Current Version: *December 15, 2022*

Did the African Slave Trades Reduce African Population?

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(Rough Draft Do Not Quote)

Abstract

This paper utilizes available historical data to estimate the effects of the Trans-Atlantic and Indian Ocean Slave trades on African population between 1 AD and 1900. We consider both exposure to the respective slave trades, and their export intensity. The parameter estimates from our specifications suggest that exposure to the Transatlantic Slave trades, and the measured intensity of slave exports under the Indian Ocean Slaves trades had the effect of reducing population growth in Africa. Counterfactually, we estimate that the Trans-Atlantic Slave trades reduced population by approximately 12.39 million individuals in 1900. To the extent that more people and less social disruption would have induced innovation and technological change that increases factor productivity and ultimately more population growth, our estimates suggest that the Trans-Atlantic Slave trades, and the slave export intensity of both the Trans-Atlantic and Indian Ocean Slave trades, constrained technological progress and material living standards in Africa.

JEL Classification: *N01,N17, N43, N73, O1,O55, Z13.*

Keywords: Slave Trades, Africa, Population

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This paper was prepared for presentation at the 2023 Allied Social Sciences Association (ASSA) meeting in New Orleans, LA. Session: Reparations and Economic Development of Africa, Sunday, January 8, 2023.

Introduction

Did the international slave trades reduce African population? The obvious answer is "yes." The trans-Atlantic slave trade alone exported more than 13 million people to the Americas, few of whom were beyond their reproductive years, so the effect was not just a one-time subtraction but a reduction in the capacity to grow the population. The empirical question is "by how much?" It is a question we attempt to answer. We deviate from previous efforts and use available historical data to estimate the effects of Christian and Muslim slave trades on African population between 1 AD and 1900. We find that the Atlantic slave trade reduced African population by approximately 25 percent compared to countries not exposed to the trade. This we interpret as a lower-bound estimate.

Contemplating the effects of international slave trades on African population has a long history, dating back to at least Malthus (Reniers, 2011). In his *Essay on the Principles of Population* (1826), Malthus appears to be arguing that African population at the time was in equilibrium; that war and slave exporting did not reduce the capacity to grow population but rather were among the natural positive checks on equilibrium population:

> "If, in order to fill up those parts that appear to be deficient in inhabitants, we were to suppose a high bounty on children, the effect would probably be the increase of war, the increase of the exportation of slaves, and a great increase of misery, but little or no increase of population (Malthus, 1826: 149-150. Quoted in Reniers (2011: 183)

Malthus knew little, if anything, about demographic regimes in Africa, but at least his view was more enlightened than some of his contemporaries who thought polygyny existed in Africa because Africans birthed more females than males. In a later edition Malthus, who was opposed to slavery, adds a footnote clarifying that he believed the wars and slave exports were caused by the international demand for Africans as slaves, and that polygyny was caused by males selectivity in slave exports (Reniers 2011: 183).

A similar population equilibrium is sometimes implied by the view that land-abundance (or low population density) was a fundamental feature of long-term African development and the source of several presumed African "traditions." This view is more an assumption than a fact -- the assumption that pre-modern African societies were built on and maintained by populations spread out geographically. The assumption has played an outsized role in efforts to reconstruct Africa's distant past and to document how it has influenced development over the long term. Iliffe (2007: 96-103), for example, argues that African polygyny can be understood as a population-growth strategy designed to match women to wealthy men, so as to increase the survival of offspring and grow a kinship-based population bound to location. Hopkins (1973) views African slavery as a labor institutions designed to tie labor to land in a land-abundant environment, similar to the ideas of Nieboer (1900) and Domar (1970). Herbst (2000) argues that African states were historically weak because of the difficulty of broadcasting political power over geographically dispersed people. Fenske (2012) presents evidence that tighter land markets among the Egba of Nigeria reduced the frequency of overlapping property rights in land. Austin (2008) revises the land-abundance perspective, recognizing the capital cost of clearing land across much of tropical Africa. Still, land-abundance is seen as the driving force behind the spread of African slavery and the choice of agricultural technique.

In this view, labor is always the scarcest resource, which naturally raises the question "why would Africans export their most valuable resource?" Going further than Malthus on this issue, the answer here often assumes that slave exports are the result of lower labor productivity in Africa relative to other regions of the world (Hogendorn and Gemery, 1991-92; Ronnback and Theodoridis, 2018), combined with the preferences of African elites who had the power and the resources to enslave and exchange people for the luxury imports they desired (Fenoaltea, 1999). Others who do not rely on the assumption of land abundance, elite preferences or agricultural productivity argue that the growth in exports was driven by the importation of gunpowder technology into the African context (Rodney, 1972; Inikori, 1977; Whatley, 2018), and that the spread and transformation of slavery and polygyny were byproducts of exposure to international slave trades (Lovejoy, 1983; Dalton and Leung, 2014; Whatley, 2022).

Since we have little empirical evidence on population density before the slave trade era it follows that we do not know if land-abundance is an outcome of that era or preceded it. In an effort to assess the validity of land-abundance prior to the trans-Atlantic slave trade, Austin (2008) present some available figures on African population density in 1750:

> "The year 1750 is an appropriate one on which to focus. More than one set of guestimates are available for it, and, while the Atlantic slave trade was in full flood, nearly two-thirds of the people it removed from the continent had yet to be deported. *So if the trade did produce an absolute fall in total population*, this was probably later. Durand gave upper and lower band estimates of 54 and 135 million. Manning's more recent estimates, informed by specialist regional knowledge, are for tropical Africa only: 63 and 48 million. Durand's figures implied an average population density of anything from 2.3 to 5.8 per square kilometer. Manning's, excluding much of southern Africa, are at the bottom of that range: 2.3 to 3.0 per square kilometer (p. 590. Emphasis added)"

Africa is a big place with lots of desert and rainforest, so continent-wide measures tell us very little about local or regional population densities. Still, these are clearly low densities for the continent as a whole, but even these contain the effects of centuries of slave exports prior to 1750. And the goal is not to estimate one-time declines in population but the accumulated effects of declines in growth rates over long periods of time.

Thornton (1977) provides the only localized estimates of population density for sub-Saharan Africa that are built up from actual historical documents. These are inferences from samples of infant baptism records from the kingdom of Kongo circa 1650-1700. Catholic priests recorded the number of unbaptized newborn that appeared between their visits to missions and villages. Thornton then uses linear interpolations of the life table models found in Cole and Demeny (1966) to infer population sizes and growth rates. He warns that the estimated populations and densities are only useful for the villages and well-defined localities where the baptisms were recorded (p. 520). His procedure produces population densities as high as 49 people per sq. km. in the capital and its environs, with densities declining as one moves away from the capital (pp. 520-521). Other districts range from 9.2 to 3.4 people per sq. km. Yet even these population estimates include the effects of slave exports. The Kongo kingdom was among the first kingdoms to be destabilized by the trans-Atlantic slave trade, disrupted so much that the King requested that Portugal stop buying slaves in the area (Thornton, 1983; Heywood, 2009).

In sum, we know the size of the continent of Africa and its regions, but we have very few reliable estimates of population before the late 19th and early 20th century. We have scattered estimates for specific areas during pre-colonial times, for example the works of Thornton (1977) for the kingdom of Kongo and Nouschi (1961) for Algeria. Aggregate data for the entire continent are being improved by extrapolating backwards from 20th century population census data (see Frankema and Jerven, 2014), mostly building on Manning (2010). But these go back no further than 1850. The population estimates found in Murdock (1959) and digitized by Alsan (2015) are also for the late 19th and early 20th centuries.

So far, the best effort to assess the effects of slave exports on African population growth is Manning (1990) who runs simulation models backwards from colonial era population estimates. Parameters include regional estimates of slave exports; estimates of age and gender selection in slave exports producing age and gender profiles of the remaining African population; and an assumed population growth rate of .5% per year (which Iliff says is high by historic standards). This Manning does for what he calls the Oriental and Occidental slaves trades and for each region of Africa separately. He concludes:

> If the population of 1700 had been able to grow at this, their assumed normal rate (.5%), the 1850 population of sub-Saharan Africa would have been roughly double that which actually lived in 1850: that is, it would have been nearly 100 million instead of roughly 50 million. Most of the difference was concentrated in the regions of the West Coast, which suffered more heavily than the rest of the continent (p. 85).

Almost every comment on the subject, while qualifying the accuracy of the population projections, invariably notes that the other populations of the Old World, in Europe and Asia, were growing rapidly during the era of the African slave trades. Later estimates by Manning (2009, 2010) and by Frankema and Jerven (2014) place the population figure for all of Africa between 114.1-139.6 million in 1850 and between 137.1-151.2 million in 1900.

The Atlas of World Population History

None of these estimates of African population go back further than 1700, yet the trans-Atlantic slave trade extended back to 1500 and the Muslim slave trades before then. Only one population estimate for Africa covers the entire history of all international slave trades and that is McEvedy and Jones (hereafter MJ) *The Atlas of World Population History* (1978). This is a controversial but widely-used resource that contains population estimates dating back to the year 1 AD. The MJ *Atlas* has 1,953 citations in Google Scholar, but more important, the data have been used in the most-influential studies on long-term economic development published in the past two decades, receiving literally *hundreds of thousands* of citations in literatures[1] on the rise

[1] Counts for just some of the articles cited in this paper: Acemoglu, Johnson and Robinson (2001) has 16,627 citations; Pomerantz (2021) already has 5,949; Kremmer (1993) has 2,204; Nunn (2008) has 1,747; Galor (2011) has 1,211; and Clark (2008) has 2,914.

of Europe and its off-shoots, the Great Divergence between East and West Eurasia, and the origins of global economic inequality in general, even tests of the new Unified Growth Theory. To say that the MJ *Atlas* has been an influential and fundamental piece of information in the modern economic development literature would be an understatement. Economic historians, however, are more skeptical (see Guinnane, 2021).

One might be surprised to know that such an influential source of data is a scant 368 pages long, with little documentation and often offering no more than educated guesses of the populations in areas of the world that would eventually become modern nation-states. Even the method of "jabbing back" from later and more reliable population estimates using historical birth and death rates is not tried, nor possible. Guinnane (2021) discusses in detail how MJ estimates their numbers. They often start by estimating populations based on how they thought the economy of the region was structured at the time: hunting and gathering; pastoral; part of the Roman Empire; Islamic; agricultural; the Bantu expansion in Africa; immigration; urbanization; and most important for our purposes, the African slave trades. They then apply a small set of growth rates to these estimates of population, with constant rates holding until the late medieval period.

It would be misleading, therefore, to say these are historical data built up from archival or census records, like the estimates for 1850 and 1900 by Manning (2009, 2010), or Frankema and Jerven (2014) or even Thornton (1977). It is best to think of them as informed guesses based on the literature existing in 1978. 368 pages is not a lot for an Atlas of World Population, so the coverage of the literature is also thin. The estimates must contain an abundance of noise around the true populations, as if we could ever know what those were. As an example of underestimation, the discussion in MJ does not mention Great Zimbabwe or the Akan chieftaincies behind the Gold Coast of Ghana. Both areas exported large quantities of gold into medieval bullion markets and were among the most-densely populated regions of Late Medieval Africa. As an example of overestimation, the discussion in MJ fails to mention the Moroccan invasion of the Mali-Songhai region in 1591 that destabilized a large section of the Western Sudan, or the Muslim Jihads of the 18th and 19th centuries that had similar effects. In other words, the MJ population estimates contain lots of measurement error, but the reading of history is so superficial that much of the error can be thought of as the classical type: large random errors above and below that reduce the probability of detecting any significant causes of variations in the data.[2]

What is particularly germane to the present study, is the fact that MJ themselves were unable to conclude from their own population estimates and their own reading of African history how the transatlantic slave trade affected African population growth. They believed slave exports could have slowed population growth, especially in 18th century West Africa, but they also believed reductions were offset by population-enhancing imports that were exchanged for slaves (like maize, manioc and cheap manufactured imports like textiles). They also believed, like Malthus and many others, that male-selectivity in slave exports, with the associated change in African family structure (polygyny) could have increased fertility among the remaining population. We quote the at length:

> "… There is no reason to believe that even the maximum uptake did more than cause a slowing down in the rate of expansion… On the other hand three men were taken for every woman and the practice of polygamy could have gone a long way towards compensating for this sort of loss. And, unpleasant though the idea is, the slave trade did bring a certain amount of material prosperity to the successful slave states, the Ashanti of the Gold Coast for example, as well as leading to the introduction of new food crops such as manioc and maize that resulted in an overall improvement in native diet (p. 242)."

And Again:

> "The demographic effects of the Atlantic slave trade have been much debated. Simple arithmetic shows that it is only in the 18th century that there is any case for it having an adverse effect on African population *levels* and that even then *it can have hardly have done more than slow the rate of increase of a sub-Saharan total* that was around 50 million. It is in fact arguable that, in a society where numbers press so hard on resources and where mortality was so high, the losses could be so rapidly compensated for that the slave trade, even at its peak rate, can have had no effect on African numbers at all. Some have even gone further. Any trade, they say, is better than none and the introduction of manioc and maize to the continent in the 16th century so improve native diet that population growth actually accelerated during the heyday of the slave trade. It is very difficult to come to any positive

[2] Guinnane (2021) demonstrates how MJ round population estimates as they cross certain thresholds, and how this introduces systematic bias because the rounding is larger at larger populations. This bias is not serious in the African numbers. Only 11 African population estimates cross one of these rounding thresholds, and these are the lowest thresholds. Nine cross the 1 million threshold and two cross the 10 million threshold.

> conclusions particularly as we have no knowledge at all of such factors as whether contact with Europe brought new diseases as well as new foods. *The fair conclusion would seem to be that the Atlantic slave trade was of great importance to the demography of the Americas but of no lasting quantitative significance to Africa* (p. 214)."

We quote MJ at length to show that they did not concoct their data to show how devastating the slave trade was for African population growth. Much of the literature addressing the population effects of slave exports focuses on the peak effects of the trans-Atlantic slave trade between 1750 and 1850, and whether or not these large exports reduced the *size* of African population. But earlier and smaller exports from smaller population could have reduced growth over longer periods of time. In addition, there is evidence that maize cultivation did little more than increase slave exports (Cherniwchan and Moreno-Cruz 2019) and that polygyny does not necessarily increase fertility (). MJ, and Maddison who relies on MJ, place the population of Africa at 16.5 million in the year 1 AD and 33 million in the year 1000 AD, at which time the Muslim trades were extracting Africans from the continent. By 1500 they estimate a population of 46 million and the rate of growth thereafter exhibits a perceptible slowing. Yet, they conclude that the Muslim and Christian slave trade had no appreciable effect on the growth of African population because the exports at the end of the trade (1750-1850) may not have reduced the size of the population.

This conclusion, we contend, is unwarranted. As such, one can think of our analysis as one designed to answer the question that MJ could not. We regress MJ estimates of African populations between 1 AD and 1900 on measures of spatial and temporal exposure to international slave trades to see if exposure reduced *the rate of growth* of African population and the ultimate size of the African population in 1900.[3] MJ often aggregate nation-states into regional population estimates, like "West Africa" or "Equatoria." We do the same for our measures of exposure to international slave trades. We do not disaggregate these regions into what Guinnane (2021) calls "hard clones" of individual states because these simply add noise without adding new information about rates of change. We find that exposure to the Atlantic slave trades and the intensity of exposure to the both Muslim and Atlantic slave trades had large negative effects on the growth of African population.

[3] We are forced to end our analysis in 1900 rather than 1850 when the Atlantic slave trade virtually ended because MJ have few observation on 1850 population but many more for 1900.

Measures of Exposure to Slave Trades

Spatial and temporal intensity of exposure. A widely-used measure of the intensity of exposure to international slave trades is the estimate of slave exports per African country developed by Nunn (2008). These are the estimated numbers of slave exports, but are limited to the trans-Atlantic and Indian Ocean slave trades after 1500. They are not available for the Red Sea and trans-Saharan slave trades or any slave trades before 1500. Nunn (2008) used the total number of exports between the 16th and 19th centuries, but these total were built up from estimates of exports for ethnicities found in the EA for each century between the 16th and the 19th. Figures 1-8 in the Appendix map these ethnicity-century estimates for the trans-Atlantic and Indian Ocean slave trades. They are converted into century measures per state by weighting ethnicities by their shares of the state's territory. The measure of intensity of exposure divides exports by population.

Dummy variables for exposure. Nunn's intensity measures have limited coverage. They are only available for the trans-Atlantic and Indian Ocean slave exports, and only for the 16th thru 19th centuries. They are not available for the trans-Saharan and Red Sea slave trade, yet all of the slave trades except the trans-Atlantic slave trade began before the 16th entury. In addition, some states were exposed to more than one slave trade, like states in the western and eastern Sahel. To account for this, we consult the historical record and Figures 1-8 to assign dummy variables that take the value 1 when a state's area exported slaves into any of the four international slave trade. Unlike the export numbers, the dummy variables do not account for the intensity of exposure, but they do have complete coverage spatially and temporally. Sometimes it will be convenient to refer to the Red Sea, Indian Ocean and trans-Saharan slave trades collectively as the Muslim slave trades.

Spatial measures of the intensity of exposure. We complement the complete coverage of the dummy variables on exposure with independent data on the intensity of exposure, which also have complete coverage. These are the average travel times from anywhere in the state or region to the nearest international slave port. Travel times are taken from Whatley (2022) who estimates travel times to the nearest port for each ethnicity found in Murdock's Ethnographic Atlas. The travel times per state or region are the weighted averages of these travel times, where the weights are the ethnicities' shares of the state or regional territory. Two variables are calculated. Travel time to the nearest Atlantic or Indian Ocean slave port divides the African continent along a north-south axis, and travel time to the nearest trans-Saharan or Red Sea slave port runs along an east-west line through the Sahel. These are calculated for every African state and region. See the maps in Figure

9. They do not vary over time but they capture some state-level variations in the intensity of exposure once a coast (ocean or Sahel) is exposed to an international slave trade. They are also available for all four slave trades.

Tsetse Fly Suitability Index. Estimated travel times do not account for horse and camel travel, so we add the Index of Tsetse Fly Suitability developed by Alsan (2015). The tsetse fly was devastating to horses and camels, so the index is highly negatively correlated with the availability of camels and horses for travel and transport. Together, the estimates of travel time and the Tsetse Fly Suitability Index capture variation in inland exposure to international slave ports.

Methodology and Results

As our data constitute a panel, we first specify the population growth process of African countries within both a pooled Ordinary Least Squares (OLS) and Generalized Least Squares (GLS) estimation framework. Given the long time period under consideration, a GLS framework enables the capturing of possible heteroskedasticity and autocorrelation both within and across countries. In particular, we estimate the parameters that condition population growth in Africa from the following specification:

$$y_{it} = \mathbf{x}'_{it}\boldsymbol{\beta} + \epsilon_{it}$$

If (1) $E(\epsilon_{it}^2 \mid \mathbf{x}_{it}) = \sigma^2$, (2) $E(\epsilon_{it}\epsilon_{is} \mid \mathbf{x}_{it}) = 0$ (t ≠ s), and (3) $E(\epsilon_{it}\epsilon_{jt} \mid \mathbf{x}_{it}) = 0$ (i ≠ j), then pooled OLS is adequate. As these restrictions may not be satisfied we also estimate GLS specifications allowing for heteroskedasticity, panel-specific and common autocorrelation of order one errors.

As the OLS and GLS parameter estimates are parametric and do not necessarily identify a causal treatment effect which may limit their interpretation, we also estimate the treatment effect of the Slave trades on population growth in Africa within the nonparametric Rubin potential outcomes causal framework (Rubin, 2005). In particular, conditional upon relevant covariates, we estimate with a matching estimator, the effects of the treatment on the treated—African countries actually exposed to the Slave trades—where the outcome and treatment does not depend upon any explicit functional form. As in Price and Robinson (2022), within the Rubin potential outcomes framework our sample can be characterized by (Y_i, X_i, T_i), where the Y_i are population growth outcomes for the treated and untreated states of Y(1) and Y(0) respectively, the X_i are covariates measuring country characteristics, and the T_i are treatment indicators for whether a country was exposed to the Slave trades. For M potential matches on countries exposed to the Slave trades, the imputed potential outcomes are $\hat{Y}_i(0) = Y_i$ if $T_i = 0$, $\hat{Y}_i(0) = \frac{1}{M}\sum_{j \in l_{m(i)}} Y_j$ if $T_i = 1$, $\hat{Y}_i(1) = \frac{1}{M}\sum_{j \in l_{m(i)}} Y_j$ if $T_i = 0$, and $\hat{Y}_i(1) = Y_i$ if $T_i = 1$, where $l_m i$ is an index l for $T_l \neq T_i$ that satisfies $\sum_{j|T_j \neq T_i} 1[||X_j - X_i|| \leq ||X_l - X_i||] = m \in M$. The indicator function $l(\cdot)$ selects and matches countries not exposed to the Slave trades—with index j—that are the m^{th} closest to countries exposed to the Slave trades governed by the distance norm $|| \cdot ||$.

In a sample of N observations with N_1 treated and N_0 controls, we estimate the treatment effect for those African countries actually exposed to the slave trades defined as follows (Abadie et al., 2004):

$$\tau_T^P = \frac{1}{N_1}\sum_{i:T_i=1} [\hat{Y}_i(1) - \hat{Y}_i(0)]$$

If selection into the treatment is based on observables, τ_{T}^{P} enables inference on the causal effect of the slave trades with the use of so-called *counterfactuals*—an alternative state in which an individual African country is not actually exposed to the treatment (Shadish, 2010). Thus, the causal effect of the treatment is conceptualized as a comparison of the African countries in our sample in two possible states of the world; one in which they are exposed to the slave trades, and one in which they are not. When estimating the treatment effects of the slave trades, the generation of the counterfactual is enabled by the matching distance function which compares treated countries with untreated countries that have similar characteristics in the covariates in **x** *iiii*.

Table 1 reports a summary of our data. Our dependent variable of interest is the growth rate of the population for the African countries in our sample.[4] The differences in population growth rates over the sample period---not depicted in Table 1—is approximately .14 and .29 for countries exposed and not exposed, respectively to the Atlantic slave trades. For the Muslim slave trades the population growth rates are .31 and .24 respectively—suggesting that relative to the Atlantic slave trades, the Muslim slave trades were not harmful, but instead beneficial for population growth rates in Africa. Below, we aim to determine if exposure to the distinct slave trades can explain population growth rates consistent with the simple averages in the sample.

As the slave trades alone are not the only conditioning factor of African population growth, we include additional controls in our specification of $\mathbf{x}_{it}$. To the extent that initial population conditions population growth (Kremer, 1993), we include for each country, its population in year one. As there is evidence that the presence of the tsetse fly—unique to Africa—reduced both animal travel and population density (Alsan, 2015), we include as a covariate the Tsetse Fly Suitability Index for each country or region. Given evidence that distance to slave ports is a determinant of slave exports (Nunn, 2008; Whatley 2022), we include as control covariates hours to the nearest Atlantic/Indian Ocean port and hours to the nearest Saharan/Red Sea port. Lastly, to the extent that there are population dynamics obscured by countries in our sample that are coded in broad geographical groupings, we include a dummy variable for such country grouping.[5]

The OLS and GLS parameter estimates are reported in Tables 2 - 4.[6] We report parameter estimates across 12 specifications. The first three, in columns 1 - 3 of Table 2, are of primary interest. They estimate, via dummy variables, the effects of the slave trades on the expected value of population growth conditional upon the other covariates in $\mathbf{x}_{it}$. It is possible that the estimated sign and magnitudes of the slave trade dummies may be sensitive to the intensity of the distinct Atlantic and Muslim slave trades. Travel time to port picks up some of the effects of intensity in that proximity to slave port increases the probability of exposure (Whatley, 2022) The remaining specifications in Tables 2 - 3 consider an additional measure of intensity, as measured by the ratio of slave exports to population, to determine if the intensity of exports matters for population dynamics, like the ability to defend against attack by others. This enables some insight and inference as to how robust the effects of the slave trades are as measured by the dummy variable specifications in columns 1 - 3 of Table 2, which have the largest number of representative observations to estimate the slave trades effects. As a goodness-of fit measure, we report the RR^2

[4] The data are available upon request from the authors.

[5] For example, while the majority of our data include measurements for particular singular-named countries, there are measurements for broad African geographies such as “West Africa" which contained many separate countries.

[6] All parameter estimates were done in Stata 15.0 with the *regress* and *xtgls* commands.

for the OLS specifications.[7] An F-test and Chi-square test for the Null hypothesis of joint zero restrictions on the estimated coefficients are reported for the OLS and GLS specification respectively. We also report the Akaike Information Criterion (AIC) for each specification, to enable selection of the relevant specification that best characterizes the effects of the slave trades on population growth.[8]

The first 3 columns of Table 2 report our core parameter estimates of interest. Across the OLS and GLS specifications the estimated coefficient for the Atlantic slave trades is always negative and statistically significant, whereas that on the Muslim slave trades, while negative, is not statistically significant. This suggests that exposure to the Atlantic slave trades, and not the Muslim slave trades, reduced population growth in Africa. The minimum AIC is for the pooled OLS estimates. Thus, notwithstanding panel-specific heteroskedasticity and panel-specific or general autocorrelation of order one, the pooled OLS estimates are associated with the lowest information loss. The coefficient estimate on the Atlantic slave trade dummy implies that relative to African countries on average over the time period under consideration, countries exposed to the

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[7] For GLS, sums of squares are not necessarily bounded between zero and one and do not explain the percentage of total variation in the regressand that is accounted for by regressors as in OLS.

[8] Given the absence of a comparable R 2 for the GLS specification, the AIC is based upon a regression of the predicted GLS value on the actual value of the dependent variable—the population growth rate.

Atlantic slave trades experienced a reduction in population growth of approximately .38 relative to the average population growth rate for the continent. This effect also constitutes the estimated marginal effect of the Atlantic slave trade—evaluated at the mean of the covariates—on African population growth.

If all of the covariates in the specification for the Pooled OLS estimates in column 1 of Table 2 were zero, the predicted average growth rate in population would have been approximately 69 percent. This suggests that exposure to the Atlantic slave trade reduced the population growth rates of African countries by approximately (.69 - .38)/(.69) = 45 percent over the time period under consideration—year 1 to 1900. This predicted percentage change coheres with the sample percentage change (.29 - .14)/.29= 52 percent. Thus, the predicted difference in population growth rates conditioned on Atlantic slave trades is approximately 86 percent of the difference in the actual unconditional population growth rates conditioned on the Atlantic slave trades.

The remaining parameter estimates in columns (4) - (12) across Tables 3 - 4 consider the extent to which the intensity of the Atlantic and Indian Ocean slave trades, as measured by the ratio of each trades exports to a country's population, can inform the robustness of our slave trade dummy variables. In particular, the actual intensity of people lost to the slave trades, not just their proximity to slave port, could result in distinct population dynamics that lead to some bias in the dummy variables capturing overall exposure to the slave trades. Across the specifications we swap out the dummies for the Atlantic and Muslim slave trades and replace them with the slave export intensity ratios for the Atlantic and Indian Ocean slave trades. In all these cases it is the Atlantic slave trade that reduces population growth.

Of course, our parameter estimates are not necessarily causal. To enable a causal interpretation, Table 5 reports nonparametric matching treatment parameters based on the Rubin potential outcomes causal framework. These estimates enable matching each treated country—those exposed to the slave trades—with their counterfactual matches. We consider two treatments. The first one is just the binary treatment captured in our OLS/GLS specifications in columns (1) - (3) Table 2—exposure to the Atlantic and Muslim slave trades. Second, given the sign and statistical significance of the Atlantic slave trade export intensity variable in columns (4) - (12) across Tables 2 - 4, we create a binary treatment based upon whether the Atlantic and

Indian Ocean slave export intensity was in the upper quartile for all countries. This essentially measures the effects of slave export intensity outliers on population growth, as measured by it being in the upper tail of the interquartile range—a standard measure of normal dispersion in a distribution.

Table 5 reports treatment effect parameter estimates.[9] As there is evidence that matching achieves minimum root mean square error and median absolute error with bias-adjustment when using 4 matches with replacement (Abadie and Imbens, 2002; 2006), the treatment effect parameter estimates are based on 4 Mahalanobis distance nearest neighbor matches with replacement. To allow for heterogeneity in treatment effects, the parameter estimates are estimated with robust standard errors—also with 4 matches. To capture the treated individual's counterfactual non-treated state as precise as possible, the treatment effect parameters are estimated with exact matching, and with bias adjustment on all the covariates.

For the binary treatment of exposure to the slave trades, the treatment effect parameter estimates are similar to the OLS/GLS parameter estimates in columns (1) - (3) of Table 2. Only the Atlantic slave trade has a statistically significant and negative effect on population growth, however the estimated magnitude is smaller, -.25 rather than -.38. With respect to export intensity, both the Atlantic and Indian Ocean slave trade had a negative and statistically significant effect on population growth, with that of the Indian Ocean slave trades being slightly larger. This suggest that being exposed to large numbers of exports relative to population—in the upper quartile— had the effect of reducing population growth in Africa for both the Atlantic and Indian Ocean slave trades.

[9] All parameter estimates were estimated with Stata 15.0 using the *nnmatch* (Abadie et al., 2004) command. The matching is on the basis of all the covariates in our core specification in columns (1) - (3) of Table 2, and each parameter—the effect of the treatment on the treated—is estimated as its sample analogue.

Counterfactual African Populations

While our treatment parameter estimates suggest that slave export intensity in the upper quartiles for both the TransAtlantic and Indian Ocean Slave trades adversely impacted population growth in Africa, the dummy variable parameter estimates capture exposure to the trades more generally, our estimates suggests that it is was the Trans-Atlantic slave trades that mattered for population growth. In general, our regression parameter estimates suggest that the TransAtlantic Slave trades reduced the average population growth rate of exposed countries by 25 percent. In our sample of countries the post-1500 average growth rate for countries not exposed to the trans-Atlantic slave trade is .18, and for countries exposed to the slave trade it is .14—a 22 percent reduction. A credible counterfactual, therefore, is this: *what would the 1900 African population have been had there not been a 22 percent reduction in the population growth rate for countries exposed to the Atlantic slave trade?*

To calculate the counterfactual population, we assume population grows continuously. The continuous population growth regime has two-parts: Up to 1500 and after 1500 through 1900. The growth rates for each regime are based upon the sample population growth averages in each period conditional upon exposure or not to the TransAtlantic Slave trades. In the second period, the growth rates for countries exposed and not exposed to the TransAtlantic Slave trades are utilized. Initial populations are the average population for the countries at the start of the period.

Up To 1500: A_0 exp(.379 x 3) = 3.11, where .379 is the average growth rate of population, 3 = number of time periods. For A_0 = 1 million (average year 1 population): 3.11 x number of countries in sample for the period = 3.12 x 18 = 56.16 million persons.

After 1500 (No exposure to Atlantic Slave Trades): A_0 exp(.18 x 5) = 3.81, where .18 is the average growth rate of population for countries not exposed to the Atlantic Slave Trades , 5 = number of time periods. For A_0 = 1.55 million (average year 1500 population for countries not exposed to Atlantic slave trades): 3.81 x number of countries in sample for the period = 3.81 x 11 = 41.91 million persons.

After 1500 (Exposure To Atlantic Slave Trades): A_0 exp(.14 x 5) = 7.97, where .14 is the average growth rate of population for countries exposed to the Atlantic slave trades , 5 = number of time periods. For A_0 = 3.96 million (average year 1500 population): 7.97 x number of countries in sample for the period = 7.97 x 7 = 55.79 million persons.

After 1500 (Counterfactual for Exposed Countries): If the population of countries exposed to the Atlantic Slave Trades had grown at the same rate of countries not exposed, the populationwould have been determined by A_0 exp(.18 x 5) x 7 = 9.74 x 7 = 68.18 million. This implies that, counterfactually, if the population of African countries exposed to the TransAtlantic slaves trades had grown at the same rate of countries not exposed, the population in 1900 would have been 56.16 + 41.91 + 68.18 = 166.25 million people and the Atlantic slave trade reduced population by approximately 68.18 – 55.79 = 12.39 million individuals in 1900.

Discussion/Conclusion

The results of our regressions allowed us to build-up population estimates from historical data. Frankema and Jerven (2014) use demographic growth regimes from Asia to project 20th century African population data back in time. Our 1900 estimate is 153.86 million, almost identical to Manning's estimate of 151.2 and only 4-12 percent higher that Frankema and Jerven's estimates of 137.1-147.4.

The value of our exercise, however, is the ability to calculate the counterfactual 1900 population, which is approximately 13-21 percent higher than the others. This is a minimum effect of the slave trades in that we do not account for population losses due to the intensities effects of both the trans-Atlantic and Indian Ocean slave trades, and presumably the other Muslim slave trades as well. Also, the structure of our data forced us to estimate the effects of the slave trades on the 1900 population, but the Atlantic slave trade virtually ended by 1850. Frankenma and Jerven (2014) estimate that African population grew by 23 to 24.7 million people between 1850 and 1900. This growth is a recovery from the slave trade era, yet we still estimate a 12.39 million loss by 1900. Even these minimum effects disprove MJ and others who argue that the slave trade had no effects on African population.

Another advantage of an approach that uses historical population numbers is that we can speculate on what they imply about African population history. First, note that the .379 average growth rate for all countries before 1500 is consistent with the iron-age Bantu expansion of population through and around the rainforests of central Africa, with its associated population explosion. This period also witnessed the rise of several great medieval African Empires like Ghana and Mali in the Western Sudan, Benin in southeast Nigeria, Kongo in Southwest Africa and Great Zimbabwe on the Southeast Plateau. Each of these empires collapsed after 1500.

Second, note that after 1500 all African countries in our sample grew at a slower pace. While countries exposed to the Atlantic slave trade grew at only 14 percent, countries not exposed to the Atlantic slave trade grew at only 18 percent. Our regressions imply that the growing intensity of the Indian Ocean slave trades (and presumably other Muslim slave trades) slowed population growth too, so our estimate of the Atlantic losses and the counterfactual populations may be vastly underestimated.

Third, the population losses we estimate are close to the 13 million enslaved Africans exported into the trans-Atlantic slave trade between 1500 and 1850, as estimated by the Trans-Atlantic Slave Trade Database. One might ask why these losses were not replaced over such a long period of time. One reason is that the actual population losses that generated the 13 million exports includes collateral fatalities associated with the conflict, wars, kidnapping and violence involved in capturing people and marching them to the coast. Our counterfactual estimates imply that some of these collateral fatalities were recovered by 1900 but not all of them.

Fourth, recent econometric studies have highlighted the effects of the slave trades on economic fundamentals like social trust, credit availability, polygyny, savings, ethnic stratification and slavery itself – all of which reduce cooperation, wealth accumulation, innovation, specialization and trade, and ultimately population growth.[10] To the extent that more people and less social disruption would have induce more of the kinds of innovation and technological change that increases factor productivity (Kremer, 1993) and ultimately more population growth (Clark 2007; Galor 2005, 2011), our estimates suggest that the Atlantic slave trades, and the intensity of both the Atlantic and Muslim slave trades, constrained technological progress and material living standards in Africa.

[10] See 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 (2020), Pierce and Snyder (2018), Besley and Reynal-Querol (2014), Bhattacharyya (2009).

Table 1

Statistical Summary of Variables

Variable	Mean	Standard Deviation	Number of Observations
Population [aa] (Millions)	3.42	4.53	116
Population Growth Rate	.271	.306	72
Tsetse Fly Suitability Index	-.1570	.3185	143
Hours to Nearest Atlantic/Indian Port [bb]	274.83	136.08	144
Hours to Nearest Saharan/Red Sea Port [cc]	295.89	175.28	144
Country Group	.389	.489	144
Population in Year One	1.09	1.08	144
Atlantic Slave Trade (Binary)	.111	.315	144
Muslim Slave Trade (Binary)	.361	.482	144
Ratio of Total Atlantic Slave Exports To Population [d]	.017	.069	89
Ratio of Total Indian Ocean Slave Exports To Population [e]	.007	.023	55

The data are for the years 1, 1000, 1500, 1600, 1700, 1800, 1850 and 1900. The sample consists of African countries, or in some instances broad geographical regions with no singular country name, which can be viewed as groups of countries. These countries/groups are: Algeria, Egypt, Equatoria, Ethiopia, Kenya, Libya, Morocco, Namibia-Botswana, Rwanda-Burundi, Sahel, Swaziland-Lesotho, South Central Africa, Somalia, Sudan, Tanzania, Tunisia, Uganda, and West Africa.

Table 2
The Effect of the Slave Trades On African Population Growth:
OLS/GLS Parameter Estimates

Specification:	**(1)** Pooled OLS	**(2)** Panel GLS heteroskedastic errors with panel-specific autocorrelation of order one	**(3)** Panel GLS heteroskedastic errors with common autocorrelation of order one	**(4)** Pooled OLS
Constant	.6870	.5559	.6369	.4776
	(.000) [a]	(.000) [a]	(.000) [a]	(.001) [a]
Tsetse Fly	.149	.1600	.1051	.1739
Suitability Index	(.248)	(.095) [c]	(.260)	(.238)
Hours to Nearest	-.0009	-.0008	-.0009	-.0007
Atlantic/Indian Port	(.007) [a]	(.000) [a]	(.000) [a]	(.034) [b]
Hours to Nearest	-.00002	.0001	.00003	.00008
Saharan/Red Sea Port	(.933)	(.488)	(.869)	(.651)
Country Group	.0406	.0596	.0209	.0211
	(.687)	(.466)	(.794)	(.798)
Population in	-.0635	-.0465	-.0481	-.0632
Year One	(.055) [b]	(.014) [a]	(.046) [b]	(.077) [b]
Atlantic Slave	-.3812	-.3276	-.3726	
Trade	(.000) [a]	(.000) [a]	(.000) [a]	
Muslim Slave	-.0516	.0028	.0211	
Trade	(.552)	(.966)	(.762)	
Ratio of Total				-.8642
Atlantic Slave Trade				(.000) [a]
Exports to Population				
Ratio of Total				.2581
Muslim Slave Trade				(.865)
Exports to Population				
$H_o: \beta_k = 0, \forall k$				
(χ^2_k)		98.37 [a]	69.69 [a]	
($F_{k,n-k}$)	6.86 [a]			7.26 [a]
R^2	.362			.00
Number of Observations	72	71	71	47
Akaike Information Criterion	4.48	5.55	5.85	-13.09

NOTES:
Approximate p-values are in parentheses.
[a] Significant at the .01 level.
[b] Significant at the .05 level.
[c] Significant at the .10 level.

Table 3
The Effect of the Slave Trades On African Population Growth:
OLS/GLS Parameter Estimates

Specification:	**(5)** Panel GLS heteroskedastic errors with panel-specific autocorrelation of order one	**(6)** Panel GLS heteroskedastic errors with common autocorrelation of order one	**(7)** Pooled OLS	**(8)** Panel OLS heteroskedastic errors with panel-specific autocorrelation of order one
Constant	.4235	4442	.7076	.5602
	(.000) [a]	(.000) [a]	(.000) [a]	(.000) [a]
Tsetse Fly	.1266	.0980	2045	.3257
Suitability Index	(.001) [a]	(.140)	(.188)	(.000) [a]
Hours to Nearest	-.0008	-.0008	-.0009	-.0008
Atlantic/Indian Port	(.000) [a]	(.000) [a]	(.006) [a]	(.000) [a]
Hours to Nearest	.0001	.0001	.00004	.0002
Saharan/Red Sea Port	(.092) [c]	(.091) [c]	(.878)	(.305)
Country Group	.0477	.0208	-.0067	.0607
	(.275)	(.642)	(.946)	(.396)
Population in	-.0501	-.0426	-.0789	-.0861
Year One	(.000) [a]	(.009) [a]	(.048) [b]	(.000) [a]
Atlantic Slave Trade				
Muslim Slave			-.0483	-.0167
Trade			(.609)	(.792)
Ratio of Total	-.8171	-.8516	-1.31	-1.47
Atlantic Slave Trade	(.000) [a]	(.000) [a]	(.000) [a]	(.000) [a]
Exports to Population				
Ratio of Total	.0747	-.2153		
Muslim Slave Trade	(.927)	(.866)		
Exports to Population				
$H_o: \beta_k = 0, \forall k$				
(χ^2_k)	898.93 [a]	115.71 [a]		122.88 [a]
$(F_{k,n-k})$			9.43 [a]	
R^2			.381	.00
Number of Observations	42	42	64	63
Akaike Information Criterion	-12.52	-12.39	8.06	9.61

NOTES:
Approximate p-values are in parentheses.
[a] Significant at the .01 level.
[b] Significant at the .05 level.
[c] Significant at the .10 level.

Table 4
The Effect of the Slave Trades On African Population Growth:
OLS/GLS Parameter Estimates

Specification:	**(9)** Panel GLS heteroskedastic errors with common autocorrelation of order one	**(10)** Pooled OLS	**(11)** Panel GLS heteroskedastic errors with panel-specific autocorrelation of order one	**(12)** Panel GLS heteroskedastic errors with common autocorrelation of order one
Constant	.7974	.5144	.4284	.4895
	(.000) [a]	(.001) [a]	(.000) [a]	(.000) [a]
Tsetse Fly Suitability Index	.0483	.1228	.1272	-.0004
	(.716)	(.329)	(.077) [c]	(.995)
Hours to Nearest Atlantic/Indian Port	-.0012	-.0008	-.0008	-.0010
	(.000) [a]	(.014) [b]	(.000) [a]	(.000) [a]
Hours to Nearest Saharan/Red Sea Port	-.00009	-.00007	.00009	-9.1e-06
	(.663)	(.707)	(.464)	(.934)
Country Group	-.0623	.0850	.0809	.0404
	(.451)	(.355)	(.155)	(.525)
Population in Year One	-.0735	-.0454	-.0389	-.0124
	(.032) [b]	(.159)	(.013) [b]	(.448)
Atlantic Slave Trade		-.2936	-.2081	-.2386
		(.000) [a]	(.000) [a]	(.000) [a]
Muslim Slave Trade	-.1012			
	(.169)			
Ratio of Total Atlantic Slave Trade Exports to Population	-.9676			
	(.004) [a]			
Ratio of Total Muslim Slave Trade Exports to Population		.2644	.1791	-.3137
		(.857)	(.846)	(.848)
$H_o: \beta_k = 0, \forall k$				
(χ^2_k)	38.81 [a]		406.67 [a]	92.04 [a]
$(F_{k,n-k})$		6.19 [a]		
R^2		.409		
Number of Observations	63	47	42	42
Akaike Information Criterion	10.66	-15.23	-13.84	-13.25

NOTES:
Approximate p-values are in parentheses.
[a] Significant at the .01 level.
[b] Significant at the .05 level.
[c] Significant at the .10 level.

Table 5
The Effect of the Slave Trades On African Population Growth:
Treatment Effect Matching Parameter Estimates For Countries Exposed To The Slave Trades

Treatment:	Atlantic Trade Slave	Atlantic Slave Trade Export Intensity	Muslim Slave Trade	Muslim Slave Trade Export Intensity
τ_T^P	-.2533 (.001) [a]	-.1971 (.005) [a]	-.0202 (.817)	-.1975 (.007) [a]
Number of Observations	72	72	72	72
Number of Matches	4	4	4	4

NOTES:
Approximate p-values are in parentheses.
[a] Significant at the .01 level.

Trans-Atlantic Slave Exports

Figure 1. 16th Century

Figure 2. 17th Century

Figure 3. 18th century

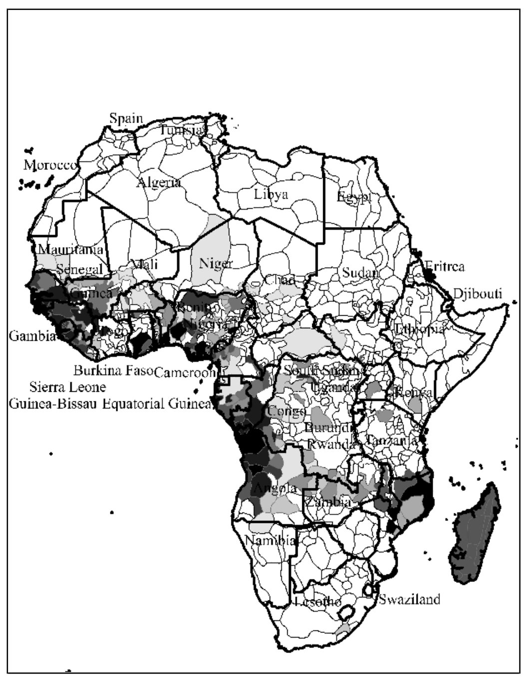

Figure 4.19th Century

Indian Ocean Slave Exports

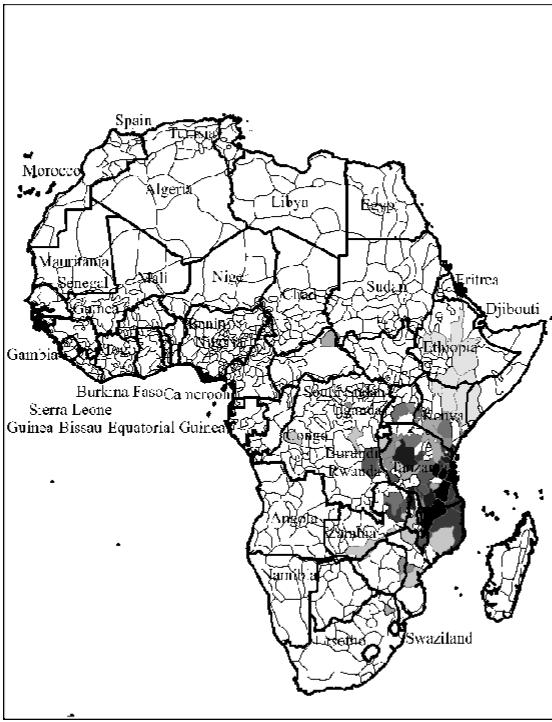

Figure 5. 16th Century

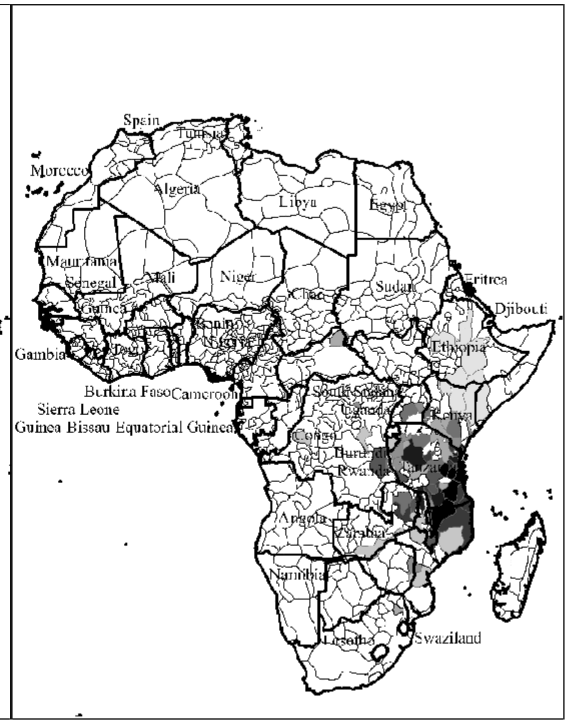

Figure 6. 17th Century

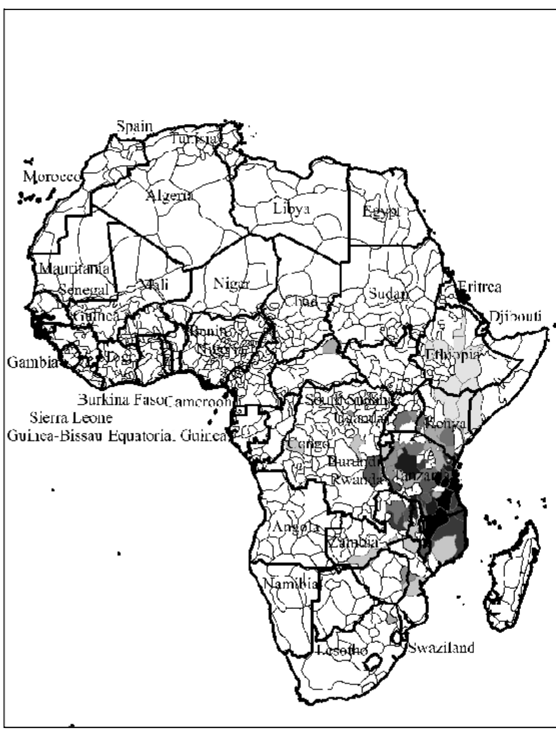

Figure 7. 18th Century

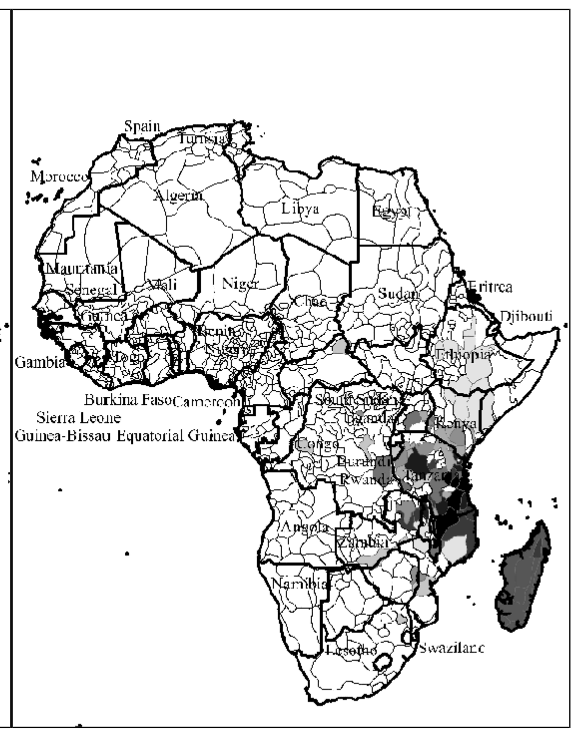

Figure 8. 19th Century

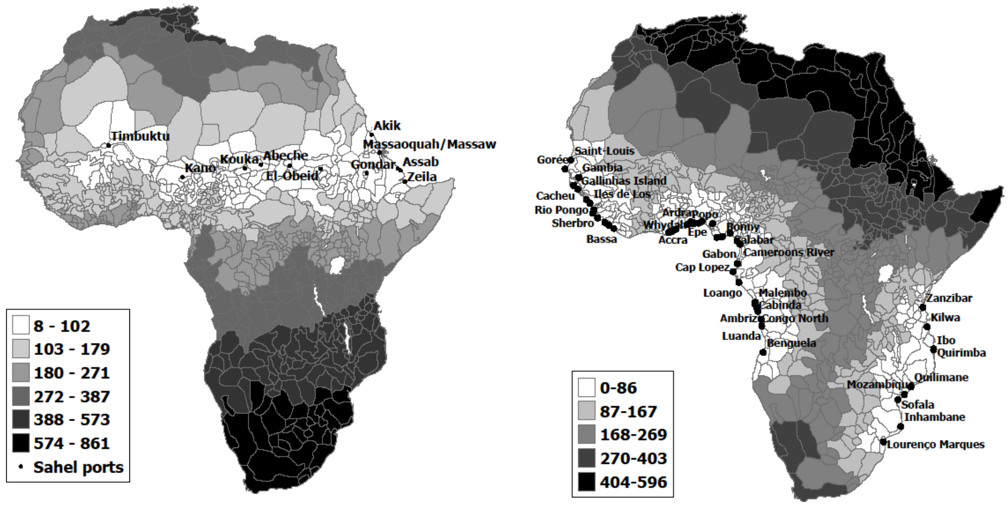

Figure 9. Hours to Slave Ports

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