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THE LABOR PRODUCTIVITY DIFFERENTIAL BETWEEN THE WEST INDIES AND WEST AFRICA: 1680-1830

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ABSTRACT

This paper is an empirical test of Stefano Fenoaltea's (1999) hypothesis that the labor productivity differential between the Americas and West Africa was insufficient to cover the high mortality and transport costs of the forced transatlantic migration of slave labor. Using data on slave hire rates and slave subsistence costs in the West Indies from the mid-17th to the early 19th century, we measure surplus-to-subsistence ratios in the Americas and compare those measures to estimates of the surplus-to-subsistence ratios in Africa. Since there is almost no data on labor productivity in precolonial Africa, we impute surplus-to-subsistence ratios for Africa using estimates of fertility derived from the consensus view that the annual population growth in West Africa prior to the mid-19th century was 0.2% to 0.3%. We estimate the surplus-to-subsistence ratio required to maintain this population growth rate. By comparing an upper-bound estimate of the surplus-to-subsistence ratios of slave laborers in the West Indies to a lower-bound estimate for subsistence farmers in West Africa, we conclude that the labor productivity differential between West Africa and the West Indies was insufficient to cover the transport and mortality costs of the slave trade.

Keywords: Slavery, Transatlantic, Labor Productivity, Africa, Trade Costs.
JEL Codes: N77, F2, J2.

Introduction and literature review

This paper will compare the productivity of slave labor in the West Indies and free agricultural laborers in West Africa between the late 17th

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century and the early 19th century using data, taken from secondary sources, on hire rates and subsistence costs for slaves in the West Indies as well as surplus to subsistence ratios in precolonial West Africa. The results of this comparison, between upper-bound estimates of labor productivity in the West Indies and lower-bound estimates of labor productivity in Africa, verify the hypothesis of Stefano Fenoaltea (1999) – that the intercontinental labor productivity differential was not large enough to have made the forced mass migration of African labor to the Americas economically efficient. We find that the cost of transporting slaves to the Americas and the high mortality rate of slaves, erase any increase in world output that can be attributed to the transatlantic slave trade.

Explanations for the economic causes of the transatlantic slave trade can be divided into two general categories: demand-side explanations which claim that high labor productivity in the Americas pulled labor from Africa and market-failure interpretations which argue that insecure property rights in slave labor in Africa caused by the ease with which captives could escape there led to the export of slave labor to the Americas where property rights in slave labor were more secure. Stanley Engerman (1973), Richard Bean (1975), and Herbert Klein (1978) all argue that labor productivity was low in Africa, but high in the Americas, hence these scholars conclude that the transatlantic slave trade was driven by American demand for African labor. Herbert Klein (1978: 3) argues that the "forced migration of peoples of sub-Saharan Africa to the New World was the direct outgrowth of a seemingly inexhaustible demand for labor on the part of European colonizing powers". Richard Bean claims that

> [t]he reason Africa provided so much of the un-free labor shipped to America was because Africans were available cheaply, and were more efficient than were most other types of labor. The choice between African, European, Asian, or Amerindian labor was a function of their relative costs and relative efficiencies (Bean 1975: 120).

In a rare empirical study of agricultural labor productivity in mid-18th century Senegambia, Rönnbäck and Theodoridis (2019) found that labor productivity on maize, cotton, and indigo plantations in the mid-19th century was far lower in Senegal and Gambia than the United States. Unfortunately, their data are of limited use in comparing labor productivity between Africa's major slave-exporting regions and the New World's most important slave-importing regions because Senegambia and the United States represented less than 10% of total transatlantic slave exports and imports. Furthermore, they (*ibid.*) provide no information on labor productivity in sugar cultivation – the sector where the vast majority of slave labor was deployed. They also describe a period decades after British Aboli-

tion when the volume of slave exports from West Africa had plunged. To accurately assess the labor productivity differential between Africa's major exporting and the New World's most important regions, investigators must find data or develop labor-productivity estimates for the regions and time periods most representative of the transatlantic slave trade.

Scholars specializing in the economic history of Africa such as Philip Curtin, Robert Harms, and Patrick Manning have explained the origins of the transatlantic slave trade differently from scholars like Bean, Engerman, and Klein who study the economic history of the Americas. Scholars of African economic history have explained the trade as a response to a differential in the exploitability of slave labor between the Americas and Africa. For example, Philip Curtin (1979) and Robert Harms (1981) have both argued that slaves were less exploitable in Africa because proximity to the point of capture made it difficult to prevent escape or revolt. The further slaves were taken, the more valuable they became because the chances of their escaping or revolting declined the further they were moved from home.

Low African slave prices result from the uncertainty of property rights in slave captives within Africa. Curtin (1979: 116) compares the cost of raising a child to a productive age of fourteen and finds the cost to be significantly higher than the nominal cost of a fully grown slave captive.

The major weakness in Curtin's diagnosis is that the food price data that he uses, for food purchased in Africa by Europeans for use as provisions during the middle passage, included the high costs of hauling and loading the food aboard European ships. Since loading costs for food were likely to be higher than the loading costs for slaves, high food prices relative to low slave prices originate in differences in their relative mobility. Subtracting loading costs from final food and slave prices would probably reduce the high food to slave price ratio significantly and thus undermine Curtin's contention that, in Africa, it cost more to raise a child to the age of fourteen than it cost to purchase a fully grown slave captive.

A second weakness in the relative exploitability model found in work by Africanists is that if relative exploitability were a simple function of distance from the point of capture, exploitability would increase with distance going in any direction away from the point of capture, but in fact prices rose only in the direction of the slave exporting coast. Furthermore, if the percentage of surplus that an owner could appropriate from his labor force was higher given a lower risk of slave rebellion or escape, the greater the exploitability and hence value of women and child slaves in Africa, nevertheless women and children were a clear majority in the Indian Ocean and trans-Saharan trades. If relative exploitability were the primary concern, then the slaves that were exported should have been those most likely to escape or rebel – the men rather than the women and children.

Patrick Manning was the first to note that slave prices were not equivalent, as is the case when markets function well, to the marginal physical product of their labor.

> The level of productivity – the value of the output of an African man or woman – was the most basic determinant of slave prices. But when we note, for instance, that the average price of slaves rose by a factor of from five to six over the course of a century, we can be sure that this does not mean the productivity of African workers increased by a similar factor (Manning 1990: 93).

Manning attributes the disjuncture between low slave prices and high African levels of labor-productivity to a local inability to efficiently exploit slave labor. Because property rights in slave captives were relatively insecure in Africa, most captives were destined for labor in the Americas. Manning claims that

> prices of slaves in Africa were also held down by the limited demand for slave labor or for slave produced produce: while monarchs relied on slaves to produce for the palace entourage, few other Africans had the wealth to sustain many slaves, nor could they find purchasers for goods the slaves might produce (Manning 1990: 30).

1. Estimating the labor productivity differential between Africa and the Americas

Because there is no data on the hourly productivity of labor in Africa or the Americas in the era of the transatlantic slave trade, this paper compares the net lifetime output of individual laborers in Africa and the West Indies. The vast majority of production, investment, and savings in Africa was devoted to reproducing the population, thus the ratio of surplus product to subsistence needs can be estimated based on the number of children Africans, on average, must have had for the population there to have remained stable or to have grown at a slightly positive rate. Patrick Manning (1990: 196) estimates Africa's population growth rate to have been 0.3 to 0.5 percent throughout the era of the transatlantic slave trade.

In the Americas, with few exceptions, the slave population had a negative natural rate of growth and, until the end of the 18th century, most slaves had few or no children. Thus, the proportion of output that constituted a surplus must be estimated differently. Slave-labor productivity can be calculated using daily hire rates for slaves on Caribbean sugar plantations. Slaves were hired for periods of acute labor need, during planting or harvest periods, when slave-labor productivity per day was likely to be especially high. Hire rates are used to measure labor productivity for two reasons. Firstly,

the hire rate would approximate the market value of a slave's marginal physical product; the more productive a slave was expected to be by virtue of physical strength, special skills, and level of work-experience, the greater the hire rate they could command. The second reason for choosing hire rates in the Caribbean as a proxy measure for a slave's surplus product is that the data on subsistence costs, to be paired with slave hire rates, come from the same West Indian sugar plantations and for the same dates for which hire rates exist.

Comparing the ratio of surplus to subsistence levels in Africa and the Americas bypasses the problems of converting other nominal labor-productivity measures into comparable units of real value. If the surplus to subsistence ratio increased by more than the transportation and mortality costs of the slave trade, then the forced slave migration produced more value than it erased via mortality and expensive transportation.

Price data in this study are quoted in pounds sterling for reasons of convenience and accuracy. The pound's value in terms of gold was constant throughout the era of the slave trade (Jastram 1977: 26). Data on wholesale commodity prices in England between the 1640s and 1795, when the English were heavily involved in trading and using slaves, point to negligible levels of inflation. The pound's ubiquity in source material, its stable purchasing power, and its constant value in terms of gold combine to make it the ideal unit of account for this study.

2. Labor productivity in Africa

Scholars generally agree that Africa, relative to Europe and even the Americas, was sparsely populated. According to Ester Boserup (1981), food production techniques evolve in response to the relative abundance or scarcity of land and labor. Where population densities are low, food is produced in ways that take advantage of land, yet economize on scarce labor. Hunting and gathering or long fallow systems of cultivation are almost never found in places where land is scarce relative to labor. As larger populations come to depend on a fixed amount of land for sustenance, cultivation techniques become more intensive: fallow periods are shortened, the number of crops grown each season is increased, irrigation systems are built, fertilizer is produced, and more sophisticated systems of land tenure evolve. In Africa, low population densities created an economy where most food was produced by hunting, gathering, or in areas of greater population, by 'extensive' rather than 'intensive' systems of cultivation. In Boserup's schema, areas of "bush fallow" or "forest fallow" agriculture, capable of sustaining a population density similar to Africa's, produce (at most) one or two

crops a year for one or two years followed by an eight-to-ten-year fallow period. Despite their use of primitive technology, extensive systems of cultivation are characterized by high labor productivity (Hayami and Ruttan 1971: 732). Cultivators in Africa worked fewer hours, on average, and were able to support a larger number of non-productive dependents, per-hour worked, than farmers in more densely populated Europe or Asia (Boserup 1981: 147).

Given the close link between land-to-labor ratios and labor productivity found by Boserup (1981), comparisons of population density between pre-colonial Africa and slave using economies in the Americas will, at the very least, prove how labor scarce Africa was in absolute and relative terms. According to Joseph Miller (1988: 7), the slave catchment area in West Central Africa including Angola was approximately 2.5 million square kilometers. Miller estimates that before 1830, the area had 12.5 million inhabitants and a population density of 1.54 persons per square mile. Ester Boserup (1981: 11) concurs and gives a population density range for tropical Africa between 1500 and 1750 of 0.386 to 1.54 persons per square mile. At the upper limit, according to Boserup (1981), food production in African, long-fallow agricultural systems would support densities of 5.8 persons per square mile, but no higher. There were, of course, pockets of high-density populations in Africa including some urban areas. Population densities in certain humid forest regions such as the Pende area in West Central Africa's forest were quite high. Curtin (1975: 28) finds that Sereer regions in mid-20th century Senegambia had a population density approaching 28.95 persons per square mile; Curtin credits the use of cattle manure for fertilizer and millet for cattle fodder with generating the surplus that enabled the high Sereer population density. Generally speaking, however, the few urbanized areas along the Gold Coast and in colonial enclaves were exceptions to the rule of low population density in Africa during the slave trade.

Before Europeans arrived, population density in the Americas was 0.386 to 1.54 persons per square mile – similar to population densities in tropical Africa (Boserup 1981: 11). The immigration of 10 million Africans and, by 1920, 60 million Europeans increased population densities in the Americas to levels far higher than in Africa. During the slave trade, however, all available data indicate that population density in the Americas was higher than in Africa. In the West Indian sugar colonies, the general rule of thumb was one acre of land per slave could produce one ton of unrefined sugar (Curtin 1990: 197). Even as output of sugar per acre rose, planters kept their slave-to-land ratio constant at one slave per acre. With one slave per acre or about 95 acres in a square mile, the population density of sugar plantation land would have been 95 slaves per square mile – far higher than any parcel of land in even the most densely populated regions of pre- colonial Africa.

Between 1771-1778 population and sugar production in Barbados peaked – a 166 square mile island supported a population of 89,000, meaning that Barbados had a population density of 79.53 persons per square mile. Jamaica had 276 times the land area of Barbados and, in 1771, still possessed much unused frontier land; its total population density was 7.72 persons per square mile (Sheridan 1973: 123). Data on population density for Africa and the Americas are enumerated in the tables below.

Tab. 1. *Population density in Africa*

Source	*Date*	*Place*	*Persons per square mile*
(Miller 1988: 7)	Before 1830	West Central Africa	1.54
(Miller 1988: 7)	1650-1700	Lunda Area (Desert area of Angola)	0.772
(Miller 1988: 7)	1650-1700	Pende Area (Southern Angola Forest)	15.44
(Curtin 1975: 28)	1950s	Sereer Region	23.16 – 28.95
(Curtin 1975: 28)	1950s	Wolof Region	3.86 – 11.58

Tab. 2. *Population density in the British West Indies*

Source	*Date*	*Place*	*Persons per square mile*
(Sheridan 1973: 123)	1771-1778	St. Kitts	55.5
(Sheridan 1973: 123)	1771-1778	Barbados	78.37
(Sheridan 1973: 123)	1771-1778	Nevis	45.56
(Sheridan 1973: 123)	1771-1778	Antigua	55.59
(Sheridan 1973: 123)	1771-1778	Montserrat	42.47
(Sheridan 1973: 123)	1771-1778	Jamaica	7.72
(Sheridan 1973: 123)	1771-1778	Grenada	34.7

We conclude that Africa was scarce in labor relative to the Americas in the 18th century. To the extent that high land-to-labor ratios suggest that labor was highly productive, then Africa, where labor was scarce and productive, was exporting its people to the Americas, where labor was less scarce.

3. Definition of surplus

Before continuing with the discussion on labor productivity in Africa, the term "surplus output" must be defined as the manner in which it is used here is unconventional. In the formulas below, "producers" are the able-bodied adults who produce enough food to cover their own subsistence needs as well as the subsistence needs of children, elders, and others who do not produce food.

Output = Subsistence of Producer + Surplus
w = average subsistence of food producers
c = average subsistence costs of 'non-productive' children and the elderly
K_t *= number of non-productive dependents at period t* Q_t *= total output at period t*
L_t *= total number of producers at period t* $Q_t = f(L_t)$
Surplus $= Q_t - wL_t = cK_t$ $K_t = \underline{Q_t - wL_t}$
c

$L_{t+1} = K_t$

So, if surplus is 0, $K_t = 0$ and $L_{t+1} = 0$. In Africa, surplus over subsistence ratios are defined as the number of non-productive dependents per worker or:

$\underline{cK_t} = \underline{K_t}$ if $c = w$ wL_t L_t

If $w > c$, then ratio for surplus over subsistence, given above, will overstate the surplus per worker.

Total output consists of subsistence output and surplus output; surplus output is that portion of total output which is not needed for the subsistence of the producer alone. Resources used to raise children and care for the elderly are here defined as surplus output because they are not consumed by the producer themselves. This way of defining surplus, as being equal to the maintenance cost of non-productive dependents is unusual because the cost of raising children is usually defined as subsistence, not surplus. In Meillassoux (1981: 55), for instance, subsistence is defined as total maintenance costs including food, clothing, health, shelter, education of non-productive dependents – children under 15 and elderly over age 45 – as well as productive members of a family. Ensuring that slaves did not have their own children allowed the slave's owner to maximize the appropriable surplus of a slave's output – the less used to care for the children of

slaves, the more that owners could appropriate for themselves. Since labor productivity in the Americas (where slaves were often childless) cannot be measured by counting the average number of offspring for slave couples, we compare the number of non-productive dependent producers in Africa could support with the hire rates divided by the subsistence costs of slaves in the West Indies in order to arrive at African and American surplus to subsistence ratios that allow a transcontinental comparison of labor productivity. This method bypasses unit and price conversion problems; also, there is virtually no data on surplus product from precolonial Africa. A conjecture on the minimum number of children necessary to maintain population levels will serve as an adequate lower-bound measure for surplus output in Africa.

Demographic historians and anthropologists believe that Africa's population grew at an annual rate of 0.3 to 0.5 percent (Manning 1990: 196). According to Meillassoux (1983: 53), men and women supported large families. In the Sahel, a male adult produced enough during his active life (between the ages of fifteen and forty-five) to bring up to the age of seventeen years about nine children (Meillassoux 1983: 53). The high African mortality rate made it necessary for women to have an average of about 4 surviving children for the population to continue to increase (Retel-Laurentin 1974). In addition to non-productive children, African producers generally had to support elderly non-productive dependents – mostly those surviving past age forty-five. If, as is the case for peoples living in difficult subsistence environments, most production, savings, and investment were devoted to reproduction and maintenance of the population then it is possible, from population growth rates, to estimate a lower-bound figure for the proportion of output which constituted the surplus. Though it is quite likely that some of the surplus generated in African subsistence agricultural societies was expended on items such as clothing, housing, ritual, war, and culture, at a minimum a couple in Africa supported two children and one elderly dependent if the population were to reproduce itself. If a couple had three non-productive dependents, then in addition to their own subsistence needs, the couple produced a surplus that was 1.5 times larger than their own subsistence requirement. If the number of children increased to four and there were no elderly dependents, the surplus would have been roughly two times the value of subsistence. At the upper limit, a couple with nine children, as Meillassoux claims was common in Africa during the slave trade, produced a surplus 4.5 times as large as their own subsistence needs.

In order to apportion the surplus produced by the man versus that produced by the woman, data or estimates of gender specific production is required. Based on data gleaned from field work done among sorghum eaters in the Sahel, Meillassoux (1986: 96) reports that an adult male con-

sumes approximately 300 kilograms of sorghum per year. He produces at least 1,000 kilograms a year while a woman in the same group produces 500 kilograms a year and consumes at least 180 kilograms. Together they support at least 3 non-productive dependents (each non-productive member consuming the annual average of 180 kilograms) for fifteen years if the man and woman remain productive between the ages of fifteen and forty-five. While men produce 67 percent of the surplus product, double the amount for women, they would have to produce an even larger proportion of the surplus if women had more children, since pregnant and/or lactating women have less time to work the more children they bear. It is difficult to be precise about the percentage of the surplus product men produced, but it would most likely rise above 67 percent with the birth of each extra child so that a couple with nine children would be twice as dependent on the surplus produced by the male as a family with only four non-productive dependents. The ratio of surplus over subsistence and the estimated proportion of the surplus generated by the male family member will vary with the number of non-productive members in a family unit as seen in Table 3.

Tab. 3. *Surplus over subsistence ratios in Africa*

Number of non-productive dependents	*Estimated proportion of surplus generated by male member*	*Surplus over subsistence ratio*
4	67%	1.34
5	70%	1.75
6	73%	2.19
7	76%	2.66
8	79%	3.16
9	82%	3.69

The reason for focusing on the labor productivity of a male with dependents is that African males made up a majority of African slave exports.

4. Labor productivity in the Americas

Whereas Africa's population had a slightly positive rate of growth, most slave populations in the Americas, especially those where first-generation arrivals from Africa were a majority, had negative rates of growth. The situation in Barbados was typical of many American sugar economies. Between 1712 and 1734, 75,898 slaves were shipped there, yet the island's

slave population rose by less than 5,000. Barbadian plantation records indicate that there was only one slave birth for every six slave deaths (Blackburn 1997: 423). Birth rates generally rose as the proportion of American-born slaves in a slave population increased. Slave population growth rates were positive only for slaves in temperate climates such as North America and Minas Gerais in Brazil. Until the end of the 18th century, African born slaves comprised the majority of all American slaves and slaves in temperate climate zones were too small a part of the total to accurately reflect the average level of slave-labor-productivity in the Americas.

Consequently, slave labor-productivity cannot be measured in the Americas in the way it was determined in Africa, based on the number of children families raised to adulthood.

This paper's null hypothesis is that the labor-productivity differential between Africa and the Americas was large enough to support the high mortality and resource cost of the trade. As such, upper-bound estimates of American slave labor productivity, based on data from the most productive sugar growing regions such as Barbados (Eltis 1995), will be considered representative and used for comparison with Africa. A lower-bound estimate of American subsistence costs will be juxtaposed with an upper-bound estimate of surplus product to provide a ratio of surplus to subsistence that, if anything, errs on the side of exaggerating the productivity of slave labor in the Americas.

This paper's goal is to compare the ratio of surplus output to subsistence output in West Africa and the Americas. Nominal-unit-conversion problems are bypassed because identical units, employed to measure surplus and subsistence, cancel out when surplus is divided by subsistence. One notable limitation in using surplus output as a measure of labor productivity is that surplus fails to describe output-per-labor-hour which is the preferred metric when evaluating labor productivity. The shortcomings inherent in using surplus-to-subsistence ratios as a proxy for labor productivity become apparent when one considers the following: the longer one works, the greater the portion of output considered as 'surplus' relative to that which is considered 'subsistence'. Higher gross output, when it emerges from more labor hours expended, may sometimes mask low labor productivity.

There were two important differences between slave subsistence diets in the Americas and in Africa. Slaves had more food to eat in the Americas and this food was more costly than the food African captives were given before boarding transatlantic ships. Until the mid-18th century, most food for slaves in the British West Indies was imported because the islands only produced sugar and had little land left for anything else including food (Ward 1991). In Africa, on the other hand, slave captives consumed food that was

locally produced. Slave diets in the Americas tended to be higher in calories required by their intense labor regimen, while the diet of captives in Africa was simply meant to keep individuals healthy enough to survive the middle passage. The average daily caloric intake for slave captives in Africa was 2,700 calories (Watts 1987: 64). A young male slave laboring during the most trying period of a sugar harvest consumed between 3,200 and 4,000 calories per day (Kiple and Kiple 1991: 124).

Information about the cost to owners of feeding slaves on sugar plantations in the Americas came from a variety of secondary sources in the literature on Caribbean economic history. For the earliest period of slave use in the British West Indies, the 1680s in Barbados, plantation owners spent less than two pounds sterling per annum to feed and clothe each slave according to Richard Dunn (1972: 248). A hundred years later in the British West Indies, the annual cost of maintaining a slave, from 1763 to 1788, averaged between four and five pounds sterling according to Robin Blackburn (1997: 425). J.R. Ward examined the expense records of several plantations in Jamaica and Barbados for annual maintenance costs including food, medicine, and clothing for slaves. From 1799 to 1807, annual maintenance costs totaled 4.45 pounds per slave; for the period 1808 to 1819, annual maintenance per slave equaled 5.5 pounds and for 1820 to 1834, these costs totaled 3.170 pounds. The final observations for Cuba and Brazil from 1821 to 1860 near the end of slaving in the Americas, yield a yearly maintenance cost per slave of fifty dollars (Le Veen 1977: 53). When converted into pounds sterling, at the approximate exchange rate of five dollars per pound, the total annual maintenance cost per slave in pound sterling was ten pounds for Cuba and Brazil in the final days of American slavery. Over a two-hundred-year period, yearly maintenance costs ranged from a low of two pounds and a high of ten pounds, but the median was closer to four pounds.

Tab. 4. *Yearly subsistence expenses in the Americas*

Source	*Time*	*Place*	*Yearly cost*
Dunn (1972: 248)	1680s	Barbados	2 £
Blackburn (1997: 425)	1763-1788	Caribbean	4 to 5 £
Ward (1991: 84)	1799-1807	British West Indies	4.5 £
Ward (1991: 84)	1808-1819	British West Indies	5.5 £
Ward (1991: 84)	1820-1834	British West Indies	3.2 £
Le Veen (1977: 53)	1821-1860s	Cuba/Brazil	$50/year = 10 £

One way of estimating the value of the surplus product obtainable from slave labor is to examine hire rates for slaves on sugar plantations during certain short periods when intense labor inputs are needed. Slaves were routinely hired out for particularly onerous tasks such as the holing of fields before new sugar cane was planted and harvested – both times when extreme effort was required for short durations. The daily price charged for hired slave labor approximates, in a competitive market, an upper-bound figure for the value and productivity of slave labor. Slaves were hired on a day-to-day basis, so an upper-bound yearly rate is computed by multiplying the daily rate by 365. An upward bias is created because slaves rarely worked every day of the year. Ignoring the many days where work was not done, ensures that the resulting measure for slave-labor productivity in the Americas is a maximum-upper-bound measure.

Tab. 5. *Slave hire rates in pounds sterling*

Source	*Time*	*Place*	*Daily hire rate*	*Hire rate in British pounds per year*
Ward (1991: 86)	1670-1725	Barbados	6 ducats	9.125
Ward (1991: 86)	1761-1763	Barbados	6 ducats	9.125
Ward (1991: 86)	1783-1791	Barbados	7.5 ducats	11.41
Ward (1991: 86)	1792-1798	Barbados	9 ducats	13.68
Ward (1991: 86)	1799-1819	Barbados	12 ducats	18.25
Ward (1991: 86)	1820-1834	Barbados	11 ducats	16.73
Ward (1991: 86)	1670-1725	Jamaica	8 ducats	12.16
Ward (1991: 86)	1761-1763	Jamaica	8 ducats	12.16
Ward (1991: 86)	1783-1791	Jamaica	16 ducats	24.3
Ward (1991: 86)	1792-1798	Jamaica J	2 ducats	33.45
Ward (1991: 86)	1799-1819	amaica	24 ducats	36.5
Ward (1991: 86)	1820-1834	Jamaica	22 ducats	33.46
Ward (1991: 86)	1830s	Trinidad	30 ducats	45.62
Bergad (1999: 201)	1783	Brazil	112.5 reis	11.49
Bergad (1999: 198)	1772	Brazil	200 reis	20.72
Bergad (1999: 198)	1774	Brazil	150 reis	15.15
Marshall (1993: 213)	1789-1791	Windward Islands (on average land)		6 to 20
Marshall (1993: 213)	1789-1791	Windward Islands (most fertile land)		30 to 40
Walsh (1993: 195)	1790-1807	Maryland & Eastern Shore		25
Walsh (1993: 197)	1810-1818	Maryland & Eastern Shore		35

The data accumulated now allow some interesting comparisons. Note that the data on subsistence expenses for slaves in the Americas, though more complete than similar data for Africa, does not match up exactly for every observation on slave hire rates. In Brazil and Maryland from 1783 to 1818, for example, I do not have good data on subsistence expenses. There is reason to believe that expenses in Brazil and Maryland were different from subsistence costs in the West Indies; Brazil and Maryland were self-sufficient in food production while the West Indies was dependent on imports.

Consequently, we have excluded Brazil and Maryland from the tabulations giving surplus -to-subsistence ratios in the Americas. I also have not included Brazil and Maryland in calculating productivity differentials between Africa and the Americas. The omission is excusable since the original intent of this paper was to compare the most productive regions in the Americas with areas in Africa. On average, slave labor in Barbados and the other West Indian sugar colonies, not in Brazil or North America, were the most productive (Eltis 1995).

A few large numbers stand out in slave hire rates; they are generally for dates near the end of the legal trade in 1808. In newly cultivated and highly productive sugar colonies such as Jamaica and Trinidad from 1783 onwards, planters expected the legal import of slaves to cease; the fear of future shortage led to speculation and a huge rise in slave prices that, as the figures below confirm, also greatly increased slave hire rates.

These rates do stand out from the rest and must be considered aberrations from the trend in slave hire rates. Barbados did not experience an equivalent rise in rates since its economy was already in steep decline as a sugar economy and would not have had many planters interested or capable of paying high prices to buy or hire slave labor. The surplus-to-subsistence ratios and productivity differentials quoted for Jamaica and Trinidad after 1783 must therefore be interpreted with caution.

The productivity differential tabulated in the last column of Table 6 tells us how much more or less productive an American slave was than a free African worker. The differentials are positive, indicating higher labor productivity in the Americas.

Since most of the data on subsistence costs and surplus values for Africa come from the late 17th century, it is best to compare that time period with the 17th century in the West Indies. Fortunately, the data presented above allow such a comparison. The Slave Coast, especially Whydah and Allada furnished a disproportionately high number of slaves who ended up in Barbados (Eltis 2000: 245). As a result, any estimates of productivity differentials between the Slave Coast and Barbados are meaningful indicators of change in labor productivity brought about by the forced migration

Tab. 6. *Surplus over subsistence ratios in the Americas and the intercontinental labor productivity differential*

Time	*Place*	*Slave hire rate in £/yr*	*Slave subsistence expenses in £/yr*	*Upper bound estimates of the American surplus to subsistence ratios*	*Lower bound estimate of African surplus to subsistence ratio*	*Upper bound estimates of the productivity differential between Africa and the Americas*
1670-1725	Barbados	9.125	2	4.5625	1.34	3.22
1761-1763	Barbados	9.125	4	2.28	1.34	0.94
1783-1791	Barbados	11.41	4	2.85	1.34	1.51
1792-1798	Barbados	13.68	4	3.42	1.34	2.08
1799-1819	Barbados	18.25	4.455	4.10	1.34	2.66
1820-1834	Barbados	16.73	5.470	3.058	1.34	1.72
1670-1725	Jamaica	12.16	2	6.08	1.34	4.74
1761-1763	Jamaica	12.16	4	3.04	1.34	1.70
1783-1791	Jamaica	24.3	4	6.075	1.34	4.74
1792-1798	Jamaica	33.45	4	8.3625	1.34	7.02
1799-1819	Jamaica	36.5	4.455	8.19	1.34	6.85
1789-1791	Windward Islands (average land)	20	4	5	1.34	3.66
1789-1791	Windward Islands (fertile land)	40	4	10	1.34	8.66

between these areas. In Barbados, the per-annum-hire rate for slaves was 9.125 pounds from 1670 to 1725. The per annum subsistence needs of slaves in Barbados at the same time cost 2 pounds. The ratio of surplus-to-subsistence therefore equaled 4.56. If this is an accurate description of labor-productivity in the Americas and if we have correctly measured the lower-bound of African labor-productivity, then American slaves were 3.22 times as productive as free men in Africa in the 1680s. Note that the productivity differential between the two continents declines as the average number of non-productive dependents an African male supported increased.

For instance, if Slave Coast residents had, on average, nine children per couple instead of just four, the productivity differential declines from 3.22 to 0.96. Since we seek an upper-bound measure of the intercontinental-labor-productivity differential, we use the higher number and now compare that figure to an estimate for the costs of the transatlantic migration to determine whether the upper-bound estimate for productivity increase would compensate for a lower-bound estimate of the costs of the transatlantic slave trade.

5. The costs of the trade

The information and data on mortality as well as transportation costs presented in Tables 7 and 8 indicate that the forced transatlantic migration of Africans was very costly. As is the case with many other variables in this study, mortality and transport costs fell within a broad range.

Slaves were procured in a variety of ways, both peaceful and violent, and the challenge in finding mortality rates for the African segment of the trade is to judiciously estimate the percentage gathered in each of the two ways. Some slaves were prisoners of war sold by victors for profit. Others were victims of organized raiding parties that preyed on the many acephalous populations in the African interior. Still others were debtors in default who were sold by their creditors or hapless individuals intended for ritual sacrifice, but spared death only to be sold into slavery. For those who were captured violently and then marched long distances to coastal embarkation points, mortality was extremely high. The English abolitionist, Thomas Fowell Buxton, claimed that 71 percent of the total mortality of the slave trade occurred in Africa during capture and travel to the coast and only 18 percent occurred during the middle passage during which mortality was well documented. While the transatlantic journey from Africa to Brazil took a month to complete and the journey from West Africa to other areas in the Americas, including the Caribbean, took two months, slaves spent at least triple that amount of time after their capture in Africa. According to Klein (1999: 130), most slaves spent at a minimum six months from their capture to embarkation with time waiting in coastal barracoons averaging about three months.

Given the duration of the African segment of their journey from freedom to slavery, the distance from the point of capture to the coast, and the incidence of sickness, hunger, thirst, and violence throughout the journey, high estimates of mortality in Africa are quite credible. According to Joseph Miller (1988: 384),

one experienced Luanda merchant reported that slavers toward the second half of the 18th century expected to lose about 40 percent of their captives to flight and death between the time they purchased them in the interior and the time they put them aboard the ships in Luanda.

Miller's own final estimate, based on a careful distinction between cases of peaceful and violent enslavement, separates slavery-induced mortality rates into three components. The violent capture of slaves killed 10 percent of the potential captives; the march to the coast killed 25 percent and the sometimes-lengthy stay in coastal barracoons killed another 15 percent so that, on average, 50 percent of all those intended for sale in Angola and Central Africa died before they could be loaded onto America-bound ships (Miller 1986: 64).

After embarkation, it took Africans one to two months of sailing to reach destinations in the Americas. Mortality during the middle passage ranged between 9 and 20 percent. The variance in mortality rates was quite high and there were many ships with mortality rates far below 9 percent and a few with mortality rates over 20 percent.

Middle passage mortality rates fell steadily from the 17th century, when they were routinely in the 20 percent range, until the late 18th century, but rose again in the early 19th century.

The 19th century rise in mortality rates is blamed on the practices of smugglers who dominated the trade after the 1830's when Britain began to capture and confiscate transatlantic slavers. Rising mortality is also blamed on the fact that African captives in the 19th century originated from further inland since African coastal populations were depleted of potential captives. The greater the distance from the point of capture to the coast, the sicker slaves were likely to be on boarding transatlantic ships and the higher their middle passage mortality rates.

Finally on arrival in the Americas, African slaves died from sickness and disease contracted during the ocean crossing. These sick slaves, unwanted by any potential buyers, were left to die. Miller (1988: 440) estimates that 5 percent of the slaves who made it alive to the Americas died after landing and before sale. Klein (1999: 157) says that mortality after landing and before sale was lower – in the range of 0.4 to 0.6 percent. This study will accept Klein's lower estimate. If the productivity differential can sustain a lower-bound estimate of the trade's mortality costs, then the trade did increase world surplus output. Because a lower-bound estimate of the slave trade's costs is greater than an upper-bound measure for the productivity differential between Africa and the Americas, the slave trade could not have increased world surplus output.

The last hurdle to survival was the two to three year 'seasoning' period after sale in the Americas. Miller (1988: 440) estimates that 15 percent of

all African arrivals died within a year either from new diseases for which they lacked immunity or from exhaustion as a result of inability to adjust to the harsh new regimen, especially on sugar plantations in the Americas. Bean (1975: 223) finds that in Jamaica, 33 percent of all African born slaves died within 2.5 years of their arrival. J.R. Ward's (1988) research indicates that from 1700 to 1750, 40 to 50 percent of African slaves died within three years of coming to the West Indies.

Enumerating all the information on mortality above, we can calculate that out of an initial group of one hundred Africans set upon by raiders, captured, and marched to the coast, only fifty will survive to board ships for the Americas. Of these, 15 percent or eight will die during the middle passage leaving forty-two who disembark in the Americas. A further 5 percent will die in the Americas before sale leaving forty for the three year 'seasoning' period. After three years 'seasoning', only twenty to twenty-four of the original one hundred slaves remained. In other words, for every slave that survived to become a productive laborer in the Americas, three or four perished along the way. Without factoring in transport costs, each surviving slave would have to be four times as productive (in terms of the African surplus to subsistence ratio) as a unit of labor in Africa in order for this trade to have increased world output.

To complete the description of the cost of the slave trade, data on transportation in the African interior and shipping costs to the Americas are presented and discussed.

Before reaching coastal embarkation points, slaves were brought great distances from the interior. Inland transport costs rose over time as slave exports led to the depletion of coastal populations and new captives were brought to embarkation points from further and further inland. The absence of pack animals (attributed to the prevalence of the *tse- tse* fly), the inhospitable bush that separated the coast from slave catchment zones, and the need to pay frequent tolls to local power brokers made overland transport far more expensive than the transoceanic movement of captives. Fisher and Fisher (1971) claim that transport to the coast increased a slave's price by 500 percent. Le Veen points out that high transport costs to the coast made slaves in the African interior extremely cheap:

> Slaves might be bought for as little as a few old buttons in some areas. One observer noted that slaves were initially selling for the cost of an old musket; another states that, when the coastal price of a slave was eight pounds, the interior price was 1.5 pounds (Le Veen 1971: 136).

The transport cost for slaves varied with time. Slave prices more than doubled in the 18th century because captives were brought from further

inland. Curtin (1975: 174) notes that while goods brought to Africa from England in 1733 increased in cost by 45.8 percent as a result of shipping charges, slaves brought from the interior of Africa to coastal European forts such as James Island, at the mouth of the Gambia River, increased in cost by 280 percent. The equivalent price differential, between coastal and inland prices, was 360 percent for ivory, and 230 percent for wax. The average increase in price for the large majority of slaves taken from their homes in the interior to coastal loading points was over 400 percent.

Tab. 7. *Slave transport costs in the African interior*

Source	*Slave price differential between interior and coast*
Fisher and Fisher (1971)	500%
Le Veen (1977: 136)	533%
Curtin (1975: 174)	280%
Average	**437%**

The charge for the transatlantic shipping of slaves did not have any particular time trend; with the exception of periods of inter-European war or 19th century British attempts to suppress the trade, the cost of shipping slaves for most of the trade's 400-year history is best described as a 'random walk'. Constancy in freight rates is attributed to the competitive organization of the slave shipping industry and the fact that there were only minor increases in slave shipping productivity over time (Eltis and Richardson 1995). Unlike other shipping activity that benefited from a drastic decline in the number of crew per ton of cargo due to a reduction in piracy (North 1968), slavers remained heavily manned because of the constant threat of on-board-slave revolts.

Ships not only brought slaves to the Americas, they also brought the goods that were traded for slaves from Europe and the Americas to Africa, thereby doubling the value of the trade goods and increasing the portion of final slave prices that went to shipping. Shipping costs made up, with some variation, approximately 75 percent of the final selling price of slaves in the Americas (Eltis 2000: 115). On average, transatlantic freight charges doubled the African coastal price of slaves, just as shipping trade goods from Europe to Africa doubled the value of those trade goods from their 'f.o.b.' (free on board) values in Europe (Richardson 1991: 29).

According to Bean (1975: 177), "no series of per-capita freight rates for slaves from Africa to Americas seems to have come down to us". In-

stead, scattered observations from merchants' correspondence, business contracts with private shippers, and various estimates based on geographic price differences provide a general range for transatlantic freight rates. The freight rates charged in the Americas for each slave delivered alive, included the cost of transportation for the entire voyage, for trade goods from Europe to Africa and then slaves to the Americas. Ships generally returned to Europe in ballast so that freight rates for slaves were paid for the entire-round-trip voyage.

Note that slave prices in the fifth column of Table 8 below are 'f.o.b.' (free-on-board) prices, meaning that the prices represent the prime cost in Europe, before customs, insurance, and freight charges are added, of a bundle of goods to be traded for each slave in Africa. Due to transport costs in the course of traveling between Europe, Africa and the Americas, 'f.o.b.' values usually increased several times over (Eltis 2000: 115).

Tab. 8. *Transcontinental shipping costs*

Source for freight rate data	*Time*	*Place (destination given. Origin is West Africa unless specified otherwise)*	*Freight rate*	*FOB (free-on-board) price of slave on African coast from (Richardson 1991)*	*Freight cost as % of African coastal price*
Richardson (1988)	1678-1679	Barbados	5 £	5.1 £	98%
Davies (1957: 198)	1678-1689	Barbados	5 £	5.1 £	98%
Davies (1957:198)	1678-1689	Leeward Islands	4.83 £	5.1 £	94%
Davies (1957:198)	1678-1689	Jamaica	5.5£	5.1 £	107%
Davies (1957:198)	1701	West Indies	8 £	4.1 £	195%
Davies (1957:198)	1702	West Indies	10 to 11 £	3.6 £	291%
Richardson (1988)	1715	Barbados	5 £	2.1 £	238%
Richardson (1988)	1719	Barbados	7 £	4.5 £	155%
Richardson (1988)	1732-1740	West Indies	6.81 £	5 £	136.2%
Richardson (1988)	1752	Jamaica	7 £	6.8 £	103%
Richardson (1988)	1788	West Indies	9 £	17 £	53%
Average					**142.7%**

Because profits were made by successful voyages, the marginal cost of transportation was lower than actual freight rates by the rate of profit for successful voyages – a deduction of 7 to 27 percent. At a minimum then, shipping costs would have doubled the cost of slaves from their value in terms of the prime cost of the goods they were traded for in Europe. In addition, overland transport costs raised slave prices by more than 400 percent between the interior and the coast.

Taking the five-fold increase in slave prices from the African inland to the coast, and the further two-fold increase due to the transatlantic crossing, the transportation to the Americas (at a minimum) raised a slave's price ten times. If mortality is included in this analysis of costs, then for the trade to have increased world surplus output, each slave arriving in the Americas would have to cover the total costs of their own output and the output of at least three others who did not survive the journey to the Americas. Incorporating a total mortality rate of 75% into the calculation raises the productivity differential necessary to ensure that world output increased to fourteen.[1] At a lower-bound, each slave surviving past seasoning in the Americas would have to produce a surplus to subsistence ratio that was fourteen times larger in the Americas than it had been in Africa if the slave trade were to have increased world surplus output – this is much higher than 8.66 – the highest upper-bound estimate (presented in Table 6) of the productivity differential between Africa and the Americas.

Conclusion

Stefano Fenoaltea (1999) argued that the most cited economic explanations for the transatlantic slave trade were incorrect. His strongest critique was directed at scholars who described the forced transatlantic slave migration in terms that better described free labor migrations – as an efficiency-improving economic process in which labor flowed from source regions characterized by low labor productivity to destinations where labor productivity was higher. If such reallocations of labor were, in fact, efficient, then the costs of the migration could not exceed the productivity gains that the migration enabled. Unfortunately, Fenoaltea did not offer much beyond an-

[1] The loss of three Africans for every American survivor means that Africa lost the surplus of four workers (1+3). The total transportation cost of each surviving slave divided by their inland African price is equal to ten. Adding the figures for transportation cost of surviving slaves with mortality of all (10+4) indicates that unless the average slave who survived to work in the Americas produced fourteen times his marginal physical product in Africa, the slave trade reduced world surplus output.

ecdotal evidence to bolster his argument. This paper presents the first empirical and quantitative test of Fenoaltea's critique. By comparing data on surplus to subsistence ratios for slave labor in the West Indies from the 17th to the 18th centuries and comparing those to estimates of surplus-to-subsistence ratios in West Africa, we find that the labor-productivity differential between West Africa and the West Indies was 0.94 to 8.66 while the costs of the trade could only have been covered with a minimum labor-productivity differential of 14. As such, we confirm the substance of Fenoaltea's argument by concluding that the transatlantic slave trade could not have been caused by an efficiency-improving reallocation of labor from low-productivity source regions in West Africa to higher-productivity areas in the Americas.

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