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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 endogenous 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 can explain institutional differences across regions, but not within regions. I present suggestive evidence that this is due to institutional spillovers.

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1. INTRODUCTION

The "land abundance" view of African history accounts for the economic institutions that existed on the continent before colonial rule (Austin, 2008a; Hopkins, 1973; Iliffe, 1995). It holds that, since 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 this paper, I use cross-sectional data on a sample of 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.

Although I am motivated by a literature that focuses on Africa, the "land abundance" view attempts to explain land rights and slavery globally. The Lagerlöf (2010) model need not apply only to Africa. I, then, test the model using a global sample. Land tenure and slavery matter today. Land tenure shapes investment incentives (Goldstein and

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Udry, 2008), labor-supply (Field, 2007), and violence (Andre and Platteau, 1998). Nunn (2008a) shows that those African countries that exported the most slaves are comparatively poor today. Within the Americas, legacies of slavery explain differences in income across countries and U.S. counties (Engerman and Sokoloff, 1997; Nunn, 2008b), as well as long term racial gaps in education and income (Miller, 2011; Sacerdote, 2005).

The "land abundance" view of African history argues that the continent's geography has given it an abundance of land relative to labor. I add, then, to our understanding of the geographic origins of institutions. Geographic features such as continental orientation, ruggedness, settler mortality, and suitability for specific crops predict contemporary institutional differences across countries (Easterly and Levine, 2003; Engerman and Sokoloff, 1997; Nunn and Puga, 2012). The crucial geographic variables in the Lagerlöf (2010) model are land quality and population density. Michalopoulos et al. (2010) and Michalopoulos (2011) have shown that heterogeneity in land quality predicts both ethnic fragmentation and the emergence of Islam. Acemoglu et al. (2002) argue that pre-colonial population densities determined the colonial institutions imposed by Europeans. I highlight institutional consequences of these two variables that have been neglected in the literature.

In the Lagerlöf (2010) model, exogenous land quality increases the returns to landownership, compensates for the inefficiencies of slavery, and sustains greater population in the steady state. Endogenously evolving population responds to 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 model using a cross-section of global societies from Murdock's (1967) *Ethnographic Atlas*. 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, 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. 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 this theory of land rights and slavery better explains the data than some prominent alternatives, including ecological risk as a cause of common property, and suitability for specific crops as a predictor of slavery. In Section 6, I demonstrate that the model is unable to predict differences within regions, and present evidence that this is due to spatial correlation in institutional outcomes. In Section, 7 I conclude.

2. THE LAND ABUNDANCE VIEW OF AFRICAN HISTORY

2.1. **Literature.** A first-order task in African history is explaining the continent's long-run differences from the rest of the world. The starting point of the land abundance view is Africa's distinctive settlement pattern. 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.[1] 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." Here, I outline the implications for land rights and slavery.

Austin (2009, p. 33) argues that African land was often "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. Citizens were given land virtually freely. Austin (2008a, p. 591-594) notes that 'islands' of intensive agriculture have existed in Africa where insecurity has created artificial land scarcity and in specific locations of exceptional value. Against these views, Spear (1997, p. 154-157) argues that population density cannot explain individual cases. Berry (1988), similarly, has noted that inheritance rules, tenancy contracts, and labor arrangements prevent the evolution of individualized land tenure. Thornton (1992, p. 75-76) suggests that ownership of land results from legal claims, not population pressure.

For Austin (2008a, p. 606-610), scarcity of labor explains forced labor. He builds on Nieboer (1900) and Domar (1970), who argue that coercion is cheaper than paying a wage when labor is scarce and wages high. Writers such as Kopytoff and Miers (1977, p. 68-69), Lovejoy (1978, p. 349), or Miers and Klein (1998, p. 4-5) object that slaves were employed in non-economic uses and distributed by non-market means. Kopytoff (1987, p. 46) and Goody (1980, p. 26-31) add that dependents must be "seduced" rather than coerced, so slavery can only exist in complex societies and states with "well-developed systems of compulsion."

I clarify this literature and test its claims. With the Lagerlöf (2009) model as a reasonable formalization, the "land abundance" view can be reconciled with some of its criticisms. While high wages resulting from population density explain the preference for slavery over free labor under certain conditions in the model, there are also conditions under which population is too sparse for slavery to be worthwhile, corresponding with the less complex societies in Africa that have poorly developed systems of compulsion. I show that the institutional effects of population and agricultural productivity follow regular patterns, and that the presence of slavery is systematically related to the economic value of slaves and to population.

[1] His estimate for North Africa is 9.4 persons per Sq. Km.

2.2. **Model.** 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, 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 free labor 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" view. 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 neglected by the Africanist literature. Lagerlöf (2009) makes the concept of "land abundance" more precise; it is the availability of cultivable land relative to both population and productivity that matters. 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:

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

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, which depends on P_t. The elite's payoff is:

(4) $$\pi_t^F = \max_{L_t \geq 0} \{A_t^{\alpha} L_t^{1-\alpha} - w_t L_t\}.$$

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.

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 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. 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. This 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 average product has fallen, making enclosure worthwhile. $A_t \leq \Psi(P_t)$ occurs when population growth pushes down wages 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 (A_t, P_t) space, where average product and the counterfactual wage are both relatively high.

The model has dynamics that 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 both 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.

2.3. **Tests.** 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, these are still correlations implied by the model and part of its implications. 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 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 "land abundance" view.

2.4. **Other implications.** I use land quality $\bar{A}$ and population P_t to test the land abundance view. There are seven additional parameters in the model. I do not use these to derive additional tests. Three parameters, β, q and α, do not yield clear predictions for the existence of land rights or slavery. The remaining parameters, γ, D, θ and $\bar{c}$, do give clear predictions (see the web appendix), but are not directly observed in geographic data. The geographic controls I am able use will affect several parameters at once. Ruggedness, for example, may increase the cost of guarding slaves (γ) through the mechanisms identified by Nunn and Puga (2012), but will also impact technological parameters (θ, D, and α) directly, since feasible agricultural systems differ between flat and rugged areas.

3. Data and Specifications

In this section, I outline how I test the predictions of the model. I use a cross section of data on 1,205 societies. In Section 3.1, I detail the econometric specifications. 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:

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

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 vector 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 specific functional form is chosen because slavery peaks towards the left hand side of the population distribution. A strictly 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 $\beta_{p2} < 0$. I estimate equations with log population density and land quality separately, since the correlation between the two ($\rho = 0.36$) inhibits joint tests. I do not report results of the land rights regression with the quadratic term, since an inverse-U relationship is not anticipated by the model. If I do estimate the land rights equation with the quadratic term, that term not statistically significant.

3.2. **Data.** I use two types of data to test the ability of the model to explain institutions. Details of the variables used and their sources are in the web appendix. The first type of data covers institutions, and is taken from Murdock's (1967) *Ethnographic Atlas*. This is a database of 1,267 societies from around the world. It contains categorical variables describing several institutional and cultural features of these societies, usually 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 (Ancient Egypt, Aryans, Babylonia, Romans, Icelander, Uzbeg, Khmer, Hebrews), and 52 for which land quality information is missing (mostly small Pacific islands). This leaves a base sample of 1,205 societies. 801 of these have data on land rights, 1,040 on slavery.

I construct binary variables for whether land rights or slavery exist. Summary statistics are given in Table 1. For each society, I observe land rights and slavery at the same point in time. I map these variables in Figure 2. Why use this data? The principal justification is availability. This is the only source of cross-cultural information on land rights and slavery that has global scope. In addition, the variables were compiled by the same author, and so are internally consistent.

The second type of data includes features of the natural environment. I join these to the *Ethnographic Atlas* using one of five map sources. First, I join African societies to ethnic groups mapped by Murdock (1959). Second, I merge First Nations groups in the United States and Canada with maps from the *Handbook of North American Indians* (Heizer and Sturtevant, 1978).[2] Third, I join ethnic groups from the rest of the

[2]These were digitized for the United States by Dippel (2010) and for Canada by myself.

world to Global Mapping International's (GMI) detailed World Language Mapping System. Fourth, if no match can be found in the GMI map, I use the less detailed Geo-Referencing Ethnic Groups (GREG) map of Weidmann et al. (2010). Finally, if no match can be found in any of these, I match groups with modern administrative boundaries. For example, the Nunivak are matched to Nunivak Island.

I use the historical maps first in order to reduce migration-induced errors. The Murdock (1959) and Heizer and Sturtevant (1978) maps show ethnic groups prior to European contact. Historical maps are not available for Asia or Latin America, necessitating use of the more modern GMI and GREG maps. Of 1,267 societies, 100 were matched to a different group indicated in the same location 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 and a map of the assembled polygons are given in the web appendix.[3]

Once these matches are formed, I join geographic raster data to them by taking the average of the raster points within an ethnic group's territory. Two of these controls are of particular importance – land quality and population density.

3.2.1. *Land quality.* To measure land quality, I re-scale Fischer et al.'s (2002) index of climate, soil and terrain slope constrains on rainfed agriculture so that it is a standard normal variable between 0 and 1. Larger values of the re-scaled variable indicate better land. This is a proxy for $\bar{A}$ in the model.

Constraints were measured as part of the Food and Agriculture Organization's Global Agro-Ecological Zones (FAO-GAEZ) project.[4] This measure is not particular to any specific crop or technology. It is a non-additive combination of:

(1) *Climate constraints:* Coldness constraints are "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 fewer than 120 days with an average temperature below 5°C during which moisture conditions are adequate to permit crop growth. They are severe if there are fewer than 60 such days.
(2) *Soil constraints:* Soil depth, fertility, drainage, texture and chemical constraints are considered. "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

[3]The Ethnographic Atlas gives co-ordinates for each society. All but 46 of these societies are within 500 km of the centroid of the polygon to which they are joined. Of these discrepancies, 22 are due to obvious errors in the Ethnographic Atlas. For example, the Ethnographic Atlas gives the Koreans a coordinate that is in Tibet. 14 are groups that cover diffuse areas, making it difficult to assign them a meaningful coordinate. These include Russians and the Eastern Cree. 8 are given coordinates in the Ethnographic Atlas that differ from their locations in the other maps for no obvious reason. The remaining two are idiosyncratic. The GMI map divides the Botocudos into 3 polygons. Two of are in Minas Gerais, as expected, but one is in Rio Grande do Sul. Second, the polygon that represents the Diegueno in Heizer and Sturtevant (1978) is truncated at the US border.

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

stony soils are severe constraints. Cracking clay is a moderate constraint. Salinity, sodicity, and gypsum are severe constraints.

(3) *Terrain slope constraints:* Terrain slopes greater than 8% are "moderate" constraints, and slopes greater than 30% are "severe."

An advantage of this constraints-based measure is that it is not based on expected yields in contemporary agriculture, in which greater crop diversity is available for many of the societies than at the time they are observed. I do not adjust land quality for the relative distribution of population within an ethnic group's territory, since this creates implausibly high estimates of land quality in the Arctic and Sahara.

3.2.2. *Population density.* All historical population reconstructions are guesses. One book on pre-Columbian America is entitled "Numbers from Nowhere" (Henige, 1998). The principal measure I use for historical population density is from the History Database of the Global Environment (HYDE) version 3.1. This raster data on historical population covers the years 1500, 1600, and every ten years since 1700. For each ethnic group, I measure historical population density as the average of the raster points within its territory for the year of observation recorded in the *Ethnographic Atlas*.[5]

Details of these estimates are reported by Bouwman et al. (2006), Klein Goldewijk et al. (2010) and Klein Goldewijk (2005). This data source takes as its base a map of 3441 administrative units from 222 countries. Historical data are then reconstructed on this base map using Lahmeyer (2004), Helders (2000), Tobler (1995), several local studies, interpolation, and back projection. The data are reported on a five minute grid.

I plot land quality and population density in Figure 3. I present the percentiles of the HYDE data and the two principal alternatives, described below, in Table 1. These range from nearly zero persons per square mile for several groups in the Mato Grosso and interior Amazon, to over 3,000 persons per square mile for the Okinawans of Japan.[6]

3.2.3. *Alternative measures of population density.* Because historical population reconstruction is unavoidably inexact, it is important to show that the results can be obtained using alternatives to the HYDE estimates. Because the alternatives are not raster data, I adopt a simple method to estimate alternative spatially disaggregated historic population densities for the societies in my data. I begin with raster data on population density in 1995 for each of these ethnic groups and combine it with historical estimates for the broader regions within which these groups are located. Specifically, my alternative estimates take the form:

[5]For computational reasons, I use data from each 50 year interval, imputing intermediate years exponentially.

[6]This is an over-estimate due to over-representation of Naha in the original data; administrate records give a modern density of just above 1,500 persons per square mile. Results are robust to excluding the Okinawans.

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

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. GIS data on population in 1995 is from the FAO-GAEZ. I use two sources of regional estimates. The first is McEvedy and Jones (1978). There are well-known problems with these data (Austin, 2008b; Hopkins, 2009), and so I also use the ARVE Group's estimates (Krumhardt, 2010).[7]

While only a first-order approximation, this approach is preferable to using the unweighted regional densities directly. McEvedy and Jones (1978), for example, assign a single population density to all of Canada. To treat the the Inuit and Ojibwe as equally dense would be implausible, and would introduce substantial measurement error.[8] In addition to these two main alternatives, 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 *Standard Cross-Cultural Sample* (SCCS) of Murdock and White (1969). A derivative of the *Ethnographic Atlas*, the SCCS contains a larger number of variables for a smaller sample of societies.

3.2.4. *Other controls.* I control for other factors that may determine the existence of land rights and slavery. These are re-scaled as standard normal variables in the regressions. Definitions and sources are outlined in the web appendix. These are the presence of a major river, distance to the coast, elevation, the percentage of the society's territory in which malaria is endemic, precipitation, ruggedness, temperature, date of observation, absolute latitude, share desert, and an indicator for whether the society derives most of its income from fishing. These capture variation in the parameters of the model that I am unable to measure directly, i.e. $\bar{c}$, β, α, γ, q, D, and θ.

Access to a major river and distance from the coast proxy for water-borne diseases that affect the cost of fertility (q). They also capture the presence of trade, which affects the production function (α) through the goods that are traded and through technological transfer. These affect the cost of slavery (γ) through what uses exist for slaves and whether they can be punished by sale for export. Proximity to markets also affects the

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

[8]Ruff (2006) suggests that the Northeast had a population density at contact roughly seven times that of the Arctic. The method used here assigns the Ojibwe a historic population density of 2.20 per square mile and the Copper Eskimo a population density of 0.31 per square mile – a roughly seven-fold difference.

relative utility of fertility (β) through the usefulness of children as substitutes for insurance and savings. Elevation alters q trough the disease environment and α via the range of available crops and technologies.

Malaria affects q through child mortality and γ via slave mortality. Malaria and absolute latitude both proxy for unobservable features of the tropics that make their institutions systematically different from those in other parts of the world.[9] Precipitation determines what crops can be grown, shaping α. Ruggedness, as discussed above, shapes γ, α and D. Temperature affects the physical cost of effort, and hence γ. In hostile environments such as deserts, it is more difficult for slaves to flee; γ is lower. Temperature affects q through nutrition and disease.

The date of observation is a proxy for the degree of European influence and other institutional contamination that pushes societies towards a Westernized recognition of land rights and abolition of slavery. If these societies were viewed at another point in time, there is no guarantee they would possess the same institutions or population densities.

The control for fishing is included with the Pacific Northwest in mind. Here, groups such as the Haida captured slaves in canoe raids and used them in fishing and hunting (Donald, 1997). This region is known for having a high surplus and developed material culture despite the unimportance of agriculture. For groups with easy access to fish, land quality may be a poor measure of $\bar{A}$ in the model. This is why Nieboer (1900) formulated his view in terms of the abundance of resources in general.

4. RESULTS

4.1. **In pictures.** I divide the sample into percentiles of land quality and historic population density. In Figure 4, I report the fraction of societies in each percentile that have land rights. In Figure 5, I do the same for slavery. The raw correlations are as predicted. Land rights are positively related to land quality and population density. Slavery is positively correlated with land quality, though this is weaker than the relationship for land rights. In the model, the existence of multiple steady states helps explain this. Further, slavery is most prevalent in societies with intermediate population densities.

4.2. **Regressions.** In Table 2, I report the results of estimating (5), (6) and (7). I report marginal effects. 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 deviation improvement in land quality raises the probability that land rights exist by roughly 4.6%. Interpreting the coefficient on population density as an elasticity, a 1% increase in population density is associated with a 0.12% increase in

[9] I report results excluding absolute latitude in the web appendix. Results are similar without this control, though the quadratic term on population density becomes marginally insignificant in the slavery equation.

the chance that land rights exist.[10] A one standard deviation increase in land quality predicts a 4.7% increase in the chance of slavery. The coefficients on the nonlinear function of population density are not directly interpretable. The inverted-U probability profile visible in Figure 5 is visible here. The level of historic population density at which slavery peaks, $(e^{\beta_{p1}/(2\beta_{p2})})$, is 70 persons per square mile. This is between the 85^{th} and the 90^{th} percentiles of the data.

5. Robustness: What the model can explain

In this section, I show that the results are robust to several possible objections. First, they can be replicated using alternative measures of land rights and slavery. The measures used for the dependent variables are correlated with alternatives from other samples too small to be used for replication. Second, similar results are obtained using different estimates of population density and land quality. Third, the results survive checks for the importance of influential observations, for the endogeneity of land quality, and for alternative clustering of standard errors. Fourth, while the data provide only limited scope for testing the model against alternative explanations of land rights and slavery, the model performs well against competing theories.

5.1. **Alternative measures of the dependent variables.** The measures of land rights and slavery are coarse indicators. Land rights, in particular, exist for 74% of societies in the data, but this does not distinguish how well defined these rights are. I show, first, that the main measure is positively correlated with $v1726$ in the *SCCS*, an indicator for whether land is mostly private. A full description of the *SCCS* variables and their coding is given in the web appendix. 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 Table 3.

Next, I use an indicator for whether the inheritance of land is patrilineal as an alternative measure of land rights.[11] Here, I follow Goody (1969, p. 65), who argues that:

> [T]he scarcer productive resources become and the more intensively they are used, then the greater the tendency towards the retention of these resources within the basic productive and reproductive unit, which in the large majority of cases is the nuclear family.

If land is scarce, it is an important consideration in marriage. This puts emphasis on transmission of property from parents to children. Under patrilineal inheritance, land may pass from a man to his son or his brother. Under matrilineal inheritance, land necessarily passes out of the nuclear family to a man's brother or to his sister's son. I also use an indicator for whether land is inherited by children as a more precise measure of

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

[11] 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.

the degree to which land is retained within the nuclear family.[12] I show in Table 3 that both of these are positively related to land quality and population density.

For slavery, I make similar tests. First, I show in 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. I also show that the results can be mostly replicated by constructing alternative measures of slavery from the *Ethnographic Atlas.* Slavery is recorded as "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 relationship 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 insignificant.

5.2. **Alternative measures of land quality and population density.** I validate the land quality measure by showing that it is strongly correlated with three alternatives contained in the *SCCS* – $v921$, $v924$ and $v928$. This is reported in Table 4.

I replicate the results with alternative proxies of population density. In Table 4, I show that the main measure of population density is correlated with an indicator of land shortage ($v1720$) from the *SCCS*. I also show that the main results can be replicated with three alternative measures of population density – density in 1995, and densities computed using McEvedy and Jones (1978) or ARVE estimates as in (8). If I do not weight the regional densities, I find an inverse-U but insignificant relationship with slavery using the McEvedy and Jones (1978) estimates, and a significant inverse-U using the ARVE data (not reported). 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 the baseline.

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 categorize the societies into bins. While there are not enough observations to replicate the econometric analysis, I show in Figure 6 that these alternative measures have inverse-U relationships with slavery.

Any historical population density estimate is untrustworthy on its own. The measures here agree that land rights have existed where population was densest, and that slavery was most likely at intermediate values of population density. This is consistent with the model and the "land abundance" view.

5.3. **Other robustness checks.** No sub-set of the data is determining the results. In the web appendix, I list the ten most influential societies for each of the major coefficients of interest. The societies that drive the relationships between land rights and the two variables of interest are not concentrated in any one region.

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[12]This is equal to 1 if V74=4, 5 or 7.

In the web appendix, I show that removing statistical outliers or Europeans and their offshoots has little effect on the results. If I remove 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 within the Americas was most prominent in areas of the Pacific Northwest where agriculture was unimportant. Excluding non-agricultural societies eliminates the relationship between land quality and land rights, leaving other results unchanged. 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 with endogeneity of population density. The model expects that population growth will respond to institutions, and I am only testing a correlation between two endogenous variables. I am, however, concerned about the endogeneity of land quality. Soil depth and soil fertility may be potentially human-caused. In Table 5, I address this by controlling directly for these components. The result survives separating land quality into its separate parts. Baseline results are included for comparison.

Finally, I have reported heteroskedasticity-robust standard errors. How sensitive is the statistical inference to correlations in the errors within possible clusters of observations? I address this in the web appendix, clustering the standard errors by ethnographic region (of which there are 60), by country, or by global region as classified by the UN. The results are generally stable, though clustering by country pushes the p. values of the population quadratic term to 0.15 in the slavery equation. 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, particularly for slavery. In the web appendix, I also adjust standard errors for spatial correlation using the Conley (1999) logit model. Again foreshadowing the next section, the relationship between slavery and population density becomes insignificant once spatial correlations are accounted for. The other results of interest are robust to this correction.

5.4. **Other theories of land rights.** The two most influential theories of land rights are those of Boserup (1965) and Demsetz (1967). Boserup (1965) argues that exogenous population increase is the principal driver of agricultural intensification and more permanent tenure. This is the intuition captured by the Lagerlöf (2009) model. Other formalizations of this argument have captured these changes as the selection of production technology in response to the relative scarcity of land and labor (e.g. Hayami (1997); Quisumbing and Otsuka (2001)). The correlation of population density and land rights supports this view. Further, this result supports the model against informal critiques of Boserup (1965) that have argued that population pressure can lead to multiple outcomes, including open access (e.g. Baland and Platteau (1998)).

These data do not, of course, allow the model to be tested against all possible mechanisms by which population density is positively correlated with the existence of rights over land. Specific alternatives can be evaluated. It may be supposed, for example, that population density affects land rights only through the existence of states. Re-estimating (6) separately for stateless societies and those with states, however, gives a positive and significant coefficient on historic population density in both sub-samples (not shown).

Demsetz (1967), by contrast, focuses on trade. He argues that land rights internalize externalities when the gains outweigh the costs. This drives enclosure of the commons in the formal treatments of Hotte et al. (2000) or Copeland and Taylor (2009), and explains the empirical results of Bogart and Richardson (2012). It is similar to the greater effort expended in defending rights over more valuable resources predicted by models of the economics of conflict (e.g. Baker (2003); Grossman and Kim (1995)). These are not inconsistent with the land abundance view, and are incorporated into Austin's (2008a) account of it. The data do not include direct information on trade. The two controls that best capture trade in the data – distance from the coast and access to a major river – do not significantly predict the existence of land rights in Table 2.

Beyond these two influential theories, there is a literature on the enclosure of common property (e.g. Baland and Francois (2005); Baland and Platteau (2003); Grantham (1980); Lueck (1994); Netting (1976); Ostrom (1991); Runge (1986)). These works identify several benefits of common property that help explain why it survives. These include scale economies, risk pooling, exclusion and effort costs, and equity concerns. None of these explanations exclude land abundance as an explanation of weakly defined land rights. Most of these variables are not available in the data, making it impossible to test the land abundance view against them. The exception to this is risk. In Table 6, I add a measure of ecological risk, including the coefficient of variation of annual rainfall over the period 1950-1999.[13] This does not diminish the direct effect of land quality.

5.5. **Other theories of slavery.** Several theoretical analyses of slavery and coercion exist (e.g. Barzel (1977); Bergstrom (1971); Canarella and Tomaske (1975); Findlay (1975); Genicot (2002)). Some, such as Conning (2004), formally capture the same intuition as Nieboer (1900) or Domar (1970), which is the basis of the Lagerlöf (2009) model. In this section, I contrast the results outlined in Section 4 with two other broad explanations of slavery.

First, several theories emphasize coerced workers' outside options. These include what Acemoglu and Wolitzky (2011) refer to as the "neo-Malthusian" explanations of the decline of serfdom. North and Thomas (1971), for example, hold that serfs voluntarily exchanged their labor for protection.[14] Several models find that worse outside options for workers increase the degree of coercion in labor contracts (Beber and Blattman,

[13] Data here come from the University of Delaware Center for Climatic Research.

[14] 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.

2011; Chwe, 1990).[15] Similarly, Acemoglu and Wolitzky (2011) find that labor scarcity has two effects, raising coercion through a Domar-type increase in the price of output, but also reducing coercion by improving workers' outside options.

If workers' outside options help explain the existence of slavery, this does not rule out labor scarcity as an explanation. Workers' outside options are not directly observed in the data, making it impossible to test the model against this explanation directly. Following the narrative of Nunn and Puga (2012), ruggedness is expected to improve the outside option of slaves by making it easier for them to flee. Contrary to this intuition, however, the marginal effect of ruggedness on slavery in Table 2 is positive.

There are four reasons North and Thomas (1971) cannot explain Africa. First, Fenoaltea (1975), demonstrates that they 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." Second, land quality and population density at low levels are positively associated with slavery. North and Thomas (1971) predict these would promote the development of trade and markets, lessening the need for contracts to be written in labor dues. Third, their prediction that trade will discourage the use of serfs runs counter to African history, in which external trade spurred greater use of slaves in production (Law, 1995; Lovejoy, 2000). 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.

The second set of theories I address argues 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 is unnecessary. Fogel and Engerman (1974) link the productivity of slaves in the American south to economies of scale that could only be achieved through gang labor. 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. Studies of slavery in individual African societies frequently make reference to slave labor and free labor working in the same tasks. Austin (2005), for example, 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 "[i]n domestic activities ... no operation was strictly reserved for slaves." Second, the literature on the

[15]Naidu and Yuchtman (2011), by contrast, argue that British industrial workers committed to coercive contracts in order to reduce wage variation.

"legitimate commerce" period suggests that slaves were used in the activities where labor of all kinds was most productive. Nineteenth century export markets created higher returns to slave labor, and slavery within Africa intensified (Law, 1995; Lovejoy, 2000; Lynn, 1997) 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.

The data only allow limited tests of the land abundance view against these arguments, since economies of scale, turnover costs, or the detailed care needed in production are not observed. The FAO does, however, report the suitability of land for eight classes of rainfed crop – wheat, maize, cereals, roots/tubers, pulses, oil crops, sugar, and cotton. I test whether including these measures in the slavery regressions has any effect on the results. This tests the Lagerlöf (2009) model against the alternative that slavery is explained by its productivity in the production of specific crops. I report the results in Table 6. With one exception, none of these specific crops has a major impact on the coefficient on land quality. The exception is maize suitability, which weakens the effect of land quality, making it marginally insignificant. Since the main effect of maize is itself insignificant and the two variables have a high raw correlation of 0.44, this is likely due to multi-collinearity.

6. HETEROGENEITY: WHAT THE MODEL CANNOT EXPLAIN

In Table 7, I show a simple method to do away with 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 disappeared. The model can predict differences across regions, but not within them.

Why? Anthropologists have a name for the diffusion of institutions across societies: "Galton's problem." Economists would call this serial correlation or spatial dependence. I propose that the lack of robustness of the main results stems from these spillovers. If a nearby society has slavery, it is almost impossible to avoid developing the institution or becoming slaves, regardless of 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. Within the Lagerlöf (2009) model, these make sense as parameter shifts dependent on a neighboring group's institutions. The cost of slavery (γ), for example, should be lower if a slave who flees can only do so to another slave-holding society.

In Table 8, 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.[16] The spatial error model is similar. Now, the error term is given by $u = \lambda W u + \epsilon$, so that a society's error term may depend on the error terms for societies that are close to it.

In Table 8, it is clear that there is very strong spatial correlation in land rights. The Wald tests for ρ and λ are large, even conditional on the observed controls. Once 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. These strong spatial correlations in institutional outcomes help explain why the model can explain differences across regions, but not variation within them.

I confirm the ability of the model to explain differences across regions in the web appendix. 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. 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 visible. 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. In the web appendix, I report the regional means for these variables for the six major regions of the *Ethnographic Atlas*.

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 state centralization and high rates of polygyny in Africa 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 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 the web appendix, I replicate (5), (6) and (7) with states and polygamy as outcomes. The prevalence of states in the global sample mimics that of rights over land, rising

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

monotonically with land quality and population density.[17] Polygyny, by contrast, mimics the pattern seen for slavery – its presence increases weakly with land quality, but is strongest at intermediate levels of population.[18] The relationships between polygyny and the controls of interest are not robust to the inclusion of additional controls – malaria ecology is sufficient to make either one insignificant. This suggests that the land abundance view may have some power to explain the relative prevalence of states, though its application to polygamy may be more limited.

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 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. Finally, there are substantial institutional spatial correlations across 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.

REFERENCES

Acemoglu, D., Johnson, S., and Robinson, J. A. (2002). Reversal of fortune: Geography and institutions in the making of the modern world income distribution. *Quarterly Journal of Economics*, 117(4):1231–1294.

Acemoglu, D. and Wolitzky, A. (2011). The economics of labor coercion. *Econometrica*, 79(2):555–600.

[17]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.

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

Andre, C. and Platteau, J.-P. (1998). Land relations under unbearable stress: Rwanda caught in the Malthusian trap. *Journal of Economic Behavior and Organization*, 34(1):1–47.

Austin, G. (2004a). Markets with, without, and in spite of states: West Africa in the pre-colonial nineteenth century. *Working Paper*.

Austin, G. (2004b). *Sub-Saharan Africa: land rights and ethno-national consciousness in historically land abundant economies*, pages 276–293. Land Rights, Ethno-nationality and Sovereignty in History. Routledge, London.

Austin, G. (2005). *Labour, land, and capital in Ghana: from slavery to free labour in Asante, 1807-1956*. University of Rochester Press, Rochester, NY.

Austin, G. (2008a). Resources, techniques, and strategies south of the Sahara: revising the factor endowments perspective on African economic development, 1500-2001. *The Economic History Review*, 61(3):587–624.

Austin, G. (2008b). The "reversal of fortune" thesis and the compression of history: Perspectives from African and comparative economic history. *Journal of International Development*, 20(8):996–1027.

Austin, G. (2009). Factor markets in Nieboer conditions: Pre-colonial West Africa, c. 1500-c. 1900. *Continuity and Change*, 24(01):23–53.

Baker, M. J. (2003). An equilibrium conflict model of land tenure in hunter-gatherer societies. *Journal of Political Economy*, 111(1):124–173.

Baland, J. M. and Francois, P. (2005). Commons as insurance and the welfare impact of privatization. *Journal of Public Economics*, 89(2-3):211–231.

Baland, J.-M. and Platteau, J.-P. (1998). Division of the commons: A partial assessment of the new institutional economics of land rights. *American Journal of Agricultural Economics*, 80(3):644–650.

Baland, J. M. and Platteau, J. P. (2003). *Economics of common property management regimes*, volume 1 of *Handbook of Environmental Economics*, pages 127–190. Elsevier.

Barzel, Y. (1977). An economic analysis of slavery. *Journal of Law and Economics*, 20(1):87–110.

Beber, B. and Blattman, C. (2011). The logic of child soldiering and coercion. *Unpublished working paper, Yale University*.

Bergstrom, T. (1971). On the existence and optimality of competitive equilibrium for a slave economy. *The Review of Economic Studies*, 38(1):23–36.

Berry, S. (1988). Property rights and rural resource management: The case of tree crops in West Africa. *Cahier des sciences humaines*, 24(1):3–16.

Bogart, D. and Richardson, G. (2012). Property rights and parliament in industrializing Britain. *Forthcoming in Journal of Law and Economics*.

Boserup, E. (1965). *The conditions of agricultural growth: The economics of agrarian change under population pressure*. Aldine Pub. Co., New York.

Bouwman, A., Kram, T., and Klein Goldewijk, K. (2006). *Integrated modelling of global environmental change: an overview of Image 2.4.* Netherlands Environmental Assessment Agency Bilthoven,, The Netherlands.

Canarella, G. and Tomaske, J. (1975). The optimal utilization of slaves. *The Journal of Economic History*, 35(3):621–629.

Chwe, M. (1990). Why were workers whipped? Pain in a principal-agent model. *The Economic Journal*, 100(403):1109–1121.

Conley, T. (1999). GMM estimation with cross sectional dependence. *Journal of econometrics*, 92(1):1–45.

Conning, J. (2004). The causes of slavery or serfdom and the roads to agrarian capitalism: Domar's hypothesis revisited. *Hunter College: Department of Economics*.

Copeland, B. and Taylor, M. (2009). Trade, tragedy, and the commons. *The American Economic Review*, 99(3):725–749.

Demsetz, H. (1967). Toward a theory of property rights. *The American Economic Review*, 57(2):347–359.

Dippel, C. (2010). Forced Coexistence and Economic Development: Evidence from Native American Reservations. *Working Paper*.

Domar, E. D. (1970). The causes of slavery or serfdom: A hypothesis. *The Journal of Economic History*, 30(1):18–32.

Donald, L. (1997). *Aboriginal slavery on the northwest coast of North America*. University of California Press.

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

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.

Fenoaltea, S. (1975). The rise and fall of a theoretical model: The manorial system. *Journal of Economic History*, 35(2):386–409.

Fenoaltea, S. (1984). Slavery and supervision in comparative perspective: A model. *The Journal of Economic History*, 44(3):635–668.

Field, E. (2007). Entitled to work: Urban property rights and labor supply in Peru. *Quarterly Journal of Economics*, 122(4):1561–1602.

Findlay, R. (1975). Slavery, incentives, and manumission: a theoretical model. *The Journal of Political Economy*, 85(5):923–933.

Fischer, G., Shah, M., Velthuizen, H., and Nachtergaele, F. O. (2002). *Global Agro-Ecological Assessment for Agriculture in the 21st Century: Methodology and results.* International Institute for Applied Systems Analysis/Food and Agriculture Organization of the United Nations, Laxenburg and Rome.

Fogel, R. W. and Engerman, S. L. (1974). *Time on the cross: The economics of American Negro slavery*. Little, Brown and Company, Boston.

Genicot, G. (2002). Bonded labor and serfdom: a paradox of voluntary choice. *Journal of Development Economics*, 67(1):101–127.

Goldstein, M. and Udry, C. (2008). The profits of power: Land rights and agricultural investment in Ghana. *Journal of Political Economy*, 116(6):981–1022.

Goody, J. (1969). Inheritance, property, and marriage in Africa and Eurasia. *Sociology*, 3(1):55–76.

Goody, J. (1976). *Production and reproduction: A comparative study of the domestic domain*. Cambridge University Press, Cambridge.

Goody, J. (1980). *Slavery in time and space*, pages 16–42. Asian and African Systems of Slavery. University of California Press, Berkeley and Los Angeles.

Grantham, G. W. (1980). The persistence of open-field farming in nineteenth-century France. *Journal of Economic History*, 40(3):515–531.

Grossman, H. I. and Kim, M. (1995). Swords or plowshares? A theory of the security of claims to property. *The Journal of Political Economy*, 103(6):1275–1288.

Hanes, C. (1996). Turnover cost and the distribution of slave labor in Anglo-America. *The Journal of Economic History*, 56(2):307–329.

Hayami, Y. (1997). *Development economics: From the poverty to the wealth of nations*. Oxford University Press, USA.

Heizer, R. and Sturtevant, W. (1978). Handbook of North American Indians.

Helders, S. (2000). *The world gazetteer*.

Henige, D. (1998). *Numbers from nowhere: the American Indian contact population debate*. University of Oklahoma Press.

Herbst, J. (2000). *States and Power in Africa: Comparative Lessons in Authority and Control*. Princeton University Press.

Hopkins, A. G. (1973). *An economic history of West Africa*. Columbia University Press, New York.

Hopkins, A. G. (2009). The new economic history of Africa. *The Journal of African History*, 50(02):155–177.

Hotte, L., Long, N., and Tian, H. (2000). International trade with endogenous enforcement of property rights. *Journal of Development Economics*, 62(1):25–54.

Iliffe, J. (1995). *Africans: the history of a continent*. Cambridge University Press, Cambridge.

Inikori, J. E. (1999). *Slaves or Serfs? A Comparative Study of Slavery and Serfdom in Europe and Africa*, pages 49–75. The African Diaspora: African Origins and New World Identities. Indiana Univ Press.

Klein Goldewijk, K. (2005). Three centuries of global population growth: A spatial referenced population (density) database for 1700–2000. *Population & Environment*, 26(4):343–367.

Klein Goldewijk, K., Beusen, A., and Janssen, P. (2010). Long-term dynamic modeling of global population and built-up area in a spatially explicit way: Hyde 3.1. *The Holocene*, 20(4):565.

Kopytoff, I. (1987). *The internal African frontier: The making of African political culture*, pages 3–84. The African frontier: The reproduction of traditional African societies. Indiana University Press.

Kopytoff, I. and Miers, S. (1977). African 'slavery' as an institution of marginality. *Slavery in Africa: historical and anthropological perspectives*, pages 3–81.

Krumhardt, K. (2010). Methodology for worldwide population estimates: 1000 BC to 1850.

Lagerlöf, N. (2010). Pacifying monogamy. *Journal of Economic Growth*, pages 1–28.

Lagerlöf, N. P. (2009). Slavery and other property rights. *Review of Economic Studies*, 76(1):319–342.

Lahmeyer, J. (2004). Populstat database. growth of the population per country in a historical perspective, including their administrative divisions and principal towns.

Law, R. (1995). *From Slave Trade to "Legitimate" Commerce*. Cambridge University Press, Cambridge.

Lovejoy, P. E. (1978). Plantations in the economy of the Sokoto Caliphate. *Journal of African History*, 19:341–368.

Lovejoy, P. E. (2000). *Transformations in Slavery: A History of Slavery in Africa*. Cambridge University Press.

Lueck, D. (1994). Common property as an egalitarian share contract. *Journal of Economic Behavior & Organization*, 25(1):93–108.

Lynn, M. (1997). *Commerce and economic change in West Africa: The palm oil trade in the nineteenth century*. Cambridge University Press, Cambridge.

Mahadi, A. and Inikori, J. E. (1987). *Population and capitalist development in precolonial West Africa: Kasar Kano in the nineteenth century*, pages 62–73. African Population and Capitalism: Historical Perspectives. The University of Wisconsin Press, Madison, Wisconsin.

McEvedy, C. and Jones, R. (1978). *Atlas of world population history*. Penguin books Harmondsworth, UK.

Michalopoulos, S. (2011). The origins of ethnic 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 Working Papers*.

Miers, S. and Klein, M. A. (1998). Introduction. *Slavery & Abolition*, 19(2):1–15.

Miller, M. (2011). Land and racial wealth inequality. *The American Economic Review*, 101(3):371–376.

Murdock, G. and White, D. (1969). Standard cross-cultural sample. *Ethnology*, 8(4):329–369.

Murdock, G. P. (1959). *Africa: Its Peoples and Their Culture History.* McGraw-Hill.

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

Naidu, S. and Yuchtman, N. (2011). Coercive contract enforcement: Law and the labor market in 19th century industrial Britain. *Working paper.*

Netting, R. M. (1976). What alpine peasants have in common: Observations on communal tenure in a Swiss village. *Human Ecology*, 4(2):135–146.

Nieboer, H. J. (1900). *Slavery as an industrial system: Ethnological researches.* M. Nijhoff, The Hague.

North, D. C. and Thomas, R. P. (1971). The rise and fall of the manorial system: A theoretical model. *The Journal of Economic History*, 31(4):777–803.

Nunn, N. (2008a). The long-term effects of Africa's slave trades. *The Quarterly Journal of Economics*, 123(1):139–176.

Nunn, N. (2008b). Slavery, inequality, and economic development in the Americas: an examination of the Engerman-Sokoloff Hypothesis. *Institutions and economic performance*, pages 148–181.

Nunn, N. and Puga, D. (2012). Ruggedness: The blessing of bad geography in Africa. *The Review of Economics and Statistics*, 94(1):20–36.

Ostrom, E. (1991). *Governing the commons: The evolution of institutions for collective action.* Cambridge University Press.

Quisumbing, M. A. R. and Otsuka, K. (2001). *Land, Trees, and Women: Evolution of Land Tenure Institutions in Western Ghana and Sumatra.* IFPRI.

Ruff, C. (2006). *Population size, contact to Nadir.* Handbook of North American Indians: Volume 3, Environment, Origins, and Population. Smithsonian Institution, London.

Runge, C. F. (1986). Common property and collective action in economic development. *World Development*, 14(5):623–635.

Sacerdote, B. (2005). Slavery and the intergenerational transmission of human capital. *Review of Economics and Statistics*, 87(2):217–234.

Spear, T. T. (1997). *Mountain farmers: Moral economies of land and agricultural development in Arusha and Meru.* James Currey; University of California Press, Oxford; Berkeley, Calif.

Thornton, J. (1992). *Africa and Africans in the Making of the Atlantic World, 1400-1680.* Cambridge University Press.

Tobler, W. (1995). *The global demography project: National Center for Geographic Information & Analysis (US).* National Center for Geographic Information and Analysis Santa Barbara.

Uchendu, V. C. (1979). *Slaves and slavery in Iboland, Nigeria*, pages 121–132. Slavery in Africa: historical and anthropological perspectives. University of Wisconsin Press.

Weidmann, N., Rød, J., and Cederman, L. (2010). Representing ethnic groups in space: A new dataset. *Journal of Peace Research*, 47(4):491.

FIGURE 1. Institutional regions and dynamics

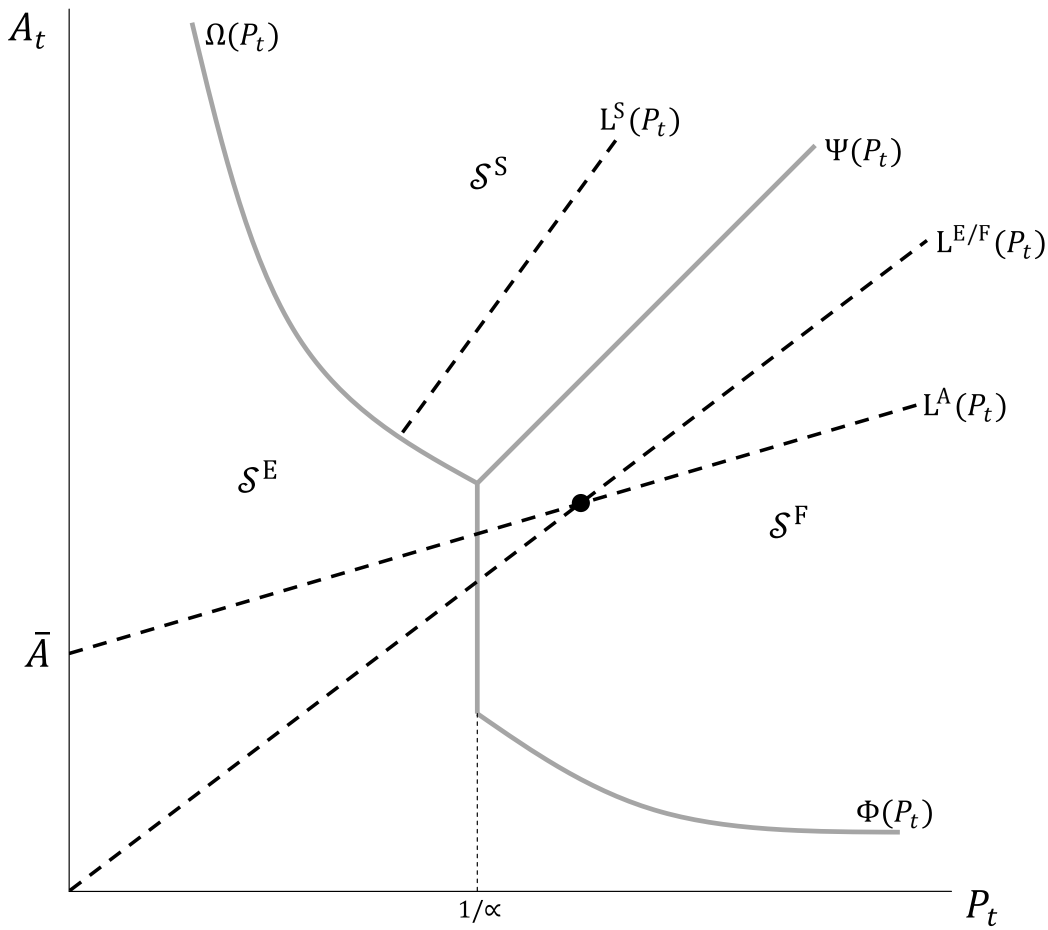
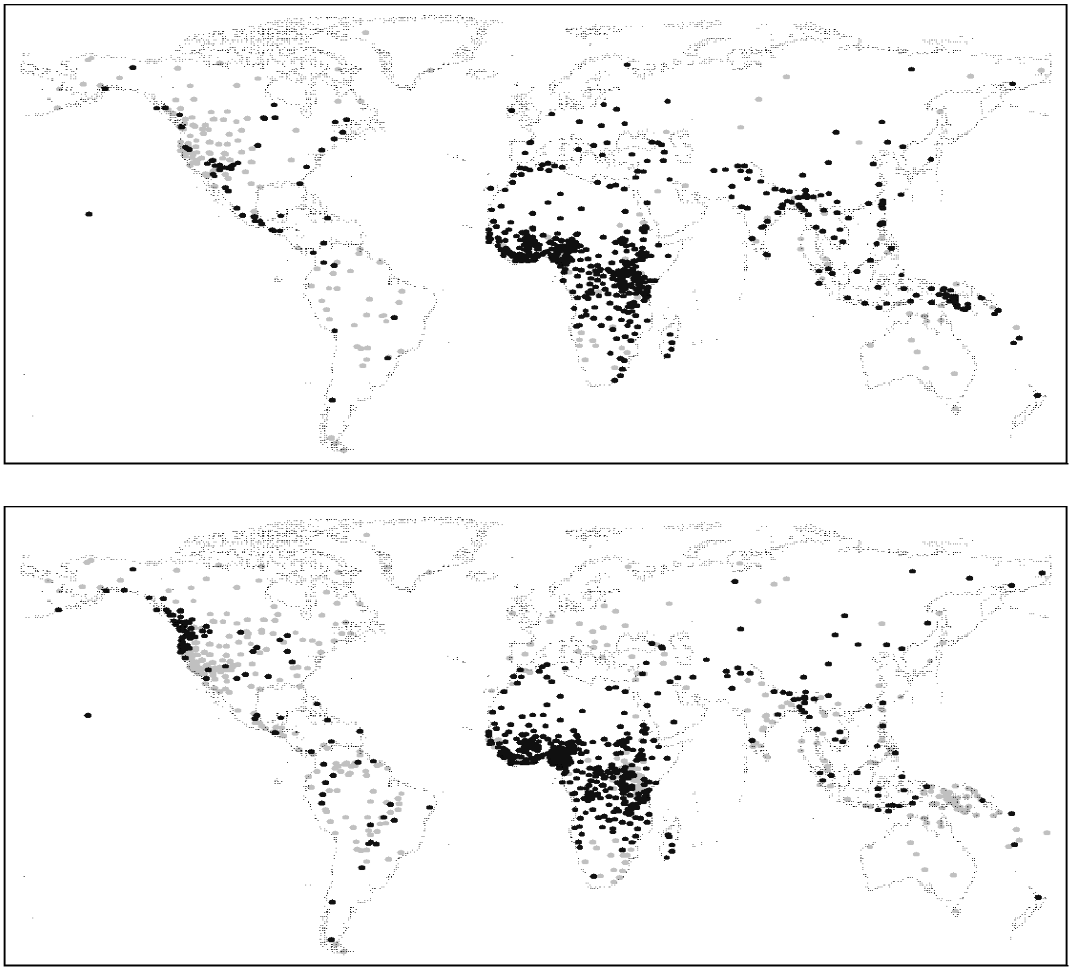
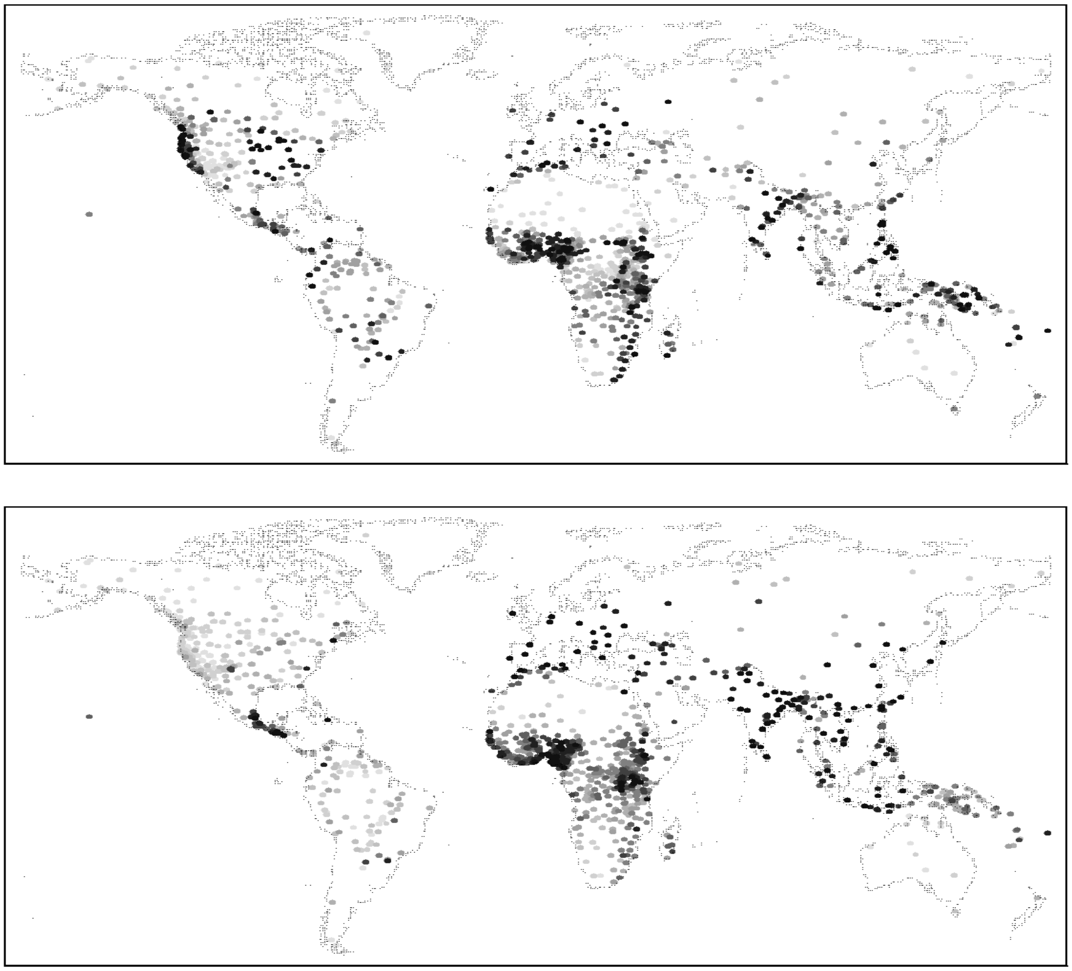


FIGURE 2. Land rights and slavery



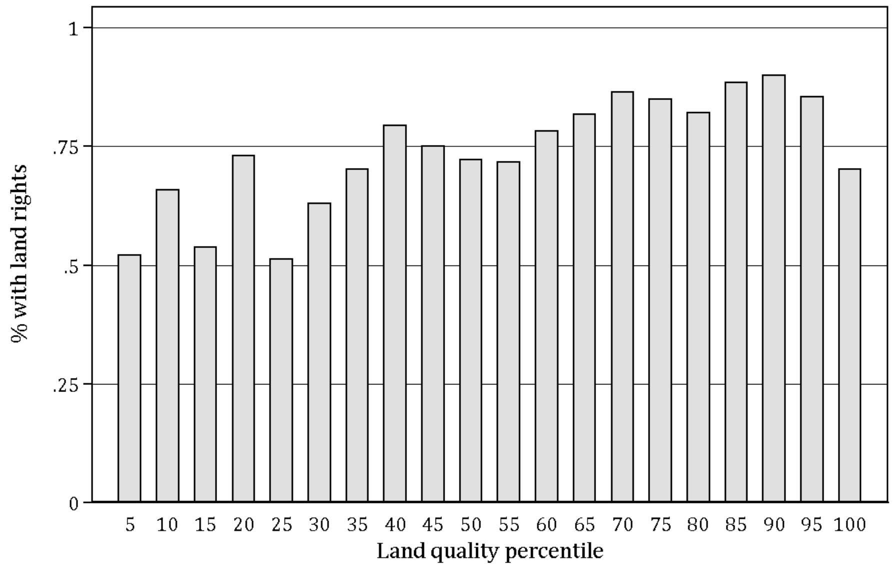
Land rights are on top, slavery on bottom. Black circles indicate presence, grey circles absence.

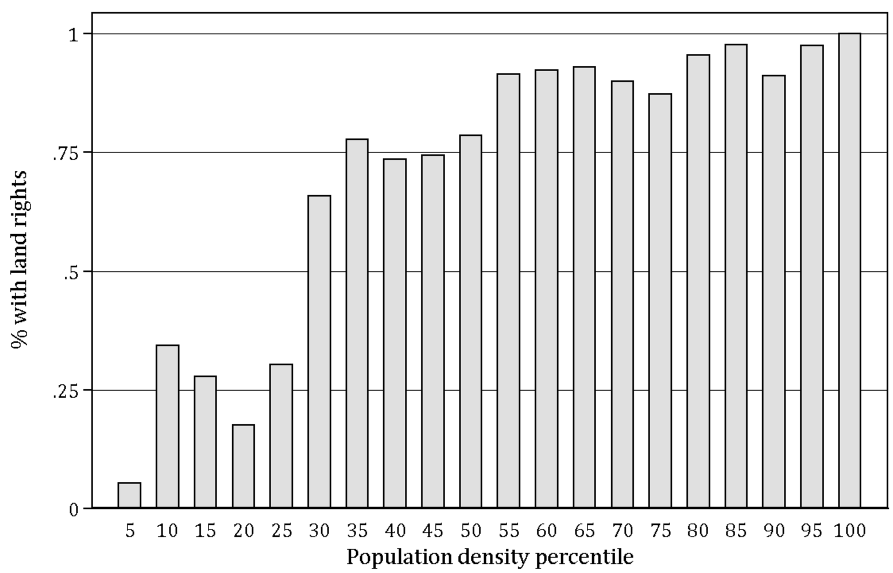
FIGURE 3. Land quality and historic population density



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

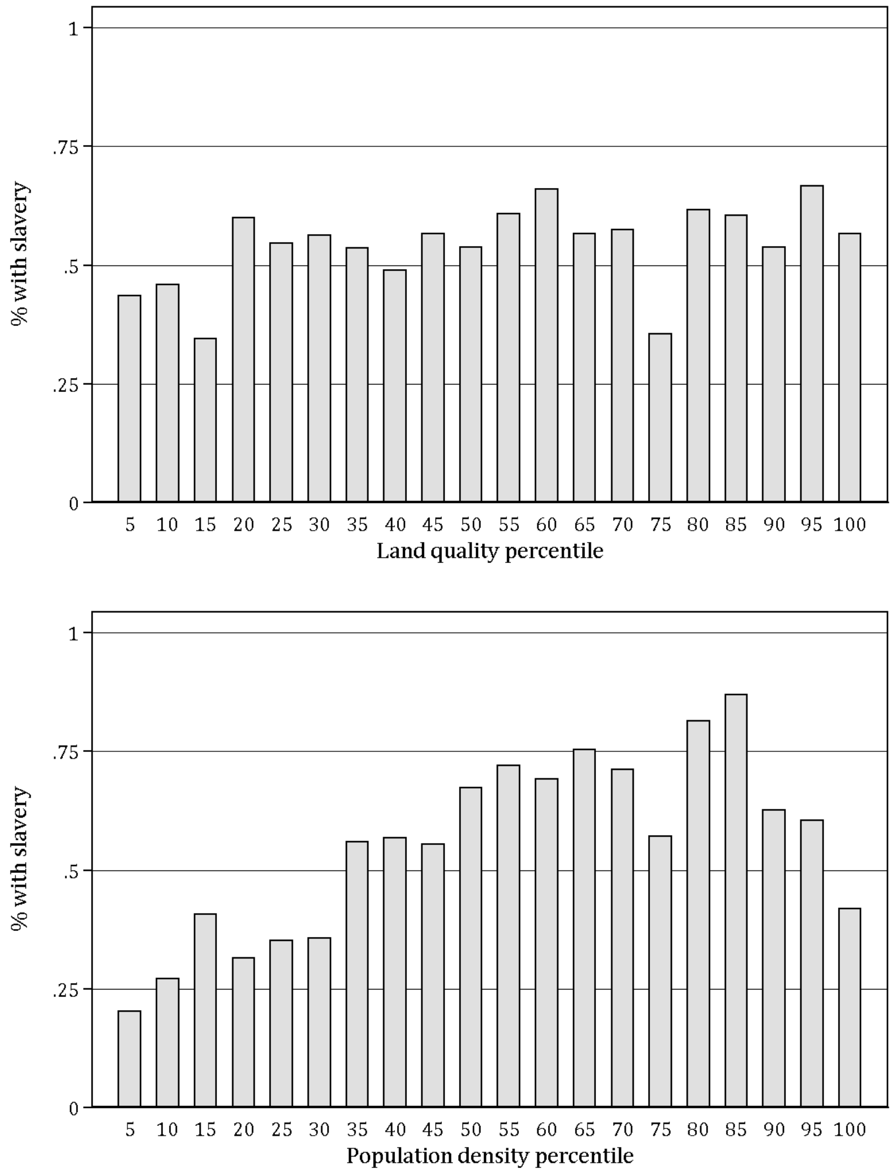
FIGURE 4. Land rights by percentiles of land quality and hist. pop. density





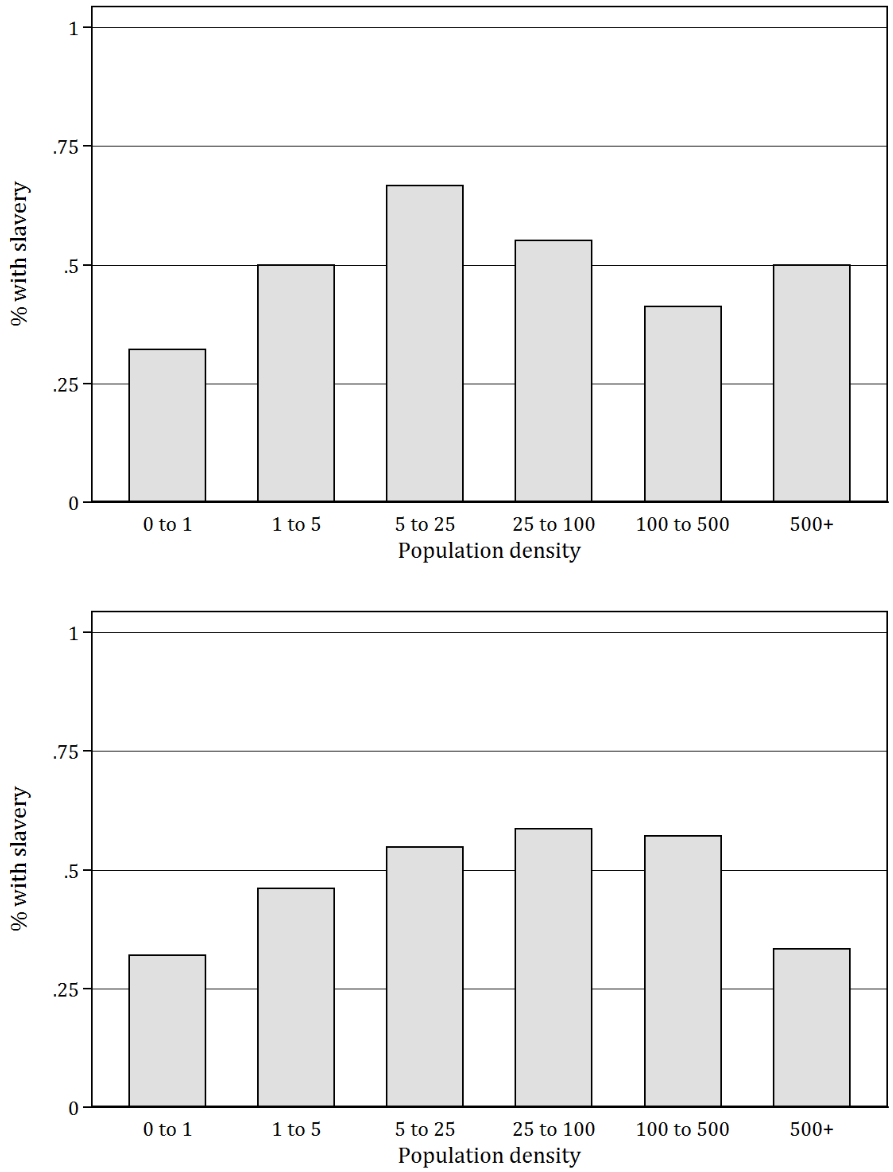
The y axis is the percentage of societies with land rights. The top picture divides this by twenty percentiles of land quality, each representing 5% of the sample. The bottom picture is divided by similar percentiles of population density.

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



The y axis is the percentage of societies with slavery. The top picture divides this into twenty percentiles of land quality, each representing 5% of the sample. The bottom picture is divided by similar percentiles of population density.

FIGURE 6. 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 $v1130$.

Table 1: Summary statistics and percentiles of population density

	(1)	(2)	(3)	(4)	(5)		(6)	(7)	(8)
							HYDE	ARVE	
	Mean	s.d.	Min	Max	N	Pct.	Estimate	Base	MJ Base
						5	0.02	0.05	0.29
Any slavery	0.54	0.50	0	1	1,040	10	0.09	0.17	0.59
Any land rights	0.74	0.44	0	1	801	15	0.26	0.28	1.21
Land quality	1.33	0.90	-4.0e-07	3.98	1,205	20	0.51	0.49	1.92
Date observed	1,905	53.1	1,500	1,965	1,205	25	1.21	0.88	2.58
Historic pop density	42.7	141	2.6e-07	3,627	1,205	30	2.39	1.96	3.79
Precipitation	1,262	855	12.6	6,164	1,205	35	3.70	3.86	5.07
Temperature	7,198	2,776	35.5	10,830	1,205	40	5.78	7.08	6.61
Absolute latitude	20.7	17.0	0.017	78.1	1,205	45	7.64	10.03	8.27
Pct. malarial	0.17	0.20	0	0.69	1,205	50	10.04	14.72	10.10
Dist. to coast	4.26	3.88	0	16.5	1,205	55	12.56	19.39	13.11
Elevation	167	9.60	141	230	1,205	60	15.78	24.39	17.33
Major river	0.28	0.45	0	1	1,205	65	20.14	32.31	22.56
Ruggedness	121,220	132,855	137	977,941	1,205	70	25.97	40.25	29.84
Share desert	0.11	0.26	0	1	1,205	75	35.17	55.00	39.13
Mostly fishing	0.069	0.25	0	1	1,205	80	47.25	76.05	53.36
						85	62.98	105.86	71.90
						90	95.85	151.97	115.18
						95	162.79	246.17	197.82

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.)					0.161***	(0.010)	0.122***	(0.011)
Precipitation			-0.046**	(0.021)			-0.021	(0.021)
Temperature			-0.027	(0.030)			-0.056*	(0.032)
Date observed			0.050***	(0.019)			0.004	(0.017)
Share desert			0.010	(0.018)			0.038**	(0.016)
Dist. to coast			-0.023	(0.018)			0.006	(0.018)
Elevation			-0.006	(0.019)			0.004	(0.018)
Pct. malarial			0.174***	(0.026)			0.127***	(0.025)
Ruggedness			0.064***	(0.017)			0.030*	(0.016)
Absolute latitude			-0.106***	(0.033)			-0.087**	(0.037)
Major river			-0.031	(0.034)			-0.073**	(0.035)
Mostly fishing			-0.126*	(0.074)			0.023	(0.071)
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.)					0.288***	(0.029)	0.112***	(0.038)
ln(1+pop. den.) sqrd.					-0.042***	(0.005)	-0.013**	(0.007)
Precipitation			-0.062**	(0.025)			-0.046*	(0.026)
Temperature			0.218***	(0.038)			0.216***	(0.038)
Date observed			-0.049***	(0.019)			-0.064***	(0.021)
Share desert			0.033	(0.022)			0.031	(0.020)
Dist. to coast			0.047**	(0.023)			0.053**	(0.024)
Elevation			0.015	(0.022)			0.016	(0.023)
Pct. malarial			0.388***	(0.030)			0.361***	(0.030)
Ruggedness			0.134***	(0.021)			0.119***	(0.022)
Absolute latitude			0.110***	(0.042)			0.136***	(0.043)
Major river			0.094**	(0.042)			0.089**	(0.042)
Mostly fishing			0.390***	(0.078)			0.419***	(0.081)
Observations	1,040		1,040		1,040		1,040	
Pop. den. at peak slavery					30.99		70.40	

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*		*Lnd. inherit. by children*	
Land mostly private (v1726 in SCCS)	0.301**				
	(0.144)				
Land quality		0.049**		0.050**	
		(0.023)		(0.022)	
ln(1+pop. den.)			0.120***		0.180***
			(0.015)		(0.016)
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.)			0.220***		0.101***
			(0.042)		(0.029)
ln(1+pop. den.) sqrd.			-0.027***		-0.011**
			(0.007)		(0.005)
Observations	166	1,040	1,040	1,040	1,040
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 precipitation, temperature, date observed, share desert, distance from the coast, elevation, percentage malarial, ruggedness, absolute latitude, major river, and mostly fishing.

Table 4: Alternative measures of land quality and population density

	(1)	(2)	(3)	(4)
	Land quality (v921)	*Land quality (v924)*	*Land quality (v928)*	*Land scarcity (v1720)*
Land quality	1.677***	0.703***	0.871***	
	(0.254)	(0.112)	(0.107)	
ln(1+pop. den.)				0.080***
				(0.030)
Observations	172	172	172	79
R-squared	0.223	0.196	0.274	
Other cont.	N	N	N	N

	(5)	(6)	(7)	(8)	(9)	(10)
	Any land rights			*Any slavery*		
Ln pop density 1995	0.096***			0.127***		
	(0.010)			(0.046)		
squared.				-0.013**		
				(0.006)		
ln(1 + pop. den.) - MJ Base		0.122***			0.125***	
		(0.011)			(0.040)	
squared.					-0.012*	
					(0.007)	
ln(1 + pop. den.) - ARVE Base			0.122***			0.112***
			(0.011)			(0.038)
squared.						-0.013**
						(0.007)
Observations	801	801	801	1,040	1,040	1,040
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 1-3, with marginal effects reported. Columns 1-3 are OLS. Other controls are precipitation, temperature, date observed, share desert, distance from the coast, elevation, percentage malarial, ruggedness, absolute latitude, major river, and mostly fishing.

Table 5: Possible endogeneity of land quality

	(1)	(2)	(3)	(4)	(5)	(6)
	Any land rights			*Any slavery*		
Land quality	0.046***	0.069***	0.055***	0.047**	0.061***	0.085***
	(0.018)	(0.018)	(0.019)	(0.021)	(0.022)	(0.027)
Soil depth constraints		0.092***			0.050**	
		(0.018)			(0.021)	
Soil fertility constraints			0.019			0.075***
			(0.018)			(0.026)
Observations	801	801	801	1,040	1,040	1,040
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, with marginal effects reported. Other controls are precipitation, temperature, date observed, share desert, distance from the coast, elevation, percentage malarial, ruggedness, absolute latitude, major river, and mostly fishing.

Table 6: Alternative theories

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Any land rights							
Land quality	0.079***		0.045**					
	(0.017)		(0.018)					
Rainfall CV	-0.315**	0.041	-0.116	0.019				
	(0.143)	(0.114)	(0.138)	(0.139)				
ln(1+pop. den.)		0.162***		0.122***				
		(0.010)		(0.012)				
Observations	801	801	801	801				
Other cont.	N	N	Y	Y				
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	Any slavery							
Other crop	*Wheat*	*Maize*	*Cereals*	*Roots/ tubers*	*Pulses*	*Oil crops*	*Sugar*	*Cotton*
Land quality	0.041*	0.036	0.048**	0.056***	0.039*	0.071***	0.049**	0.042*
	(0.023)	(0.023)	(0.023)	(0.022)	(0.022)	(0.023)	(0.021)	(0.022)
Other crop suitability	0.013	0.037	-0.002	-0.042*	0.032	-0.074***	-0.030	0.042*
	(0.021)	(0.025)	(0.028)	(0.025)	(0.024)	(0.028)	(0.025)	(0.025)
Observations	1,040	1,040	1,040	1,040	1,040	1,040	1,040	1,040
Other cont.	Y	Y	Y	Y	Y	Y	Y	Y
ln(1+pop. den.)	0.109***	0.106***	0.112***	0.115***	0.108***	0.126***	0.114***	0.113***
	(0.039)	(0.039)	(0.038)	(0.038)	(0.039)	(0.039)	(0.038)	(0.038)
ln(1+pop. den.) sqrd.	-0.013*	-0.013*	-0.013**	-0.013**	-0.013*	-0.015**	-0.013**	-0.014**
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Other crop suitability	0.009	0.036	0.006	-0.039	0.032	-0.059**	-0.035	0.048*
	(0.021)	(0.024)	(0.027)	(0.026)	(0.024)	(0.026)	(0.026)	(0.025)
Observations	1,040	1,040	1,040	1,040	1,040	1,040	1,040	1,040
Other cont.	Y	Y	Y	Y	Y	Y	Y	Y
Corr(Land qual., suit.)	0.36	0.44	0.49	0.37	0.42	0.49	0.21	0.30

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 precipitation, temperature, date observed, share desert, distance from the coast, elevation, percentage malarial, ruggedness, absolute latitude, major river, and mostly fishing.

Table 7: 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.)		0.100***		0.022
		(0.013)		(0.042)
ln(1+pop. den.) sqrd.				-0.006
				(0.007)
Observations	801	801	1,040	1,040
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 precipitation, temperature, date observed, share desert, distance from the coast, elevation, percentage malarial, ruggedness, absolute latitude, major river, and mostly fishing.

Table 8: 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		0.007		0.016	
	(0.014)		(0.015)		(0.014)		(0.015)	
ln(1+pop. den.)		0.081***		0.079***		0.091***		0.051*
		(0.010)		(0.011)		(0.029)		(0.030)
ln(1+pop. den.) sqrd.						-0.018***		-0.009*
						(0.005)		(0.005)
Wald test (λ=0)	698.6	364.0	526.8	211.4	1632	1634	730.3	744.8
Observations	801	801	801	801	1,040	1,040	1,040	1,040
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	0.028**		0.016		0.012		0.009	
	(0.013)		(0.013)		(0.012)		(0.014)	
ln(1+pop. den.)		0.068***		0.072***		0.068***		0.035
		(0.008)		(0.009)		(0.022)		(0.027)
ln(1+pop. den.) sqrd.						-0.014***		-0.007
						(0.004)		(0.005)
Wald test (ρ=0)	593.4	176.8	189.1	68.39	1592	1096	254.5	260.3
Observations	801	801	801	801	1,040	1,040	1,040	1,040
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 linear probability models. Other controls are precipitation, temperature, date observed, share desert, distance from the coast, elevation, percentage malarial, ruggedness, absolute latitude, major river, and mostly fishing.