Does land abundance explain African institutions?

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DOES LAND ABUNDANCE EXPLAIN AFRICAN INSTITUTIONS?

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ABSTRACT. I show that abundant land and scarce labor shaped African institutions before colonial rule. I test a model in which exogenous land quality and endogenously evolving population determine the existence of land rights and slavery. I use cross-sectional data on a global sample of societies to demonstrate that, as in the model, land rights occurred where land quality was high and where population density was greatest. Slavery existed where land was good and population density was intermediate. The model predicts institutional differences across regions, but not within regions. I present suggestive evidence that this is due to institutional spillovers.

1. INTRODUCTION

The "land abundance" view of African history is an influential explanation of the economic institutions that existed on the continent before colonial rule (Austin, 2008a; Hopkins, 1973; Iliffe, 1995). This theory holds that, since uncleared land was freely available, land had no price, and rights to land were ill-defined. Because cultivators would not become free workers, coerced and household labor substituted for wage employment. Lagerlöf's (2010) model of "slavery and other property rights" mirrors these arguments in a formal model. In this paper, I use cross-sectional data on a sample of global societies to test this view. I show that land rights and slavery existed in those regions predicted by the model, but that institutional spillovers prevent the model from predicting differences within broad geographic regions.[1]

The pre-colonial institutions explained by the "land abundance" view constrained the actions of colonial powers (e.g. Austin (2008b)). As a result, pre-colonial institutions

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[1]In earlier versions of this paper, I extended the model to include raiding of neighboring societies for slaves and an explanation for polygyny. These have been removed. Earlier, I used only African data. Now I use data from the whole world, and so the results are now different.

and the forces that shaped them affect current performance in Africa (e.g. Gennaioli and Rainer (2007) or Tertilt (2005)). It is well established in economics that institutions matter (Acemoglu et al., 2001; Dell, nd). Land rights and slavery, in particular, continue to affect outcomes in Africa and in the rest of the world. Land tenure shapes investment incentives (Goldstein and Udry, 2008), labor-supply (Field, 2007), and violence (Andre and Platteau, 1998). Nunn (2008) shows that those African countries that exported the most slaves are comparatively poor today. The pre-colonial prevalence of indigenous slavery is negatively correlated with current income within Africa (Bezemer et al., 2009). Within the Americas, legacies of slavery explain differences in income across countries and U.S. counties (Engerman and Sokoloff, 1997; Nunn, 2007), as well as long term racial gaps in education and other measures (Miller, 2008; Sacerdote, 2005). Explaining pre-colonial land tenure and slavery is, then, important in understanding African poverty.

The "land abundance" view of African history argues that the continent's geography has given it an abundance of land relative to labor, which explains the general features of its development. In other contexts, geographic features, such as continental orientation, ruggedness, settler mortality, suitability for specific crops, and other biogeographic endowments predict contemporary institutional differences across countries (Bubb, 2009; Easterly and Levine, 2003; Engerman and Sokoloff, 1997; Nunn and Puga, 2007). The model I test, from Lagerlöf (2010), similarly allows geography to shape institutions. There are two important variables determining land rights and slavery. The first is exogenous land quality. This increases the returns to landownership, compensates for the inefficiencies of slavery, and sustains greater populations in the Malthusian steady state. The second is population, which responds to both the geographic and institutional environments. It shapes the relative values of land and labor and the relative costs of free and forced workers.

I test this thesis. I use data on a cross-section of global societies from Murdock's (1967) Ethnographic Atlas to support a model of land rights and slavery in which the land-labor ratio determines the institutions that exist. I find that the model correctly predicts that land rights and slavery were found in those societies that occupied the best land, and that greater population densities were correlated with rights over land. Slavery was present when population densities were intermediate, as in the model. While the model predicts differences across regions, there are forms of slavery that it cannot predict, and it is not capable of predicting differences within regions.

In Section 2, I outline the literature in African history on how land abundance has shaped economic institutions. Here, I present the basic features of the model and its testable implications. In Section 3, I describe the data used and lay out the econometric specifications. In Section 4, I report the results of these tests. In Section 5, I show that these results are robust to different measures of the institutional outcomes, alternative proxies for land quality and historical population density, and the possible endogeneity of land quality. I also argue that the present theory of slavery better explains the data than some prominent alternatives. While the model is generally robust to removing influential observations, some exceptions suggest the mechanisms by which institutional transitions occur. In Section 6, I demonstrate that the model is unable to predict differences within regions, and that there is substantial spatial correlation in institutional outcomes. This is consistent with what anthropologists call "Galton's problem" – the lack of independence in cultural observations. In Section 7 I conclude. In the appendix, I provide further evidence in favor of the "land abundance" view by using it to explain institutions and institutional in one Nigerian society, summarizing an argument I have made elsewhere.[2]

2. The land abundance view of African history

2.1. **The literature.** A first-order task in African history is explaining the continent's long-run differences in economic organization from the rest of the world. The starting point of the land abundance view is the difference in settlement patterns between Africa and the rest of the world on the eve of colonial rule. Herbst (2000, p. 16) estimates the population density of Sub-Saharan Africa in 1900 at 4.4 persons per Sq. Km, contrasted with 38.2 for South Asia, 45.6 for China, and 62.9 for Europe.[3] Explanations of low African population densities stress geographic factors, the disease environment, and historical factors such as the slave trades (Mahadi and Inikori, 1987, p. 63-64). This sparse settlement, Hopkins (1973, p. 23-27) argues, shaped institutions, because Africans "measured wealth and power in men rather than in acres."[4] Here, I focus on the implications for land rights and slavery.

Before the Atlantic slave trade, Africa was characterized by settled clearings surrounded by vast wastelands in the Equatorial region, circles of increasingly wild vegetation in the West African forest, and clusters with oscillating frontiers in the West African Savanna (Iliffe, 1995, p. 36,64-67). Austin (2009, p. 33) argues that, as a consequence, land was "easily and cheaply accessible in institutional terms"; pre-colonial authorities were eager to attract "more people with whom to subdue nature and, if necessary, their neighbors," so that strangers could generally acquire land indefinitely for token payments. These payments were made solely to acknowledge the sovereignty of the local authorities. Citizens were given land virtually freely. Austin (2008a, p. 591-594) notes that 'islands' of intensive agriculture have existed where insecurity has created artificial land scarcity and in specific locations of exceptional value. These had minerals, trees, market access, or suitability for particular crops.

[2]"Land abundance and economic institutions: Egba land and slavery, 1830-1914", forthcoming, *Economic History Review*.
[3]His estimate for North Africa is 9.4 persons per Sq. Km.
[4]Austin (2008a, p. 589) argues that Hopkins was the first to make this analysis systematic; earlier writers on Africa did account for the existence of slavery, for example, by noting Africa's land abundance – see Dowd (1917).

Against these views, Spear (1997, p. 154-157) argues that population density cannot explain individual cases. While on Mount Meru both the Arusha and the Meru intensified their agriculture as population rose, the less densely settled Meru did so more readily. Berry (1988), similarly, has noted that inheritance rules, tenancy contracts, and labor arrangements often prevent tree crops from leading to individualized land tenure in West Africa. Thornton (1992, p. 75-76) suggests that ownership of land results from legal claims, not population pressure. In Section 4, I show that the institutional effects of population and agricultural productivity are systematic, even if they are not deterministic.

For Austin (2008a, p. 606-610), scarcity of labor explains African use of extensive agriculture, dry season crafts and industries, and forced labor. With some notable exceptions (Rodney, 1966), slavery was prevalent in much of Africa even prior to the Atlantic slave trade (Fage, 1969). Watson (1980, p. 10) suggests that the ability of slaves and their descendants to assimilate into their owners' lineages was a "logical extension of the institutionalized need for more people." Land abundance has been used to explain differences across societies. Northrup (1979) contrasts the densely-settled Igbo of the palm belt with the relatively sparsely populated northeastern Igbo during the palm oil trade. Slavery did not expand in the palm belt, while the northeastern Igbo used slaves to colonize new land.

The use of underpopulation to explain African slavery is controversial. Writers such as Kopytoff and Miers (1977, p. 68-69), Lovejoy (1978, p. 349), or Miers and Klein (1998, p. 4-5) have stressed that they were employed in non-economic uses, distributed by non-market means, and that colonial rulers turned a blind eye to slavery for political reasons. I show that the presence of slavery is systematically related to the economic value of slaves and to population. Kopytoff (1987, p. 46) and Goody (1980, p. 26-31) suggest that dependents must be "seduced" rather than coerced, so slavery can only exist in complex societies and states with "well-developed systems of compulsion." The model I test demonstrates that high opportunity costs of coercion at low population densities can be incorporated into a model in which slavery is explained by the high cost of free labor.

2.2. **Model.** In this paper, I test the model of "slavery and other property rights" from Lagerlöf (2009). This is for two reasons. First, his model echoes the arguments made by historians of Africa, making explicit the testable implications of their views. Greater population lowers average product, which is shared equally in an egalitarian regime. This creates incentives to create rights over land. Similarly, the relative costs of land rights and slavery are determined by the competitive wage, which is itself a function of population size. If population pressure increases labor supply and depresses the wage, free labor becomes profitable relative to keeping slaves.

Second, his model extends the "land abundance" literature. If population is sufficiently low, slavery will not exist, since population pressure has not adequately depressed the returns to an egalitarian sharing of output while the opportunity costs of wasting labor on coercion remain high. This reconciles the land abundance view with the critiques of Kopytoff and Goody. In addition, the quality of land determines both the relative profitability of institutional regimes for a given population and the level of population that can be supported. This variable has been generally neglected by the Africanist literature. Here, I briefly sketch the basic elements of the model and state its testable implications.

The model takes a society in period t with a population P_t of non-elite agents and a comparatively small elite that does not work. The elite chooses institutions. Output Y_t depends on land M, land-augmenting productivity $\tilde{A}_t$, and the labor used L_t:

$$Y_t = (M\tilde{A}_t)^\alpha L_t^{1-\alpha} \equiv A_t^\alpha L_t^{1-\alpha}. \tag{1}$$

At the beginning of each period, the elite chooses between three regimes based on which one yields them the greatest profits π_t^i, where i denotes one of three institutional regimes. The first is egalitarianism. Under this arrangement, there are no land rights or slavery. The elite and the non-elite each receive average product, and so:

$$\pi_t^E = \left(\frac{A_t}{P_t}\right)^\alpha. \tag{2}$$

The second possible outcome is slavery. Here, the elite enclose the entire land, creating rights over it. They enslave S_t slaves from the population, paying them only subsistence income $\bar{c}$. Each slave requires γ guards, who are also paid $\bar{c}$, and so the elite payoff is:

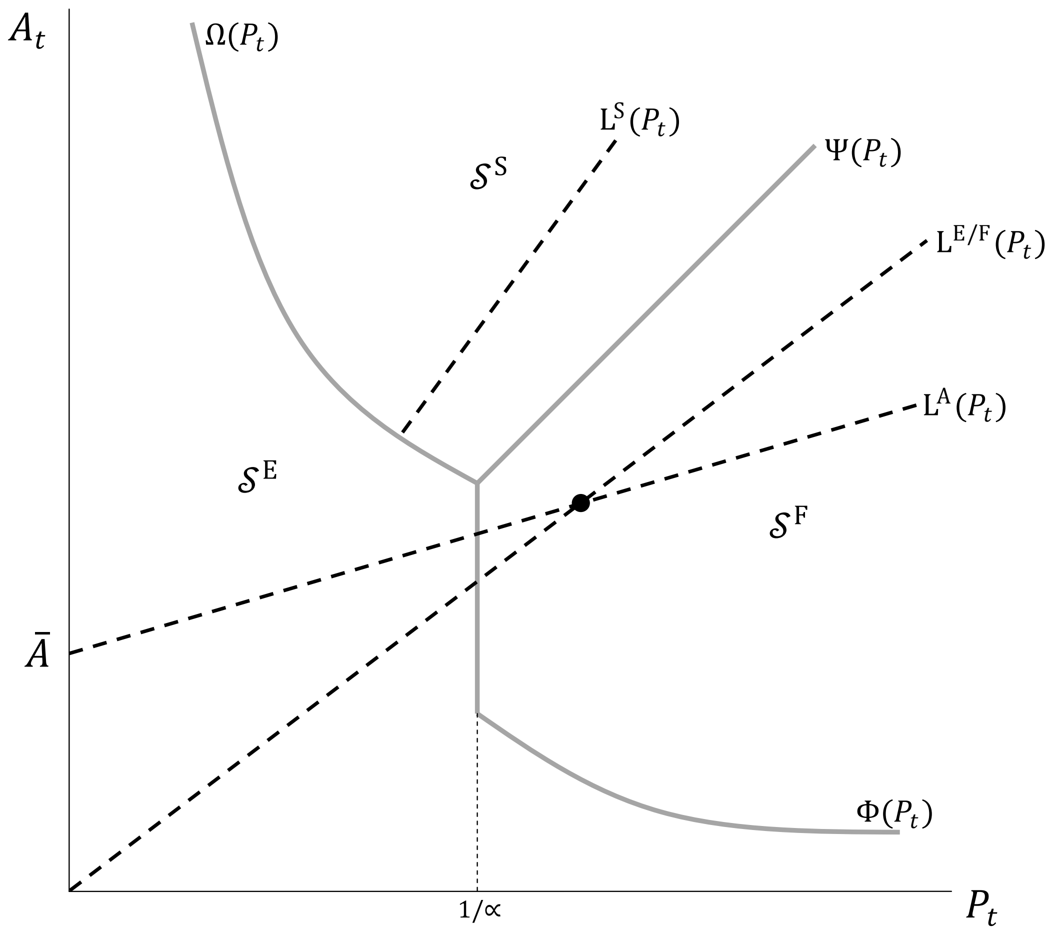
$$\pi_t^S = \max_{S_t \le P_t/(1+\gamma)} \{A_t^\alpha S_t^{1-\alpha} - (1+\gamma)\bar{c}S_t\}. \tag{3}$$

The third possible outcome is free labor. Again, the elite enclose the entire land. Now, however, they hire members of the population at a competitive wage w_t. The elite's payoff is:

$$\pi_t^F = \max_{L_t \ge 0} \{A_t^\alpha L_t^{1-\alpha} - w_t L_t\}. \tag{4}$$

Lagerlöf (2009) shows that the state space in A_t and P_t can be divided into three sets: $\mathcal{S}^E$, in which the elite prefer egalitarianism; $\mathcal{S}^S$, in which they prefer slavery, and; $\mathcal{S}^S$, in which they prefer free labor. The boundaries of these regions are defined by three functions of P_t: $\Psi(P_t)$, $\Omega(P_t)$, and $\Phi(P_t)$. These are depicted in Figure 1.

FIGURE 1. Institutional regions and dynamics



The slavery region, $\mathcal{S}^S$, is where $A_t \geq \max\{\Psi(P_t), \Omega(P_t)\}$, and $P_t > (1+\gamma)^{1-\alpha}$. $A_t \geq \Psi(P_t)$ implies that population given A_t is still sufficiently low that w_t is high relative to the cost of keeping slaves. $A_t \geq \Omega(P_t)$ implies that population is sufficiently dense that the average product under egalitarianism has fallen, while high productivity also ensures the elite is willing to waste some labor on guarding slaves in order to take a greater share of output for themselves. The opportunity cost of these guards is particularly high when population is very low, which explains both the slope of $\Omega(P_t)$ and the condition that $P_t > (1+\gamma)^{1-\alpha}$.

$\mathcal{S}^F$ is the free labor region, in which $\Phi(P_t) \leq A_t \leq \Psi(P_t)$ and $P_t > 1/\alpha$. $P_t > 1/\alpha$ ensures that population is great enough that the average product has fallen, making enclosure worthwhile. $A_t \leq \Psi(P_t)$ occurs when population growth pushes down wages sufficiently relative to the costs of keeping slaves. The condition that $\Phi(P_t) \leq A_t$ is of less interest, driven by an assumption that the wage is bounded below by $\bar{c}$. $\mathcal{S}^E$ occurs in the remainder of the state space, where average product and the counterfactual wage are both relatively high.

The dynamics of the model are Malthusian and Boserupian. They are Malthusian in that fertility is increasing in income. Two upward-sloping zero population growth lines exist – one under slavery and one under egalitarianism and free labor. To the left of these, income is high and population is growing. To the right, income is low and population is falling. These are shown in Figure 1 as $\mathbf{L}^{E/F}(P_t)$ and $\mathbf{L}^{S}(P_t)$.

The dynamics are Boserupian in that agricultural technology in period $t+1$ has an intercept of $\bar{A}$ and depends positively on both A_t and P_t. Lagerlöf (2009) takes $\bar{A}$ as the "minimum level of agricultural technology," and I interpret it as exogenous land quality. The result is an upward-sloping zero-technological-growth line $\mathbf{L}^{A}(P_t)$. Above this, productivity degrades, while below this it improves. This is also shown in Figure 1. A steady state exists where either $\mathbf{L}^{E/F}(P_t)$ or $\mathbf{L}^{S}(P_t)$ intersects $\mathbf{L}^{A}(P_t)$. Figure 1 depicts a steady state in the free labor region.

What are the testable implications of this model and, by extension, the land abundance view? First, land quality $\bar{A}$ should positively predict the existence of land rights and slavery. Land rights do not exist under egalitarianism, and if $\bar{A}$ is too low, it is impossible to support a steady state under either regime. Similarly, $\bar{A}$ must be high in order for a steady state to exist with slavery. However, since larger values of $\bar{A}$ can support steady states in both the slavery and free labor regions, the relationship between $\bar{A}$ and slavery is expected to be weaker than for land rights. Second, population density, which I take as corresponding to P_t in the model, will predict land rights and slavery. While this is an endogenous variable, this is still a correlation implied by the model. For land rights to exist, P_t must be greater than the cutoffs implied by $\Omega(P_t)$, $1/\alpha$, and $\Phi(P_t)$. For slavery to exist, P_t must be great enough that enclosure of land is worthwhile and the opportunity costs of coercion are not too high, but also sparse enough that wages are not too low. It must, then, be between the cutoffs implied by $\Omega(P_t)$ and $\Psi(P_t)$. It is the implied relationships between land quality, population density, land rights, and slavery that I test in assessing the ability of the "land abundance view" to explain pre-colonial institutions in Africa.

3. Data and Specifications

In this section, I outline how I test the two predictions of the model described above. I use a cross section of data on 1,206 societies. In Section 3.1 I detail the specific econometric specifications that I use. In Section 3.2, I describe the sources of data on institutions, the proxies for the variables $\bar{A}$ and P_t in the model, and the additional controls that I include.

3.1. **Specifications.**

The first prediction of the model is that raising $\bar{A}$ will make it possible for steady states to exist with land rights or slavery. I test this by estimating:

$$y_i = \alpha + \beta_A A_i + X_i'\gamma + \epsilon_i, \tag{5}$$

TABLE 1. Summary statistics

[Table 1 here]

where y_i is an outcome of interest for soceity i, A_i is a proxy for land quality (analogous to $\bar{A}$ in the model), X_i is a matrix of geographical controls, and ϵ_i is random error. (5) is estimated as a probit with heteroskedasticity-robust standard errors. I expect that $\beta_A > 0$ when y_i is an indicator for land rights or slavery.

The second implication of the model is that land rights exist at higher levels of P_t, while slavery exists at intermediate levels of P_t. I test these by estimating:

$$y_i = \alpha + \beta_p \ln(1 + p_i) + X_i'\gamma + \epsilon_i, \tag{6}$$

and

$$y_i = \alpha + \beta_{p1} \ln(1 + p_i) + \beta_{p2}(\ln(1 + p_i))^2 + X_i'\gamma + \epsilon_i, \tag{7}$$

where (abusing notation) y_i, X_i, and ϵ_i are defined as in (5). p_i is population density, the proxy used for P_t. The unusual functional form comes from a visual inspection of the data – slavery peaks towards the left hand side of the distribution, while a strict logarithmic specification gives undue influence to very sparsely settled societies. These are also estimated as probit models. I expect that $\beta_p > 0$, $\beta_{p1} > 0$, and $\beta_{p2} < 0$.

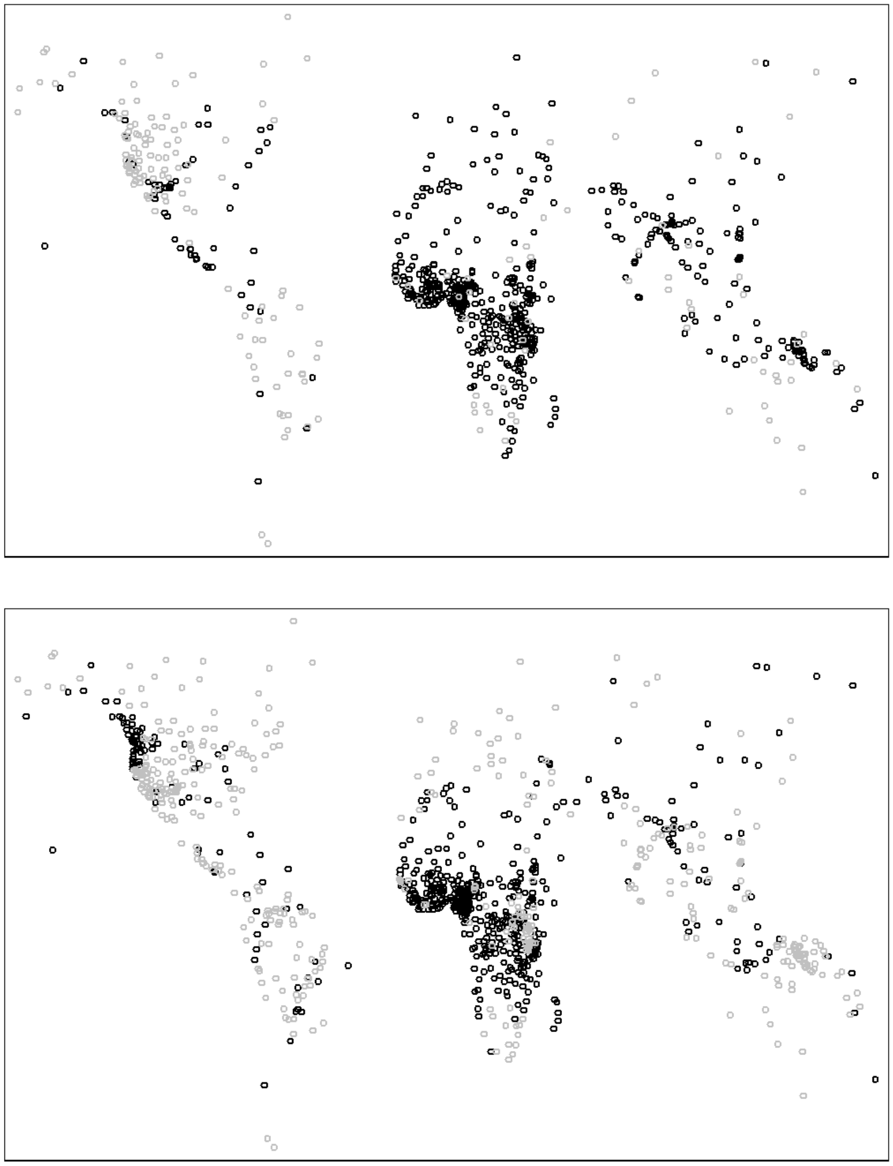
3.2. **Data.** I use two types of data to test the ability of the model to explain institutional differences across societies. The first covers institutions, and is taken from Murdock's (1967) *Ethnographic Atlas*. Published in 29 installments of the journal *Ethnology* between 1962 and 1980, the Atlas is a database of 1267 societies from around the world.[5] It contains categorical variables describing several institutional and cultural features of these societies, often at the time of first contact with Europeans. From this sample, I remove 2 duplicate observations (the Chilcotin and Tokelau), 8 societies from before 1500 (Anc Egypt, Aryans, Babylonia, Romans, Icelander, Uzbeg, Khmer, Hebrews), and 51 for which land quality information is missing (mostly small Pacific islands). This leaves a base sample of 1206 societies. 801 of these have data on land rights, 1041 on slavery.

Two variables from the Ethnographic Atlas are used to construct binary dependent variables, and summary statistics for these are given in Table 1.[6] Indicators are used for whether individual land rights or slavery exist. I map these variables by the latitude and longitude coordinates of each society in Figure 2.

[5]A revised version of the Atlas has been made available for download in SPSS format by J. Patrick Gray at http://eclectic.ss.uci.edu/~drwhite/worldcul/EthnographicAtlasWCRevisedByWorldCultures.sav. This is the version used for the present study.

[6]These are: V74: Inheritance Rule for Real Property (Land) and V70: Type of Slavery. The definitions of the binary variables are: 1) Land rights exist if V74$\neq$1, 2) slavery exists if V70 $>$ 1.

FIGURE 2. Land rights and slavery



Land rights are on top, slavery on bottom. Black circles indicate presence, grey circles absence.

Why use this data? The principal justification is availability. This is the only source of cross-cultural information on land rights and slavery of which I am aware that has global scope. The only other alternative, the *Standard Cross-Cultural Sample* (SCCS) of Murdock and White (1969), is a derivative of the *Ethnographic Atlas*. It contains a smaller sample of societies and a greater number of ethnographic variables. Throughout the analysis, I validate the measures I use by showing that they are correlated with alternatives from the *SCCS*. In addition, the measures in the *Ethnographic Atlas* are internally consistent, having been compiled by the same author.

The greatest concern with these data are that they may be anachronistic. They are intended to cover societies at an idealized, timeless and synchronic moment of first European description. In practice, however, many of the observations are constructed from the works of colonial anthropologists. It is clear from Figure 2, however, that most of the observations are intended to be uncontaminated by colonial rule. While colonial governments generally abolished slavery sooner or later, what is coded in the data is what anthropologists recorded as a society's "historical" institutions; there is still much of slavery in Africa according to the *Atlas*. In so far as the date at which a society is observed is a proxy for colonial effects and the severity of measurement error, I control for it in the econometric analysis.

The second type of data used includes features of the natural environment. These are joined to the data from the *Ethnographic Atlas* using one of five map sources. First, African societies were joined to one or more ethnic groups mapped by Murdock (1959) in his "Tribal Map of Africa." Second, First Nations groups in the United States and Canada were joined to the maps that begin the volumes the *Handbook of North American Indians* (Heizer et al., 1978), digitized for the United States by Dippel (2010) and for Canada by myself. Third, ethnic groups from the rest of the world were joined to Global Mapping International's (GMI) detailed World Language Mapping System. Fourth, if no match could be found in the GMI map, the less detailed Geo-Referencing Ethnic Groups (GREG) map created by Weidmann et al. (2010) was used. Finally, if no suitable match could be found in any of these, groups were matched with modern administrative boundaries manually. For example, the Dieri are matched with Australia's "Unincorporated Far North," while the Nunivak are matched to Nunivak Island. Not all societies could be matched exactly. Of 1,267, 100 were matched to a different group indicated in the same location (such as the Wiyambitu matched to the Shoshone Panamint) while 76 were matched to a larger group of which they form a smaller part (such as the Efik to the Ibibio). A full table of matches are given in the web appendix.

Once these matches are formed, geographic raster data is joined to them by taking the average of the points within an ethnic group's territory. Summary statistics for these variables are presented in Table 1. Two of these controls are of particular importance – land quality and population density.

3.2.1. *Land quality.* The variable used to capture land quality is based on Fischer et al.'s (2002) measure of combined climate, soil and terrain slope constrains. This is re-scaled as a standard normal variable between 0 and 1, with larger values indicating an absence of environmental constrains on rainfed agriculture. This is treated as a proxy for the variable $\bar{A}$ in the model.

The constraints measure was constructed as part of the Food and Agriculture Organization's Global Agro-Ecological Zones (FAO-GAEZ) methodology.[7] This methodology

[7]See `http://www.iiasa.ac.at/Research/LUC/GAEZ/index.htm`

combines multiple sources of data on climate, soils, and landform to quantify the expected productivity of all feasible land use and management options on a global scale. The constraints measure is not particular to any particular crop or technology, and is a non-additive combination of three components:

(1) *Climate constraints:* The coldness constraint is "moderate" if there are fewer than 180 days with an average temperature below 5°C, and "severe" if there are fewer than 120. Aridity constraints are moderate if there are less than 120 days with an average temperature below 5°C during which moisture conditions are adequate to permit crop growth and severe if there are less than 60.
(2) *Soil constraints:* Five characteristics of soils are considered – depth, fertility, drainage, texture and chemical constraints. "Medium" and "shallow" depth are moderate and severe constraints, respectively. "Medium" and "low" fertility are treated similarly as moderate and severe constraints. "Poor" drainage is a severe constraint. Sandy and stony soils are severe constraints, and cracking clay is a moderate constraint. Salinity, sodicity, and gypsum are severe chemical constraints.
(3) *Terrain slope constraints:* Terrain slopes greater than 8% are "moderate" constraints, and slopes greater than 30% are "severe."

Climate constraints and soil texture are clearly exogenous. Given the manner in which they are measured, it is unlikely that terrain slope, drainage, and chemical constraints are consequences of institutions. It is possible, however, that societies that developed slavery or rights over land were able to avoid degrading the soil depth and fertility. Since these are only two components of a larger measure, the bias should be small. In addition, the direct measures of soil depth and fertility constraints can be added as additional controls. All results for land quality are robust to the inclusion of soil depth and fertility as separate control variables.

3.2.2. *Population density.* Constructing historical estimates of population density is guesswork. One book on estimates for pre-Columbian America is entitled "Numbers from Nowhere" (Henige, 1998). For Africa, Manning (1990) has made explicit the assumptions needed to reconstruct African populations on the eve of colonial rule and earlier. My approach is to find a simple method to estimate historic population density that can be applied uniformly over the whole world. In particular, I take raster data on population density in 1995 for each of my ethnic groups and combine it with other estimates of historical population densities for the broader regions within which these groups are located. Specifically, my estimate of historical population density is:

$$\text{Historical population density} = \text{Population density in 1995} \times \frac{\text{Regional density at the date of observation}}{\text{Regional density in 1995}}. \tag{8}$$

Critically, this assumes that the relative distribution of population has not changed within regions over time. If the Tamil were 1.37 times as dense as the entirety of the broad region "India" in 1995, this ratio is pushed back to 1880, the date at which they are observed. While reasonable as a first order approximation for much of the world, this will clearly overestimate the densities of some groups (e.g. the Wu Chinese near modern Shanghai, or Yana of Long Island), while underestimating others. As a result, I show that the general results survive the use of several different estimators of historic population density. I use the 1995 densities directly, the historical regional densities directly, and for roughly 175 societies I have access to independent estimates of their population densities from the *SCCS*.

While GIS data on population in 1995 is readily available from the FAO-GAEZ, historical regional estimates are harder to come by. The most commonly used source for economists is McEvedy et al. (1978), who create estimates at regular intervals for 163 regions of the world. There are, however, well-known problems with these data (Austin, 2008b; Hopkins, 2009). I choose instead to use the ARVE Group's estimates, constructed by Krumhardt (2010).[8] She incorporates additional estimates and corrections from Durand (1977), Clark (1967), Biraben (1979), Dobyns (1966), and Nevle and Bird (2008), among others. She divides the world into 209 regions, and gives population estimates for hundred year periods between 6050 BC and 1850 AD. I impute values between these years, and between these years and 1995 using exponential trends.[9] I use McEvedy et al. (1978) data as a robustness check and impute values for intermediate years by the same method. Where McEvedy et al. (1978) report country-level estimates in recent years and broad regions (e.g. "The Sahel States") in earlier years, I divide the population among countries according to their ratio in the earliest year that they are separately reported. My key estimates of land quality and population density are plotted together in Figure 3.

3.2.3. *Other controls.* In addition, I control for several other factors that may determine the existence of land rights and slavery. To make the econometric results easier to interpret, these are re-scaled as standard normal variables.[10] These are:

Major river: This is a dummy that equals one if a river with a rank of at least 6 according to the North American Cartographic Information Society (NACIS) intersects the ethnic group's territory.

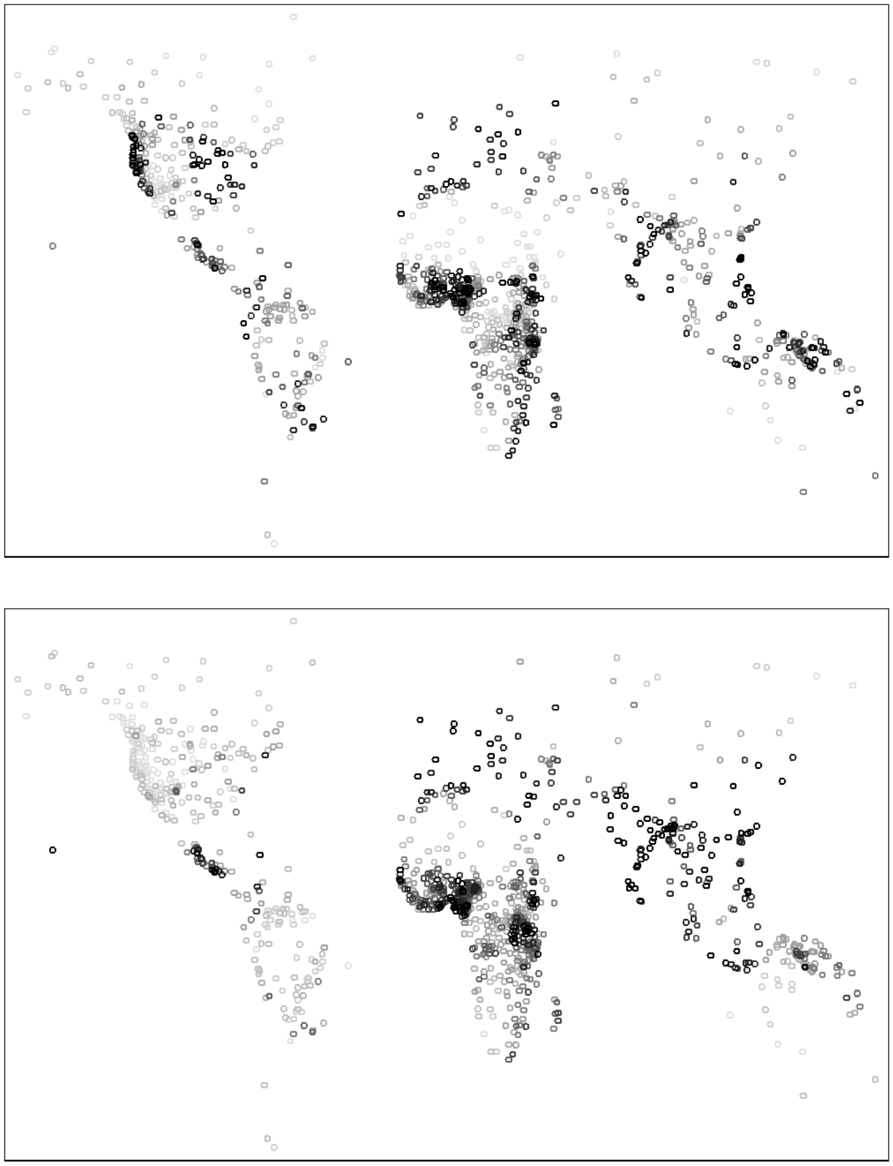
Dist. to coast: This is average distance from each point in the ethnic group's territory to the nearest point on the coast, in decimal degrees, calculated in ArcMap.

[8]See `http://ecospriv4.epfl.ch/index.php?dir=pub/&file=pop_landuse_data.tar.gz`

[9]Population density estimates for 1995 were obtained from the World Bank for country-level regions, and populstat.info for sub-national regions.

[10]Raster data are taken from `http://www.naturalearthdata.com/`, `http://www.iiasa.ac.at/Research/LUC/GAEZ/index.htm`, and `http://www.map.ox.ac.uk/data/`.

FIGURE 3. Land quality and historic population density



Land quality is on top, population density on bottom. Darker colors indicate higher values; the ranges of both are given in Table 1.

Elevation: This is average elevation for the ethnic group. Raster data are provided by the NACIS.

Pct. malarial: This is the fraction of the society's territory in which malaria is endemic, according to the Malaria Atlas Project.

Precipitation: This is average annual precipitation (mm). Because some societies are too small for a raster point to fall within their territory, I impute missing data using the nearest raster point.

Ruggedness: This is a measure of terrain ruggedness used by Nunn and Puga (2007). This measures the elevation distance between a raster cell and its neighbors at a fine level.

Temperature: This is the accumulated temperature on days with mean daily temperature above 0°C, computed using monthly data from 1961 to 2000 collected by the Climate Research Unit (CRU) of the University of East Anglia. I treat 55537 is as an error code and drop these points. I impute missing values using the nearest raster point.

Date observed: This is the rough date at which the information on the society was recorded, according to the *Ethnographic Atlas*. Where this is missing, I impute it using the average value for other ethnic groups within the society's ethnographic region, of which there are 60 in the final sample.

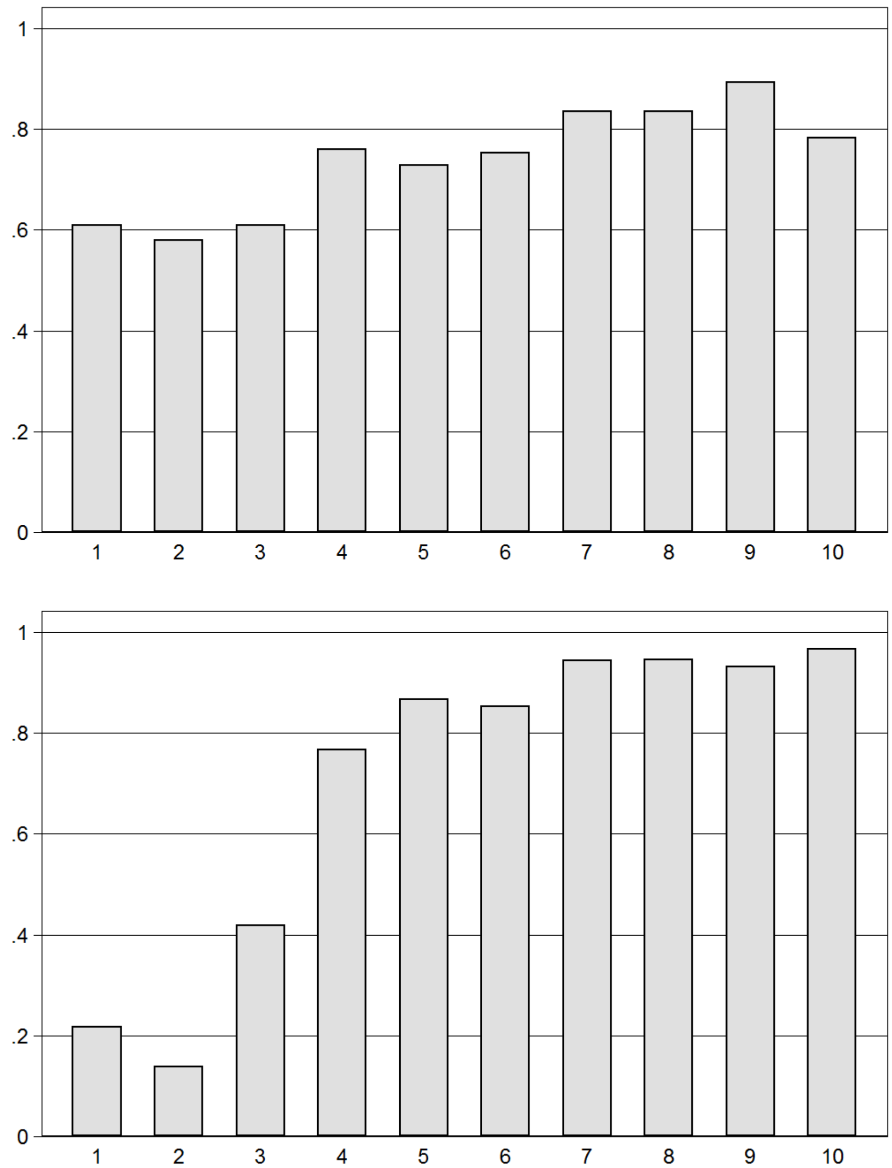
Absolute latitude: This is the absolute value of the society's latitude. This proxies for unobservable characteristics that vary smoothly over space and may be correlated with land quality or population density.

There are two additional controls added because of failings of the model – the share of land devoted to desert (computed from the FAO-GAEZ data) and a dummy whether the society obtains most of its income from fishing (computed from $V3$ in the *Ethnographic Atlas*). There are two major parts of the world where slavery is prevalent and land quality is poor, contrary to the model's predictions. The first is the Sahara, where, despite low land quality, slaves could be used in transport and were easily captured from neighboring societies by raiders on camel or horseback (Webb, 1995). The second is the Pacific Northwest, in which groups such as the Haida used slaves in fishing and hunting, and were able to capture them using canoe raids (Donald, 1997). This region is well known for having a relatively high surplus and developed material culture despite the lack of importance of agriculture. These need not imply rejection of the model as a whole. They are instead evidence that there are certain forms of slavery that cannot be explained by a strictly agrarian interpretation of the model. Summary statistics for these controls are given in Table 1.

4. Results

4.1. **In pictures.** It is useful, first, to know whether the correlations predicted by the model are apparent in the raw data. Because the dependent variables are binary, a scatterplot will not represent the relationship clearly. Instead, I show the correlations between land rights, slavery, land quality and population density by dividing the sample into deciles of land quality and historic population density. In Figure 4, I report the fraction of societies in each decile that have land rights. In Figure 5, I do the same for slavery. The raw correlations are as predicted. Land rights are strongly positively related to land quality and population density. Slavery is positively correlated with land quality, though this is much weaker than the relationship for land rights. In the model, the existence of multiple steady states helps explain this. I do confirm below that the correlation is statistically significant. Further, slavery is most prevalent in societies with intermediate population densities.

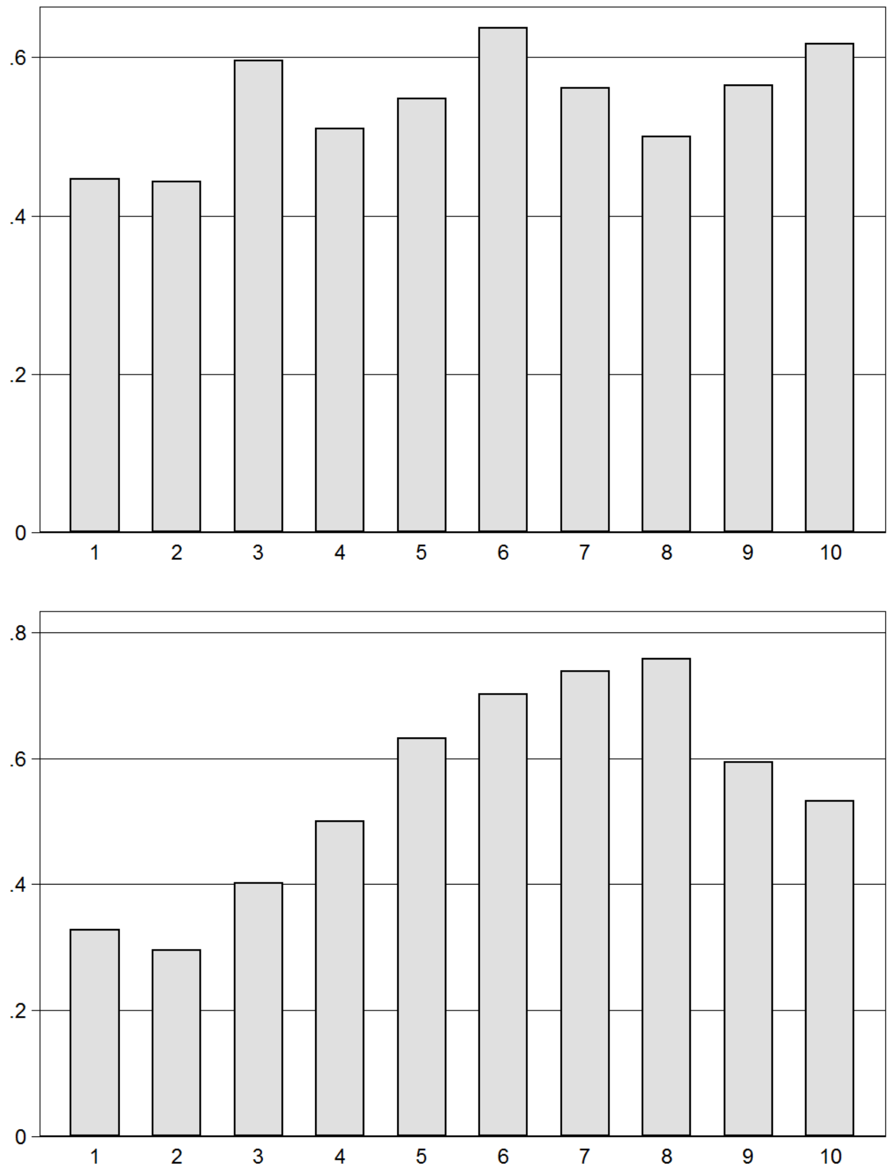
FIGURE 4. Land rights by deciles of land quality and hist. pop. density



The y axis is the percentage of societies with land rights. The top picture divides this by deciles of land quality, the bottom picture by deciles of population density.

4.2. **Regressions.** In Table 2, I report the results of estimating (5), (6) and (7). Specifically, I report the marginal effects for the land rights and population density variables. For land quality, these can be interpreted as the effects of a one standard deviation improvement. When additional controls are added, the results suggest that a one standard

FIGURE 5. Slavery by deciles of land quality and hist. pop. density



The y axis is the percentage of societies with slavery. The top picture divides this by deciles of land quality, the bottom picture by deciles of population density.

deviation improvement in land quality raises the probability that land rights exist by roughly 4.5%. Interpreting the coefficient on population density as an elasticity, a 1% increase in population density is associated with a 0.118% increase in the chance that land rights exist.[11] A one standard deviation increase in land quality predicts a 4.7% increase in the chance of slavery. While interpretations of the coefficients on the quadratic

[11]This is a reasonable approximation, though not strictly correct, because the normalization is log(1+pop. den.), not log(pop. den.).

TABLE 2. Main results

[Table 2 here]

TABLE 3. Alternative measures of the dependent variables

[Table 3 here]

of population density are less easy to interpret, the inverted-U probability profile visible in Figure 5 is visible here.

5. ROBUSTNESS: WHAT THE MODEL CAN EXPLAIN

In this section, I show that the results in Section 4 are robust to several objections that could be raised against them. I show that they can be replicated using alternative measures of land rights and slavery, and that the measures used for the dependent variables are correlated with other measures of these in other samples not large enough to be used for replicating the results. Second, I show that similar results can be obtained using different estimates of both land rights and land quality, and that these alternative measures are correlated with those used for the analysis. Third, I show that the results generally survive additional robustness checks – for the importance of influential observations, for the possible endogeneity of land quality, and for alternative clustering of the standard errors. Fourth, I argue that the results suggest that the model better explains slavery then some notable competing theories.

5.1. **Alternative measures of the dependent variables.** Because land rights and slavery are sharp indicators of the existence of these institutions, I use alternative measures of each. Land rights in particular exist for some 74% of societies in the data, but do not necessarily capture differences in how well defined these rights are. I begin by demonstrating that my measure of land rights is positively correlated with $v1726$ in the *SCCS*, an indicator for whether land is mostly private. The *SCCS* is a sub-sample of 186 societies from the *Ethnographic Atlas*, to which researchers have been continually adding new variables since its creation. These variables are not, however, regularly available for all 186 societies. Because $v1726$ is only available for 80 societies, I am not able to replicate the econometric analysis with it. The results of regressing the existence of land rights on $v1726$ are positive and significant, as reported in column (1) of Table 3.

Next, I use an indicator for whether the inheritance of land is patrilineal as an alternative measure of land rights.[12] Following Goody (1969), this captures the degree to which the control of real property is directed towards the nuclear family. Roughly, this is one step along the transition from weakly defined to strongly defined rights in land. Similarly, I use an indicator for whether land is inherited by sons.[13] I show in columns

[12]Like the indicator for land rights, this is constructed using V74: Inheritance Rule for Real Property (Land). This is equal to 1 if V74=4, V74=5, V74=6, or V74=7.
[13]This is equal to 1 if V74=7.

TABLE 4. Alternative measures of land quality and population density

[Table 4 here]

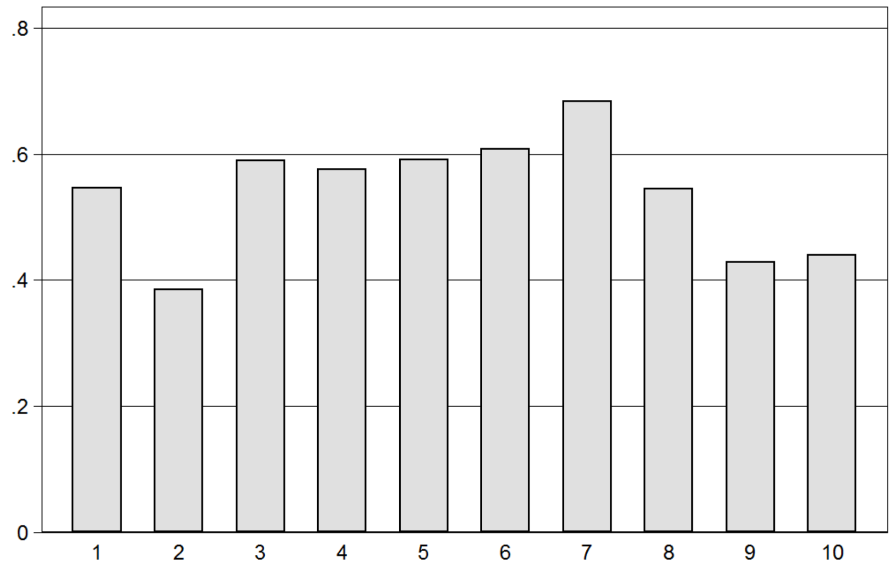
(2) through (5) of Table 3 that both of these are positively related to land quality and population density, conditional on the other controls.

For slavery, I can make similar tests. First, I show in column (6) of Table 3 that the main measure of slavery is correlated with an indicator constructed from $v919$ of the *SCCS* for the existence of large-scale slaveholding. In columns (7) through (10), I show that the results can be mostly replicated by constructing alternative measures of slavery from the *Ethnographic Atlas.* Slavery is recorded as either “absent” (1), “ incipient or nonhereditary” (2) “reported but type not identified” (3), or “hereditary and socially significant” (4). I create a “slavery above incipient” dummy for whether $V70 > 2$, and a “hereditary slavery” dummy for $V70 = 4$. The positive conditional correlation between land quality and non-incipient slavery is still apparent, as are the hump-shaped relationships with population density, though the link between land quality and hereditary slavery is small and statistically insignificant.

5.2. **Alternative measures of land quality and population density.** I validate the use of the land quality measure by showing that I am capable of replicating the results for land rights using an alternative index of land quality created by Ramankutty et al. (2002), and that I am able to correlate the principal measure with three alternative measures of land quality contained in the *SCCS* – $v921$, $v924$ and $v928$. I show in column (1) of Table 4 that the land rights result survives the use of the Ramankutty et al. (2002) measure, and in columns (3) through (5) I show the strong correlation between my principal measure and the alternatives from the *SCCS*. Column (2), however, shows that the slavery result cannot be replicated. Why? I show in Figure 6, in a manner similar to Figure 5, that the raw data appear to reveal an inverse-U relationship between this measure and slavery. Again, since at high population densities it becomes possible in the model to have a steady state under free labor, this weakens the positive relationship of land quality and slavery.

The use of population density in 1995 to weight ethnic groups within regions is necessitated by data availability. Further, the regional population density estimates are themselves no more than educated guesses. My approach here is to replicate the results with alternative proxies. In column (6) of Table 4, I show that the main measure of population density is correlated with an indicator of land shortage ($v1720$) from the *SCCS*. In Columns (7) through (12), I show that the main results for land rights and slavery can be replicated with two alternative measures of population density – density in 1995 and regional estimates from the ARVE data. Regional density from McEvedy et al. (1978) gives an inverse-U but insignificant relationship with slavery. If the principal measure of historical population density is replaced for Canada and the United States with the estimates reported in Ruff (2006), the results (not reported) are very similar to those given

FIGURE 6. Slavery by deciles of Ramankutty et al. (2002) land quality



The y axis is the percentage of societies with slavery, divided by deciles of land quality.

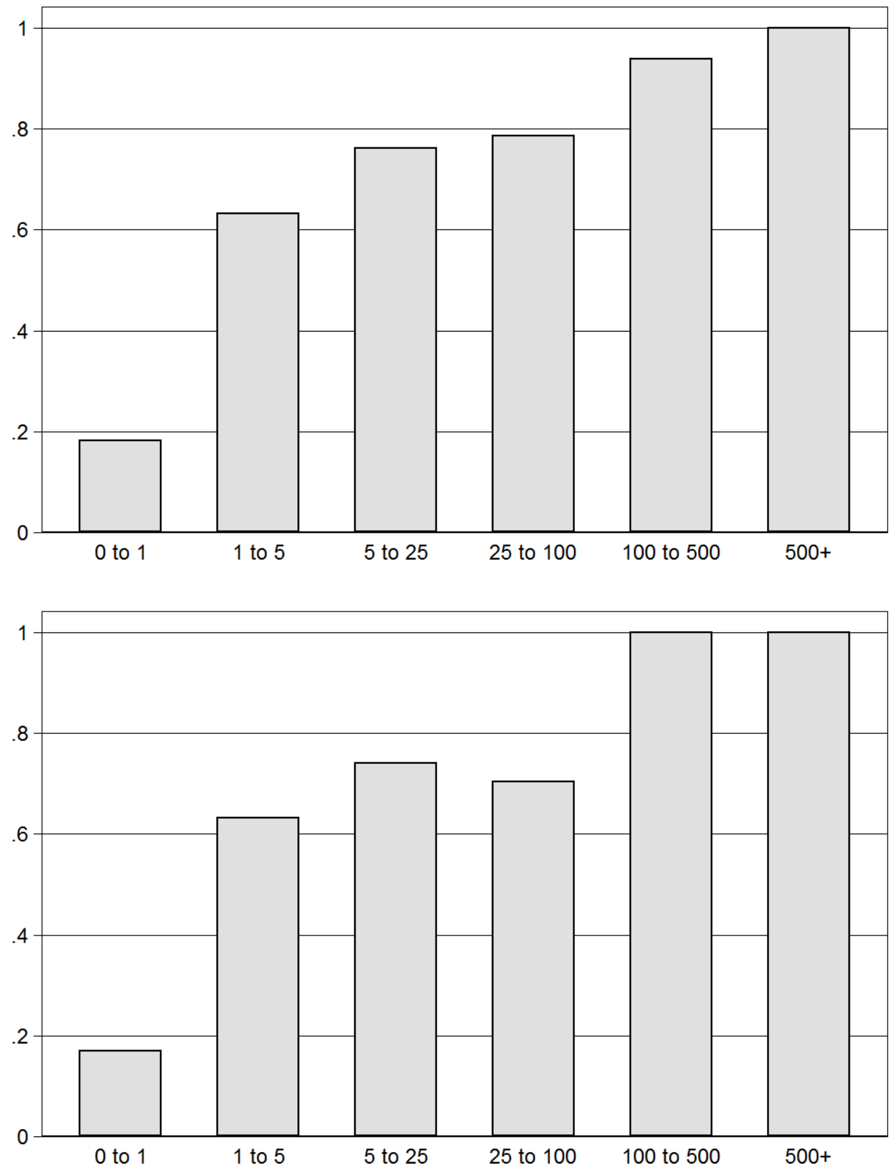
in Table 2. Similarly, using the McEvedy et al. (1978) regional estimates as a base in (8) (as opposed to the ARVE estimates) gives results gives results that are qualitatively the same as in in Table 2, and just as statistically significant (not reported).

In addition, there are two variables in the *SCCS* ($v64$ and $v1130$) that create independent estimates of the population densities of several societies in the data. These are not continuous measures, but instead categorize the societies into bins. While there are not enough observations and the data are too coarse to replicate the econometric analysis, I show in Figures 7 and 8 that these alternative measures have similar relationships with the institutions of interest as the main measure. Land rights are increasing in both measures of population density, and slavery has a hump-shaped relationship with each.

How similar are these alternative measures of population density? In Table 5, I report Spearman rank correlations and correlation coefficients between the various measures used. For the African sub-sample, I add population density in 1960 as estimated by the UNEP.[14] While some of these measures are more strongly correlated than others, they are all significant at the 1% level. What general lesson can be taken away from this? Historical population density estimates are untrustworthy. They are correlated with each other, but at times they disagree even about the relative rankings of societies by population density. Even still, they agree on two conclusions. Land rights have existed where population was densest, and slavery was most likely at intermediate values of population density, as in the model and consistent with the literature on African history.

[14]See `http://na.unep.net/metadata/unep/GRID/AFPOP60.html`.

FIGURE 7. Land rights by bins of population density in the *SCCS*



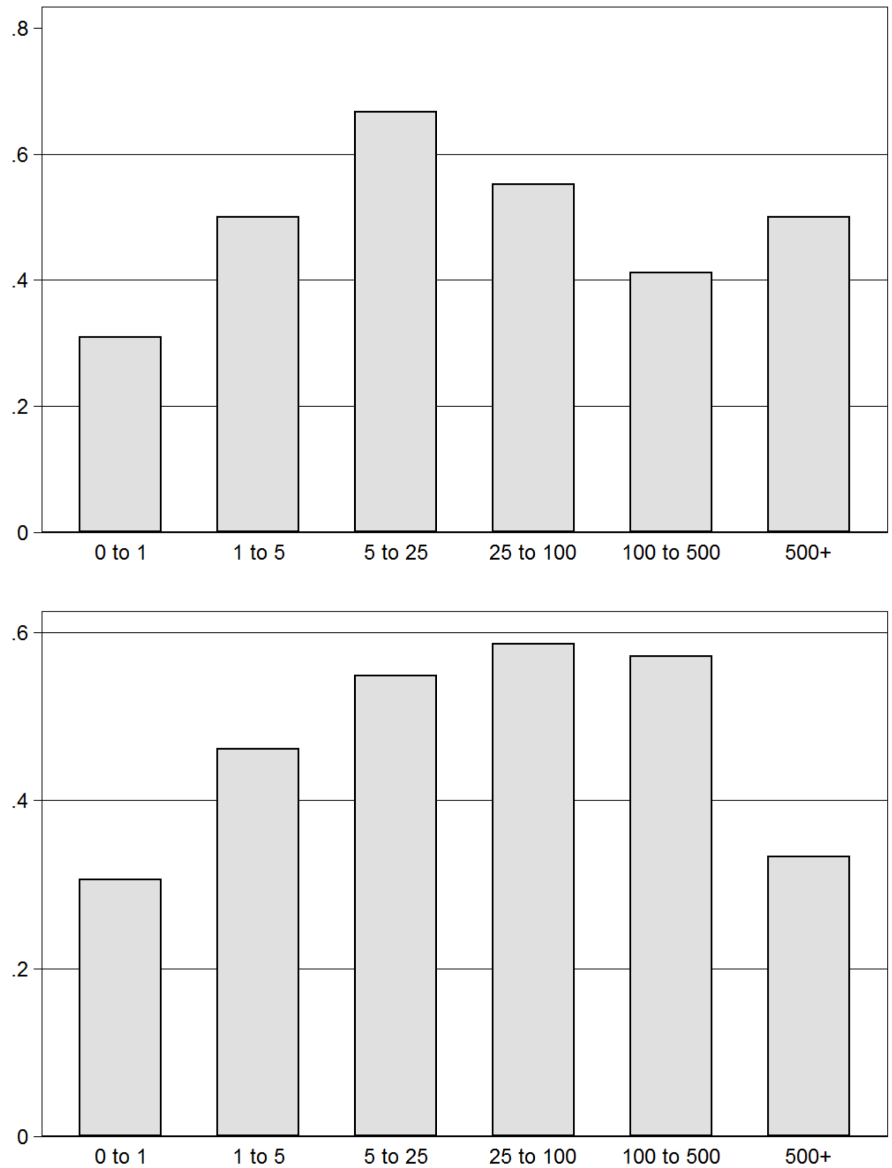
The y axis is the percentage of societies with land rights. The top picture divides this by population density bins according to $v64$, while the bottom picture does so following $v1130$.

TABLE 5. Correlations of population density measures

[Table 5 here]

5.3. **Other robustness checks.** In Table 6, I test whether the results are sensitive to the inclusion of influential observations and sub-samples. I begin by re-estimating the results by Ordinary Least Squares (OLS), and computing both leverage and dfbeta statistics for the variables of interest. In the slavery quadratic, this calculated for the linear term. In columns (1) through (4) and (11) through (14), it is clear that the results do

FIGURE 8. Slavery by bins of population density in the *SCCS*



The y axis is the percentage of societies with slavery. The top picture divides this by population density bins according to $v64$, while the bottom picture does so following $v1130$.

not depend on including these observations. In columns (5), (6), (15), and (16), I replicate the results excluding both North and South America. The results are unchanged excepting that the relationship between slavery and land quality becomes small and insignificant. This is surprising, as slavery was most prominent in areas of the Pacific Northwest where agriculture was unimportant.

Dropping Europeans (columns 7-8 and 17-18) and their offshoots does not change the results by much. Excluding non-agricultural societies (columns 9-10 and 19-20) completely eliminates the relationship between land quality and land rights, suggesting that

TABLE 6. Influential observations

[Table 6 here]

TABLE 7. Possible endogeneity of land quality

[Table 7 here]

TABLE 8. Alternative clusters (p. values)

[Table 8 here]

this is driven by better land quality permitting the existence of settled agriculture. This highlights a mechanism by which societies move from $\mathcal{S}^E$ to $\mathcal{S}^S$, rather than providing evidence against the model.

I am not concerned here with possible reverse causation of population density. The model expects that population growth will respond to institutions, and I am only testing a correlation between two endogenous variables. Even if I were seeking a one-way causal impact, it is unlikely that an instrumental variable exists that could alter population levels on a macroeconomic scale without also affecting institutions.

I am, however, potentially concerned about the endogeneity of land quality. The FAO measure is an index of several constraints, of which soil depth and soil fertility may be potentially anthropogenic. In Table 7 I address this concern by controlling directly for these components. If the entire relationship between the variables of interest and land quality can be explained by correlation with these potentially endogenous components, it is evidence that the causal inference may be spurious. The results show, however, that the result survives separating land quality into its separate parts.

Finally, I have reported results with heteroskedasticity-robust standard errors. How sensitive is the statistical inference to correlations in the errors within possible clusters? I address this question in Table 8, clustering the standard errors by ethnographic region (of which there are 60), by the principal country of the ethnic group, or by that country's global region classified by the UN.[15] The "robust" errors are the baseline results. The results are generally stable, though some choices of cluster push the results to p. values of .12 or .14. The major exception is that slavery is not significantly related to land quality if the results are made robust to arbitrary correlation by country or by UN region. This foreshadows the results of Section 6, suggesting that there are strong correlations in institutions within broad regions.

5.4. **Theories of slavery.** In this section, I contrast the results outlined in Section 4 with two other major theories of slavery and explain why the model outlined in Section 2 does a better job of explaining African slavery than either of these.

[15] Ethnic groups were classified according to the location of their centroid, and then obvious errors were corrected manually. For example, the centroids for the Japanese and Annamese fall outside of Japan and Vietnam, respectively.

First, writers such as Inikori (1999) have suggested that African "slaves" held a position closer to that of the European serf. In the model, slaves differ from free laborers in that they are coerced workers whose price does not depend on the local supply of labor. The severity of slavery is not important to this conceptual distinction. The dominant theory of serfdom is that of North and Thomas (1971), who hold that serfs voluntarily exchanged their labor for protection from lords. These payments were in inputs rather than money because of the limited nature of output markets.

There are at least four reasons why this model cannot explain Africa. First, that model's applicability to any case has been called into question by Fenoaltea (1975), who demonstrates that North and Thomas (1971) err in treating serfdom as voluntary, underestimate the transactions costs in labor contracts, misidentify the historical trends that acted on the manorial system, and overemphasize the rigidity of "custom" in constraining institutional change. Second, both land quality and population density at low levels have been shown in Section 4 to be positively associated with slavery. In the North and Thomas (1971) model, these should promote the development of trade and markets, lessening the need for contracts to be written in labor dues. This prediction is similar to the argument of Acemoglu and Wolitzky (2011) that better outside options for coerced workers may lower the amount of force used in equilibrium. Third, their model predicts that trade will discourage the use of serfs. This runs counter to the literature on African history, which has shown that external trade in particular spurred greater use of slaves in production (e.g. Lovejoy (2000) or Law (1995)). Finally, there is no evidence that African slaves received payments that approximated their marginal products. In many cases, slaveowners had to be compelled to receive manumission payments from their slaves under colonial rule, suggesting that they were earning rents for which they needed to be compensated. Austin (2009) provides several examples from nineteenth century West Africa in which it was possible for the purchaser of a slave to recoup his investment within six years.

The second theory of slavery I address is the collection of arguments that, in certain contexts, slavery is more productive than free labor, which explains its use. For Fenoaltea (1984), this occurs where "pain incentives" are effective and detailed care by the worker is unnecessary. Fogel and Engerman (1974) link the exceptional productivity of slaves in the American south to economies of scale that could only be achieved through gang labor, an activity so grueling that free men could not be induced to take part at any price. Engerman and Sokoloff (1997), similarly, argue that the cultivation of crops with economies of scale is more conducive to slavery. Hanes (1996) explains the concentration of slaves in rural and domestic production by invoking the high turnover costs in these industries.

These arguments again cannot alone explain slavery in Africa, even if they can explain it in other contexts. First, there is no evidence that slaves were used in production in sectors systematically different than those dominated by free peasants. The fact

TABLE 9. Results with region fixed effects

[Table 9 here]

that, over a few generations, slaves were often partly assimilated into their masters' societies is evidence that they were not kept in economic isolation (Austin, 2009). Where large slave communities or communities were present, (see e.g. Lovejoy (1978) for the Sokoto Caliphate or Oroge (1971) for nineteenth century Yorubaland), these existed not because slaves were used in economic tasks that free peasants were not, but because they were acquired in large numbers by authorities and other elites. Studies of slavery in individual African societies frequently make reference to slave labor and free labor working in the same tasks. Austin (2005) notes gold and kola production in Asante were both carried out by free people, pawns, *corvée* labor, slaves, and descendants of slaves. Uchendu (1979) shows for Igbo society that slaves first were used to fill subsistence needs by farming and fishing, and only secondarily filled prestige functions. "In domestic activities," he argues, "no operation was strictly reserved for slaves." Describing the Kerebe of Tanzania, Hartwig (1979) writes that masters often worked alongside their slaves, who performed the same tasks as their owners and their owners' wives.

Second, the literature on the "legitimate commerce" period suggests that slaves were used in the activities where labor of all kinds was most productive; in the model this is consistent with a rise in $\bar{A}$, and does not require a different production function under slavery. The nineteenth century export markets for oils, ivory, ostrich feathers and other goods created higher returns to slave labor, and slavery within Africa intensified (Lovejoy, 2000).[16] Third, African agriculture both past and present has been overwhelmingly characterized by diminishing or constant returns to scale (Hopkins, 1973). Without evidence of scale economies, an appeal to "pain incentives" is not necessary to explain slavery over and above a comparison of the costs of slavery to those of free labor.[17]

6. HETEROGENEITY: WHAT THE MODEL CANNOT EXPLAIN

In Table 9, I show a simple method to do away with most of the results presented so far: add fixed effects for the major ethnographic regions in the data. These are North America, South America, Africa, the Circum-Mediterranean, the Insular Pacific, and East Eurasia. There is still a relationship between population density and land rights, and the marginal effect of land quality on slavery has not fallen by much, but the other results have now disappeared completely. The model can predict differences across broad regions, but not within them.

[16] Lynn (1997) also provides a survey of the period, while Law (1995) contains a number of case studies.

[17] Returning to the model, if slaves are worked harder than free laborers, their productivity may be enhanced by some factor η. This parameter will carry over into the definitions of Φ, Ψ, and Ω. However, unless the shape of the production function itself changes, the qualitative shapes of the institutional regions will not be different.

TABLE 10. Galton's problem

[Table 10 here]

Why? Anthropologists have a name for the fact that institutions diffuse across societies, making it impossible to have any truly independent ethnographic observations. This is "Galton's problem." Economists would refer to it either as serial correlation, or as spatial dependence. I propose that the lack of robustness of the main results stems from spillovers across neighboring societies. If a nearby society has slavery, it is almost impossible to avoid developing the institution or becoming slaves of your neighbor, regardless of prevailing land quality and population density. The existence of rights over land is an idea that can spread across societies, and can be used to defend claims against a rival group.

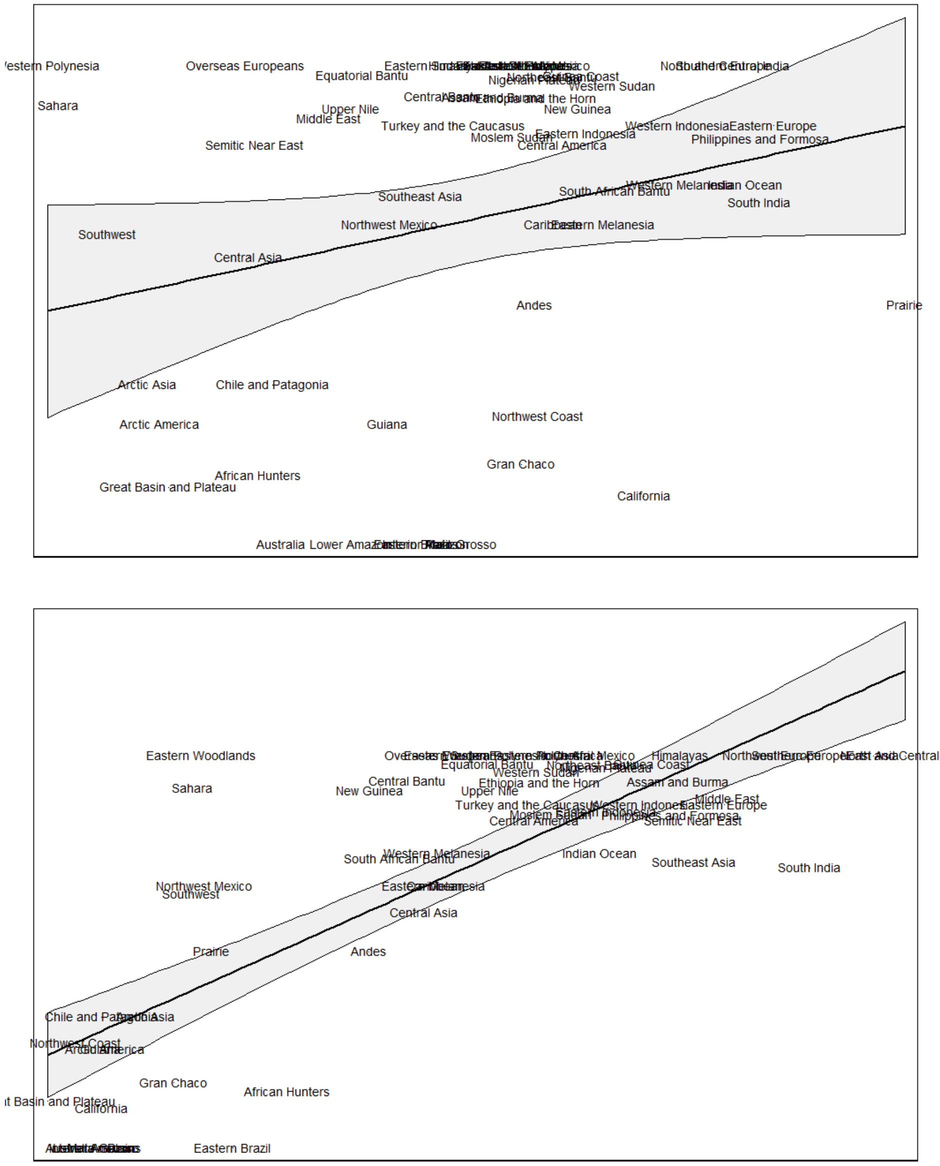
In Table 10, I provide suggestive evidence that these neighbor effects exist by estimating spatial lag and spatial error models. The spatial lag adds a term $\rho W y$ to the estimating equation. W is an $N \times N$ spatial weight matrix, in which each entry W_{ij} is the inverse of the distance between observation i and observation j, normalized so that its rows sum to 1 or 0. ρ captures whether the institutional outcome of one group will affect its neighbor's institutions. The reason this evidence is only suggestive is that ρ is not separately identified from localized unobservables. This is estimated as a linear probability model using maximum likelihood.[18] The spatial error model is similar. Now, the error term is given by $u = \lambda W u + \epsilon$, so that a society's random error may depend on the error terms for societies that are close to it.

In Table 10 it is clear that there is very strong spatial correlation in land rights. The Wald tests for ρ and λ are very large, even conditional on the observed controls. While I do not report the estimates of ρ and λ, all values are positive. Once these controls are added, none of the results concerning land quality survive. The results with population density fare better, but for slavery these are only marginally significant in the spatial lag model. While the model can explain differences across regions, it cannot explain differences within them, and the strong spatial correlation in institutional outcomes suggests this is due to neighbor effects.

I confirm the ability of the model to explain differences across regions in Figures 9 and 10. I show that the relationships between the averages of land quality and population density within an ethnographic region are correlated with the fraction of societies possessing land rights or slavery as the model predicts. These results will differ from the plots in 4 and 5 because the number of observations differs by region. The positive relationships of land rights with both land quality and population density are still apparent, and the inverse-U correlation between slavery and population density is still apparent. Only the correlation between slavery and land quality cannot be seen across regions in the data. Once again, the existence of multiple steady states can explain this.

[18] In particular, I use the spatreg command in Stata.

FIGURE 9. Land rights, land quality and population density across regions

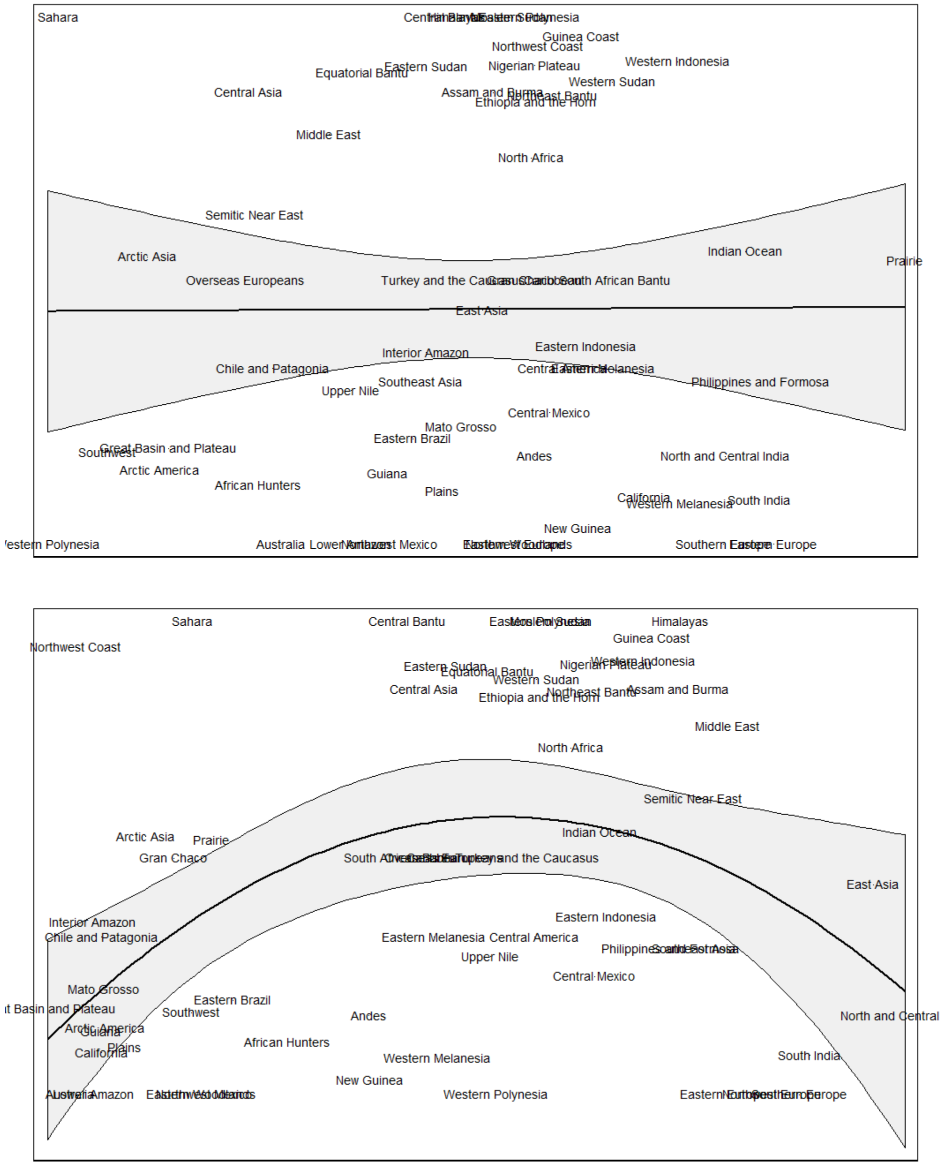


The y axis is the percentage of societies within a region with land rights. The x axis in the top picture is average land quality for the region. In the bottom picture it is average log population density.

7. CONCLUSION AND DISCUSSION

It appears then, that, the land abundance view performs reasonably well in predicting broad differences in the prevalence of land rights and slavery between Africa and the rest of the world, though not as well at predicting outcomes within regions. What of other institutions discussed by historians of Africa? The relative lack of states centralization and high rates of polygyny have also been tied to sparse population. Rulers were unable to tie subjects to the land and tax them, sought subjects and cattle, rather than

FIGURE 10. Slavery, land quality and population density across regions



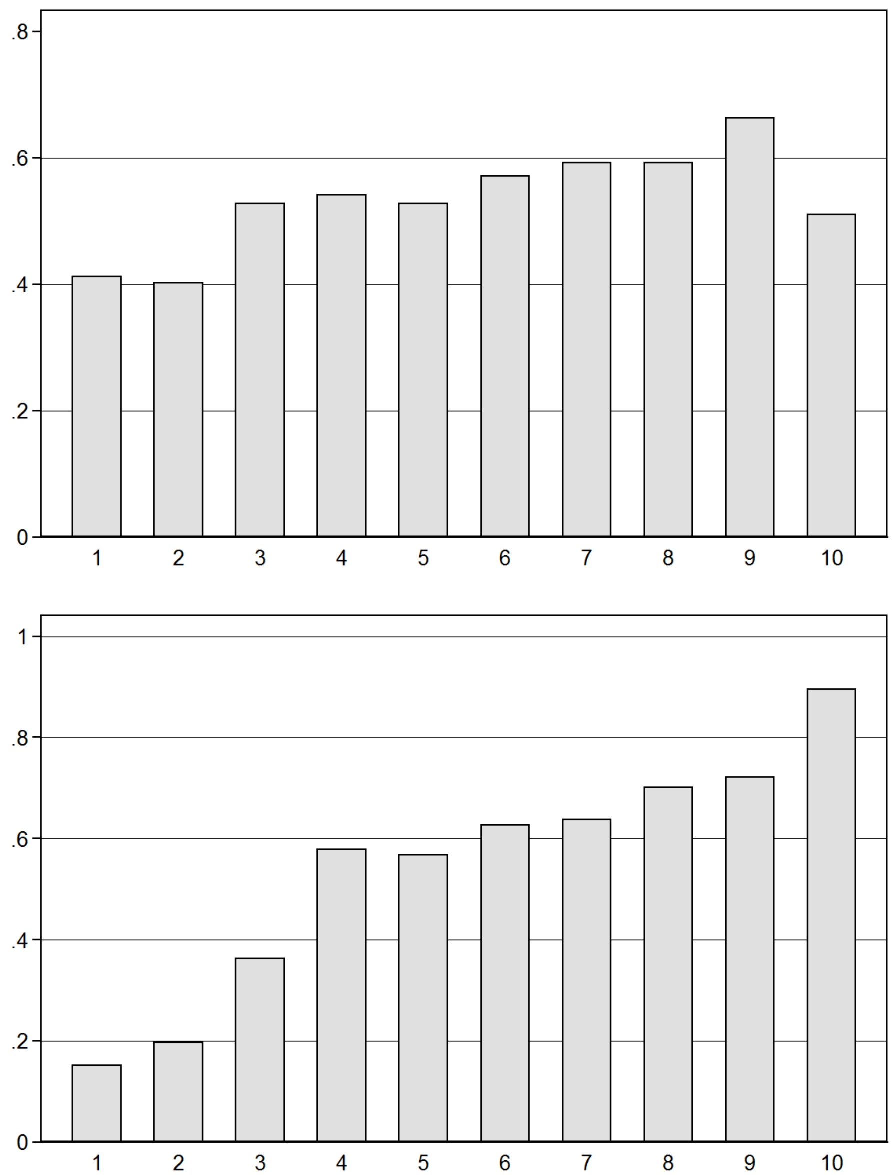
The y axis is the percentage of societies within a region with slavery. The x axis in the top picture is average land quality for the region. In the bottom picture it is average log population density.

territory, and had to contend with the ability of subjects to exit easily (Austin, 2004a,b). Goody (1976) argues that polygyny exists where allocating land to additional wives is less costly but their labor is valuable.

In figures 11 and 12, I show that the prevalence of states in the global sample mimics that of rights over land, rising monotonically with land quality and population density.[19] Polygyny, by contrast, mimics the pattern seen for slavery – its presence increases

[19]I measure state centralization as a dummy variable, equal to one if variable 33 in the *Ethnographic Atlas*, the levels of jurisdiction above the local, is greater than one.

FIGURE 11. State centralization by deciles of land quality and hist. pop. density

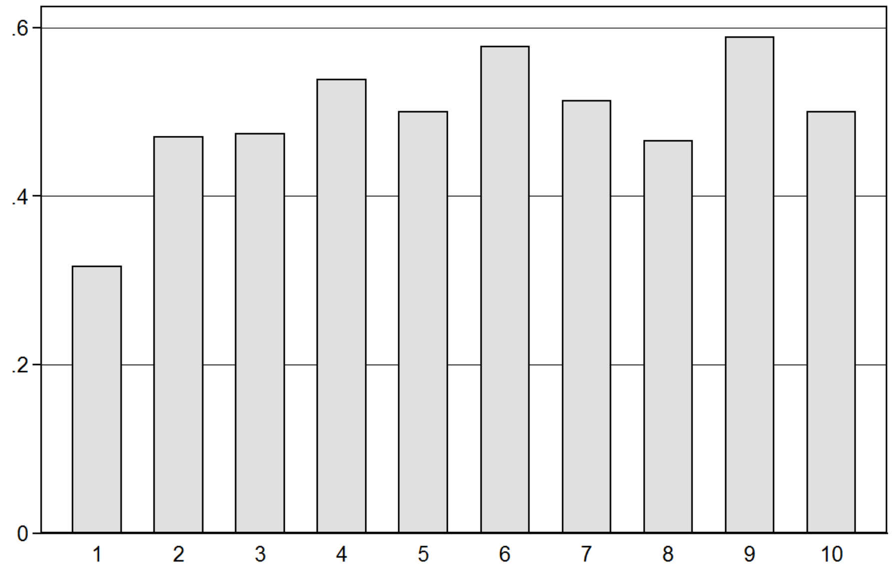


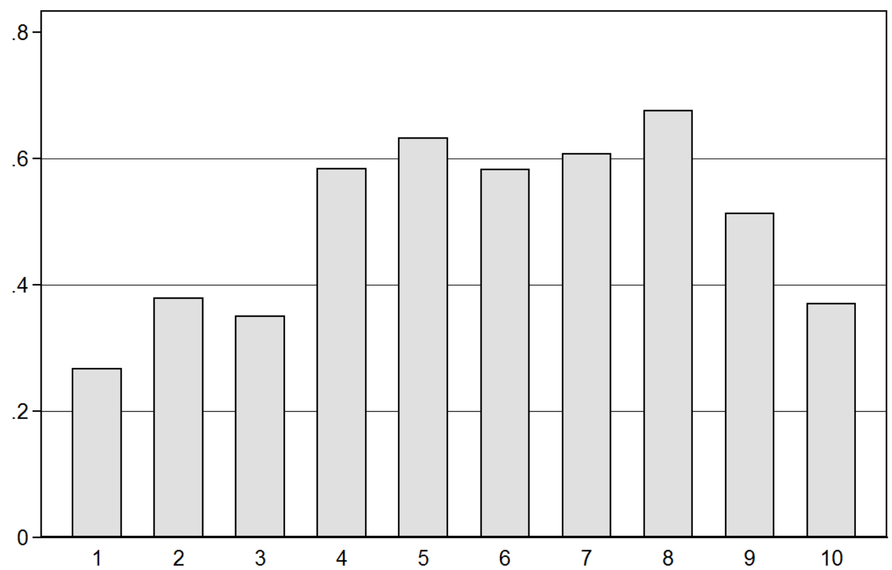
The y axis is the percentage of societies with state centralization. The top picture divides this by deciles of land quality, the bottom picture by deciles of population density.

weakly with land quality, but is strongest at intermediate levels of population.[20] In Table 11, I replicate (5), (6) and (7) with these variables as outcomes. The correlations between state centralization, land quality and population density remain apparent. The relationships between polygyny and these variables are not robust to the inclusion of additional controls – malaria ecology is sufficient to make either one insignificant. Generally, then,

[20]I measure polygyny as a dummy variable, equal to one if variable 9 in the *Ethnographic Atlas*, marial composition, is 3, 4, 5, or 6. This codes outcome 2, "Independent nuclear, occasional polygyny", as zero.

FIGURE 12. Polygyny by deciles of land quality and hist. pop. density





The y axis is the percentage of societies for which polygyny is the norm. The top picture divides this by deciles of land quality, the bottom picture by deciles of population density.

TABLE 11. Other outcomes

[Table 11 here]

this suggests that the land abundance view may have power to explain institutions in addition to land rights and slavery.

Bad institutions are one of the fundamental causes of African poverty, and the institutions that exist on the continent currently have been shaped by those that existed prior to colonial rule. I have addressed a theme in the economics literature – how geography affects institutions – by looking in depth at one hypothesis from the literature on African history. I find that African land tenure and slavery have been decisively shaped by the continent's abundance of land and scarcity of labor. I find that this perspective explains much about institutions across a global cross-section of societies, but that neighbor effects weaken its ability to predict differences within them.

These tests have made several points that must be taken into account in understanding the impacts of under-population on African institutions. First, when both productivity and population are low, the opportunity cost of coercion is high, and the benefit to creating estates is low. This explains why slavery is less common among the most sparsely populated societies. Africa appears not as the least populous region in the sample, but as one that of medium density. While it is comparatively more prone to slavery than Europe or South Asia, there the is more slavery on the continent than in many parts of the Americas. Second, greater land quality (as well as access to trade), will encourage increased reliance on slavery conditional on population. This explains why some of the most agriculturally prosperous though densely populated regions in Africa, such as Sokoto, also used slaves most intensively (cf. Hill (1985)). Finally, there are substantial institutional spatial correlations across African societies relating to land rights and slavery. These revisions to the current thinking allow the "land abundance" perspective to better explain institutions and are borne out in comparative data.

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APPENDIX A. APPLICATION OF THE "LAND ABUNDANCE" VIEW TO THE EGBA

In order to supplement the econometric tests, I have also collected information on the Egba of southwestern Nigeria from their arrival at the town of Abeokuta in 1830 to their loss of formal independence in 1914. While the Egba fit many standard predictions for a land-abundant society, there are two key exceptions. First, they sold land amongst themselves as early as 1870. Second, land disputes existed. These are explained by initially high population densities created by their settlement as refugees at Abeokuta, and by the specific features of certain parcels of land that gave them uncommon value.

During the nineteenth century, the Egba mostly cultivated maize, cotton, yams, cassava and beans, and exported oil and kernels gathered from wild palm trees to European markets. Late in the century, cocoa and kola were introduced. I take data from secondary sources, oral histories, missionary records, travelers' descriptions, official correspondence and private letters. My principal sources are a collection of 541 Native Court cases involving farmland that took place between 1902 and 1919; these are housed in the National Archives, Abeokuta, and in the Hezekiah Oluwasanmi Library at Obafemi Awolowo University, Ile-Ife.

The "land abundance" narrative has significant power to explain Egba land tenure. In 1877, an Anglican missionary reported that cultivators could acquire land they developed from forest, either for free or in return for token payments (Agiri, 1974, p. 467). This could be true even when land was acquired for planting cocoa or kola. Because land was so cheaply available, the market for land was thin. European visitors did not believe that the Egba sold land during the nineteenth century, and even after sales had come into existence many disputants in the court records stated that they did not believe these to be legitimate. The use of long fallows – sometimes up to twenty years – economized on labor. Rights over land were often held only so long as the land was under cultivation, and the "caretakers" left behind to keep track of a fallow plot could, over time, acquire *de facto* ownership.

How, then, do we explain land sales and land disputes among the Egba? First, land was not abundant at all times in Egba society. Mabogunje (1961) notes that during the initial scramble for land at Abeokuta, township chiefs were required to give up their rights to land so that newcomers could settle, so that the town would grow larger and more secure from attack. This devolved control of land to families. Mabogunje (1961) believes that this set the stage for later land sales. A Boserupian interpretation of his argument would, within the model, represent this as a shift from $\mathcal{S}^E$ to $\mathcal{S}^S$. Using legendary accounts of the Egba homeland and travelers' estimates of Abeokuta's population during the 1850s and 1860s, it is clear that the Egba lost over 80% of their territory, and were at least twice as densely settled in 1830 as they were in 1914. In the area immediately around Abeokuta, fallows were shorter, intercropping more intense, and forest less present as late as 1902.

Second, Austin (2008a) has noted that, even while land is abundant, "good" land is always scarce. For the Egba, lands closer to their settlements and under the protection of powerful chiefs were more valuable and often the subject of dispute. Within the sample of court records, land that was more valuable due to cocoa or palm trees was more vigilantly defended and more likely to be involved in a commercial transaction. Plots endowed with palm trees were pawned more often, and more frequently defended with the placement of a caretaker. Greater damages were claimed in cases involving cocoa.

For the Egba, the abundance of land prevented the emergence of wage labor. Even during the slack season, individuals could gather forest products for themselves. Examples of paid work in the nineteenth century almost always involve missionaries hiring (or struggling to hire) laborers. Slavery was, as Oroge (1971) has described, an important means used by the war chiefs and major traders to secure access to labor where wage work was absent. Various estimates suggest that slaves were anywhere from one fifth to a "very considerable" proportion of the population.[21] The war chiefs, who in the model had the smallest γ, were the biggest holders of slaves. They were owed captives taken by their soldiers in raids, and could use their slaves in a variety of other tasks. Most slaves were used where the model would predict – where $\bar{A}$ was highest. Male and female slaves were used as porters and canoe pullers, and female slaves were used in palm oil production. Burton (1863, p. 301) believed that commerce raised the demand for slaves. British officials and traders, believing that slavery was indispensable, were afraid to upset the institution. Instead, they moved to abolish slave dealing (as opposed to slave holding), and worked only to check the worst abuses by slave owners.

For the Egba, institutional spillovers in land tenure resemble those suggested by the econometric results. This was because the Egba had Lagos as a southern neighbor. After 1861, this was a British colony. It was through Lagos that missionaries and mission-educated repatriated slaves came to Lagos, introducing ideas of individual ownership, and asking to purchase land in freehold as they had in Sierra Leone (Mabogunje, 1961). The Egba also influenced land tenure in Lagos. After an anti-Christian uprising in 1867, many Egba converts fled to Lagos, and were allotted parcels by the Governor on land given to him by a Lagos chief. Over time, these came to be viewed largely as freehold grants and were one of the spearheads for alienability of land in Lagos (Mann, 2007). In

[21]See, for example, Oroge (1971, p. 166), Bowen (1857, p. 320), Burton (1863, p. 299) or NAUK, CO 147/133, enc in 4 June, 1898: Denton to Chamberlain, Evidence for 18th day.

the case of slavery, the Egba also gained from their neighbors' practices; by mid-century, slaves were increasingly purchased in markets to the North, in Rabba and Ilorin. By 1870, "Hausa" slaves were the majority in Abeokuta (Agiri, 1981, p. 137). These northerners were far from home and less likely to flee. Anti-slavery policies in Lagos gave Egba slaves a means of escape, and led to political crises between the two states (Oroge, 1975).

That the Egba can be so easily understood in terms of the "land abundance" view gives this narrative further support.

Table 1: Summary statistics

	(1) Mean	(2) s.d.	(3) Min	(4) Max	(5) N
Any slavery	0.54	0.50	0	1	1,041
Any land rights	0.74	0.44	0	1	801
Land quality	1.33	0.90	0.00	3.98	1,206
Date observed	1905	53.0	1500	1965	1,206
Historic pop density	54.5	111	0.00	1,074	1,206
Precipitation	1,263	858	12.6	6,164	1,206
Temperature	7,203	2,774	35.5	10,830	1,206
Absolute latitude	20.7	17.0	0.017	78.1	1,206
Pct. malarial	0.17	0.20	0.00	0.69	1,206
Dist. to coast	4.26	3.87	0.00	16.5	1,206
Elevation	167	9.61	141	230	1,206
Major river	0.28	0.45	0	1	1,206
Ruggedness	121,122	132,811	137	977,941	1,206
Share desert	0.11	0.26	0	1	1,206
Mostly fishing	0.069	0.25	0	1	1,206

Notes: Variable definitions in text.

Table 2. Main results

	(1)		(2)		(3)		(4)	
	Any land rights							
Land quality	0.091***	(0.017)	0.046***	(0.018)				
ln(1+pop. den.)					0.147***	(0.009)	0.118***	(0.011)
Precipitation			-0.047**	(0.021)			-0.026	(0.022)
Temperature			-0.028	(0.030)			-0.056*	(0.033)
Date observed			0.050***	(0.019)			-0.004	(0.017)
Share desert			0.010	(0.018)			0.035**	(0.016)
Dist. to coast			-0.023	(0.018)			0.020	(0.018)
Elevation			-0.007	(0.019)			-0.006	(0.018)
Pct. malarial			0.174***	(0.026)			0.125***	(0.025)
Ruggedness			0.064***	(0.017)			0.025	(0.017)
Absolute latitude			-0.107***	(0.033)			-0.076*	(0.039)
Major river			-0.031	(0.034)			-0.063*	(0.034)
Mostly fishing			-0.125*	(0.074)			0.025	(0.069)
Observations	801		801		801		801	

	(5)		(6)		(7)		(8)	
	Any slavery							
Land quality	0.040***	(0.015)	0.047**	(0.021)				
ln(1+pop. den.)					0.269***	(0.029)	0.103***	(0.038)
ln(1+pop. den.) sqrd.					-0.039***	(0.005)	-0.013**	(0.006)
Precipitation			-0.063**	(0.025)			-0.051**	(0.026)
Temperature			0.218***	(0.038)			0.222***	(0.038)
Date observed			-0.049***	(0.019)			-0.065***	(0.021)
Share desert			0.033	(0.022)			0.025	(0.020)
Dist. to coast			0.048**	(0.023)			0.053**	(0.024)
Elevation			0.013	(0.022)			0.010	(0.023)
Pct. malarial			0.386***	(0.030)			0.360***	(0.030)
Ruggedness			0.135***	(0.021)			0.127***	(0.022)
Absolute latitude			0.111***	(0.042)			0.138***	(0.042)
Major river			0.089**	(0.042)			0.088**	(0.042)
Mostly fishing			0.388***	(0.078)			0.402***	(0.081)
Observations	1041		1041		1041		1041	

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Robust standard errors in parentheses. All regressions are probit, with marginal effects reported.

Table 3: Alternative measures of the dependent variables

	(1)	(2)	(3)	(4)	(5)
	Any land rights	*Land is patrilineal*		*Land inherited by sons*	
Land mostly private (v1726 in SCCS)	0.301**				
	(0.144)				
Land quality		0.050**		0.051**	
		(0.023)		(0.022)	
ln(1+pop. den.)			0.126***		0.175***
			(0.014)		(0.015)
Observations	80	801	801	801	801
Other cont.	N	Y	Y	Y	Y
	(6)	(7)	(8)	(9)	(10)
	Any slavery	*Slavery above incipient*		*Hereditary slavery*	
Large scale slaveholding (v919 in SCCS)	0.538***				
	(0.166)				
Land quality		0.037*		0.014	
		(0.021)		(0.015)	
ln(1+pop. den.)			0.215***		0.116***
			(0.040)		(0.029)
ln(1+pop. den.) sqrd.			-0.027***		-0.014***
			(0.006)		(0.005)
Observations	166	1,041	1,041	1,041	1,041
Other cont.	N	Y	Y	Y	Y

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Robust standard errors in parentheses. All regressions are probit, with marginal effects reported. Other controls are as in the table of main results.

Table 4: Alternative measures of land quality and population density

	(1)	(2)	(3)	(4)	(5)	(6)
	Any L.R.	*Any Sl.*	*v921*	*v924*	*v928*	*v1720*
L.Q. (Ramankutty et al.)	0.066***	-0.007				
	(0.018)	(0.021)				
Land quality			1.677***	0.703***	0.871***	
			(0.254)	(0.112)	(0.107)	
ln(1+pop. den.)						0.062**
						(0.027)
Observations	801	1,041	172	172	172	79
R-squared			0.223	0.196	0.274	
Other cont.	Y	Y	N	N	N	N

	(7)	(8)	(9)	(10)	(11)	(12)
	Any land rights			*Any slavery*		
Ln pop density 1995	0.098***			0.123***		
	(0.010)			(0.046)		
ln pop. den. 95 sqrd.				-0.013**		
				(0.006)		
ln(MJ pop. den.)		0.077***			0.033	
		(0.012)			(0.029)	
ln(MJ pop. den.) sqrd.					-0.006	
					(0.005)	
ln(1+ ARVE pop. den.)			0.090***			0.186***
			(0.014)			(0.048)
ln(1+ARVE pop. den.) sqrd.						-0.027***
						(0.008)
Observations	801	801	801	1,041	1,041	1,041
Other cont.	Y	Y	Y	Y	Y	Y

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Robust standard errors in parentheses. All regressions are probit, excepting columns 3, 4 and 5, with marginal effects reported. Columns 3, 4, and 5 are OLS. Other controls are as in the table of main results.

Table 5: Correlations of population density measures

Spearman correlations	*Historic pop density*	*Pop. den. 1995*	*MJ pop. den.*	*ARVE pop. den.*	*v64*	*v1130*	*Hist pop. den. (bins)*	*Af. pop. den. 1960*
Historic pop density	1.00							
Pop. den. 1995	0.94	1.00						
MJ pop. den.	0.72	0.70	1.00					
ARVE pop. den.	0.82	0.78	0.92	1.00				
v64	0.69	0.67	0.38	0.48	1.00			
v1130	0.66	0.65	0.35	0.44	0.88	1.00		
Hist pop. den. (bins)	0.95	0.91	0.70	0.78	0.65	0.62	1.00	
Af. pop. den. 1960	0.66	0.68	0.29	0.38	0.71	0.72	0.58	1.00
Correlation coefficients								
Historic pop density	1.00							
Pop. den. 1995	0.86	1.00						
MJ pop. den.	0.64	0.56	1.00					
ARVE pop. den.	0.72	0.58	0.84	1.00				
v64	0.53	0.58	0.39	0.42	1.00			
v1130	0.58	0.62	0.37	0.42	0.90	1.00		
Hist pop. den. (bins)	0.64	0.64	0.48	0.56	0.70	0.73	1.00	
Af. pop. den. 1960	0.83	0.89	0.23	0.26	0.58	0.58	0.63	1.00

Notes: All values significant at 1%.

Table 6: Influential observations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Any land rights									
Land quality	0.059***	0.086***			0.032***		0.036*		0.004	
	(0.018)	(0.017)			(0.012)		(0.018)		(0.010)	
ln(1+pop. den.)			0.111***	0.124***		0.044***		0.115***		0.029***
			(0.012)	(0.011)		(0.008)		(0.011)		(0.006)
Dropped	Lev LQ	DfB LQ	Lev PD	DfB PD	Americas	Americas	Euro.	Euro.	NonAg	NonAg
Observations	744	744	749	754	597	597	781	781	610	610
Other cont.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
	Any slavery									
Land quality	0.039*	0.046**			0.010		0.055***		0.044*	
	(0.022)	(0.023)			(0.023)		(0.021)		(0.024)	
ln(1+pop. den.)			0.124***	0.162***		0.122**		0.118***		0.112**
			(0.041)	(0.043)		(0.049)		(0.039)		(0.046)
ln(1+pop. den.) sqrd.			-0.015**	-0.017**		-0.017**		-0.014**		-0.012*
			(0.007)	(0.007)		(0.007)		(0.006)		(0.007)
Dropped	Lev LQ	DfB LQ	Lev PD	DfB PD	Americas	Americas	Euro.	Euro.	NonAg	NonAg
Observations	983	973	984	966	687	687	1,016	1,016	759	759
Other cont.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Robust standard errors in parentheses. All regressions are probit, with marginal effects reported. Other controls are as in the table of main results.

Table 7: Possible endogeneity of land quality

	(1)	(2)	(3)	(4)
	Any land rights		*Any slavery*	
Land quality	0.069***	0.056***	0.061***	0.084***
	(0.018)	(0.019)	(0.022)	(0.027)
Soil depth constraints	0.095***		0.053**	
	(0.019)		(0.021)	
Soil fertility constraints		0.020		0.074***
		(0.018)		(0.026)
Observations	801	801	1,041	1,041
Other cont.	Y	Y	Y	Y

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Robust standard errors in parentheses. All regressions are probit, with marginal effects reported. Other controls are as in the table of main results.

Table 8: Alternative clusters (p. values)

		(1)	(2)	(3)	(4)
		Any land rights		*Any slavery*	
	Clustering				
Land quality	Robust	0.00	0.01	0.01	0.03
	Ethno. region	0.02	0.05	0.01	0.02
	Country	0.00	0.03	0.37	0.08
	UN region	0.00	0.08	0.34	0.10
ln(1+pop. den.)	Robust	0.00	0.00	0.00	0.01
	Ethno. region	0.00	0.00	0.00	0.01
	Country	0.00	0.00	0.00	0.07
	UN region	0.00	0.00	0.00	0.02
ln(1+pop. den.) sqrd.	Robust			0.00	0.03
	Ethno. region			0.00	0.04
	Country			0.00	0.14
	UN region			0.00	0.09
Observations		801	801	1,041	1,041
Other cont.		N	Y	N	Y

Notes: All regressions are probit, with marginal effects reported. Other controls are as in the table of main results.

Table 9: Results with region fixed effects

	(1)	(2)	(3)	(4)
	Any land rights		*Any slavery*	
Land quality	0.014		0.037	
	(0.018)		(0.023)	
ln(1+pop. den.)		0.102***		-0.004
		(0.012)		(0.043)
ln(1+pop. den.) sqrd.				-0.004
				(0.007)
Observations	801	801	1,041	1,041
Other cont.	Y	Y	Y	Y

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Robust standard errors in parentheses. All regressions are probit, with marginal effects reported. Other controls are as in the table of main results.

Table 10: Galton's problem

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Spatial error model	*Any land rights*				*Any slavery*			
Land quality	0.031**		0.017		0.006		0.015	
	(0.014)		(0.015)		(0.014)		(0.015)	
ln(1+pop. den.)		0.085***		0.082***		0.079**		0.040
		(0.010)		(0.011)		(0.031)		(0.031)
ln(1+pop. den.) sqrd.						-0.017***		-0.009*
						(0.005)		(0.005)
Wald test (λ=0)	660.8	299.8	527.7	191.3	1481	1543	638.2	676.8
Observations	801	801	801	801	1,041	1,041	1,041	1,041
Other cont.	N	N	Y	Y	N	N	Y	Y
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Spatial lag model	*Any land rights*				*Any slavery*			
Land quality	0.029**		0.017		0.011		0.009	
	(0.013)		(0.013)		(0.012)		(0.014)	
ln(1+pop. den.)		0.070***		0.075***		0.061***		0.031
		(0.009)		(0.010)		(0.023)		(0.027)
ln(1+pop. den.) sqrd.						-0.013***		-0.007
						(0.004)		(0.004)
Wald test (ρ=0)	555.8	127.0	191.8	56.63	1435	1071	217.0	225.4
Observations	801	801	801	801	1,041	1,041	1,041	1,041
Other cont.	N	N	Y	Y	N	N	Y	Y

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Robust standard errors in parentheses. All regressions are probit, with marginal effects reported. Other controls are as in the table of main results.

Table 11: Other outcomes

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Any state centralization				*Polygyny is usual*			
Land quality	0.057***		0.052***		0.044***		0.013	
	(0.016)		(0.019)		(0.015)		(0.019)	
ln(1+pop. den.)		0.134***		0.166***		0.253***		-0.052
		(0.009)		(0.013)		(0.027)		(0.038)
ln(1+pop. den.) sqrd.						-0.042***		0.000
						(0.005)		(0.006)
Observations	1,075	1,075	1,075	1,075	1,172	1,172	1,172	1,172
Other cont.	N	N	Y	Y	N	N	Y	Y

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Robust standard errors in parentheses. All regressions are probit, with marginal effects reported. Other controls are: Absolute latitude, major river, mostly fishing, precipitation, temperature, date observed, dist. to coast, pct. malarial, elevation, ruggedness, share desert, elevation.