Dispersion and Distortions in the Trans-Atlantic Slave Trade

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Abstract

This paper documents the variation in economic characteristics across voyages during the trans-Atlantic slave trade. Dispersion in output, measured as slaves disembarked, is highest across Portuguese voyages, lower across French voyages, and lowest across British voyages. We use a structural approach to identify market distortions from wedges in first order conditions. The dispersion in market distortions is highest for Portuguese voyages, followed by French and British. We then calculate the share of output dispersion due to the dispersion in market distortions. Dispersion in market distortions accounts for as much as 17% of the dispersion in output. Dispersion in total factor productivity accounts for the largest share of dispersion in output.

JEL Classification: N77, F14, F54
Keywords: slave trades, market distortions, output dispersion, productivity

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1 Introduction

The institutional efficiency of different countries has long been a research topic for economic historians. Substantial evidence suggests various distortions exist in labor, credit, and product markets across and within major European countries throughout history. For instance, the wage dispersion across major European cities documented by Phelps Brown and Hopkins (1981) is one indicator of labor market inefficiency before the 1900's. While there are studies on institutional inefficiencies for the whole of Europe or in specific European countries such as Great Britain, there are few quantitative studies on the relative institutional inefficiencies of different European countries prior to the Industrial Revolution.

This paper aims to fill the hole in the literature by studying a large scale trading system between Europe, Africa, and the New World: the trans-Atlantic slave trade. The slave trade is ideal for such a study for several reasons. First, many Western European countries participated in slave trading, such as Great Britain, France, and Portugal. This allows us to compare the relative performance of voyages across countries. Second, data on slave voyages are very detailed. This allows us to document the variation in economic characteristics among voyages within and across different countries. We can then use this variation to uncover a measure of institutional efficiency for each country. The data prevent us from measuring the level of institutional efficiency for each country. Instead, we measure the dispersion in institutional efficiency, which we describe momentarily.

Using the *Trans-Atlantic Slave Trade Database*, we first document a stylized fact in the slave trade in the period 1700-1850: voyage output, measured as the number of slaves disembarked in the Americas, varied substantially across voyages within a country. In particular, the dispersion in output is highest across Portuguese voyages, lower across French voyages, and lowest across British voyages. Two natural accounting explanations exist for the dispersion in output.

The first is dispersion in productive efficiency, which we document for different countries. We measure voyage productivity in four different ways: slaves per ton, slaves per crew, total factor productivity (TFP), and distance per day traveled during the Middle Passage. Productivity is most dispersed across Portuguese voyages. Also, we find Portuguese voyages were the most productive, followed by British voyages and then French voyages, corroborating the findings in

North (1968) and Eltis and Richardson (1995).[1]

The second explanation for the dispersion in output is dispersion in institutional efficiency. To uncover relative institutional inefficiencies, we use the framework developed by Chari, Kehoe, and McGrattan (2007) and applied by Hsieh and Klenow (2009) and Song and Wu (2012), among others. This framework, which is commonly used in macroeconomics, identifies market distortions from wedges in first order conditions. To the best of our knowledge, our paper represents the first application of this structural approach in the literature on the African slave trades. In particular, we assume voyage owners are price takers in both the slaves and input markets. We then consider a short-run decision problem for a voyage owner in which he chooses the amount of labor, thus the amount of slaves, to maximize profit, holding capital fixed. Voyage-specific distortions in the slaves and input markets enter a voyage owner's decision problem in the form of wedges. These wedges represent the combination of taxes, regulations, and all other types of market distortions faced by individual voyage owners. When the dispersion in market distortions is high, it means the degree of differential access in the slaves and input markets is high across individual voyage owners, which represents less efficient institutions.[2] In an environment in which institutions are perfect, or market distortions do not exist, labor-output ratios would be constant across voyages. We then make use of the actual dispersion of labor-output ratios across voyages in the data to structurally identify the dispersion of market distortions in Great Britain, France, and Portugal separately.[3] We find the dispersion of market distortions is highest in Portugal, then followed by France and Great Britain. This is broadly consistent with the view that British institutions were the most efficient prior to the Industrial Revolution.[4]

[1]Specifically, North (1968) shows productivity was increasing in the shipping industry in general over the period we study, 1700-1850. Since Portuguese voyages tend to occur in the latter part of this period, our findings are consistent with North (1968). Eltis and Richardson (1995) finds British voyages were more productive than French voyages during the trans-Atlantic slave trade, as we do here. When comparing Portuguese productivity with British and French productivity we do not include TFP for technical reasons. We discuss this point in detail in Section 2.2.

[2]Hsieh and Klenow (2009) provide further discussion of this idea in the context of resource misallocation.

[3]Data limitations prevent us from separately identifying the variation in the product and labor market distortions, but we are able to identify the sum of the variances in the product and labor market distortions, which we term the dispersion of market distortions here.

[4]Given our focus on market distortions, the reader might wonder why we do not also examine, in the case of Great Britain, the impact of the Royal African Company losing its monopoly by comparing the pre and post 1698 periods. Unfortunately, the data are too sparse before 1698 to make any meaningful comparison.

As a final exercise, we consider the relative contributions of the dispersions in TFP and market distortions in explaining the dispersion in output. Our structural approach allows us to back out an estimate for the share of dispersion in output due to each source. The dispersion in TFP accounts for the largest share of dispersion in output. The dispersion in market distortions still accounts for a share of output dispersion which is economically meaningful. Market distortions account for 17% of the output dispersion across British and 17% across French voyages. 7% of the output dispersion across Portuguese voyages results from market distortions.

A large and well-established literature in economic history exists on the African slave trades.[5] Recent contributions include the following: Eltis and Engerman (2000) on the slave trades and British industrialization, Eltis, Lewis, and McIntyre (2010) on decomposing the transport costs of slave voyages, Eltis, Lewis, and Richardson (2005) on slave prices and productivity in the Caribbean, Eltis and Richardson (1995) on productivity of French and British slave voyages, Fenske and Kala (2012) on the role of supply-side environmental shocks in Africa, and Hogerzeil and Richardson (2007) on slave purchasing strategies and mortality.

Our paper will also interest economists working in the field of international trade. Melitz (2003) initiated an explosion in theoretical innovations driven by new insights from firm-level data. The slave trades data we present occur at the voyage-level, which is closer to shipment-level data. The data represent the largest and richest source of shipment-level data on the world economy, 1700-1850. New tools developed in the international trade literature should provide further insights on this important period of history surrounding the Industrial Revolution.

2 Stylized Facts on Output, Productivity, and Institutions

We begin by describing our data on slave voyages and documenting the distributions of various characteristics of economic interest across voyages. Viewing distributions of the data is useful, because it allows us to identify such regularities as the differences in dispersion in, say, output

[5]There is also a literature examining the link between the slave trades and current African development. Darity (1992) and Rodney (1972) represent earlier efforts along these lines, while more recent contributions include Dalton and Leung (2012), Fenske (2012), Nunn (2007), Nunn (2008), and Nunn and Wantchekon (2011).

across slave voyages sailing under different countries' flags.[6] We then consider the causes of the differences in dispersion in output by examining the differences in dispersion in productivity, i.e. one reason we might observe different distributions of output for different countries is that the distributions of productivity might also differ. This still leaves open a role for product and labor market distortions driving part of the observed dispersion.

Our data on slave voyages come from the *Trans-Atlantic Slave Trade Database*, which consists of information on 34,948 voyages. The database resides online at `http://www.slavevoyages.org` and is widely used by historians and economic historians in their study of the African slave trades. Eltis and Richardson (2010) provides a useful visual summary in the form of an atlas. We consider the years 1700-1850, the time period when the bulk of the slave trade occurred. The database contains 30,874 voyages for these years. Although not all voyage observations contain the information we consider in this paper, our sample sizes are still quite large and allow us to observe variation across voyage size, output, and productivity. One of the drawbacks of the data is the lack of voyage-level price information.

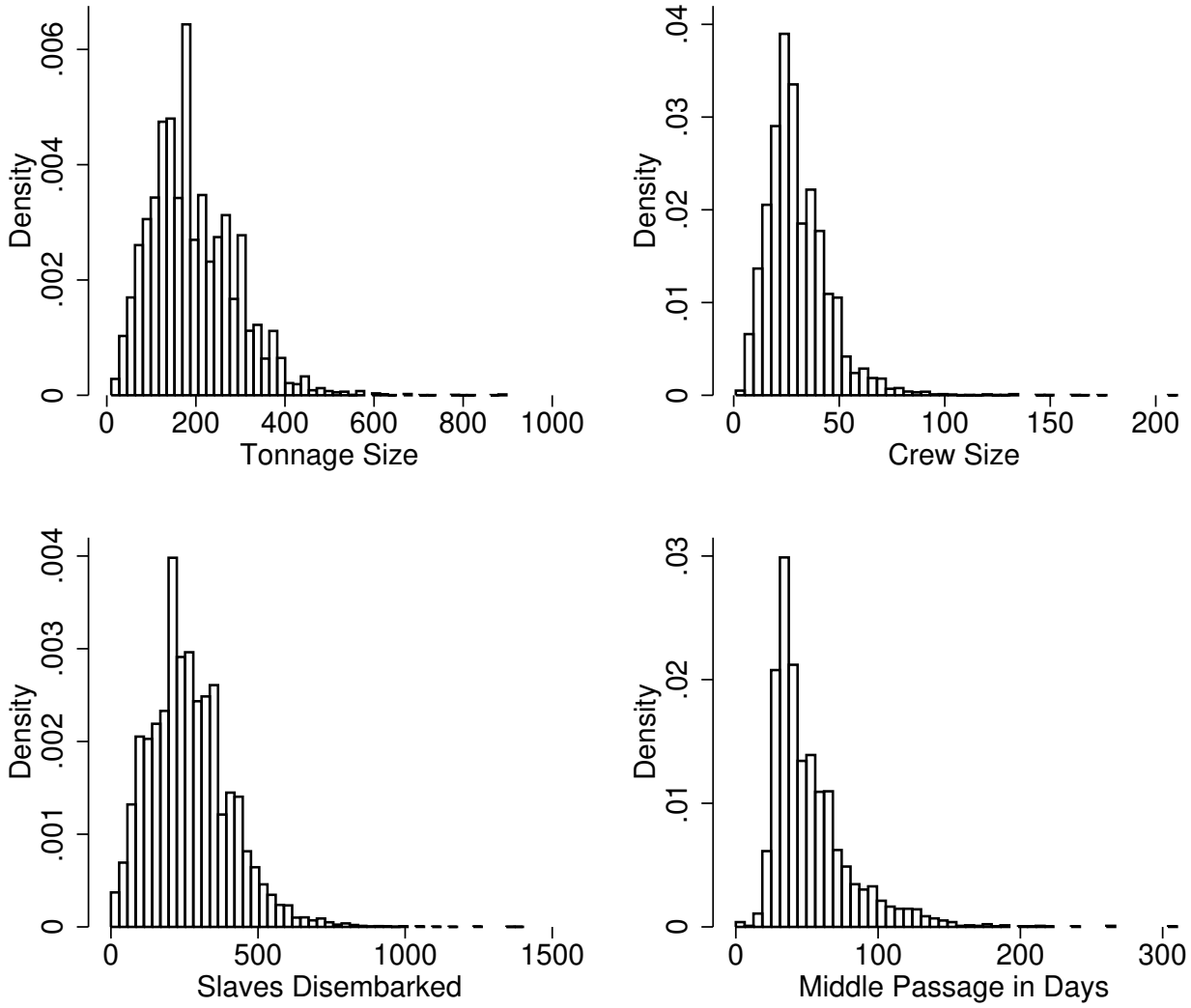
Figure 1 documents the distributions of various voyage characteristics, including ship tonnage, number of crew members at the voyage's outset, number of slaves disembarked, and number of days spent completing the Middle Passage.[7] The voyage's ship tonnage and crew size correspond to capital and labor inputs, whereas slaves disembarked is a measure of voyage output. Since not every voyage observation contains information on all four characteristics, the number of voyage observations varies across the four distributions. Voyage-level heterogeneity is immediately apparent, and all four distributions appear log-normal. We suppress the x-axes of the graphs to more easily show the long and thin right tails of the distributions.[8] Table 1

[6]In general, studying firm heterogeneity in the data and building economic models incorporating this heterogeneity have been a major research focus in industrial organization, macroeconomics, and, more recently, international trade. Lucas (1978) and Hopenhayn (1992) are classic references in this area of industrial organization and macroeconomics. Melitz (2003) incorporated these earlier methods into an international trade model and has become the basis for heterogeneous firm models in international trade. Hopenhayn (2011) provides a recent review of the literature.

[7]These characteristics appear as the variables *tonmod*, *crew1*, *slamimp*, and *voyage* in the *Trans-Atlantic Slave Trade Database*. The countries represented by the voyages include Spain/Uruguay, Portugal/Brazil, Great Britain, the Netherlands, the United States, France, Denmark/Baltic, and a residual category.

[8]Many empirical regularities in economics exhibit fat tails and follow power laws. Economists typically look at log-log plots when analyzing these phenomena. For example, we plotted the log of voyage rank in the distribution versus the log of voyage ship tonnage. We did this for all the distributions we consider. The log-log plots show the distributions are log-normal overall and Pareto in the tail, i.e. the tails follow a power law. Since the focus of our paper is on the heterogeneity across voyages, not the examination of the tails in particular, we do not

Figure 1: Distributions of Voyage Characteristics, 1700-1850



reports summary statistics for the four voyage characteristics.

2.1 Voyage Output

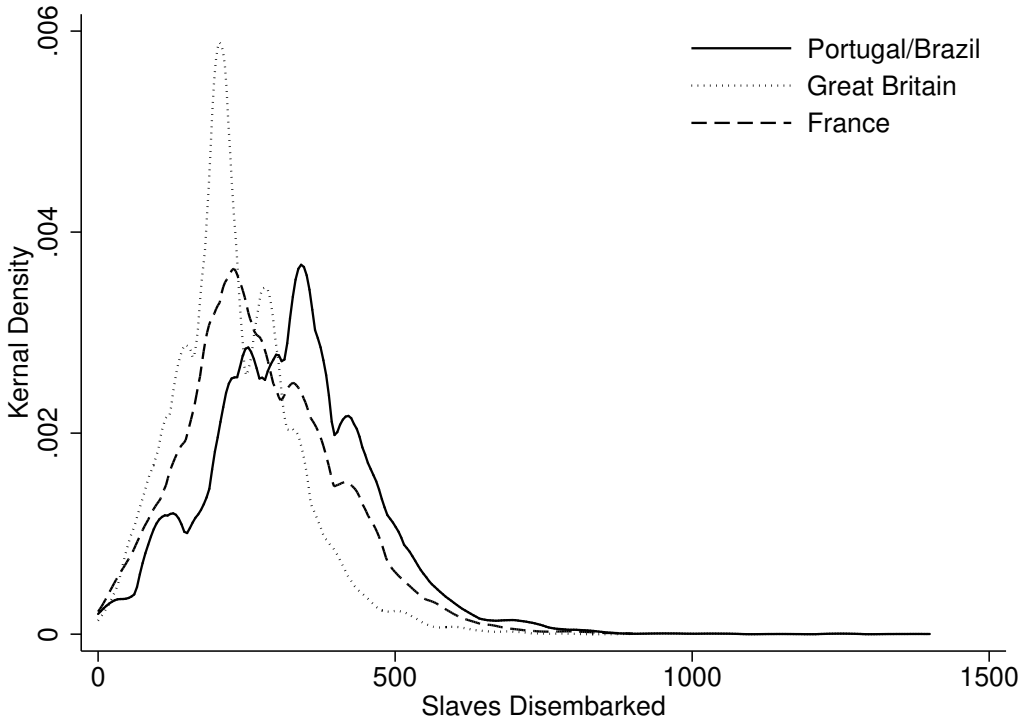
The distribution of output varies across countries. Figure 2 documents the distribution of slaves disembarked over the period 1700-1850 for Portugal/Brazil, Great Britain, and France, the most heavily represented countries in our data. Summary statistics appear in Table 1. The average number of slaves disembarked is considerably higher for Portuguese/Brazilian voyages.

show the log-log plots. For an overview of power laws in economics, see Gabaix (2009).

Table 1: Summary Statistics for Voyage Characteristics, 1700-1850

	Mean	Min	Max	Std. Dev.	Skewness	N
			All Voyages			
Tonnage Size	194.7226	10	897.1	96.0795	0.8932	15513
Crew Size	30.2323	1	210	14.9142	1.8057	11975
Slaves Disembarked	267.5401	0	1400	136.6735	0.8198	29201
Middle Passage in Days	52.5995	0	310	28.3594	2.0147	3735
			Portugal/Brazil			
Slaves Disembarked	322.8620	0	1400	140.1146	0.5681	9929
			Great Britain			
Slaves Disembarked	230.6686	0	898	103.1359	0.7774	10383
			France			
Slaves Disembarked	275.3668	0	900	130.6422	0.5967	3939

Figure 2: Comparing Distributions of Voyage Output Across Countries, 1700-1850



Technological changes in shipping likely explain this difference, as the Portuguese/Brazilian voyages are heavily concentrated in the 1800's. The dispersion in output is highest across Portuguese/Brazilian voyages, lower across French voyages, and lowest across British voyages.

Two natural candidates come to mind when thinking about the causes of dispersion in output within and across countries: dispersion in productive efficiency and dispersion in institutional

efficiency. Dispersion in productivity would contribute to dispersion in output. Countries also differ by their institutions, though, and this helps to explain the differences in the output distributions across countries. Even within a country, firms face different institutional constraints due, for instance, to political connections. After documenting the distributions of various productivity measures across voyages in Section 2.2, we examine the role played by institutional efficiencies in Section 2.3.

2.2 Productive Efficiency

We consider four different measures of voyage-level productivity: slaves per ton, slaves per crew, TFP, and distance, measured in kilometers, per day traveled during the Middle Passage. The four characteristics in Figure 1 help us to construct the productivity measures. We calculate slaves per ton and slaves per crew directly from the data. TFP and distance per day require additional steps.

In order to measure TFP, we use the standard approach of assuming a Cobb-Douglas production function for each voyage i:

$$\begin{aligned} Y_i &= A_i K_i^{\alpha} L_i^{1-\alpha} \\ &= A_i (\phi \hat{K}_i)^{\alpha} L_i^{1-\alpha} \\ &= \hat{A}_i \hat{K_i}^{\alpha} L_i^{1-\alpha}, \end{aligned} \tag{1}$$

where Y_i is the number of slaves disembarked in the Americas, K_i is capital, and L_i is the number of crew, all for voyage i. α and $1-\alpha$ represent the shares of capital and labor in production, which we will assume constant across voyages due to data constraints. A_i is unadjusted TFP. We only observe a voyage's ship tonnage $\hat{K}_i$ in the data, which is a proxy for the voyage's total capital K_i. The manipulations in (1) show how we adjust ship tonnage by the factor ϕ to arrive at our final production function for disembarked slaves in terms of ship tonnage, number of crew, and TFP, $\hat{A}_i$. TFP is expressed as

$$\hat{A}_i = \frac{Y_i}{\hat{K_i}^{\alpha} L_i^{1-\alpha}}. \tag{2}$$

TFP measures all those determinants of the number of slaves disembarked not captured by a

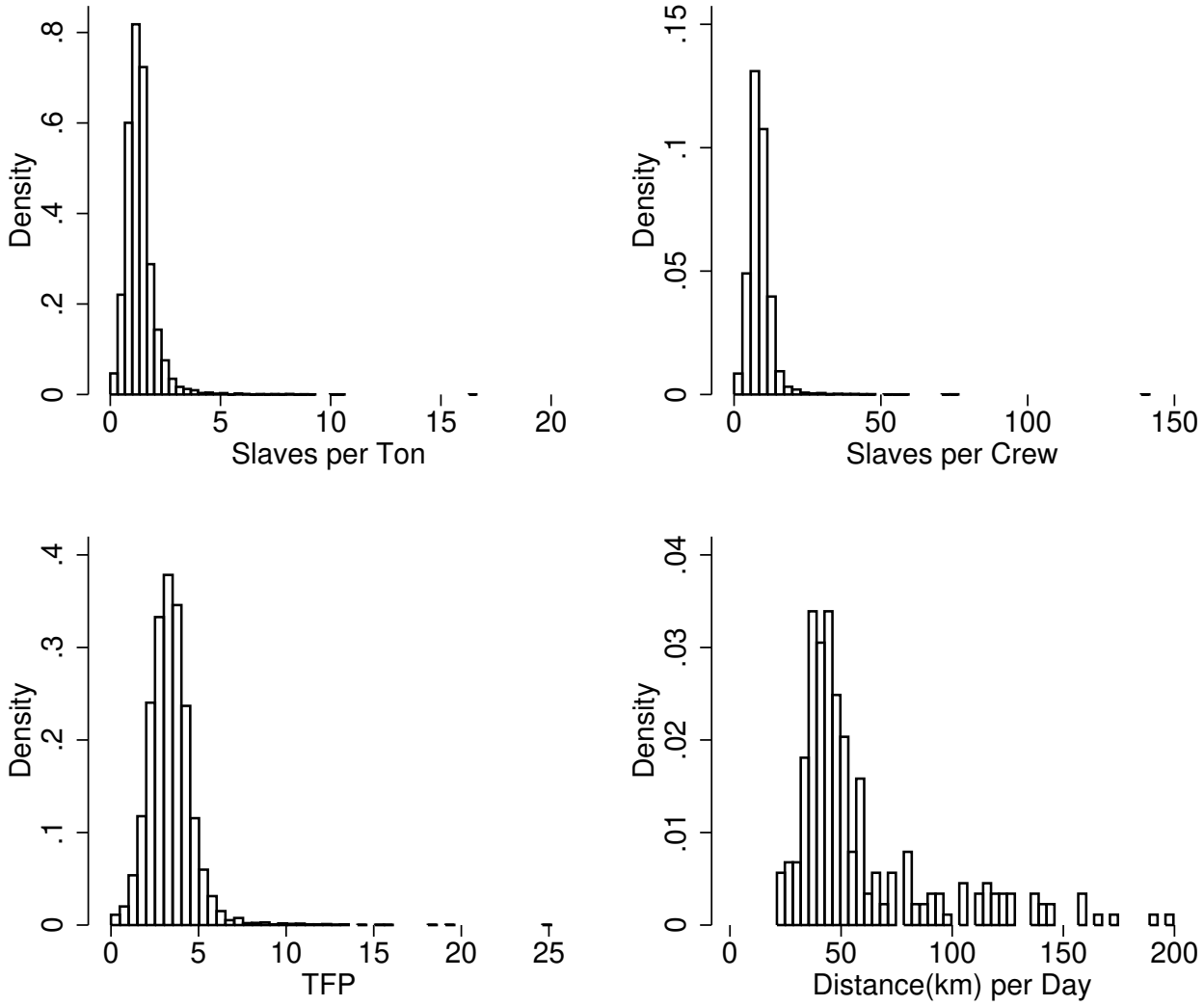
voyage's ship tonnage and crew size, such as the quality of a voyage's captain. Better captains would have knowledge about the best routes for minimizing the Middle Passage. This could include knowledge on local climates, wind patterns, ocean currents, areas prone to piracy, and many other factors. Better captains might also practice methods for maintaining good sanitation on their ships. Better captains might practice different strategies for purchasing and loading slaves on their ships to minimize the amount of time slaves spent on board before embarking on the Middle Passage. All of these factors would have an impact on slave mortality and were undoubtedly important in determining the variation in productivity across voyages. TFP captures the effects of mortality on output.

The last pieces of information we need to calculate voyage-level TFP are values for the capital and labor shares α and $1-\alpha$. We use the estimates reported in Eltis and Richardson (1995) to construct separate measures for the labor share during the 1700's and 1800's. Eltis and Richardson (1995) reports values of 0.479, 0.492, and 0.532 for labor shares during the 1680's, the period 1764-1775, and the 1780's. The values reported for the periods 1826-1835, 1836-1845, and 1856-1865 are 0.346, 0.276, and 0.242. We average the two sets of values to calculate a labor share of 0.501 for the 1700's and 0.288 for the 1800's. Since the labor share differs in the 1700's versus 1800's, we cannot compare our measures of TFP across the two periods. This is an important point to keep in mind, because British and French voyages occur primarily, though not exclusively, in the 1700's, while Portuguese/Brazilian voyages are concentrated in the 1800's. From this point forward in the paper, we only consider British and French voyages in the 1700's and Portuguese/Brazilian voyages in the 1800's. We are only able to compare TFP for British and French voyages. However, the structural approach we use later to identify the dispersion in market distortions does not rely on the labor share, and, thus, we make comparisons between all three countries.

The denominator of our distance per day productivity measure is taken directly from the data presented in Figure 1. The distance traveled during the Middle Passage is constructed by using GIS software. Using the geographic coordinates of a voyage's last port of call before making the Atlantic crossing and the first port where a voyage lands slaves, we construct the Euclidean distance traversed during the Middle Passage.[9] Our measure of distance might be

[9]The variables we use for a voyage's last and first port are *npafftra* and *sla1port* in the *Trans-Atlantic Slave*

Figure 3: Distributions of Voyage Productivities, 1700's



rough, but it allows us to capture the variation of the Middle Passage across different voyages in a simple, tractable, and commonly used way. Alternatively, great-circle distance could be used. The trade winds used to sail across the Atlantic influenced the "distance" of the Middle Passage, but we are unable to take into account their impact on our measure of distance.

Figure 3 shows the distributions of the four measures of voyage productivity during the 1700's. Each distribution is again log-normal. The correlations between the four types of productivies are all positive. Table 2 reports summary statistics for the voyage productivities

Trade Database.

for different cuts of the data, including for all voyages presented in Figure 3, all voyages during the period 1800-1850, and voyages by different countries.

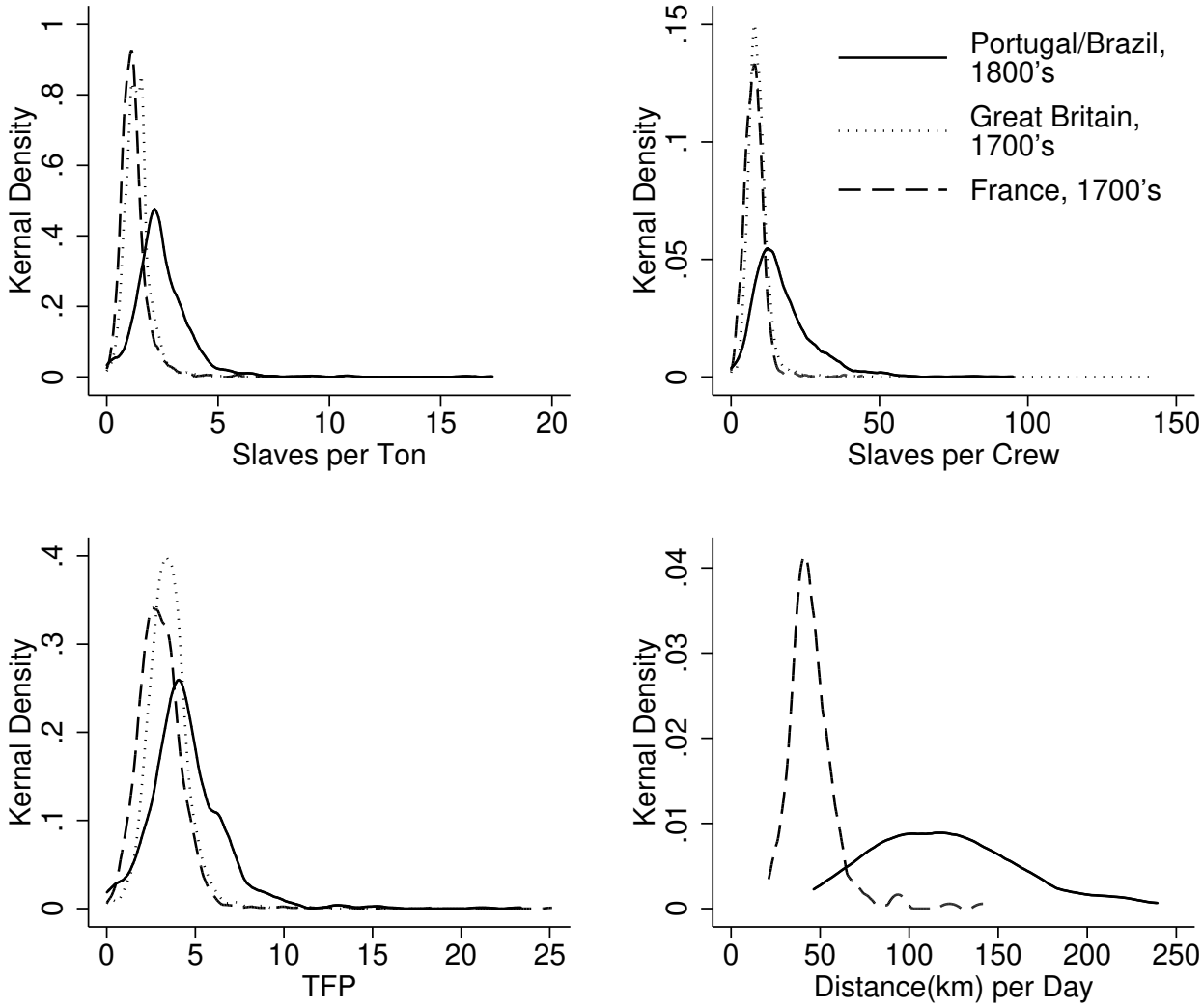
Table 2: Summary Statistics for Voyage Productivities, 1700-1850

	Mean	Min	Max	Std. Dev.	Skewness	N
			All Voyages, 1700's			
Slaves per Ton	1.3408	0	16.6063	0.6929	3.9791	10927
Slaves per Crew	8.7250	0	141.4500	4.3210	6.7879	8461
TFP	3.3845	0	25.1271	1.3163	2.5213	7510
Distance(km) per Day	59.7129	21.1417	199.5254	33.8018	1.7735	248
			All Voyages, 1800's			
Slaves per Ton	1.8355	0.0042	17.3306	1.2425	3.2407	3377
Slaves per Crew	13.7272	0.0426	95	9.7955	2.4281	2710
TFP	3.1521	0.0128	23.3714	1.9903	2.4055	2068
Distance(km) per Day	120.6148	46.3681	239.4305	42.6388	0.5825	69
			Portugal/Brazil, 1800's			
Slaves per Ton	2.5243	0.0042	17.3306	1.4473	3.5938	1105
Slaves per Crew	17.5295	0.0667	95	10.8061	1.9586	1247
TFP	4.5467	0.0128	23.3714	2.3024	2.1731	688
Distance(km) per Day	120.7905	46.3681	239.4305	42.3295	0.6199	67
			Great Britain, 1700's			
Slaves per Ton	1.3949	0	10.4250	0.6387	3.2202	7781
Slaves per Crew	9.0546	0	141.4500	4.3938	8.1904	5803
TFP	3.4800	0	19.1237	1.2203	1.8283	5771
			France, 1700's			
Slaves per Ton	1.2299	0	16.6063	0.7743	6.2570	2188
Slaves per Crew	7.8475	0	44.2833	3.7042	2.7695	2156
TFP	3.0854	0.0213	25.1271	1.5565	4.1109	1577
Distance(km) per Day	45.7658	21.1417	141.4387	14.9083	2.6161	195

Figure 4 compares the productivity distributions over the period 1700-1850 for Portugal/Brazil, Great Britain, and France. We show TFP for all three countries on the same graph only for space considerations, but, again, we cannot compare TFP across the two periods, 1700's and 1800's. We only have enough observations to report the distributions of distance per day for Portugal/Brazil and France.[10] In terms of the patterns in the data, we first compare British and French voyages during the 1700's and then consider Portuguese/Brazilian voyages during the 1800's. British voyages are more productive than French voyages on average, which is consistent with the findings reported in Eltis and Richardson (1995). This is true for all three measures of productivity we are able to compare (slaves per ton, slaves per crew, and TFP).

[10]There is only one British observation for distance per day.

Figure 4: Comparing Distributions of Voyage Productivities Across Countries, 1700-1850



Average British TFP, for example, is approximately 13% higher than average French TFP. We are also interested in any patterns in dispersion. Table 2 and Figure 4 show French productivity exhibits more dispersion than British productivity when measured as slaves per ton or TFP. French slaves per crew, however, is less disperse than British slaves per crew. Considering now the three measures of productivity we are able to compare with the British and French (slaves per ton, slaves per crew, and distance per day), Portuguese voyages appear more productive on average. Decreased dispersion does not accompany higher average productivity, though. Portuguese/Brazilian productivity is more dispersed than British and French for these three

measures of productivity.

2.3 Institutional Efficiency

Not only did productive efficiency (i.e. TFP) vary across and within different countries between 1700 and 1850, there was also substantial variation in the institutional efficiency that can help explain the output dispersion observed in the data. Before the early 1600's, most European countries' institutions, including Great Britain's, were exploitative. Kings controlled a significant part of the economy through the granting of monopoly rights. As Hill (1982) puts it, a man living in early 1600's Great Britain would

> [live] in a house built with monopoly bricks, with windows ... of monopoly glass; heated by monopoly coal (in Ireland monopoly timber), burning in a grate made of monopoly iron ... He washed himself in monopoly soap, his clothes in monopoly starch ... He wrote with monopoly pens, on monopoly writing paper; read (through monopoly spectacles, by the light of monopoly candles) monopoly printed books.

In these economies, firms with close connections to royal families would be in more advantageous positions than firms without such connections. While the institutional inefficiencies were similar in most parts of Europe before the early 1600's, things changed after the Glorious Revolution of 1688. After victory in the Glorious Revolution, King William of England and the Parliament negotiated a new constitution in which the power of the Parliament was greatly enhanced. As Acemoglu and Robinson (2012) and North and Weingast (1989) describe, institutions in Great Britain became more efficient compared to other countries such as France and Portugal. For instance, the Royal African Company lost its monopoly over the English slave trade in 1698, while the royal families in France and Portugal still had a lot of influence on the slave trade throughout the 1700's. French slave trading was characterized by an elaborate subsidy system known as the Acquits de Guinée, and the Compagnie du Sénégal maintained monopoly rights over exporting slaves from Senegambia. The differences in institutional efficiencies can potentially explain part of the output dispersions.

Institutional inefficiencies affect output dispersion through their effects on the profitability of different slave voyages. There have been different opinions on the profitability of different slave

voyages in the literature, which Darity (1985) discusses in detail. On the one hand, Thomas and Bean (1974) argues the profits from slaving were small and conclude in their paper, "Entry into each competitively organized stage of the slave trade was rapid, and the marginal firms could have experienced only brief periods at anything but zero economic profits. The supplies of all factors of production except slaves were highly elastic so the most efficient firms could have done little better than the marginal firms."

But, on the other hand, Inikori (1981) argues, "the best firms earned upwards of 50 percent on their investments." One of the main reasons for the abnormal profits is that both the factor (e.g. labor) market and the product (i.e. slaves) market were inefficient, and personal connections were important for success.[11] The inefficiencies of the factor and product markets at the time were well documented. For instance, the slave prices in non-British colonies were higher than that in the British colonies in the 1700's, as mentioned in a letter cited in Inikori (1981) from John Tarleton to his brother and partner in 1790:

> Since I wrote you last, I have seen Mr. H. Le Mesurier, who set out in the Mail last night for Liverpool, and had a long conversation with him respecting his scheme for our future adventures to St. Domingo, as a joint concern with the house at Havre; which from the continuance of the French bounties, and an uncommon demand for negroes, would, I am persuaded, turn out a most lucrative one, and far superior in every respect to what we can possibly expect in any of the English Islands, where the risk of bad debts is nearly equal with what it is in the French Islands, with only two-thirds of the price for each slave.

Eltis and Richardson (2004) also documents substantial slave price variations across different ports in the New World. In their paper, they show that Jamaica and St. Domingue, which are close geographically, had different slave prices in the eighteenth century.

The European labor market in the 1700's and 1800's was also highly inefficient. One indication of labor market inefficiency is wage dispersion. Historical wage dispersion across European cities, as well as within a European country such as Great Britain and France, has been well documented. Allen (2001), making use of the wage and grain price data made available by

[11] In a different context well-known to economic historians, Greif (1989) and Greif (1993) describe the important role played by reputation in smoothing international transactions.

Phelps Brown and Hopkins (1981), shows that wage dispersion existed in Europe in the 1700's. Williamson (1995) and Williamson (1996) document substantial wage dispersion among the OECD members in the 1800's. Hunt (1973), Pollard (1959), and Sicsic (1992) provide evidence of the wide wage gaps between the urban and rural areas in Great Britain and France in the 1800's.

One of the major sources of labor market distortion is low geographic mobility of labor. Williamson (1987) documents that the annual rural emigration rates in Great Britain were below 1% in the 1700's and slightly above 1% in the 1800's. Ravenstein (1885), Redford (1926), and Baines (1985) argue that migrants in nineteenth century Great Britain only moved short distances. Also, most migrants were young, implying that older people with less to gain from a better career tend not to move. Long (2005) constructs a unique panel data set of 28,000 individuals matched between 1851 and 1881 population censuses in Great Britain and shows that, "not all gains from migration were exploited, potentially indicating some degree of inefficiency." The emigration rates in France were low before the 1900's, and the land system in France is a major reason for that. As Hohenberg (1972) claims, "slow migration can ... be accounted for by developments in land tenure." Also, Lévy-Leboyer (1978) claims that peasants' reluctance to leave the farm intensified after the Second Empire.

While every firm was exposed to distortions in either the factor market or the product market, the levels of distortion that firms faced at the time were highly asymmetric. For instance, slave prices were higher in non-British colonies in the 1700's, as mentioned above, but access for British voyages to those non-British colonies was either by special license from the European governments in charge or by underground arrangements. These set a high entry barrier which favored the large firms that had connections. In 1789, John Dawson, the largest supplier of slaves to non-British colonies at the time, told a committee of the Privy Council that he signed a special contract with the Spanish government and had landed 12,000 slaves in the Spanish colonies between 1785 and 1788.

Small firms were also disadvantaged in the credit market such that they might have to pay a premium to secure labor services. A letter mentioned in Inikori (1981) from Joseph Canton, one of the small slave traders in Liverpool, to James Rogers, who owned a badly managed slave trade firm which went bankrupt in the 1790's indicated the importance of connections in the

local credit market:

> When you sent me that Bill of £500 I put it into Mr. Heywood's Bank with that intent to take cash as occasion required. Mr. Heywood sent this bill up to Mr. Joseph Denison in London, their Banking house, to enquire into the utility of the Bill. Mr. Denison in his usual way as he often does sends this bill down again and says the Bill may be good but he knows nothing of the acceptor or Drawer and such bills is out of his way. So Heywood has sent it to me which I have by now.

3 Accounting for Output Dispersion

3.1 A Structural Model for Measuring Distortions

Our method for analyzing the data resembles the business cycle accounting framework developed by Chari, Kehoe, and McGrattan (2007) and applied by Hsieh and Klenow (2009) and Song and Wu (2012), among many others.[12] The procedure relies on a structural model of the economy and infers the distortions in the input and output markets from the residuals, or wedges, in the first order conditions. For example, when used in examining the sources of the fluctuations in a series of GDP per capita, this approach allows the researcher to identify the relevant distortions, information which can then be used to think about the details and underlying mechanisms generating the fluctuations. The procedure can also be applied under various market structures and different types of models. Chari, Kehoe, and McGrattan (2007) bases the discussion around a perfectly competitive environment but establishes equivalency results for a large class of models, whereas Hsieh and Klenow (2009) consider a monopolistically competitive environment à la Melitz (2003).

In order to examine the product and labor market distortions during the slave trades, we consider a simple short-run decision problem where a firm, or a voyage, hires labor to produce output, slaves disembarked, keeping capital, the ship's tonnage, fixed.[13] Of course, firms did

[12]The term *business cycle accounting* originates with the application to business cycles in Chari, Kehoe, and McGrattan (2007), but their method can be extended to many other applications, including the distribution of resources as done by Hsieh and Klenow (2009).

[13]We do not consider a long-run problem, because this would involve analyzing a firm's entry and exit decision. This would require voyage panel data, which is beyond the scope of our paper.

adjust their levels of capital over the long-term during the slave trades. We consider as short a period of time as possible when looking at the data to try to control for these effects. Each voyage has access to the constant returns to scale production function shown in equation (1) and makes decisions in a competitive environment where prices, wages, and rental rates are given. Voyages differ by their TFP, equation (2). Lastly, the slaves disembarked are homogeneous products. While slaves differed by age, gender, quality, etc., the data do not permit us to identify this variation. Also, newly arrived slaves may have been largely undifferentiated from the perspective of the buyer, because characteristics, such as field productivity and life expectancy, were difficult to measure before being tested by life in the Americas. Eltis, Lewis, and Richardson (2005) makes this same point when assuming slaves were largely homogeneous products. We now can turn to the voyage decision problem.

Fixing a voyage's capital $\hat{K}_i = \bar{K}_i$, every voyage i maximizes its profit subject to its production function by solving the following problem:

$$\max_{Y_i, L_i \geq 0} (1 - \tau_i^p) p Y_i - (1 + \tau_i^w) w L_i - r \phi \bar{K}_i \qquad \text{s.t.} \quad Y_i = \hat{A}_i \bar{K}_i{}^{\alpha} L_i^{1-\alpha}, \tag{3}$$

where p is the price received for a slave in the Americas, w is the wage rate paid to a voyage crew member, and r is the rental rate paid on the voyage's capital. τ_i^p and τ_i^w represent the distortions in the product and labor markets faced by an individual voyage i.[14] Solving the voyage problem yields a first order condition for the choice of labor which can be rearranged to give an expression for the labor-output ratio:

$$\frac{L_i}{Y_i} = (1 - \alpha) \frac{p}{w} \frac{(1 - \tau_i^p)}{(1 + \tau_i^w)}. \tag{4}$$

Equation (4) shows the potential role played by the product and labor market distortions in generating different voyage labor-output ratios.[15] If there were no market distortions ($\tau_i^p = 0$ and $\tau_i^w = 0 \ \forall \ i$), then all voyages would have the exact same labor-output ratio. Instead, the presence of the distortions generates dispersion. In order to see this, we take the log of equation

[14] Similarly, if the voyage problem included a choice of voyage i's capital, then we could include the capital market distortion τ_i^r. Given the capital market distortion plays no significant role in problem (3), we choose to suppress it to avoid any confusion.

[15] Our focus on the short-run is important, because it controls for the role played by time variation in the labor share, prices, and wages.

(4) and then calculate the variance to show the variance of the labor-ouput ratio equals the sum of the variances of the distortions in the product and labor markets:[16]

$$\text{Var}\left[ln\left(\frac{L_i}{Y_i}\right)\right] = \text{Var}[ln(1+\tau_i^p)] + \text{Var}[ln(1+\tau_i^w)]. \tag{5}$$

Although we cannot identify the variation in the product and labor market distortions separately, equation (5) does provide us with a convenient and simple statistic for measuring the sum of the variances in the product and labor market distortions.[17] The variance of the labor-output ratio is easily obtained for a large number of observations in the *Trans-Atlantic Slave Trade Database*. Figure 5 reports the sum of the variances of the product and labor market distortions by decade for Portuguese/Brazilian, British, and French voyages over the period 1700-1850. We consider British and French voyages during the 1700's and Portuguese/Brazilian voyages during the 1800's. We only report a value for variances in those decades with a large number of voyage observations.[18] Both the model and data considerations motivate the decision to report variances for voyages during the period of a decade. Given the fixed capital assumption in the model, we would ideally measure variances over as short a period of time as possible when potential changes in capital would be less of a factor. The low number of voyage observations reported on a yearly basis prevents us from doing this. Using a decade as the period of time provides a large number of observations while allowing us to minimize the problems associated with changing capital the best we can.

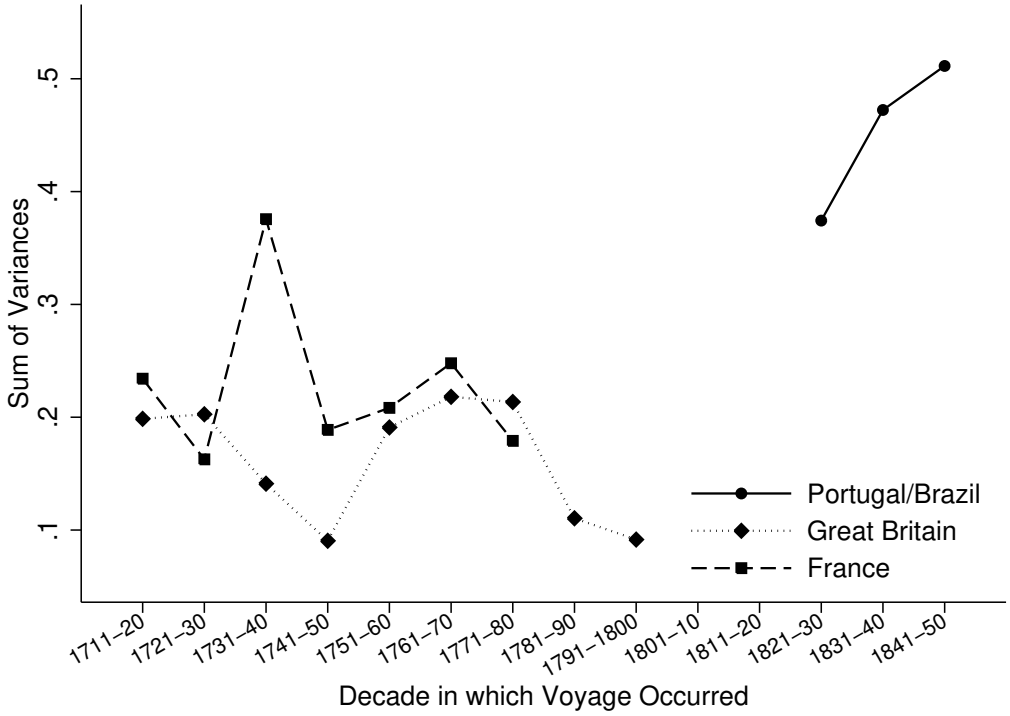
The dispersion in the product and labor market distortions differs across countries. Dispersion in the French product and labor market distortions exceeds British dispersion in five out of the seven decades for which we have values for both countries. In the two decades when French dispersion dips below British, the magnitude of French dispersion still reaches 80% or more of the magnitude of British dispersion. On average, French dispersion is 40% larger than

[16] We assume the log of the distortions is distributed normally with zero mean and that the distributions are independent.

[17] There are a few things our model does not capture which might distort our estimate of the sum of the variances of the market distortions. Measurement error in the labor-output ratio is one example. If we assume the measurement error is multiplicative to labor and output, then our estimate would be biased upward. Also, we do not capture variation in prices and wages, which would again bias our estimate upward. In order to minimize this source of bias, we consider the shortest time period possible, a decade, when estimating the sum of the variances of the market distortions.

[18] The average number of voyage observations in the decades we report is 415.

Figure 5: Variances of Product and Labor Distortions Across Countries, 1700-1850



British during the decades for which we have values for both countries. As Figure 5 makes clear, dispersion in the Portuguese/Brazilian product and labor market distortions is much higher than both French or British. Since there are no overlapping decades, we just compare the average dispersions across the three countries. The average Portuguese/Brazilian dispersion is 98% larger than the average French dispersion and 179% larger than the average British dispersion. The cross-country patterns seen in Figure 5 are consistent with the historical evidence discussed in Section 2.3. In particular, Great Britain appears to have had more efficient institutions, as measured by the dispersion in the voyage-level distortions.

3.2 Contributions of Productive and Institutional Efficiency to Output Dispersion

In order to measure the contributions of TFP and the distortions to the dispersion in output, consider the optimal quantity of labor derived from problem (3):

$$L_i^* = \left[(1-\alpha)\frac{p}{w}\frac{(1-\tau_i^p)}{(1+\tau_i^w)}\right]^{\frac{1}{\alpha}} \hat{A}_i{}^{\frac{1}{\alpha}}\bar{K}_i, \tag{6}$$

which can then be used to solve for the optimal quantity of output

$$Y_i^* = \left[(1-\alpha)\frac{p}{w}\frac{(1-\tau_i^p)}{(1+\tau_i^w)}\right]^{\frac{1-\alpha}{\alpha}} \hat{A}_i{}^{\frac{1}{\alpha}}\bar{K}_i. \tag{7}$$

Taking the log of equation (7) and calculating the variance gives the variance of output in terms of the sum of the variances of the product and labor market distortions, voyage TFP's, and voyage capitals:

$$\begin{aligned}\text{Var}[ln(Y_i^*)] = \left(\frac{1-\alpha}{\alpha}\right)^2 &\{\text{Var}[ln(1-\tau_i^p)] + \text{Var}[ln(1+\tau_i^w)]\} \\ &+ \left(\frac{1}{\alpha}\right)^2 \text{Var}[ln(\hat{A}_i)] + \text{Var}[ln(\bar{K}_i)].\end{aligned} \tag{8}$$

Equation (8) serves as the structural equation by which we estimate the impact of the productive and institutional efficiencies on the dispersion in output.[19] To measure the impact of productive efficiency, we report the share of the variance of the optimal quantity of output, the entire RHS of equation (8), due to the variance in TFP, the second term on the RHS of equation (8). In terms of institutional efficiency, the statistic we report shows the impact of the sum of the variances of the product and labor market distortions, measured as the first term on the RHS of equation (8), as a share of the variance of the optimal quantity of output. Table 3 reports these statistics. The variance of TFP accounts for a larger share of the variance in output, but the sum of the variances in the product and labor market distortions still accounts for a meaningful share of the output variance. In the 1700's, the average share of output dispersion due to TFP dispersion is 0.66 for France and 0.60 for Great Britain, whereas that due to the sum of the dispersions in the product and labor market distortions is 0.17 for France and 0.17 for Great Britain. In the case of Portugal/Brazil in the 1800's, the average share of output dispersion due to TFP dispersion is 0.66. The average share due to market distortions is 0.07.

[19] Unlike equation (5), the labor share and TFP do appear in equation (8), which means we will again not be making comparisons between the British and French in the 1700's and the Portuguese/Brazilians in the 1800's.

Table 3: Variances of Market Distortions and TFP as a Share of Output Variance Across Countries, 1700-1850

	Great Britain		*France*		*Portugal/Brazil*	
Decade	Distortions	TFP	Distortions	TFP	Distortions	TFP Share
1711-20	0.17	0.64	0.18	0.67		
1721-30	0.17	0.62	0.17	0.62		
1731-40	0.18	0.64	0.19	0.72		
1741-50	0.16	0.57	0.17	0.62		
1751-60	0.17	0.63	0.18	0.64		
1761-70	0.18	0.65	0.19	0.71		
1771-80	0.20	0.65	0.14	0.63		
1781-90	0.16	0.50				
1791-1880	0.17	0.49				
1821-30					0.07	0.68
1831-40					0.07	0.70
1841-50					0.06	0.61

4 Conclusion

This paper documents the substantial heterogeneity across voyages during the trans-Atlantic slave trade, emphasizing the differences in the dispersion in output across the three main countries engaged in the trade: Great Britain, France, and Portugal/Brazil. We structurally decompose the sources of output dispersion with a procedure identifying the distortions in the output and input markets from wedges in first order conditions. This procedure should prove useful as a diagnostic tool for economic historians working on a range of topics. The dispersion in product and labor market distortions is largest for Portuguese/Brazilian voyages and smallest for British voyages. The dispersion in distortions can account for at most 17% of the dispersion in output. The bulk of the dispersion in output is attributed to dispersion in TFP.

Our findings shed new light on the industrial structure of the Atlantic economy during the time of the slave trades. Although historians and economic historians have made great strides in documenting and analyzing the slave trades, there is still room for further research, especially given the wealth of firm-level data during this historical period. Future research should exploit the richness of the data, as we have tried to do in this paper.

References

Acemoglu, D., and J. Robinson (2012): *Why Nations Fail: The Origins of Power, Prosperity, and Poverty*. New York, NY: Crown Publishers.

Allen, R. C. (2001): "The Great Divergence in European Wages and Prices from the Middle Ages to the First World War," *Explorations in Economic History*, 38(4), 411–447.

Baines, D. (1985): *Migration in a Mature Economy: Emigration and Internal Migration in England and Wales, 1861-1900*. Cambridge, UK: Cambridge University Press.

Chari, V., P. J. Kehoe, and E. R. McGrattan (2007): "Business Cycle Accounting," *Econometrica*, 75(3), 781–836.

Dalton, J. T., and T. C. Leung (2012): "Why is Polygyny More Prevalent in Western Africa? An African Slave Trade Perspective," working paper.

Darity, Jr., W. (1985): "The Numbers Game and the Profitability of the British Trade in Slaves," *Journal of Economic History*, 45(3), 693–703.

——— (1992): "A Model of "Original Sin": Rise of the West and Lag of the Rest," *American Economic Review*, 82(2), 162–167.

Eltis, D., and S. L. Engerman (2000): "The Importance of Slavery and the Slave Trade to Industrializing Britain," *Journal of Economic History*, 60(1), 123–144.

Eltis, D., F. D. Lewis, and K. McIntyre (2010): "Accounting for the Traffic in Africans: Transport Costs on Slaving Voyages," *Journal of Economic History*, 70(4), 940–963.

Eltis, D., F. D. Lewis, and D. Richardson (2005): "Slave Prices, the African Slave Trade, and Productivity in the Caribbean, 1674-1807," *Economic History Review*, 58(4), 673–700.

Eltis, D., and D. Richardson (1995): "Productivity in the Transatlantic Slave Trade," *Explorations in Economic History*, 32, 465–484.

——— (2004): "Prices of African Slaves Newly Arrived in the Americas, 1673-1865: New Evidence on Long-Run Trends and Regional Differentials," in D. Eltis, F. D. Lewis, and K.

L. Sokoloff, editors, Slavery in the Development of the Americas, London, UK: Cambridge University Press, 181-218.

——— (2010): *Atlas of the Transatlantic Slave Trade*. New Haven, CT: Yale University Press.

Fenske, J. (2012): "African Polygamy: Past and Present," working paper.

Fenske, J., and N. Kala (2012): "Climate, Ecosystem Resilience, and the Slave Trade," working paper.

Gabaix, X. (2009): "Power Laws in Economics and Finance," *Annual Review of Economics*, 1, 255–293.

Greif, A. (1989): "Reputation and Coalitions in Medieval Trade: Evidence on the Maghribi Traders," *Journal of Economic History*, 49(4), 857–882.

——— (1993): "Contract Enforceability and Economic Institutions in Early Trade: The Maghribi Traders' Coalition," *American Economic Review*, 83(3), 525–548.

Hill, C. (1982): *The Century of Revolution: 1603-1714*. New York, NY: W. W. Norton & Company.

Hogerzeil, S. J., and D. Richardson (2007): "Slave Purchasing Strategies and Shipboard Mortality: Day-to-Day Evidence from the Dutch African Trade, 1751-1797," *Journal of Economic History*, 67(1), 160–190.

Hohenberg, P. (1972): "Change in Rural France in the Period of Industrialization, 1830-1914," *Journal of Economic History*, 32(1), 219–240.

Hopenhayn, H. A. (1992): "Entry, Exit, and Firm Dynamics in Long Run Equilibrium," *Econometrica*, 60(5), 1127–1150.

——— (2011): "Firm Microstructure and Aggregate Productivity," *Journal of Money, Credit and Banking*, 43(5), 111–145.

Hsieh, C.-T., and P. J. Klenow (2009): "Misallocation and Manufacturing TFP in China and India," *Quarterly Journal of Economics*, 124(4), 1403–1448.

Hunt, E. H. (1973): *Regional Wage Variations in Britain 1850-1914*. Oxford, UK: Clarendon Press.

Inikori, J. (1981): "Market Structure and the Profits of the British African Trade in the Late Eighteenth Century," *Journal of Economic History*, 41(4), 745–776.

Lévy-Leboyer, M. (1978): "Capital Investment and Economic Growth in France, 1820-1930," in P. Mathias and M. M. Postan, editors, The Cambridge Economic History of Europe, vol7: The Industrial Economies: Capital, Labour, and Enterprise, Cambridge, UK: Cambridge University Press, 231-295.

Long, J. (2005): "Rural-Urban Migration and Socioeconomic Mobility in Victorian Britain," *Journal of Economic History*, 65(1), 1–35.

Lucas, Jr., R. E. (1978): "On the Size Distribution of Business Firms," *Bell Journal of Economics*, 9(2), 508–523.

Melitz, M. J. (2003): "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity," *Econometrica*, 71(6), 1695–1725.

North, D. C. (1968): "Sources of Productivity Change in Ocean Shipping, 1600-1850," *Journal of Political Economy*, 76(5), 953–970.

North, D. C., and B. R. Weingast (1989): "Constitutions and Commitment: The Evolution of Institutional Governing Public Choice in Seventeenth-Century England," *Journal of Economic History*, 49(4), 803–832.

Nunn, N. (2007): "Historical Legacies: A Model Linking Africa's Past to its Current Underdevelopment," *Journal of Development Economics*, 83(1), 157–175.

——— (2008): "The Long-Term Effects of Africa's Slave Trades," *Quarterly Journal of Economics*, 128(1), 139–176.

Nunn, N., and L. Wantchekon (2011): "The Slave Trade and the Origins of Mistrust in Africa," *American Economic Review*, 101(7), 3221–3252.

Phelps Brown, E. H., and S. V. Hopkins (1981): *A Perspective of Wages and Prices*. London, UK: Methuen.

Pollard, S. (1959): "Labour in Great Britain," in P. Mathias and M. M. Postan, editors, The Cambridge Economic History of Europe, vol7 : The Industrial Economies: Capital, Labour, and Enterprise, Cambridge, UK: Cambridge University Press, 97-179.

Ravenstein, E. G. (1885): "The Laws of Migration," *Journal of the Statistical Society of London*, 48(2), 167–235.

Redford, A. (1926): *Labour Migration in England, 1800-1850*. Manchester, UK: Manchester University Press.

Rodney, W. (1972): *How Europe Underdeveloped Africa*. London: Bogle-L'Ouverture Publications.

Sicsic, P. (1992): "City-Farm Wage Gaps in Late Nineteenth-Century France," *Journal of Economic History*, 52(3), 675–695.

Song, Z. M., and G. L. Wu (2012): "A Structural Estimation of Capital Market Distortions," working paper.

Thomas, R. P., and R. N. Bean (1974): "The Fishers of Men: The Profits of the Slave Trade," *Journal of Economic History*, 34(4), 885–914.

Williamson, J. G. (1987): "Did English Factor Markets Fall during the Industrial Revolution?," *Oxford Economic Papers*, 39(4), 641–678.

——— (1995): "The Evolution of Global Labor Markets since 1830: Background Evidence and Hypotheses," *Explorations in Economic History*, 32, 141–196.

——— (1996): "Globalization, Convergence, and History," *Journal of Economic History*, 56(2), 277–306.