Up the River: International Slave Trades and the Transformations of Slavery in Africa

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UP THE RIVER: THE INTERNATIONAL SLAVE TRADES AND THE TRANSFORMATIONS OF SLAVERY IN AFRICA *

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Abstract

According to western observers, slavery was almost universal in Africa by the end of the slave trade era. I investigate the extent to which the international slave trades transformed the institutions of slavery in Africa. I use newly-developed data on travel time to estimate the inland reach of international slave demand. I find that societies in decentralized catchment zones adopted slavery to defend against further enslavement. More generally, I find that the international slave trades incentivized the evolution of aristocratic slave regimes characterized by slavery as a property system, polygyny as a family organization, inheritance of property within the nuclear family and hereditary succession in local politics. I discuss the implications for literatures on long-term legacies in African development.

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1 African Slavery: The Missing Link

Recent econometric research has found recurring evidence that the international slave trades underdeveloped Africa over the long-term. The evidence begins with Nathan Nunn's influential article published in 2008, where he develops new anthropological data on African slave exports in the distant past. Researchers have used these data to identify a number of *long-term* legacies of the slave trades that manifest today in a variety of ways: lower national incomes per capita, greater ethnic diversity, more polygyny as a family organization, heightened conflict and mistrust, underdeveloped access to credit, greater political corruption and less local schooling.[1] We do not know if or how these legacies are related, but each constrains growth.

This paper investigates an important but overlooked *immediate* outcome of the slave trades, an institutional response that could carry many of these long-term effects forward -- namely, the possibility that the international slave trades spread the institution of slavery in Africa. Among historians this is known as the Transformations in Slavery Debate, a debate that attracted the attention of historians like John Fage (1959, 1969, 1980), Walter Rodney (1966) and Paul Lovejoy (2000), and anthropologists like Claude Meillassaux (1971, 1991) and Suzzane Miers and Igor Kopytoff (1977). Institutions that support slavery are likely to be carriers of many of the long-term effects mentioned above, yet two recent surveys of the new literature fail to mention a single reference to African slavery, or a single quantitative assessment of the issues at stake in the transformation debate.[2]

This study bridges this gap in the literature. It investigates the effects of the international slave trades on the spread and transformation of slavery across the continent of Africa. Data limitations do not allow me to address questions concerning increases in the shares of populations or the uses to which slaves were put. Scattered evidence suggests that in some places the percentages were very high and the uses widespread.[3] Here I estimate the impact of the international slave trades on the probability that an African society is observed by the end of the slave trade era as having slavery as one of its institutions, and what property rights systems supported the institution.

The empirical design is similar to previous research in this area. All data have a spatial marker. The primary data are observations on the locations and characteristics of precolonial African societies circa 1900 found in George Murdock's Ethnographic Atlas. One of Murdock's variables (V70) codes whether or not an African society ever practiced slavery. This is my main dependent variable. I merge spatial data on the international slave trades (circa 1600-1850) and look for meaningful correlations.

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[1] Nunn (2008), Nunn and Wantchenkon (2011), Dalton and Leung (2014), Bertocchi (2015), Obikili (2016a, 2016b), Whatley (2014), Whatley and Gillezeau (2011), Bottero and Wallace (2013), Boxell, (2019), Dalton and Cheuk (2014), Levine, Lin and Xei (forthcoming), Pierce and Snyder (2018), Besley and Reynal-Querol (2014), Bhattacharyya (2009).

[2] See Michalopoulos and Papaioannou (2018) and Fourie (2019). The only econometric study the author is aware of that looks at the legacy of African slavery is Bezemer, Bolt and Lensink (2014) who find negative correlations with postcolonial incomes per capita.

[3] See Patterson (1982), Miers and Kopytoff (1977), Miers and Roberts (1988), Robertson and Klein (1983), Fisher (2001), Lovejoy (2016), Latham (1973) and Roberts (1987).

First I add estimates of past slave exports from named ethnicities found in Nunn and Wantchenkon's (2011). These data have been used in most of the studies mentioned at the outset. Since they are estimates of slave exports, they are useful in identifying the impact of the slave trades in areas called catchment zones.

Second, I add new estimates of distance to the nearest international slave port. In this context, distance measures transport and communication cost. It also serves as an excluded instrumental variable that helps identify the impact of international demand on the number of slaves captured and exported. In this literature, distance has been measured in a variety of ways, sometimes as inclusion within an arbitrary buffer around an international slave port (e.g., Whatley and Gillezeau, 2011; Whatley, 2014; and Fenske and Kala, 2015), but most often as a mixture of straight-line distances by land and sea, with mixed results (e.g., Nunn, 2008; Nunn and Wantechkon, 2011; Whatley and Gillezeau, 2011; Obikili 2016, Bhattacharyya (2009); also see footnote 1).

In this paper I use newly-developed data on distance that outperforms straight-line distance in that it identifies outcomes that straight-line distance misses, which might help explain why the transformation debate has alluded econometric investigations thus far. I develop an estimate of travel time to the nearest port serving one of the four international slave trades. This is a manageable calculation for precolonial Africa because the transportation technology was limited to horses, camels, human portage and canoes. The estimate takes into account the effects of groundcover type (e.g., jungle v. plains), terrain (uphill or down), river velocity and headload. Parameters come from hydrological studies, survey maps, hiking and headload studies, and travel times recorded by early British ambassadors, missionaries and explorers. I use these parameters to estimate the hours to travel from anywhere on the continent of Africa to the nearest port serving one of the four international slave trades.[4]

A major portion of this paper and its Appendix are devoted to introducing this new data and demonstrating how it improves our ability to track transport and communication costs in precolonial Africa. First, I use the estimates of travel time to generate demand-driven variation in slave exports. I then look to see if increases in demand-driven exports encouraged the eventual adoption of slavery. I find that catchment increased the probability that a society would become a slave society and that the greatest effect was among politically decentralized villages and petty chiefdoms.

Second, I drop the focus on catchment and use proximity to slave ports to estimate the effects of the four international slave trades more broadly. This analysis finds that proximity to international slave ports incentivized the spread of a set of related institutions that looks like aristocratic slavery in the African context: slavery as a property system, polygyny as a family

[4] Ozak (2018) introduces a global measure of the distances to pre-industrial technology frontiers, but the measure is not applicable to the African continent. The measure is based on estimates of "the maximal sustainable speeds of dismounted infantry movements under different temperature, relative humidity, slope, and terrain conditions," before becoming a victim of heat-exhaustion (p. 191). As such, the measure closely tracks global distances from the equator and tropics (see Fig. 4, p. 192) with corrections for variations in the earth's slope. All groundcover is assumed to be sand and there is no accounting for river transportation.

organization, the inheritance of capital and land within the nuclear family and inherited succession in local politics.

I argue that these findings help historically decompress two long term legacies identified in the development literature because they integrate the history of African slavery into both. One legacy is a negative long-term effect of the slave trades on income (Nunn, 2008). The other is a positive long-term effect of pre-colonial political centralization (Michalopoulos and Papaioannou, 2013, 2015; Englebert, 2000). The institutions of aristocratic slavery were key institutions in both precolonial *and* colonial Africa, which helps explain why the negative income effect of the slave trades does not show-up until after colonialism (Bezemer, Bolt and Lensink, 2014; Bottero and Wallace, 2013). Similarly, virtually all centralized precolonial societies were slave societies, so some of the long term benefits of political centralization accrued during the colonial era as well. In my concluding remarks I return to these issues and the related issue of customary authority in Africa today.

2 The Transformations of Slavery Debates

Africa is generally viewed as a labor-scarce environment, so why export its people? Fenoaltea (1999) proposes a model to explain this seeming contradiction, but his model does not explain why Africans emigrated as slaves rather than free persons.[5] Domar (1970), Nieboer (1900) and Hopkins (1973) offer models that predict the institution of slavery in labor-scarce environments, but these models do not explain why African slaves were exported rather than employed domestically. This is where the transformation of slavery debate comes in. If slavery was widespread in Africa prior to the international slave trades, then the emigration of Africans as slaves has a strong supply-side component. The subsequent history of African slavery might then be seen as a continuation of previous domestic trends (see Eltis, 1987; Thornton, 1998). If, on the other hand, the international slave trades transformed property systems in Africa and spread the institutions of slavery, then Africans emigrated as slaves (rather than, say, indentured servants) because of strong demand-side factors. The international slave trades should then be viewed as transformative shocks to African social institutions.

The modern debate begins with an exchange between John Fage (1959) and Walter Rodney (1966) -- an exchange that focused on the extent of slavery in Africa before the coming of the trans-Atlantic slave trade, a theme Fage returns to repeatedly over the course of his career. Fage (1959) initially argued that,

> "…the presence of a slave class among the coastal people meant that there was already a class of human beings who could be sold to Europeans if there was an incentive to do so… So the coastal merchants began by selling the domestic slaves in their own tribes (p. 78)."

Rodney (1966) investigates the upper Guinea Coast between the Gambia River and Cape Mount, and concludes that the growth in slave exports from the region did not rely on existing stocks,

[5] Fenoaltea (1999) argues that even if the marginal productivity of labor is the same in Africa and America, one might observe a short-run labor outflow from Africa to America if African importers paid the transport costs to import goods for elites. Nowhere in this formulation is there a discussion of contract form.

but growth was a response to increasing demands for slave exports. Fage (1969) responds that Sudanese slave states existed prior to European arrival and spread to coastal areas during a golden era of trade (1500-1650). The growing transatlantic slave trade (1650-1850) expanded slavery further. Later, Fage (1980) generalizes from a growing body of case studies that slavery was integral to the process of political centralization and state-building in medieval and precolonial Africa. As for the impact of the transatlantic slave trade, Fage speculates that it could have encouraged political centralization, and therefore slavery, but he was uncertain about the net effect.

The further proliferation of historical case studies and the collection of early demographic data on slave exports prompted Paul Lovejoy to attempt a synthesis in his 1983 book *Transformations in Slavery*. Lovejoy concludes that

> "…the opening of the Atlantic to trade marked a radical break in the history of Africa... Slavery was closely associated with this transformation not only because slaves were a major export, but also because slaves became far more common in local society than previously (p. 19)…. and the changes that took place resulted in the emergence of slave societies in places where previously there had only been a few slaves in society. That is, slavery became a central institution and not a peripheral feature (p. 21)."

Critics of Lovejoy, like Eltis (1987) and Thornton (1998), counter that internal economic, political, and social factors were so overwhelmingly dominant or otherwise impervious to external influence that there were no transformations within Africa that resulted from the slave trade.[6]

Anthropologists debated a similar issue -- the social origins of slavery in Africa -- exemplified by the contrasting views of Miers and Kopytoff (1977) and Meillassoux (1971, 1991). Miers and Kopytoff (1977, pp. 66-72) consider slavery to be an extension of African kinship systems in a labor-scarce environment, similar to the models of Domar (1970), Nieboer (1900) and Hopkins (1973).

> "We see the roots of these servile institutions in the need for wives and children, the wish to enlarge one's kin group, and the desire to have clients, dependents, servants, and retainers (67)."

They take a decidedly Smithian view of a human propensity to "truck and barter (p. 68)."

Meillassoux (1991) argues the exact opposite -- that "slavery is the antithesis of kinship (p. 35)." He begins with a conception of a closed kinship-based economy equilibrating internally through a nexus of lifecycle obligations and exchanges between productive and unproductive kin. Kin are people *brought up* in the lifecycle. People not brought up in the lifecycle are aliens. Over the life course, kin pass from being unmarried cadets, who contribute to social reproduction by

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[6] Eltis (1987, p. 74) argues that the slave export sector was a small share of African gross domestic product. Thornton (1998, chapter 3) argues that slave exports came primarily from existing stocks of slaves.

producing a surplus and transferring it to elders, into married men who contribute to social reproduction by raising families that eventually produce and care for elders.

In this conception of kinship economy, cadets can be exploited if elders limit their access to wives and the products of progeny, but Meillassoux argues that slavery as an institution cannot emerge from the internal dynamics of such an economy. Since "gentles" are born into the lifecycle, a permanent class of exploited gentles must be permanently denied access to wives. But if this happens the lineage dies out. Institutionalized exploitation of gentles requires a new "alien" lineage/class to justify and enforce the exploitation. Slavery, according to Meillassoux, is one such institution: the systematic and institutionalized limitation on access to progeny's product; the institutionalized denial of kin status enforced by rules that reproduce alien status. Institutionalized war and regularized slave raiding can accomplish this, as in regions caught-up in a gun-slave cycle (Whatley, 2018; Gemery and Hogendorn, 1974, Lovejoy 2000, p. 80-86). Racialized slavery can accomplish this, as in the Muslim Sudan region of Africa (Hall, 2011). Kinship-based African societies had difficulty accomplishing this. As evidence, Meillassoux (1991, pp. 78-84) cites data showing African societies having difficulty biologically reproducing their slave populations (Klein, 1983).

This debate, like the one among historians, is about the impact of the slave trades on African social relations and institutions. The different anthropological conceptions apply best to different levels of political and economic development. Meillassoux's theory of kinship economy applies best to politically decentralized villages organized into age-groups with elders and lineage heads wielding power, and how these societies might have difficulty introducing and enforcing slavery. Miers and Kopytoff's conception applies best to societies centralizing politically around an aristocratic elite's capacity to control land and exploit resources to produce a surplus.[7]

The development question is how might an external slave trade drive the transformation of kinship-based economies into aristocratic slave-based economies? An obvious mechanism is through the incorporation of enslaved women. Male cadets retain the products of progeny. Slave wives, concubines and dependents are exploited. The reproduction of the slave population depends on the social status of the off-spring. According to Meillassoux (1991), as well as Miers and Kopytoff (1977), the macro challenge is for free people to introduce slaves without undermining the social norm that freedom (as opposed to slavery) means "belonging to kin."

In this context, the rules that govern the inheritance of social status will influence the form that slavery takes, but in the final analysis the reproduction of slave property concentrates wealth within male-headed nuclear families as opposed to the lineage, the clan or the tribe. In matrilineal societies, the social status of offspring is inherited from the slave mother, so the off-spring of a free man and a slave mother is a slave, which does not violate the social norm. They also have no kin other than the father.[8] In patrilineal societies, the social status of offspring is

[7] See Schneider (1981) for an anthropological argument that surplus production is a necessary condition for political centralization, the sufficient condition being monopolization of a strategic resource.

[8] These considerations might help explain the male dominance in the trans-Atlantic slave trade. Regional variation in the male/female ratio of exports from Africa were much larger than variation across receiving regions of the Americas, implying that supply-side factors were important (Eltis, 1986). In kinship economies, male slaves were

inherited from the father, so the offspring of a free man and a slave mother should be free. According to Meillassoux (1991, pp. 130-140), this violates a fundamental societal norm and explains why patrilineal societies seldom condone marriage between free men and slave women, but instead incorporate slave women through concubinage. The offspring still have no kin other than the father. Miers and Kopytoff (1977), summarize the results of centuries of this type of pressure on inherited slave status and conclude that the "… position of the second generation is least ambiguous in matrilineal societies…Most patrilineal societies, however, made some distinction between the various children of "free" man, based on the status of their mother (p. 33)." Lovejoy, focusing on the property aspect of inherited slave status, concludes that the incorporation of slaves "… enabled wealthy men to establish large households that were dependent upon them and not some larger kinship unit (p. 123)."

Lagerlof (2009) models a similar transition, one from "egalitarian" ownership of land and labor into a "state of despotism and slavery, with a political elite owning both people and land (p. 319)." Here the transition is driven by the joint evolution of agricultural technology and population growth. The transformation of slavery debate advances the hypothesis that in Africa this evolution was also driven by pressures from the international slave trades.

3 Data Section

The empirical section will test these hypotheses by estimating relationships between the international slave trades and transformations in African slavery. Before we can do that we need to generate exogenous variation in exposure to the slave trades. In this section I introduce estimates of travel time to the nearest international slave port as a measure of local exposure to international slave demand. Once exposed, people and societies coordinate a response.

Travel Time. In pre-colonial Africa the transportation and communication technology was relatively simple. The tse-tse fly eliminated draft animals from the technology set in much of tropical Africa (Alsan, 2015). The camel and the horse were confined primarily to the desert and its savannah fringes (Bulliet 1990; Law 1980). The wheel, like in most parts of the world at this time, was virtually non-existent (Bulliet 2016).[9] The major modes of transportation were walking and canoeing. Slave were transported by these methods even when horses and camels were available.

I develop an index of precolonial TRAVEL TIME for the entire continent of Africa. The index estimates travel time by portage and canoe, measured in hours per kilometer. I estimate and combine two GIS rasters. The first raster uses historical observations on walking speeds and the *Waldo Tobler Hiking Function* (1993) to estimate walking speeds over a variety of FAO land-

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more-difficult to integrate into society than female slaves, which might also help explain the high percentage of male children in the export trade (Eltis, 1986, Eltis and Engerman 1992, Geggus, 1989). The status of children of mixed parentage, if not tightly controlled, challenged societal norms of freedom and belonging. The sale of such children was one way to relieve this pressure and preserve the status quo.

[9] According to Bulliet (1990) the camel displaced the wheel from Roman Syria and North Africa. While the history is complex, major developments include the diffusion of the north Arabian saddle (500-100 BC), the collapse of the Roman Empire and its road system, and camel breeders' seizing control of trade at Mecca by the time of Mohammad's birth (circa 570 AD).

cover types and earth slopes. The second raster estimates canoe speeds along rivers of different velocities using data from the Global Runoff Data Center's *Major River Basins of the World, classified by mean annual discharge* (GRDC, 2007). The two rasters are joined to form a raster of travel time for each .452 square kilometer cell of the African continent. I use the ArcGIS Path Distance tool to estimate the least-cost time to travel from any point on the continent to the nearest international slave port.

Estimates of land cover come from the *Land Cover Map of Africa* developed by Mayaux, et al (2003) at the European Commission Joint Research Centre. The 27 FAO land classifications are reduced to six (6) classes that capture broad differences in walking friction. Table 1 reports the reclassifications and the corresponding estimates of travel time with and without headload (see the Appendix for details). These are for flat surfaces, to which the effects of slope are added using the The Waldo Tobler's Hiking Function (1993), a function commonly used to account for the impact of slope on walking velocity. I adopt a maximum vertical slope of 20%. The lower the maximum slopes the more travelers are assumed to use local knowledge to find the easiest local paths forward.[10] Figure 1 displays the raster of hours to walk 100 kilometers.

Canoe speeds are calculated differently. To the rowing speed of .216 hours per kilometer I add estimates of river velocities based on data and models developed at the Global Runoff Data Centre. Velocity is the rate of flow measured in meters per second. It is a function of the rate at which the river system discharges its cubic volume of water, divided by the cross-section (width x depth) of the riverbed through which the water is discharged. The Global Runoff Data Centre (GRDC, 2007) maintains a GIS database that contains volumetric discharge rates for 687 major river systems around the world, recorded at 3,843 gauging stations between 1961 and 1990. Andreadis, et al (2013) add estimates of river width and depth using well-established geomorphic relationships between discharge rates and drainage areas (p. 7164).[11] They evaluate their estimates of river width using satellite imagery.

The resulting mean time for the continent of Africa is 0.44 hours to cover a kilometer. This average includes numerous seasonal streams and creeks. The fastest river segment takes only 0.15 hours to cover a kilometer. The slowest takes 0.95 hours per km. Figure 2 displays the raster for river that take less than .27 hours to cover a kilometer. This velocity cut-off captures all of the major river systems in Africa and their major tributaries, including the Senegal, Gambia, Niger, Benue, Congo, Nile and Zambezi river systems.[12] Estimates of river velocity already incorporate the effects of slope, which is gradual along the run-off. Discontinuous sections like

[10] The ArcGIS Cost Path algorithm retains in memory a table of transition costs for all directions leading from a cell, not just the least cost direction. Imposing a maximum vertical factor forces the calculation to "backtrack" and find a path that is not blocked by the maximum vertical factor.

[11] For a review of this literature and a discussion of similar but alternative algorithms for calculating river width, see Yamazaki, et al, (2014).

[12] The .27 cut-off was set early in the project to equal Dupuis' estimate of 16 miles per 7-hour day for walking across savanna. This is also comparable to the .255 hours per kilometer for walking across desert. The goal was to set a lower limit on river velocity to be at least as fast as walking to avoid the scene of traders sitting in canoes floating downstream slower than walkers passing by.

waterfalls and rapids have been removed using available maps, forcing travelers to portage around these sections (see the Appendix).

Taking all of these factors into account, the end product is a raster that combines estimates of walking speeds over a variety of land cover types and slopes, and canoe speeds along rivers of different velocities. Given a value for each cell of the continent, the ArcGIS Cost Path tool can estimate the least-cost path to a set of destinations. Figure 3 displays the estimated average travel times from each society in Murdock's Ethnographic Atlas to the nearest slave port serving the Transatlantic and Indian Ocean slave trades. The ports are taken from the Transatlantic Slave Trade Database.[13] Figure 4 displays the estimated travel times to the nearest trans-Saharan or Red Sea slave port, taken from Austen (2010, p. 29). Each society's travel time is the average weighted travel time for all of the cells contained within a society's boundaries. These are the measures of travel time used in the empirical section.

Other Data. Table 2 reports means of the other variables. AFRICAN SLAVERY is the main dependent variable. It comes from variable V70 in the Ethnographic Atlas. It takes the value one if the society is reported as ever having the institution of slavery, zero if slavery was recorded as "absent or near absent."[14] Bezemer, Bolt and Lensink (2014) check Murdock's classifications against the references used by Murdock and others, and find that it "…did not lead to major changes in the coding of our data (p. 150)." They found less agreement with the types of slavery recorded in the Ethnographic Atlas (Incipient, Unspecified and Hereditary). I follow their lead and confine the analysis to the presence and absence of the institution of slavery as recorded by western observers in the Ethnographic Atlas.

The variable SLAVE EXPORTS estimates the number of locally captured people exported as slaves into international slave markets. The data come from Nunn and Wantchenkon (2011) and are only available for Transatlantic and Indian Ocean exports. Potential bias from the absence of data on trans-Saharan and Red Sea exports is handled by a travel time variable that measures proximity to the nearest trans-Saharan and Red Sea slave port.[15] The slave export data are normalized by square kilometer to reflect intensity. Exports per square kilometer are highly skewed, with 60 percent zeros, 90 percent less than 1 and outliers as large as 43. The estimation uses the natural log transformation which removes the truncation at zero, produces more symmetry around the mode and compresses outliers.[16]

[13] Slave ports are taken from the Transatlantic Slave Trade Database. They include all mainland slave ports on the West coast of Africa that exported more than 4,000 slaves between 1600 and 1865. On the East African coast the ports included all mainland slave ports plus Zanzibar, a major island port in the Indian Ocean trade that was just off the coast.

[14] In the original data published in the journal *Ethnology*, V70 was coded as 1 if slavery "ever existed." If slavery had been abolished by the date of observation then the suffix "f" for "former" was added (Murdock 1963, p. 114). In later editions of the Ethnographic Atlas the suffix "f" became the basis for V71.

[15] Nunn (2008, p. 152) estimates that between the years 1400 and 1900, the trans-Saharan and Red Sea trades were one-third the size of the trans-Atlantic and Indian Ocean trades, but the trans-Saharan and Red Sea trades lasted for a longer period of time. Austen (2010, p. 33) estimates that the total of the trans-Saharan, Red Sea and Indian Ocean trades was as large as the trans-Atlantic trade.

[16] I add the extremely small value of .00001 to the data (smaller than the smallest positive number) to approximate the value of zero because ln(0) is undefined.

Sociological controls include POLITICAL HIERARCHY and PATRILINEAL descent. POLITICAL HIERARCHY is Murdock's variable V33. It measures jurisdictional hierarchy beyond the local community. Hierarchical ordering begins with village societies that recognize no political authority beyond the local community; then one level of jurisdictional hierarchy beyond the local community (for example, petty chiefdoms); two levels of hierarchy beyond the local community (larger chiefdoms); three levels (states); and four levels (large states). The variable has been used in a number of influential studies on the causes and consequences of pre-colonial political centralization defined as large chiefdoms and states (Osafo-Kwaako and Robinson, 2013; Gennaioli and Rainer, 2007; Michalopoulos and Papaioannou, 2013, 2015 and 2018).

The variable PATRILINEAL descent comes from Murdock's V43. It takes the value 1 if the major descent type is patrilineal, zero otherwise. According to Meillassoux, patrilineal societies had more-difficulty incorporating slave women as the wives of free men (1991, pp. 130-140).

Other CONTROL variables capture exogenous variations across regions that might influence the presence or absence of slavery. The first is an index of agricultural suitability, which controls for variations in population density and the potential economic returns from exploiting slaves. The second is an index of tse-tse fly suitability, which reduces agricultural productivity overall (Alsan, 2015), reduces the availability of camels and horses as instruments of warfare and state-building (Goody, 1971), and eliminates an important store of wealth other than slaves. The third is a region-indicator that captures broad regional differences, like Islam in the north, coastal versus interior, Atlantic Ocean versus Indian Ocean trade histories, and early European occupation of the Southern Cape. I include the date of observation to account for any changes in the probability of observing slavery dues to changes in the date at which the society was observed, as recorded in the Ethnographic Atlas.

4 The Spread of Slavery in Catchment Zones

Did the international slave trades spread slavery in Africa? The development literature traces the effect through slave exports, so the analysis begins there. I estimate the following relationships:

SLAVERY = F (EXPORTS, HIERARCHY, PATRILINY, CONTROLS)

EXPORTS denotes losers in the kinds of conflicts that produced slaves. SLAVERY denotes users of the slaves produced by such conflict. Why would societies suffering loses become users of slaves? The first order effect would be adoptions of slavery among people defending against further enslavement, as in catchment zones. Historical case studies show how pressures from the probability of being captured transformed decentralized kinship-based societies into marauding bands of young cadets and warriors using newly-acquired slaves to raid the countryside for more recruits (Klein 2001; Hawthorne 2003; Roberts 1980, 1987; Meillassoux 1991, pp. 143-156). Along the southern shores of the Sahara desert, 18^{th} and 19^{th} century Islamic Jihads began as defensive movements to protect against enslavement, only to become justifications for enslaving others (Lovejoy, 2016).

Losers also became users because the kinds of social conflict that produced slaves did not always produce clear winners and losers. The importation of new weapons-of-war often pushed entire regions into a prisoners' dilemma arms race of raid-or-be-raided, with belligerents sometimes winning, sometimes losing (Whatley, 2018; Gemery and Hogendorn, 1974; Lovejoy 2000, pp. 80-86; Inikori, 1977). As the volume of slave raiding and trafficking grows, so too do the opportunities and temptations to use slaves in military and administrative functions, which requires recognition and enforcement of the institution. Many African slave systems were designed to slowly integrate descendants of slaves into society, so continued slave raiding and slave trading were required to reproduce the system (Meillassoux, 1991; Miers and Kopytoff, 1997).

Table 3 reports estimates of the linear relationship between slave exports and African slavery. Column (1) reports the simple regression of SLAVERY on EXPORTS per sq. kilometer. The coefficient is .011 and significant at .01 percent. Column (2) clusters robust standard errors by ethno-linguistic affiliation. Column (3) adds travel time to the nearest trans-Saharan and Red Sea slave ports to account for bias from missing data on export into those trades. Column (4) adds the other environmental controls. These pick-up a substantial amount of variation in slavery, the most important variable being the index of Tsetse Fly Suitability. Column (5) adds the two institutional variables. The coefficients on political hierarchy shows a positive correlation with slavery. The coefficient on patrilineal descent shows a negative correlation with slavery. The coefficient on EXPORTS is positive and significant throughout.

Table 4 presents probit estimates of the relationship between exports and slavery. The dependent variable, SLAVERY, is a dichotomous variable that takes the value zero or one, so the errors from the linear model violate the homoskedasticity and normality assumptions of OLS, resulting in invalid standard errors and hypothesis tests. They can also predict probabilities that fall outside the 0-1 interval. Probit models solve these problems by fitting a nonlinear function to the data that constrains the probability to fall between zero and one. Here, the bivariate outcome Y (SLAVERY) has a Bernoulli distribution with probability of success $p \in (0,1)$. EY=p. The probit link function uses the inverse normal distribution (Φ^{-1}) to transform the expectation of the 0/1 dependent variable,

$$\textit{probit}(EY)=\Phi^{-1}(p)=\Phi^{-1}(P[Y=1]).$$

The inverse standard normal distribution of the probability is then modeled as a linear combination of the predictors (X),

$$\text{probit}(EY)=X\beta,$$

where β is a vector of unknown parameters.

The maximum likelihood based approach is used for parameter estimation. The estimated coefficient is the increase in the z-score due to a one unit increase in the independent variable. For categorical variables it is the increase in the z-score per increase in category. For *X=ln(EXPORTS)* a 1% increase would lead to a $\beta/100$ increase in the z-score. Conditional predicted probabilities are obtained by the inverse probit transformation where the predicted probabilities will change over the distribution of covariates.

Table 4 reports results. The estimated coefficient on slave exports is always positive and significant. According to these results, a one percent increase in slave exports per square kilometer increased the z-score by 4.6 to 6.5 percent. Figure 5 graphs the within-sample predicted probabilities with 95% confidence intervals. They show how catchment increased the probability of adopting slavery as an institution.

Table 5 presents instrumental variable estimates of the probabilities. Reverse causality is a concern. Pressures from the slave trade could have encouraged societies in catchment zones to adopt slavery. Alternatively, slave societies could have welcomed the opportunity to sell slaves to international slave traders. Omitted variable bias is also a concern. The variable EXPORTS measures cumulative export over three centuries. Variables omitted from the analysis could be positively correlated with both slave exports and the probability of adopting slavery. Lagerlof (2009), for example, proposes a model where improved agricultural productivity and increased population density make slavery a more profitable institution for elites to consider. In this model, the additional cost of non-productive guards is offset by the opportunity to pay slaves less than their marginal product. Over the centuries of the international slave trades, new crops like maize diffused throughout Africa, increasing the carrying capacity of land and encouraging the export of slaves (McCann 2005; Cherniwchan and Moreno-Cruz 2019). The importation of weapons like guns, knives and swords improved the productivity of guards and was also correlated with the export of slaves (Whatley 2018).

Instrumental variable estimation addresses these concerns by identifying the effects of slave *demand* on the probability of slavery as an institution.[17] I use DAYS (days to the nearest trans-Atlantic or Indian Ocean slave port) to estimate the cost of transporting slaves to coastal slave ports. Variation in DAYS should correlate with variation in the intensity of demand for slaves. Column 7 of Table 4 presents evidence that DAYS satisfies the exclusion condition, in that it has no direct effect on the probability of observing the institution of slavery once exports are controlled for. As an excluded instrument, variations in DAYS should affect the probability of slavery only through its correlation with slave exports.

I use first-stage F-tests to assess the strength of the instrument. The preferred estimator is the maximum likelihood estimator, which estimates the parameters of the reduced form first-stage regressions jointly with the parameters of the probit equation. An alternative method uses Newey's (1987) two-step estimator, which generates first stage F-statistics. The reduced form equation for the endogenous explanatory variable is linear, so I also report the diagnostic first-stage F-statistics from the corresponding linear probability model (Cragg-Donald and Kleibergen-Paap F-statistic).

Table 5 reports results. DAYS performs well as an excluded instrument. The coefficient is large, negative and statistically significant at .01 percent. The coefficient on EXPORTS in the probit equation is .10 and also significant at .01 percent. F-statistics are all above 10. Figure 6 graphs

[17] See Amemiya (1978) and Newey (1987) for the estimation of simultaneous equation probit models.

the predicted impact of catchment on the probability that an African society adopts slavery. The graph is similar to the graph for the reduced-form probit with the exception of larger standard errors around the upper end of the distribution of exports. Table 6 reports results using Euclidean distance to the nearest slave port as the excluded instrument. The estimated impact is statistically insignificant from zero.

As a last step, the model is used to investigate the roles of political hierarchy and patrilineal descent. Each of these variables had a significant impact on the probability of being a slave society, but the variables could be endogenous to catchment. Fage suggests that the slave trade could have encouraged the spread of slavery through the spread of political centralization. Controlling for the final level of political centralization does not preclude this possibility. The same applies to patrilineal descent, if catchment discouraged patriliny.

Table 7 reports the results of running the catchment model on political hierarchy and patrilineal descent. The coefficients reveal no evidence that catchment encouraged the building of political hierarchy or influenced the probability of observing patrilineal descent. The pattern across hierarchies suggests that catchment may have *reduced* the probability of building political hierarchies beyond petty chiefdoms, but the last column shows that this was not the case. The estimated coefficient on political centralization is negative but statistically insignificant.

Figure 7 graphs the predicted effects of political hierarchy and patrilineal descent on the probability of observing slavery. Panel (a) graphs the predicted probabilities for the four levels of political hierarchy. Large chiefdoms and states were likely to be slave societies regardless of the numbers of inhabits exported. The major effect of catchment is on politically decentralized societies. Catchment made villages and petty chiefdoms look more like large chiefdoms and states. Panel (b) graphs the effects of decentralization on the probabilities of slavery and shows both the negative effects of decentralization and the convergence towards centralized societies.[18] Panel (c) shows the same pattern for patrilineal descent. The graphs show how political decentralization and patrilineal descent constrained the transition to slavery, as Miellassaux argues, but catchment incentivized societies to overcome those constraints.

5 The Transformations of African Slavery

The previous section showed how catchment incentivized societies to adopted slavery and overcome the constraints of political decentralization and patrilineal descent. In this section I go beyond catchment and investigate how the international slave trades transformed African societies more broadly. Meillassoux's historical-anthropological theory derives from the Western Sudan, where he is theorizing about how the growing trans-Saharan slave trade transformed kinship societies. Our finding that patrilineal descent was a constraint on the ability to transition to slavery is support for Meillassaux's theory and for a later time period. Lovejoy argues, from a large body of case studies, that the international slave trades transformed African slavery into a "slave mode of production," where slavery was transformed from a peripheral feature of society

[18] The larger standard errors at the higher levels of slave exports reflect the smaller number of observations and cells, and the smaller differences in probabilities across categories. Confidence intervals are tighter around the mean of -8.39.

into a fundamental right that ordered social reproduction. Lagerlof models how societies in an egalitarian state of land abundance with few incentives to enclose land, could evolve into a “state of despotism and slavery, with a political elite owning both people and land (p. 319).”

To investigate these broader transformations I go beyond a focus on catchment and use the travel time variables to estimate the effects of proximity to slave port regardless of the number of inhabitants exported. I estimate the effects of proximity on the probability of observing a set of institutions that one could call aristocratic slavery in the African context. These are slavery as a property right over people, polygyny as a property right over women as wives, inheritance rules that favor the retention of wealth within the nuclear family, and hereditary succession in local politics.

Table 8 reports results. The first panel reports results for catchment. The second panel reports results for proximity to ports. Column (1) reports the coefficient on the joint spread of slavery and polygyny, and shows that the international slave trades spread the institution of slavery joint with the institution of polygyny.[19] The very first sentence of *Women and Slavery in Africa* edited by Robertson and Klein (1983) explains why. It reads: “Most slaves in sub-Saharan Africa were women (page 3).”

The spread of slavery also spread slave wealth. Columns (2) and (3) of Table 8 report slave trade effects on the joint spread of slavery and inheritance rules that favor the retention of wealth within the nuclear family.[20] Patrilineal descent controls for the fact that patrilineal societies are more-likely to allow own-children to inherit property. The estimated coefficients are large and statistically significant. To the author’s knowledge, this is the first empirical evidence of the international slave trades altering patterns of intergenerational wealth accumulation in Africa.[21]

Column (4) shows that hereditary succession in local politics was not closely correlated with slavery alone. Column (5) reports results for observing all five institutions together. The coefficient is large and statistically significant at .05. Figure 8 graphs the predicted probabilities of observing aristocratic slavery by proximity to slave ports. Proximity to an international slave port had large and positive effects on the probability of observing aristocratic slavery, and the magnitude of the effect declines as one moves away from international slave ports.

6 Concluding Remarks: In the Shadow of Slavery

This study has used new estimates of travel times to investigate the effects of the international slave trades on the transformation of slavery in precolonial Africa. I find that the international slave trades incentivized decentralized societies in catchment zones to adopt slavery as a defense against further enslavement. I also find that the international slave trades encouraged the spread

[19] Dalton and Cheuk (2014) find this result for polygyny alone.

[20] According to Murdock (1949) “…the nuclear family consists typically of a married man and woman with their offspring (p. 1).” This includes both polygamous families of one man and several wives, and extended families incorporating the families of married children (pp. 1-42).

[21] Land in precolonial Africa is often thought to be communally owned, but this was not always the case for all land rights. In Asante law, for example, “the land belongs to the chief, but the farm is mine.” Improvements made to the land, including trees, belonged to the cultivator so long as the land was producing or in rotation (Rattray, 1969, pp. 213-241). The cultivator could bequeath these usufruct rights to others.

of a set of institutions that looks like aristocratic slavery in the African context. As a result, slavery was almost universal in Africa by the end of the 19th century, with much of it caused by pressures from the international slave trades.

Over the long-term, the locations of these precolonial societies become sub-national regions of European colonies and post-colonial nation-states. As mentioned at the outset, the results of this study help historically decompress two findings in the development literature on long term legacies in African development. One is a positive long term effect of precolonial political centralization (Gennaioli and Rainer, 2007; Michalopoulos and Papaioannou, 2013, 2015 and 2018). The other is a negative long-term effect of the slave trades (Nunn, 2008; Bezemer, Bolt and Lensink, 2014; Bottero and Wallace, 2013). Documenting the transformations of slavery in precolonial Africa integrates the history of African slavery into both of these trajectories.

First, African slavery was a key institutional feature of precolonial *and* colonial Africa. While the abolition of slavery was a stated justification for European colonization in the late 19th century, colonial authorities quickly realized that precolonial traditions of authority were required for political stability, infrastructure development and revenue enhancement (Phillips 1989; Getz 2004; Miers and Klein 1999; van Waijenburg 2018; Austin 2004; Lovejoy and Falola 2003; Crowder, 1978; Bolt and Gardner, 2015). Phillips (1989) carefully analyzes the internal documents of the British Colonial Office and shows that prior to World War I the British were committed to establishing free land and free labor in the colonies, but the strategy destabilized the situation to the point where authorities feared they would lose control. Chiefs were selling land to anyone who would buy it; land speculation was widespread; peasants and slaves were becoming landless laborers concentrating in cities and mining towns; and labor effort under free labor contracts was not proving profitable. Following World War I, British authorities changed strategies and moved towards a more-indirect form of colonial rule. Rather than encourage competitive markets in labor and land, colonial authorities strengthened indigenous chiefly authority over "customary" laws and lands, and enlisted allied chiefs in the collection of taxes and the recruitment of labor for the colonial effort.[22]

In addition, the colonial-era efforts to abolish African slavery intensified gender-based exploitation by making the pawning of wives the more acceptable form of property rights in people. Lovejoy and Falola (2003) document that most pawns in the colonial era were women and that pawning rose substantially in the colonial era, although they caution that this might be a reflection of better recordkeeping in the colonial era (pp. 1-26). The anthropologist Mary Douglas (1964) describes how the pawning of wives in Central Africa converted matrilineal rights in land into inheritable patrilineal rights in the pawned wife and her children. Vansina (2010) describes a similar dynamic among the matrilineal Kuba in colonial Congo.[23]

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[22] Bolt and Gardner (2015) present evidence that precolonial political centralization increased the taxing capacity of local native authorities. van Waijenburg (2018) concludes that "…especially in the early colonial period, the invisible value of unpaid labor obligations often may have well exceeded the total size of French African budgets (p. 74)".

[23] "Women pawns fetch almost ten times the amount given as ordinary bridewealth, both because the marriages could not be dissolved and because a specified number of their children would belong to the husband's lineage rather than to their own (p. 241)."

The implications of the present study are straightforward: the international slave trades spread slavery in Africa, a legacy of which was the move towards indirect colonial rule and the colonial sanctioning of indigenous precolonial authority structures.[24] Any long-term legacies traced using precolonial ethnicity-level data are, by construction, long term legacies that evolved under the kinds of customary authority documented in this study.[25] The negative effect of the slave trades on state-level incomes was delayed until after colonialism partly because slavery was beneficial to the colonial effort.[26] Economic development in politically centralized regions outpaced development in politically decentralized regions partly because centralized regions were typically aristocratic slave regimes while catchment effects were concentrated among the politically decentralized.[27]

Today, slavery in Africa is officially dead,[28] but customary authority lives on. The 2008 AfroBarometer survey asks several questions about customary authority as distinct from formal state authority. In Ghana (2009), 68 percent of the respondents said traditional leaders had "primary responsibility for allocating land." 59 percent said they had primary responsibility for "solving local disputes." 60 percent said they should remain non-partisan, independent of government and without government salary. 65 percent said their power should be increased, and 42 percent said "by a lot!" For the 19 countries in the survey, on a scale of 1-5, the average influence of traditional leaders was 3.30 and respondents wanted them to have 3.8 (Logan, 2011). Legal scholars debate the future of customary authority in a modern democracy, but there is no debating the fact that customary authority is currently a mechanism for discriminating against migrants (aliens) and women, and their rights to own and inherit property (Fenrick, Galizzi and Higgins, 2011; Sheleff, 1999; Bowman and Kuenyehia, 2003; Burrill et. al., 2010; Catherine Coquery-Vidrovitch, 1997).

[24] Whatley (2014) presents data showing a simple correlation at the state level between precolonial slave exports and the percentage of colonial court cases adjudicated in native courts.

[25] The colonial sanctioning of a "customary" authority must have changed the local distribution of rights, otherwise the new colonial policy would not have stabilized the situation. Either labor gained incentives to stay on the land (or protections from displacement) or landlords gained powers to control labor mobility. In Domar's (1970) conception the outcome depends on the prevailing strength of the aristocracy. Strong aristocracies tend to oppress serfs and slaves, while weaker ones tend to incentivize tenants and peasants.

[26] Bezemer, Bolt and Lensink (2014) reports OLS results showing negative effects of slave exports on state-level GDP per capita from 1990 to 2008, but not before (1950-1980). Bottero and Wallace (2013) finds a negative effect on income per capital after 1970, but not before.

[27] According to the Ethnographic Atlas, the only region of centralized states without slavery was the Zulu/Sotho/Ndebele/Swazi region in southeast Africa.

[28] A lesson from the Americas is that the political economy of abolition also has long-term effects. In Africa, abolition occurred hundreds, if not thousands of times, in as many places and ways, over many decades and under increasing international pressure. See the articles in Miers and Roberts (1988). This heterogeneity has yet to be explored.

7 Tables and Figures

Table 1.

Estimates of Hours to Walk a Kilometer, by 28 FAO Land Cover Classifications

FAO Land Cover Class	Reclassification	Hours per km	
		No load	With load
Closed evergreen low land forest	Jungle	0.880	1.06
Degraded evergreen low land forest	Jungle	0.880	1.06
Sub montane forest (900 to 1500 m)	forest	0.417	0.500
Montane forest (greater than 1500 m)	forest	0.417	0.500
Swamp forest	Water	0.216	0.216
Mangrove	Water	0.216	0.216
Mosaic forest/cropland	Mosaic forest	0.368	0.442
Mosaic forest/savanna	Mosaic forest	0.368	0.442
Close deciduous forest	forest	0.417	0.500
Deciduous woodland	forest	0.417	0.500
Deciduous shrubland with sparse trees	field	0.329	0.395
Open deciduous shrubland	field	0.329	0.395
Closed grassland	field	0.329	0.395
Open grassland with sparse shrubs	field	0.329	0.395
Open grassland	field	0.329	0.395
Sparse grassland	field	0.329	0.395
Swamp bushland and grassland	water	0.216	0.216
Cropland (greater than 50%)	field	0.329	0.395
Cropland with open the woody vegetation	field	0.329	0.395
Irrigated cropland's	field	0.329	0.395
Tree crops	field	0.329	0.395
Sandy desert with dunes	desert	0.255	0.306
Stony desert	desert	0.255	0.306
Bare rock	desert	0.255	0.306
Salt hard pans	desert	0.255	0.306
Water bodies	water	0.216	0.216
Cities	Field	0.329	0.395

Source: Estimates of hours per kilometer comes from Wilks (1975, pp. 1-31), Constance (2009), Smith (1970, p. 523), and Stanley (1891, p. 98). Headload factors are based on a formula found in Pandolf, Givoni and Goldman (1977). See the Appendix for a complete discussion.

Table 2. Means and Frequencies, circa 1900

	N	Mean	Std. Dev.	Min	Max
a. Slave Exports					
Slave Exports per sq. km.	817	0.55	3.38	0	43.73
ln (Slave Exports per sq. km.)	817	-8.39	4.57	-11.51	3.78
b. Institutions (Categorical Variables)					
Slavery	392	0.85	0.36	0	1
Political Centralization	439	0.34	0.48	0	1
Patrilineal Descent	441	0.70	0.46	0	1
Polygyny	434	0.80	0.40	0	1
Children Inherit Capital	345	0.60	0.49	0	1
Children Inherit Land	342	0.57	0.50	0	1
Hereditary Local Headship	320	0.50	.50	0	1
c. Control Variables					
Travel time to nearest Atlantic or Indian Ocean slave port (days)	819	25.30	19.38	0.31	85.12
Travel time to nearest trans-Saharan or Red Sea slave port (days)	819	32.93	23.51	1.11	122.94
Euclidean Distance to nearest Atlantic or Indian Ocean slave port	843	980748	773807	15193	3599533
Euclidean Distance to nearest trans-Saharan or Red Sea slave port	843	1394790	1070383	22805	5142754
Agricultural Suitability Index	421	0.53	0.20	0.00	0.91
TseTse Fly Suitability Index	421	0.06	0.95	-3.12	1.50
North Region	441	0.06	0.23	0.00	1.00
South Region	441	0.07	0.26	0.00	1.00
East Region	441	0.28	0.45	0.00	1.00
West Region	441	0.31	0.46	0.00	1.00
Central Region	441	0.28	0.45	0.00	1.00
Date of Observation	440	1917.8	21.27	1830	1960
d. Political Hierarchy and Slavery	**N**	**%**	**% Slave**		
No levels (village = 1)	113	24.74	76.0		
One level (eg. Petty Chiefdoms = 2)	175	39.86	83.0		
Two levels (eg. Larger Chiefdoms = 3)	102	23.23	92.0		
Three levels (eg., States = 4)	45	10.25	90.7		
Four levels (eg., large States = 5)	4	0.01	100.0		
Totals	439	100			

Notes: Slave exports come from Nunn and Wantchenkon (2011). Institution categorical variables come from Murdock's Ethnographic Atlas: Slavery (V70); Polygyny (V9); Political Hierarchies (V33); Patrilineal Descent (V43); Children Inherit (V74, V76) and Hereditary Local Headship (V72). Tsetse Fly Suitability comes from Alsan (2015). Region Indicators and Agricultural Suitability Index come from Michalopoulos and Papailoannou (2013). Date of observation comes from Murdock's Ethnographic Atlas (V102). Data on Ethno-Linguistic Affiliation is taken from Alsan (2015). Euclidean distance is calculated using the Distance Tool in ArcGIS. See the Appendix for construction of the Travel Time variables.

Table 3.

Linear Estimates of Effects of Slave Exports on African Slavery

VARIABLES	(1)	(2)	(3)	(4)	(5)
ln (Slave Exports per km)	0.011***	0.011**	0.012**	0.008**	0.006*
	(0.003)	(0.005)	(0.005)	(0.003)	(0.004)
Days to Trans-Saharan or Red Sea Port			-0.005***	-0.003	-0.005***
			(0.001)	(0.002)	(0.001)
Patrilineal Descent					-0.159***
					(0.044)
Petty Chiefdoms					0.129***
					(0.041)
Large Chiefdoms					0.271***
					(0.052)
States					0.265***
					(0.072)
Large States					0.477***
					(0.101)
Agricultural Suitability Index				-0.083	-0.028
				(0.092)	(0.079)
TseTse Suitability Index				0.081***	0.098***
				(0.027)	(0.026)
North				0.138	0.146
				(0.106)	(0.089)
South				-0.110	-0.101*
				(0.064)	(0.056)
East				-0.083	-0.066
				(0.134)	(0.135)
West				0.036	0.009
				(0.050)	(0.051)
Date of Observation				-0.001	-0.001
				(0.001)	(0.001)
Constant	0.923***	0.923***	1.104***	3.607	2.735*
	(0.025)	(0.035)	(0.053)	(2.096)	(1.511)
R-squared	0.022	0.022	0.119	0.173	0.295
Observations	384	384	384	337	337
R-squared	0.022	0.022	0.119	0.172	0.295

Notes: Robust standard errors in parentheses, columns (3)-(5) clustered by ethno-linguistic affiliation. *** p<0.01, ** p<0.05, * p<0.1. Slave exports come from Nunn and Wantchenkon (2011). Institution categorical variables come from Murdock's Ethnographic Atlas: Slavery (V70); Political Hierarchies (V33); Patrilineal Descent (V43); Tsetse Fly Suitability comes from Alsan (2015). Region Indicators and Agricultural Suitability Index come from Michalopoulos and Papailoannou (2013). Date of observation comes from Murdock's Ethnographic Atlas (V102). Data on Ethno-Linguistic Affiliation taken from Alsan (2015). See the Appendix for construction of the Travel Time variables.

Table 4.
Probit Estimates of Effects of Slave Exports on African Slavery

	(1)	(2)	(3)	(4)	(5)	(6)
ln (Slave Exports per km)	0.050**	0.054**	0.046**	0.065***	0.055**	0.057***
	(0.020)	(0.022)	(0.020)	(0.021)	(0.025)	(0.020)
Days to Trans-Saharan or Red Sea Port		-0.020***	-0.012	-0.027***	-0.029***	-0.031***
		(0.004)	(0.009)	(0.009)	(0.008)	(0.009)
Patrilineal Descent				-1.849***	-1.850***	-1.864***
				(0.573)	(0.644)	(0.605)
Petty Chiefdoms				0.660***		0.642***
				(0.210)		(0.215)
Large Chiefdoms				2.209***		2.193***
				(0.264)		(0.249)
States				2.429***		2.465***
				(0.384)		(0.394)
Large States				-		-
Decentralized					-1.868***	
					(0.234)	
Days to trans-Atlantic/Indian Ocean Port						-0.008
						(0.011)
Environmental Controls	No	No	Yes	Yes	Yes	yes
Regional Controls	No	No	Yes	Yes	Yes	yes
Pseudo R-squared	0.027	0.12	0.196	0.428	0.403	0.429
Observations	384	384	337	335	337	335

Notes: Robust standard errors in parentheses clustered by ethno-linguistic affiliation. *** p<0.01, ** p<0.05, * p<0.1. Slave exports come from Nunn and Wantchenkon (2011). Institution categorical variables come from Murdock's Ethnographic Atlas: Slavery (V70); Political Hierarchies (V33); Patrilineal Descent (V43). The Decentralized category includes Villages and Petty Chiefdoms. Environmental controls include Tsetse Fly Suitability from Alsan (2015) and Agricultural Suitability Index come from Michalopoulos and Papailoannou (2013). Region controls included North South East, West and Central from Michalopoulos and Papailoannou (2013). Date of observation comes from Murdock's Ethnographic Atlas (V102). Data on Ethno-Linguistic Affiliation taken from Alsan (2015). Euclidean distance is calculated using the Distance Tool in ArcGIS. See the Appendix for construction of the Travel Time variables.

Table 5
Instrument Variable Probit Estimates of Effects of Catchment on Slavery
(excluded instrument is average weighted travel days to port)

	Maximum Likelihood Estimates				Two-Step Estimates			
	(1)		(2)		(3)		(4)	
VARIABLES	Slavery	Exports	Slavery	Exports	Slavery	Exports	Slavery	Exports
ln (Slaves Exports per km)	0.103**		0.105**		0.105*		0.108*	
	(0.051)		(0.052)		(0.064)		(0.061)	
Days to Trans-Saharan or Red Sea Port	-0.029***		-0.031***		-0.030***		-0.032***	
	(0.009)		(0.008)		(0.010)		(0.010)	
Days to Trans-Atlantic or Indian Ocean Port		-0.177***		-0.176***		-0.177***		-0.176***
		(0.033)		(0.034)		(0.022)		(0.022)
Patrilineal Descent	-1.795***		-1.772***		-1.830***		-1.833***	
	(0.513)		(0.556)		(0.490)		(0.478)	
Petty Chiefdoms	0.629***				0.642**			
	(0.205)				(0.259)			
Large Chiefdoms	2.128***				2.169***			
	(0.211)				(0.454)			
States	2.386***				2.432***			
	(0.423)				(0.675)			
Decentralized			-1.787***				-1.848***	
			(0.193)				(0.392)	
Institutional Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Environmental Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Regional Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First Stage F Statistic						10.27		12.45
Cragg-Donald F Statistic		65.5		65.9				
Kleibergen-Paap Wald F Statistic		26.3		26.7				
Observations	335	335	337	337	335	335	337	337

Notes: Robust standard errors in parentheses clustered by ethno-linguistic affiliation. *** p<0.01, ** p<0.05, * p<0.1. Coefficient estimates obtained from instrumental variable probit using the Maximum Likelihood Method. First-stage F statistics come from the instrumental variable probit using the Newey Two-Step Method. Cragg-Donald and Kleibergen-Paap Wald F-statistics obtained from linear instrumental variable estimation. Slave exports come from Nunn and Wantchenkon (2011). Institution categorical variables come from Murdock's Ethnographic Atlas: Slavery (V70); Institutional controls include Political Hierarchies (V33) and Patrilineal Descent (V43). The Decentralized category includes Villages and Petty Chiefdoms. Environmental controls include Tsetse Fly Suitability from Alsan (2015) and Agricultural Suitability Index from Michalopoulos and Papailoannou (2013). Region controls of North, South, East, West and Central come from Michalopoulos and Papailoannou (2013). Date of observation comes from Murdock's Ethnographic Atlas (V102). Data on Ethno-Linguistic Affiliation taken from Alsan (2015). See the Appendix for construction of the Travel Time variables.

Table 6.
Instrument Variable Probit Estimates of Effects of Catchment on Slavery
(excluded instrument is Euclidean distance from centroid to port)

	Maximum Likelihood Method				Two-Step Method			
	(1)		(2)		(3)		(4)	
VARIABLES	Slavery	Exports	Slavery	Exports	Slavery	Exports	Slavery	Exports
ln (Slave Exports per km)	0.045		0.042		0.045		0.042	
	(0.062)		(0.062)		(0.064)		(0.062)	
Distance to Trans-Sahran or Red Sea Port (000th)	-0..065***		-0.067***		-0.065***		-0.065***	
	(0.021)		(0.019)		(0.023)		(0.027)	
Distance to Trans-Atlantic or Indian Ocean Port (000th)		-0.411***		-0.410***		-0.411***		-.411***
		(0.084)		(0.084)		(0.052)		(0.052)
Patrilineal Descent	-1.928***		-1.947***		-1.938***		-1.951***	
	(0.569)		(0.632)		(0.491)		(0.476)	
Petty Chiefdoms	0.698***				0.702***			
	(0.223)				(0.257)			
Large Chiefdoms	2.286***				2.297***			
	(0.248)				(0.465)			
States	2.519***				2.532***			
	(0.375)				(0.686)			
Decentralized			-1.913***				-1.917***	
			(0.234)				(0.398)	
Institutional Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Environmental Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Regional Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First Stage F Statistic						9.93		12.02
Cragg-Donald F Statistic	61.98		62.18					
Kleibergen-Paap Wald F Statistic	22.92		23.2					
Observations	335	335	337	337	335	335	337	337

Notes: Robust standard errors in parentheses clustered by ethno-linguistic affiliation. *** p<0.01, ** p<0.05, * p<0.1. Coefficient estimates obtained from instrumental variable probit using the Maximum Likelihood Method. First-stage F statistics come from the instrumental variable probit using the Newey Two-Step Method. Cragg-Donald and Kleibergen-Paap Wald F-statistics obtained from linear instrumental variable estimation. Slave exports come from Nunn and Wantchenkon (2011). Institution categorical variables come from Murdock's Ethnographic Atlas: Slavery (V70); Institutional controls include Political Hierarchies (V33) and Patrilineal Descent (V43). The Decentralized category includes Villages and Petty Chiefdoms. Environmental controls include Tsetse Fly Suitability from Alsan (2015) and Agricultural Suitability Index from Michalopoulos and Papailoannou (2013). Region controls of North, South, East, West and Central come from Michalopoulos and Papailoannou (2013). Date of observation comes from Murdock's Ethnographic Atlas (V102). Data on Ethno-Linguistic Affiliation taken from Alsan (2015). Euclidean distance is the distance from the centroid to the nearest international slave port.

Table 7.

Instrument Variable Probit Estimates of Effects of Catchment on Political Hierarchy and Patrilineal Descent

VARIABLES	Villages	Petty Chiefdoms	Large Chiefdoms	States	Politically Centralized	Patrilineal Descent
	(1)	(2)	(3)	(4)	(5)	(6)
ln (Slave Exports per km)	0.012	0.043	-0.035	-0.031	-0.056	-0.018
	(0.046)	(0.031)	(0.026)	(0.047)	(0.036)	(0.030)
Institutional Controls	Yes	Yes	Yes	Yes	Yes	Yes
Environmental Controls	Yes	Yes	Yes	Yes	Yes	Yes
Regional Controls	Yes	Yes	Yes	Yes	Yes	Yes
First Stage F Statistic	15.86	15.86	15.86	15.86	15.86	13.01
Cragg-Donald F Statistic	69.57	69.57	69.57	69.57	69.57	70.94
Kleibergen-Paap Wald F Statistic	20.25	20.25	20.25	20.25	20.25	20.9
Observations	379	379	379	379	379	376

Notes: Robust standard errors in parentheses clustered by ethno-linguistic affiliation. *** p<0.01, ** p<0.05, * p<0.1. Coefficient estimates obtained from instrumental variable probit using the Maximum Likelihood Method. First-stage F statistics come from the instrumental variable probit using the Newey Two-Step Method. Cragg-Donald and Kleibergen-Paap Wald F-statistics obtained from linear instrumental variable estimation. Slave exports come from Nunn and Wantchenkon (2011). Institution categorical variables come from Murdock's Ethnographic Atlas: Institutional controls include Political Hierarchies (V33) or Patrilineal Descent (V43). The Centralized category includes Large Chiefdoms and States. Environmental controls include Tsetse Fly Suitability from Alsan (2015) and Agricultural Suitability Index from Michalopoulos and Papailoannou (2013). Region controls of North, South, East, West and Central come from Michalopoulos and Papailoannou (2013). Date of observation comes from Murdock's Ethnographic Atlas (V102). Data on Ethno-Linguistic Affiliation taken from Alsan (2015). See the Appendix for construction of the Travel Time variables.

Table 8.
Estimates of the Effects of Slave Trades on Aristocratic Slavery

VARIABLES	Slavery Joint with Polygyny	Slavery Joint with Own Children Inherit Capital	Slavery Joint with Own Children Inherit Land	Slavery Joint with Hereditary Political Succession	All 5 Institutions Cols. (1)-(4)
	(1)	(2)	(3)	(4)	(5)
Due to Catchment					
ln (Slave Exports per km)	0.137***	0.085***	0.077***	0.003	0.098**
	(0.024)	(0.030)	(0.027)	(0.029)	(0.038)
Proximity to Trans-Saharan or Red Sea Port	0.012**	0.034***	0.036***	0.006	0.020***
	(0.005)	(0.005)	(0.006)	(0.006)	(0.004)
Patrilineal Descent	0.273*	0.661***	0.635***	0.973***	1.121***
	(0.165)	(0.104)	(0.184)	(0.239)	(0.225)
Political Centralization	0.646***	0.785***	0.666***	0.532***	0.731***
	(0.160)	(0.236)	(0.201)	(0.195)	(0.172)
Institutional Controls	Yes	Yes	Yes	Yes	Yes
Environmental Controls	Yes	Yes	Yes	Yes	Yes
Regional Controls	Yes	Yes	Yes	Yes	Yes
First Stage F Statistic	12.25	8.82	9.26	9.39	6.13
Cragg-Donald F Statistic	60.3	49.92	49.89	51.68	28.85
Kleibergen-Paap Wald F Statistic	26.99	21.55	22.25	20.78	14.89
Observations	333	275	273	261	181
Due to Proximity to Slave Ports					
Proximity to Trans-Atlantic or Indian Ocean Port	0.029***	0.017**	0.015**	0.000	0.024**
	(0.005)	(0.008)	(0.006)	(0.005)	(0.011)
Proximity to Trans-Saharan or Red Sea Port	0.017***	0.040***	0.041***	0.006	0.028***
	(0.005)	(0.007)	(0.008)	(0.006)	(0.007)
Patrilineal Descent	0.204	0.621***	0.594***	0.970***	1.181***
	(0.201)	(0.119)	(0.169)	(0.232)	(0.263)
Political Centralization	0.865***	0.876***	0.745***	0.533***	0.873***
	(0.135)	(0.254)	(0.192)	(0.202)	(0.149)
Institutional Controls	Yes	Yes	Yes	Yes	Yes
Environmental Controls	Yes	Yes	Yes	Yes	Yes
Regional Controls	Yes	Yes	Yes	Yes	Yes
McFadden Psuedo R-squared	0.281	0.214	0.187	0.137	0.236
Observations	333	275	273	261	181

Notes: Robust standard errors in parentheses clustered by ethno-linguistic affiliation. *** p<0.01, ** p<0.05, * p<0.1. Coefficient estimates obtained from instrumental variable probit using the Maximum Likelihood Method. First-stage F statistics come from the instrumental variable probit using the Newey Two-Step Method. Cragg-Donald and Kleibergen-Paap Wald F-statistics obtained from linear instrumental variable estimations. Slave exports come from Nunn and Wantchenkon (2011). Institution categorical variables come from Murdock's Ethnographic Atlas: Slavery (V70); Polygyny (V9); Political Hierarchies (V33); Patrilineal Descent (V43); Children Inherit (V74, V76) and Hereditary Local Headship (V72). The Political Centralization category includes Large Chiefdoms and States. Environmental controls include Tsetse Fly Suitability from Alsan (2015) and Agricultural Suitability Index from Michalopoulos and Papailoannou (2013). Region controls of North, South, East, West and Central come from Michalopoulos and Papailoannou (2013). Date of observation comes from Murdock's Ethnographic Atlas (V102). Data on Ethno-Linguistic Affiliation taken from Alsan (2015). See the Appendix for construction of the Travel Time variables.

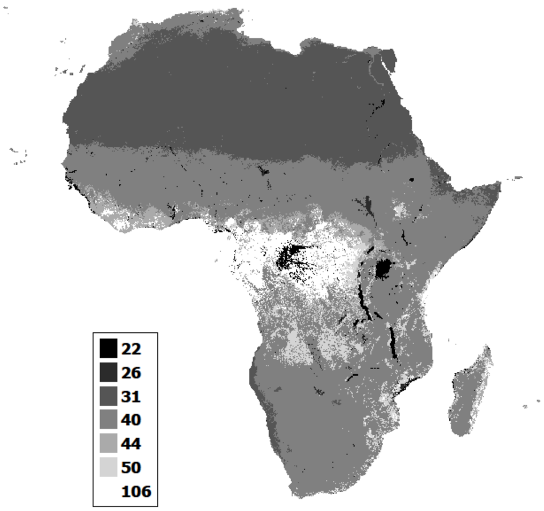


Figure 1. Hours to walk 100 km

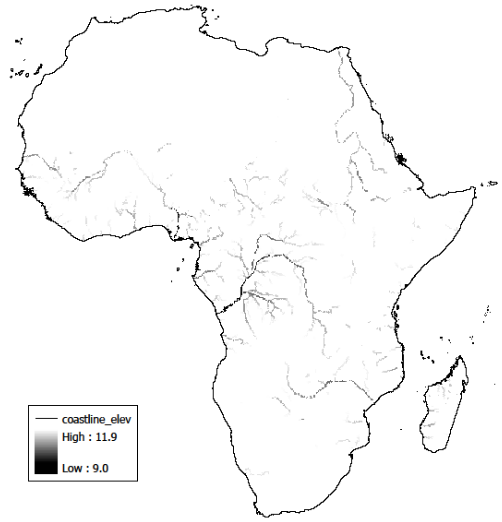


Figure 2. Hours to row 100km

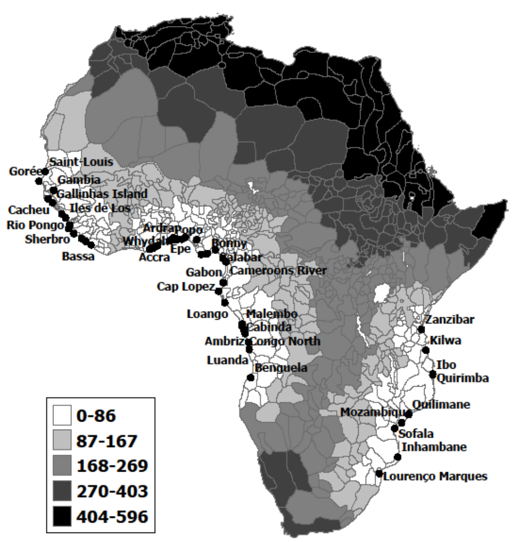


Figure 3. Hours to nearest port

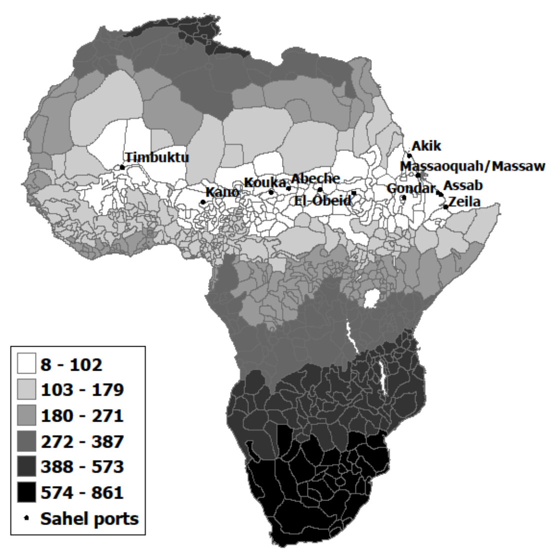


Figure 4. Hours to nearest port

Figure 5. Predicted Probabilities of Slavery by Exports

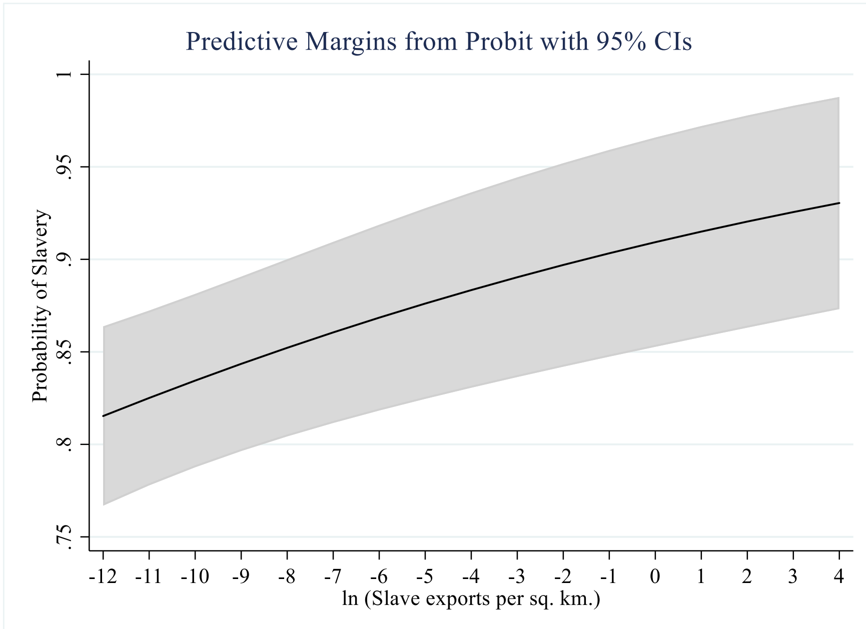


Figure 6. Predicted Probabilities of Slavery by Catchment

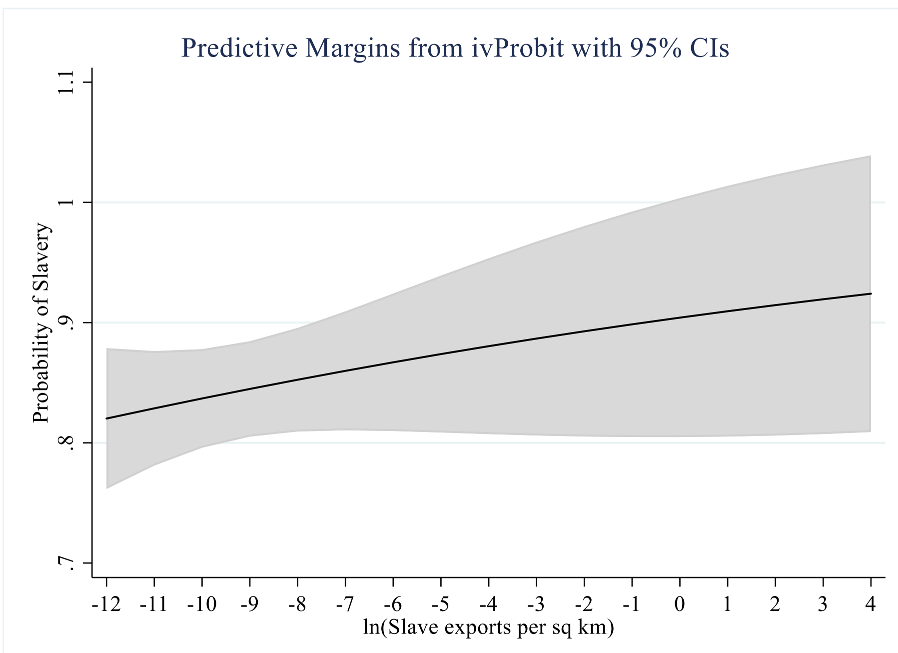


Figure 7. The Constraints of Political Decentralization and Patrilineal Descent

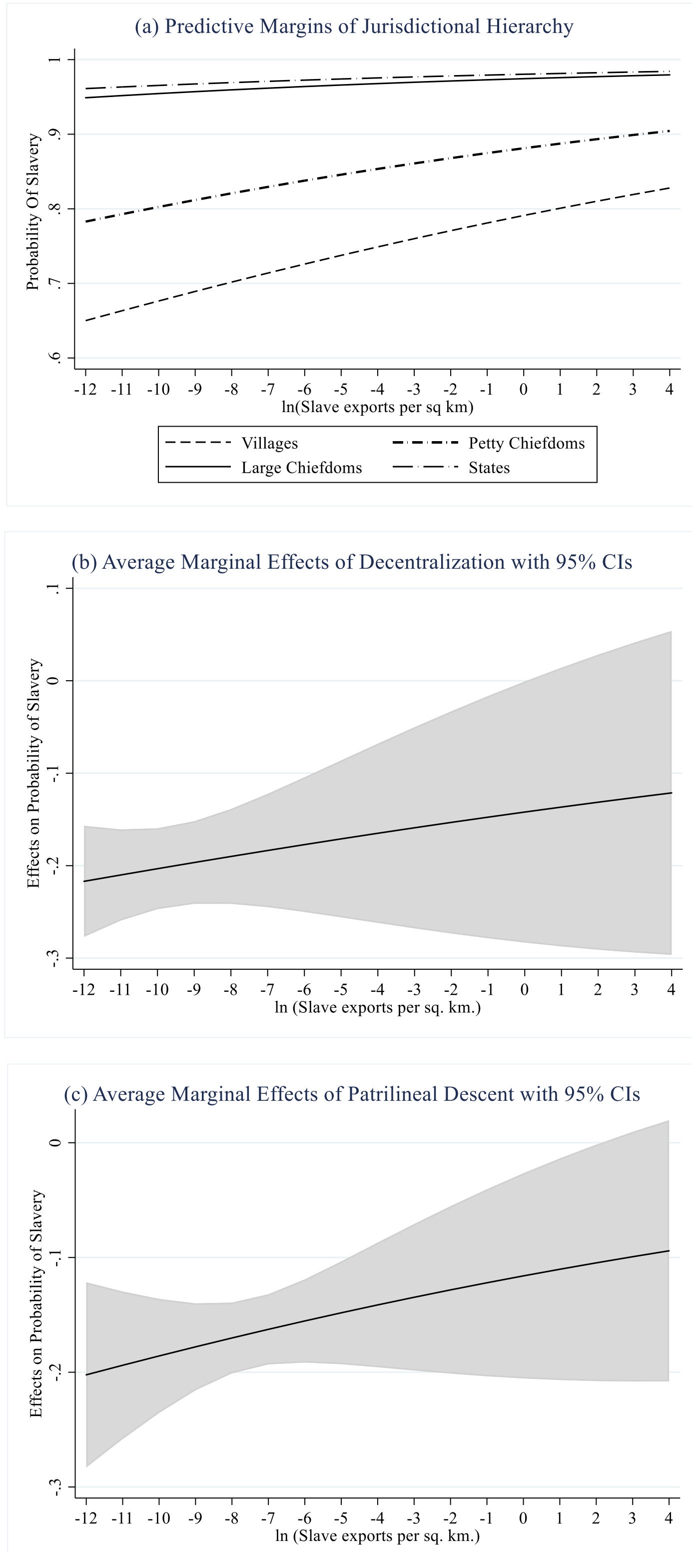
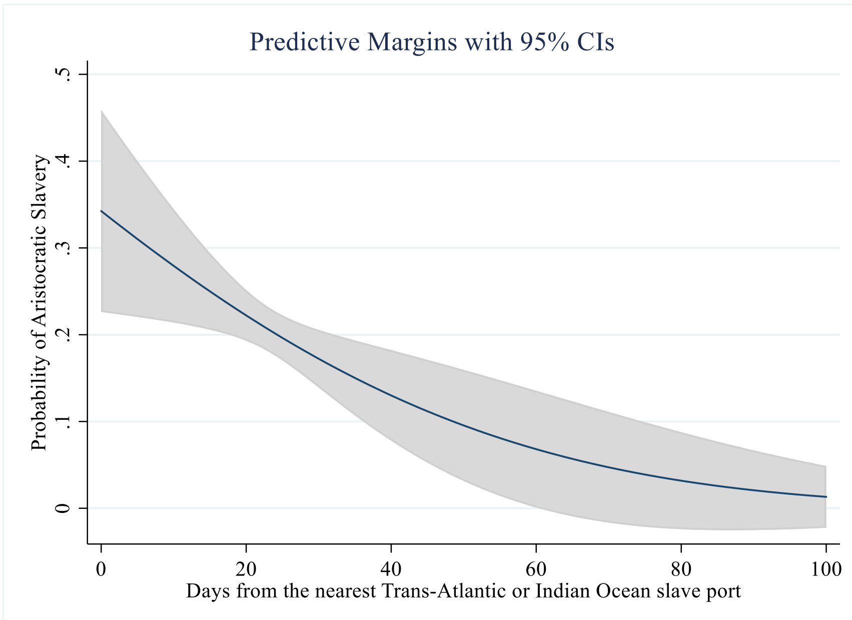
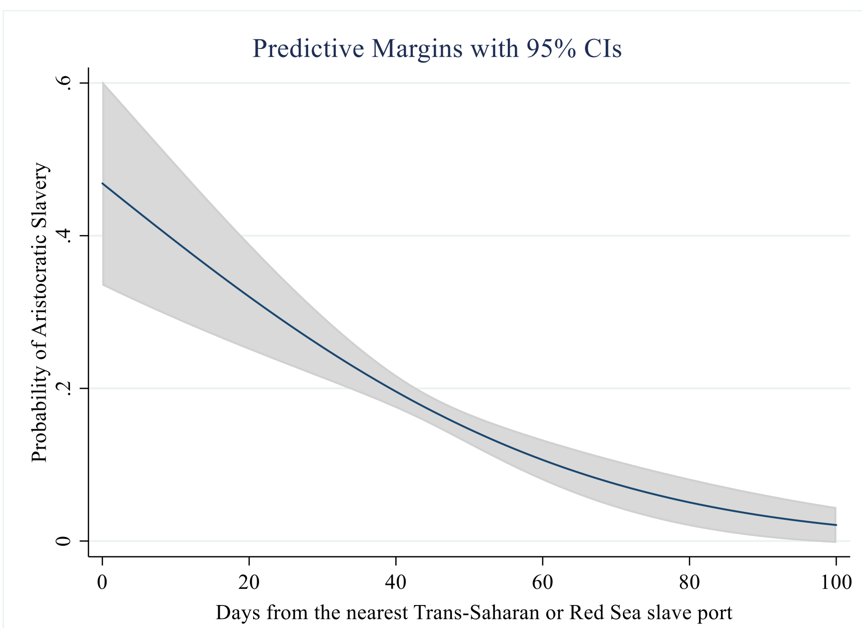


Figure 8. Predicted Probabilities of Aristocratic Slavery

(a) By Proximity to Trans-Atlantic or Indian Ocean Slave Port



(b) By Proximity to Trans-Saharan or Red Sea Slave Port



8 Appendix: Estimating Travel Times

I estimate the time to travel from point A to point B. I control for the effects of time-cost components like the ruggedness of terrain, obstacles to straight-line travel and the possibility of travelling by canoe. The goal is to account for broad variations of transport cost across the continent.

Let H = the number of hours to travel through a square kilometer. The calculation uses the following framework:

$$H = F*SD*VF.$$

F = the "friction" of traveling through a square surface kilometer, measured in number of hours to travel a Euclidian distance of 1 kilometer. SD = adjustment for the actual distance traveled per Euclidian kilometer, taking into account the impact of the earths slope on the actual distance covered. VF = the average vertical factor, or the average impact of slope on hours of travel**.** The steeper the slope the longer it takes to travel a surface kilometer. Each square kilometer of the continent is assigned an average value of F, SD and VF.

8.1 Walking speed (Fi).

Table 1 reclassifies the 27 FAO cover types and reports the associated estimates of walking speeds, measured in hours per kilometer. Column (1) lists the 27 FAO classifications. Column (2) lists six re-classifications, aggregated by walking friction. (1) Jungle is evergreen forest of thick canopy with vines and tangles. (2) Forest areas are woods of varying degrees of thickness, with spacing between trees for walking. (3) Mosaic forest is a patchwork of woody forest and clearings of either savanna or cropland. (4) Fields are open areas of grassland, shrub land or cropland with few trees. (5) Desert is barren land of dunes or rock. (6) Swamp/Mangrove is not walkable and requires a canoe.

The best available data on precolonial walking speeds is Ivor Wilks (1975, pages 1-31). Wilks estimates the time to walk the Great Roads of Asante in the early 19th century. The Great Roads were public roads that radiated out from the capitol city of Kumasi. The eight Great Roads were maintained by the central government to extend the broadcast of its political power, to administer the affairs of state and to facilitate commerce. It is likely that these were among the best roads in precolonial sub-Saharan Africa. They traversed three of the five land cover classes for which we need data (forest, savanna and mosaic). In addition, the terrain in this region is relatively flat, minimizing contamination by variations in elevations, which will be added later.

I set travel time per day at 7 hours. According to Wilks, each of the Great Roads had a series of appointed "halting places." Each halting place was a seat of authority where banditry could be reported, lodging could be secured and provisions replenished. Wilks describes the travel time between each halting places as "equidistant," in the sense that they were separated by a conventional measure of a journey (in Twi language a "Kwansi," literally "part of the road"). Each journey (interpreted as a day's journey) was further divided into "watches" or "hours" or kwansimma (or little kwansin). A kwansin apparently consisted of seven kwansimma or seven travel hours. Two detailed travel itineraries from the early 1840s record the actual number of hours spent by travelers as they moved between halting places (Wilks 1975, page 9). One itinerary records an average travel time of 6.78 hours per day, the other an average travel time of 7.5 hours per day. Morton Stanley, during his trek across Africa in the late 1870s estimates 6-7 hours as a standard day's travel time (see below).

Many of the halting places along the Great Roads survive today as towns or villages. Wilks uses Ghana Ordnance Survey Maps to compute the approximate straight-line distances between halting places. These are straight-line distances, not the actual travel distances that account for road curvatures. Wilks reports separate frequency distributions for forest and savanna country:

> "The tendency to constancy in the length of a journey, shown in both forest and savanna regions, reflects the attempt of those concerned with the development of the great roads to evenly distribute the halting places along the route in so far as the nature of the terrain, and similar environmental factors, permitted (p. 30)."

Wilks is essentially arguing that the distances between halting places mark a standard expected travel day in forested and savanna regions. By this method Wilks estimates an average day's journey to be 10 ½ miles per 7-hour day in the forest and 13.3 miles per 7-hour day in the savanna (p. 31). As a check, Wilks reports estimates recorded in the journals of Bowdich (1819) and Dupuis (1824), two British ambassadors resident in Asante in the early 19th century. Bowdich estimates an average linear distance of 10 miles per day in forest and 13.3 in savanna, almost exactly what Wilks estimates. Dupuis estimates a slightly higher average -- 12 miles per day in forest zones and 16 miles per day in savanna. I apply Wilks estimates. Table 1 reports the estimates in kilometers, converted at a rate of 1.6 kilometers per mile.

Mosaic land cover is a combination of forest and savanna or forest and cropland. It is an important land cover type in much of sub-Saharan Africa because over much of the continent the historic expansion of agriculture required the conversion of forest and jungle into arable land. For mosaic regions I take the mean of savanna and forest. This equals 11.9 miles per day.

For desert, I take the estimate of 27.5 km per 7 hour day = .233 hours per km. The estimate comes from Constant (2009). Constant walks across the Sahara desert and often comments on her pace. Some quotes include the following: "For the first time in the desert I will simply have to walk between twenty-five and thirty kilometres per day in order to keep to schedule (3438)." "He sets a fast stride and maintains it, for at least 30 kilometres over rough terrain. (4107)." "30 kilometres per day (4281)." "…plodding through prickles and over hills for twenty-five, thirty kilometres – then camp, eat, sleep…. Every day when I check our location and mark the kilometers on the map, I can see that we are covering good ground. (4870)." "I walk over 25 kilometres every day (4964)." "25 to 30 kilometres a day walking (6142)." Her guide said he did 50 per day, but he was riding camels and donkeys.

For jungle, I use the average daily estimate of .88 hours per km found in Henry Morton Stanley (1891):

> "The next day left the track and struck through the huge towering forest and jungle with undergrowth by compass....Naturally penetrating a trackless wild for the first time the march was at a funeral pace, in some places at the rate of 400 yards an hour (.366 km per hr. or 2.73 hours per km), in other more open portions that is of less undergrowth, we could travel at a rate of half, three quarters, and even a mile per hour (.625 hours per km) – so that from 6:30 AM to 11 AM when we halted for lunch and rest, and from 12:30 PM to 3 o'clock or 4 PM and from 6 to 7 hours per day, we could make a march of about 5 miles (.880 hours per km) (p. 98)."

For Mangrove, swamp and waterbodies with no water current I use the estimate of 2.9 mph (.216 hours per km) found in Smith (1970, p. 523), who reports average rowing speeds in the lagoons along the Lower Guinea coast in the early 19th century.[29]

Table 1 converts all estimates into hours per kilometer using 1.6 kilometers per mile and 7 hours per day.

8.2 Accounting for Headload.

Transport times have to account for the impact of any headload being carried. Ergonomic tests conducted by the U. S. Army Department concluded that carrying load by head is more efficient than carrying load by arms because arms rely on small muscle groups that tend to tire quickly. S. J. Legg (1985) reports:

> "In the head-carriage method, the stress is born by the vertebral column and the legs. The limiting factor in carrying heavy loads on the head is not energy cost but rather the mechanical load tolerated by the musculature. Movement of the body as a whole is restricted, but the method is very suitable for repeated short distance carries (p. 199)."

Stanley (1878, vol. I, p. 82) describes how he used this principle to allocate the 18,000 pounds of his caravan load among his 300 porters:

> "… each man's load was given to him according as we judge to his power of bearing burthen. To the man of strong sturdy make, with a large development of muscle, the cloth bail of 60 pounds was given, …; to the short compactly formed man, the bead sack of 50 pounds weight; to the light use of 18 or 20 years old, the box of 40 pounds,…. To each section of the boat there are four men, to relieve one another in couples. (p. 81-2)"

Pandolf, Givoni and Goldman (1977) use the following equation to predict the energy expenditure of carrying various headloads:

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[29] My estimate excludes the 1.1 mph quote because that quote is for travelling upstream from Kuramo to Ikorodu where "a canoe meets the strong currents caused by the outflow of the Ogun and other rivers into the lagoon (p. 523)."

$$M = 1.5W + 2.0(W+L)(L/W)^2 + n(W=L)(1.5V^2 + 0.35VG)$$

M = metabolic rate in watts; W = porters' weight in kg; L = load carried; V = speed of walking in meters per second; G = grade in %; and n = terrain ruggedness. According to this equation, a 190 pound man (77 kg) carrying a 60-pound head-load (27.2 kg) at a rate of .329 hours per km would burn 23.4% more watts of energy than a 190 pound man carrying nothing. A 170 pound porter carrying 50 pounds would burn an additional 21%, and a 150 pound man carrying 40 pounds would burn an additional 23%. Additions are less at slower walking rates. Through jungle (.88 hours per km) the additions are between 16.2% and 20.0%. The additional energy would need to be replenished with food and rest. In addition, "movement of the body as a whole is restricted," which should reduce walking speed. I add a load factor of 20% to the walking rates to account for load-related effects on speed and headload.

8.3 Using Henry Morton Stanly's Travel Log as a Check.

As a check on the walking rate reported in Table 1, Table A1 reports rates collected from the published logs of Henry Morton Stanley's multi-year expedition through Africa between 1874 and 1876 (1879, Vol II, pp. 516-550). Stanley was the first European to march inland from Zanj on the east coast of Africa westward up to Lake Victoria in the Highlands, southward down the Great Rift Valley, westward again through a portion of jungle in the Congo Basin, before floating down the Congo River to Isangila Falls and from there overland to the Atlantic Ocean. At the end of vol. II of the book that documents this expedition Stanley published a travel log that records "dates," "name of country," "name of station, village, or camp," "distance between (miles)," and "remarks." I found 355 entries in these logs for which distance and date are reported.

Table A1 reports the average travel times by water and land for what Stanley calls "Wanderings" or sections of his trek across Africa. Columns (1) and (3) report the hours per kilometer assuming 7 hour days. Not all dates in the log are sequential. The hourly travel rates reported in column (1) include non-marching days used for rest and re-provisioning. Care is taken to exclude off-days used for other purposes (like the side trip to visit the Emperor of Uganda). Column (2) reports the number of observations used in these calculations. Column (3) reports average travel times that do not include rest days. It includes only observations with consecutive dates, and so cannot include a day of rest. These are the observations that are most comparable to the estimates in Table 1, the major exception being they include the impact of slope. Column (5) reproduces the Wilks estimates that match the dominant land cover type of each of Stanley's wanderings.

Wilk's estimates of travel times are comparable to Stanley's observed travel times. The slight differences reflect the fact that Stanley's elevations were more varied than those found along the Great Roads of Asante. Stanley traveled over mountain passes, up to the highland lakes region and down into the surrounding valleys before reaching the Congo River.[30] Stanley also took longer to travel by water. Lake Victoria and Lake Tanganyika are bodies of

[30] The last two entries have only 4 observations.

relatively still water, so their rates should be similar to the ones observed in the lagoons off the Lower Guinea coast. Stanley's vessel was called Lady Alice, constructed in Europe, dismantled into parts, transported to the African Coast and carried overland to the lakes and rivers in the interior. Pictures show it to be significantly wider and heavier than the average African canoe. Stanley repeatedly refers to the swiftness of the African canoes he encountered on the Congo River and to the elegance of their construction. Also, while circumnavigating Lake Victoria and Lake Tanganyika, Stanley was interested in exploring and documenting as many bays, inlets and rivers as possible, which slowed progress.

8.4 Canoe speed (F_j)

Rivers attract traders. They serve as natural highways across the landscape. Compared to overland transportation, rivers have advantages and disadvantages. They are not available everywhere and they often do not flow in the direction one might want. On the plus side, water reduces friction and facilitates the transformation of human energy into velocity. The buoyancy of water, when manipulated by a paddler in an appropriately constructed vessel, can carry much more weight than an overland porter.

Roberts (1987, pp. 73-74) discusses the relative carrying capacities of the transport technologies available in the 19th century Western Sahel. Here traders had the option to use draft animals in addition to human porters and canoes. According to Roberts, in the Middle Niger Valley a 20-30 ton freight canoe could transport as much produce as a caravan of 1000 porters, 20 camels, or 30 pack oxen. Stanley (1878, vol. I, p. 64) used 300 porters to carry 8 tons of bulk, which is a comparable carrying capacity for porters.

In the forested regions to the south, the tsetse fly removes camels and oxen from the technology set. Harms (1981) discusses relative carrying capacities in the Congo River Basin, one of the largest river systems in the world and almost entirely contained within evergreen rainforest. According to Harms:

> "A porter could carry 23-32 kg and walk 15-30 km a day. A paddler in a trading canoe could transport 65-90 kg 65-80 km per day going downstream, and 40-50 km a day going upstream (48)."

According to the estimates in Tables 1 and A1, these appear to be optimistic estimates for porters, but the general point remains: canoes can float more weight and move the weight faster than porters. Ideally, we would like to estimate transport costs per ton-mile of river transport. Roberts (1987, p. 62) reports that "[a] colonial officer in 1892 estimated that it costs six times more to move the quantity of goods by caravan than by canoe…," but we have no way of evaluating such claims or conducting an analysis for the entire continent.

We do know that canoe transport required additional capital investment. The quality and size of canoes was dictated by the availability of trees and the returns to trade. Canoes were dug out of trees by hand using iron axes and adze-like tools. As early as 1506, Fernandes writes about "huge canoes carrying 120 warriors" on the Sierra Leone River (Smith 1970, p. 518). As early as 1682 Barbot describes canoes along the Gold Coast being 70 feet long and 7-8 feet wide (Smith 1970 , p. 518). Around the Niger Bend, wood was scarce because here the

Niger River approached the edge of the encroaching Sahara desert. In the late 18th century Mungo Park (2000) observed a canoe here composed of two log sections attached end-to-end (unlike a catamaran) that ferried four horses and several men across the river (p. 293). By the end of the 19th century Murdock's Ethnographic Atlas records guilds of specialized boat-makers along the Niger River and on the western shore of Lake Victoria. Stanley (1879, p. 392) depicts sketches of the variety of canoes he observed during his trek across Africa in the 1870s. War and trade spurred developments in the technology (Smith 1970).

There were also additional labor cost when transporting slaves by canoe. On land, slaves destined for sale often doubled as porters, but in canoes they were seldom paddlers. Paddlers were most-often recruited from among the best and most reliable workers in a village and required remuneration of some kind. There were also small additional costs for transporting slaves on land. Land caravans may have required a few more guards because there were more opportunities for captives to escape; slaves as porters required more food than slaves as canoe passengers; and women and children might slow the march on land. These costs, however, are negligible compared to the cost of a canoe and its crew.

Since canoes are lumpy inputs there is the possibility of economies of scale in the canoe technology. According to Roberts (1987, 73-74) this was not the case in the Middle Niger Valley. A common canoe of 6-10 ton capacity was often manned by two crew members and a captain. A large 20-30 ton freight canoe was often manned by a crew of 16-18 plus 2 mates and a captain. Henry Morton Stanley describes war canoes on the Congo River as large as 85 and 90 feet in length "with two rows of upstanding paddles, 40 men on a side... (1879, Vol II, p. 270)." The ratios of canoe tonnage or canoe size relative to crew size does not suggest appreciable economies of scale. Economies of scale did exist in the size of caravans, on land and water, to protect from attack when travelling through hostile territory.

States sometimes provided public goods on water similar to the halting place along the Great Roads of Asante. Mountains divide and river unite, the saying goes. Roberts discusses how the King of Segu in the late 18th century spaced villages 15 km apart along the Niger River in order to regularize and protect trade. The growth of Segu plantations and their grain production spurred this development (Roberts 1987, pp. 71-72). Smaller merchants who could not tie up capital in canoes could rent passage as individuals or groups (pp. 73-74). Harms (1987, chapters 2 and 3) discusses similarly-spaced trading towns and sharing arrangements along the lower Congo River. Here the advantage may be with river transport. It may have been cheaper to protect waterways than to maintain and protect roads. In addition, canoes did double-duty. When not in use for trade they could be used to dispatch troops, blockade enemies and wage war (Smith 1970, pp. 525-532).

These are all interesting and important economic considerations, but in a global sense, they pale in comparison to the differences in speed by land and by water. The major advantage of river transportation was speed, the combination of rowing tonnage on flowing water. Not all rivers were navigable at all times. Some were shallow streams that could not support a canoe full of people and trade goods. Some rivers dried up during the drier seasons. Some rivers flowed faster than others, some were wider than others, and some were deeper than others.

All of these features of rivers find expression in the hydrological identity for river velocity:

$$\text{Velocity (meters/sec)} = \text{Discharge rate (m}^3\text{/sec) / Cross-sectional area (m}^2\text{).}$$

Velocity is the rate of flow measured in meters per second. It is a function of the rate at which the river system discharges its volume of water, divided by the cross-section (width x depth) of the riverbed through which the water is discharged. The Global Runoff Data Centre (GRDC) maintains a GIS dataset that contains volumetric discharge rates for 687 major river systems around the world. Based on the concept that a river basin covers all land that drains to the point of lowest elevation, the estimation procedure starts at river outlets (pour points) that coincide with either a confluence with a river, a mouth into an ocean or an endorheic sink (like Lake Chad). The basins above the pour points are mapped using the flow direction data in the HYDRO1k Elevation Derivative Database. The procedure identifies 405 river basins and 687 river networks around the world.

The GRDC dataset also contains data on average river discharge rate. Discharge rates measure the volume of water discharged per second from the basin. The GRDC dataset contains discharge rates recorded at 3,843 gauging stations between 1961 and 1990. The dataset splits river polylines into equidistant 0.25-length units. The WaterGAP 2.1 program is used to assign a discharge rate to each river segment. The spatial resolution is 0.5 degree.

Andreadis, et al (2013) estimate river width and depth using well-established geomorphic relationships between discharge rates and drainage areas (p. 7164).[31] Their estimates of river width are evaluated using LANSAT satellite imagery data. I convert the estimates of river velocity into hours per kilometer to make them comparable to the walking rates. The estimated mean for the continent of Africa is 0.44 hours per km (a velocity of 2.3 kilometers per hour). The standard deviation is 0.11. 68.2 percent of the river segments flow at an estimated rate between 0.55 hours per km (1.82 km per hour) and 0.33 hours per kilometer (3.0 km/hr.). The fastest river segment takes 0.15 hours to cover a km (6.6 km/hr.) The slowest is 0.95 hours per km (1.05 km/hr.). Segments are removed if they contain a major waterfall and rapids.[32] This forces traders to portage through these cells.

The 1961-90 readings on discharge rates appear to be applicable to the precolonial era. When Nohara et al (2006) extend climate change models back to 1900, the rapid economic growth scenario produces little change in mean precipitation and river discharge, although the variance among the individual models is very large. Alsan (2015, online appendix) reports paleoclimatic data that shows no change in African temperature between 1500 and 1900.

[31] For a review of this literature and a discussion of similar but alternative algorithms for calculating river width, see Dai Yamazaki, Fiachra O'Loughlin, Mark A. Trigg, Zachary F. Miller, Tamlin M. Pavelsky, & Paul D. Bates, (2014).

[32] The project consulted online maps for the Congo River Basin, East Africa Rivers, the Niger River system, South Africa Rivers and Sudan River Rapids. The project also consulted maps and descriptions in four books. See Livingstone (1857), Hamilton (2005), Harwood (2013) and Coppinger and Williams (1994).

Fenske and Kala (2015, online appendix) reports observed temperatures for Benguela and Whydah between 1725 and 1875 that show no trend. Nohara et al (2006, p. 1081) do show that the WEM (weighted ensemble mean) statistic for climate change models shows more variance around the equator than elsewhere. There is certainly direct evidence of southward expansion of the Sahara desert. Timbuktu was a great medieval city situated at the bend of the Niger River. The city is now well within the desert. The calculations presented here do not account for localized changes in river discharge and land-cover.

8.5 The Vertical Factor (VF)

The estimates of river velocity already capture the effect of slope, which is gradual along the run-off. Discontinuous sections like waterfalls and rapids have been removed using available maps, forcing travelers to portage through these sections. The estimated walking rates are different. They assume a flat surface. The calculation must therefore take into account the fact that it is more difficult to walk uphill than downhill or along a flat surface. It is not reasonable to expect traders to scale cliffs, steep mountains or canyons walls. The vertical factor for walking deals with these issues. It is derived from Waldo Tobler's (1993) Hiking Function, a function commonly used to account for the impact of slope on walking velocity.

$$V = 6e^{-3.5|s+.05|}$$

"V" is the walking velocity (measured in km per hour) and "s" is the slope of the terrain. On flat terrain, V(s) equals approximately 5 km per hour. At a slope of 50 degrees the predicted walking rate is virtually zero. At 30 degrees it is 0.5 km per hour. On the downside, the drop in velocity is approximately .5 km per hour less at each absolute slope value, so at a slope of -30% the walking velocity drops to approximately 1km per hour instead of 0.5.

The vertical factor (VF) enters the calculation of H as a multiplicative factor that is applied to F*SD. Since V(0) = 5, the vertical factor is normalized as VF = V(s)/5. Also, the vertical factor and F*SD must be in the same units. The Tobler V is measured in km per hour while F*SD is measured in hours per km. The final vertical factor used in the calculation is 5/V(s), where $dV/ds < 0$. A 30% up slope generates a vertical factor of 5/.5 = 10, estimating that it takes ten times as long to walk up a 30 degree slope as it does to walk on a flat surface.

A maximum slope can be imposed beyond which the Vertical Factor is infinity. Imposing a maximum is like imposing the assumption that walkers find a way around cliffs and steep mountains. For reference, a 6% slope is the maximum allowed for an interstate highway in the United States. Safe building access ramps are between 7-15 percent. Stair slopes are between 30-35 percent. The steepest gradient in San Francisco is on Filbert Street at 31.5 percent. According to the Guinness Book of World Records, Baldwin Street in New Zealand is the world's steepest residential street, a 350 meters street with a section of 35% slope. In our estimate, the VF captures changes in average altitude between two square-kilometer cells. Setting a maximum of, say, 30 percent assumes that a trading caravan facing a kilometer-long path as steep as a staircase will find an alternate way around. It is not unreasonable to assume that trader will avoid kilometer-long slopes steeper than a steep building access ramp (15%), especially if the porters in the trading party are carrying loads.

Low maximum slopes are synonymous to assuming that travelers used local knowledge to find the easiest local paths forward.[33]

8.6 Travel Times (F_{ij})

I use these data to estimate travel times in precolonial Africa. I estimate the time (measured in hours or days) to travel from point A to point B. This is accomplished using the Path Distance tool in ArcGIS. I calculate an H for each .452 square kilometer of the African continent.[34] The data projection is Africa Equidistant Conic, which is a secant projection with standard parallels at approximately 20 and -23 latitudes. It is the appropriate projection for calculating distances in Sub-Saharan Africa because it straddles the equator. Cell sizes are set to the cell size of the Digital Elevation Model.

First, a cost raster F_i is calculated that measures the time to walk across cells. The vertical factor (VF) is applied to F_i. If a cell in F_i contains a river then the value of the cell is set to zero. This prevents double counting when the river velocities in raster F_j are added to form $F_{ij} = F_i + F_j$. ArcGIS generates SD and estimates an H. H is a raster of the quickest way to get to the closest of a set of destinations. Destinations could be the coast or a slave port or a pre-1500 urban center. Figures 3 and 4 show the resulting estimates of average travel times per society to the nearest slave port assuming a maximum vertical factor of 20% and a minimum river velocity of .27 hours per kilometer.[35] Travel time per society is the weighted average of all cells contained within the society's borders. Adjustable parameters are F_i (land frictions), minimum Fj (river velocity) and max VF (% slope).

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[33] The ArcGIS Cost Path algorithm retains in memory a table of transition costs for all directions leading from a cell, not just the least cost direction. Imposing a maximum vertical factor forces the calculation to "backtrack" and find a path that is not blocked by the maximum vertical factor.

[34] These layers should all be in the same projection. I use WGS_1984_Equidistant_Conic.

[35] Slave ports are taken from the Transatlantic Slave Trade Database. They include all mainland slave ports on the West coast of Africa that exported more than 4,000 slaves between 1600 and 1865. On the East African coast the ports included all mainland slave ports plus Zanzibar, which was a major island port in the Indian Ocean trade that was just off the coast.

Table A1. Henry Morton Stanley's Logs

	Observed From Stanley's Logs				Estimates (with and without load)
	Avg. for all days		Avg. for travel days		Avg for travel days
Stanley's Wanderings	hrs./km	Obs.	hrs./km	Obs.	hrs./km
	(1)	(2)	(3)	(4)	(5)
Overland to Lake Victoria	0.591	50	0.42	26	.329, .395
Circumnavigation of Lake Victoria	0.282	53	0.240	47	0.216
Overland in Uganda	1.281	17	0.425	8	.329, .395
Overland from Nyanza Muta-Nzige to Ujiji	0.694	102	0.422	62	0.329, .395
Circumnavigation of Lake Tanganyika	0.295	64	0.245	58	.216
Overland to Lualaba River near Nyangwe	0.695	40	0.417	26	.368, .442
Congo River to Isangila Falls (minus cateracts)	0.380	21	0.265	4	.216
Overland from Isangila Falls to Atlantic Ocean	0.703	7	0.841	4	.88, 1.06

Notes: The source is Stanley (1878, pp. 516-561). Columns (1) and (3) report the hours per kilometer assuming 7 hour days. Column (1) includes non-marching days used for rest and re-provisioning. Column (3) reports average travel times that do not include rest days (only observations with consecutive dates). Column (5) reproduces the estimates from Table 1 that match the dominant land cover type of each of Stanley's wanderings.

9 References

(CCD-Ghana), Center for Democracy and Development. 2009. "Round 4 Afrobarometer Survey in Ghana,"

Amemiya, T. 1978. "The Estimation of a Simultaneous Equation Generalized Probit Model." *Econometrica*, 46, 1193-205.

Andreadis, K. ; G. Schumann and T. Pavelsky. 2013. "A Simple Global River Bankfull Width and Depth Database." *Water Resource Research*, 49, 7164-68.

Austen, Ralph A. 2010. *Trans-Saharan Africa in World History*. Oxford: Oxford University Press.

Austin, Gareth. 2004. *Labour, Land, and Capital in Ghana : From Slavery to Free Labour in Asante, 1807-1956*. Rochester, NY: University of Rochester Press.

Bertocchi, Graziella. 2015. "The Legacies of Slavery in and out of Africa," *IZA Discussion Paper.*

Besley, T. and Reynal-Querol. 2014. "The Legacy of Historical Conflict: Evidence from Africa." *American Political Science Review*, 108(2), 319-36.

Bezemer, Dirk; Jutta Bolt and Robert Lensink. 2014. "Slavery, Statehood, and Economic Development in Sub-Saharan Africa." *World Development*, 57, 148-63.

Bhattacharyya, Sambit. 2009. "Root Causes of African Underdevelopment." *Journal of African Economies*, 18(5), 745-80.

Bolt, Jutta and Leigh Gardner. 2015. "De-Compressing History? Pre-Colonial Institutions and Local Government Finance in British Colonial Africa,"

Bottero, Margherita and Bjorn Wallace. 2013. "Is There a Long-Term Effect of Africa's Slave Trades," *Economic History Working Papers.* Banca D'Italia

Bowdich, T. E. 1819. *Mission from Cape Coast Castle to Ashantee*. London: John Murray.

Bowman, Cynthia Grant and Akua Kuenyehia. 2003. *Women and Law in Sub-Saharan Africa*. Accra: Sedco Publishing Limited.

Boxell, Levi. 2019. "Drought, Conflict and the African Slave Trade." *Journal of Comparative Economics*, 47(4), 775-91.

Bulliet, Richard W. 1990. *The Camel and the Wheel*. New York: Columbia University Press.

____. 2016. *The Wheel: Inventions and Reinventions*. New York: Columbia University Press.

Burrill, Emily S.; Richard L. Roberts and Elizabeth Thornberry eds**.** 2010. *Domestic Violence and the Law in Colonial and Postcolonial Africa*. Athen: Ohio University Press.

Center, Global Runoff Data. 2007. "Major River Basins of the World," Koblenz, Germany: GRDC in the Bundesanstalt fuer Gewaesserkunde,

Constant, Paula. 2009. "Sahara: A Journey of Love, Loss and Survival," Sydney: Bantam,

Coppinger, Mike and Jumbo Williams. 1994. *Zambezi: River of Africa*. London: New Holland.

Coquery-Vidrovitch, Catherine. 1997. *African Women: A Modern History*. Oxford: Westview Press.

Crowder, Michael. 1978. *Colonial West Africa*. London: Frank Cass and Company.

Dalton, John T. and Tin Cheuk Leung. 2014. "Why Is Polygyny More Prevalent in Western Africa: An African Slave Trade Perspective." *Economic Development and Cultural Change*, 62(4), 599-632.

Domar, Evsey D. 1970. "The Causes of Slavery or Serfdom: A Hypothesis." *Economic History Review*, 30(1), 18-32.

Douglas, Mary. 1969. "Is Matriliny Doomed in Africa?," M. Douglas and P. Kaberry, *Man in Africa.* London: Tavistock Publications,

____. 1964. "Matriliny and Pawnship in Central Africa." *Journal of the International African Institite*, 34(4), 301-13.

Dupuis, Joseph. 1824. *Journal of a Residence in Ashantee*. London.

Eltis, David. 1987. *Economic Growth and the Ending of the Transatlantic Slave Trade*. New York: Oxford University Press.

____. 1986. "Fluctuations in the Age and Sex Ratios of Slaves in the Nineteenth-Century Transatlantic Slave Traffic." *Slavery and Abolition*, 7(3), 257-72.
Eltis, David and Stanley L. Engerman. 1992. "Was the Slave Trade Dominated by Men?" *The Journal of Interdisciplinary History*, 23(2), 237-57.
Englebert, Pierre. 2000. "Pre-Colonial Institutions, Post-Colonial States, and Economic Development in Tropical Africa." *Political Science REsearch Quarterly*, 53(1), 7-36.
Fage, John. 1959. *An Introduction to the History of West Africa*. London: University Press.
____. 1969. "Slavery and the Slave Trade in the Context of West African History." *Journal of African History*, 10(3), 393-404.
____. 1980. "Slaves and Society in Western Africa C.1445-C.1700." *Journal of African History*, 21(3), 289-310.
Fenoaltea, Stephano. 1999. "Europe in the African Mirror: The Slave Trade and the Rise of Feudalism." *Rivista Di Storia Economica*, 15(2), 123-65.
Fenrich, Jeanmarie; Paolo Galizzi and Tracy E. Higgins eds**.** 2011. *The Future of African Customary Law*. New York: Cambridge University Press.
Fenske, James and Namratta Kala. 2015. "Climate and the Slave Trade " *Journal of Development Economics*, 112, 19-32.
Fisher, Humphrey. 2001. *Slavery in the History of Muslim Black Africa*. London: Hurst and Company.
Fourie, Johan. 2019. "Who Writes African Economic History? ." *Economic History of Developing Regions*, 34(2), 111-31.
Geggus, David. 1989. "Sex Ratio, Age and Ethnicity in the Atlantic Slave Trade: Data from French Shipping and Plantation Records." *The Journal of African History*, 30(1), 23-44.
Gemery, Henry and Jan Hogendorn. 1974. "The Atlantic Slave Trade: A Tentative Economic Model." *Journal of African History*, 15(To), 223- 46.
Gennaioli, Nicola and Ilia Rainer. 2007. "The Modern Impact of Precolonial Centralization in Africa." *Journal of Economic Growth*, 12, 185-234.
Getz, Trevor R. 2004. *Slavery and Reform in West Africa: Towards Emancipation in Nineteenth Century Senegal and the Gold Coast*. Athens: Ohio University Press.
Goody, Jack. 1971. *Technology, Tradition and the State in Africa*. London: Oxford University Press.
Hall, Bruce S. 2011. *A History of Race in Muslim West Africa, 1600-1960*. Cambridge ; New York: Cambridge University Press.
Hamilton, A. 2005. *The Niger River: A Lecture Delivered at the Bromley Literary Institute, Tuesday, 25th March, 1862*. Baltimore: Black Classics Press.
Harms, Robert. 1981. *River of Wealth, River of Sorrow: The Central Zaire Basin in the Era of the Slave and Ivory Trade, 1500-1891*. New Haven: Yale University Press.
Harwood, Phil. 2013. *Canoeing the Congo: The First Source-to-Sea Descent of the Congo River*. West Sussex: Summersdale.
Hawthorne, Walter. 2003. *Planting Rice and Harvesting Slaves: Transformations Along the Guinea-Bissau Coast, 1400-1900*. Portsmouth: Heinemann.
Hopkins, Anthony. 1973. *An Economic History of West Africa*. New York: Columbia University Press.
Inikori, Joseph. 1977. "The Import of Firearms into West Africa 1750-1807: A Quantitative Analysis." *Journal of African History*, 18(3), 339-68.
Klein, Martin. 1983. "Women in Slavery in the Western Sudan," C. Robertson and M. Klein, *Woman and Slavery in Africa.* Madison: University of Wisconsin Press, 67-92.
Klein, Martin A. 2001. "The Slave Trade and Decentralized Societies." *The Journal of African History*, 42(1), pp. 49-65
Lagerlof, Niles-Petter. 2009. "Slavery and Other Forms of Property." *Review of Economic Studies*, 76, 319-42.

Latham, A. J. H. 1973. *Old Calabar, 1600 to 1891: The Impact of the International Economy Upon a Traditional Society*. Oxford: Clarendon press.
Law, Robin. 1980. *The Horse in West African History*. Oxford: Oxford University Press.
Legg, S. J. 1985. "Comparisons of Different Methods of Load Carriage." *Ergonomics*, 28(1), 197-212.
Levine, Ross; Chen Lin and Wensi Xie. forthcoming. "The African Slave Trade and Modern Household Finance." *Economic Journal*.
Livingstone, David. 1857. *Missionary Travels and Researches in South Africa*. London: W. Clowes and Sons.
Logan, Carolyn. 2011. "The Roots of Resilience: Exploring Popular Support for African Traditional Authorities," *Afrobarometer Working Paper No. 128.*
Lovejoy, Paul. 2016. *Jihad in West Africa During the Age of Revolutions*. Athens: Ohio University Press.
Lovejoy, Paul E. 2000. *Transformations in Slavery : A History of Slavery in Africa*. Cambridge, UK ; New York: Cambridge University Press.
Lovejoy, Paul and Toyin Falola eds**.** 2003. *Pawnship, Slavery and Colonialism in Africa*. Trebton: Africa World Press.
Marcella, Alsan. 2015. "The Effect of the Tse Tse Fly on African Development." *American Economic Review*, 105(1), 382-410.
Mayaux, Philippe and et. al. 2003. "A Landcover Map of Africa," European Center Joint Research Centre,
Meillassoux, Claude. 1991. *The Anthropology of Slavery*. London: The Athlone Press.
____ ed**.** 1971. *The Development of Indigenous Markets in West Africa*. Oxford: Oxford University Press.
Michalopoulos, Stelio and Elias Papailoannou. 2015. "Further Evidence on the Link between Precolonial Political Centralization and Contemporary African Development." *Economic Letters*, 126(1), 57-62.
____. 2018. "Historical Legacies and African Development," *Working Paper* National Bureau of Economic Research,
Michalopoulos, Stelios and Elias Papailoannou. 2013. "Precolonial Ethnic Institutions and Contemporary African Development." *Econometrica*, 81(1), 113-52.
Miers, Suzanne and Martin A. Klein. 1999. *Slavery and Colonial Rule in Africa*. Portland, OR: Frank Cass.
Miers, Suzanne and Igor Kopytoff. 1977. *Slavery in Africa : Historical and Anthropological Perspectives*. Madison: University of Wisconsin Press.
Miers, Suzanne and Richard Roberts eds**.** 1988. *The End of Slavery in Africa*. Madison: University of Wisconsin Press.
Murdock, George P. 1963. "Ethnographic Atlas." *Ethnology*, 2(1), 109-33.
____. 1949. *Social Structure*. New York: Macmillan Co.
Newey, W. K. 1987. "Efficient Estimation of Limited Dependent Variable Models with Endogenous Explanatory Variables." *Journal of Econometrics*, 36, 231-50.
Nieboer, H. J. 1900. *Slavery as an Industrial System*. The Hague: Martinus Nijhoff.
Nohara, Daisuke; Akio Kitoh; Masahiro Hosaka and Taikan Oki. 2006. "Impact of Climate Change on River Discharge Projected by Multimodel Ensemble." *Journal of Hydrometeorology*, 7, 1076-89.
Nunn, Nathan. 2008. "The Long Term Effects of Africa's Slave Trades." *Quarterly Journal of Economics*, 123(1), 139-76.
Nunn, Nathan and Leonard Wantchekon. 2011. "The Slave Trade and the Origins of Mistrust in Africa." *American Economic Review*, 111(7), 3221-52.
Obikili, Nonso. 2016a. "The Impact of the Slave Trade on Literacy in West Africa: Evidence from the Colonial Era." *Journal of African Economics*, 25(1), 1-27.

____. 2016b. "The Transatlantic Slave Trade and Local Political Fragmentation in Africa." *The Economic History Review*, 69(4), 1157-2277.
Osafo-Kwaako, Philip and James Robinson. 2013. "Political Centralization in Pre-Colonial Africa," *NBER Working Paper No. 18770.*
Ozak, Omer. 2018. "Distance to the Pre-Industrial Technological Frontier and Economic Development." *Journal of Economic Development*, 23(2), 175-221.
Pandolf, K. B. ; B. Givoni and R. F. Goldman. 1977. "Predicting Energy Expenditure with Loads While Standing or Walking Very Slowly." *Journal of Applied Physiology*, 43(4), 577-81.
Park, Mungo. 2000. *Travels in the Interior Districts of Africa*. Durham: Duke University Press.
Patterson, Orlando. 1982. *Slavery and Social Death: A Comparative Study*. Cambridge: Harvard University Press.
Phillips, Anne. 1989. *The Enigma of Colonialism: British Policy in West Africa*. London.
Pierce, lamar and Jason Snyder. 2018. "The Historical Slave Trade and Firm Access to Finance in Africa." *Review of Financial Studies*, 31(One), 142- 74.
Rattray, R. S. 1969. *Ashanti*. New York,: Negro Universities Press.
Rivers, D and Q. H. Vuong. 1988. "Limited Information Estimators and Exogeneity Tests for Simultaneous Probit Models." *Journal of Econometrics,* 39, 347-66.
Roberts, Richard L. 1980. "Production and Reproduction of Warrior States: Segu Bambara and Segu Tokolor, Circa 1712 – 1890." *The International Journal of African Historical Studies*, 13(Three), 389 – 419.
____. 1987. *Warriors, Merchants, and Slaves : The State and the Economy in the Middle Niger Valley, 1700-1914*. Stanford, Calif.: Stanford University Press.
Robertson, Claire and Martin Klein eds**.** 1983. *Women and Slavery in Africa*. Madison: University of Wisconsin Press.
Rodney, Walter. 1966. "African Slavery and Other Forms of Social Oppression on the Upper Guinea Coast in the Context of the Atlantic Slave Trade." *Journal of African History*, 7(3), 431-43.
Schneider, Harold K. 1981. *The Africans: An Ethnological Account*. New Jersey: Printice-Hall.
Sheleff, Leon. 1999. *The Future of Tradition: Customary Law, Common Law and Legal Pluralism*. London: Frank Cass.
Smith, Robert. 1970. "The Canoe in West African History." *The Journal of African History*, 11(4), 515-33.
Stanley, Henry Morton. 1891. *In Darkest Africa: Or the Quest, Rescue and Retreat of Emin Governor of Equatoria*. New York: Charles Scribner's Sons.
____. 1878. *Through the Dark Continent, Vol. I*. New York: harper Brothers.
____. 1879. *Through the Dark Continent, Vol. Ii*. New York: Harper Brothers.
Thornton, John. 1998. *Africa and Africans in the Making of the Atlantic World, 1400- 1800*. Cambridge: Cambridge University press.
Tobler, Waldo. 1993. "Three Presentations on Geographical Analysis and Modeling," N. C. f. G. I. a. Analysis, *Technical Report 93-1*. University of California, Santa Barbara:
van Waijenburg, Marlous. 2018. "Financing the African Colonial State: The Revenue Imparative and Forced Labor." *The Journal of Economic History*, 78(1), 40-80.
Vansina, Jan. 2010. *Being Colonized: The Kuba Experience in Rural Congo, 1880-1960*. Madison: University of Wisconsin Press.
Whatley, Warren. 2018. "The Gun-Slave Hypothesis and the 18th Century British Slave Trade." *Explorations in Economic History*, 67(1), 80-104.
____. 2014. "The Transatlantic Slave Trade and the Evolution of Political Authority in West Africa," E. Akyeampong, R. Bates, N. Nunn and J. Robinson, *Africa's Development in Historical Perspective.* Cambridge: Cambridge University Press, 460-88.
Whatley, Warren and Rob Gillezeau. 2011. "The Impact of the Slave Trade on Ethnic Stratification in Africa." *American Economic Review*, 101(3), 571-76.

Wilks, Ivor. 1975. *Asante in the Nineteenth Century : The Structure and Evolution of a Political Order*. London ; New York: Cambridge University Press.

Yamazaki, Dai ; Fiachra O'Loughlin; Mark A. Trigg; Zachary F. Miller; Tamlin M. Pavelsky and Paul D. Bates. 2014. "Development of the Global Width Database for Large Rivers." *Water Resources. Research*, 50, 3467-80.