SLAVERY AND THE BRITISH INDUSTRIAL REVOLUTION

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ABSTRACT

Did overseas slave-holding by Britons accelerate the Industrial Revolution? We provide theory and evidence on the contribution of slave wealth to Britain's growth prior to 1835. We compare areas of Britain with high and low exposure to the colonial plantation economy, using granular data on wealth from compensation records. Before the major expansion of slave holding from the 1640s onwards, both types of area exhibited similar levels of economic activity. However, by the 1830s, slavery wealth is strongly correlated with economic development – slave-holding areas are less agricultural, closer to cotton mills, and have higher property wealth. We rationalize these findings using a dynamic spatial model, where slavery investment raises the return to capital accumulation, expanding production in capital-intensive sectors. To establish causality, we use arguably exogenous variation in slave mortality on the passage from Africa to the Indies, driven by weather shocks. We show that weather shocks influenced the continued involvement of ancestors in the slave trade; weather-induced slave mortality of slave-trading ancestors in each area is strongly predictive of slaveholding in 1833. Quantifying our model using the observed data, we find that Britain would have been substantially poorer and more agricultural in the absence of overseas slave wealth. Overall, our findings are consistent with the view that slavery wealth accelerated Britain's industrial revolution.

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1 Introduction

Europeans enslaved millions on the African continent during their colonization of the Americas, consigning the survivors of transatlantic voyages to forced labor on sugar, tobacco, cotton and coffee plantations in the Caribbean and North and South America. In the process, Europeans accumulated wealth, either from the slave trade itself, plantation production, or the wider triangular trade between Europe, Africa, and the Americas. To what extent did this wealth contribute to the growth and economic development of modern Europe?

We provide new theory and evidence on this question for Britain's Industrial Revolution. We use granular data on the location of slaveholders within Britain collected under the terms of the 1833 Abolition of Slavery Act. We combine these data on the spatial distribution of slavery wealth with rich geographic information on economic activity in Britain before and after its entry into transatlantic slavery in the 1560s. To identify causal effects, we develop an instrument for slavery wealth exploiting exogenous variation in slave mortality during the middle passage, from Africa to the Americas: Where poor weather conditions led to longer voyages, there were fewer survivors. By linking slave-traders to the locations of their ancestors, we show that higher mortality on voyages spelled lower slavery wealth in 1833. We show that areas with exogenously more slavery wealth grow faster, experience more structural change, develop more mills and factories, and adopt more steam engines. We rationalize these findings using a dynamic spatial model, in which slavery wealth stimulates domestic capital accumulation, and hence expands production in capital-intensive sectors.

A growing literature has documented slavery's adverse effects on African economic development: African countries exposed to the slave trade are still markedly poorer today, with lower levels of interpersonal trust (Nunn and Wantchekon 2011, Nunn 2008). While statues commemorating slave traders and slaveholders continue to adorn European cities, and endowed hospitals and libraries perpetuate their names, slavery's economic consequences in today's developed countries are not well understood. The idea that slavery and the trade in enslaved human beings jump-started the Industrial Revolution is not new: Eric Williams (1944) famously argued that Britain accumulated vast wealth from the triangular trade – and that it re-invested this wealth in the leading sectors of the Industrial Revolution.[1] Indeed, no country had greater involvement in the transatlantic slave trade than Britain, and it also industrialized first. At the same time, quantitative economic historians have questioned the idea that the slave trade boosted economic development in Europe, and in industrializing Britain in particular. Profits from the slave trade were no higher than in other lines of business, the argument

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[1]Relatedly, historians of global capitalism (Wallerstein 2004, Frank 2011) have emphasized that Atlantic slavery was crucial for economic development after 1500.

goes; absolute levels of profit from the slave trade were small relative to the size of the British economy (Engerman 1972, Eltis and Engerman 2000).

We make a number of contributions to this debate. First, we emphasize *slaveholding* in addition to *slave trading*. The purchase and sale of human beings was only one part of the slave economy. Much of the wealth accumulated from slavery was derived from colonial sugar, tobacco, cotton and coffee plantations. Participation in the slave trade often facilitated a transition to plantation ownership. Indeed, Solow (1993) argues that the profits from slaveholding were an order of magnitude greater than direct profits from the slave trade itself.[2] To measure this wealth from slaveholding, we use a distinctive feature of our empirical setting: Britain, through the Abolition of Slavery Act in 1833, provided compensation payments to existing slaveholders. These compensation payments were substantial, equal to £20 million in current prices, which was around 40 percent of the government's budget and 5 percent of gross domestic product (GDP), with the resulting debt not paid off until 2015. We use individual-level data on these compensation payments to more than 25,000 slaveholders, as compiled by historians over more than a decade in the *Legacies of British Slavery* database (Hall et al. 2014). This allows us to directly measure slavery wealth for each slaveholder in terms of the total number of enslaved persons and their assessed value.

Second, much of the existing debate about the Williams hypothesis has occurred at the level of the economy as a whole. Since many factors change over time at the aggregate level, this creates challenges for identification and measurement. In contrast, we exploit geographical variation in slavery participation across locations within Britain, which enables us to control for these other aggregate time-varying factors. We combine our measure of slaveholder wealth from the claims for compensation with detailed information on population, employment structure and property values across locations within Britain.

Third, a key challenge in the existing debate about the Williams hypothesis is that slavery wealth is endogenous. To address this concern, we first use our spatially-disaggregated data on economic activity before the rise of the slave economy, using property values in Britain dating back to 1086. We use these data to check for balancedness and differences in pre-trends between locations that subsequently have high or low slavery wealth. We also develop a new instrumental variables estimation strategy based on the fact that many slave traders eventually became slaveholders, investing their wealth in West Indian plantations. In the age of sail, the idiosyncrasies of wind and weather heavily influenced the duration of transatlantic voyages. Crowded and inhumane conditions on slave voyages led to high rates of mortality

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[2]According to conventional estimates, profits from slave *trading* amounted to around 0.5 percent of GDP. In contrast, Solow (1993) estimates that profits from *slaveholding* were around 5 percent of GDP, or roughly 80 percent of total domestic investment.

during the middle passage. A primary determinant of mortality for the enslaved was voyage duration (Eltis 1984). As voyage times increased because of unfavorable winds, water began to run out, and infectious diseases spread, raising mortality among the enslaved. High mortality reduced slave traders' profits, making their continued involvement in the trade less likely. Hence, inclement weather shocks both directly reduced wealth, and also induced exit from the slave trade, thereby reducing slaveholder wealth in 1833 (at the time of abolition). We therefore instrument 1833 slavery wealth using a voyage outcome measure inversely related to middle-passage mortality.

Fourth, we develop a dynamic spatial model to evaluate the aggregate and distributional consequences of slaveholding. The model highlights three mechanisms through which slavery wealth affects economic development. First, for a given capital stock, greater access to colonial slavery investments makes domestic investments less attractive through a standard substitution effect, thereby decreasing the domestic capital stock. Second, greater access to colonial slavery investments raises the productivity of the investment technology, which stimulates capital accumulation and increases the steady-state domestic capital stock. Third, slavery investments are more collateralizefable than other investments, which alleviates collateral constraints, and again stimulates domestic capital accumulation.[3] We show that the net effect of these three forces is that locations with greater access to colonial slavery investments exhibit faster capital accumulation along the transition path to steady-state and a higher steady-state domestic capital stock. In the presence of financial frictions, this increased capital is disproportionately invested locally, which in turn stimulates local economic growth, and structural transformation towards capital-intensive manufacturing.

We use our voyage outcome instrument to identify the effect of exogenous variation in slavery wealth on local economic development. In our first-stage regression, we find that a one standard deviation increase in this voyage outcome instrument (reduction in middle-passage mortality) implies a 0.16 standard deviation increase in slaveholder wealth in 1833. In our second-stage regression, we find that a one standard deviation increase in slaveholder wealth translates into a 0.52 standard deviation increase in property values, a 0.61 standard deviation increase in agricultural employment, a 0.87 standard deviation increase in manufacturing employment, a 0.79 standard deviation increase in the average number of cotton mills in 1839, and a 1.78 standard deviation increase in the number of steam engines.

Combining our model and rich geographic data, we find substantial aggregate and distributional consequences of access to slavery investments. At the aggregate level, we find an

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[3]Of the twelve rules governing slavery in the West Indies in (Stephen 1824), rule X states "The slave may be mortgaged, demised, and settled for any particular Estate or estates, in possession, remainder, or reversion." The Legacies of British Slavery Database contains many examples of enslaved persons used as collateral.

increase in national income of 3.5 percent, which is sizeable relative to conventional estimates of the welfare gains from international trade, such as the upper bound of 9 percent for 19th-century Japan in Bernhofen and Brown (2005). Capitalists were the largest beneficiaries with an increase in their aggregate income of 11 percent, both because of the direct income from slavery capital invested in colonial plantations, and because of the induced increase in steady-state domestic manufacturing capital. Landowners experience small aggregate income losses of just under 1 percent, because of the reallocation of labor away from agriculture. Expected worker welfare rises by 3 percent, because of the substantial wage increases in slaveholding locations, and the positive probability of living in those locations. At the disaggregated level, we find that access to slavery investments played an important role in shaping the geography of the industrial revolution, consistent with our causal estimates using variation in middle-passage mortality. The locations with the greatest levels of participation in slavery investment experience increases in total income of more than 40 percent, with population increasing by 6.5 percent, capitalists' income rising by more than 100 percent, and landlords' income declining by just over 7 percent.

The remainder of the paper is structured as follows. Section 2 reviews the related literature. Section 3 discusses the historical background. Section 4 introduces our data. Section 5 provides motivating evidence on patterns of slaveholding and economic activity within Britain over time. Section 6 develops the theoretical model that guides our empirical analysis. Section 7 reports our main empirical results. Section 8 summarizes our conclusions.

2 Related Literature

There is a large literature examining links between slavery and the Industrial Revolution in Britain after 1750. The idea that riches derived from slavery accelerated economic development is almost as old as capitalism itself – and so are the counterarguments. Adam Smith considered slavery and the colonial system economically inefficient. On the other hand, in 1788, when the British parliament debated the possible abolition of slavery, merchants involved in the trade argued that "the effects of this trade to Great Britain are beneficial to an infinite Extent ... [and] ... were this [trade to be] abolished, it would [cause] very great Detriment to our Manufacturers...." (Eltis and Engerman 2000). Karl Marx Marx (1867), in "Das Kapital," famously opined that "the veiled slavery of the wage-workers in Europe needed, for its pedestal, slavery pure and simple in the new world..." In 1944, Eric Williams (1944) argued

> "Britain was accumulating great wealth from the triangular trade. ... that trade
> inevitably [increased] ... the productive power of the country... the investment
> of profits from the triangular trade in British industry ... supplied ... the huge

outlay for the construction of vast plants to meet the needs of the new productive process..."

Williams' hypothesis stimulated a large body of academic research on links between the triangular trade and industrial development in Britain. Historians of the 'world system of capitalism' in the vein of Immanuel Wallerstein and Gunder Frank have argued that economic development in the European 'core' cannot be separated from exploitation and political suppression in the periphery (Frank 1967, Wallerstein 2004), emphasizing the importance of capital accumulation. Using data on slave-trading voyages from British and European ports over time, Derenoncourt (2019) estimates the contribution of the slave trade to city population growth.[4] Findlay (1990), for example, argues "slavery was an integral part of a complex ... system of trade in goods and factors within which the Industrial Revolution ... emerged... [but there is] no causal arrow from slavery to British industrialization." Price and Whatley (2020) estimate the financial impact of the South Sea Company's monopoly on the trade of enslaved Africans to Spanish America (the Asiento de Negros), as granted by the British Parliament. While some studies focus on the profits from the slave trade, other historical research emphasizes the contribution of the wealth derived from colonial slavery plantations Darity (1990).[5] Solow (1993) emphasizes that profits from slave trading and slave holding were large compared with domestic investments in Britain.[6]

Critical assessments focus on the limited profitability of the slave trade. Some historians have argued that planters in the West Indies barely covered their cost and that profitability declined from the 1750s onwards (Ragatz 1928), but this notion has been disputed (Drescher 2010). Thomas and Bean calculated that Britain did not profit from slave plantations producing colonial produce (Thomas and Bean 1974). Similarly, Eltis and Engerman (2000) examine aggregate effects of the slave trade and conclude their analysis by saying, "African slavery ... did not ... cause the British Industrial Revolution ... ."

Therefore, with a few exceptions, slavery has mainly been viewed as little more than a sideshow in the transformation of Britain's economy. However, there remains a scarcity of

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[4]Related research by Acemoglu and co−authors emphasizes that, in North−Western Europe, Atlantic trade led to better institutions by strengthening the hand of merchants (Acemoglu et al. 2005). However, these authors do not emphasize that much of this trade derived from the trafficking of enslaved Africans.

[5]Using data from Maryland in the United States, González et al. (2017) provide empirical evidence that slavery wealth was an important source of collateral used to finance U.S. entrepreneurship. For the United States as a whole, Francis (2021) emphasizes the role played by the tariff revenue derived by the Federal Government from the imports that were made possible by the export of the cotton produced by slave plantations.

[6]While not all scholars agree, there is substantial evidence that slavery did not accelerate development in the U.S. (Bleakley and Rhode 2021, Wright 2006). A key difference is that slavery occurred domestically in the U.S., which implies that three forces were at work: slavery's effect on capital returns, the local labor market, and institutions and culture. Britain's exposure to slavery was fundamentally different, with nationals investing in overseas slave plantations and the slave trade, but without any substantive domestic slavery.

quantitative, well−identified evidence on the contribution of slavery towards Britain's Industrial Revolution, combining aggregate and cross-sectional evidence.

Our research is also related to the wider literature on structural transformation and economic development, including Matsuyama (1992), Caselli and Coleman (2001), Lucas (2002), Ngai and Pissarides (2007), Uy et al. (2012), Herrendorf et al. (2012), Bustos et al. (2016), Gollin et al. (2016), Caprettini and Voth (2020) and Fajgelbaum and Redding (2022). We contribute to research on the geography of the British Industrial Revolution (Crafts and Wolf 2014), and to work on the role of financial development in economic growth generally, as well as during the British Industrial Revolution in particular, including Gerschenkron (1962), Guiso et al. (2004), Moll (2014), Itskhoki and Moll (2019), and Heblich and Trew (2019). Our main contribution relative to this research is to provide theory and evidence on the role of slavery wealth in influencing structural transformation and regional economic development.

3   Historical Background

Britain's involvement in the slave trade dates back to the 1560s and expanded substantially after 1640. In 1660, the Royal African Company was granted a monopoly over English trade with the West Coast of Africa, including the slave trade. However, following the Glorious Revolution of 1688 and the accession of William III, this monopoly was broken up; subsequent slave voyages were financed and organized by individual ship owners.

By the 1700s, the 'triangular trade' from Europe-Africa-Americas was the mainstay of the British West Coast ports of Bristol and Liverpool. This trade involved the export of manufacturing goods, including textiles, from Britain to the West Coast of Africa; the transportation of enslaved persons from the West Coast of Africa to the Americas; and the export of plantation products such as sugar, tobacco, coffee and cotton from the Americas to Britain.

Figure 1 shows the annual number of enslaved persons transported across the Atlantic by ships from British ports (solid line) and ships from all nations (dashed line). From 1701-1807, British ships are estimated to have have carried over 2.5 million enslaved persons, more than one third of the over 6 million total transported during this period.[7] The British slave trade was concentrated in three British ports: Liverpool (49 percent); London (29 percent); and Bristol (21 percent); with all other ports accounting for only 1 percent of trade.

The wealth accumulated from the slave trade and slaveholding was far from evenly distributed within Britain. James Penny, who was heavily involved in the slave trade, predicted instant ruin from its abolition for the British towns most involved in it: "[s]hould this trade be abolished, it would not only affect the Commercial Interest . . . of the County of Lancaster, and

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[7]The total number of enslaved persons embarked, including years after 1807, was 10.6 million (Eltis 1984).

Figure 1: Slave Trade - Annual Total of Enslaved Persons Shipped, British vs ROW
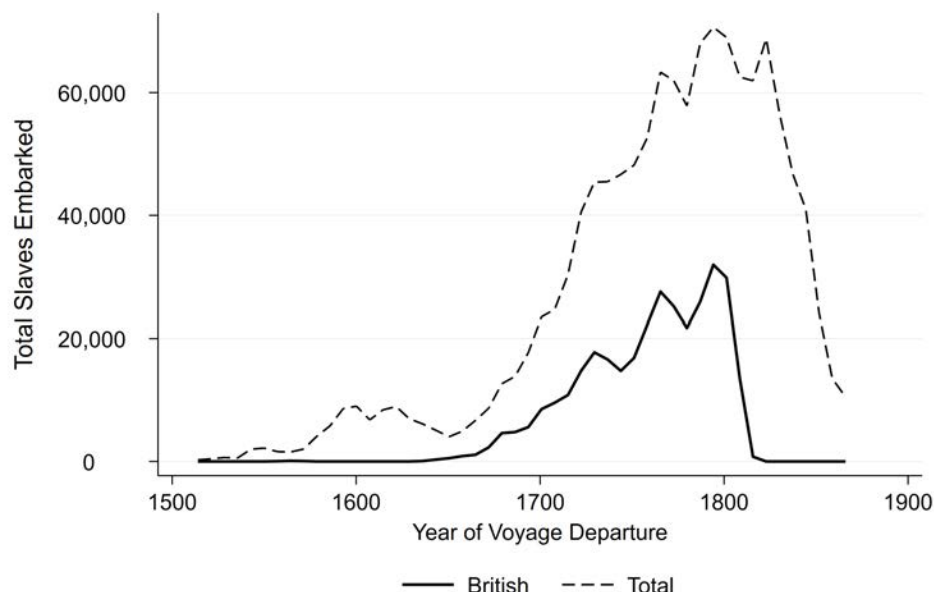
Note: Annual total number of enslaved persons transported across the Atlantic ocean using ships from British ports and ships from all nations.

more particularly the Town of Liverpool, whose fall, ... would be as rapid as its Rise has been astounding." (Eltis and Engerman 2000).

At the individual level, the sums involved were large. The Grade I-listed Harewood House is one of England's finest country houses, and is still owned by the Lascelles family, who amassed substantial wealth through slavery. In 1833, the Second Earl of Harewood received £26,307 in slavery compensation payments for 1,277 enslaved persons, which equals £19 million adjusted for inflation, or £128 million when expressed as the same share of GDP.[8]

Over time, reports of barbaric conditions on slave ships led to a campaign for the abolition of the slave trade.[9] In response to this growing campaign, the Abolition of the Slave Trade Act was passed in 1807, which prohibited the slave trade (but not slavery) in the British Empire. Some abolitionists hoped that slavery would be unsustainable without the slave trade, but further legislation was delayed by the Revolutionary Wars. Eventually, the Slavery Abolition Act of 1833 was passed, making the ownership of enslaved persons illegal within the British Empire (Taylor 2020).

Under the terms of the 1833 Act, the British government spent £20 million to compensate slaveholders, equivalent to 40 percent of government revenue or 5 percent of GDP (Barro

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[8]The grandfather of the Earl of Harewood was Edwin Lascelles, born in Barbados without a title in 1712. A relative, Alan Lascelles, is The Queen's private secretary in Netflix's series The Crown.

[9]Black African writers played an important role in making these barbaric conditions more widely known, including Equiano (1789). For further discussion of the abolitionist campaigns, see Taylor (2020) .

1987). Additionally, formerly-enslaved persons were forced to work without remuneration for up to six years under an "apprenticeship" system. Slaveholders were required under the 1833 Act to register claims for the number of enslaved persons held, which were systematically collected and processed by a Slave Compensation Committee. Separate schedules were drawn up for each colony that specified a compensation rate per slave that depended on age and occupation.[10] Compensation was paid to slaveholders from 1835 onwards.

4 Data

We construct a new spatially-disaggregated dataset on slaveholding and economic activity in England and Wales.[11] We combine seven main data sources: (i) Individual-level data on slaveholding based on compensation claims paid under the 1833 Abolition of Slavery Act; (ii) Individual slave-trading voyages from British ports; (iii) Population and employment structure; (iv) Property valuations; (v) Location of cotton mills; (vi) Family linkages; (vii) Steam engines.[12]

Slaveholding We use data from the *Legacies of British Slavery Database* to measure the geographical distribution of slavery wealth within Britain at the time of the abolition of slavery in 1833. Starting with the records of the Slave Compensation Committee, this database was constructed over more than a decade by the *Centre for the Study of the Legacies of British Slavery* at University College London. The data include detailed information on compensation claims, the identity of the awardees, the legitimacy of their claims, and the ownership records of awardees. We use a digital version of these data, which includes information on 53,000 individuals connected to slavery, of whom 25,000 were awarded compensation for 425,000 enslaved persons. In Section G.1 of the online appendix, we provide an example of the entry from this database for the Second Earl of Harewood. We observe name, date of birth and death, biographical information including family history, address, the name and location of each colonial plantation, and the compensation awarded and number of enslaved persons for each plantation. We find a tight and approximately log linear relationship across slaveholders between the value of slavery compensation paid and the number of enslaved persons claimed.[13] We use the number of enslaved persons claimed for compensation purposes as our baseline measure of slaveholding in our regression analysis.

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[10]See Figure G.3 in Online Appendix G.1 for an example of such a compensation schedule.

[11]We focus on England and Wales, because the population census is reported separately for these two countries; our historical property valuation data is unavailable for Scotland; and the Act of Union with Scotland occurs later in 1707 after the start of slave trading from the British Isles.

[12]See Online Appendix G for further details about the data sources and definitions.

[13]See Figure G.4 in Online Appendix G.1 for a binscatter of this relationship.

Slave voyages   We use the slave voyages dataset constructed by Herbert Klein and collaborators.[14] This database contains information on 36,000 slave voyages, with a total of over 10 million enslaved persons shipped across the Atlantic from 1526 onward. Of these, 10,785 voyages were conducted by British owners, involving the transportation of 2.9 million enslaved persons from 1562 to the Abolition of the Slave Trade in 1807. For each voyage, we know the names of (up to) eight owners; the port of origin; the ports visited on the African coast; and the final destination. For a subset of voyages, we also observe the duration of the voyage, and the number of enslaved embarked and disembarked. We use this information to compute a voyage mortality rate, which we use to construct one of our instruments for slaveholding.

Population and Employment Structure   We obtain data on parish population from 1801-1831 from the population census (see Wrigley 2011). We supplement these population census data with information from the *History database of the Global Environment* (Hyde) for years before 1801 (see Klein Goldewijk et al. 2017). Data on employment structure by parish in 1831 are provided by Southall et al. (2004). We distinguish employment in agriculture, as well as in manufacturing.

Cotton Mills   We construct two sets of data on the location of cotton mills within England and Wales. First, we digitized data on the number of cotton mills in each parish for the year 1839, as reported in House of Commons (1839). This parliamentary report summarizes the results of factory inspections under the Factory Act and contains the most comprehensive data on industrial establishments in Britain before the start of the Census of Production during the 20th century. Second, we digitized data on the location of 212 British cotton mills that were erected in the early decades of the industrial revolution from 1768-88 from Colquhoun, as revised and extended by Chapman (1981).

Property Valuations   We use a number of different sources of data on property valuations for each parish. For the year 1086, we construct the value of land, buildings and equipment for each parish from the Domesday Book, using the digitized data for each manor in PASE (2010). For the year 1334, we use the value of personal property (excluding land and buildings) for each parish from the Lay subsidies, as compiled by Glasscock (1974) and Campbell and Bartley (2006). For the year 1798, we digitized the data on the land tax quotas for each parish, as reported in House of Commons (1844). These land tax quotas were originally specified in 1690, and were subject to gradual amendment over time (Ginter 1992). In 1798, these land tax quotas were made unalterable by law; they remained unchanged until abolished in 1963. For the years 1815, 1843 and 1881, we digitized rateable values for each parish, which correspond

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[14]Available online at `www.slavevoyages.org`.

to the market value of the annual flow of rent for the use of land and buildings. With a few minor exceptions, these rateable values include all categories of land and property, and were used to raise revenue for local public goods.

Family Linkages   We link the location of slaveholders in 1833 to that of slave traders' ancestors. We use the fact that many individuals involved in the slave trade either returned to their ancestral home areas, or continued to have family there (who would inherit, or benefit from their relative's expertise). We begin by using the Slave Voyages database (see above) to identify individuals involved in the slave trade. We next use two different approaches to link these slave traders to the locations of slaveholders in 1833. Our first approach uses genealogical information. For each slave trader, we find the largest family tree containing this person from `Ancestry.com`. From this family tree, we extract the universe of the slave trader's parents, grandparents, and great-grandparents (as far as these are available), and locate them geographically based on birth address (or death address if birth address is unavailable). Our second approach uses the geographical distribution of surnames in Britain (e.g., Cheshire and Longley 2011). We assign slave traders to locations probabilistically, based on the likelihood of observing their surname in a location in the individual-level 1851 population census. We use these two different approaches to construct our two instruments for slavery wealth, as discussed below.

Steam Engines   We use the British Newspaper Archive to collect data on the location of steam engines. We search for second-hand sales, advertisements, and job ads that contain references to steam engines from 520 local newspapers in England and Wales. Over the period 1755–1850, we obtain around 20,000 references to steam engines, which we assign geographically based on the location of publication of the newspaper.

Data Structure   To overcome changes in the boundaries of administrative units such as parishes over time, we construct a hexagonal spatial grid over England and Wales, consisting of 849 cells ("regions").[15] Each grid cell covers an area of 200 square kilometers and the distance from the centroid to the vertex measures around 9 km. Since the dominant mode of commuting during our sample period was walking, 9 km is a reasonable maximum distance over which it would be possible to walk to work. A further advantage of this grid cell structure is that it is straightforward to examine the robustness of our results to alternative sizes of grid cells, as discussed below. We assign our data to grid cells either based on exact geolocated addresses (e.g., for slaveholder addresses) or the latitude and longitude coordinates of

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[15]We choose hexagons (rather than squares or triangles) because of their advantages for partitions of geographical space, as discussed for example in Carr and Pickle (2010).

the centroids of parishes (e.g., for our population census data). With around 10,000 parishes in England Wales, each parish is small relative to the area of our 849 grid cells.

5 Motivating Evidence

We begin by providing some motivating evidence on patterns of slaveholding and economic activity in England and Wales. In Subsection 5.1, we examine cross-section patterns at the time of the Abolition of Slavery in 1833. In Subsection 5.2, we use our historical data on property values to the examine the evolution of this relationship over time.

## 5.1 Economic Activity and Slaveholding in the 1830s

In Figure 2a, we show the spatial distribution of slaveholder compensation in 1833 in England and Wales. To provide as fine a level of spatial resolution as possible, we display slavery wealth in this figure at the parish level. The size of the blue circles is proportional to the amount of slavery compensation awarded in current price 1833 pounds sterling. We find the largest concentrations in the areas surrounding the three ports most heavily involved in the slave trade and the products of the slave economy (in particular, sugar, tobacco, coffee and cotton): Liverpool in the North-West, Bristol in the South-West, and London in the South-East. But slaveholding extends throughout much of England and Wales, particularly in coastal regions, and in the main population centers.

In Figure 2b, we show the manufacturing employment share in each of our hexagonal regions in 1831. By that time, the manufacturing employment share for England and Wales as a whole was approximately 42%, and we see the emergence of industrial agglomerations in the North. However, agriculture still employs approximately 27% of the population and there is substantial heterogeneity in agricultural specialization across regions, with agriculture still accounting for more than 60% percent of employment in some counties.[16] Comparing the two figures, manufacturing employment shares and slaveholder compensation are positively correlated.

In Figure 3, we provide further evidence on the correlation between structural transformation and slaveholding using three different indicators: the agricultural employment share in 1831 (left panel), the number of cotton mills in 1839 (middle panel), and the industry employment share in 1831 (right panel). We show the fitted values and 95 percent confidence intervals from local polynomial regressions of all three measures on the number of enslaved

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[16]See Figure B.1 in Online Appendix B for a corresponding map of agricultural employment shares. To derive the 1831 figure, we linearly interpolate the Broadberry et al. (2010) employment shares for 1801 and 1851. Along similar lines, Crafts (1985) reports a share of male employment in industry later, in 1840, of 47.3%.

Figure 2: Slaveholding and Structural Transformation in the 1830s

(a) Slaveholder Compensation in 1833

(b) Manufacturing Employment Share in 1831
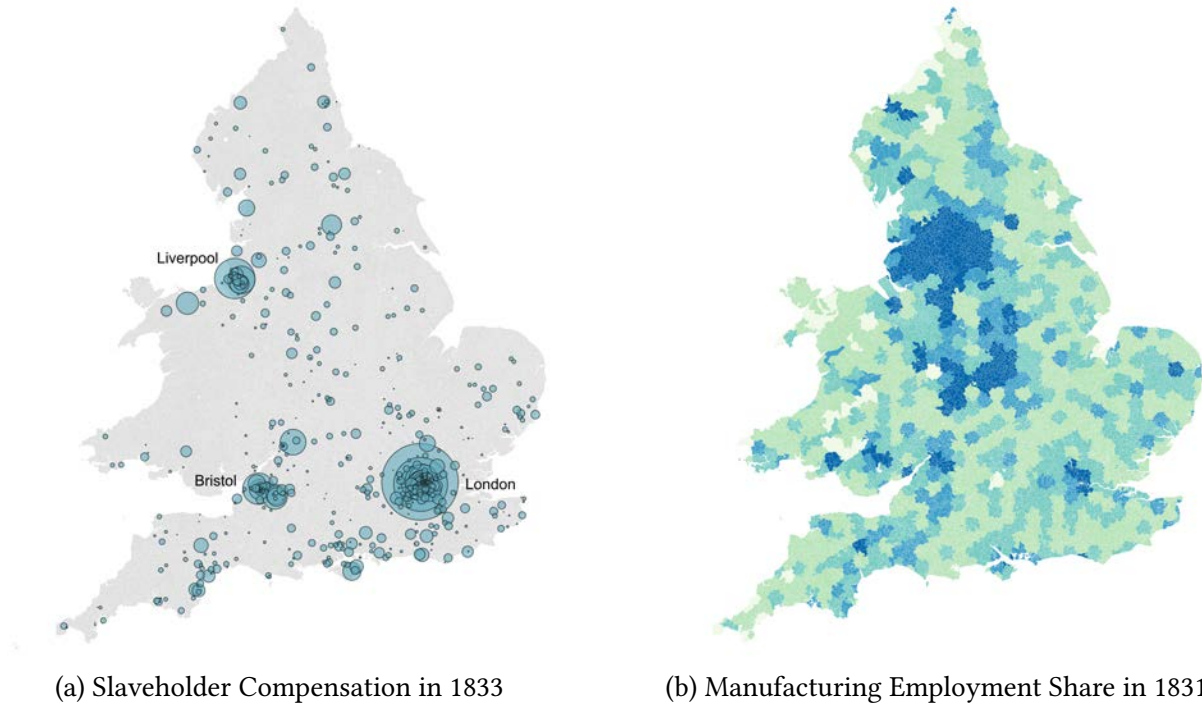
Note: *Left panel*: Slaveholder compensation in each parish in 1833 pounds sterling; size of blue circles proportional to the total value of slaveholder compensation in each region. The largest three slave trading ports by enslaved persons embarked are labelled. *Right panel*: Manufacturing employment share in each region in the 1831 census; darker blue colors correspond to higher values; lighter green colors correspond to lower values.

persons claimed in 1833. We find that areas with greater slaveholding have lower agricultural employment shares, more cotton mills, and higher manufacturing employment shares.

5.2 Economic Activity and Slaveholding over Time

We next use our long historical time-series on property valuations to examine the timing of the emergence of this relationship. We estimate non-parametric regressions of property valuations per land area in each year on the number of enslaved persons claimed in 1833. We control for other potential determinants of property valuations, such as geographical location, using the Frisch-Waugh-Lovell Theorem. In particular, we regress both property valuations and slaveholding on controls for latitude, longitude, and population, generate the residuals, and then estimate our non-parametric regressions using these residuals. We find a similar pattern of results in robustness tests without these controls.

Figure 3: Structural Transformation and Slaveholding in the 1830s
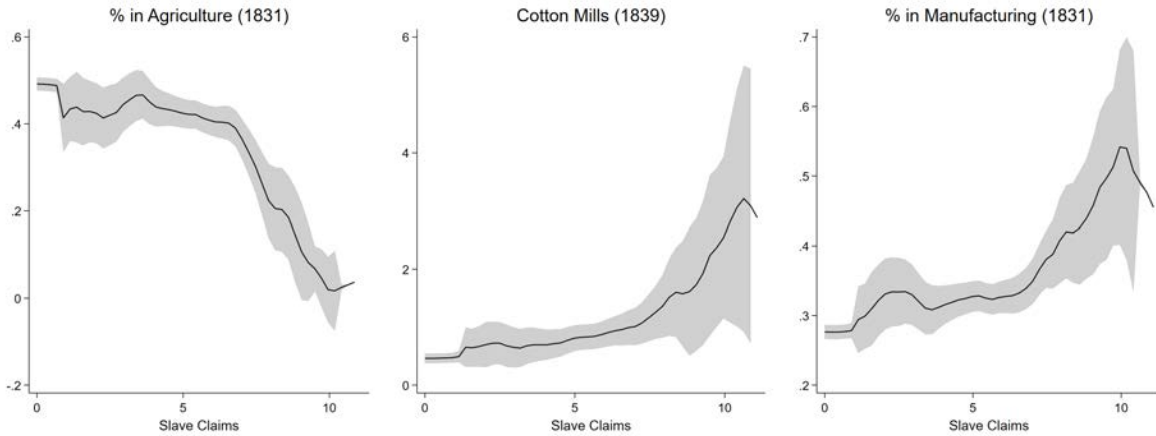
Note: In all three panels, horizontal axis shows total number of enslaved in each hexagon in 1833; vertical axes show agricultural employment share in 1831 (left panel), number of cotton mills in 1839 (middle panel), and manufacturing employment share in 1831 (right panel); dark line shows fitted values from local polynomial regression; gray shading shows 95 percent confidence intervals. Slave claims and the number of cotton mills are inverse hyperbolic sine transformed.

Figure 4: Property Valuations by Year and Number of enslaved persons Claimed in 1833
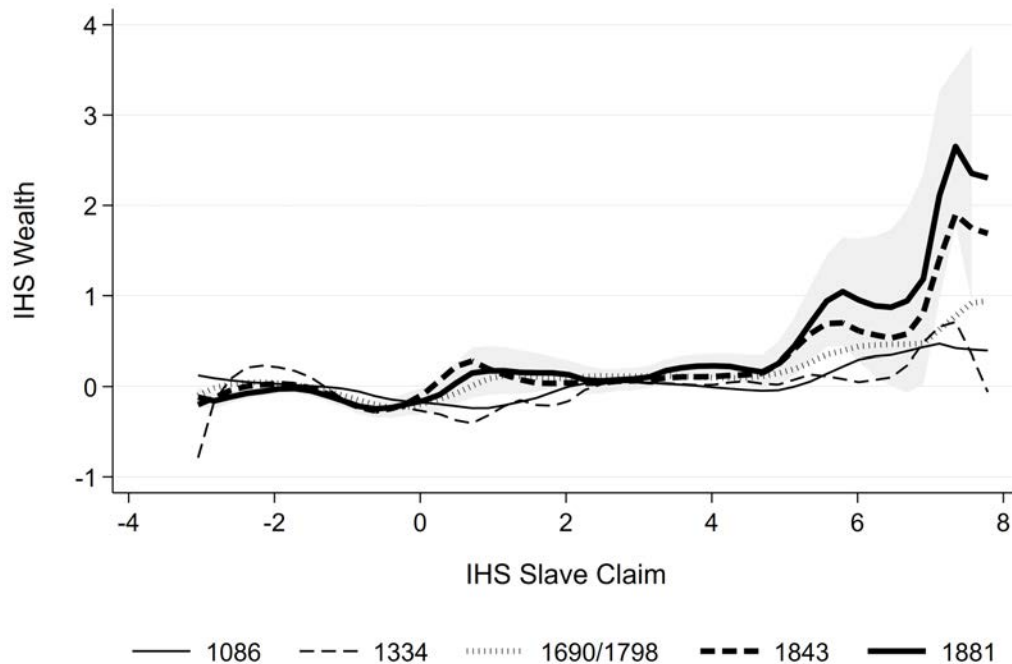
Note: Local polynomial regressions; vertical axis is residual from regressing the inverse hyperbolic sine (IHS) of property valuation on the parish centroid's latitude, longitude and population in each grid cell; horizontal axis is residual from regressing the inverse hyperbolic sine (IHS) of 1833 slavery compensation on the same control variables; gray shading shows 95 percent confidence intervals for 1881; see Section 4 above and Section G of the Online Appendix for further details about the property valuation data for each year.

In Figure 4, we show the estimated gradient between the inverse hyperbolic sines of each of our measures of property valuation per land area and the number of enslaved persons claimed in 1833. The residual property valuation and slaveholding variables both have mean zero. For 1086 (solid medium black line), we find a relatively flat relationship with only a slight upward slope. For 1334, we again observe a flat relationship, with essentially no gradient. Therefore, we find no evidence of a relationship between levels of economic activity and future slaveholding before Britain's large-scale involvement in slavery from the 1640s onwards.

In contrast, using our 1798 property valuation data, which are based on amended 1690 land tax quotas, we begin to observe a positive upward-sloping relationship. By 1843, this positive slope steepens further, particularly at higher levels of slaveholding. By 1881, there is a further steepening of this positive slope, which is again greater at higher levels of slaveholding. Hence, following Britain's large-scale participation in slave trading and slaveholding from the 1640s onwards, we start to observe a positive relationship between economic activity and our measure of slaveholding.

Taken together, these empirical findings are suggestive of a relationship between slavery wealth and economic development. In the next section, we develop a theoretical model to understand the potential mechanisms for such an empirical relationship. In the following section, we introduce our identification strategy to estimate causal effects, and use our theoretical model to quantify the aggregate and distributional consequences of slavery investments.

6 Theoretical Model

To guide our empirical analysis, we develop a simple theoretical model of economic development and structural transformation.[17] We augment a conventional specific-factors model to incorporate labor mobility, endogenous capital accumulation, and slavery investments in an overseas colony. Slavery and domestic investments are assumed to be imperfect substitutes for one another. Investments are subject to financial frictions, such that most domestic investments occur locally. Access to slavery investments raises the rate of return to capital accumulation, which increases the steady-state capital stock, and hence leads to an expansion in the local capital-intensive manufacturing sector.

6.1 Model Setup

We consider a set of small open economies: many domestic locations indexed by $i, n \in \{1, \ldots, N\}$ and a colonial plantation $\mathbb{N}$. Time is discrete and indexed by t.

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[17]For a more detailed exposition of the model and the derivation of all theoretical results in this section of the paper, see Online Appendix C.

The world economy includes four types of agents: workers, capitalists, landlords and enslaved persons. Workers, capitalists and landlords are located in the domestic economy. Enslaved persons work in the colonial plantation. There are three sectors of economic activity: agriculture and manufacturing (produced in the domestic economy) and plantation products (produced in the colony). Agriculture is produced with labor and land. Manufacturing is produced with labor and capital. Workers are mobile between the two domestic sectors. But land and capital are specific factors that can only be used in agriculture and manufacturing respectively. Enslaved persons and capital produce plantation goods.[18]

Workers are endowed with one unit of labor that is supplied inelastically. They are geographically mobile across locations within the domestic economy, but geographically immobile between the domestic economy and the colonial plantation. Landlords in each domestic location are geographically immobile and own local land (m_n).

Capitalists are geographically immobile and own local capital (k_{nt}). Each period, they allocate capital to either local manufacturing or to plantation production. They also make a dynamic consumption-investment decision. They can either invest their assets (a_{nt}) in capital (k_{nt}) or a consumption bond that pays a constant rate of return ρ. Investments in capital are subject to collateral constraints, such that capitalists can only invest a multiple of their current assets: $k_{nt} \leq \lambda_n a_{nt}$. If they invest in capital, they observe idiosyncratic productivity draws for the number of effective units of capital for use in domestic manufacturing and the colonial plantation. These idiosyncratic productivity draws give rise to a downward-sloping Keynesian marginal efficiency of capital schedule for each location. They also imply an asset demand system in which the elasticity of substitution between domestic and colonial investments is determined by the dispersion of these idiosyncratic productivity draws. Capitalists face financial frictions, such that $\phi_{nit} \geq 1$ units of capital must be invested from location n in order for one unit to be available for production in location $i \in \{n, \mathbb{N}\}$.[19]

6.2   Preferences and Endowments

The indirect utility function for a worker ϑ in location n at time t ($u_{nt}(\vartheta)$) depends on the wage (w_{nt}^L), the consumption goods price index (p_{nt}), amenities that are common across workers (B_{nt}), and an idiosyncratic amenity draw ($b_{nt}(\vartheta)$) that captures all the idiosyncratic reasons

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[18]For simplicity, we abstract from land use in plantation products and capital use in agriculture, although both can be introduced. What matters is that plantation products and domestic manufacturing both use capital, and domestic manufacturing is more capital-intensive than domestic agriculture.

[19]In our baseline specification, we capture the local nature of investment by assuming for simplicity that capitalists can only invest in their own location or the colonial plantation. In Online Appendix F, we develop an extension, in which capitalists can invest in any domestic location subject to financial frictions that increase with distance, which gives rise to a gravity equation in bilateral investment flows.

why an individual worker can choose to live in a particular location:

$$u_{nt}(\vartheta) = \ln B_{nt} + \ln w_{nt}^L - \ln p_{nt} + \kappa \ln b_{nt}(\vartheta), \tag{1}$$

where the parameter κ regulates the heterogeneity in idiosyncratic amenities. The consumption goods price index (p_{nt}) depends on the price of agriculture (p_{nt}^A), the price of manufacturing (p_{nt}^M) and the price of plantation products (p_{nt}^S):

$$p_{nt} = \left[\left(p_{nt}^A / \beta_t^A \right)^{1-\sigma} + \left(p_{nt}^M / \beta_t^M \right)^{1-\sigma} + \left(p_{nt}^S / \beta_t^S \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}, \tag{2}$$

where (β_t^A, β_t^M, β_t^S) are taste parameters that control the relative weight of the three goods in utility; we assume inelastic demand between the three sectors ($0 < \sigma < 1$), as in the macroeconomics literature on structural transformation.

Each location is connected to world markets through iceberg trade costs that can differ across sectors ($\tau_{it}^A \geq 1$, $\tau_{it}^M \geq 1$, $\tau_{it}^S \geq 1$) and faces exogenous prices for each good on world markets (p_t^{AW}, p_t^{MW}, p_t^{SW}).[20] Therefore, no-arbitrage implies that the local prices of the three goods (p_{nt}^A, p_{nt}^M, p_{nt}^S), and hence the local consumption price index (p_{nt}), are pinned down by these iceberg trade costs and exogenous world market prices.

6.3 Technology

Each good is produced under conditions of perfect competition using constant returns to scale Cobb-Douglas technologies. Cost minimization and zero profits imply that price equals unit costs if a good is produced:

$$p_{it}^A = \frac{1}{z_{it}^A} \left(q_{it} \right)^{\alpha^A} \left(w_{it}^L \right)^{1-\alpha^A}, \qquad i \in \{1, \dots, N\}. \tag{3}$$

$$p_{it}^M = \frac{1}{z_{it}^M} \left(r_{it} \right)^{\alpha^M} \left(w_{it}^L \right)^{1-\alpha^M}, \qquad i \in \{1, \dots, N\}. \tag{4}$$

$$p_{\mathbb{N}t}^S = \frac{1}{z_{\mathbb{N}t}^S} \left(r_{\mathbb{N}t} \right)^{\alpha^S} \left(w_{\mathbb{N}t}^S \right)^{1-\alpha^S}, \tag{5}$$

where z_{it}^j denotes productivity for sector $j \in \{A, M, S\}$; q_{it} is the domestic agricultural land rent; r_{it} is the domestic rental rate per effective unit of capital; $r_{\mathbb{N}t}$ is the exogenous rental rate per effective unit of capital in the colonial plantation; $w_{\mathbb{N}t}^S$ is the exogenous shadow cost of enslaved labor in the colonial plantation; and $0 < \alpha^A, \alpha^M, \alpha^S < 1$.

The equilibrium wage (w_{it}^L) is determined by the equality of labor's value marginal product in agriculture and manufacturing for each domestic location where both these goods are

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[20]While our baseline specification assumes for simplicity that locations are small open economies that face exogenous world market prices, we can also allow for an endogenous terms of trade.

produced. Given prices (p_i^A, p_i^M), productivity (z_i^A, z_i^M), land supply (m_i), capital allocated to domestic manufacturing (k_{it}^M) and total employment (ℓ_{it}) for a given location i, the model behaves as in the conventional specific-factors model. In contrast to this conventional framework, both the capital allocated to domestic manufacturing k_{it}^M) and total employment (ℓ_{it}) are endogenous, and the capital stock (k_{it}) is determined by consumption-saving decisions.

6.4 Labor Market Clearing

After observing her idiosyncratic amenity draws ($b_n(\vartheta)$), each worker chooses her preferred domestic location. We make the conventional assumption that idiosyncratic amenities are drawn from an extreme value distribution: $F(b) = \exp(-\exp(-b - \overline{\gamma}))$, where $\overline{\gamma}$ is the Euler-Mascheroni constant. Using this assumption, the share of workers who choose to live in location n depends on relative amenity-adjusted real wages, and takes the logit form:

$$\mu_{nt} = \frac{\ell_{nt}}{\overline{\ell}_t} = \frac{\left(B_{nt}w_{nt}^L/p_{nt}\right)^{1/\kappa}}{\sum_{k=1}^{N}\left(B_{kt}w_{kt}^L/p_{kt}\right)^{1/\kappa}},\tag{6}$$

where $\overline{\ell}_t$ is total domestic employment, such that labor market clearing implies $\sum_{i\in N}\ell_{it} = \overline{\ell}_t$. Worker expected utility taking into account the idiosyncratic productivity draws is:

$$\mathbb{U}_t = \kappa \log\left[\sum_{k=1}^{N}\left(B_{kt}w_{kt}^L/p_{kt}\right)^{1/\kappa}\right],\tag{7}$$

Intuitively, expected utility increases in amenities (B_{nt}) and wages (w_{nt}^L), and decreases in the consumption price index (p_{nt}).

6.5 Capital Allocation Within Periods

At the beginning of period t, the capitalists in location n inherit an existing stock of capital k_{nt}, and decide where to allocate this existing capital, and how much to consume and invest. Once these decisions have been made, production and consumption occur. At the end of period t, new capital is created from the investment decisions made at the beginning of the period, and the depreciation of existing capital occurs. In the remainder of this subsection, we characterize capital allocation decisions at the beginning of period t. In the next subsection, we characterize optimal consumption-investment decisions.

We assume that capital can be allocated either locally (k_{nnt}) or to the colonial plantation ($k_{n\mathbb{N}t}$).[21] The productivity of capital in each of these uses is subject to idiosyncratic productiv-

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[21]In Online Appendix F, we develop our theoretical extension to allow capitalists to invest in all domestic locations, subject to financial frictions that generate a gravity equation for investment. Using data from the Legacies of British Slavery database, we find that capital investments indeed decline sharply with distance, with more than 50 percent of investment occurring within 100 km, as shown in Online Appendix B.5.

ity draws (ϵ_{nnt}, $\epsilon_{n\mathbb{N}t}$) for effective units of capital, as in Liu et al. (2022). These idiosyncratic productivity draws correspond to Keynesian marginal efficiency of capital shocks, and give rise to imperfect substitutability between domestic and colonial investments.[22] The return to a capitalist from location n of investing a unit of capital in destination i (v_{nit}) depends on the rental rate per effective unit (r_{it}), the number of effective units (ϵ_{nit}) and financial frictions (ϕ_{nit}): $v_{nit} = \epsilon_{nit}r_{it}/\phi_{nit}$. We assume that these idiosyncratic productivity shocks (ϵ_{nit}) are drawn independently from a Fréchet distribution: $F(\epsilon) = e^{-\epsilon^{-\theta}}$. The shape parameter $\theta > 1$ controls the dispersion of these shocks. We normalize the scale parameter to one, because it enters the model isomorphically to financial frictions (ϕ_{nit}).

Using the properties of this Fréchet distribution, the shares of capital allocated to each location depend on relative rental rates (r_{it}) and financial frictions (ϕ_{nit}):

$$\xi_{nit} = \frac{k_{nit}}{k_{nt}} = \frac{(r_{it}/\phi_{nit})^{\theta}}{\sum_{m\in\{n,\mathbb{N}\}} (r_{mt}/\phi_{nmt})^{\theta}}, \qquad i \in \{n, \mathbb{N}\}. \tag{8}$$

Both local domestic manufacturing and the colonial plantation face an upward-sloping supply function for capital, such that each must offer a higher rental rate (r_{it}) in order to attract a larger share of capital (ξ_{nit}). If some domestic locations n have better information about slavery investments, for example through ancestral links to the slave trade, this is reflected in lower financial frictions for colonial investment (lower $\phi_{n\mathbb{N}t}$), and hence a higher share of capital invested in the colony $\mathbb{N}$ (higher $\xi_{n\mathbb{N}t}$).

Capital market clearing implies that the capital employed local manufacturing (k_{nt}^{M}) equals the capital allocated locally (k_{nnt}). Similarly, the capital employed in the colonial plantation ($k_{\mathbb{N}t}^{S}$) equals the capital allocated there from all domestic locations $n \in N$:

$$k_{nt}^{M} = k_{nnt} = \xi_{nnt}k_{nt}, \qquad\qquad k_{\mathbb{N}t}^{S} = \sum_{n=1}^{N} k_{n\mathbb{N}t} = \sum_{n=1}^{N} \xi_{n\mathbb{N}t}k_{nt}, \tag{9}$$

where $\xi_{nnt} + \xi_{n\mathbb{N}t} = 1$. As an investment location i attracts a larger share of capital from an ownership location n (ξ_{nit}), it attracts units of capital with lower realizations for idiosyncratic productivity, and hence moves further down its marginal efficiency of capital schedule, reducing the average productivity of capital. Therefore, we can write the capital market clearing condition (9) in productivity-adjusted terms as:

$$\widetilde{k}_{nt}^{M} = \gamma \xi_{nnt}^{-\frac{1}{\theta}} k_{nnt} = \gamma \xi_{nnt}^{\frac{\theta-1}{\theta}} k_{nt},$$

$$\widetilde{k}_{\mathbb{N}t}^{S} = \sum_{n\in\mathbb{N}} \gamma \xi_{n\mathbb{N}t}^{-\frac{1}{\theta}} k_{n\mathbb{N}t} = \sum_{n\in\mathbb{N}} \gamma \xi_{n\mathbb{N}t}^{\frac{\theta-1}{\theta}} k_{nt},$$

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[22]This imperfect substitutability is consistent with slavery investments being concentrated in cane sugar, tobacco, cotton and coffee, none of which could be efficiently produced domestically at the time. It is also in line with the theoretical and empirical literature on asset demand systems following Koijen and Yogo (2019).

where we use the tilde above the capital stock to denote the productivity-adjustment; $\gamma \xi_{nit}^{-\frac{1}{\theta}}$ is the average productivity of capital; $\gamma \equiv \Gamma\left(\frac{\theta-1}{\theta}\right)$; and $\Gamma(\cdot)$ denotes the Gamma function.

Again using the properties of the Fréchet distribution, the expected return to capital taking into account the idiosyncratic productivity draws is equalized across locations:

$$v_{nt} = v_{nnt} = v_{n\mathbb{N}t} = \gamma \left[\sum_{m \in \{n, \mathbb{N}\}} (r_{mt}/\phi_{nmt})^\theta \right]^{\frac{1}{\theta}}. \tag{10}$$

Intuitively, if location i has better investment characteristics in the form of a higher rental rate (r_{it}) or lower financial frictions (ϕ_{nit}), it attracts investments with lower idiosyncratic realizations for productivity, which reduces the capital productivity of capital through a composition effect. With a Fréchet distribution for capital productivity, this composition effect exactly offsets the impact of the better investment characteristics, such that the expected return to capital is equalized across locations. Therefore, the rental rate for capital can differ between local manufacturing and the colonial plantation ($r_{nt} \neq r_{\mathbb{N}t}$), but the expected return to capital taking into account the idiosyncratic productivity draws is equalized ($v_{nnt} = v_{n\mathbb{N}t} = v_{nt}$). Total capitalist income is linear in the existing capital stock: $V_{nt} = v_{nt} k_{nt}$.

A key implication of this specification is that capital market integration acts like an improvement in the productivity of the investment technology. To illustrate this point, note that the expected return to capital (v_{nt}) in equation (10) can be re-written in terms of the domestic investment share (ξ_{nnt}) using equation (8):

$$v_{nt} = \frac{\gamma \left(r_{nt}/\phi_{nnt}\right)}{\left(\xi_{nnt}\right)^{\frac{1}{\theta}}}. \tag{11}$$

In steady-state, the expected return to capital (v_{nt}) is pinned down by no-arbitrage with the rate of return on the consumption bond ($v_n^* - \delta p_n = \rho$).[23] Other things equal, a location n with better access to slavery investments (lower colonial financial frictions $\phi_{n\mathbb{N}t}$) has a lower domestic investment share (lower ξ_{nnt}) on the right-hand side of equation (11), which requires a lower rental rate (r_{nt}) for the equation to hold. Intuitively, obtaining access to slavery investments acts like an improvement in investment productivity, because capitalists obtain another set of draws for idiosyncratic productivity for the colonial plantation, which increases the average productivity of the investments that they choose to undertake in equilibrium. This increased average productivity of investment raises the rate of return to capital accumulation, which leads to a higher steady-state capital stock, and hence a lower steady-state rental rate.

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[23] A similar result holds in the absence of the consumption bond, in which case the steady-state expected return to capital is exogenously determined by parameters and the consumption price index: $v_n^* = p_n(1 - \beta(1-\delta))/\beta$.

6.6 Capital Allocation Across Periods

Capitalists choose consumption and investment to maximize intertemporal utility subject to their budget constraint:

$$\max_{\{c_{nt}, a_{nt+1}\}} \left\{ U_{nt}^k = \sum_{t=0}^{\infty} \beta^t \ln c_{nt}^k \right\}, \tag{12}$$

$$\text{subject to } p_{nt} c_{nt}^k + p_{nt} (a_{nt+1} - a_{nt}) = R_{nt} a_{nt},$$

where R_{nt} is the gross return to assets: $R_{nt} = \max\{v_{nt} - \delta p_{nt}, \rho\}$.

Given the linearity of capitalists' income in the existing stock of assets, equilibrium investments are characterized by a corner solution. If the expected return to capital net of depreciation ($v_{nt} - \delta p_{nt}$) exceeds the return from the consumption bond (ρ), capitalists invest all in capital up to the collateral constraint (λ_n): $k_{nt} = \lambda_n a_{nt} \cdot 1_{\{(v_{nt} - \delta p_{nt}) > \rho\}}$. We assume that collateral constraints do not bind in steady-state. Therefore, the expected return to capital equals the return from the consumption bond in steady-state: $v_{nt} - \delta p_{nt} = \rho$.

Given our assumption of logarithmic utility, capitalists' optimal consumption-saving decisions are characterized by a constant saving rate, as in Moll (2014):

$$a_{nt+1} = \beta \left(R_{nt}/p_{nt} + 1 \right) a_{nt}. \tag{13}$$

Therefore, although the saving rate is here endogenous, capital accumulation takes a similar form as in the conventional Solow-Swan model. There exists a steady-state capital-labor ratio in each location. If the initial capital stock in a location differs from this steady-state value, consumption smoothing implies that capitalists gradually accumulate or decumulate capital along the transition path towards this steady-state.

6.7 Slavery and Industrialization

Given time-invariant values of the exogenous variables, we show in Proposition C.1 in Online Appendix C.11 that there exists a unique steady-state equilibrium of the model. We now use the model to characterize the aggregate impact and distributional consequences of greater access to slavery investments. In particular, we undertake a comparative static in which we reduce colonial financial frictions ($\phi_{n\mathbb{N}}$) from prohibitive values for all locations (such that $\xi_{nn} = 1$ for all n) to finite values for some locations n (such that $\xi_{nn} < 1$ for some n, as observed in our data). We hold constant world prices (p^{AW}, p^{MW}, p^{SW}) and other exogenous fundamentals. Therefore, this comparative static captures the pure impact of greater access to slavery investments through capital accumulation. We show that the domestic investment share (ξ_{nn}) is a sufficient statistic for the impact of colonial financial frictions ($\phi_{n\mathbb{N}}$) on steady-state economic activity, as summarized in the following proposition.

Proposition 1. *(Slavery and Industrialization) Other things equal, in steady-state equilibrium, locations with better access to slavery investments (lower $\phi_{n\mathbb{N}}$ and hence lower ξ_{nn}^*) have (i) lower agricultural employment (ℓ_n^{A*}); (ii) higher manufacturing employment (ℓ_n^{M*}); (iii) higher total population (ℓ_n^*); (iv) a lower rental rate for capital (r_n^*); (v) higher wages (w_n^{L*}) and worker real income (w_n^{L*}/p_n); (vi) lower price of agricultural land (q_n^*); (vii) higher productivity-adjusted and unadjusted stocks of capital ($\widetilde{k}_n^*$, k_n^*); (viii) higher productivity-adjusted and unadjusted stocks of capital in domestic manufacturing ($\widetilde{k}_n^{M*}$, k_n^{M*}); (ix) higher capitalist real income ($v_n^* k_n^*/p_n$); (x) lower landlord real income ($q_n^* m_n/p_n$).*

Proof. See Section C.12 of the online appendix. □

The proposition reflects the net effect of counteracting forces. On the one hand, for a given stock of capital (k_n), the fall in colonial financial frictions ($\phi_{n\mathbb{N}}$) reduces the capital allocated to local manufacturing (lower k_{nn}) through a conventional substitution effect. On the other hand, the fall in colonial financial frictions ($\phi_{n\mathbb{N}}$) acts like an improvement in the productivity of the investment technology, which increases the return to capital accumulation, and raises the steady-state capital stock (k_n^*). The proposition establishes that the second effect dominates the first in steady-state, such that the fall in colonial financial frictions ($\phi_{n\mathbb{N}}$) increases the steady-state allocation of capital to local manufacturing (higher k_{nn}^*). In the new steady-state, the expected return to capital (v_n^*) is again equal to the unchanged rate of return on the consumption bond (ρ), but the increase in the steady-state capital stock leads to a fall in the steady-state rental rate (r_n^*).

The remaining parts of the proposition follow from the specific-factors structure of production and population mobility. Given constant prices and zero-profits in manufacturing, a lower steady-state rental rate (r_n^*) raises the steady-state wage (w_n^*). Given constant prices and zero-profits in agriculture, a higher steady-state wage (w_n^*) reduces the steady-state price of land (q_n^*). Additionally, higher wages imply higher worker real income (w_n^*/p_n) for constant goods prices, which increases steady-state population (ℓ_n^*). A higher steady-state allocation of capital to local manufacturing (k_{nn}^*) raises labor's value marginal product in manufacturing, which together with the increase in steady-state population (ℓ_n^*) implies higher manufacturing employment (ℓ_n^{M*}). Finally, given constant prices and a fixed supply of land, the higher steady-state wage (w_n^*) implies lower agricultural employment (ℓ_n^{A*}).

Therefore, we find that improved access to slavery investments both changes the structure of economic activity within locations (stimulating industrialization and structural transformation away from agriculture) and also changes the spatial distribution of economic activity across locations (raising population density in locations with better access to slavery investments and reducing population density elsewhere). Since the reduction in financial frictions

with the colonial plantation acts like an improvement in investment productivity, aggregate real income across all locations and factors of production (capitalists, workers and landowners) increases. But there are distributional consequences across the different factors of production. Given an unchanged supply of land (m_n) and constant goods prices (p_n), the fall in the price of agricultural land (q_n) in locations with better access to slavery investments reduces the real income of landowners ($q_n^* m_n / p_n$). Additionally, given an unchanged expected return to capital (v_n^*) and constant goods prices (p_n), the increase in the capital stock (k_n) in locations with better access to slavery investments raises the real income of capitalists ($v_n^* k_n^* / p_n$).

Finally, we focus for brevity here on steady-state impacts, where collateral constraints do not bind. However, if slavery wealth is more collateralizable than other wealth, better access to slavery investments also can relax collateral constraints (higher λ_n), and hence raise capital accumulation along the transition path to steady-state.

7   Main Empirical Results

A key prediction of our theoretical framework is that improved access to slavery investments stimulates local capital accumulation and induces an expansion of the capital-intensive manufacturing sector. We now provide empirical evidence in support of this prediction using exogenous variation in access to slavery investments (and hence slaveholder wealth in 1833) from the middle-passage mortality experienced by slave-trading ancestors. In Section 7.1, we introduce our identification strategy, explain the construction of our instrument, and provide some empirical evidence in support of our causal argument. In Section 7.2, we report our main instrumental variables estimation results for a range of economic outcomes. In Section 7.3, we summarize a range of robustness checks that probe our main findings. Finally, in Section 7.4, we use our theoretical model to quantify the aggregate and distributional consequences of access to slavery investments.

7.1   Identification Strategy

Our identification strategy uses the well-known link between slave trading and slaveholding. Many families started out slave trading, and through the resulting connections to the slave economy, transitioned into slaveholding (as discussed in Hall et al. 2014). Therefore, we develop an instrument for slaveholder wealth in a location in 1833 based on the middle-passage mortality that affected the investment of slave-traders hailing from the same location.

We assign slave traders to the locations of slaveholders in 1833 in two ways. First, we use genealogical information from family trees to link slaveholder locations to slave traders' areas of ancestral origin. Second, we use the geographical concentration of surnames in Britain to

probabilistically assign slave traders to locations, and then connect them to slaveholders living in each location in 1833.

In our baseline specification, we use middle-passage mortality to construct our baseline voyage-outcome measure. Since middle-passage mortality is only available for a subset of slave voyages, we also report robustness tests in which we use only variation in the number of ancestors of slave traders (for which we do not require mortality data), or in which we use the number of slave voyages as an alternative indirect measure of voyage outcomes. We now discuss in further the construction of our instrument and the causal logic underlying it.

Middle-Passage Mortality   The key ideas underlying our identification strategy are outlined in Figure 5. First, starting from the top-left, idiosyncratic wind conditions had a substantial effect on voyage duration across the Atlantic. Second, voyage duration was an important determinant of slave mortality during the middle-passage under crowded, insanitary and inhumane conditions on slave ships. As sailing times increased, water ran out and infectious diseases spread, leading to sharp increases in middle-passage mortality. Third, moving further to the right, higher middle-passage mortality reduced the profitability of slave-trading voyages. Fourth, moving downwards, this reduction in voyage profitability from adverse wind conditions discouraged (or made impossible) future participation of slave traders in subsequent slave voyages, given the substantial upfront costs involved. Fifth, moving further downwards, lower involvement in the slave trade reduced the likelihood of traders making the transition to slaveholding as plantation owners, and the wealth they could use to do so. In sum, since bad weather shocks both directly lowered trader wealth, and induced exit from the slave trade, they reduced slaveholder wealth in 1833 at the time of abolition.

Causal Mechanism   We now provide evidence in support of the steps in this causal chain. Wind speed and direction were the main determinants of ship speed and voyage times in the age of sail (Pascali 2017). Both fluctuated with atmospheric conditions. Around the equator, a lack of surface winds can becalm sailing ships for weeks, which is why sailors refer to them as *dolldrums*. This is reflected in analyses of ship log books, where slave-trading voyages from West Africa to the West Indies took between 25-60 days, as discussed in Haines et al. (2001) and Cohn and Jensen (1982). When voyages took longer than expected, and drinking water ran out, the horrendous conditions aboard for enslaved persons led to sharp increases in mortality, as documented in Kiple and Higgins (1989).

Figure 5: Identification Strategy
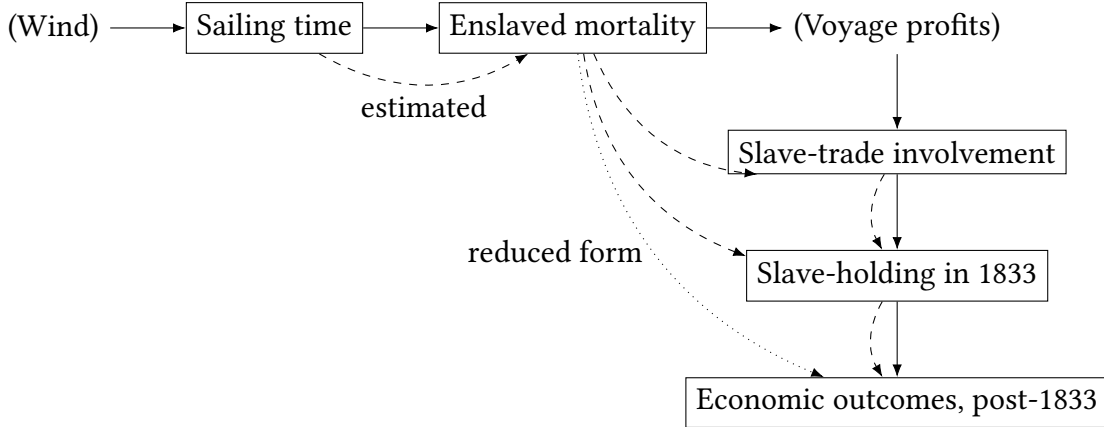
Note: Solid arrows are causal relationships; dashed arrows are estimated relationships; variables in parentheses are unobserved; dotted arrows are reduced-form relationships.

We use data from the Slave Voyages database to corroborate the relationship between sailing time and enslaved mortality. In Figure 6a, we show a histogram of middle-passage mortality across all slave voyages from British ports. We find large differences in middle-passage mortality. While many voyages experienced mortality rates of 5-10 percent, some saw rates of 20 percent or more. These differences in mortality are heavily influenced by sailing time. To illustrate this, Figure 6b presents a binscatter plot of the relationship between middle-passage mortality and the duration in days of the voyage from West Africa to the Americas. Consistent with the historical literature emphasizing voyage duration as the main determinant of middle-passage mortality, we see a strong and positive relationship between sailing time and mortality. Ten extra voyage days increase the mortality rate by 2.3 percentage points. For a ship carrying 350 enslaved persons, this corresponds to 8 additional deaths.

Financing slave-trading voyages required considerable upfront capital investments in ship and crew and to purchase slaves in West Africa. The main source of revenue was the sale of the enslaved in the Americas. Therefore, high mortality rates on slave-trading voyages could result in substantial losses for the slave traders involved. Specifically, we expect voyage duration and middle-passage mortality to be key in enabling continued involvement in the slave trade. To establish this link, Figure 7 displays mean continuation probabilities for slave traders across the number of slave voyages n. We compute these mean continuation probabilities from voyage n to $n+1$ separately for slave traders that experienced above and below-median middle-passage mortality during voyage n.[24] Consistent with the idea that adverse wind conditions and low voyage profits made it less likely that individuals were able

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[24]Table B.3 in Online Appendix B.3, we provide further evidence that voyage failure, as recorded by the Slave Voyage Database, became more common the longer the middle passage lasted.

Figure 6: Middle-passage Mortality and Voyage Duration for Slave Voyages

(a) Histogram of middle-passage mortality

(b) Voyage duration and mortality
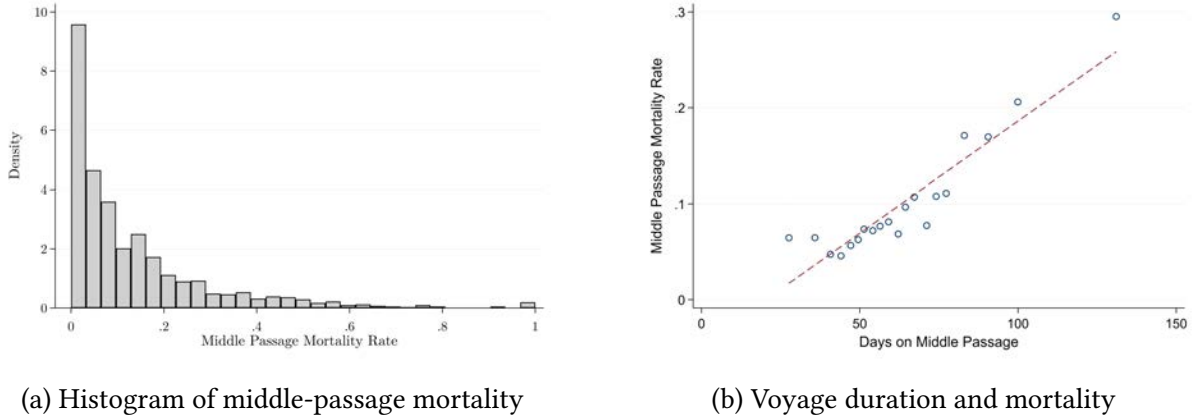
Note: *Left panel:* The figure shows a histogram of the mortality rates among the enslaved ((enslaved embarked - enslaved disembarked)/enslaved embarked) across slave-trading voyages from British ports. *Right panel:* The figure shows a binscatter of the duration of slave-trading voyages from British ports (horizontal axis) and mortality rates among the enslaved (vertical axis); blue dots correspond to ventiles and the red dashed line shows the linear fit.

to continue in the slave trade, we find lower continuation probabilities for slave traders who experience above-median middle-passage mortality. For example, after 5 voyages, we find that over one third of the owners who experienced below-median mortality of enslaved stayed involved, whereas less than 20 percent of those exposed to above-median mortality continued to participate.[25]

This pattern of results is consistent with selection on profitability in the slave trade. Those who were lucky with wind conditions and made substantial voyage profits accumulated further wealth and continued to participate in the slave trade. Those who were unlucky with weather conditions and experienced substantial voyage losses dropped out of the slave trade.

Voyage Outcomes To implement our identification strategy, we begin by constructing a voyage outcome measure for slave traders based on middle-passage mortality. We observe a decline in middle-passage mortality over time in the slave voyages data, in part because of improvements in ship technology. To abstract from this secular decline and focus on variation across voyages within the same time period, we remove decadal fixed effects from middle-passage mortality. From the residuals, we construct our outcome measure for slave-trading voyage j and ship owner or "voyager" v as the inverse of the mortality rate among the enslaved: $1/mortality_{vj}$, where mortality equals the number of enslaved embarked, minus the number

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[25]In Figure B.4 in Online Appendix B.3, we provide further evidence on this relationship between middle-passage mortality and continuation probabilities in the slave trade.

Figure 7: Continued Involvement in the Slave Trade by Middle-passage Mortality
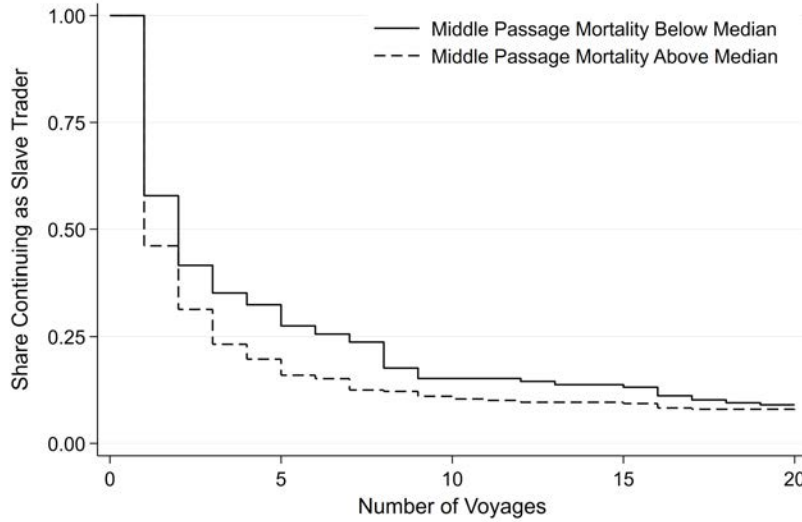
Note: Horizontal axes is number of slave voyages n; Vertical axis is continuation probability from slave voyage n to slave voyage $n+1$; mean probabilities of continued involvement shown separately for middle-passage voyages with above and below median mortality among the enslaved during voyage n.

of enslaved disembarked, divided by the number of enslaved embarked. This voyage outcome measure has a lower bound of one for voyages where all of the enslaved die, and approaches infinity as the number of deaths among the enslaved approaches zero.[26]

The slave voyages data report up to eight ship owners or "voyagers" for each slave voyage, such that a given voyager can appear multiple times for different slave voyages. We compute the average *voyage outcome* for voyager v as the average across all of their slave voyages j:

$$VO_v = \frac{1}{n_v} \sum_{j=1}^{n_v} \frac{1}{mortality_{vj}}, \tag{14}$$

where n_v is the number of slave voyages for which voyager v is observed.

Family Trees   In our baseline specification, we combine data on slave traders' voyage outcomes and the location of their ancestors, using family trees on Ancestry.com. Often, families hailing from a particular place would see one of theirs work and live in a major trading port for a few years – but the majority of the family network, including many individuals who inherit or benefit from the business advice of a relative, remained near the ancestral home. For example, the Lascelles family initially lived in Stank Hall, Yorkshire; three of the family's

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[26]For the small number of voyages with zero mortality among the enslaved, we use $0 + \epsilon = 0.005$ to avoid this voyage outcome measure becoming undefined for voyages with no deaths.

male descendants became slave traders, participating in 14 voyages between 1699 and 1736. By 1787, the Lascelles owned 27,000 acres in Barbados, Jamaica, Grenada, and Tobago. All the male lines save one eventually died out, so that only one of them - Henry, second Earl of Harewood (1767-1841) - received slavery compensation under the terms of the Abolition of Slavery Act, as shown in the family tree in Figure B.2 in Online Appendix B.1. By then, the Lascelles had returned to Yorkshire, building their country home.

Using the family trees reported on *Ancestry.com*, we identify 20,000 ancestors of these voyagers, as discussed further in Online Appendix G. We collect birth and death addresses for the parents, grandparents and great grandparents of these voyagers. We also distinguish between two groups among slave-trading ancestors: successful traders (in the sense of more than one slave-trading voyage) and all other traders (with only one slave-trading voyage). For each location i, we compute our first average voyage outcome instrument (VOI_i^{tree}) as an average of the voyager outcomes across all slave-trading ancestors in that location:

$$VOI_i^{tree} = \frac{1}{A} \sum_{a=1}^{A_i} VO_{v(a)}, \tag{15}$$

where A_i is the number of ancestors of slave-traders in location i; A is the total number of ancestors of slave-traders in England and Wales; $VO_{v(a)}$ is the average voyage outcome for voyager v who is the descendant of ancestor a, as defined in equation (14) above, where the notation $v(a)$ makes explicit that voyager v is matched to ancestor a; the scaling by $1/A$ rather than $1/A_i$ outside the summation ensures that the instrument increases with the number of slave-trading ancestors in a location, and implies that it captures a location's share of slave-trading ancestors in England and Wales weighted by their voyage outcomes.

In our first-stage regression, we predict slaveholding in 1833 in a location using this instrument for the average voyage outcome of slave-traders with ancestors in that location. Note that this instrumental variables estimation does not require there to exist direct family connections between individual slaveholders in 1833 in a given location and the ancestors of slave traders in that same location. The presence of ancestors of slave traders in a location could have predictive power for slave holding there in 1833 because of indirect connections: For example, slave traders could pass information about opportunities for slaveholding investments through friends, business and social networks that are correlated with their familial locations.

In Table 1, we report a balance test for three groups of locations – those without ancestors involved in the slave trade, those with successful ancestors in the slave trade, and those with unsuccessful ancestors in the slave trade. For all indicators of economic conditions before the large-scale expansion of Britain's role in the slave trade starting in the 1640s, we find no significant differences in property values for regions that were home to successful and unsuccessful voyagers. But regions that never engaged in the slave trade show lower levels of wealth

and industrial activity after the expansion of British involvement in the slave trade from the 1640s onwards. The remaining rows compare geographic location (as measured by latitude and longitude) and geographical distance from ports. Successful slave traders' ancestral regions do not have significantly different latitudes or longitudes but they are located slightly closer to Liverpool. The absence of major differences between columns 2 and 3 suggests that our instrument is as good as randomly assigned across regions.

Table 1: Balance Test – Ancestors and Middle Passage Mortality

Variable	(1) None Mean/SE	(2) Unsucessful Mean/SE	(3) Successful Mean/SE	T-test (1)-(2)	Difference (1)-(3)	(2)-(3)
Domesday Wealth (1086)	4.67 (0.05)	4.80 (0.09)	5.09 (0.08)	-0.13	-0.43***	-0.30***
Wealth Subsidy (1334)	4.04 (0.05)	4.03 (0.11)	4.35 (0.09)	0.01	-0.31	-0.31**
Property Wealth (1690)	7.84 (0.04)	8.21 (0.06)	8.36 (0.06)	-0.37*	-0.52***	-0.15***
Cotton Mills (1788)	0.05 (0.01)	0.43 (0.06)	0.10 (0.03)	-0.38***	-0.06	0.33***
Longitude	-1.97 (0.08)	-1.80 (0.10)	-1.44 (0.11)	-0.18	-0.53**	-0.35***
Latitude	52.50 (0.06)	52.66 (0.09)	52.23 (0.09)	-0.16**	0.28	0.44***
Dist Historic Port	19.47 (0.65)	22.82 (1.32)	21.08 (1.19)	-3.35*	-1.61	1.74
Dist Liverpool	214.46 (3.80)	162.17 (7.65)	217.35 (6.54)	52.29***	-2.89	-55.18***
N	511	170	170			

Note: The value displayed for t-tests are the differences in the means across the groups. Standard errors are robust. Group 1 is the set of regions without any identified ancestors of slave voyagers. Groups 2 and 3 split those regions with ancestors into above and below voyage outcomes (recall that voyage outcomes are inversely related to middle-passage mortality). Wealth and count variables are inverse hyperbolic sine transformed. The control variable IHS of population in 1780 is included in all estimation regressions. All missing values in balance variables are treated as the group mean. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

In Table B.5 in Online Appendix B.4, we provide evidence on the performance of the instrument in the first-stage when we use only the share of ancestors as an instrument (without taking into account middle-passage mortality) versus including information on middle-passage mortality (as in our baseline specification in equation (15)). We show that the first-stage F-statistic increases when we incorporate mortality information, consistent with our mechanism. The gain is visible both with and without controls; and the final instrument, mortality

scaled, is strong for both family trees (here) and surnames (below).

Surnames in the 1851 Fullcount Census Our first IV above exploits direct genealogical connections between slave traders and their ancestors. However, family trees on *Ancestry.com* are not available for all traders, and this selection could be non-random: Successful slave-trading families could be either more or less likely to have detailed family records. To address this potential concern, we also use the national distribution of all *surnames* (from the 1851 population census) to measure regional links with families in the slave trade. This strategy exploits the persistent geographical concentration of surnames in Britain (Cheshire and Longley 2011) and assumes that concentrations of slave voyager surnames in 1851 are informative about their familial locations. While less precise than the family-tree instrument, this strategy is exhaustive. It provides a useful cross-validation of our family-tree instrument.

The 1851 census contains a total of $N = 17,474,083$ individuals with $S = 330,329$ distinct surnames. The surname distribution is heavily skewed (Fox and Lasker 1983, Güell et al. 2014). The two most common surnames, Smith and Jones, account for about 1.4 percent of all individuals, while 37 percent of names occur only once. Of the 2,259 distinct voyager surnames, we can match 90 percent (2,040) to at least one individual in the 1851 census. Comparing the voyager and non-voyager surnames, we find that voyager surnames are a bit more common than non-voyager surnames.

We use the voyager surnames observed in the 1851 census to predict the spatial distribution of voyagers' familial locations. We observe the location of named individuals in the 1851 census by parish. To account for the frequency and spatial dispersion of surnames, we use Monte Carlo simulations, in which we randomly match all slave voyagers (unique in first name and surname) to individuals in the 1851 census using their surname. For example, we observe 21 slave voyagers with the surname *Smith*. We randomly match these 21 observations with 21 of the 240,117 individuals named *Smith* in the 1851 census.[27] For each of these voyager-surname matches m, we use a voyager's average voyage outcome across all of their slave voyages (VO_v), as defined in equation (14) above. For each region i, we compute the sum of voyage outcome measures of all voyagers matched to surnames in that region. Finally, we repeat this procedure for iterations $l = \{1, \ldots, L\}$, where $L = 1,000$. Our second average voyage outcome instrument for each region i is an average across these iterations:

$$VOI_i^{sname} = \frac{1}{L} \sum_{l=1}^{n} \sum_{m=1}^{M_{il}} VO_{v(m)}, \tag{16}$$

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[27]We take the number of voyagers directly from the slave voyages dataset. Alternatively, one could make an assumption about their population growth rate, and inflate their number between their slave voyage year and 1851. This procedure would give more weight to earlier voyagers. Since we find that this adjustment does not make a great difference, we refrain from further complicating the measure.

where the outer summation averages across iterations for a given region i; the inner summation counts the voyager-surname matches for that region in a given iteration l; M_{il} is the number of voyager-surname matches in region i for iteration l; the notation $v(m)$ makes explicit that voyager v is assigned to voyager-surname match m.

Figure 8: Bivariate Plots of Slaveholding and Ancestral Connections to the Slave Trade

(a) Family Trees   (b) Surnames
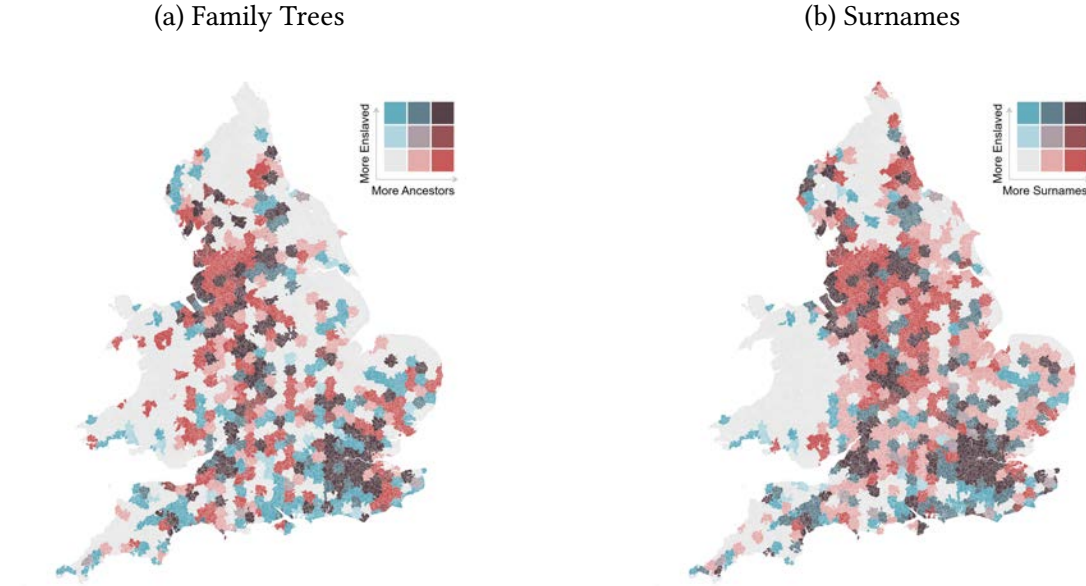
Note: The bi-plot displays tertiles of the distribution of familial connections to the slave trade as measured by family trees (left panel) and surnames (right panel) against tertiles of slaveholding across English and Welsh parishes. Data are constructed for our 849 hexagonal regions and cross-walked into parishes based on their centroids for the purposes of the visualization.

Figure 8 shows bi-variate plots of our voyage outcome instruments and slaveholders in 1833, with the left panel displaying the family-tree instrument (VOI_i^{tree}), and the right panel displaying the surname instrument (VOI_i^{sname}). Grey areas show neither slaveholding nor familial connections to slave traders; dark brown indicates a strong confluence of both. Where areas of the map are only red, there are many ancestral connections to slave trading but few 1833 slaveholders; where areas of the map are blue, there are many 1833 slaveholders but few ancestral connections to slave trading. The map shows that slaveholding and familial connections to the slave trade were widespread; and in many places, they coincide. Comparing both maps, we see strong overlap in the areas around London, Bristol and Liverpool, but also in numerous other locations in England and Wales.

7.2   Instrumental Variables Estimation

We now use our two instrumental variables to estimate the impact of slavery wealth on economic development. We start with our baseline empirical results for cross-section patterns

of economic development in the 1830s. Next, we check the plausibility of our IV strategy using never-takers: regions where ancestors of slave traders lived, but where no slaveholders dwelled in 1833. Finally, we provide evidence on the importance of capital accumulation using repeated cross-sections of steam power adoption over time.

Baseline Estimations   Our goal is to estimate the effect of 1833 slaveholding wealth across regions i (S_i) on measures of economic development (Y_i). To establish causality, we instrument 1833 slaveholding (S_i) with our voyage outcome instruments (VOI_i) discussed above:

$$Y_i = C_2 + \beta \widehat{S}_i + \delta X_i' + \epsilon_i \tag{17}$$

$$S_i = C_1 + \alpha VOI_i + \gamma X_i' + \rho_i \tag{18}$$

where C_1 and C_2 are regression constants; X' is a vector of control variables for other determinants of economic activity, including the population in 1780, latitude, longitude, distance to the nearest county bank or post town, the count of cotton mills in 1788, distance to the coast and our measure of property wealth in 1690; and ϵ_i and ρ_i are stochastic errors.

Table 2, Panel A reports results from our IV-estimation, using the family tree instrument. Col. 1 shows a strong relationship with high first-stage F-stats, well above the conventional levels and Anderson-Rubin p-values that are below 0.01 (or at 0.01 in col. 6, Panel A). This underlines the relevance of our instrument. A one standard deviation increase in the voyage outcome measure using ancestors implies a 0.16 standard deviation increase in slaveholder wealth in 1833. Instrumented slave claims strongly and positively predict the number of steam engines in the region (col. 2). It is also associated with higher property taxes in 1815 (col. 3), and negatively predicts employment in agriculture (col. 3). Employment in manufacturing is higher (col. 4), as is the number of cotton mills (col. 5).

We standardize all variables to facilitate the interpretation of the inverse hyperbolic sine transformed measures. Therefore, our estimates imply that a one standard deviation increase in compensation payments translates into a 1.78 standard deviation increase in steam engines, a 0.52 standard deviation increase in rateable values, a 0.61 standard deviation decrease in agricultural employment contrasted by a 0.88 standard deviation increase in manufacturing employment and a 0.79 standard deviation decrease in the average distance to the ten nearest cotton mills in 1839. We also derive elasticities following the approach in Bellemare and Wichman (2020) and report them at the bottom of the table. Doubling slave claims implies a 287 percent increase in steam engines, an 11 percent increase in rateable values, 8 percentage points less agricultural employment, 13 percentage points more manufacturing employment and a 7.81 percent more mills in the region.[28]

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[28] At the extensive margin, a 10 percent increase in slave claims increases the probability to host a mill by 3.48

Table 2: IV: Voyage Outcome Instruments

	(1) SlaveClaims	(2) SteamEng-1830	(3) PropTax1815	(4) %Agric1831	(5) %Manuf1831	(6) CottonMill-1839
A. VO-Scaled Ancestors	0.164***					
	(0.03)					
Slave Claims		1.760***	0.523**	-0.614***	0.861***	0.774***
		(0.42)	(0.22)	(0.17)	(0.25)	(0.29)
N Voyagers	286	286	286	286	286	286
Elasticity	0.14	2.90	0.11	-0.08	0.13	0.58
KPW F-Stat		30.64	30.64	30.64	30.64	30.64
AR p-value		0.00	0.02	0.00	0.00	0.01
B. VO-Scaled Surnames	0.435***					
	(0.05)					
Slave Claims		0.736***	0.561***	-1.360***	1.249***	0.695***
		(0.20)	(0.09)	(0.17)	(0.18)	(0.12)
N Voyagers	2040	2040	2040	2040	2040	2040
Elasticity	1.82	1.21	0.12	-0.19	0.18	0.52
KPW F-Stat		77.18	77.18	77.18	77.18	77.18
AR p-value		0.00	0.00	0.00	0.00	0.00
Observations	849	849	849	849	849	849
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Standardised coefficients with robust standard errors in parenthesis. Slave claims and the outcomes in columns 1–3 and 6 are IHS-transformed. Instrument is the grid cell share of voyager ancestors, scaled by inverse middle-passage mortality (Panel A) or voyager surnames scaled by inverse middle-passage mortality (Panel B).

This pattern of results is robust across different specifications. In Table B.8 in Online Appendix B.4, we demonstrate that we find similar results using a log-transformation instead of the inverse hyperbolic sine. Our baseline specification controls for 1690 property wealth, which implies that our results capture changes in economic performance since then. But our results are not dependent on controls. In Online Appendix B.4, we show additional results without control variables, and also report the estimated coefficients for all control variables. Our baseline specification uses robust standard errors, because our 849 regions are relatively large, which helps to alleviate potential concerns about spatially correlated errors. In Online Appendix B.4, we report results using Heteroskedasticity Autocorrelation Consistent (HAC) standard errors following Conley (1999). Again, we find a similar pattern of results.

In Panel B of Table 2, we repeat the estimations using the surname instrument. Both instruments are positively correlated (as evident from Figure 8). Since inferring family ties from surnames is more noisy than using a genealogy measure, we think of the surname specification as providing validation of our empirical strategy. Again, the instrument is strong with first-stage F-statistics well above the conventional levels. The first stage suggests that a 1 standard

percentage points or 12 percent relative to the mean probability of 27.4 percentage points.

deviation increase in the voyage outcome measure based on surnames implies 0.44 standard deviation higher claims in 1833. Overall, instrumenting slave claims with the alternative surname instrument leads to qualitatively and quantitatively similar results.

To sum up: Regions from which slave traders experiencing beneficial conditions hailed had more slave wealth in 1833. This had effects on economic development: land values increased, consistent with increased urbanization. The share of employment in agriculture declined, the share in manufacturing increased, there were more industrial establishments and more steam engines in the vicinity.

Figure 9: Beta Coefficients for our IV Specification and Never-takers

(a) Family Tree Instrument   (b) Surname Instrument
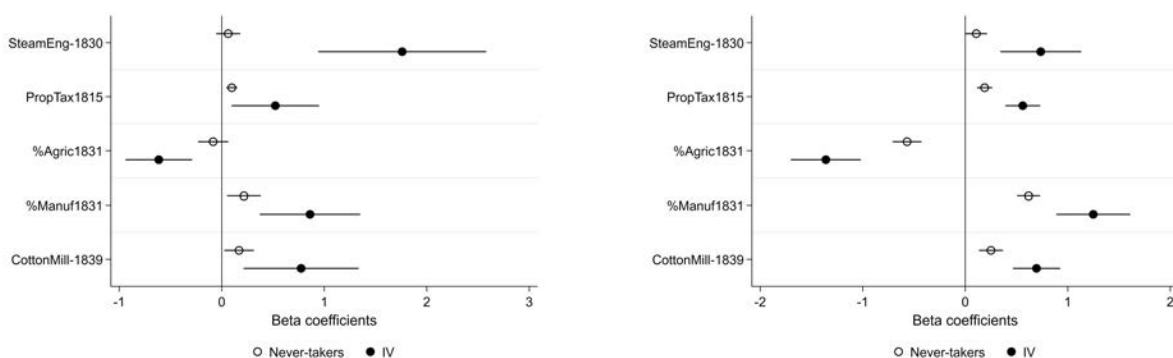
Note: Beta coefficients with 95% confidence intervals from IV estimations using the voyage outcome instrument based on family trees (left panel) or surnames (right panel) and reduced form OLS regressions for nevertaker regions with no slaveholding.

Never-takers   A simple plausibility check for our IV-strategy in the spirit of Bound and Jaeger (2000), Angrist and Krueger (1994), and D'Haultfœuille et al. (2022) looks at never-taker regions where ancestors of slave traders lived, but where we find no slave wealth in 1833. If our argument is correct, regions that merely had exposure to the slave trade –without slave-holding later– should *not* show any statistically significant differences in economic performance.

Figure 9 plots the coefficients for our main outcome variables for our baseline IV specification and the never-takers (left: family-tree instrument; right: surnames).[29] We find much larger standardised coefficients for our IV specification, whereas the never-takers show much smaller estimates and in many cases, precisely-estimated zeros.[30]

Taken together, these empirical results provide strong support for the mechanism in our model: Exogenous increases in access to slavery wealth stimulate local capital accumulation,

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[29]In this never-takers specification, we estimate reduced-form regressions of our main outcomes on our measures of familial connections to the slave-trade for regions with no slaveholding in 1833.

[30]Table B.15 in Online Appendix B.4 reports the estimated coefficients for the never-taker analysis.

which induces a reallocation of economic activity towards the manufacturing sector.

Steam Power Adoption   Steam power was arguably one of the key technologies of the Industrial Revolution, and associated with important improvements in productivity and establishment size (Atack et al. 2008). Adopting its use required a range of technological inventions and innovations, and was costly. Here, we present evidence from the adoption of steam power over time, showing that areas with more slaveholding in 1833 had an increasing edge.

Table 3: IV: Steam Engine Adoption and Slaveholding

	(1) Pre-1792	(2) 1792-1830	(3) 1830-1850	(4) Post-1850
A. VO-Scaled Ancestors	0.280	1.760***	1.427***	1.282***
	(0.26)	(0.42)	(0.35)	(0.31)
KPW F-Stat	30.64	30.64	30.64	30.64
AR p-value	0.28	0.00	0.00	0.00
Elasticity	1.17	2.90	1.87	1.32
B. VO-Scaled Surnames	0.367**	0.736***	0.884***	1.072***
	(0.18)	(0.20)	(0.18)	(0.19)
KPW F-Stat	77.18	77.18	77.18	77.18
AR p-value	0.03	0.00	0.00	0.00
Elasticity	1.53	1.21	1.16	1.11
Observations	849	849	849	849
Controls	Yes	Yes	Yes	Yes

Note: *** $p<0.01$, ** $p<0.05$, * $p<0.10$. Panels A and B give standardised IV coefficients with robust standard errors in parenthesis. Outcome is IHS count of articles mentioning steam engines from the British Newspaper Archive in the indicated time period. The independent variable is IHS of slave claims. The instrument in Panel A is the region share of voyager ancestors, scaled by voyage outcome (inverse middle-passage mortality). The instrument in Panel B is the region share of voyager surname matches, again scaled by voyage outcome (inverse middle-passage mortality). Standard controls are included in all regressions.

In Figure B.3a in Online Appendix B.1, we illustrate the geography of steam engine adoption, by showing the count of articles mentioning steam engines between 1792 and 1830. In Figure B.3b in Online Appendix B.1, we display binscatters of steam engine adoption in different time periods against slaveholding in 1833. In the period before 1792, there is hardly any relationship existent, which is consistent with James Watt's key innovations in the efficiency of the steam engine taking place from 1763-75. Starting with the period 1792-1830, we find a strong link between slavery and steam engine adoption. The effect increases over time – and the slave-owning areas' edge grows in magnitude after 1830.

Table 3 reports corresponding instrumental variables specifications, in which we instrument slaveholding in 1833 using our family-tree and surname instruments introduced in the previous section. Corresponding OLS estimates are shown in Appendix Table B.1. Again we find little evidence of a relationship before 1792 and a substantial strengthening of the relationship over time. Both instruments lead to similar results: for the ancestor (surname) instrument a 1 standard deviation increase in compensation claims implies a 0.28 (0.37) standard deviation increase in newspaper articles mentioning steam engines before 1792 and this number increases to 1.76 (0.74) standard deviations 1792-1830; 1.43 (0.88) standard deviations between 1830-50; and 1.29 (1.07) standard deviations after 1850.[31]

7.3   Robustness Tests

This section summarizes a number of robustness tests, focusing on the family-tree instrument (see Appendix B.4 for a detailed discussion).

We first assess the presence of spatial auto-correlation (SAC), using Moran's I. SAC becomes insignificantly different from zero at around 500km for the majority of our regressions, and for all within 750km. To ensure that the presence of SAC below these distances is not unduly biasing our standard errors, we calculate Conley Spatial HAC standard errors (Conley 1999) which correct for cluster correlation in spatial settings. Even at a bandwidth distance of 750 km, our main results remain statistically significant at conventional levels.

Second, we choose a different procedure to assign parish-level observations to hexagons. Our preferred approach assigns parishes to a hexagon if their centroid falls inside. The benefit of not employing area weights to map values into polygons is that we do not mechanically introduce spatial auto-correlation. On the downside, we may assign large rural parishes to a neighboring hexagon even though the majority of its area does not lie within it. To rule out that our results depend on the specific choice how we map parish information to hexagons, we rerun our results using area weights. Our results remain unchanged. In a similar vain, we experiment with hexagons of different size. Our preferred hexagons span an area of around 9km from the center to vertex, which represents a plausible commuting distance at a time when walking was the dominant transport mode. In Table B.13, we present specifications where we consider parishes, the smallest political unit; registration districts; and grid of squares with side length 0.2°, or roughly 20km. We find a similar quantitative and qualitative pattern of results across each of these alternative choices of spatial units.

Third, we report a robustness test, in which we use the number of slave voyages as an alternative measure of voyage outcomes. The logic is similar to our baseline specification.

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[31]In Table B.2 in Online Appendix B.2, we show that the same pattern holds if we examine the extensive margin of steam engine adoption.

Slave voyagers who experienced a lower middle-passage mortality are more likely to engage in more than one voyage. Therefore, higher values of the voyage-frequency instrument imply better slave-voyage outcomes and thus a higher probability to remain engaged in the slave trade. Again we find a similar pattern of results as in our baseline specification.

In a last set of checks, we assess how much our results depend on the three major slave ports, i.e. Bristol, Liverpool and London. Specifically, we exclude any region located within 30km of these slave ports and find that the magnitude and significance of the coefficients again remain largely the same. Overall, we conclude that our findings are not driven by the major slave ports alone, consistent with Figure 8, which shows that compliers with the slavery instrument are found across England and Wales.

7.4 Quantitative Analysis of the Model

Our empirical findings so far have provided evidence of causal effects of slaveholding on local economic activity. We now use our theoretical model to assess the aggregate and distributional consequences of access to slavery investments.

We assume standard values for the model's parameters (Online Appendix D). We set the share of land in agricultural costs as $\alpha^A = 0.31$, based on the share of land and buildings in farm income in Feinstein (1972). Given this parameter, we set the share of capital in manufacturing costs as $\alpha^M = 0.36$, which ensures that the model is consistent with both the 20% share of agriculture in national income in 1851 in Deane and Cole (1967), and the 65% share of labor in national income in 1850 in Crafts (2022). We assume a migration elasticity of $1/\kappa = 2$, as a central value in the range of estimates in Bryan and Morten (2019) and Galle et al. (2020). We assume an elasticity of substitution between domestic and slavery investments of $\theta = 4$, towards the high end of the estimates in Koijen and Yogo (2020). In Online Appendix E, we demonstrate the robustness of our quantitative conclusions to the assumption of alternative values for these parameters.

We quantify the model using our rateable values and employment data.[32] Our rateable values data measure flow rental values from domestic capital and land. In contrast, slavery compensation was rationalized as a one-off payment for the net present value of the labor of enslaved persons. To convert this net present value into the corresponding flow value, we assume a rate of return of 10 percent, which reflects the high rates of mortality among enslaved persons and the risk associated with slavery investments (including the risk of slave rebellion). Additionally, compensation values for enslaved persons were set at 40 percent of market values, in part because of the implicit compensation through the "apprenticeship" system. Therefore, we multiply the flow compensation values by 2.5 to obtain flow market values.

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[32] See Online Appendix C.13-C.14 for further details on the quantification of the model.

Finally, the total value of slavery plantations (including land and buildings) was typically 3 times the value of enslaved persons, according to the accounting studies in Sheridan (1965), Ward (1978), and Rosenthal (2018). Therefore, we multiply the flow market values of enslaved persons by 3 to obtain the flow market value of slavery investments. For the aggregate economy as a whole, the resulting flow income from these slavery investments equals 3.63 percent of the flow income from all capital and land (including slavery capital, domestic capital and land), which is in line with the estimates in Pebrer (1833).[33]

Our counterfactuals start at the observed equilibrium in the data in 1833 and evaluate the impact of a prohibitive increase in colonial financial frictions ($\phi_{n\mathbb{N}} \to \infty$ for all n). We hold goods price constant to focus purely on the impact of access to slavery investments through capital accumulation. For ease of interpretation, we report the changes in variables from the counterfactual equilibrium to the observed equilibrium in the data, such that the results correspond to the impact of improved access to slavery investments. We denote the counterfactual equilibrium value of variables with a prime, the observed equilibrium values with no prime, and the relative changes between the two equilibria with a hat (such that $\hat{x}_n = x'_n/x_n$). We assume that the observed equilibrium in the data on 1833 is close to the steady-state in the absence of any further changes in the exogenous variables, and we report counterfactuals for the steady-state impact of the changes in colonial financial frictions.[34]

We begin by quantifying the impact of slavery investments on the spatial distribution of economic activity. In the left panel of Figure 10, we display locally-weighted linear least squares regressions across locations of log changes in total employment ($\ln\left(\ell_n^*/\ell_n^{*\prime}\right)$) on the observed share of slavery capital in total capital in 1833 ($\xi_{n\mathbb{N}}^* = K_{n\mathbb{N}}^*/(K_{n\mathbb{N}}^* + K_{nn}^*)$), where recall $\xi_{n\mathbb{N}} + \xi_{nn} = 1$. Consistent with our analytical results in Proposition 1 and our causal estimates in the previous subsection, we find that greater access to slavery investments increases a location's total employment: The log relative changes in total employment are substantial, ranging from 0.98 (a 2 percent decline) to 1.43 (a 43 percent increase).

In the right panel of Figure 10, we show analogous locally-weighted linear least squares regressions for log changes in agricultural employment shares ($\left(\ell_n^{A*}/\ell_n^*\right) / \left(\ell_n^{A*\prime}/\ell_n^{*\prime}\right)$). Again in line with our earlier theoretical and empirical results, we find that greater access to slavery investments induces greater structural transformation away from agriculture. The magnitudes are substantial: The log change in agricultural employment shares ranges from 1.02 (a 2 percent increase) for those locations with no slavery investments to 0.47 (a 47 percent decline) for those locations with the greatest participation in slavery investments.

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[33] According to Pebrer (1833), the value of all capital and land in the West Indies was 3.44 percent of the value of all capital and land in both the United Kingdom and the West Indies in 1833.

[34] To the extent that the full steady-state impact of British participation in slavery had not been realized by the 1830s, our estimates underestimate this full steady-state impact, and hence are likely conservative.

Figure 10: Counterfactual Changes in Total Employment and Agricultural Employment Shares from Access to Slavery Investments
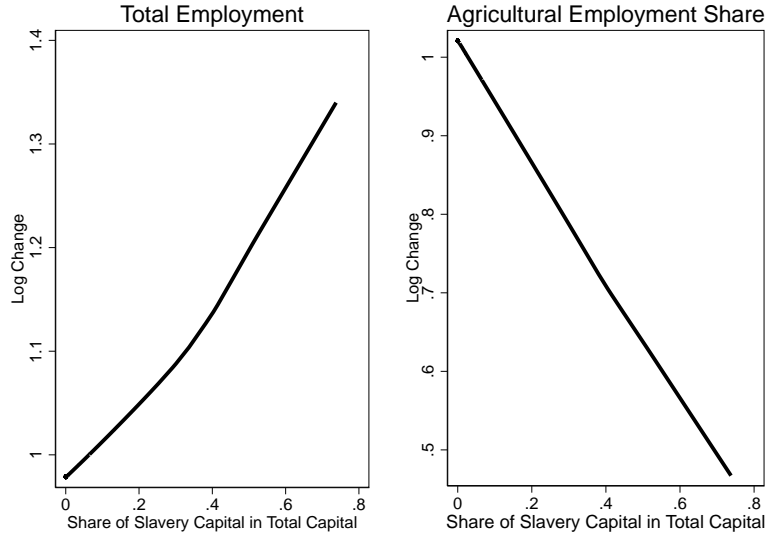
Note: Vertical axis in left panel shows log changes in total employment across locations; vertical axis in right panel shows log changes in agricultural employment shares across locations; horizontal axis in both panels displays the share of slavery investments in total investments in the 1830s; both panels show locally-weighted linear least square regressions of the changes from the counterfactual equilibrium (without slavery investments and $\xi_{nn}^{*\prime} = 1$ for all n) to the observed equilibrium in the 1830s (with slavery investments and $0 < \xi_{nn}^* < 1$ for some n).

We next turn to the aggregate and distributional consequences of access to slavery investments. In the first column of Table 4, we report percentage changes in aggregate income, capitalist income, landlord income and worker welfare from the counterfactual equilibrium with prohibitive colonial financial frictions ($\phi_{n\mathbb{N}t} \to \infty$) to the observed equilibrium in 1833. We find an increase in the aggregate income of all factors of production (capital, labor and land) of 3.54 percent. This increase in aggregate income is sizeable relative to conventional estimates of the welfare gains from international trade (an upper bound of 9 percent for 19th-century Japan in Bernhofen and Brown 2005), particularly as this counterfactual focuses solely on the mechanism of capital accumulation, holding goods price constant. During the period 1800-30, British GDP per capita was growing at 0.3% per annum according to Crafts (2022). Therefore, slavery investments increased aggregate income by the equivalent of more than a decade of growth. We find that this change in aggregate income involves substantial changes in the distribution of income across factors of production, with capitalist income rising by 11 percent, and landlord income declining by just under 1 percent. The change in worker welfare is the population-weighted average of the change in the real wage in each location and equals 3.06 percent, implying substantial welfare gains for domestic free workers from the enslavement and exploitation of black Africans in colonial plantations.

In the second to fourth columns of Table 4, we show that these aggregate changes mask

Table 4: Aggregate and Distributional Consequences of Access to Slavery Investments

Variable	Aggregate	<p50	≥p50<p75	≥p75
Population Share 1833	100	68.27	8.68	23.04
Population change	—	-1.97	-0.33	6.47
Aggregate Income change	3.54	-1.58	4.88	40.68
Capitalist Income change	11.11	-2.55	15.52	104.14
Landlord Income change	-0.87	-0.08	-1.96	-7.18
Worker Welfare change	3.06	3.06	3.06	3.06

Note: Slavery income share is the share of the flow income from slavery capital in the flow income from all capital and land; Changes are from the counterfactual equilibrium with prohibitive colonial financial frictions ($\phi_{n\mathbb{N}t} \to \infty$) to the observed equilibrium in 1833; Population change is the percent change in population; Aggregate income change is the percent change in the aggregate income of all factors of production; Capital income change is the percent change in capitalist income from slavery and domestic investments; Landlord income change is the percent change in landlord income; Worker welfare is the expected utility of the domestic workers, as defined in equation (7); Aggregate column reports values for the aggregate economy; <p50 column reports aggregate values for locations with slavery investment shares ($\xi_{n\mathbb{N}}$) less than the median across those locations with positive shares; ≥p50<p75 column reports aggregate values for locations with slavery investment shares ($\xi_{n\mathbb{N}}$) from the 50-75th percentiles across locations with positive shares; ≥p75 column reports aggregate values for locations with slavery investment shares ($\xi_{n\mathbb{N}}$) above the 75th percentile across locations with positive shares.

substantial distributional consequences across geographical locations, depending on their participation in slavery investments. We divide locations into three groups: those with slavery investment shares ($\xi_{n\mathbb{N}}^*$) less than the median across locations with positive values for slavery investment (68 percent of the 1833 population); locations with slavery investment shares from the 50-75th percentiles of these positive values (just under 9 percent of the 1833 population); and locations with slavery investment shares above the 75th percentile of these positive values (23 percent of the 1833 population).[35] For locations with the least participation in slavery investments, we see a decline in aggregate income of -1.58 percent, a fall of population of 1.97 percent, a drop in capitalist income of 2.55 percent, and little change in landlord income, as economic activity reallocates towards locations with greater participation in slavery investments. In contrast, for locations with the greatest participation in slavery investments, we find an increase in aggregate income of more than 40 percent, a rise in population of 6.47 percent, a growth in capitalist income of more than 100 percent, and a decline in landlord income of 7.18 percent. Since labor is mobile across locations, workers in all three groups of locations experience the same increase in welfare of 3.06 percent.

Therefore, we find sizeable aggregate effects on access to slavery investments on income and welfare and the distribution of income across factors of production. Additionally, our results highlight the uneven impact of slavery investments on the geography of the industrial revolution within Britain, consistent with our causal estimates using quasi-experimental varia-

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[35]The median slavery investment share ($\xi_{n\mathbb{N}}^*$) for locations with positive slavery investment is 3.55 percent.

tion above. Locations with better access to slavery investments experience greater expansions in economic activity, structural transformation away from agriculture, and redistributions of income away from landlords and towards capitalists.

8   Conclusion

Before Europe's contact with the Americas, and its heavy involvement in the trafficking of enslaved Africans to the new colonies, the continent was an also-ran in economic terms. Growth accelerated as Atlantic trade increased (Acemoglu et al. 2005), and all the more so in the countries that played a leading role in the trans-Atlantic slave trade. A number of historians have argued that Britain accumulated great wealth from the slave trade, colonial plantations, and the wider triangular trade to which these gave rise (Williams 1944). In contrast, most quantitative assessments of this argument by economic historians have remained sceptical of this view, pointing out that the profits from the slave trade were not particularly high (Eltis and Engerman 2000).

In this paper, we argue that it was not slave-trading as much as *slave-holding* that contributed to Britain's Industrial Revolution. The most optimistic estimates of slave trading profits are in the range of 0.5% of GDP in the late 18th century; for slave-holding, the estimate is closer to 5% (Solow 1993). We develop a spatial general equilibrium model that formalizes the role of slavery wealth in economic development. Greater access to slavery investments raises the productivity of the investment technology, which stimulates capital accumulation and increases the steady-state capital stock. Additionally, slavery investments can readily be collateralized, alleviating financing constraints, and again stimulating domestic capital accumulation. In the presence of financial frictions, the greater capital stock is disproportionately invested locally, which in turn accelerates local economic growth and structural transformation towards capital-intensive manufacturing.

For identification, we use the effect of weather on sailing time, enslaved mortality, and survival in the slave trade. Shipping enslaved Africans to the Americas took time, and conditions on board the ships were horrific. When passages took too long, mortality increased sharply. We show that shocks to enslaved mortality affected participation in the slave trade, and in turn, the slave-holding of slave traders' descendants in 1833. Using this source of exogenous variation, we find that greater slavery wealth promoted local economic growth and led to a reallocation of economic activity away from agriculture, and towards manufacturing, the diffusion of new manufacturing technology (cotton mills), and the adoption of steam power – the key new technology of the Industrial Revolution.

We use our theoretical model to quantify the aggregate and distributional consequences of

access to slavery investments. At the aggregate level, we find an increase in national income of 3.5 percent. Capitalists were the largest beneficiaries with an increase in their aggregate income of 11 percent, with landowners experiencing small aggregate income losses of just under 1 percent. Whereas previous research has largely focused on these aggregate effects, our work emphasizes the uneven impact of access to slavery investments on the geography of the industrial revolution. Locations with the greatest levels of participation in slavery investment experience increases in total income of more than 40 percent, with capitalists' income increasing by more than 100 percent, and landlords' income declining by around 7 percent. Domestic workers' welfare increases by around 3 percent from the enslavement and exploitation of black Africans in colonial plantations. In combination, our results strongly suggest that slavery wealth contributed causally to Britain's Industrial Revolution, accelerating growth and facilitating the escape from Malthusian constraints.

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