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Ecology, trade and states in pre-colonial Africa

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ECOLOGY, TRADE AND STATES IN PRE-COLONIAL AFRICA

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ABSTRACT. State capacity matters for growth. I test Bates' explanation of pre-colonial African states. He argues that trade across ecological boundaries promoted states. I find that African societies in ecologically diverse environments had more centralized states. This is robust to reverse causation, omitted heterogeneity, and alternative interpretations of the link between diversity and states. Ecological diversity also predicts states outside of Africa. I test mechanisms connecting trade to states, and find that trade supported class stratification between rulers and ruled. I underscore the importance of ethnic institutions and inform our knowledge of the effects of geography and trade on institutions.

1. INTRODUCTION

States that can collect taxes, protect property, and sustain markets matter for development. State capacity positively predicts economic growth (Rauch and Evans, 2000). Many variables that explain cross-country income differences require a state strong enough to provide them. These include social infrastructure (Hall and Jones, 1999), institutional quality (Acemoglu et al., 2001), and investor protection (La Porta et al., 2000). Weak states under-invest in public goods (Acemoglu, 2005). It is not only modern states that matter; state antiquity predicts economic growth, political stability, and institutional quality in the present day (Bockstette et al., 2002). The determinants of state capacity, then, are important components of modern growth.

In this paper, I test a "Ricardian" theory of states in sub-Saharan Africa originally presented by Bates (1983). Building on earlier views,[1] he argues that long-distance trade gave rise to states in Africa. His model is verbal:

> [T]he contribution of the state is to provide order and peace and thereby to render production and exchange possible for members of society. The origins of the state, then, lie in the welfare gains that can be reaped through the promotion of markets.

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[1]See Bisson (1982), Oliver and Fage (1962), and Vansina (1966), for example.

He suggests that gains from trade are greatest where products from one ecological zone can be traded for products from another. It is near ecological boundaries, then, that we should expect to see states. To support his view, he takes 34 pre-colonial African societies, and shows that the proportion of societies with central monarchs is greater on an ecological boundary.[2]

Bates' view has been overlooked because his small sample and lack of controls prevent him from making a credible econometric argument that this correlation is causal. In this paper, I use ethnographic and geographic data to overcome this limitation. I merge data on state centralization for 440 ethnic groups in pre-colonial sub-Saharan Africa with a map of African ecological zones. I use ethnic-level ecological diversity to proxy for the gains from trade. I show that ecological diversity is strongly related to the presence of pre-colonial states. For example, within the societies classified as "Equatorial Bantu," the Luba score .69 on the diversity index and 3 out of 4 on the centralization index. The Kela and Ndonko, by contrast, have no diversity and no centralization. On the "Guinea Coast," the Yoruba score 3 on centralization and .58 on diversity, while the Yako score zero on both.

I show that this result is robust. I use spatial variation in rainfall to control for possible reverse causation. The result survives additional controls, checks for unobserved heterogeneity, alternative estimation strategies, removing influential observations, and alternative measures of trade and states. I show that the "Ricardian" view better explains the relationship between states and diverse ecology than six alternative interpretations. These are: first, larger territories are more diverse and require more levels of administration; second, societies that independently develop states conquer trading regions; third, dense population in diverse regions explains statehood; fourth, defense of "islands" of land quality accounts for states; fifth, the diversity of available economic activities creates states, and; sixth, competition between ethnic groups in more diverse areas leads to state formation. I rule out these alternative explanations by controlling for these mechanisms directly, by re-estimating the results using artificial countries of a uniform shape and size as the unit of observation, and by presenting narrative evidence from the most influential observations in the data.

Unlike Bates, I am agnostic about whether it is long-distance or local trade that matters most to state formation, and about whether trade gives rise to states by increasing the returns to investment in public goods, by cheapening the cost of extending authority over space, or by making rulers more effective in public goods provision. The public goods provided by states can lower the costs of both inter-state and intra-state trade. In the appendix, I present a simple model of the mechanisms by which trade may lead to state centralization. I find that class stratification is the channel best supported by the data, though trade is associated with a wide range of state functions. No one type of trade emerges as most important.

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[2]I present a condensed version of his results in the web appendix.

Although I focus on Africa, I show that the relationship between diversity and states holds outside of Africa. While many historians of Europe link states to the growth of markets (e.g. Jones (1981)), historians of Africa put particular emphasis on trade (Bates, 1983). The importance of ecologically-driven trade in Africa is well documented in the historical literature (e.g. Lovejoy and Baier (1975)). There is also particular institutional continuity in Africa. Traditional authorities were often coopted by colonial states, and their successors possess significant powers today (Acemoglu et al., 2012; Mamdani, 1996). The historical territories of ethnic groups can be measured with more precision in Africa than in many other areas. It is in Africa that empirical studies have established the importance of "ethnic" institutions.

My results contribute to our understanding of the importance of ethnic institutions, of the origins of institutions, and of the relationship between trade and institutional quality.

Institutions predating modern nation states matter for income today. These include forms of colonial rule, land tenure, and forced labor (Banerjee and Iyer, 2005; Dell, 2010; Iyer, 2010). In particular, "ethnic" institutions shape modern development. These are especially important for Africa. Michalopoulos and Papaioannou (2012) show that pre-colonial African states better explain economic activity today than several measures of national institutions. African countries that possessed more centralized states prior to colonial rule have greater levels of public goods provision today (Gennaioli and Rainer, 2007). The congruence of modern African states with those that preceded colonial rule benefits governance today (Acemoglu et al., 2003; Englebert, 2000).

States are not the only ethnic institution that matters. Local institutions of property rights and polygamy pass smoothly over modern borders (Bubb, 2009; Fenske, 2011a), and affect Africans' investment incentives (Goldstein and Udry, 2008; Tertilt, 2005). Social sanctions within ethnic communities help overcome collective action problems (Glennerster et al., 2010; Miguel and Gugerty, 2005). The origins of these ethnic institutions have gone largely unexplored in the literature. I contribute by linking them to the gains from trade. This origin does not make historical states uninteresting today; the public goods that they provide in the present differ from those offered in the past. Further, the basis of trade in Africa has been fundamentally re-oriented, both on the eve of colonization (Eltis and Jennings, 1988) and again after independence (Head et al., 2010). Ecological diversity should not predict trade today. Because my results distinguish this theory of state formation from several alternatives, they help establish that the relationship between ethnic institutions and present-day outcomes is causal. I show below that historical gains from trade can be used as an instrument for ethnic institutions.

Geography shapes institutions (Acemoglu et al., 2001; Easterly and Levine, 2003). Biogeographical features such as population density (Acemoglu et al., 2002), crop suitability (Engerman and Sokoloff, 1997), and domesticable species (Olsson and Hibbs, 2005) have all been shown to shape the development of institutions and related outcomes.

Other geographic explanations of states point to features such as the observability of production (Moav et al., 2011), population density (Austin, 2008; Herbst, 2000), outside options (Allen, 1997), and natural boundaries (Jones, 1981) as causes of state capacity. This literature has, however, focused overwhelmingly on institutions that exist in the present day or those that were created in the circum-Mediterranean or in European colonies. Less is known about the geographic origins of institutions that have not been built by Europeans. I provide evidence on the causes of institutions indigenous to Africa. Controversy remains about the power of geography to explain historical facts such as the beginnings of agriculture (Acemoglu and Robinson, 2012; Ashraf and Michalopoulos, 2011). My results reaffirm geography as a force in history.

Countries with better institutions trade more (Dollar and Kraay, 2003). Causation runs in both directions; countries with better contract enforcement are able to specialize in products that require relationship-specific investments (Nunn, 2007), while trade may directly improve institutional quality (Rodrik et al., 2004). Similarly, the impact of trade on other outcomes such as growth and environmental management is mitigated by institutional quality (Damania et al., 2003; Mehlum et al., 2006). While some studies have found that trade reduces corruption (Dutt, 2009; Treisman, 2000) others have found either no effect or that corruption is only displaced (Knack and Azfar, 2003; Sequeira, 2011). Similarly, the effects of trade on democracy may be positive (López-Córdova and Meissner, 2005), negligible (Papaioannou and Siourounis, 2008) or may depend on the timing of trade reforms (Giavazzi and Tabellini, 2005). In this, paper, I trace out the importance of trade for one specific institutional outcome – the centralization of African states.

The Ricardian view is only one of many explanations of the strength of states. In addition to the geographic theories listed above, other views stress factors such the relative benefits of "stationary" versus "roving" bandits (Olson, 1993), the relative benefits of different mechanisms for governing markets (Dixit, 2004) inter-state competition (Gennaioli and Voth, 2011; Tilly, 1992), war (Besley and Persson, 2008; Prado and Dincecco, 2012), the slave trades (Nunn, 2008; Robinson, 2002; Rodney, 1972), patronage politics (Acemoglu et al., 2011), and past investments in state capacity (Besley and Persson, 2009, 2010). It is not within the scope of this paper to test these unless they are alternative interpretations of the link between states and ecological diversity.

In section 2, I describe my econometric specification and sources of data. In section 3, I present the baseline results. In section 4, I demonstrate the robustness of these results to endogeneity, unobserved heterogeneity, the estimation strategy, influential observations, and alternative measures of trade and states. In section 5, I give evidence that the six alternative stories mentioned above do not explain the results. In section 6, I present evidence that centralized states emerged from trade because it supported class differentiation, that no one type of trade mattered most, and that ecological diversity can be used as an instrument for ethnic institutions today. In section 7, I conclude.

2. DATA

To test whether the gains from trade due to ecological diversity predict the existence of centralized states, I estimate the following equation on a sample of pre-colonial African societies, using an ordered probit:

$$(1) \qquad \textit{State centralization}_i = \alpha + \beta \, \textit{Gains from trade}_i + x_i'\gamma + \epsilon_i.$$

In this section, I explain my sources of data on state centralization, my ecological proxies for the gains from trade, and the controls that I include in x_i. I cluster standard errors by the ethnographic regions recorded in the sample.[3]

To measure African states, I take data from Murdock's (1967) *Ethnographic Atlas*. This was originally published in 29 issues of *Ethnology* between 1962 and 1980. It contains data on 1267 societies from around the world.[4] From this source, I use variable 33, "Jurisdictional Hierarchy Beyond Local Community" to measure state centralization. This gives a discrete categorization between "No Levels" and "Four Levels." The sample used for the analysis consists of the 440 sub-Saharan societies for which this variable is not missing.[5] For comparison with Europe and Asia, the Chekiang and Japanese score a 4 on this index, the Czechs and the Dutch score a 3, while the Lolo and Lapps each have no centralization. I do not have data on possible substitutes for states, such as multi-ethnic federations that coordinate tax collection.

As far as I am aware, no data exist on pre-colonial African trade that could allow comparison of a large number of societies. My approach is to use geographic proxies for the capacity to trade. I follow Bates (1983) in assuming that the ability to trade across ecological zones creates gains from trade. I use White's (1983) vegetation map of Africa to identify these regions.[6] This classifies African vegetation into 18 major types, which I plot in the web appendix.[7] I use three measures of the ecologically-driven gains from trade: ecological diversity, distance from an ecological boundary, and ecological polarization. I merge these measures with the *Ethnographic Atlas* using Murdock's (1959)

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[3]These are: African Hunters, South African Bantu, Central Bantu, Northeast Bantu, Equatorial Bantu, Guinea Coast, Western Sudan, Nigerian Plateau, Eastern Sudan, Upper Nile, Ethiopia/Horn, Moslem Sudan, and Indian Ocean.

[4]In particular, I use the revised Atlas posted online by J. Patrick Gray at http://eclectic.ss.uci.edu/~drwhite/worldcul/EthnographicAtlasWCRevisedByWorldCultures.sav.

[5]It is probable that stateless societies are more likely to be missing from these data. This will only bias the results if they are more likely to be missing in ecologically diverse regions.

[6]This is available at http://www.grid.unep.ch/data/download/gnv031.zip.

[7]Altimontaine, anthropic, azonal, bushland and thicket, bushland and thicket mosaic, cape shrubland, desert, edaphic grassland mosaic, forest, forest transition and mosaic, grassland, grassy shrubland, secondary wooded grassland, semi-desert, transitional scrubland, water, woodland, woodland mosaics and transitions.

map of African ethnic groups.[8] This has also been used by Michalopoulos and Papaioan-nou (2011, 2012) and in several papers by Nathan Nunn.

In section 5, I supplement this with historical and anthropological evidence from six African societies.[9] In each, the exchange of products across ecological zones was signif-icant. My only other measure of pre-colonial trade is a map of trade routes from Brice and Kennedy (2001). I show in Section 6 that these predict states. I do not make them a focus of this paper, as their placement is potentially endogenous.[10]

Though Bates (1983) focuses on long distance trade, internal trade may also facilitate states. A state may protect intra-ethnic trade, but it may also facilitate trade between polities occupying two separate, internally homogenous regions. In section 6, I show that the data cannot ultimately disentangle whether it is local trade or long distance trade that matters most. Thus, I construct indices of the gains from both local and long-distance trade.

The principal measure that I use of gains from trade is ecological diversity. I calculate the share s_i^t of each society i's area that is occupied by each ecological type t. Ecological diversity is a Herfindahl index constructed from these shares:

$$(2) \qquad \text{Ecological diversity}_i = 1 - \sum_{t=1}^{t=18} (s_i^t)^2.$$

This is captures the opportunities for trade that exist within an ethnic group's territory – the gains from internal trade.

The second index that I use measures ecological polarization. This is also constructed from the vegetation shares:

$$(3) \qquad \text{Ecological polarization}_i = 1 - \sum_{t=1}^{t=18} \left(\frac{0.5 - s_i^t}{0.5} \right)^2 s_i^t.$$

This measures the degree to which a society approximates a territory in which two vegetation types each occupy half its area. Similar measures have been used for eth-nicity (Montalvo and Reynal-Querol, 2005a,b). This also captures gains from internal

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[8]This is available on Nathan Nunn's website. While most groups are matched directly by name, some require an alternative spelling, an alternative name, linkage to a supergroup or subgroup, or joining to an ethnic group in roughly the same location. A table of these matches is in the web appendix.

[9]It is possible that gains from trade could arise from other forms of geographic heterogeneity. Empirically, ecological diversity performs best. I have found no positive effect of other indices, such as ruggedness or a Theil index of land quality on states. Area under water in White (1983) indicates rivers and lakes: this has a negative impact on statehood if included with the baseline set of controls. Mangroves and coastal areas are classified as "azonal," and have no effect. The difference in land quality between the most fertile and least fertile points in an ethnic group's territory does predict states, but this is given a different interpretation in section 5.

[10]See Michalopoulos et al. (2010). This map includes mostly routes across the Sahara or connecting Lake Victoria to the coast. These are not correlated with ecological diversity.

FIGURE 1. State centralization and ecological diversity
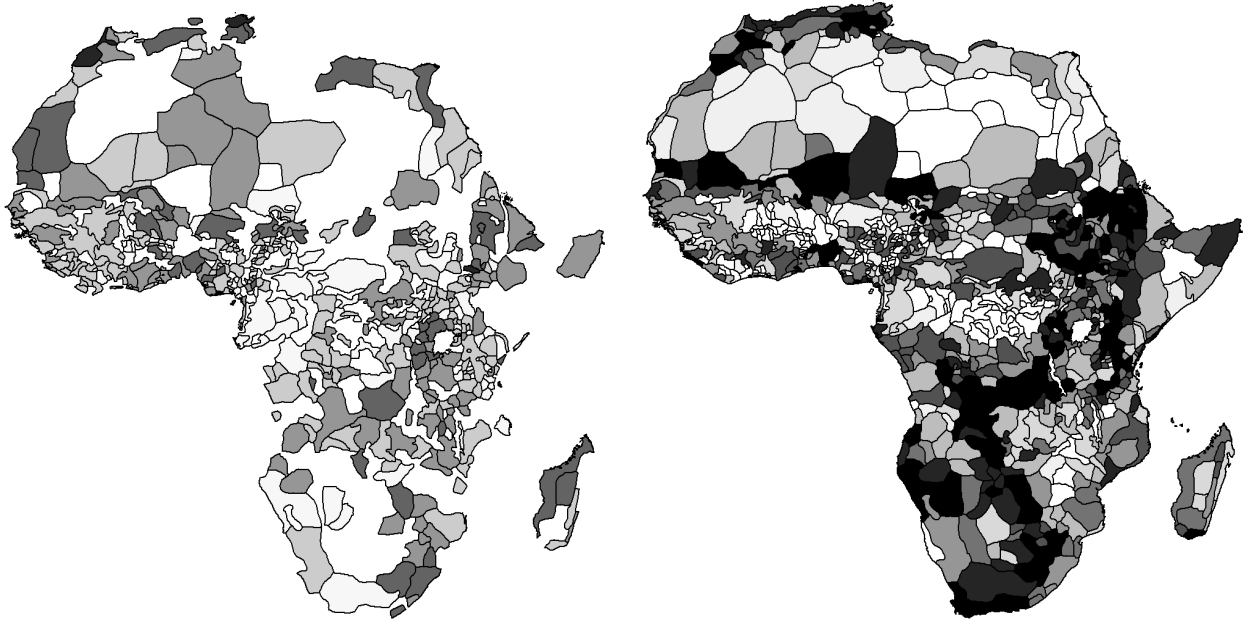
Notes: States, on the left, are from Murdock (1967). Darker regions have more centralized states. Ecological diversity, on the right, is computed using White (1983). Darker regions are more ecologically diverse.

trade. If increasing returns to scale exist in production or trade, trade may be most profitable if a society is evenly divided into two ecological zones. This would maximize the polarization index.

The third index that I use is distance from an ecological boundary. I use the White (1983) map to compute the average distance (in decimal degrees) of all points in a group's territory from the nearest boundary between two ecological regions. This captures gains from external trade, since the boundary may lie outside the ethnic group. Because a society that is intersected by a boundary will also be ecologically diverse, the measures of internal and external trade will be positively correlated. Distance from a boundary does, however, predict states even in the sub-sample of ecologically homogeneous societies.

I present maps of state centralization and ecological diversity in Figure 1.[11] The most centralized African states are clustered along an East-West line between the Sahara and West African forest, in the microclimates of the Ethiopian highlands, along the barrier between the equatorial rainforest and the East and Central African woodland mosaics, and on the divide between grassland and woodland in the continent's southeastern corner.

I join several other geographic variables to the data on ecology and states using the Murdock (1959) map of Africa. I include these in x_i as controls. Except where I note

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[11]The base map of ethnic groups is available on Nathan Nunn's website. While most ethnic groups can be matched to this map directly by name, some require an alternative spelling, an alternative name, linkage to a supergroup, or subgroup, or joining to an ethnic group in roughly the same location. A table of these matches is included in the web appendix.

FIGURE 2. State centralization above and below median diversity
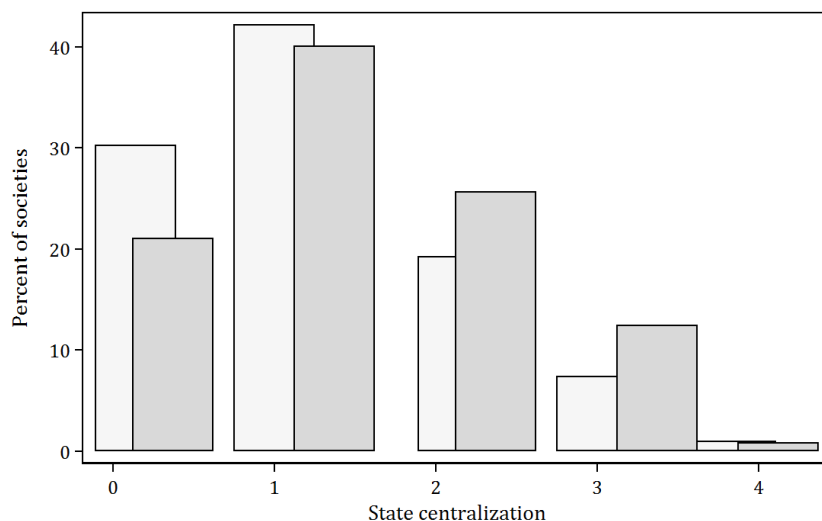
The dark bars are for ecological diversity above the median, the light bars for ecological diversity below it.

otherwise, I take data stored in raster format, and for each society I compute the average value of the points within its territory.[12] In particular, I control for the presence of a major river, agricultural constraints (an inverse measure of land quality), distance from the coast, elevation, suitability for malaria, precipitation, ruggedness, temperature, distance from Lake Victoria, date of observation, crop type dummies, and distance from each of the four major slave trades. These variables are described in more detail in the web appendix. Summary statistics are given in Table 1. These data are that they are admittedly anachronistic – the institutional variables are recorded at an earlier date than the geographic controls and the measure of ecological diversity. Because these variables are slow to change, this should only add measurement error to the analysis.

3. RESULTS

I begin by showing the unconditional relationship between gains from trade and state centralization. In Figure 2, I cut the sample into societies above and below median ecological diversity. For each, I show the relative frequencies of states of each level of centralization. Below the median (the lighter bars), it is more common for societies to have no levels of centralization, or only one level. Above the median, there is a greater prevalence of societies with two or three levels. As ecological variation rises, the distribution of state centralization shifts to the right.

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[12]Raster data taken from the following sources: Ag. Constraints, `http://www.iiasa.ac.at/Research/LUC/SAEZ/index.html`, plate 28; Elevation, `http://epp.eurostat.ec.europa.eu/`; Malaria, `http://www.mara.org.za/lite/download.htm`; Precipitation, `http://www.iiasa.ac.at/Research/LUC/SAEZ/index.html`, plate 1; Temperature, `http://www.iiasa.ac.at/Research/LUC/SAEZ/index.html`, plate 6; Ruggedness, `http://diegopuga.org/data/rugged/`.

Table 2 presents estimates of β. I report the full set of coefficient estimates in the web appendix, omitting them here for space. In column 1, only the measure of ecological diversity is included. Ecological diversity has a significant and positive correlation with state centralization. This is robust to the inclusion of additional controls in column 2.

Few of the additional controls are significant. The exceptions are date of observation (negative), no major crop (negative), roots and tubers (positive), and major river (positive). The negative effect of the date of observation suggests that colonial anthropologists chose to first study the most centralized African societies – the low hanging academic fruit. The negative effect of no major crop suggests that it is difficult to form a state without an agrarian base. The positive effect of roots and tubers is likely capturing unobservable features of forest-zone Bantu societies that better enabled them to create states. Major rivers are associated with trade, and further support the Ricardian view of African states. Results are similar if the length of river per unit area is used, rather than a dummy (not reported).

Is the effect of ecological diversity large? In Table 2, I report marginal effects. The impact of a one unit change in ecological diversity is to reduce the probability of having no centralization by roughly 22-26 percentage points. The probabilities of having two or three levels increase to match this. Ecological diversity has a bimodal distribution; societies are clustered around peaks of zero diversity and roughly 0.5 (see the web appendix). If an ecologically homogenous society such as the Tallensi or the Yako were to be and placed in a more typically diverse region, such as that of the Fur (0.496) or Wolof (0.506), the probability of any centralization would rise roughly 11 to 13 percentage points. Mirroring this thought experiment, I replace the ecological diversity measure with an indicator for being above median diversity. The marginal effect, in Table 2, is between 9 and 11 percentage points.

The pseudo-R^2 statistics, by contrast, are low. While the effect of diversity is sizable, the controls here cannot explain more than 10% of the variation in African states. The estimation without controls correctly predicts the level of centralization for 42% of the sample, barely an improvement over selecting the mode. Adding controls raises this to only 45%. Although the bulk of pre-colonial state centralization in Africa remains to be explained (Osafo-Kwaako and Robinson, 2012), the impact of ecologically-driven gains from trade is robust and economically significant.

I also use Table 2 to show that the results can be expanded to cover the rest of the world. On a sample of more than 1,000 global societies, ecological diversity continues to predict the existence of states.[13] This is true even as the sub-Saharan societies are dropped from the analysis. I conduct as many of the robustness checks as possible in

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[13]This sample has been created for Fenske (2011b). Details on these are given in the web appendix for that paper.

this global sample that I do for the sub-Saharan sample in sections 4, 5, and 6. Results are reported in the Web Appendix.[14]

4. ROBUSTNESS

4.1. **Validity of the state centralization measure.** I take two approaches to validate the state centralization measure. First, it is strongly correlated with alternative measures of states. Bockstette et al. (2002) and Chanda and Putterman (2007) report a country-level index of historical state strength for the period 1850-1900, which just precedes colonial rule for most African societies. The state centralization index has been aggregated to the country level by Gennaioli and Rainer (2007). For 41 countries, I have both measures. Their correlation is positive and significant at the 1% level. Similarly, the *Standard Cross Cultural Sample* (SCCS) gives additional variables for 186 societies. It only includes 28 sub-Saharan observations, so I cannot use it in the baseline. I show in the web appendix that several SCCS measures of state strength are positively correlated with centralization, whether they measure the existence of a police force, the presence of taxation, or the capacity of states to enforce their decrees.[15]

Second, the main result holds if I use an indicator for any levels of jurisdiction above the local as an outcome in Table 3. This might better capture state strength if, for example, a central authority cannot delegate functions to regional leaders without losing some control over them. Results are similar using centralization greater than one as an outcome (not reported).

4.2. **Validity of the gains from trade measure.** Results are robust to using alternative measures of the gains from trade are in Table 3. Distance from an ecological boundary and ecological polarization both predict states. Distance from a divide also predicts states in the sub-sample of ethnic groups not intersected by a boundary (not reported). Results using an indicator for any diversity (equivalent to intersection by a boundary) are similar. I collapse ecological classifications from White's map into eight "simpler" types.[16] This does not change the bi-modal distribution of diversity. I re-build the dataset discarding slices of map in which historical population density is less than 15% of the

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[14]Some tests cannot be carried out on the global sample due to data availability. I do not have historical trade routes, pre-colonial cities, or salt production outside of Africa. Because the global diversity measure is constructed using raster data that uses different classifications than White (1983), I cannot compute distance from an ecological boundary, construct simpler ecological classes, or measure diversity within artificial ethnic groups in the global sample.

[15]The centralization measure is v237 in the SCCS.

[16]Mountain if altimontane, other if anthropic, water or azonal, bushland if bushland and thicket or bushland and thicket mosaics, shrub if cape shrubland, transitional scrubland or grassy shrubland, desert if desert or semi-desert, grassland if grassland, secondary wooded grassland or edaphic grassland mosaics, forest if forest or forest transitions and mosaics, and woodland if woodland or woodland mosaics and transitions.

density of the entire ethnic group.[17] These potentially irrelevant regions do not deter-mine the results. Finally, an alternative diversity index using the Food and Agriculture Organization's (FAO) division of Africa into "dominant ecosystem classes" also predicts states.[18]

4.3. **Validity of the estimation.** I use a generalized ordered probit model in the web appendix (Maddala, 1986). Results are similar to the baseline. Because multi-ethnic polities might be double-counted in the data, I down-weight all centralized societies by one half, and the results are virtually unchanged (not reported). Major rivers and distances from the coast, Lake Victoria, and slave trade ports may capture trade. I show in the web appendix that excluding these controls barely affects the results. Nor does excluding the date of observation or including country-level timing of the neolithic revolution (not reported).[19] In the web appendix, I discard influential observations. I also drop each of the "South African bantu," "Ethiopia/horn," "Moslem sudan" and "Indian Ocean" in turn, as these are the regions in which most states are concentrated. I also exclude non-agricultural societies, societies with poor land, animal husbandry, and the desert fringe. These do not drive the results. The main sample includes only sub-Saharan Africa; results are similar using the whole continent (not reported).

4.4. **Possible reverse causation.** To control for the possibility that states may shape their environment, I use variation over space (not time) in rainfall to instrument for ecological diversity.[20] I use the log of the rainfall range as an instrument, where:

$$(4) \qquad \text{Log rainfall range}_i = \ln(1 + (rain_i^{max} - rain_i^{min})).$$

Here, $rain_i^{max}$ and $rain_i^{min}$ are the values of the raster points with the most and least precipitation for society i. The natural log improves fit. This cannot be computed for societies too small to have at least two raster points. Results are robust to assigning these societies a log rainfall range of zero. Results (including the reduced-form and first stage) are in Table 4. The IV estimates are larger than the ordinary least squares (OLS) estimates. Measurement error in ecological diversity is a plausible explanation, since vegetation classes are subjective and have imprecise boundaries. Further, ecological diversity may be correlated with unobservable variables that hinder states. Where ecological boundaries abut agriculturally marginal areas such as deserts and mangrove swamps, states may have less agricultural surplus to tax.

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[17]I use density in 1960.

[18]This is plate 55, downloaded from http://www.iiasa.ac.at/Research/LUC/GAEZ/index.htm.

[19]Data are from Louis Putterman's website.

[20]Variation over time is unlikely to predict ecological diversity, which is variation across space in vegetation. Further, fluctuations in rainfall over time may lead to conflict (Miguel et al., 2004), which could directly affect state formation.

4.5. **Possible omitted heterogeneity.**

I show that results are robust to seven general approaches towards omitted heterogeneity in Table 5. First, I add area shares s_i^t of each ecological type as additional controls. Second, I include a cubic in latitude and longitude with full interactions, allowing unobservables to vary smoothly across space. Third, I adjust for spatial autocorrelation using a spatial error model, a spatial autoregressive model, including the spatially-weighted observable characteristics of a society's neighbors, and estimating Conley's OLS with standard errors corrected for spatial dependence with cutoffs of 5 decimal degrees. [21] I do not use Conley's estimator in the baseline because the dependent variable is ordinal. I instead cluster standard errors by ethnographic region in the baseline.

Fourth, I interact de-meaned controls with ecological diversity (Wooldridge, 2002). Fifth, I employ a nearest neighbor matching estimator, taking diversity above the median as "treatment." [22] Sixth, I compute Altonji-Elder-Taber statistics. [23] Finally, I use fixed effects. In successive columns, I control for ethnographic region, United Nations region, [24] country, [25] and language family. [26] These are estimated using OLS. I do not use these in the baseline because they will exacerbate measurement error. In an OLS regression, ethnographic region dummies explain 19% of the variance in state centralization and 25% of the variance in ecological diversity.

5. ALTERNATIVE INTERPRETATIONS

The Ricardian view of African states better fits the data than six alternative interpretations of the link between ecological diversity and states. Some of these are complements, rather than rivals, to the Ricardian view. Still, they do not fully account for the relationship between ecology and states.

5.1. **Larger areas are more diverse and require centralized administration.**

States that cover wider territories for reasons unrelated to their strength may have more levels of jurisdiction (Spencer, 1998, 2010). These areas may be more diverse by construction. I

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[21]In particular, I use the spatwmat and spatreg commands in Stata. I select the spatial adjacency matrix W so that all societies whose centroids are within ten decimal degrees of each other are given a weight inversely proportionate to their distance from each other.

[22]In particular, I use the nnmatch command in Stata.

[23]Replicating the main regression using OLS, I obtain the estimated coefficient on ecological diversity $\hat{\beta}_1$ and the estimated variance of the residuals $\hat{V}_1$. Regressing state centralization on the controls, I obtain the predicted values xb and the estimated variance of the residuals $\hat{V}_2$. Regressing ecological diversity on xb, I obtain the coefficient estimate $\hat{\beta}_2$. Altonji et al. (2005) suggest that if $\frac{\hat{\beta}_1 \hat{V}_2}{\hat{\beta}_2 \hat{V}_1} > 1$, it is unlikely that unobservables will explain away the result of interest.

[24]I make the following assignments. Southern Africa: African Hunters, South African Bantu. Western Africa: Guinea Coast, Western Sudan, Nigerian Plateau, Moslem Sudan. Central Africa: Central Bantu, Equatorial Bantu, Eastern Sudan. Eastern Africa: Northeast Bantu, Upper Nile, Ethiopia and Horn, Indian Ocean.

[25]I assign each ethnic group to the country into which the largest slice of its territory falls.

[26]This is constructed from variables 98 and 99 in the *Ethnographic Atlas*.

have three strategies for dismissing this alternative. First, I restrict the sample to societies of similar area. In Table 5, I show that results are robust if the smallest quintile (Q1), largest quintile (Q5) or both are dropped. Second, I control for area directly in Table 5. This is not done in the main analysis, because area is potentially endogenous. Results are robust to this, as well as including the logarithm of area (not reported).

Third, I adopt the "virtual countries" approach of Michalopoulos (2011). I divide the African continent into $1°$ by $1°$ squares and repeat the main analysis. I map these virtual countries in the web appendix. Excepting coastal societies, these units have a uniform shape and area.[27] This exercise shows that, even conditioning on size and shape, diverse areas are more likely to host states. Further, this mitigates the concern that multi-ethnic states are "double-counted." Some readers may prefer these "exogenous" units. I use centralization of the strongest state in a square as its measure of centralization. Results, in Table 5, are robust to this approach.

5.2. **States conquer trading regions.** States might emerge for reasons unrelated to the gains from trade, and then occupy trading regions through migration or conquest. This could only be conclusively ruled out using panel data – data that do not exist. I use the cross section to make three arguments. First, the artificial country results above suggest that diversity does not result from the irregularly-shaped boundaries of ethnic groups that have conquered their surroundings. Second, if conquest requires that states expand, I have shown above that controlling for area does not eliminate the main result.

Third, I give narrative evidence on some of the most statistically influential societies in the data. This is effectively a very small panel taken from the larger cross section. The eighteen most influential societies (by dfbeta) are listed in Table 7. If the centralized societies in this list developed states where they are or derived their wealth and power from their proximity to trade routes, rather than migrating to capture trade, this supports the Ricardian view. I choose six centralized states for case study evidence.[28]

To test the "Ricardian" view, I ask four questions about the Yoruba, Songhai, Toro, Suku, Luba and Lozi. First, did these societies participate in trade? Second, was trade a source of wealth for the society? Third, was trade a source of state power? Fourth, did these states move to capture trading regions after they grew strong? I summarize the answers in Table 7. Though two of these did conquer areas with tradable resources, they relied on trade-related income to become powerful before expanding.

Yoruba. Morton-Williams (1969) argues that Yoruba Oyo "developed under the stimulus of external trade," benefiting initially from its proximity to northern trade routes,

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[27]Because the length of a degree of longitude varies by distance from the equator, I have also replicated the results in Table 5 down-weighting observations by the degree of this distortion. The results (not reported) are nearly identical.

[28]I choose these, rather than non-centralized societies, because the alternative story being discussed is specific to centralized ethnic groups and because the secondary historical literature is richer for these groups. These were the six most influential states when a different baseline specification was used in earlier versions of this paper.

and later from coastal markets. Law (1977), similarly, links the rise of Oyo to its imported cavalry, participation in long-distance northern commerce, and engagement in the Atlantic slave trade.

Trade was important. Oyo cloth was sold to Dahomey and Porto Novo, and the state imported kola nuts from forested areas of Yorubaland for consumption and re-export. Salt and camwood were imported, and the latter was re-exported to Nupe. Cavalry horses were imported from the north. The *Alafin* (king) relied on trade taxes for revenue (Law, 1977). Even direct taxes were collected in currencies acquired through trade. Trade upheld the *Alafin's* authority by enabling him to distribute money and trade goods while maintaining a superior lifestyle. He and other chiefs engaged in trade personally. Neither Morton-Williams (1969) nor Law (1977) mention conquest of neighboring regions as a pre-condition for trade.

Songhai. The Songhai Empire depended on trans-Saharan trade. Neumark (1977) explains the success of Songhay and the states that preceded it using "their strategic commercial position on the fringes of the Sahara." Songhay exported gold and slaves, as well as ivory, rhinoceros horns, ostrich feathers, skins, ebony, civet, malaguetta pepper, and semi-precious stones. It re-exported cloth and leather goods from Hausaland and kola from the forests. It imported salt, linen, silk, cotton cloth, copper goods, ironwork, paper, books, weapons, cowries, beads, mirrors, dates, figs, sugar, cattle and horses. This trade brought wealth; Leo Africanus noted the empire's prosperity (Levzion, 1975).

Taxes on trade provided government revenue (Shillington, 1989). Lovejoy (1978) notes that Songhay's cities "controlled trans-Saharan trade, desert-side exchange, and river traffic on the Niger. Located in the Sahil but with easy access to western and central savanna, they were at the hub of overland and river routes where staples of desert-side trade such as grain and salt could readily be transferred from river boat to camel, and vice versa."

Songhay did expand into the Hausa states to capture their fertile land and into Air to drive out Tuareg raiders (Bovill, 1995). The latter was a movement to protect existing trade interests, not to secure new routes. Songhay's strength, like the states that came before it, was based on its favorable location before it expanded.

Toro. The Toro region was one of relative prosperity, producing iron goods and salt for sale within the interlacustrine region (Ingham, 1975). Trade was a source of state revenue, through both tribute and direct control. The king, chiefs and lords of Toro maintained control over land, cattle, lakes, salt lakes, medicinal springs, canoe services, and "certain commodities having exchange or prestige value," such as tusks and lion skins (Taylor, 1962). They collected goods as tribute, reallocating them to relatives, chiefs, officials and others. Subordinate states introduced agents to collect tax from both salt producers and traders, a portion of which was sent to Bunyoro (Ingham, 1975). The Toro kings sold slaves, ivory and cows to Arab traders in return for guns and cloth (Taylor, 1962). Toro was also an exporter of salt; until 1923, the *okukama* or *Mukama* (king)

of Toro held personal ownership over the trade in salt from Lake Katwe and other lake deposits near Kasenyi (Good, 1972). Toro did expand to take advantage of a tradable resource. Lake Katwe, in Busongora, was an early conquest (Good, 1972). Salt was, however, only one of many tradable goods that enhanced the power of the Toro state.

Suku. The Suku of the Congolese savanna lacked a developed system of market places, sold no cash crops and only limited rubber, and itinerant trade was "not at all developed" in the colonial era (Kopytoff, 1967). The Suku did, however, participate as middlemen in the long-distance trade between the raffia and palm-oil producers north and east of them and southern groups who traded directly with the Portuguese (Kopytoff, 1967). They purchased raw raffia for weaving into cloth, which was exported to the southeast along with palm oil in return for shell money and European goods (Kopytoff, 1967). Though relatively poor, the Suku were known for their wealth in shell money (Kopytoff, 1964).

The Suku *MeniKongo* (king) directly ruled villages around the capital and administered the remainder through regional chiefs. Shell money was used to render tribute (Kopytoff, 1964), and so direct taxes were indirectly taxes on trade. The effect of trade on the Suku state was inherited in part from the Lunda, from whom Suku seceded (Kopytoff, 1965). Within the Lunda's territory lay both copper mines and salt, which were sources of trade and tribute (Birmingham, 1976). Slaves for export were collected through war and tributary tax collection, and this revenue allowed the royal court to distribute the trade goods over which it held a near monopoly (Birmingham, 1976). The Suku inherited state forms from their trading predecessor, and prospered from their position as middlemen.

Luba. Before they were unified, the separate Luba states controlled local dried fish, salt, oil palm, raffia cloth, and copper-working industries (Birmingham, 1976). In the late eighteenth century, Luba Lomami responded to the new long distance trade in ivory and slaves, unifying the Luba (Birmingham, 1976). Traders exchanged cloth, beads and cattle for tusks that were sold subject to taxation and supervision by either the royal household or by chiefs (Birmingham, 1976). This trade was preceded by "pioneering chiefs," who advanced into new lands and arranged for the purchase of ivory while at the same time creating "a more or less permanent Luba political superstructure" behind which traders followed (Birmingham, 1976).

After 1780, the Luba expanded, first into the space between the Lualaba and Lake Tanganyika, and later into the fishing and palm oil areas of the Lalaba lakes, the copper-producing portions of the Samba, and the ivory-producing province of Manyema (Birmingham, 1976). At its peak in the mid-nineteenth century, the empire presided over "a wide-ranging and international trade" in oil, salt, poisons, drums, slaves, copper, palm cloth, baskets, iron, skins and fish. Wilson (1972) argues that long-distance trade was the cause of this expansion. The slave trade pushed the Luba to establish Kazembe as a tributary kingdom. Birmingham (1976) argues that Luba decline followed that of the

ivory trade. Their trading partners turned to focus on copper. Swahili-Arab traders began to trade directly into the forest, cutting out the Luba. The Luba became unable to purchase the guns needed to secure their power without exporting internally captured slaves.

Lozi. The pastoral Lozi occupy the Zambezi floodplain (Gluckman, 1941). Within Lozi territory, trade was in the specialized products of each region, including bulrush millet and cassava meal, wood products and iron (Gluckman, 1941). Before 1850, the Lozi sent traders to the Lunda areas of the upper Zambezi, trading indirectly with the Portuguese (Flint, 1970). By 1860, long distance trade, especially in ivory, became important (Flint, 1970). The Lozi exported cattle and forest products (Gluckman, 1941).

The king and princess chief collected tribute in kind from "tribes" under their command, including canoes, weapons, iron tools, meat, fish, fruit, salt, honey, maize and manioc (Birmingham, 1976). The Kololo, who ruled the Lozi between 1840 and 1864, obtained ivory as tribute and sold iron hoes to the Tonga. The Kololo king established 'caravan chiefs' and kept profits from ivory within his court (Flint, 1970). On re-gaining independence, the Lozi king traded cattle, ivory and slaves for goods that he distributed (Gluckman, 1941).

Public goods. Subjects and traders received greater peace and protection from these states. The Toro "expected patronage - protection, justice, undisturbed occupation of their land, and rewards especially in stock or chieftainships or honours for good service" (Taylor, 1962, p 60). Lozi political authorities re-distributed tribute, sometimes to those in need, serving as a "clearing house" (Gluckman, 1941, p. 73). Traders gave gifts to the king, "for they traveled by his permission and largely, despite their muskets, under his protection (p. 78)." Lewanika, for example, sent a punitive expedition against subject Ila for having killed a party of traders (p. 79). Oyo caravans, similarly, often traveled under cavalry protection (Law, 1975).

Summary. These cases are consistent with the Ricardian view. Songhai and Oyo expanded, but did so after having arisen in locations favorable to trade. The Luba expanded after 1780 based on power already acquired through the Bisa ivory trade. When that trade declined, the kingdom collapsed. Lozi dominance over surrounding peoples depended trade and tribute from the diverse products of their neighbors. That the Suku participated in long-distance trade while possessing only limited internal markets highlights the importance of trade spanning macro-ecological regions. In every case, rulers taxed trade. Though Toro conquered Busongora to capture the most important source of salt in the region, it inherited its political structure from Bunyoro, which had previously grown strong due to its sale of metal goods and control of the Kibiro salt industry.

5.3. **Islands of quality.** If states emerge to protect "islands" of land quality that differ from neighboring areas, these will also have diverse ecologies. In Table 5, I control for the range of agricultural constraints – the difference in land quality between the best

and worst points in a society's territory. The effect of diversity remains significant. If I control for a Theil index of agricultural constrains, the results are similar (not reported).

5.4. **Population density.** Ecological diversity may be correlated with population density, which itself explains pre-colonial African states (Osafo-Kwaako and Robinson, 2012). I proxy for historic population density by measuring it in 1960.[29] This is reported in Table 5, and the effect of ecological diversity remains intact. This is also true if I include the log of (one plus) population density (not reported).

5.5. **Ethnic diversity.** Ecology-specific human capital gives rise to a greater number of ethnic groups in regions of diverse ecology (Michalopoulos, 2011). Competition between these groups may lead them to develop stronger states (Tilly, 1992). Alternatively, more heterogeneous communities might form more sophisticated institutions to reduce conflict (Aghion et al., 2004). To show this is not driving my results, I return to my sample of artificial countries. I count the number of ethnic groups that intersect each square, and include this as an control in Table 5. The main result survives this. It also survives controlling for modern-day heterogeneity, measured as the number of languages reported in the World Language Mapping System (not reported).[30]

This alternative interpretation would also contradict several established findings. Ethnic diversity increases the cost of nation-building (Alesina et al., 2005), inhibits public goods provision (Easterly and Levine, 1997), and predicts the break-up of nations (Desmet et al., 2009).[31] Ecological diversity overcomes both these potential effects of greater ethnic diversity and the possible substitutability between trade openness and nation-building (e.g. Alesina and Spolaore (1997)).

5.6. **Diversity and risk.** Ecological diversity may increase the number of activities a society can use to cope with risk and seasonal variation. It may permit animals to be moved to take advantage of seasonal resources and avoid diseases (Beinart, 2007). I have shown above that the results are not driven by societies dependant on animal husbandry. Results are also robust to controlling for presence of bovines (not reported). In Table 5, I show they are robust to adding subsistence diversity as a control. This is a Herfindahl index computed from the income shares derived from hunting, fishing, gathering, husbandry, and agriculture reported in the *Ethnographic Atlas*.

Cultivating a diverse set of grains may enable a state to better cope with risk (e.g. McCann (1999)). If these grains are exchanged through intra-regional trade, this is not inconsistent with an interpretation linking diversity to states through trade. Controlling for a Herfindahl index constructed from the shares of each society's territory that are

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[29]Raster data are taken from `http://na.unep.net/datasets/datalist.php`.

[30]The map can be purchased from `http://www.worldgeodatasets.com/language/`.

[31]Within artificial countries, the centralization of the median ethnic group is negatively related to the number of ethnic groups (not reported). I have found no evidence that this relationship is non-monotonic. The positive coefficient in Table 5 likely comes from selecting the maximum state from a larger number of ethnic groups.

most suitable for the grains listed in plate 48 of the FAO-GAEZ data does not change the main result (not reported).

6. MECHANISMS

6.1. **How does trade cause states?** To illustrate the possible mechanisms connecting trade to state centralization, I introduce a simple model in appendix A. This is based on Gennaioli and Voth (2011). In the model, a ruler extends his authority within his ethnic group's territory in order to tax trade. This trade cannot occur unless he offers public goods that lower the costs of trade. These public goods could include dispute-resolution services or physical protection. I do not specify whether these public goods are used to facilitate trade with the citizens of neighboring states, or to promote internal trade, since state services could lower trade costs in either case. I show that greater gains from trade will lead the ruler to centrally administer a larger fraction of group's territory. In the model, there are three mechanisms by which trade may lead to states:

(1) Greater gains from trade will directly increase the profitability of state centralization. It raises the tax base, allowing the ruler to extract greater revenues from the territory he controls. Investment in public goods and administration becomes worthwhile. Adding to this direct revenue effect, the ability of rulers to tax exchange and to trade on their own was highlighted by the case studies above.

(2) If greater access to trade makes it cheaper to project authority over space, centralization will increase. Access to trade can lower these costs. The ability to trade for horses and for firearms made it easier for states such as Oyo and Songhai to extend their power over space.

(3) If access to trade makes the ruler more effective at providing public goods, state centralization becomes more profitable. Access to trade may give the ruler access to goods that increase his authority in settling disputes and in demanding that traders not be harassed. The *Alafin* (king) of Oyo gained prestige by maintaining a superior lifestyle, while the Lozi and Toro rulers secured loyalty by redistributing the profits from trade. Cavalry and firearms could be used to extend protection to traders.

It is beyond the scope of this paper to discuss whether trade or centralization are "good" outcomes in all cases, or whether states that depend on tradable resources for revenues are "better" than states that have other sources of revenue (Brunnschweiler and Bulte, 2008; Mehlum et al., 2006; Sachs and Warner, 2001).

6.2. **Trade and intermediate outcomes.** Here, I test whether trade predicts specific outcomes related to state formation. I find that ecological diversity is strongly associated with class stratification, but not with local political structures or with religion. Trade in the SCCS is correlated with a wide selection of state functions, rather than a few narrow indicators of state capacity.

Diminished local authority. The first possible mechanism is to take over the authority of other smaller states in its vicinity. The atlas contains a variable (V32) that records the number of "levels of local jurisdiction." I take this as a crude measure of the strength of local states, and use it as an outcome in place of state centralization in (1). While there is a suggestive negative correlation between ecological diversity and local states when no other controls are added, this is not robust to the inclusion of other variables. Similarly, V72 records the rules for succession to the office of the local headman. I construct a "headman is appointed" dummy if this rule is "appointment by higher authority." In Table 8, I show that there is no correlation in the data.

Islam. Islam diffused in Africa through trade networks that encouraged both tribal unification and the adoption of Arabic (Insoll, 2003). This is one of the possible mechanisms linking trade to states. The data do not directly record Islam. They only state whether high gods are "supportive of human morality." This is only positive for a handful of societies outside of the Moslem Sudan, Western Sudan and Ethiopia, and so it is effectively a dummy variable for either Christianity or Islam. This is only available for a sample roughly half the size of the main sample, and does not appear to be related to ecological diversity in Table 8. Similarly, if I include it as a control, the coefficient on ecological diversity falls, but remains significant (not reported). Islam, then, does not drive the correlation between trade and states in the data.

Class stratification. Trade allowed kings to amass wealth through taxation, letting them gain prestige and control the flow of tribute. To test for this mechanism, I use V66, "class stratification among freemen," which is divided into five levels. In order, these are "absence among freemen," "wealth distinctions," "elite," "dual," and "complex." Ecological diversity positively predicts this in Table 8. Results (not reported) are similar if a binary class stratification measure is used. Though recent trade models argue that trade increases inequality by raising incomes of abundant factors, increasing skill premia, and through search frictions in import-competing sectors (Harrison et al., 2011), these are of limited relevance to pre-industrial societies. Instead, rulers' access to prestige goods, trade goods, and tax revenues are more likely mechanisms.

Specific state functions. I test whether the various measures of state centralization in the SCCS's global sample are correlated with any of the forms of trade mentioned in that source in the web appendix. Trade in food and the importance of trade in subsistence are related with the greatest number of state functions. The degree of police specialization and the level of the highest political office are correlated with all the trade measures. The degree to which the executive is concentrated in a single person, the presence of a judiciary and the level of highest overarching jurisdiction are correlated with all but one. Many types of trade, then, are related to several state-related outcomes in the SCCS – no one type of trade operates through one specific mechanism.[32]

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[32]Other outcomes may be of interest to the reader. Ecological diversity does predict area in an OLS regression, and this is robust to both the standard controls and regional fixed effects (not reported). I have found no relationship between ecological diversity and urbanization measured by cities in 1850 reported

6.3. **What sort of trade matters?** *Endowments of tradable products.* The ecological diversity measure cannot capture all forms of trade. In Table 8, I test whether other sources of trade – fishing, iron, gold, and salt – give similar rise to states. These data do not measure trade in these products, only the capacity to trade. Coefficients can be thought of as intent-to-treat effects.

A society's percentage dependance on fishing is V3 in the *Ethnographic Atlas*. I find no correlation between this and states. To test the importance of minerals, I take data from the US Geological Service's Mineral Resources Program.[33] These records contain data on both metallic and nonmetallic mineral resources at specific sites. "Iron" is the number of sites of iron production found within an ethnic group's territory, and "gold" is the number of sites of gold production. If there is any bias from using modern data, it will be positive, since modern states that have inherited the strength of their pre-colonial predecessors should be better able to exploit their countries' resources. Despite this, I find no evidence that iron matters.[34] Gold enters significantly when no controls are added, though the effect of gold is marginally insignificant with controls. "Salt" is the number of salt-producing cites listed by Sundström (1974) within an ethnic group's territory.[35] This too appears irrelevant.

Types of trade. I also test whether state centralization is correlated with any particular form of trade in the SCCS's global sample. In the web appendix, I present the correlations between these indicators and state centralization. Societies with states are more likely to trade for food, through more levels of intermediation, and this trade is more important to their subsistence. Political power is more likely to depend on commerce in more centralized states, trade and markets are more likely to exist, and exchange is more important both within the community. Interestingly, this suggests that it is more mundane, intra-community trade in products such as food that matters.

Local and long distance trade. Despite this suggestive finding, the main data sources here do not allow for these two types of trade to be conclusively tested against each other. I show in Table 8 that the presence of historical trade routes is correlated with state centralization. This does not, however, rule out the importance of local trade. Similarly, while "ecological diversity" is intended as a proxy for intra-ethnic trade and

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by Chandler and Fox (1974) (not reported).

Similarly, some readers may be interested in how ecological diversity and pre-colonial states relate to colonial outcomes. I show in the web appendix that ethnic groups whose largest slice of territory was conquered by Britain were generally more diverse and more centralized than those captured by France, but less than those not colonized. Within the British empire, Frankema and van Waijenburg (2010) have found early twentieth century real wages were much higher in West Africa than East Africa. If there is any pattern apparent, it is that ethnic groups in Britain's East African conquests were more diverse and centralized than those in Ghana and Nigeria, though Sierra Leone is an exception.

[33]The data are available at `http://mrdata.usgs.gov/`

[34]I similarly find no result if I use the number of iron-producing sites within a group's territory listed by Sundström (1974) as a measure of iron.

[35]Of 271 sites he lists, I match 84 to ethnic groups in the data and 157 to specific geographic locations, such as Cape Lopez. For 30 I could not find a match. The full table of matches is given in the Web Appendix.

"distance from an ecological boundary" is meant to capture long distance trade, I show in the web appendix that including both in the same regression does not allow their effects to be disentangled. They are strongly correlated, and both coefficients fall relatively 40% relative to their values in Tables 2 and 3.

6.4. **Does historical trade matter today?** It is not the case today that all African countries have strong states. Even today, a one standard deviation increase in the Gennaioli and Rainer (2007) index of State Centralization predicts a 0.3 standard deviation drop in The Fund for Peace's Failed States Index for 2012.[36] Michalopoulos and Papaioannou (2012) have shown that pre-colonial states predict greater levels of contemporary development, as measured by the intensity of night-time lights. In Table 9, I show that historical trade can be used to instrument for these ethnic institutions. Column (1) replicates the main result from Table 3A in their paper: conditional on controls and country fixed effects, "ethnic" institutions predict present-day luminosity. Column (2) uses ecological diversity as an instrument for these pre-colonial states. The IV estimate is positive and significant. This supports a causal interpretation of the results in Michalopoulos and Papaioannou (2012); ecological conditions that no longer directly influence trade predict institutions continue to matter in the present.

7. CONCLUSION

I have used this paper to provide empirical support for Bates's (1983) Ricardian view of pre-colonial African states. The gains from trade stemming from ecological diversity predict the presence of state centralization across sub-Saharan societies recorded in the *Ethnographic Atlas*. Moving from a homogenous zone to one that is ecologically diverse predicts that the chance a society is centralized rises by more than 10 percentage points. There is no evidence that the effect is overstated due to endogeneity, or is due to the influence of outliers or specific ethnographic regions. The histories of African societies are consistent with this interpretation of the data, rather than one in which states emerge and then migrate. Similarly, area, defense of fertile islands, correlation with dense population, risk mitigation, and ethnic competition do not explain away the results. Ecological diversity predicts centralization outside of Africa, and continues to matter in the present through the legacy of pre-colonial states.

What does this result add to our understanding of the link between institutions and development in the present? First, it suggests that other findings that have been interpreted as effects of culture may operate through institutions. For example, the result in Durante (2009) that historical experience with mutual insurance leads to greater levels of trust may arise through the institutional consequences of mutually-insuring trade. Second, institutions have heterogeneous effects on development, and part of this heterogeneity is both path-dependent and context-specific. The mechanisms that shaped pre-colonial states in Africa continue to shape development in the present.

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[36]In this bivariate regression, n=47, p=0.041.

REFERENCES

Acemoglu, D. (2005). Politics and economics in weak and strong states. *Journal of Monetary Economics*, 52(7):1199–1226.

Acemoglu, D., Johnson, S., and Robinson, J. (2001). The colonial origins of comparative development: An empirical investigation. *American Economic Review*, 91(5):1369–1401.

Acemoglu, D., Johnson, S., and Robinson, J. (2002). Reversal of Fortune: Geography and Institutions in the Making of the Modern World Income Distribution. *The Quarterly Journal of Economics*, 117(4):1231–1294.

Acemoglu, D., Johnson, S., and Robinson, J. (2003). An African Success Story: Botswana. *In Search of Prosperity: Analytical Narrative on Economic Growth. Edited by Dani Rodrik, Princeton University Press.*

Acemoglu, D., Reed, T., and Robinson, J. (2012). Chiefs. *Working Paper*.

Acemoglu, D. and Robinson, J. (2012). *Why Nations Fail.* Random House Digital, Inc.

Acemoglu, D., Ticchi, D., and Vindigni, A. (2011). Emergence and persistence of inefficient states. *Journal of the European Economic Association*, 9(2):177–208.

Aghion, P., Alesina, A., and Trebbi, F. (2004). Endogenous political institutions. *The Quarterly Journal of Economics*, 119(2):565.

Alesina, A. and Spolaore, E. (1997). On the number and size of nations. *The Quarterly Journal of Economics*, 113(4):1027–1056.

Alesina, A., Spolaore, E., and Wacziarg, R. (2005). Trade, growth and the size of countries. *Handbook of economic growth*, 1:1499–1542.

Allen, R. (1997). Agriculture and the Origins of the State in Ancient Egypt. *Explorations in Economic History*, 34(2):135–154.

Altonji, J., Elder, T., and Taber, C. (2005). Selection on observable and unobservable variables: Assessing the effectiveness of Catholic schools. *Journal of Political Economy*, 113(1):151–184.

Ashraf, Q. and Michalopoulos, S. (2011). The climatic origins of the neolithic revolution: Theory and evidence. *Unpublished*.

Austin, G. (2008). Resources, Techniques, and Strategies South of the Sahara: Revising the Factor Endowments Perspective on African Economic Development, 1500-2000. *The Economic History Review*, 61(3):587–624.

Banerjee, A. and Iyer, L. (2005). History, institutions, and economic performance: the legacy of colonial land tenure systems in India. *The American Economic Review*, 95(4):1190–1213.

Bates, R. (1983). *Essays on the political economy of rural Africa.* University of California Press.

Beinart, W. (2007). Transhumance, Animal Diseases and Environment in the Cape, South Africa. *South African Historical Journal*, 58(1):17–41.

Besley, T. and Persson, T. (2008). Wars and state capacity. *Journal of the European Economic Association*, 6(2-3):522–530.

Besley, T. and Persson, T. (2009). The origins of state capacity: Property rights, taxation, and politics. *The American Economic Review*, 99(4):1218–1244.

Besley, T. and Persson, T. (2010). State capacity, conflict, and development. *Econometrica*, 78(1):1–34.

Birmingham, D. (1976). The Forest and Savanna of Central Africa. *J.E. Flint (ed.) The Cambridge History of Africa, Volume 5, c. 1790 to c. 1870*, pages 222–269.

Bisson, M. (1982). Trade and Tribute. Archaeological Evidence for the Origin of States in South Central Africa. *Cahiers d'études africaines*, 22(87):343–361.

Bockstette, V., Chanda, A., and Putterman, L. (2002). States and markets: The advantage of an early start. *Journal of Economic Growth*, 7(4):347–369.

Bovill, E. (1995). *The golden trade of the Moors: West African kingdoms in the fourteenth century*. Markus Wiener Pub.

Brice, W. C. and Kennedy, H. (2001). *An Historical Atlas of Islam*. Leiden: Brill Academic Publishers.

Brunnschweiler, C. and Bulte, E. (2008). The resource curse revisited and revised: A tale of paradoxes and red herrings. *Journal of Environmental Economics and Management*, 55(3):248–264.

Bubb, R. (2009). States, law, and property rights in West Africa. *Working Paper*.

Chanda, A. and Putterman, L. (2007). Early Starts, Reversals and Catch-up in the Process of Economic Development. *Scandinavian Journal of Economics*, 109(2):387–413.

Chandler, T. and Fox, G. (1974). *3000 years of urban growth*. Academic Press.

Damania, R., Fredriksson, P., and List, J. (2003). Trade liberalization, corruption, and environmental policy formation: theory and evidence. *Journal of Environmental Economics and Management*, 46(3):490–512.

Dell, M. (2010). The Persistent Effects of Peru's Mining Mita. *Econometrica*, 78(6):1863–1903.

Desmet, K., Le Breton, M., Ortuno-Ortin, I., and Weber, S. (2009). The stability and breakup of nations: a quantitative analysis. *Journal of Economic Growth*, 16(3):1–31.

Dixit, A. (2004). *Lawlessness and economics: alternative modes of governance*. Princeton University Press.

Dollar, D. and Kraay, A. (2003). Institutions, trade, and growth. *Journal of Monetary Economics*, 50(1):133–162.

Durante, R. (2009). Risk, Cooperation and the Economic Origins of Social Trust: An Empirical Investigation. *Job Market Paper, Brown University*.

Dutt, P. (2009). Trade protection and bureaucratic corruption: an empirical investigation. *Canadian Journal of Economics*, 42(1):155–183.

Easterly, W. and Levine, R. (1997). Africa's growth tragedy: policies and ethnic divisions. *The Quarterly Journal of Economics*, 112(4):1203.

Easterly, W. and Levine, R. (2003). Tropics, germs, and crops: how endowments influence economic development. *Journal of Monetary Economics*, 50(1):3–39.

Eltis, D. and Jennings, L. (1988). Trade between Western Africa and the Atlantic world in the pre-colonial era. *The American Historical Review*, 93(4):936–959.

Engerman, S. L. and Sokoloff, K. L. (1997). *Factor endowments, institutions, and differential paths of growth among new world economies*, pages 260–304. How Latin America Fell Behind. Essays on the Economic Histories of Brazil and Mexico, 1800-1914. Stanford University Press.

Englebert, P. (2000). Solving the Mystery of the AFRICA Dummy. *World development*, 28(10):1821–1835.

Fenske, J. (2011a). African polygamy: past and present. *Working paper*.

Fenske, J. (2011b). Does land abundance explain African institutions? *Working paper*.

Flint, E. (1970). Trade and politics in Barotseland during the Kololo period. *Journal of African History*, 11(1):71–86.

Frankema, E. and van Waijenburg, M. (2010). African Real Wages in Asian Perspective, 1880-1940. *Working Papers: Utrecht University, Centre for Global Economic History*.

Gennaioli, N. and Rainer, I. (2007). The modern impact of precolonial centralization in Africa. *Journal of Economic Growth*, 12(3):185–234.

Gennaioli, N. and Voth, H. (2011). State capacity and military conflict. *Working paper*.

Giavazzi, F. and Tabellini, G. (2005). Economic and political liberalizations. *Journal of Monetary Economics*, 52(7):1297–1330.

Glennerster, R., Miguel, E., and Rothenberg, A. (2010). Collective action in diverse Sierra Leone communities. *NBER Working Paper No. 16196*.

Gluckman, M. (1941). *Economy of the central Barotse plain*. Rhodes-Livingstone Institute.

Goldstein, M. and Udry, C. (2008). The profits of power: Land rights and agricultural investment in Ghana. *Journal of Political Economy*, 116(6).

Good, C. (1972). Salt, trade, and disease: Aspects of development in Africa's northern Great Lakes Region. *International Journal of African Historical Studies*, 5(4):543–586.

Hall, R. and Jones, C. (1999). Why do some countries produce so much more output per worker than others? *The Quarterly Journal of Economics*, 114(1):83–116.

Harrison, A., McMillan, M., and McLaren, J. (2011). Recent Perspectives on Trade and Inequality. *Annual Review of Economics*, 3(1):261–289.

Head, K., Mayer, T., and Ries, J. (2010). The erosion of colonial trade linkages after independence. *Journal of International Economics*, 81(1):1–14.

Herbst, J. (2000). *States and power in Africa: comparative lessons in authority and control*. Princeton University Press.

Ingham, K. (1975). *The kingdom of Toro in Uganda*. Methuen; New York: distributed by Harper & Row, Barnes & Noble Import Division.

Insoll, T. (2003). *The archaeology of Islam in sub-Saharan Africa.* Cambridge University Press.

Iyer, L. (2010). Direct versus indirect colonial rule in India: Long-term consequences. *The Review of Economics and Statistics*, 92(4):693–713.

Jones, E. (1981). *The European miracle: Environments, economies, and geopolitics in the history of Europe and Asia.* Cambridge University Press.

Knack, S. and Azfar, O. (2003). Trade intensity, country size and corruption. *Economics of Governance*, 4(1):1–18.

Kopytoff, I. (1964). Family and Lineage among the Suku of the Congo. *The family estate in Africa: studies in the role of property in family structure and lineage continuity*, pages 83–116.

Kopytoff, I. (1965). The Suku of Southwestern Congo. *Peoples of Africa*, pages 441–80.

Kopytoff, I. (1967). Labor allocation among the Suku. *Paper presented at conference on competing demands for the time of labor in traditional African societies.*

La Porta, R., Lopez-de Silanes, F., Shleifer, A., and Vishny, R. (2000). Investor protection and corporate governance. *Journal of financial economics*, 58(1-2):3–27.

Law, R. (1975). A West African cavalry state: the Kingdom of Oyo. *The Journal of African History*, 16(01):1–15.

Law, R. (1977). *The Oyo empire: c. 1600-c. 1836: a west African imperialism in the era of the Atlantic slave trade.* Clarendon press.

Levzion, N. (1975). The Western Maghrib and Sudan. In Gray, R., editor, *The Cambridge history of Africa: from c. 1600 to c. 1790*, pages 331–462. Cambridge University Press.

López-Córdova, J. and Meissner, C. (2005). The globalization of trade and democracy, 1870-2000. *NBER Working Paper No. 11117.*

Lovejoy, P. (1978). The role of the Wangara in the economic transformation of the central sudan in the fifteenth and sixteenth centuries. *The Journal of African History*, 19(02):173–193.

Lovejoy, P. and Baier, S. (1975). The desert-side economy of the central Sudan. *The International Journal of African Historical Studies*, 8(4):551–581.

Maddala, G. (1986). *Limited-dependent and qualitative variables in econometrics.* Cambridge University Press.

Mamdani, M. (1996). *Citizen and subject: Contemporary Africa and the legacy of late colonialism.* Princeton University Press.

McCann, J. (1999). *Green land, brown land, black land: an environmental history of Africa, 1800-1990.* James Currey.

Mehlum, H., Moene, K., and Torvik, R. (2006). Institutions and the resource curse. *The Economic Journal*, 116(508):1–20.

Michalopoulos, S. (2011). The Origins of Ethnnolinguistic Diversity. *Forthcoming in the American Economic Review.*

Michalopoulos, S., Naghavi, A., and Prarolo, G. (2010). *Trade and geography in the economic origins of Islam: theory and evidence*. Fondazione Eni Enrico Mattei.

Michalopoulos, S. and Papaioannou, E. (2011). The Long-Run Effects of the Scramble for Africa. *NBER Working Paper No. 17620*.

Michalopoulos, S. and Papaioannou, E. (2012). Pre-colonial Ethnic Institutions and Contemporary African Development. *Forthcoming in Econometrica*.

Miguel, E. and Gugerty, M. (2005). Ethnic diversity, social sanctions, and public goods in Kenya. *Journal of Public Economics*, 89(11-12):2325–2368.

Miguel, E., Satyanath, S., and Sergenti, E. (2004). Economic shocks and civil conflict: An instrumental variables approach. *Journal of Political Economy*, 112(4):725–753.

Moav, O., Neeman, Z., and Mayshar, J. (2011). Transparency, Appropriability and the Early State. *CEPR Discussion Paper 8548*.

Montalvo, J. and Reynal-Querol, M. (2005a). Ethnic diversity and economic development. *Journal of Development economics*, 76(2):293–323.

Montalvo, J. and Reynal-Querol, M. (2005b). Ethnic polarization, potential conflict, and civil wars. *American Economic Review*, 95(3):796–816.

Morton-Williams, P. (1969). The influence of habitat and trade on the polities of Oyo and Ashanti. In *Man in Africa*, pages 79–98. Tavistock Publications.

Murdock, G. (1959). *Africa: Its Peoples and Their Culture History*. Nueva York.

Murdock, G. (1967). *Ethnographic Atlas*. University of Pittsburgh Press.

Neumark, S. (1977). Trans-Saharan Trade in the Middle Ages. *An Economic History of Tropical Africa: Vol 1. The pre-colonial period*, pages 127–131.

Nunn, N. (2007). Relationship-specificity, incomplete contracts, and the pattern of trade. *The Quarterly Journal of Economics*, 122(2):569–600.

Nunn, N. (2008). The Long-Term Effects of Africa's Slave Trades. *Quarterly Journal of Economics*, 123(1):139–176.

Oliver, R. and Fage, J. (1962). *A short History of Africa*. Harmondsworth: Penguin.

Olson, M. (1993). Dictatorship, democracy, and development. *American Political Science Review*, 87(3):567–576.

Olsson, O. and Hibbs, D. (2005). Biogeography and long-run economic development. *European Economic Review*, 49(4):909–938.

Osafo-Kwaako, P. and Robinson, J. A. (2012). Political Centralization in Pre-Colonial Africa. *Working Paper*.

Papaioannou, E. and Siourounis, G. (2008). Economic and social factors driving the third wave of democratization. *Journal of Comparative Economics*, 36(3):365–387.

Prado, M. and Dincecco, M. (2012). Warfare, fiscal capacity, and performance. *Forthcoming in the Journal of Economic Growth*.

Rauch, J. and Evans, P. (2000). Bureaucratic structure and bureaucratic performance in less developed countries. *Journal of Public Economics*, 75(1):49–71.

Robinson, J. (2002). States and Power in Africa by Jeffrey I. Herbst: A review essay. *Journal of Economic Literature*, 40(2):510–519.

Rodney, W. (1972). *How Europe Underdeveloped Africa*. Bogle-L'Ouverture Publications.

Rodrik, D., Subramanian, A., and Trebbi, F. (2004). Institutions Rule: The Primacy Of Institutions Over Geography And Integration In Economic Development. *Journal of Economic Growth*, 9(2):131–165.

Sachs, J. and Warner, A. (2001). The curse of natural resources. *European Economic Review*, 45(4):827–838.

Sequeira, S. (2011). Displacing corruption. *Working paper*.

Shillington, K. (1989). *History of Africa*. Bedford Books.

Spencer, C. (1998). A mathematical model of primary state formation. *Cultural Dynamics*, 10(1):5–20.

Spencer, C. (2010). Territorial expansion and primary state formation. *Proceedings of the National Academy of Sciences*, 107(16):7119–7126.

Sundström, L. (1974). *The exchange economy of pre-colonial tropical Africa*. C. Hurst & Co. Publishers.

Taylor, B. (1962). The western lacustrine Bantu. *London: International African Institute*.

Tertilt, M. (2005). Polygyny, fertility, and savings. *Journal of Political Economy*, 113(6):1341–1374.

Tilly, C. (1992). *Coercion, capital, and European states, AD 990-1992*. Blackwell.

Treisman, D. (2000). The causes of corruption: a cross-national study. *Journal of Public Economics*, 76(3):399–458.

Vansina, J. (1966). *Kingdoms of the Savanna*. University of Wisconsin Press London.

White, F. (1983). The vegetation of Africa: a descriptive memoir to accompany the UNESCO/AETFAT/UNSO vegetation map of Africa. *Natural resources research*, 20:1–356.

Wilson, A. (1972). Long distance trade and the Luba Lomami Empire. *The Journal of African History*, 13(04):575–589.

Wooldridge, J. (2002). *Econometric analysis of cross section and panel data*. The MIT press.

APPENDIX A. MODEL

An ethnic group exists on a unit interval, stretching from 0 to 1. The natural ruler of the ethnic group lives at point 0. He chooses $S \in [0, 1]$, the fraction of the ethnic group's territory to bring under his direct jurisdiction. That is, he will choose the level of state centralization. He will do this in order to tax the inhabitants in their trading activities. I will show that greater gains from trade will lead him to centralize a larger fraction of group's territory.

The territory is inhabited by a continuum of agents of mass 1. They are spread uniformly over the interval. Each of these agents chooses between one of two activities: farming and trading. The returns from farming are normalized to 1. Farming cannot be

taxed. Trading, if successful, gives a return of $\theta > 1$. Trading can be taxed, and so an agent who lives within the centralized state pays a tax rate of $\tau \in [0, 1]$ on trade income. τ is chosen by the ruler. Agents who live outside the state pay no tax.

In addition to being taxable, trading is also costly. If the agent chooses trading, it entails a cost of q. This could represent, for example, the cost of avoiding theft or resolving disputes. The net income from trade is, then, $(1 - \tau)\theta - q$. Agents will engage in trade if $(1 - \tau)\theta - q \geq 1$.

As the ruler expands the size of the state, he provides public goods to his subjects that lower q. These could include dispute-resolution services or physical protection. In particular, if the ruler spends p units of revenue per unit of territory on public goods, the cost of trade is $q = \frac{1}{\gamma p}$. Here, γ is a parameter that captures the effectiveness of public goods. Agents outside the state receive no public goods. For them, q is infinite, and no trade is possible.

The ruler is self-interested, and maximizes his net revenues. If he brings a piece of territory under his jurisdiction, he will ensure that p and τ are set such that all of the subjects choose trade, rather than agriculture. Otherwise, he cannot collect any taxes from them. He must select p and τ such that $(1-\tau)\theta - q \geq 1$. In addition to expenditures on public goods, pS, the ruler must pay a cost to extend his authority over space. This takes the form cS^2. $c > 0$ is a parameter that captures the costs of projecting power. If the ruler controls a territory of length S, and all of the inhabitants engage in trade rather than agriculture, his net revenue will be $(\theta\tau - p)S - cS^2$. Given a state of size S, the ruler maximizes:

$$(5) \qquad V^R(S) = \max_{\tau, p}(\theta\tau - p)S - cS^2$$

$$(6) \qquad s.t.(1 - \tau)\theta - \frac{1}{\gamma p} \geq 1$$

Because net revenue is obviously increasing in τ and decreasing in p, the constraint in (6) will bind. The ruler will be compelled to choose τ and p such that $\tau = 1 - \frac{1+\gamma p}{\theta \gamma p}$. When this is substituted into (5), the ruler's problem can be solved from its first order conditions. At an interior solution, these give the ruler's optimal p and τ:

$$p^* = \sqrt{\frac{1}{\gamma}}$$

$$\tau^* = \frac{\theta - 1}{\theta} - \frac{1}{\theta\sqrt{\gamma}}$$

If $\theta\tau^* \leq p^*$, then γ and θ are such that no territory can be administered profitably. For a given S, the ruler will choose to set $\tau = p = 0$ in order to minimize his losses. The ruler's net revenue, conditional on S, can now be written as:

$$V^R(S) = \max\left\{\left(\theta - 2\sqrt{\frac{1}{\gamma}} - 1\right)S - cS^2, -cS^2\right\}$$

If the ruler maximizes this with respect to S, the degree of state centralization that maximizes the ruler's self interest is:

$$(7) \qquad S^* = \min\left\{1, \max\left\{\frac{1}{2c}\left(\theta - 2\sqrt{\frac{1}{\gamma}} - 1\right), 0\right\}\right\}$$

Define θ^L as the value of θ that solves $\theta\tau^* = p^*$. This is the minimum θ for which any state centralization is profitable. Below this threshold, the ruler does not bring any of the ethnic group's territory under his control. Similarly, define θ^H as the level of θ for which $S^* = 1$. For this level of θ and above, the ruler centralizes the entire territory. If $\theta \in (\theta^L, \theta^H)$, three results hold that highlight mechanisms by which ecologically-determined gains from trade spurred state centralization in pre-colonial Africa:

(1) $\frac{\partial S^*}{\partial \theta} > 0$. Greater gains from trade will directly increase the profitability of state centralization.

(2) $\frac{\partial S^*}{\partial c} < 0$. If greater access to trade makes it cheaper to project authority over space, centralization will increase.

(3) $\frac{\partial S^*}{\partial \gamma} > 0$. If access to trade makes the ruler more effective at providing public goods, state centralization becomes more profitable.

Table 1. Summary Statistics

	(1) Mean	(2) s.d.	(3) Min	(4) Max	(5) N
Outcomes					
State centralization	1.15	0.93	0	4	440
Any centralization	0.73	0.44	0	1	440
Local state	2.91	0.68	2	4	439
Class stratification	1.25	1.41	0	4	364
Headman appointed	0.066	0.25	0	1	320
Light density	1.50	0.18	1.15	3.34	440
Gains from trade					
Ecological diversity	0.30	0.23	0	0.80	440
Eco. Div. (FAO)	0.47	0.23	0	0.80	440
Ecological polarization	0.51	0.38	0	1.00	440
Dist. ecological boundary	0.45	0.53	0.019	2.95	440
Any diversity	0.78	0.42	0	1	440
Salt	0.42	0.88	0	6	440
Gold production	0.34	1.86	0	24	440
Iron production	0.12	0.33	0	1	440
% dep. on fishing	8.32	10.9	0	70	440
Controls					
Major river	0.23	0.42	0	1	440
Ag. constraints	5.41	1.06	2.94	8.92	440
Dist. coast	5.54	3.76	0	14.9	440
Elevation	728	520	-7.41	2,308	440
Malaria	0.83	0.27	0	1	440
Precipitation	846	468	0	2,474	440
Ruggedness	71,792	70,413	0	421,381	440
Temperature	8,882	1,112	5,295	10,699	440
Dist. L. Victoria	2,198	1,438	131	5,708	440
Date observed	1,919	21.6	1,830	1,960	440
Dist. Atlantic ST	6,688	1,515	3,671	9,949	440
Dist. Indian ST	4,546	1,589	1,028	7,953	440
Dist. Saharan ST	3,333	975	806	6,999	440
Dist. Red ST	2,887	1,360	107	5,773	440
Crop: None	0.025	0.16	0	1	440
Crop: Trees	0.084	0.28	0	1	440
Crop: Roots/tubers	0.19	0.39	0	1	440
Other variables used					
Log rainfall range	5.18	1.01	1.39	7.42	370
Area	2.43	3.64	8.2e-06	27.0	440
Pop. density	22.2	28.5	0	311	440
Ag. constraints range	4.66	1.95	0	9	440
Subsistence diversity	0.52	0.12	0.13	0.74	440

Table 2. Ecological diversity predicts states

	(1)		(2)		(3)		(4)	
				State centralization				
	Sub-Saharan Africa				*Whole world*		*Excl. sub-Saharan Africa*	
Ecological diversity	0.794***		0.719***					
	(0.266)		(0.239)					
Eco. Div. (FAO)					0.913***		0.713***	
					(0.199)		(0.236)	
Other controls	No		Yes		Yes		Yes	
Observations	440		440		1,077		637	
Pseudo R-squared	0.0111		0.070		0.122		0.163	
				Marginal effects				
	Continuous	*> median*	*Continuous*	*> median*	*Continuous*	*> median*	*Continuous*	*> median*
0 levels	-0.259***	-0.108***	-0.225***	-0.090***	-0.363***	-0.123***	-0.270***	-0.081*
	(0.087)	(0.033)	(0.070)	(0.025)	(0.079)	(0.037)	(0.092)	(0.045)
1 level	-0.022	-0.009	-0.024	-0.010	0.119***	0.039***	0.124***	0.036**
	(0.038)	(0.016)	(0.030)	(0.012)	(0.036)	(0.014)	(0.044)	(0.019)
2 levels	0.152***	0.063***	0.152***	0.061***	0.138***	0.047***	0.074***	0.022*
	(0.052)	(0.019)	(0.051)	(0.018)	(0.032)	(0.015)	(0.026)	(0.013)
3 levels	0.118***	0.050***	0.093***	0.038***	0.084***	0.029***	0.053**	0.016
	(0.044)	(0.018)	(0.035)	(0.013)	(0.020)	(0.010)	(0.022)	(0.011)
4 levels	0.010	0.004	0.004	0.002	0.022***	0.008**	0.019*	0.006
	(0.008)	(0.003)	(0.004)	(0.001)	(0.008)	(0.003)	(0.010)	(0.005)

*** p<0.01, ** p<0.05, * p<0.1. Regressions estimated by ordered probit. Standard errors in parentheses clustered by region. Coefficient estimates where ecological diversity is replaced with an "above median" indicator are not reported. Other controls in columns (1) and (2) are major river, agricultural constraints, distance to coast, elevation, malaria, precipitation, ruggedness, temperature, distance to Lake Victoria, distance from the four major slave trades, and dummies for crop type, unless otherwise specified. Other controls in columns (3) and (4) are land quality, distance from coast, elevation, malaria, rainfall, temperature, date, crop dummies, major river, ruggedness and absolute latitude.

Table 3. The main result holds with alternative measures of states and diversity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Any cent.	*Cent. > 1*			*State centralization*			
Ecological diversity	0.272**	0.271***						
	(0.126)	(0.096)						
Dist. ecological boundary			-0.303***					
			(0.069)					
Ecological polarization				0.370***				
				(0.132)				
Any diversity					0.355**			
					(0.145)			
Ecological diversity (Simpler classes)						0.806**		
						(0.316)		
Ecological diversity (High density areas)							0.643***	
							(0.210)	
Eco. Div. (FAO)								0.996***
								(0.281)
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	440	440	440	440	440	440	440	440

*** $p<0.01$, ** $p<0.05$, * $p<0.1$. Regressions estimated by ordered probit with coefficients reported, except with "any centralization" as the outcome, in which case probit is used with marginal effects reported. Standard errors in parentheses clustered by region. Other controls are major river, agricultural constraints, distance to coast, elevation, malaria, precipitation, ruggedness, temperature, distance to Lake Victoria, distance from the four major slave trades, and dummies for crop type, unless otherwise specified.

Table 4. The main result is robust to reverse causation

	(1)	(2)	(3)	(4)
	OLS: Baseline		*IV*	
	State centralization			
Ecological diversity	0.559***	0.606***	2.676***	3.840***
	(0.167)	(0.188)	(0.949)	(1.472)
Other controls	Yes	Yes	Yes	Yes
Observations	440	370	440	370
F-statistic			66.80	16.17
	(5)	(6)	(7)	(8)
	OLS: Reduced form		*OLS: First Stage*	
	State centralization		*Ecological diversity*	
Log rainfall range	0.090***	0.185**	0.034***	0.048***
	(0.029)	(0.076)	(0.004)	(0.011)
Other controls	Yes	Yes	Yes	Yes
Observations	440	370	440	370

*** $p<0.01$, ** $p<0.05$, * $p<0.1$. Standard errors in parentheses clustered by region. Other controls are major river, agricultural constraints, distance to coast, elevation, malaria, precipitation, ruggedness, temperature, distance to Lake Victoria, distance from the four major slave trades, and dummies for crop type, unless otherwise specified. The excluded instrument is the log rainfall range. In columns 3, 5, and 7, missing values of the log rainfall range are recoded to zero. In columns 2, 4, 6, and 8, these observations are excluded.

Table 5. The main result is robust to unobserved heterogeneity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Including area shares	Latitude longitude cubic	Spatially correlated errors	Spatial lag	Conley's OLS	Including neighbors' X	Interactions with de-meaned controls
				State centralization			
Ecological diversity	0.981***	0.673***	0.508**	0.532***	0.559***	0.583***	0.748***
	(0.284)	(0.212)	(0.216)	(0.200)	(.199)	(0.200)	(0.259)
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	440	440	440	440	440	440	440
Wald test (λ=0)			1.221				
Wald test (ρ=0)				4.428			
WX p						0	
Moran p						0.273	

	(8)	(9)	(10)	(11)	(12)	(13)
	Nearest neighbor matching	Altonji-Elder-Taber Statistic	Ethno. region F.E.	UN region F.E.	Country F.E.	Lang. family F.E.
			State centralization			
Ecological diversity			0.336*	0.521**	0.325*	0.347**
			(0.170)	(0.183)	(0.164)	(0.140)
Above Median Diversity SATE	0.265***					
	(0.100)					
Altonji-Elder-Taber Statistic		4.77				
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	440	440	440	440	440	437

*** p<0.01, ** p<0.05, * p<0.1. Regressions estimated by ordered probit with coefficients reported, excepting the spatial estimators as noted in the text, and columns (10) through (13), which are OLS. Standard errors in parentheses clustered by region, excepting spatial estimators as noted in the text. Other controls are major river, agricultural constraints, distance to coast, elevation, malaria, precipitation, ruggedness, temperature, distance to Lake Victoria, distance from the four major slave trades, and dummies for crop type, unless otherwise specified.

Table 6. The Ricardian interpretation better explains the main result than six alternatives

	(1) Artificial countries	(2) Artificial countries	(3) Drop Area Q1	(4) Drop Area Q5	(5) Drop Area Q1 and Q5
			State centralization		
Ecological diversity	0.450***	0.418***	0.890***	0.671**	0.982***
	(0.114)	(0.120)	(0.274)	(0.264)	(0.288)
No. of Ethnic Groups		0.105***			
		(0.039)			
Other controls	Yes	Yes	Yes	Yes	Yes
Observations	1523	1523	440	440	440

	(6)	(7)	(8)	(9)
		State centralization		
Ecological diversity	0.686***	0.548**	0.697***	0.731***
	(0.233)	(0.259)	(0.234)	(0.240)
Area	0.019			
	(0.023)			
Ag. Constraints Range		0.065*		
		(0.036)		
Pop. density			0.001	
			(0.002)	
Subsistence diversity				-0.328
				(0.557)
Other controls	Yes	Yes	Yes	Yes
Observations	440	440	440	440

*** p<0.01, ** p<0.05, * p<0.1. Regressions estimated by ordered probit with coefficients reported. Standard errors in parentheses clustered by region. Other controls are major river, agricultural constraints, distance to coast, elevation, malaria, precipitation, ruggedness, temperature, distance to Lake Victoria, distance from the four major slave trades, and dummies for crop type, unless otherwise specified.

Table 7. The Ricardian interpretation is consistent with the histories of six influential states

	(1) Name	(2) Cent.	(3) dfbeta	(4) Name	(5) Cent.	(6) dfbeta
	Songhai	3	0.18	Luba	3	0.11
	Yoruba	3	0.18	Kunama	0	0.11
	Chiga	0	0.16	Rundi	3	0.09
	Laketonga	0	0.15	Fur	3	0.09
	Bagirmi	3	0.15	Akyem	2	0.09
	Lozi	3	0.15	Tigon	0	0.09
	Toro	3	0.15	Lokele	0	0.08
	Barea	0	0.12	Bombesa	0	0.08
	Shuwa	2	0.12	Suku	3	0.08
	(7) Yoruba	(8) Songhai	(9) Toro	(10) Suku	(11) Luba	(12) Lozi
Participated in trade?	Yes	Yes	Yes	Yes	Yes	Yes
Trade a source of wealth?	Yes	Yes	Yes	Unclear	Yes	Yes
Trade a source of state power?	Yes	Yes	Yes	Yes	Yes	Yes
No capture of trading regions?	Yes	Yes	No	Yes	No	Yes

These summarize the results of the case studies described in the text.

Table 8. Trade supports class stratification, and no one type of trade matters most

	(1)	(2)	(3)	(4)	
	Local state	Class Stratification	Headman is appointed	High gods	
Ecological diversity	-0.200	1.514***	0.035	-0.029	
	(0.249)	(0.221)	(0.136)	(0.884)	
Other controls	Yes	Yes	Yes	Yes	
Observations	439	364	320	242	
	(5)	(6)	(7)	(8)	(9)
			State centralization		
% dep. on fishing	0.003				
	(0.004)				
Iron production		0.041			
		(0.164)			
Gold production			0.020		
			(0.016)		
Salt				0.032	
				(0.055)	
Hist. trade route					0.526***
					(0.158)
Other controls	Yes	Yes	Yes	Yes	Yes
Observations	440	440	440	440	440

*** p<0.01, ** p<0.05, * p<0.1. Regressions estimated by ordered probit with coefficients reported, except column (5), which is OLS. Standard errors in parentheses clustered by region. Other controls are major river, agricultural constraints, distance to coast, elevation, malaria, precipitation, ruggedness, temperature, distance to Lake Victoria, distance from the four major slave trades, and dummies for crop type, unless otherwise specified.

Table 9. Ecological diversity is an instrument for state centralization

	(1) OLS	(2) IV
	Light Density	
State centralization	0.279***	0.810**
	(0.066)	(0.361)
Other controls	Yes	Yes
Country FE	Yes	Yes
Kleibergen-Paap F		12.09
Observations	683	683

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses clustered by region. Other controls are distance to capital, distance to coast, distance to border, log water area, log land area, elevation, suitability for agriculture, malaria ecology, petroleum and diamonds.