empirical strategy may be unsuccessful in capturing all biases from the contemporary inputs to the HYDE population data that we use to simulate road networks.

However, the IV approach reduces the scope for potential endogeneity since we move from assuming conditional exogeneity of road networks to assuming conditional exogeneity of population distributions, with the latter being stickier and less policy-dependent than roads.

Results

Estimating 2SLS-IV models, we now measure observed RSC based on the 1990 roads data. Assuming that our instrument is valid, we no longer need to rely on historical road network data. Coming with a strong first stage, the IV results support Hypotheses 1 and 2 that low levels of RSC facilitate the emergence of challengers and lead to violent competition between them. The results also indicate that these dynamics come with more violence between challengers and state forces (Hypothesis 3). While such fighting decreases with instrumented RSC, this result is not stable across all robustness checks and mainly driven by the state access component of RSC.

In the upper panel of Table 3, we present the reduced form estimates. As expected, states' access to ethnic groups on the simulated network relates negatively and statistically significantly to the number of challengers, fighting between them, and battles between challengers and state forces ($p = .057$). Conversely, the simulated internal connectedness of ethnic groups has a positive effect on the number of challengers and fighting between them. However, the measure's estimated effect on battles between challengers and the state is neither significant nor large. With this exception, the effects are precisely estimated and coincide with our baseline results. The consistent negative association of simulated state access with conflict supports Herbst's (2000) argument that states' ability to penetrate peripheral areas is a crucial factor of contemporary political development and conflict in Africa.

The explanatory power of our two instruments in the first stage is high, yielding a F-statistic of 62.[20] As expected, `state access`^{sim} has a positive effect on RSC, while `internal connectedness`^{sim} impacts the measure negatively. Both coefficients are statistically significant.

The second stage estimates in the lower panel of Table 3 suggest substantive effects of RSC on the number of challengers, violence among them, and violence between them and the state. The coefficients for instrumented RSC in 1990 are statistically significant and larger than the baseline estimates for the first two outcomes. In substantive terms, the IV-estimates suggest that decreasing RSC in 1990 by 10 percent increases the number of local challengers by approximately 3.7 and violent events between them by 2.7 percent. The same decrease in RSC raises the number of battles between challengers and the state by 1.3 percent, an estimate that is similar in size than the baseline result but associated with more uncertainty ($p = .066$). Estimating effects of `state access` and `internal connectedness` instrumented separately confirms

Table 3. Relational State Capacity and Violence in Africa 1997 to 2016: Main Results, 2SLS.

	First Stage	Reduced form		
	RSC 1990 (1)	Challengers (2)	Challenger events (3)	State events (4)
State access 1880 (sim; log)	0.645***	−0.221***	−0.155***	−0.090*
	(0.063)	(0.046)	(0.052)	(0.047)
Internal connectedness 1880 (sim; log)	−0.262***	0.123***	0.098***	0.023
	(0.032)	(0.028)	(0.030)	(0.028)
State access 1880; foot (log)	0.261***	0.062**	0.012	−0.029
	(0.040)	(0.030)	(0.036)	(0.032)
Internal connectedness 1880; foot (log)	−0.210***	−0.054**	−0.032	−0.002
	(0.030)	(0.027)	(0.030)	(0.026)
		Two-stage least squares		
RSC 1990 (log)		−0.370***	−0.269***	−0.128*
		(0.077)	(0.081)	(0.070)
State access 1880; foot (log)		0.168***	0.092*	0.0002
		(0.051)	(0.056)	(0.048)
Internal connectedness 1880; foot (log)		−0.113***	−0.069*	-0.037
		(0.036)	(0.039)	(0.032)
Country-year FE:	yes	yes	yes	yes
Controls:	yes	yes	yes	yes
Mean DV	−1.11	0.21	0.17	0.15
SLS F-Stat:		21.18	19.38	15.49
SLS F-Stat Stage 1:		61.99	61.99	61.99
Observations	31,280	31,280	31,280	31,280
Adjusted R^2	0.891	0.371	0.356	0.307

Note: 2SLS-IV models. Control variables as described in Table 1. Two-way clustered standard errors in parentheses (ethnic group and country-year clusters). Significance codes: *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

that the association of RSC with state-challenger battles is mainly driven by states' access to ethnic groups (online Appendix A6.4).

The results are robust to a number of robustness checks that follow those presented above (online Appendix A4). In particular, and directly related to the potential violations of the exclusion restriction discussed above, the results are robust to only comparing ethnic groups in the same country with a similar population size, geodesic distance to capital and distance between their inhabitants. In coincidence with the results in Table 3, the effect of RSC on the number of fatalities in battles between the state and its challengers is estimated less robustly in some robustness checks.

Taken together, these results further support Hypotheses 1 and 2 that low levels of RSC allow rebels and militias to mobilize and compete violently over local power. The IV-estimates yield more mixed support for Hypothesis 3 that states fight with their challengers more often in ethnic groups with low levels of RSC.

Conclusion

The civil war literature highlights state weakness as a central conflict determinant. While shifting the theoretical focus to structural properties of the state, Fearon and Laitin (2003) leave the interaction between governments and non-state actors mostly implicit. Subsequent work has proposed better country-level proxies for state capacity and turned to the local level, without however fully capturing the state-society nexus that is at the heart of conflict processes.

In order to address this gap, we have proposed a relational theory of state capacity and conflict that builds on Mann (1984) and Migdal (1988), as well as Herbst's (2000) previous work on road networks in Africa. We argue that we can better understand conflict processes when we consider state weakness in relation to the social control maintained by non-state actors that compete for power among themselves and with the state. Road networks, which we use to proxy for social control, do not merely serve as radial power projectors of the central government, but also constitute the backbone of challengers' attempts to exert control. For each kilometer of roads paved, and by extension, for each radio station, cell phone tower, or internet cable built, the state may provide competitors with the tools to outgovern it.

We have found empirical support for this dual perspective on governance. Focusing on ethnic groups in Africa, we have measured relational state capacity (RSC) as the difference between groups' accessibility from the capital and their internal connectedness. Our baseline analysis suggests that RSC decreases the number of challengers to state power, the risk of political violence among them, and between them and state forces. We address potential endogeneity biases through an instrumental variable approach based on simulated networks. The results further support the baseline estimates, with the exception of the effect of RSC on the number of battles fought between the state and its challengers, which is positive in the main IV specification but not robust in some sensitivity analyses.

There are good reasons to believe that these results generalize beyond Africa. For example, Scott (2009) highlights similar dynamics in his work on how state penetration in Southeast Asia forced ethnic groups to flee into inaccessible terrain where they eventually mobilized against the state. Historically, Hechter's (1975) account of "internal colonialism" and Weber's (1977) analysis of French nation building illustrate the pivotal role of roads for extending states' social control. The problem of dual technologies of social control is also not limited to road networks. In recent work, Gohdes (2020) highlights that the internet sets off a similar dynamic than we have emphasized here: it improves rulers' ability to target rebels, but also allows rebels to mobilize.

Moving forward, our argument about the opportunity-driven effect of relational state capacity on violent conflict needs to be extended to encompass the motives of the state and its violent challengers. Under what conditions will states choose to fight peripheral rebels? And when does extending RSC, necessarily at the expense of local actors, affect their readiness to take up arms in defense of their realm? This question is of particular importance, since extending states' social control does not necessarily imply inclusive rule and good governance, but may instead lead to repression and exclusion. In that regard, the different strands of the literature on the motivations for armed conflict can offer a good starting point to explore how RSC can be increased without causing violent backlash.

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Supplemental Material

Supplemental material for this article is available online.

Notes

1. But see Harbers (2015), who uses subnational tax data from Ecuador.
2. Also see Tollefsen and Buhaug (2015), who account for accessibility from major towns. Hammond (2018) and Toft and Zhukov (2012) model conflict strategies on transport networks.
3. Dargent, Feldmann, and Luna (2017) conceptualize state capacity as relational, but do not study its relationship with organized violence.
4. We here abstract from nationalism and other ideologies that facilitate state rule through indoctrination and ideological persuasion.
5. We focus on capitals and not regional capitals or military bases for two reasons. First, we lack data on the location and relative importance of such outposts. Second, even if such information was available, employing it may not be advisable because peripheral, mutinying state agents sometimes challenge the state.
6. Due to limited road data, we drop Madagascar and all African islands from the sample.
7. See online Appendix A4.6 for results based on these alternative datasets.

8. Contemporaneous road data can create reverse causality bias if conflicts before 1990 have destroyed the road networks and caused conflict after 1990.
9. With our focus on group-years, we abstract from seasonal variation in road quality.
10. We use population data from either 1960 or 1990, depending on the timing of the road network data.
11. For cross-sectional robustness checks, see online Appendix A4.8.
12. All variables are coded from ACLED's interaction codes.
13. Unfortunately, we possess no data on such alliances.
14. Computed as the maximum suitability for eight cash crops: cotton, coffee, cocoa, groundnuts, oil palms, sugarcane, tea, or tobacco (FAO 2015).
15. Online Appendix A3 contains presents the correlations between covariates and RSC.
16. We log all RSC-related variables to account for decreasing marginal effects of accessibility and connectedness.
17. Note that Equation 3 implies: $ln(\texttt{RSC}_g) = ln(\texttt{state access}_g) - ln(\texttt{internal connectedness}_g)$.
18. Percentages are approximate because we added a unit constant before the log-transforming the outcomes. For low outcome values, actual effects are larger.
19. This ensures that simulated and observed networks' length and composition are equivalent. Results are robust to using 1990 road mileages (online Appendix A4.3). We prefer the data from 1966 because conflict patters might have affected 1990 road networks' extent.
20. We can reject the weak instrument null under a maximum size of 10% of a 5% Wald test of $\beta_{RSC} = 0$ (Stock and Yogo 2005, 101).

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