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DOES LAND ABUNDANCE EXPLAIN AFRICAN INSTITUTIONS?

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Abstract. I show how abundant land and scarce labor shaped African institutions before colonial rule. I present a model in which exogenous land quality and endogenously evolving population determine the existence of land rights, slavery, and polygyny. I use cross-sectional data on pre-colonial African societies to demonstrate that, as in the model, the existence of land rights, slavery, and polygyny occurred where land was most suitable for agriculture, and where population density was greatest. These results are robust to alternative measures of institutions and historical population, and better fit the data than alternative theories of slavery.

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, rights to land were ill-defined, cultivators would not become free workers, coerced and household labor substituted for wage employment, capital markets were constrained because land had no value as collateral, and states that could not tax land remained small and weak. In this paper, I use a formal model and cross-sectional data on African societies to explain African institutions. I show how land rights, slavery, polygyny, and state strength in Africa prior to colonial rule were shaped by the continent's sparse population.

Institutional failures are a major cause of African poverty. These include corruption, bureaucracy, a lack of democracy, and poor public services (Collier and Gunning, 1999a,b). The continent's rare successes, similarly, are understood largely as stories of institutions (Acemoglu et al., 2003). This is not unique to Africa, as institutions a principal channel through

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which history affects the present (Greif, 2006; North, 1991; Nunn, 2009). Institutions, in particular those that protect private property, were instrumental in the rise of the "West" (Acemoglu et al., 2009, 2005; North and Weingast, 1989) and explain many differences in outcomes across former colonies (Acemoglu et al., 2001; Banerjee and Iyer, 2005; Dell, 2009).

History has shaped African development. Colonial institutions and investments affect outcomes today (Bertocchi and Canova, 2002; Price, 2003). Existing arrangements, African resistance and limited resources, however, constrained colonial powers (Austin, 2008b; Bubb, 2009). As a result, pre-colonial institutions and the forces that shaped them, including states, polygyny, and slavery, also affect current performance in Africa (Gennaioli and Rainer, 2007; Nunn, 2008; Tertilt, 2005). Explaining pre-colonial institutions in Africa is, then, important in understanding its current poverty. Geography is one candidate. Geographic features, such as continental orientation, ruggedness, settler mortality, suitability for specific crops, and other biogeographic endowments predict contemporary institutional differences across countries (Easterly and Levine, 2003; Engerman and Sokoloff, 1997; Nunn and Puga, 2007).

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. I test this thesis. I use data on a cross-section of African 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 in the most densely settled parts of Africa, reflecting the high opportunity cost of coercion at low levels of population and the inability of population to grow to the point where free labor replaced slavery. Polygyny existed in the most agriculturally suitable and most thickly settled parts of Africa; dense population is needed for inequality to emerge. This is consistent with an extension I make to the model, but is a revision to the "land abundance" thesis. While states were more developed in the most populated regions, agricultural suitability was not one of their systematic determinants.

I provide further evidence in favor of the "land abundance" view by using it to explain institutions and institutional change among the Egba of southwestern Nigeria between 1830 and 1914. This is an abbreviated form of an analytical narrative I have made in greater detail in The Author (2010). 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.

In Section 2, I outline the literature in African history on how land abundance has shaped economic institutions. In Section 3, I present the model, extend it to include polygyny, and identify its testable implications. In Section 4, I describe the data used and lay out the econometric specifications. In Section 5, I report the results of these tests. In Section 6, I show that these results are robust to different measures of the institutional outcomes, alternative proxies for historical population density, several other interpretations of the results, and rival theories of slavery. In Section 7 I conclude.

2. The land abundance view of African history

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."[2] Iliffe (1995, p. 1-2) summarizes this "land abundance" view:

> Sparse populations with ample land expressed social differentiation through control over people, possession of precious metals, and ownership of livestock ... Scattered settlement and huge distances hindered transport, limited the surplus the powerful could extract, prevented the emergence of literate elites and formal institutions, left the cultivator much freedom, and obstructed state formation.

Here, I review the literature on how sparse population shaped land, labor, and states in pre-colonial Africa.[3]

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 (2009b, 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

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

[2] 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).

[3] Capital markets are another major theme of this literature, but the data that I have do not permit any statistical tests. I examine Egba credit institutions in The Author (2010).

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.

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 5, 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.

Family structures in Africa have also been linked to sparse population. Tambiah and Goody (1973, p. 23) explain bride-price by noting that, since men are not distinguished by land holdings, the price of a husband is low. Iliffe (1995, p. 96) argues that intense competition for women within and across generations led to the payment of bridewealth. Because wives' labor and reproductive capacities are so important, more than half of customary court cases in Africa are disputes over marriage, divorce or bridewealth (Kopytoff, 1987, p. 43). I argue instead that polygyny can only exist when population is great enough for an elite to have already differentiated itself from the population.

The use of underpopulation to explain African slavery is controversial. Kopytoff and Miers (1977, p. 68-69) object that slaves filled social and political functions for which entire persons were needed, and not simply their labor. Political insecurity prevented people from taking advantage of surplus land. Lovejoy (1978, p. 349) argues that slavery in the Sokoto Caliphate was "based on non-market principles," as slaves and output were redistributed mostly through the state. Miers and Klein (1998, p. 4-5) and Roberts and Miers (1988, p. 20) stress factors other than labor scarcity that made colonial rulers hesitant to abolish slavery, including their dependence on slave-owners, fear that abolition would divert trade, worries about disrupting peace, unwillingness to undermine male control of women, and their

experience with India. Austin (2009a) responds that the rise in slave-holding throughout the Atlantic slave trade and the nineteenth century cannot be explained by the non-economic uses of slaves. I show that the presence of slavery across African regions was 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." I show 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.

Prior to colonial rule, the "typical" Atlantic African lived in a state with an area no larger than 1,500 square kilometers and fewer than 30,000 inhabitants (Thornton, 1992, p. 105). African states were, Austin (2004a, p. 25) argues, "webs of relationship which grew steadily weaker with distance from the capital until they merged into the statelessness of peripheral peoples." States could not raise revenues from land. Unable to tie subjects to the land and tax them, states could not make land artificially scarce. Revenues came from other sources, such as trade tolls. Rulers sought subjects and cattle, rather than territories (Austin, 2004b). I demonstrate that state strength in Africa has been systematically related to population, but not to agricultural suitability.

3. Model

In this section, I formalize the literature outlined in Section 2. I use an extension of the model of "slavery and other property rights" from Lagerlöf (2009), adding both slave raiding from neighboring societies and polygyny. Elite preferences over the three institutional regimes of egalitarianism, slavery, and free labor are driven by agricultural productivity and population size. Population lowers wages and average product, making free labor preferable to slavery or egalitarianism. Productivity makes coercion worthwhile. This adds to the literature by recognizing the importance of productivity and the opportunity cost of coercion when population is low. Section 3.1 sets up the model. Section 3.2 describes its dynamics. Section 3.3 adds polgyny. Section 3.4 derives two testable implications of the model. Greater suitability for agriculture will positively predict the existence of land rights, slavery and polygyny. Endogenous population density will be positively correlated with land rights and polygyny, positively correlated with slavery if population growth is limited by the disease environment, and non-monotonically correlated with slavery if population growth is not so constrained.

3.1. **Setup.**

A society in period t has a population P_t of non-elite agents and a population of elite agents that has zero mass. Non-elite agents work; elite agents do not. Both live for one period. The elite is randomly selected from the population at the beginning of each

period. Agents choose fertility n_t and consumption c_t. Children cost q each. If income is I_t, each agent's budget constraint is:

$$c_t = I_t - qn_t. \tag{1}$$

With no utility from leisure, non-elite agents supply one unit of labor each. Utility is:

$$U_t = (1-\beta)\ln c_t + \beta \ln n_t. \tag{2}$$

This implies that optimal fertility n_t^* for each agent is given by:

$$n_t^* = (\beta/q)I_t. \tag{3}$$

Output Y_t depends on land T, land-augmenting productivity $\tilde{A}$, and the labor used L_t:

$$Y_t = (T\tilde{A})^{\alpha} L_t^{1-\alpha} \equiv A^{\alpha} L_t^{1-\alpha}, \tag{4}$$

where $\alpha \in (0,1)$. A depends on $\tilde{A}$ and T, but is interpreted here as agricultural suitability, given exogenously by the environment. The elite's payoff in period t under each of the three institutions, egalitarianism, slavery, and free labor, is given by π_t^i, where $i \in \{E, S, F\}$. The population's payoff is m_t^i. At the beginning of each period, the society's neighbors raid it for R slaves, and nothing can prevent this. There is no voluntary migration; agents who leave will be enslaved by their neighbors.

3.1.1. *Egalitarianism.* Under egalitarianism, there are no land rights or slavery. The elite and the non-elite agents that remain after the society is raided receive average product:

$$\pi_t^E = m_t^E = \left(\frac{A}{P_t - R}\right)^{\alpha}. \tag{5}$$

3.1.2. *Free labor.* Under free labor, the elite encloses a fraction θ of the land, creating rights over it. To do this, they require the support of an infinitely-lived external elite of mass 1. They share their income equally with this external elite, though members of the external elite do not make decisions or have children.[4] They hire L_t non-elite agents to work for them at a competitive wage w_t. The elite's problem is:

$$\pi_t^F = \max_{L_t \in [0, P_t - R]} \{(\theta A)^{\alpha} L_t^{1-\alpha} - w_t L_t\}. \tag{6}$$

[4]This is done solely so that the elite's vanishingly small income under egalitarianism is comparable to its finitely positive income under free labor or slavery.

Non-elite agents not hired continue to work the remaining land communally, receiving income $m_t^F = \left(\frac{(1-\theta)A}{P_t-R-L_t}\right)^{\alpha}$. Equilibrium is achieved in the labor market when the wage (equal to the marginal product of labor on the elite's estate) is equal to the average product on the unenclosed land. This will be true when:

$$(1-\alpha)(\theta A)^{\alpha}L_t^{-\alpha} = \Big(\frac{(1-\theta)A}{P_t-R-L_t}\Big)^{\alpha}, \tag{7}$$

which implies that the optimal choice of labor for the elite, L_t^*, is given by:

$$L_t^* = \frac{(1-\alpha)^{\frac{1}{\alpha}}\theta}{(1-\theta)+(1-\alpha)^{\frac{1}{\alpha}}\theta}(P_t-R) \equiv \sigma(P_t-R), \tag{8}$$

which in turn implies that the equilibrium wage (and hence non-elite income) is given by:

$$w_t = m_t^F = (1-\alpha)(\theta A)^{\alpha}(\sigma(P_t-R))^{-\alpha}. \tag{9}$$

Substituting (8) and (9) into (6), the elite's payoff is:

$$\pi_t^F = \alpha\theta^{\alpha}\sigma^{1-\alpha}A^{\alpha}(P_t-R)^{1-\alpha}. \tag{10}$$

3.1.3. *Slavery.* Under slavery, the elite again uses the help of the external elite to enclose a fraction θ of the land, creating rights over it. They raid their neighbors for slaves, at an elastic cost r,[5] which includes the cost of guarding the slaves and feeding them while they are used in production. It is assumed for simplicity that free workers will not work alongside slaves. Slaves do not reproduce.

The elite's problem is:

$$\pi_t^S = \max_{S_t}\{(\theta A)^{\alpha}S_t^{1-\alpha} - rS_t\}. \tag{11}$$

Solving for the elite's preferred number of slaves, the elite's payoff is:

$$\pi_t^S = \alpha\Big[\frac{1-\alpha}{r}\Big]^{\frac{1-\alpha}{\alpha}}\theta A. \tag{12}$$

The non-elite population receives the average product on the unenclosed land:

[5]It is assumed the elite's holding is small enough relative to its neighbors' population that it does not face the possibility of enslaving the entire neighboring population.

$$m_t^S = \Big(\frac{(1-\theta)A}{P_t - R}\Big)^{\alpha}. \tag{13}$$

3.1.4. *Comparing payoffs.* The elite chooses the institutional regime that suits them the most in any particular period. Because they are only lived for one period, they are not forwards-looking. Their preferences will be determined by the level of agricultural suitability, A, and by the population that period, P_t. In comparing their payoffs under each regime, is is helpful to define the following functions of P_t:

$$\Psi(P_t) = \Big[\frac{r}{1-\alpha}\Big]^{1/\alpha}\frac{\sigma}{\theta}(P_t - R). \tag{14}$$

$$\Omega(P_t) = \Big(\frac{1}{\alpha\theta}\Big)^{\frac{1}{1-\alpha}}\Big(\frac{r}{1-\alpha}\Big)^{\frac{1}{\alpha}}(P_t - R)^{-\frac{\alpha}{1-\alpha}}. \tag{15}$$

$$\Phi = \frac{1}{\alpha\theta^{\alpha}\sigma^{1-\alpha}}. \tag{16}$$

These partition the (A,P_t) space into three sets:

$$\begin{aligned} \mathcal{S}^E &= \{(A,P_t) \in \mathbb{R}^2_+ : (A,P_t) \notin \mathcal{S}^S \cup \mathcal{S}^F\}, \\ \mathcal{S}^S &= \{(A,P_t) \in \mathbb{R}^2_+ : A \geq \max\{\Psi(P_t), \Omega(P_t)\}, \\ \mathcal{S}^F &= \{(A,P_t) \in \mathbb{R}^2_+ : P_t \geq \Phi + R \text{ and } A \leq \Psi(P_t)\}. \end{aligned} \tag{17}$$

These regions are depicted in Figure 1. These define the elite's institutional preferences:

Proposition 1. *Elite preferences over institutions are determined by A and P_t:*

I. Egalitarianism is weakly preferred when:

$$\pi_t^E \geq \max\{\pi_t^S, \pi_t^F\} \Leftrightarrow (A,P_t) \in \mathcal{S}^E.$$

II. Slavery is weakly preferred when:

$$\pi_t^S \geq \max\{\pi_t^E, \pi_t^F\} \Leftrightarrow (A,P_t) \in \mathcal{S}^S.$$

III. Free labor is weakly preferred when:

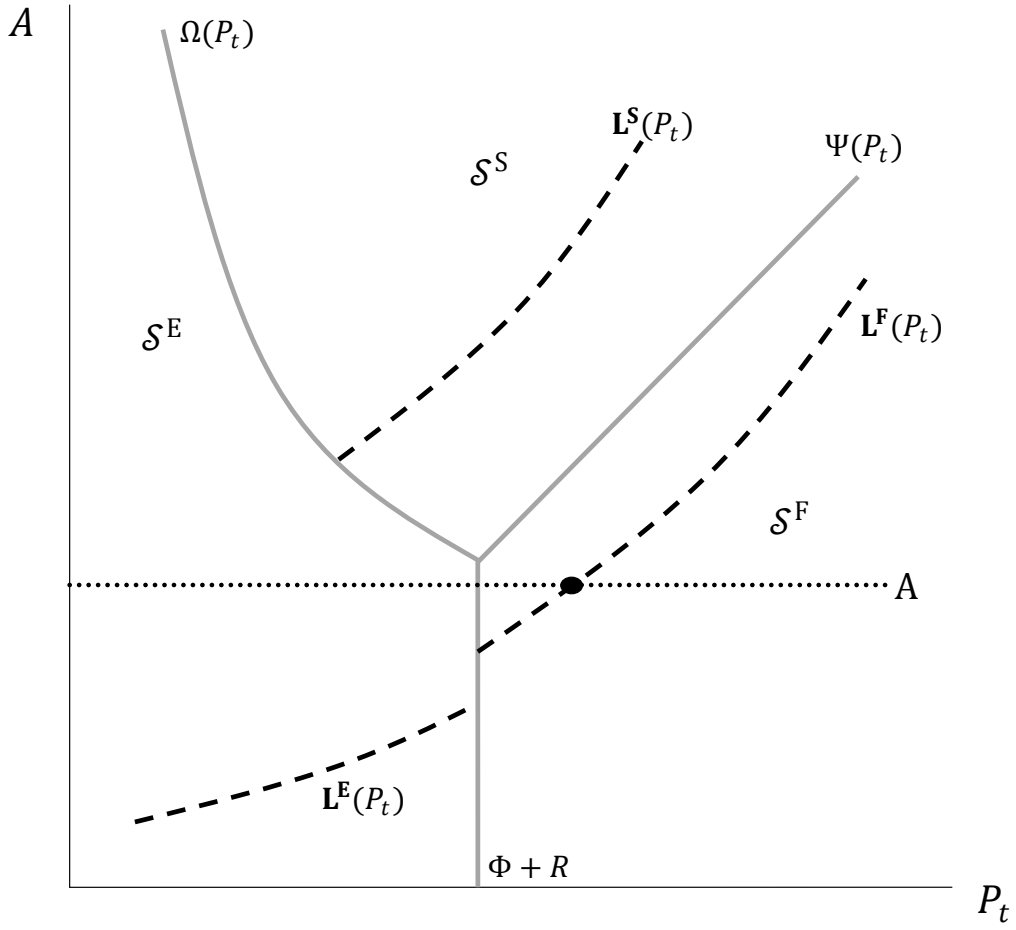
$$\pi_t^F \geq \max\{\pi_t^E, \pi_t^S\} \Leftrightarrow (A,P_t) \in \mathcal{S}^F.$$

Proof. (5) and (12) imply that $\pi_t^S \geq \pi_t^E$ iff $A \geq \Omega(P_t)$. (10) and (12) imply that $\pi_t^S \geq \pi_t^F$ iff $A \geq \Psi(P_t)$. (5) and (10) imply that $\pi_t^F \geq \pi_t^E$ iff $P_t \geq \Phi + R$. □

Slavery is preferred when population is large enough that the opportunity cost of coercion is low, but small enough that free labor is expensive in comparison. Greater agricultural

productivity overcomes the inefficiency of coercion. Population growth pushes down the average product of land, making egalitarianism unattractive.

FIGURE 1. Institutional regions and dynamics



3.2. **Dynamics.** Population evolves according to:

$$P_{t+1} = n_t^{\text{non-elite}}(P_t - R). \tag{18}$$

Using (3), (5), (9), (13), and (18), population is constant when:

$$A = \begin{cases} \left(\frac{q}{\beta}\right)^{\frac{1}{\alpha}} \left(\frac{P_t}{(P_t-R)^{1-\alpha}}\right)^{\frac{1}{\alpha}} \equiv \mathbf{L}^E(P_t) & \text{if } (A, P_t) \in \mathcal{S}^E \\ \left(\frac{q}{\beta(1-\alpha)}\right)^{\frac{1}{\alpha}} \frac{\sigma}{\theta} \left(\frac{P_t}{(P_t-R)^{1-\alpha}}\right)^{\frac{1}{\alpha}} \equiv \mathbf{L}^F(P_t) & \text{if } (A, P_t) \in \mathcal{S}^F \\ \left(\frac{q}{\beta}\right)^{\frac{1}{\alpha}} \frac{1}{1-\theta} \left(\frac{P_t}{(P_t-R)^{1-\alpha}}\right)^{\frac{1}{\alpha}} \equiv \mathbf{L}^S(P_t) & \text{if } (A, P_t) \in \mathcal{S}^S \end{cases} \tag{19}$$

If $A > \mathbf{L}^S(P_t)$ under slavery, P_t is rising. If $A < \mathbf{L}^S(P_t)$ under slavery, P_t is falling. If $A > \mathbf{L}^E(P_t)$ under egalitarianism, P_t is rising. If $A < \mathbf{L}^E(P_t)$ under egalitarianism, P_t is falling. If $A > \mathbf{L}^F(P_t)$ under free labor, P_t is rising. If $A < \mathbf{L}^F(P_t)$ under free labor, P_t is falling. These are simple Malthusian "zero population growth" lines; if A is large relative to P_t, income is high, and population is growing. If A is low, income is low, and population is falling. The lines themselves depend on the institutional region, because income is shared differently under each regime.

Again, it is helpful to define the levels of A at which these zero population growth lines intersect the borders of the institutional regions:

$$A^{\Phi}_{\Psi,\Omega} = \Big(\frac{r}{1-\alpha}\Big)^{\frac{1}{\alpha}}\Big(\frac{\sigma}{\theta\Phi}\Big), \tag{20}$$

$$A^{F}_{\Phi} = \Big(\frac{q}{\beta(1-\alpha)}\Big)^{\frac{1}{\alpha}}\frac{\sigma}{\theta}\Big(\frac{\Phi+R}{\Phi^{1-\alpha}}\Big)^{\frac{1}{\alpha}} \tag{21}$$

$$A^{S}_{\Phi} = \Big(\frac{q}{\beta}\Big)^{\frac{1}{\alpha}}\frac{1}{1-\theta}\Big(\frac{\Phi+R}{\Phi^{1-\alpha}}\Big)^{\frac{1}{\alpha}} \tag{22}$$

$A^{\Phi}_{\Psi,\Omega}$ is the level of A at which $\Psi(P_t)$ and $\Omega(P_t)$ intersect $P_t = \Phi + R$. A^F_Φ is the level of A at which $\mathbf{L}^F(P_t)$ intersects $P_t = \Phi + R$. A^S_Φ is the level of A at which $\mathbf{L}^S(P_t)$ intersects $P_t = \Phi + R$. The dynamics in (19) determine what steady states will exist:

Proposition 2. *Steady states.*

I. So long as A is below a cutoff $A^E(\alpha, \beta, \theta, q, r, R)$, there is a steady state under egalitarianism.

II. If $A^F_\Phi \leq A^{\Phi}_{\Psi,\Omega}$ and A is above a cutoff $A^F(\alpha, \beta, \theta, q, r, R)$, then a steady state under free labor may exist.

III. If $A^S_\Phi \geq A^{\Phi}_{\Psi,\Omega}$ and A is above a cutoff $A^S(\alpha, \beta, \theta, q, r, R)$, then there is a steady state under slavery.

Proof. So long as A is low enough, it will obviously intersect $\mathbf{L}^E(P_t)$ in $\mathcal{S}^E$. $A^F_\Phi \leq A^{\Phi}_{\Psi,\Omega}$ ensures $\mathbf{L}^F(P_t)$ is flat enough to intersect $\mathcal{S}^F$. If A^F is chosen as the level of A at which $\mathbf{L}^F(P_t)$ intersects $P_t = \Phi + R$, above this the intersection of A and $\mathbf{L}^F(P_t)$ may occur in $\mathcal{S}^F$. Finally, $A^S_\Phi \geq A^{\Phi}_{\Psi,\Omega}$ ensures $\mathbf{L}^S(P_t)$ is steep enough to intersect $\mathcal{S}^S$. If A^S is chosen as the level of A at which $\mathbf{L}^S(P_t)$ intersects $\Omega(P_t)$, for any $A \geq A^S$, the intersection of A and $\mathbf{L}^S(P_t)$ will occur in $\mathcal{S}^S$. □

An example with a steady state under free labor is depicted in Figure 1.

3.3. **Polygyny.** Assume now that "wives" are an input into the production of children. Following Tertilt (2005), the cost of producing n_t children using W_t wives is now qn_t^2/W_t.

If the purchase price of a wife is b_t, the total cost of n_t children borne by W_t wives will be $b_t W_t + q n_t^2 / W_t$. This captures the idea that, while wives must be purchased, the cost of additional children is convex for any particular wive, due (for example) to maternal mortality or time constraints. Each member of the elite and of the non-abducted non-elite population has h sisters who he sells at the market price of b_t. With a balanced sex ratio, h would equal 1. Payment of bride price to the brother simplifies the model by removing receipt of bride price as a motivation for fertility.

The cost-minimizing choice of W_t for an agent taking b_t as given will be $\sqrt{(q/b_t)} n_t$. The cost-minimizing choice of wives implies that there is a linear marginal cost of children equal to $2\sqrt{b_t q}$. If an agent has income I_t, his optimal number of children will be $\beta I_t / (2\sqrt{b_t q})$, which implies that his demand for wives is $\beta I_t / (2b_t)$. Under institution i, elite income is $\pi_t^i + b_t h$, while non-elite income is $m_t^i + b_t h$. Since the elite has zero mass, total demand in the market for wives is:

$$\frac{\beta}{2b_t}\Big[m_t^i + h b_t\Big](P_t - R). \tag{23}$$

The total supply of wives is given by $h(P_t - R)$. In equilibrium, b_t is set by the intersection of total demand with total supply, where:

$$b_t^i = \frac{\beta}{(2-\beta)h} m_t^i. \tag{24}$$

Polygyny exists when the elite has more wives than members of the population, i.e when $\beta(\pi_t^i + b_t h)/(2b_t) > \beta(m_t^i + b_t h)/(2b_t)$ or $\pi_t^i > m_t^i$. The addition of polygyny will not qualitatively change the elite's preferences over institutions.[6] Under egalitarianism, the elite's income will be the same as that of the non-elite, and so polygyny will not exist. Under free labor, the condition that $P_t \geq \Phi + R$ ensures that the elite's income will be greater than that of the non-elite, and so polygyny will exist. Under slavery, the condition that $A > \Omega(P_t)$ similarly ensures that the elite has more wives. Inequality is a precondition for polygyny. This is a revision of the "land abundance" interpretation of African history.

[6]Under institutional setting i, if the elite receives income π_t^i and the equilibrium bride price is b_t^i, the elite's maximized utility will be equal to:

$$V_t^i = (1-\beta)\ln\Big(\pi_t^i - 2\sqrt{b_t^i q} n_t^*\Big) + \beta \ln(n_t^*) = \ln(\pi_t^i) - \frac{\beta}{2}\ln(b_t^i) + K,$$

where K is a constant. Thus, institution i will be preferred to institution j if $V_t^i \geq V_t^j$, or:

$$\ln(\pi_t^i) - \frac{\beta}{2}\ln(b_t^i) \geq \ln(\pi_t^j) - \frac{\beta}{2}\ln(b_t^j) \Rightarrow \frac{\pi_t^i}{\pi_t^j} \geq \Big(\frac{b_t^i}{b_t^j}\Big)^{\frac{\beta}{2}}.$$

From (24), $b_t^i / b_t^j = m_t^i / m_t^j$. The ratios m_t^i / m_t^j are constants independent of A and P_t. While the definitions of Φ, Ω, and Ψ must be adjusted to include these constants, their general shapes will not change.

3.4. **Tests.** Two implications of the model are tested in Section 5:

I. Increasing exogenous agricultural suitability (A) predicts the existence of slavery, polygyny and rights over land.
II. Polygyny and land rights exist when endogenous population density (P_t) is high. If there are no constraints on population growth, slavery exists at intermediate P_t. If population growth is limited, slavery will be positively correlated with population density.

Rights over land and polygyny exist under both slavery and free labor. $A \geq A^F$ is necessary for a steady state to exist under free labor. Since A^F is a nonlinear function of model parameters that are not observed, a matrix of geographic controls X is used to proxy for A^F by assuming:

$$A^F \approx \frac{1}{\delta_0}(-X'\lambda_0 - \epsilon_0), \tag{25}$$

where δ_0 and λ_0 are regression coefficients and ϵ_0 is an error term. The probability that a steady state exists under free labor (i.e. with land rights and polygyny) is:

$$\Pr(\text{Steady state in } \mathcal{S}^F) = \Pr(\epsilon_0 \geq -\delta_0 A - X'\lambda_0). \tag{26}$$

If $\epsilon_0 \sim N(0,1)$, this can be estimated as a probit. Similarly, $A \geq A^S$ is necessary for a steady state to exist under slavery. The probability of a steady state with slavery is:

$$\Pr(\text{Steady state in } \mathcal{S}^S) = \Pr(\epsilon_1 \geq -\delta_1 A - X'\lambda_1). \tag{27}$$

Again, if $\epsilon_1 \sim N(0,1)$, this can be estimated as a probit.

Land rights and polygyny exist under free labor and slavery, i.e. when $P_t \geq \min\{\Phi + R, \Omega^{-1}(A)\} = \min\{\Phi + R, \Omega^{-1}(A, P_0, t)\}$. Again using X as a proxy, the probability that land rights or polygyny exist for an observed A and P_t is:

$$\Pr(\text{Land Rights, Polygyny}) = \Pr(\epsilon_2 \geq -\delta_{2i} P_t - \delta_{2ii} A - X'\lambda_2). \tag{28}$$

If $\epsilon_2 \sim N(0,1)$, this can be estimated using a probit. According to the "land abundance" view of African history, population could not grow to the point where free labor replaced slavery, and so this will also be the condition for the existence of slavery. Without this restriction on population, if A is large enough, slavery will exist when $\Psi^{-1}(A) \geq P_t \geq \Omega^{-1}(A)$. Using X, this is equivalent to stating that slavery exists if:

$$\delta_{3i} P_t + \delta_{3ii} A + X'\lambda_3 + \epsilon_3 \geq 0 \text{ and } \delta_{4i} P_t + \delta_{4ii} A + X'\lambda_4 + \epsilon_4 \geq 0. \tag{29}$$

If $(\epsilon_3, -\epsilon_4) \sim N(0, \Lambda)$, this is the Poirier (1980) partially unobserved bivariate probit model. However, because this could not be implemented on the actual data, the tests used look for an inverted-U relationship between population density and slavery.[7]

4. 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 531 African societies, observed on the eve of colonial rule. In Section 4.1 I detail the specific econometric specifications that I use. In Section 4.2, I describe the sources of data on institutions, the proxies for the variables A and P_t in the model, and the additional controls that I include. In Section 4.3, I describe the historical sources that are used to provide supporting detail on Egba institutions and their evolution.

4.1. **Specifications.**

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

$$y_i = \delta_r + \beta_A A_i + X_i'\gamma + \epsilon_i, \tag{30}$$

where y_i is an outcome of interest for ethnic group i, δ_r is a vector of dummies for the fifteen regions in the data (described below), A_i is a proxy for agricultural suitability, X_i is a matrix of geographical controls, and $\epsilon_i \sim N(0,1)$ is random error. (30) is estimated as a probit, and observations are weighted by estimated population. This is done to avoid giving smaller groups undue influence in the results. Standard errors are clustered by region. I expect that $\beta_A > 0$ for land rights, slavery, and polygyny.

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

$$y_i = \delta_r + \beta_P \ln(P_i) + \beta_A A_i + X_i'\gamma + \epsilon_i, \tag{31}$$

and

$$y_i = \delta_r + \beta_{P1} P_i + \beta_{P2} P_i^2 + \beta_A A_i + X_i'\gamma + \epsilon_i, \tag{32}$$

where y_i, δ_r, A_i, X_i, and ϵ_i are defined as in (30). P_i is the proxy used for P_t. These are also estimated as probit models, with observations weighted by estimated population and standard errors clustered by region. I expect that $\beta_P > 0$ for land rights, polygyny, and

[7]There are no elements of X that can be excluded *a priori* from either of the two equations in the partially unobserved bivariate probit model. Without an exclusion restriction of this type, the model may not be identified on actual data, as is the case with the data used below.

slavery in the restricted model, and that $\beta_{P1} > 0$ and $\beta_{P2} < 0$ for slavery in the unrestricted model.

Finally, I test for neighbor effects by estimating a spatial autoregressive (SAR) model:

$$y_i = \alpha + \rho W_i y_{i-1} + \beta_A A_i + X_i'\gamma + \epsilon_i. \tag{33}$$

Here, α is a constant and W_i is an $N \times N$ spatial weight matrix, in which each entry W_{ij} is an indicator for whether observation i borders observation j, normalized so that its rows sum to 1 or 0. y_{i-1} is a vector of outcomes for the other observations. ρ captures whether the institutional outcome of one group will affect its neighbor's institutions. In the model, this could operate through many parameters. For example, if a society's neighbor shifts into the slavery region, R, the number of slaves raided, will likely increase. ρ is not separately identified from localized unobservables. However, not all estimates of ρ are found to be positive, which suggests that the spillovers found are not due solely institutional shocks common to neighboring societies. Because of the spatial lag, standard probit estimates will be inconsistent. The model is estimated using the Markov Chain Monte Carlo SAR probit estimator described by LeSage and Pace (2009, p. 283-289).

4.2. **Data.** Two types of data are used to test the ability of the model to explain institutional differemces across societies within Africa. 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.[8] It contains categorical variables describing several institutional and cultural features of these societies at the time of first contact with Europeans. 531 African societies are used for the analysis.[9]

Four variables from the Ethnographic Atlas are used to construct binary dependent variables, and summary statistics for these are given in Table 1.[10] Indicators are used for whether individual land rights, slavery, or polygyny exist. The measure used of state power is whether

[8]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.

[9]The Guanche, an extinct people of the Canary Islands, are dropped because they are observed more than 300 years earlier than any of the other groups in the African sample barring Ancient Egypt, which is similarly dropped. Dates of observation are missing for the Bomvana and Betsileo. The Bomvana are recoded to 1850, to match the date of observation for the other Xhosa, while the Betsileo are recoded to 1900, the modal date for the other Malagasy societies in the data.

[10]These are: V74: Inheritance Rule for Real Property (Land); V70: Type of Slavery; V9: Marial Composition: Monogamy and Polygamy; and V33: Jurisdictional Hierarchy Beyond Local Community. The definitions of the binary variables are: 1) Land rights exist if V74$\neq$1, 2) slavery exists if V70 $>$ 1, 3) polygyny exists if V9$\neq$1, and 4) state centralization exists if V33$>$2.

TABLE 1. Summary statistics

	Mean	Std. Dev.	Min	Max	N
		Institutional Outcomes			
Any Individual Land Rights	0.93	0.25	0	1	404
Any Slavery	0.85	0.36	0	1	454
Polygyny	0.95	0.21	0	1	517
State Stratification	0.34	0.47	0	1	475
		Alternative Institutional Outcomes			
Patrilineal Land Rights	0.77	0.42	0	1	404
Consideration for Bride	0.93	0.26	0	1	529
Class Stratification	0.53	0.50	0	1	426
		Geographic Controls			
Agricultural Suitability	0.53	0.18	0	1	531
Population Density (1960)	21.8	29.3	0	315	531
Elevation	703	506	-14.9	2306	531
Precipitation	1.12	0.57	0.013	2.98	531
Temperature	8.82	1.19	5.31	10.8	531
Malaria Suit.	0.77	0.33	0	1	531
Tsetse Suit.	0.54	0.42	0	1	531
Dist. to Coast.	5.50	3.84	0.023	14.9	531
Dist. to Lake Victoria	2.37	1.51	0.13	5.8	531
Ruggedness	0.22	0.08	0.031	0.77	531
Abs. Latitude	9.89	7.58	0.017	36.6	531
Population Weight	410	1267	0.34	25611	531
		Controls from Ethnographic Atlas			
Major Crop: Missing	0.07	0.26	0	1	531
Major Crop: None	0.02	0.15	0	1	531
Major Crop: Tree Fruits	0.09	0.28	0	1	531
Major Crop: Roots and Tubers	0.16	0.37	0	1	531
Date Observed	1919	21.7	1830	1960	531

Notes: The omitted crop type is cereal grains, the mode.

there is more than one level of jurisdiction above the local. The model gives clear predictions for land rights and slavery, and there is adequate variation in these measures for stable econometric tests. For polygyny, however, the lack of variation in the data makes the results of econometric tests sensitive to the specification chosen. Results for polygyny, then, will be suggestive but not dispositive. The model says nothing about states, but these are included as an outcome because they are central to the "land abundance" view.

The second type of data used includes features of the natural environment. These are joined to the data from the Ethnographic Atlas using the "Tribal Map of Africa" from Murdock (1959). Sources and definitions of these variables are given in Table 10 in Appendix A. The first step of this join requires matching ethnic groups in the Atlas to those in the Map. This was done first by name, then by location. The majority (426) were matched exactly by name, and most of the rest were matched by using an alternative spelling (40) or alternative name (15). For some, the division of ethnic groups in the atlas did not match that in the map, and so these were matched either to a larger group of which they are are a part (a "supergroup" – 20), a smaller group (a "subgroup" – 4), or another group that is part of the same "supergroup" (an "alternative supergroup" – 5). Finally, 21 groups could not be identified with those in the map, and so were matched to the group that is at the latitude and longitude co-ordinates specified in the Atlas. Table 11 in Appendix A reports how groups that did not match exactly by name were joined. This table also includes an ISO 693-3 code that indicates a corresponding entry in Gordon and Grimes (2005). Where this entry does not contain enough information on its own to justify the match, additional notes have been added to Table 11.

The second step in this merge involves joining geographic raster data to Murdock's (1959) map 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 – agricultural suitability and population density.

4.2.1. *Agricultural suitability.* The variable used to capture agricultural suitability is based on Fischer et al.'s (2002) measure of combined climate, soil and terrain slope constrains. This is re-scaled to lie 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 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. This methodology 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.

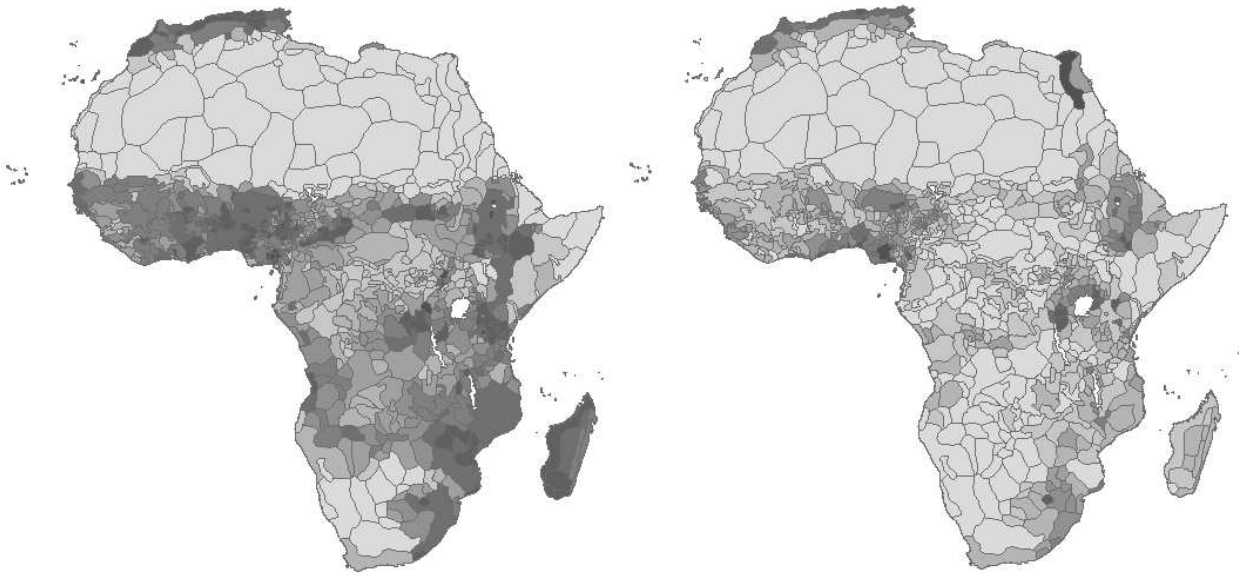
(3) *Terrain slope constraints:* Terrain slopes greater than 8% are "moderate" constraints, and slopes greater than 30% are "severe."

Climate constraints and soil texture are clearly exogenous. Given the low level of pre-colonial agricultural technology, it is unlikely that terrain slope, drainage, and chemical constraints are consequences of institutions. It is possible 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 agricultural suitability are robust to the inclusion of soil depth. Soil fertility constraints do, however, eliminate the direct effect of agricultural suitability on land rights. A caveat must be added, then, that the relationship between agricultural suitability and land rights may be overstated because land rights create incentives to preserve soil fertility.

4.2.2. *Population density.* The second important control is population density in 1960, published by the United Nations Environment Programme. This is treated as a proxy for P_t in the model. These data are the work of Nelson and Deichmann (2004), who construct population measures from official censuses, yearbooks, gazetteers, area handbooks and other country studies. These data are then interpolated to standardized years using intercensal growth rates. The use of population density from 1960 as a proxy for pre-colonial densities is reasonable insofar as the relative distribution of population within Africa has been stable over time across regions as large as those used as observations. Population density in 1960 and 2000 have a correlation coefficient of 0.92 and their logs have a correlation coefficient of 0.97, which suggests that this is a fair assumption. In the analysis, I also account for the date of observation, which will capture growth effects. In addition, population growth rates between 1960 and 2000 are used to back-project population densities in Section 6, and the results do not change substantially. The measures of agricultural suitability and population density are plotted together in Figure 2.

4.2.3. *Other controls.* The other controls listed in Table 1 are included as proxies for the unobserved cutoffs described in Section 3.4. These are nonlinear functions of α, β, q, r, and θ. Elevation is related to the disease environment, and hence the cost of children (q). It also affects the range of available crops and technologies, and hence α. McCann (1999, p. 38-39), for example, notes that the Ethiopian highlands were a unique source of crops such as teff and supported both animal husbandry and use of the plough. Precipitation determines what

FIGURE 2. Agricultural Suitability and Population Density, 1960



Agricultural suitability is on the left, population density on the right. Darker colors indicate higher values; the range of agricultural suitability is from 0 to 1, while the range for population density is from 0 to 315.25.

crops can be grown, shaping α. African growing seasons and diseases are constrained by the seasonal availability of moisture (McCann, 1999, p. 15-18). Areas with low rainfall are also those most susceptible to drought (Bloom and Sachs, 1998, p. 222); β and r accounting for storage needs will be greater.

Temperature affects the physical cost of effort, and hence r and β. In hostile environments, it is more difficult for slaves to flee; r is lower.[11] Temperature affects q through nutrition and disease (Bloom and Sachs, 1998, p. 228). Distances from the coast and from Lake Victoria proxy for water-borne diseases that affect q. These distances also capture the presence of trade, which affects both α and β through what goods are bought and sold, and the cost of slavery (r) through what uses exist for slaves and whether they can be punished by sale for export.

The suitability of the environment for malaria affects q through child mortality and r via slave mortality. It may also alter the physical cost of effort in adults (Gallup and Sachs, 2001, p. 94-95). Suitability for tsetse makes the survival of draught animals and cattle difficult, shaping α. Kjekshus (1977, p. 51) writes that the "overwhelming feature in the study of cattle-keeping in East Africa is the presence of the tsetse fly." Trypanosomiases also affect q via human mortality, as well as the ability to use cavalry (and thus r). Webb (1995) cites this as a decisive factor in the history of the Western Sahel. Ruggedness, following Nunn and

[11]Isaacman et al. (1980, p. 598) makes a similar point in discussing the difficulties faced by refugees who fled colonial rule in northern Mozambique.

Puga (2007), is related to the cost of capturing slaves, and hence r. Crop dummies are taken as exogenous determinants of the available technologies (α). Absolute latitudes north and south of the equator and the date at which the society was first observed are also included as controls for unobservable heterogeneity.

4.3. **Historical sources.** 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. During the period of study, the Egba cultivated maize, cotton, yams, cassava and beans, supplementing these with other crops, and exported oil and kernels gathered from wild palm trees to European markets. Late in the century, cocoa and kola were introduced. These were both tree crops that were planted intentionally. 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 testimonies of the participants of these disputes reveal many details about how land has been used, what transactions have occurred, what rights exist over the land, and and what the causes are of land conflicts. For a fuller description and transcribed example, see The Author (2010).

5. Results

In this section, I implement both tests of the model described in Section 3.4. The model correctly predicts the existence of land rights, slavery and polygyny where A is highest, and land rights and polygyny are positively correlated with population density. Slavery, however, is positively related to population density – it does not exist only at intermediate levels. This may be understood within the model as due to Africa's disease environment or to its overall sparse population, as discussed below. I describe the results by outcome, before turning to the spatial autoregressive model.

5.1. **Land Rights.** Table 2 presents the results for land rights. As predicted by the model, an increase in A predicts the existence of rights over land. When only the proxy A_i and a dummy for the North and Saharan regions (taken together) are included, the estimated coefficient on A_i is positive and significant. As more controls are included in Column (2), the estimated coefficient on agricultural suitability becomes larger. 36 observations are lost, because all societies for which trees are their principal crop have land rights. This is itself interesting. It supports the argument that agricultural suitability, in this case conditions favorable for tree crops, predicts the existence of land rights. Further, it fits with the "land abundance" view that, as embodied labor, tree crops are valuable assets over which rights were more valuable than rights over land in general. The increase in the magnitude of the

TABLE 2. Tests of the model: Land rights

	(1)	(2)	(3)	(4)	(5)
	Any individual land rights				
Agric. Suitability	2.12***	3.06**	3.23***	2.94***	2.50**
	(0.740)	(1.539)	(0.936)	(1.019)	(0.976)
Ln(Pop. Density)				0.55***	
				(0.143)	
Pop. Density (1960)					-2.56
					(4.322)
Pop. Density Sqd.					12.92
					(8.531)
Observations	404	368	321	321	321
Other Controls	No	Yes	Yes	Yes	Yes
Region F.E.	North/Sahara	No	Yes	Yes	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Robust standard errors in parentheses. All regressions are probit, with coefficients reported. Observations are weighted by estimated population in 1960 and standard errors are clustered by region. Region FE: African Hunters, South African Bantu, Central Bantu, Northeast Bantu, Equatorial Bantu, Guinea Coast, Western Sudan, Nigerian Plateau, Eastern Sudan, Upper Nile, Ethiopia/Horn, Moslem Sudan, Sahara, North Africa, and Indian Ocean. Other Controls: Malaria suitability, tsetse suitability, ruggedness, dummies for major crop types (missing, none, tree fruits, roots/tubers included, cereal grains excluded), date of observation, absolute latitude, absolute latitude X latitude > 0, and quadratics in elevation, annual precipitation, accumulated temperature, distance to lake Victoria, and distance to the nearest coast.

coefficient on agricultural suitability suggests that its significance is not due to correlation of agricultural suitability with other unobservable variables that make the existence of land rights more likely. If these unobservable features have similar correlations with agricultural suitability as the observable variables, including them would strengthen the estimated effect of agricultural suitability on land rights (Altonji et al., 2005). Similarly, the results are robust to the inclusion regional dummies in Column (3). The marginal effects, while present, are small; in Columns (1) and (3), a one standard deviation increase in agricultural suitability raises the probability of land rights by roughly 2%.[12]

The results concerning P_t in Column (4) also confirm the predictions for land rights. This is not a causal effect; as an endogenous variable, it is correlated with land rights as the model predicts. The marginal effect here suggests that a one standard deviation increase in log population density is associated with a 2% increase in the likelihood of land rights existing. Column (5) has no meaning in this table; it is reported for completeness, and corresponds with the test for the non-monotonic relationship between population density and slavery predicted by the unrestricted version of the model. The ordering of columns (1) through (5) are preserved in Tables 2 through 5.

[12]These marginal effects are evaluated at the mean, and are calculated using the dprobit command in Stata.

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.[13]

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. Cocoa and palm trees both led disputes to have been discussed before the township chiefs prior to a case coming to court. This could be because disputes were more common over these plots, or because claimants were willing to expend more effort. Greater damages were claimed in cases involving cocoa.

5.2. **Slavery.** Table 3 gives results for slavery. The model's predictions for slavery confirm the restricted version of the model. While the point estimate on A_i is positive when only a North/Sahara dummy is included, it is not significant. Once other controls and regional dummies are added, this effect grows in magnitude and becomes significant, supporting the

[13]National Archives of the United Kingdom (NAUK), CO 147/162: 20 Oct, 1902: Acting Governor to Chamberlain.

TABLE 3. Tests of the model: Slavery

	(1)	(2)	(3)	(4)	(5)
	Any slavery				
Agric. Suitability	0.03	1.93***	1.63*	1.66*	1.74**
	(0.600)	(0.715)	(0.888)	(0.877)	(0.815)
Ln(Pop. Density)				0.47**	
				(0.187)	
Pop. Density (1960)					1.98
					(1.295)
Pop. Density Sqd.					-0.63
					(0.456)
Observations	454	454	366	365	366
Other Controls	No	Yes	Yes	Yes	Yes
Region F.E.	North/Sahara	No	Yes	Yes	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. See notes for Table 2

predictions of the model. This suggests that agricultural suitability is correlated with both observed and unobserved features that make slavery less likely, and so the estimated impact is not due solely to omitted variables bias. In Columns (2) and (3), a one standard deviation increase in agricultural suitability raises the probability of slavery between 1% and 3%.

While the log of population density is positively correlated with the existence of slavery, there is no significant quadratic correlation of slavery with population density.[14] This need not imply a rejection of the model, for two reasons. First, the disease environment in Africa may be so severe, and q so high, that the zero-population growth locus $\mathbf{L}^F(P_t)$ is too steep to intersect the free labor region, $\mathcal{S}^F$. Population simply cannot grow to the point where free labor replaces slavery. Second, Africa is sparsely populated. There may not be enough densely-populated societies in the data with relatively low agricultural suitability to identify the relationship statistically. Both of these fit well with the land abundance view of African history.

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"

[14]I have also tested whether population splines or quantiles reveal a significant inverted-U pattern in groups of 3, 5 and 10. They do not, and these results are not reported.

TABLE 4. Tests of the model: Polygyny

	(1)	(2)	(3)	(4)	(5)
	Any polygyny				
Agric. Suitability	-0.68	4.69***	6.06***	6.06**	5.26*
	(0.447)	(1.672)	(2.286)	(2.605)	(2.858)
Ln(Pop. Density)				0.38	
				(0.413)	
Pop. Density (1960)					2.38
					(3.151)
Pop. Density Sqd.					-0.80
					(2.234)
Observations	517	434	205	203	205
Other Controls	No	Yes	Yes	Yes	Yes
Region F.E.	North/Sahara	No	Yes	Yes	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. See notes for Table 2

proportion of the population.[15] The war chiefs, who in the model had the smallest r, 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 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.

5.3. **Polygyny.** Table 4 presents results for polygyny. As in the extension in Section 3.3, the existence of polygyny are more likely in locations where agricultural suitability is high. 86 observations are lost in column (2), since all societies cultivating roots and tubers are polygynous. Polygyny is positively correlated with population density, though this is not significant. The marginal effects of either variable are negligible, which is not surprising given the lack of variation in the dependent variable. This positive correlation runs contrary to the conventional arguments in the literature on African history, particularly those of Goody (1969) and Tambiah and Goody (1973). Inequality between men is a precondition for polygyny, and so the positive correlation between class stratification and population density suggests that polygyny is not possible in the most egalitarian, sparsely-settled societies.

[15]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.

TABLE 5. Land abundance and state stratification

	(1)	(2)	(3)	(4)	(5)
	State stratification				
Agric. Suitability	0.93*	1.32**	0.53	0.59	0.08
	(0.536)	(0.665)	(0.715)	(0.737)	(0.746)
Ln(Pop. Density)				0.32**	
				(0.141)	
Pop. Density (1960)					2.67*
					(1.373)
Pop. Density Sqd.					-1.43
					(0.950)
Observations	475	475	475	472	475
Other Controls	No	Yes	Yes	Yes	Yes
Region F.E.	North/Sahara	No	Yes	Yes	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. See notes for Table 2

Polygyny was one of the strategies Egba farmers used to cope with the shortage of labor. Bride price, paid to the wife's parents, involved work, payment of crops, assistance with major expenses, and transfers of cash. Coercion and violence could be used to keep a women married (Byfield, 1996). Payment of bride price established claims over children. Junior wives worked for senior wives, and all wives worked for their husbands' other male relatives. Women did the bulk of "domestic" labor and processed palm fruits into oil. The largest harems, however, were those of the war chiefs, who could have up to two hundred wives at the peak of their power. Inequality spurred polygyny in Egba society. Outright purchase of slaves as wives was common during the nineteenth century.

5.4. **State Power.** In Table 5, I report results for state stratification. Surprisingly, it is not related to A_i once regional fixed effects are included. Validating Herbst (2000), it is correlated with population density, but intrinsic agricultural productivity does not appear to be one of its systematic determinants. This may reflect the prevalence of African states, such as ancient Ghana, which drew their revenues from access to trade routes and mineral resources in environments that were relatively hostile to agriculture. Also surprisingly, the (insignificant) marginal effects are relatively large – a one standard deviation increase in agricultural suitability prompts a 3% to 8% increase in the probability of state centralization, depending on the column. For population density, a one standard deviation rise in log population is associated with a 17% increase in the chance of a centralized state.

Fitting with the "land abundance" narrative, authority in pre-colonial Egba society was decentralized, and chiefs did not derive their revenues from land. Political power lay at the township level, and was divided among the the *olorogun* (war chiefs), *ogboni* (civil chiefs), *ode*

TABLE 6. Neighbor effects

	(1)	(2)	(3)	(4)
	Any individual land rights	*Any slavery*	*Any polygyny*	*State stratification*
Spatial lag ($\hat{\rho}$)	-0.22	0.70	0.23	0.31
90% CI	[-0.36,-0.06]	[0.31,0.96]	[-0.05,0.63]	[0.16,0.44]
Agric. Suitability	2.16	2.09	-2.01	0.59
90% CI	[0.48,3.91]	[0.37,4.19]	[-4.48,0.26]	[-0.23,1.46]
Region FE	North/Sahara	North/Sahara	North/Sahara	North/Sahara
Other Cont.	Yes	Yes	Yes	Yes
Observations	368	454	434	475

Notes: 90% confidence intervals in brackets. All regressions are spatial probit, with coefficients reported (see LeSage and Pace (2009)). See notes for Table 2

(hunters), and *parakoyi* (trade chiefs). Before Abeokuta, there was no political organization above the level of the township. While the Alake (king) may have had judicial supremacy over the Ake townships, he had no authority over the other "provinces" of Egba society. Political loyalties in Abeokuta after 1830 continued center on townships (Pallinder-Law, 1973, p. 17). Political leaders at Abeokuta derived their powers from military strength. The most important political leader among the Egba when they arrived Abeokuta was Sodeke, the Seriki. "Seriki," or "general of the youths" (Biobaku, 1952) was a military title. His successor, Okukenu, was eventually given the restored title of Alake, but was described as "too weak to assert himself when challenged" (Pallinder-Law, 1973, p. 28). Egba political history to 1893, when the British intervened to create a united central government, is of competing interests limiting the power of the nominally most senior authorities.

In addition, the Egba did not prosecute war to capture land. Rather, three concerns drove Egba military adventures – trade, captives, and security. Pallinder-Law (1973, p. 19) points to access to the coast as the Egba motivation for capturing Ota. When the town was defeated, the inhabitants were allowed to remain so long as they did not rebuild their walls (Losi, 1924, p. 56). Losi (1924, p. 87) stresses that the Egba sacked Ikorodu in 1865 to gain access to the Lagos lagoon and as punishment for supporting their enemies during the Kutuye war. Ajisafe (1924, p. 65-67) notes that after defeating several townships of Ijebu Remo, "as was the custom, they left without taking absolute possession of the towns"; similarly, when they defeated the Egbado in retaliation for "harassment" at Oke Ogun, "they did not take possession." Descriptions of Egba wars during the period are replete with mention that captives were brought back as slaves, whether in the 1862 Makun war (Champness, 1907, p. 113), or the descriptions given by Losi (1924) of the Dado (1834) and Iperu (1835) Wars.

5.5. **Institutional spillovers.** The estimate of ρ for land rights is negative. A society with land rights discourages its neighbors from having rights over land. In the model, if neighbors switch from egalitarianism to slavery, creating rights over land in their own societies, this will increase R. This raises the population threshold above which free labor is preferred to slavery, because more people are drawn out each period. An explanation from outside the model is that, if secure rights or other "good" institutions correlated with these encourage in-migration, this will depopulate neighboring regions, delaying the development of land rights. Positive spill-overs exist in slavery; if a society uses slaves it encourages its neighbors to do the same. This may be because it is more difficult for a slave to escape to a neighboring slave society, lowering r. It may also, outside the model, reflect the military value of slaves and the need for a society to defend itself from neighboring militarized societies. The impact of agricultural suitability disappears for polygyny in the spatial regressions because these results are sensitive to the weighting of observations; this is not surprising, given the lack of variation in these outcomes. There is no evidence that marital institutions show correlation across space. Finally, state stratification displays positive neighbor effects. This may reflect the need for societies to defend themselves against their organized neighbors. This may also be due to direct institutional spillovers. Oral tradition, for example, states that the institution of kingship was transferred directly from Ife to Benin during the thirteenth century (Ryder, 1965). Similarly, the formation of the Swazi and Lesotho states was a direct response to the rise of Zulu power during the *mfecane* (Maddox, 2006, p. 114).

For the Egba, institutional spillovers in land tenure run contrary to 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 the case of slavery, by contrast, the Egba 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). What efforts did exist to form a centralized authority in Abeokuta was motivated by military concerns – what strength existed in the Egba state was necessitated by the rise of rivals such as Ibadan and Ijebu (Ajayi and Smith, 1964).

In sum, the model correctly predicts that land rights and polygyny existed in pre-colonial Africa where population and agricultural suitability were greatest. As in the model, slavery existed where agricultural suitability was high, but population was positively correlated with slavery. This is consistent with the literature's characterization of Africa as land abundant. Due to geographic factors and the disease environment, population could not expand in the African context to the point where free labor would replace slavery. While state power was correlated with population density, its existence was not systematically based on agricultural suitability. The nature of Egba land tenure, slavery, polygyny, and state power can all be understood within the "land abundance" narrative that is formalized by the model in Section 3.

6. Robustness

In this section, I show that the results in Section 5 are not solely due to the use of dependent variables with little variation in their outcomes, that they can be replicated with an alternative measure of historical population density, that they are robust to additional controls that represent alternative interpretations of the results, and that they are better explained by the model than by other theories of slavery.

6.1. **Dependent variables.** Because there is not much variation in the existence of land rights and polygyny in the data, I use alternative measures of each. The first is an indicator for whether the inheritance of land is patrilineal.[16] 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, there is not much variation in the presence of polygyny. Hence, the "willingness to pay" for wives is measured by using an indicator for whether consideration is given in return for a bride (a non-token bride-price, labor service, or another female relative).[17] Sadly, there is not much variation in this alternative measure either. Finally, measuring state stratification as the number of levels of jurisdiction may not capture the existence of stratified, albeit localized states. Hence, class stratification among freemen is used as an alternative measure of the presence of states.[18] Summary statistics for these variables are given in Table 1.

Table 7 replicates columns (3) and (4) from each of Tables 2, 4 and 5 using these alternative measures. The results generally follow the same pattern as in Section 5. Patrilineal land inheritance is positively correlated with both agricultural suitability and population density,

[16]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.

[17]This is constructed using V6: Mode to Marriage (Primary). Consideration for bride exists if V6=1 or V6=2 or V6=5.

[18]This uses V66: Class Stratification. Class stratification exists if V66>1.

TABLE 7. Alternative dependent variables

	(1)	(2)	(3)	(4)	(5)	(6)
	Land inheritance is patrilineal		*Consideration given in return for bride*		*Class stratification*	
Agric. Suitability	1.72*	1.62	3.44*	3.43*	-0.33	-0.37
	(1.033)	(1.076)	(2.039)	(1.988)	(1.020)	(1.009)
Ln(Pop. Density)		0.33***		0.13		0.21
		(0.109)		(0.226)		(0.164)
Observations	354	354	413	412	401	400
Other Controls	Yes	Yes	Yes	Yes	Yes	Yes
Region F.E.	Yes	Yes	Yes	Yes	Yes	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. See notes for Table 2

though the link with agricultural suitability is only marginally significant in Column (2). Payment of consideration for brides is again positively correlated with agricultural suitability, though there is generally only a weak positive relationship with population density. All societies in the North or Sahara offer more than a token price for wives, which reduces the sample size. Class stratification, like state stratification, is unrelated to agricultural suitability, though the positive correlation with population density is now statistically insignificant. With a p-value of less than 0.2, this is still somewhat suggestive. In general, while these alternative measures are not as statistically robust as the more direct measures used in Section 5, they yield qualitatively similar results.

6.2. **Population density.** The use of population density in 1960 is necessitated by data availability. There are two possible problems with its use. First, population growth between 1900 and 1960 may have been determined by the institutions that prevailed on the eve of colonial rule. For this to produce spurious correlations, however, would require restrictive and implausible narratives about the nature of colonial rule. For example, if there were no true correlation between land rights and population density, societies with rights to land would have to have grown especially quickly as a result of colonial rule to produce the observed results. Colonial policies that promoted population growth (or crowded people together) would have had to have been targeted particularly at societies in which land rights were well developed. Medical innovations were largely introduced after 1950, and would have come too late to have an appreciable effect. Similarly, the confinement of Africans onto reserves in countries such as Kenya was not motivated by their pre-colonial institutions, but instead by the attractiveness of the areas they inhabited.

Second, population density in 1960 may be a poor historical proxy. The strong correlation between it and population density in 2000 mentioned above suggests that this concern is

TABLE 8. Population density projected to date of observation

	(1)	(2)	(3)	(4)
	Any individual land rights		*Any slavery*	
Agric. Suitability	3.11***	2.48***	1.81**	1.67**
	(0.958)	(0.756)	(0.884)	(0.836)
Ln(Pop. Den., D.O.)	0.16**		0.35*	
	(0.075)		(0.186)	
Pop. Density (D.O.)		-12.28**		3.53
		(5.798)		(2.613)
Pop. Density Sqd.		75.22***		-3.51
		(21.344)		(2.295)
Observations	321	321	365	365
Other Controls	Yes	Yes	Yes	Yes
Region F.E.	Yes	Yes	Yes	Yes
	Any polygyny		*State stratification*	
Agric. Suitability	6.19**	5.74**	0.60	0.61
	(2.486)	(2.663)	(0.705)	(0.839)
Ln(Pop. Den., D.O.)	0.29		0.25*	
	(0.367)		(0.138)	
Pop. Density (D.O.)		-20.80*		0.31
		(10.859)		(1.595)
Pop. Density Sqd.		47.00***		-0.03
		(16.566)		(0.947)
Observations	203	203	472	472
Other Controls	Yes	Yes	Yes	Yes
Region F.E.	Yes	Yes	Yes	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. See notes for Table 2

minor. In this section I use the growth rate between 1960 and 2000 to impute an alternative proxy for historical population density. I project back to the date of observation reported in the Ethnographic Atlas. While the range of observed growth rates is fairly large, this is uncorrelated with initial population density, and so is not likely to be systematically biased.[19] These growth rates have been stable over time; population growth from 1960 to 1980 is tightly correlated with growth from 1960 to 2000.[20] Table 8 replicates Columns (4) and (5) of Tables 2, 3, 4 and 5. The positive correlations of all four institutions with population density are apparent. For polygyny this is still insignificant.

6.3. **Other robustness checks.** In addition to the lack of variation in the dependent variables and the validity of the proxy for population density, there are other objections that

[19]The correlation coefficient is -0.0614, with p-value 0.154.
[20]The correlation coefficient is 0.8234, with p-value 0.000.

may be raised about the approach used to test the model. I have tested the robustness of the results to these objections in Table 9. Each odd-numbered column replicates Column (3) from Table 2, 3, 4 or 5 – the principal specification for agricultural suitability. Each odd-numbered column does the same with column (4) from these earlier tables, reproducing the main specification for population density. To conserve on space, I have only reported the p-values on agricultural suitability and the log of population density, to show whether the estimates remain statistically significant.

First, it is not clear to what degree identification of the results are coming off differences within regions that are not representative of the whole of Africa. I present the results of the main specifications excluding the Saharan and North African regions. Second, because of the possible endogeneity of soil depth and soil fertility, I add variables that control directly for soil depth and soil fertility constraints.[21] Third, while data on religion is not available, exposure to Islam is likely to directly affect land rights, slavery, polygyny, and states. As a proxy for this and other North African cultural influences, I add distance from the nearest of: Cairo, Tripoli, Tunis, Algiers and Casablanca. Third, it is clear from visual inspection of Figure 2 that agricultural suitability may be systematically mis-measured in areas where major rivers provide access to water even in the presence of precipitation constraints, or where rivers can facilitate trade. I thus present the results including a dummy for whether each ethnic group's territory is intersected by the Nile, and a dummy for whether any major river (the Benue, Blue Nile, Chire, Congo, Lualaba, Lukaga, Niger, Nile, Orange, Ubangi, White Nile, or Zambezi) intersects the group's territory.

Fourth, an alternative hypothesis is that agricultural suitability and population density are proxies for urbanization, which is itself responsible for the existence of land rights and slavery. To control for pre-colonial urbanization, I add the number of cities in 1850 given by Chandler and Fox (1974), who take 40,000 as the cutoff population for including a city in their list. Because greater agricultural suitability may also be correlated with greater pastureland suitability, I add the society's percentage dependence on animal husbandry.[22] Finally, to ensure that identification is not driven by comparison of small, non-cultivating societies with settled agrarian groups, I have included percentage dependence on agriculture as an additional control.[23]

While many of the results look very similar in the baseline and the robustness specifications, there are three major exceptions. First, including soil fertility constraints makes the effect of agricultural suitability on land rights disappear. Second, discarding North Africa or including the Nile renders the relationship between agricultural suitability and slavery insignificant, while making the effect of agricultural suitability on polygyny negative and

[21]These are Plates 21 and 22 in the FAO data.
[22]This is V4 in the Ethnographic Atlas.
[23]This is V5 in the Ethnographic Atlas.

TABLE 9. Other Robustness Checks: P-values on A and $ln(P)$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Robustness Check	*Land Rights*		*Slavery*		*Polygyny*		*State Stratification*	
	A	ln(P)	A	ln(P)	A	ln(P)	A	ln(P)
Baseline	0.00	0.00	0.07	0.01	0.01	0.36	0.45	0.02
Drop Sahara	0.00	0.00	0.07	0.01	0.02	0.45	0.54	0.03
Drop North Africa	0.00	0.00	0.39	0.03	0.00*	0.00	0.61	0.26
Add Dist. to Islamic Cities	0.01	0.00	0.09	0.02	0.08	0.62	0.51	0.00
Add Soil Depth	0.00	0.00	0.06	0.02	0.00	0.34	0.72	0.02
Add Soil Fertility	0.74	0.05	0.02	0.00	0.00	0.15	0.88	0.03
Add Nile	0.00	0.00	0.16	0.02	0.01	0.39	0.31	0.03
Add Any Major River	0.00	0.00	0.06	0.01	0.01	0.00	0.53	0.01
Add Cities in 1850	0.00	0.00	0.12	0.08	0.35	0.83	0.76	0.44
Add Husbandry	0.00	0.00	0.05	0.01	0.00	0.00	0.49	0.03
Add Agriculture	0.00	0.02	0.05	0.00	0.00	0.08	0.61	0.05

Notes: Odd-numbered columns include other controls and regional fixed effects, while even-numbered columns additionally control for agricultural suitability. See notes for Table 2. Soil depth is the FAO-GAEZ measure of constraints on soil depth. Soil fertility is the FAO-GAEZ measure of constraints on soil fertility. Nile is a dummy for whether the ethnic group is intersected by the Nile. Any major river is a dummy for whether the ethnic group is intersected by the Benue, Blue Nile, Chire, Congo, Lualaba, Lukaga, Niger, Nile, Orange, Ubangi, White Nile, or Zambezi. Cities in 1850 is the number of cities listed by Chandler and Fox (1974) in the ethnic group's territory (these are cities of 40,000 and above). Husbandry is the percentage dependence of the society on animal husbandry (V4 in the Ethnographic Atlas). * indicates that the effect, while statistically significant, is negative.

significant. Third, the correlation between state stratification and population density is not robust to the exclusion of North Africa or the inclusion of pre-colonial urbanization.

Soil fertility constraints enter strongly and negatively into the land rights equation. While it is hard to imagine soil fertility predicting land rights except through the suitability of the land for agriculture, this suggests that one of the most important dimensions through which agricultural suitability affects land rights is soil fertility. Insofar as more well defined rights over land create incentives to preserve soil fertility, this suggests that the parameter estimates in the baseline are overstated due to endogeneity. To believe that the entire result is spurious, however, would require that the entire correlation is due to reverse causation. This would contradict studies that have found the relationship between land tenure and soil conservation investments in Africa to be surprisingly weak – see for example Besley (1995) or Hagos and Holden (2006).

Sensitivity of the slavery result to the exclusion of North Africa or addition of the Nile is more problematic. That the polygyny results are sensitive is not surprising, given their lack

of variability. This result may be in part due to greater variance in the estimates; the causal effect of agricultural suitability is still significant when regional fixed effects are excluded. As well, with a standard deviation of 0.24, North Africa has the most within-region variability in agricultural suitability that can be used for identification. Without region fixed effects, if an interaction term is included between North Africa and agricultural suitability, both the direct effect and interaction are significant. What this suggests is that the impact of agricultural suitability is present both in North Africa and Sub-Saharan Africa, but that the effect is stronger in the North and along the lower Nile. This may be due to the greater ability to import technologies that intensify agriculture where population density is high and the land is suitable.

That states are not correlated with population in the absence of North Africa is surprising. If regional fixed effects are excluded, the correlation is still significant, which suggests that this may result in part from multi-collinearity and the loss of observations. That cities eliminate the relationship between population density and states is not as surprising. Cities facilitate centralized administration and are, of course, highly correlated with population density.

6.4. **Theories of slavery.** In this section, I contrast the results outlined in Section 5 with two other major theories of slavery and explain why the model outlined in Section 3 does a better job of explaining African slavery than either of these.

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 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 agricultural suitability and population density have been shown in Section 5 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 labor dues. 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. This was true for the Egba, where colonial courts took note of manumission payments into the 1920s. Austin (2009b), similarly, 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. First, there is no evidence that slaves were used in production in sectors systematically different than those dominated by free peasants. The fact 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, 2009b). Where large slave communities of slaves 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 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).[24]

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

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.[25]

7. Conclusion

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, slavery, polygyny, and states have all been decisively shaped by the continent's abundance of land and scarcity of labor. I find that this perspective explains much about institutions in pre-colonial Africa, using cross-sectional evidence. That the Egba can be so easily understood in terms of the "land abundance" view gives that narrative further support.

The use of a formal model and comparative data 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 African societies. Second, greater agricultural suitability (as well as access to trade), will encourage increased reliance on slavery. 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)). Third, where brides were costly and polygyny existed in pre-colonial Africa, agricultural productivity (and hence the marginal product of labor) was highest, but population density was also greater. Inequality, then, is a prerequisite for unequal access to wives. Fourth, state strength in Africa has been associated with population density, but is not systematically related to agricultural productivity. Finally, there are substantial institutional spillovers across African societies relating to land, slavery, and the power of states. These revisions to the current thinking allow the "land abundance" perspective to better explain institutions and are borne out in comparative data.

[25]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.

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Appendix A. Data Appendix: Not for Publication

This appendix gives sources and definitions for the geographic variables used and lists the matches used to connect the ethnic groups from Murdock (1967) to those in Murdock's (1959) map.

Table 10: Data Sources

Variable	Description	Citation	Link
Agric. Suit.	The GAEZ reports an index between 0 and 10 combining climate, soil and terrain slope constraints. The "Agric. Suit." Measure is this the maximum of the observed values, minus this index, divided by the observed range.	Fischer et al. (2002)	http://www.iiasa.ac.at/Research/LUC/SAEZ/index.html
Pop. Dens. 1960	Population density in 1960 per Sq. Km.	UNESCO (1987) through UNEP/GRID-Sioux Falls	http://na.unep.net/datasets/datalist.php
Elevation	Elevation in Km.	N/A	http://epp.eurostat.ec.europa.eu/
Precipitation	Average annual precipitation (m). Missing values (due to differences in resolution between the data and map) are imputed using the nearest raster point.	Fischer et al. (2002)	http://www.iiasa.ac.at/Research/LUC/SAEZ/index.html

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Variable	Description	Citation	Link
Temperature	The accumulated temperature on days with mean daily temperature above 0 °C. 55537 is treated as missing and these points are dropped before the join. Missing values imputed using the nearest raster point.	Fischer et al. (2002)	http://www.iiasa.ac.at/Research/LUC/SAEZ/index.html
Abs. Latitude	Absolute value of the latitude of the ethnic group's centroid, reported by ArcMap.	N/A	N/A
Dist. to Lake Victoria	Distance, in 1000 Km, from the ethnic group's centroid to the center of Lake Victoria, calculated using the globdist function for Stata written by Kenneth Simons.	N/A	N/A
Dist. to Coast	Average distance from all points in the ethnic group territory to the nearest point on the coast, in decimal degrees, calculated in ArcMap.	N/A	N/A
Malaria Suit.	Climatic suitability for malaria transmission.	Adjuik et al. (1998)	http://www.mara.org.za/lite/download.htm

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Variable	Description	Citation	Link
Tsetse Suit.	The raw data is the predicted presence of tsetse using satellite imagery on eco-climatic data, human population, and predicted cattle and cultivation levels. Because human population may be endogenous, this is converted into a binary variable (1 if it is greater than 0.5) and regressed as a probit on quadratics in precipitation, elevation, temperature, latitude and longitude. The predicted probability from this probit is used as the measure of tsetse suitability.	Wint and Rogers (2000)	http://ergodd.zoo.ox.ac.uk/paatdown/index.htm
Ruggedness	This is calculated using the user-written Vector Ruggedness Measure script for ArcMap. It "measures terrain ruggedness as the variation in three-dimensional orientation of grid cells within a neighborhood." The input data is the elevation data listed above, and the neighborhood size selected is 3, the smallest possible. Missing values imputed using the nearest raster point.	Sappington et al. (2007)	http://arcscripts.esri.com/details.asp?dbid=15423

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Variable	Description	Citation	Link
Population Weight	This is an estimate of the population of the ethnic group, calculated by summing over the populations of cells contained in the population density data. If more than one group is assigned to a single territory, the population of each group is taken as the sum of the population within that territory divided by the number of groups.	N/A	N/A

Table 11: Matches

Name in Atlas	Name in Map	ISO 639-3	Name in Atlas	Name in Map	ISO 639-3
		Alternative Spelling			
AULLIMIND	AULLIMINDEN	ttq	KARAMOJON	KARAMOJONG	kdj
BAFIA	FIA	ksf	KIPSIGIS	KIPSIGI	kln
BALI	LI	mhk	KURAMA	KURAMA, GURE (SE)	krh
BAMUM	MUM	bax	LAKA	LAKA(ADAMAWA)	lak
BANEN	NEN	baz	LENGE	HLENGWE	cce
BANYANG	ANYANG	ken	MBANDJA	BANZA	mmz
BASAKOMO	BASA	bzw	NGULU	NGURU	ngp
BENIAMER	AMER	amf	NGUMBI	NGUMBE	khu
BIRIFOR	BIRIFON	bfo	NYANKOLE	NKOLE	nyn
BISA	BUSANSI	bib	PLTONGA	TONGA	toi
BOMBESA	MBESA	zms	PLAINSBIR	BIRA	brf
CHAGGA	CHAGA	jmc/old	PLAINSSUK	SUK	pko
CHAWAI	JERAWA, CHAWAI(SW)	cch	SAPEI	SABEI	kpz
DAKAKARI	BAKAKARI	dri	SARA	SALA	sba
FUNGOM	FUNGON	bfm	SHAWIYA	SHAWIA	shy
FUTAJALON	FOUTADJALON	fuf	SIWANS	SIWA	siz
GIRIAMA	GYRIAMA	nyf	XHOSA	XOSA	xho
GURE	KURAMA, GURE (SE)	krh	ZENAGA	ZENEGA	zen
HILLSUK	SUK	pko	ZINZA	SINZA	zin
HONA	KONA	hwo	ZUANDE	ZUANDE, BATU(E)	N/A
		Alternative Name			
ABRON	BRONG	abr	KAKWA	BARI	keo
AWUNA	GRUNSHI	ewe	LAKETONGA	NYASA	tog
BORoroful	SOKOTO	fuv	MAMBWE	LUNGU	mgr
FALASHA	KEMANT	ahg	MBUTI	LESE	les
GALAB	RESHIAT	dsh	NGONDE	NYAKYUSA	nyy
HATSA	KINDIGA	hts	RIFFIANS	RIF	rif
JIMMA	JANJERO	jnj	TURA	GURO	goa/neb
KAGURU	SAGARA	kki			
		Subgroup			
SHONA	KARANGA	sna	SOMALI	MIJERTEIN	som
SIDAMO	KAMBATA	sid	TSWANA	NGWATO	tsn
		Alternate Subgroup			
ALAGYA	AVIKAM	ald	SHANGAMA	BAKO	aiz
KAGORO	KATAB	kcg	UBAMER	BAKO	aiz
NANKANSE	GURENSI	gur			
		Supergroup			

Continued on next page

Name in Atlas	Name in Map	ISO 639-3	Name in Atlas	Name in Map	ISO 639-3
AFIKPO	IBO	ibo	HAMMAR	OMETO	amf
ANFILLO	MAO	myo	KANAWA	HAUSA	hau
ARBORE	KONSO	arv	KASENA	GRUNSHI	xsm
BANNA	OMETO	amf	MALE	OMETO	mdy
BASKETO	OMETO	bst	NGONI	SENGA	ngo
BASSARI	TENDA	bsc	TALLENSI	GURENSI	gur
BOMVANA	XOSA	xho	TSAMAI	KONSO	tsb
CONIAGUI	TENDA	cou	VUGUSU	LUO	luo
DIME	OMETO	dim	YATENGA	MOSSI	mos
DORSE	OMETO	doz	ZAZZAGAWA	HAUSA	hau
EFIK	IBIBIO	efi			
		Location			
ANAGUTA	AFUSARE	nar	LOWIILI	BIRIFON	N/A
BADITU	OMETO	N/A	MESAKIN	KOALIB	jle
BODI	TOPOTHA	mym	MORO	TALODI	mor
BURJI	BORAN	bji	NYARO	KOALIB	fuj
DJAFUN	NAMSHI	fub	OTORO	TAGALI	otr
ISALA	WABA	sil	SHAKO	KAFA	she
KARA	KEREWE	reg	TIRA	TALODI	tic
KORONGO	TUMTUM	kgo	TIRIKI	NANDI	ida
KUSASI	GURENSI	kus	TULLISHI	NYIMA	tey
LALIA	KELA	lal	WODAABE	KANURI	fuq

*Notes:*For AWUNA, see Grindal (1972). KANAWA refers to the city of Kano. For VUGUSU, see Wagner (1949).YATENGA refers to the Mossi capital. ZAZZAGAWA refers to the city of Zaria. Djafun-Bororo is a Fulbe group.