Horses, Serfs, Slaves, and Transitions Debates

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Abstract

This research note/paper examines several factors that have been mentioned and debated as determinants of how Britain moves from feudalism to mercantilism and then to capitalism by way of agricultural and industrial innovations and also how it arrives at the cusp of the industrial revolution. Of special interest are somewhat recent conjectures of macroeconomic data, investment estimates, and data on horses, serfs, and slaves of previous centuries that perhaps can better contribute to and add some clarification to the debates over the transition from feudalism to capitalism and the transition from an early form a capitalism or mercantilism to the industrial revolution. The estimates, empirical notes, and exploratory analyses in this paper partially support the Brenner thesis or concept of the transition from feudalism to capitalism and also support the notion that the proceeds of slave sales and slave production provide a substantive portion of British investment amounts leading up to the industrial revolution of the 18th Century. The mainstream economic notions of property rights, thrift, free markets, and free trade are only part of the picture of how Britain achieves economic prominence in the 19th Century. Exploitation of people and animals play a very significant role that has been ignored or minimized in many history and economic history accounts.

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Introduction

Much has been written by heterodox economists over the decades about how the economic system of feudalism in Western Europe changes and evolves into one of capitalism. It is probably impossible to list all of the major writings, but some of the more significant ones include writings by Dobb (1947), Baran (1953), Tawney (1962), Wallerstein (1974), Sweezy (1976 and 1978), Brenner (1976, 1977, 1978, and 1985), Takahashi (1976), Ashton and Philpin (1985), Heller (2011), Anderson (2013) and Dimmock (2014) among others. Smith (2002) and Marx and Engels (Marx, Engels, Mandel and Fowkes 1990) discuss the transition even earlier, and later Engels does so again in an unpublished manuscript (1957). Debates about how and why feudalism transitions to capitalism, known as the transition debate(s), usually have revolved around which factor or set of factors are the "prime movers" in the transition: class struggle, demographic changes, the growth of towns and cities, innovations in agriculture, the growth of trade and exchange, political changes, and/or innovations in manufacturing (Lambert 2020a). The class struggle of serfs against an aristocracy is often cited as a driving force of change, and, although to a lesser degree, the exploitation of draught animals, especially horses, is sometimes mentioned as playing a key role in the expansion of domestic trade and transportation beginning in late medieval society and up to the dawn of the railroads (Langdon 1982, 1986). The use of horses is key to economic development as it replaces the ox as the preferred work animal on the farm and even more importantly helps in the expansion and widening of markets for agricultural products through the greater uses of cart horses (Langdon 1982 and 1986).

Dobb (1947) and Brenner (1976, 1977, 1978, and 1985) generally believe that class struggle between serfs and the aristocracy in Western Europe is the main reason for the transition from feudalism to capitalism. Serfs are exploited severely by their masters, and when labor shortages and wages rise for non-serfs after the Black Death, serfs and laborers begin to gain the upper hand on their masters by becoming agrarian and petty production capitalists and by expanding their output, especially during the 16th Century. Serfs and peasants begin to keep more of their production and sell it on the market, which in turn helps them to gain more economic and political power over time. As their property rights increase, investment in plant and equipment increases dramatically to levels not seen during the Middle Ages as society's economic surplus is used more productively (Lambert 2020b and 2023a).

Likewise, and especially and more recently in the 21st Century, there has been a great deal of literature generated on the role that the slave trade has played in helping to launch the industrial revolution in Britain (see, for example, Olusoga 2015).[2] Much of the original work begins in 1944 with a book by Eric Williams (1994) who claims that the proceeds of the sales of slaves make investments possible and necessary in the technologies and industries needed to propel Britain to the next level of economic development. Many historians and economic historians either ignore, minimize, and/or underestimate these claims (e.g., Niemietz 2024), yet as time goes by, they gain either partial or full support from different scholars (Heblich, Redding, and Voth 2022, Berg and Hudson 2023). The plantation systems, especially those of sugar and cotton, cause ripple effects that give rise to new and different industries in processing, manufacturing, and shipping/transportation. Trade patterns in the Atlantic Ocean that develop because of the dominance of the British Empire propel these industries into high growth because British colonies in North America and the West Indies become territories of resources extraction and at the same time become markets for finished goods made in Britain. All of these events are connected to the

[2] For ease of exposition, the term Britain will be used to refer to England and Wales and the United Kingdom over time.

growth of Britain's slave trade according to Berg and Hudson (2023), although they claim that many effects of the slave trade are not detectable at the national level and have to be accounted for at the local and regional levels, although Heblich, Redding, and Voth (2022) show national/aggregate effects. Finally, Berg and Hudson claim that their book is not an attempt to show a linkage between the slave trade and the industrial revolution in Britain, yet each chapter makes a strong case for such a linkage.

This paper uses conjectures from different economic historians to do some exploratory, empirical examinations to see if there is some support for the notion of the important role of horses and draft animals in British economic history; support for the Dobb-Brenner points of view; and some support for the Williams thesis of slavery providing the economic growth needed for the industrial revolution. The linkages are often indirect but provide some insight into how animal and human exploitation lead to greater capital investment that takes Britain from feudalism to capitalism and then to the industrial revolution. The next section of this paper is on the use of horses to advance the British economy, and this is followed by how the exploitation of serfs and peasants and how their subsequent rise in economic status lead to higher levels of investment and economic growth; and then it is shown how the growth of slavery is correlated with the growth of different British industries at the national level. A concluding section ties these topics together and helps to further underscore the concept of exploitation, whether animal or human, as a central feature of capitalism. Perhaps these discussions and findings are not that surprising to many economists, especially heterodox economists, but they provide additional empirical support to certain arguments that have been made in the various transitions debates.

Horses

(Insert Figures 1 to 10 around here)

According to Gimpel (1976) and Langdon (1982, 1986), the horse is not as important of a draft animal as the ox on demesnes and peasant farms during medieval times. The horse is more expensive to own by virtue of how much it costs to feed and care for it, and its meat is not demanded like that of an ox if slaughter is an option. Broadberry, et al (2015) give estimates of the number of oxen and horses in Britain from 1221 to 1870 with the exception of the years 1497 to 1546 because of data limitations. See Figure 1. The ox is the dominant animal until around the middle of the 16th Century, about the time that Dobb and others claim that feudalism begins to end and about when Brenner sees the growth and proliferation of capitalist farmers. According to Langdon (1986) and Gimpel (1976),most farms do not see big productivity gains in output until the 15th and 16th Centuries, and the horse becomes more important in farm production not because it is better than the ox in pulling a plow but because it has economies of scope in that it can plow and is also useful in hauling goods around farms that are becoming larger on average as well as hauling goods to markets that are gradually becoming larger as the demesne system collapses and as some tenant farmers buy out less successful competitors and increase their holdings. Previously during medieval times, peasant farmers are only concerned with trying to minimize costs rather than to expand output in Langdon's opinion, and so the ox is usually the preferred animal for farming. This is despite medieval innovations in the plow, horse collars, harnesses, and the development of the "three-field system" (Klemm 1964, Gimpel 1976). The horse is also popular for hauling during medieval times, but because markets are limited or almost non-existent, the use of cartage horses is limited because there is not much need for medium or longer distance hauling beyond a local area (Langdon 1984). Edwards (2007) notes that the number of cartage horses begins to rise dramatically during the 16th and 17th Centuries in comparison to previous times because of market expansions, the use of four-wheeled wagons, and more people traveling by carriage throughout

Britain. Many techniques are available during medieval times that would have helped to have boosted agricultural output such as the use of nitrogen, but these are bypassed because of their expense or because peasants have little incentive to produce more because of high degrees of exploitation (Brenner 1982, Clark 1992, Anderson 2013). That is, they do not capture any extra value from their production, so there is little motivation to innovate. Also, most technological innovations in medieval times come about due to initiatives of the lords, such as the use of mills. It is not until the average farm becomes larger and wealthier, again thanks to more successful farmers buying out less successful ones, and enclosure movements that displace poorer peasants, that the investment dollars become available to invest in more pastoral land, nitrogen, and more horses.[3] As Figure 2 indicates (Broadberry, et al 2015), agricultural output begins to trend upward in the 16th Century in Britain as probably would be expected by Brenner and others, and when plotting the agricultural output index by the number of horses in millions from 1547 to 1870[4], Figure 3 shows a correlation between the two variables that is very strong with an adjusted r-square of around 0.89. For everyone million increase in the number of horses, the agricultural output index goes up by 261 on average. Admittedly there is endogeneity in this simple model in that more horses can lead to more output, and in turn, more output can lead to a demand for more horses, and so on. The simple bivariate model is mostly offered to show correlation and not necessarily to imply possible cause and effect between the two variables. This will be true of most, if not all, models displayed in this

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[3] Langdon (1986) credits smaller peasant farmers with being first to innovate with the horse, although this catches on throughout farms of all sizes as time goes by. Cockshott (2019) cites McDonald (2002) and argues that medieval peasant farms are fairly productive when compared to modern farms but that aggregate agricultural production is held back due to the waste generated by feudalism and by lords and barons wanting to hold on to the wastefulness of the demesne system.

[4] Recall that there is a gap in the Broadberry, et al data from 1497 to 1546 for horses, so data including and before 1546 is not used. Also, if the Brenner thesis is correct, and if Langdon and others are correct, the 16th Century and beyond is when the greatest amount of economic growth should occur because the capitalist mode of production is becoming stronger.

paper. Both variables have trends that are non-stationary according to an Augmented Dickey-Fuller (ADF) test, yet an Engle-Granger (E-G) test shows them to be cointegrated. A Breusch-Godfrey test indicates that there is no serial correlation (see Janacek 2001, Harris and Sollis 2003, and Studenmund 2017 on time series diagnostics, etc.). The appendix contains all of the output for Figure 3 as well other figures in this paper displaying regression results. Newey-West standard errors (NWSE) are given for all coefficients and are displayed in the appendix.

Figure 4 illustrates how the horse possibly has made a significant contribution to British economic growth and advancement. When plotting the Broadberry, et al (2015) data for real GDP per capita by the number of horses in millions for 1547 to 1870, there is a very strong association between these variables with an adjusted r-square of 0.90, and they are cointegrated with no evidence of serial correlation. For every one million additional horses, real GDP per capita goes up by 125 British Pounds per capita. Using Clark's (2007, 2009, and 2010) estimates of real net national income (NNI) for 1547 to 1868 and regressing it against horses in millions, in Figure 5 we get similar results to those of Figure 4, although the adjusted r-square of 0.71 is not as quite as high as that in Figure 4. For every one million increase in horses, real NNI per capita is predicted to rise by around 34 Pounds on average. Both of these variables are cointegrated, and there is no serial correlation.

According to Langdon (1982, page 37), on an annual basis cart horses cost around 23 shillings and 8.5 pence to maintain whereas a plow horse can be maintained annually for 10 shillings and 2 pence during medieval times. These estimates include allowances for depreciation. The ox needs only a little over 7 shillings for its upkeep, and until the 16th Century, is usually preferred for plowing on farms. Figure 6 gives a conjecture on the investment in horses in Britain over time using an average cost of 1 Pound Sterling (20 shillings = 1 GBP) to maintain a horse in late medieval times, then adjusting this cost over time by inflation by Clark's (2009) measurement of a GDP price index, and then adding on a cost of capital premium (based on Clark's (2009) estimated returns to capital (1209 to 1860)) to get a market price for the average price of a horse over several centuries as shown in Figure 6. According to the UK National Archives (The National Archives 2024), in 1270, the furthest back in time its price calculator goes, 1 GBP could buy a horse. In 1860, it took 15 GBPs. The values displayed in Figure 6 come close to approximating this span in prices.[5] Finally, despite the higher costs of maintaining a horse, the opportunity cost of capital and land (or the estimated return to capital and land) according to Clark (2009) falls by about half from late medieval times during and up to the 19th Century (see Figure 7). This makes the rising, inflation adjusted total investment in horses shown in Figure 8 possible as well as the rise in surplus earned by the owners of land and capital as well as the level of taxes collected by the monarchy and government. This investment is also enabled by road and canal building projects of the 18th Century which make greater transportation and hauling by horse possible. The economic surplus accumulated by an emerging capitalist class makes these investments possible, and the economic surplus concept is addressed next.

A macroeconomic "economic surplus"[6] is an idea developed by Paul A. Baran (1957), and then later enhanced by him and his co-author Paul M. Sweezy (Baran and Sweezy 1966). The economic surplus is mostly the rents, profits, other capital income and the tax revenues collected by the government in an economic system that are basically extracted from a working class. The surplus can either be invested and reused to enhance productivity in production and/or in life

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[5] These are averages, and there is probably a large standard deviation given horse age, quality, etc. Yet these estimates come approximately close when it comes to averages of other historical accounts of horse prices over the centuries. See Clark (2004), Edwards (2007) and Claridge (2011 and 2015),

[6] This is different from the mainstream economics concept of economic surplus in microeconomics which involves the concepts of consumers' and producers' surpluses.

enhancing ways (e.g., better healthcare, better educational systems) or "wasted" on things such as advertising, wars, weapons, etc., things which are not life enhancing. Xu (2019) takes this concept and incorporates it into what he calls a "Baran Ratio", which is the amount of productive investment that an economy makes as a portion of its economic surplus. He shows that modern economies that have low Baran Ratios also have low growth rates. Lambert (2020b, and 2023) uses the Baran Ratio to show how the greatest amounts of investment out of surplus for Britain begin to rise slightly in the 16th Century and then dramatically increases in the late 1700s. Prior to the 16th Century, the Baran Ratio is quite small. He also displays results which indicate that the size of British capital stock (inflation adjusted) does not really begin to climb until the 1600s. Using these estimates of British capital stock on a decadal basis over the centuries, Figure 8 illustrates the portion of the capital stock of horses is of the total capital stock on a decadal basis. Although never greater than 2%, the conjectures indicate that horse investment jumps dramatically during the 16th Century and remains relatively high subsequently when compared to late medieval times and until the beginning of and takeoff of the railroads in the 1800s. Investment in horses as a percentage of overall investment begins to shrink as investment in other innovations begin to accelerate. This era is also roughly the time period that the Baran Ratio is climbing and there is greater investment in Britain's public works and housing, especially in roads, canals, and turnpikes. See Figures 9a, 9b, and 10.[7] Figure 9b shows a strong correlation in the proliferation of horses in farming and transport with real economic surplus from 1547 to the 1860s. Figure 10 is based upon conjectures by

[7] Because Clark's (2009) estimates are only for domestic activity, the Baran Ratio can be greater than one due to conquest of new lands or assets and/or borrowing. Investment amounts by Lambert (2020b and 2023) are estimated using Clark's estimates of domestic capital income and his estimated rates of return. It is possible that Clark has overestimated the amount of capital income or underestimated rates of returns to capital which could explain the large values of the Baran Ratio in Figure 9. However, his methodology is based upon his use of historical documents and estimates by other economic historians, and he employs reasonable methods and assumptions in a 105 page document that details how he arrives at his estimates (Clark 2009).

Lambert (2024a and 2024b) based on the work of other historians, and these show an increase in roadbuilding in Britain in the 1600s and especially in the mid-1700s. For centuries and until around the 16th or 17th Centuries, most major British roadways are still based upon and can be traced back to those built by the Romans and are estimated only to be around 3,000 miles total (Bogart 2005). The rise in horse investment corresponds well with the expansion of British roadways. Horses are used for hauling in medieval times, but with larger markets and now more roadways, the horse becomes even more important in transporting goods. The appendix shows the diagnostic results of the time series regression displayed in various figures where the variables are deemed cointegrated by the Engel-Granger test, and where Newey-West standard errors are used to correct for any serial correlation.

Serfs

(Insert Figures 11 to 13 around here)

In the debates over the transition from feudalism to capitalism, the exploitation of and struggle by serfs are a focus of several writers. Dobb (1947), Brenner (1976, 1977, 1978, and 1985), and others mostly emphasize these factors as the main causes of the transition. Figure 11 displays the ratio of the economic surplus to wage income from 1209 to 1860 for Britain (Clark 2009). This ratio is somewhat of an estimate of a macro level rate of exploitation. In looking at the figure, the highest rate of exploitation occurs toward the end of what most consider the late medieval period of the 13th Century and then begins to decline and then decrease at an even greater rate after the Black Death arrives in Britain around the year 1348. It stays below 100% for almost three centuries showing that most of national income during this period is wage income. It is not until around the beginning of the 17th Century, and after beginning to rise in the 16th Century, that the economic surplus rises back to the level of wage income. Recall that it is the 16th Century that

Dobb and Brenner believe that capitalism becomes the dominant economic system after a period of transition. During the second half of the 1300s, all of the 1400s, and the first half of the 1500s, labor seems to have an upper hand on landlords, petty producers, merchants, and the aristocracy because of severe labor shortages due to the devastating impact of the plague. It takes a few generations for this to change (Lambert 2020a). See Figure 12 on Clark's (2009) estimates of England's population alone over the centuries. During the Tudor reign of the 16th Century things begin to change as the Tudors raise taxes, create a bigger and stronger central government, and oversee an expanding enclosure movement which uproots and moves many peasants from the English countryside (Marx, Engels, Mandel and Fowkes 1990). Dobb writes that with increases in commerce, especially in agriculture and trade, the 15th and 16th Centuries see the further decline of the medieval demesne system, and as more peasants are forced into wage labor or pauperism, those who cannot adjust are thrown into cruel and brutal workhouses started by the Tudor poor laws (Tawney 1912, Dobb 1947). Henry VIII's taking of Catholic Church property and treasure along with his and his father's attempts to have a stronger central government with greater taxing powers are also a break with the feudal period. These successes contrast with attempts by his predecessors in the previous century, especially Richard III, to reform and improve government tax collections and to create a stronger central government (Elton 1953, Cippola 1993, Bonney 1995, Gelabert 1995, Ormrod 1999, O'Brien and Hunt 1999, Brayson 2019, and Lambert 2024c). Richard III cannot put into effect "lay taxation" or direct taxes on the general public to raise needed funds as other tax revenues fall, and his government faces deficits (Brayson 2019). Goddard (2016) writes that credit and finance expands during this period in England, although the early 15th Century is marked by a long period of economic depression and stagnation. In the 16th and 17th Centuries the Baran Raio displayed in Figure 9 starts to trend upward. Additionally, Hexter (1961) disputes assertions that the Tudor period is one that benefits most royal subjects contrary to Tudor mythology and writes that it is only the upper strata of the aristocracy and a growing capitalist class that truly benefit.

Figure 13's scatterplot displays the relationship between real NNI per capita and economic surplus per capita (another measure of exploitation) for Britain over the centuries using Clark's (2009) conjectures. There is serial correlation, but the use of robust/Newey-West standard errors show that the independent variable of surplus per capita is still statistically significant at 5% alpha. The two variables are non-stationary but co-integrated, and the model has an adjusted r-square of around 62%. Please see the appendix for details. As exploitation goes up on average, so does national income. This somewhat underscores the notion that capitalism relies upon greater and greater levels of exploitation at the expense of the working class in order to achieve greater levels of economic growth. Of course, greater levels of income and wealth allow a ruling class to engage in even greater levels of exploitation, so there is endogeneity in the relationship between the two variables. These results somewhat support the Dobb and Brenner notions of labor exploitation and class conflict being strong forces in the transition from feudalism to capitalism. As long as wages or labor income are high, capitalism and national income growth appear to be held back and constrained.

Slaves

(Insert figures 14 to 28 around here)

This section of the paper cannot cover all of the major works on how slavery could have propelled Britain toward the Industrial Revolution because it is such a large volume of literature. Berg and Hudson (2023) have a 34 page list of references in their book, which at the time of the writing of this paper, provides a comprehensive review of works from historians and economic historians on the slave trade as well as British economic history in general.[8] Acemoglu, Johnson, and Redding (2005) credit much of Europe's economic growth due to the growth of Atlantic trading, part of which includes the slave trade, and Acemoglu and Robinson (2012) acknowledge how empires are built on colonialism but stop short of identifying the slave trade as a key factor in colonialism (2012, page 271). Because of such a large volume of research on the slave trade, some of the findings of this paper may duplicate those of other researchers. However, the main purpose of this paper is to show the linkages among the slave trade, different industries and markets, investment in the British economy, and Baran's concept of the economic surplus with some statistical analysis. Using as an independent variable data from the Trans-Atlantic Slave Trade Database from the Slave Voyages site (2021) for the total number of slaves disembarked from ships using the British flag from 1563 to 1809, which is the entire span of the site's data, although up until the mid-1600s there are many zeroes; and using Clark's (2009) data for real net national income per capita as a dependent variable, the results are displayed in the scatter diagram in Figure 14a.[9] The number of slaves disembarked is nonstationary although real NNI per capita is not, yet the two variables are cointegrated. Robust standard errors show that the number of slaves is statistically significant at $\alpha<0.05$, although the adjusted r-square is only around 0.3 (see appendix). Again, it is admitted that there is endogeneity in this model and others in this paper. The aim is to show some type of correlation. Although the variable of slaves disembarked correlates somewhat with Clark's estimates of NNI per capita, it does not correlate well with his estimates for capital

[8] Adam Smith (2002) basically thought slavery and maintaining an empire, despite the wealth they generated, were wasteful and inefficient efforts. Yet Marx thought slave labor in the New World helped to give rise to more industries and wage labor in Europe, and the growth of ship building related to slavery helped to move Britain toward and through the Industrial Revolution (Marx, Engels, Mandel, and Fowkes 1990, Foster, Holleman, and Clark 2020).

[9] Interestingly, Berg and Hudson (2023) do not reference Clark's data set, although they do reference Broadberry, et al (2015).

income over the same time period. The adjusted r-square is only around 9%, and the two variables are non-stationary and not cointegrated using an Engle-Granger test.

One of the claims that Berg and Hudson (2023) make is that various economic historians indicate that although one cannot demonstrate that the slave trade has aggregate level impacts on British income and wealth, it can be shown that the slave trade causes the rise and growth of different industries within Britain at different cities such as Bristol, Liverpool, etc. and the growth of these regions can be linked to the industrial revolution. Heblich, Redding, and Voth, however, link national wealth and economic growth increases at aggregate levels due to slaveholdings (not slave sales) by different owners in Britain. Figure 14a does show some correlation between the slave trade and income over the years at a macroeconomic level. Figure 14b shows similar yet stronger results regarding correlation using the disembarked slaves data and the Broadberry, et al (2015) data for a real GDP per capita index for the same time period. The adjusted r-squared is 0.75, the slave numbers are statistically significant, and although both variables are non-stationary, co-integration exists between the two (see appendix on more). Figure 14b indicates that for every 10,000 slaves disembarked in various territories, real GDP per capita goes up by a score of 18 using the Broadberry, et al scale/index where 1700=100. These results possibly suggest more than just urban and regional effects of the slave trade on British economic growth. In modern times, national economies are partially if not mostly an aggregation of urban economies. Next, the different industries affected by the slave trade are examined.

According to most accounts, the rise of the slave trade by Britain is mostly due to the rise and growth of sugar plantations in the New World, especially in the West Indies. Figure 15 illustrates the relationship between total slaves disembarked (x) and the inflation adjusted value of the total amount of sugar imported in millions of GBP (y), much of which is processed and reexported from the early 17th Century to 1808 (data from Mitchell 2011, which only goes back to 1700 for sugar).[10] The year 1808 is one year after a law that is passed that prohibits slave trading within the British Empire, although a lot continued subsequently in underground economic activity. The adjusted r-squared is a modest one at 0.58, the two variables are co-integrated, and the x-variable is statistically significant at 5% using Newey-West standard errors (see appendix). The results further emphasize in addition to other works the linkages between slavery and the sugar industry.

Thanks to the growth of the popularity of sugar, cotton, and coffee in Britain and the rest of Europe and the world and due to the rising production of these commodities, according to Berg and Hudson (2023) other related industries grow such as tin for making housewares; more shipbuilding for hauling more goods; food processing of imported commodities; more iron for cooking hearths; coal production to provide energy for expanding manufacturing; furniture making; expanded clothing production; growth in the banking sector to help finance developing industries; growth in public investment for ports and land transportation; and other related industries which receive a boost in growth thanks to the import of slave created commodities. The Slave Voyage database can give the total amount of slaves disembarked in the West Indies (site of most sugar production) as well as other regions which specialize in other commodities, but there is no way of knowing

[10] For most of the 18th and 19th Centuries the total disembarked number of slaves is in the hundreds, thousands, or tens of thousands. There are some zero values for sugar values in the Mitchell data. For the slave trade data, the values for 1808 and 1809 plummet down to around 8,000 and 18, respectively, after being in the tens of thousands for the years in prior decades. The standardized residuals for the value for 1809 and the corresponding inflation adjusted value of sugar imports in a regression model of slaves (x) and sugar imports values (y) is greater than an absolute value of 4.0, and so it is dropped from the final model displayed in Figure 15. None of the zero values for sugar imports (extremes) yields a value over absolute value of 3.0, however. Therefore, these values are retained for use in the model. For other models in this paper, values for the years 1808 and/or 1809 are retained unless the standardized residuals are greater than or equal to an absolute value of 4.0 or more which indicates an outlier. In some of the models for this reason, the time series only extends to 1807 or 1808 because values for these years are outliers.

whether these are from ships under the British flag or the flag of other nations. Therefore, annual aggregate numbers for all destinations have to be used using data on ships under the British flag. This is a crude method of approximation but gives some ideas regarding correlation. This paper also speculates on what impact, if any, the slave trade has on British military spending and public infrastructure spending. Finally, as Marx notes, the employment of "slave" wage labor goes up and increases on the "pedestal" of ordinary slave labor (Foster, Holleman, and Clark 2020), and so the relationship between slave labor and wage labor growth is examined.

First, the growth in the number of wage laborers and their average, daily, real wages can be examined. Figure 16 displays the relationship between the portion of the male, non-farm labor force in Britain from 1563 to 1807[11] (Clark 2009) and total slaves disembarked. The regression model indicates, as slaves disembarked goes up by 10,000, the portion of the male, non-farm labor force goes up by 5% on average. The two variables are co-integrated, and the independent variable is statistically significant and explains about 62 percent of the variation of this labor force share. See the appendix for more as with all the models in this paper. An inference is that the industries claimed to have been spawned by the slave trade may have increased non-farm employment. According to Clark's (2009) conjectures, farm labor makes up around 50 to 70% of male employment in the 14th, 15th, and 16th Centuries but then begins to drop in the 1700s as the slave trade climbs further. Figure 17 shows a weaker correlation between real, average non-farm daily wages and the slave trade (adjusted r-square = 0.204), yet the number of slaves is statistically

[11] For 1808 and 1809, standardized residuals for these years from the regression model are greater than an absolute value of 4.0, and so these are dropped as outliners. The slave trades has a little over 29,000 disembarked in 1807 and then falls dramatically to only around 8,000 in 1808 and further down to only 18 in 1809 according to the Slave Voyage data.

significant as an independent variable, the two variables are co-integrated despite non-stationarity present, and for every 10,000 increase in slaves, real average daily wages go up on average 1 pence.

Next, Figure 18 displays the relationship between slaves disembarked and tin production from 1563 to 1809 in Britain. Slaves disembarked explains around 67% of the variation of the Broadberry et al index of tin production during this time, is statistically significant using Newey-West standard errors, and the two variables are cointegrated despite the presence of non-stationarity. An increase in 10,000 slaves increases the tin output index by 9 points on average.

Figure 19 displays the relationship between a textile production index created by Broadberry, et al (2015) and the number of disembarked slaves from 1563 to 1807. The fit is fairly strong at an adjusted r-square of 0.803, and the two variables are cointegrated with disembarked slaves statistically significant with a p-value of less than 0.001 using Newey-West standard errors (see appendix). Newey-West standard errors are used in all models to avoid any problems of possible serial correlation.

For Figures 18 and 19, the Broadberry, et al (2015) data are originally on a decadal basis and linear interpolation is used to get estimates for the years between each set of decades such as 1600, 1610, etc. Trying to do this for their indices for wool, food processing, financial services, and then trying to correlate these results with total slaves disembarked yields results that show that they are not cointegrated for the years 1563 to 1807 or 1809.[12] Yet, when the time series is from 1641 to 1807, which eliminates many zero values for disembarked slaves, the number of slaves

[12] There is a relationship between sugar production (x) and the food processing index (y) from the 1700s to the beginning of the 1800s that is statistically significant with an adjusted r-squared of around 58%. As Berg and Hudson note, the sugar industry and its boom triggers a whole host of industries including food processing, so perhaps, and this is the case in many of the relationships covered in this paper, the slave trade is more of an indirect yet important variable in the models given.

disembarked is co-integrated with the food processing industry. See Figure 19a. When using the decadal data and using only the decadal slaves disembarked data for corresponding years, only the relationship between the financial services index and slaves disembarked variable shows cointegration, an adjusted r-squared of around 0.26, and statistical significance at 5% for the slaves variable. But this makes for a crude time series analysis by using decadal values. Using data from Mitchell (2011) for coffee production there is some type of connection that is statistically significant and not spurious. The fit is around 40% when slave numbers and inflation adjusted coffee values are put in a natural log form. Inflation adjusted tobacco imports do show a statistically significant but weak connection (20% fit) with the slave trade if one uses slaves disembarked in mainland North America as a subset of all slaves disembarked from British ships. Supposedly sugar and some other forms of agricultural production were more labor intensive than tobacco and coffee, and so this may explain why greater slave numbers do not correlate that well with these other goods (Solow 1987, Ronnback 2023, Lowcountry Digital History Initiative n.d., Understanding Slavery Initiative n.d.). The Slave Voyage Database states that the total number of slaves used in the production of sugar is around 5.25 million whereas the number used for cotton, tobacco, rice, cacao, etc. total only 1.5 million by comparison (Behrendt 2024). Interestingly, the relationship between slaves and coffee does not hold up if slaves disembarked only in the colonies/states of Maryland, Virginia, and North Carolina are matched with tobacco values. Not all tobacco producing colonies/states are listed, and one problem in using more specific regional data from the Slave Voyages is that some regions are missing. For instance, in trying to pinpoint cotton production, the colonies/states of Alabama and Louisiana are missing, and yet these were important states for cotton production.

Figures 20 and 21 display how the slave trade is correlated with iron and steel production for import and export. In Figure 20, iron imports are linked to the slave trade and in Figure 21, iron and steel exports are moderately correlated (adjusted r-square = 0.64) with the number of slaves disembarked from 1697 to 1807. The variables in each scatterplot are co-integrated and the x variables are statistically significant. The growth of the iron and steel industries are often discussed as having their growth linked to the slave trade, especially in the latter half of the 18th Century (Berg and Hudson 2023, pages 131-136).

Figure 22 plots Broadberry et al (2015) data for their trade and transport index by disembarked slaves, and this relationship is co-integrated with an adjusted r-square of around 0.81 where a 10,000 increase in disembarked slaves boosts the index by 6.6 points on average. Broadberry, et al (2015, pages 169-171) note that the index that they have developed cover both domestic as well as international trade and transport. Figure 23 displays the relationship between the estimated public investment (spending on roads, canals, bridges, ports, lighthouses, etc.) as a portion of NNI (Clark 2009, Lambert 2024b) and slaves disembarked. The adjusted r-squared is 0.803, the slaves variables is statistically significant at an alpha of 5%, and the two variables are co-integrated. Every 10,000 slaves boosts the conjectured share of public investment by 4% on average.

Figure 24 illustrates the correlation between inflation adjusted customs revenues over time with the slave trade from 1691 to 1801 which is the time series given in the Mitchell book for customs revenues (Mitchell 2011, pages 575-577). The slave variable is statistically significant at 5% alpha, the adjusted r-square is 0.33, and the two variables are cointegrated. For 1801, there is a negative value for customs revenues, and the standardized residual for the predicted y in the regression model is larger than an absolute value of 4.0. When dropped, the adjusted r-squared becomes around 0.59 for the regression line. Every 10,000 slaves disembarked is associated with an increase of around 688,000 Pounds in customs revenues on average. With respect to military spending, the best model that can be developed is one between inflation adjusted expenditures on the British Navy and slaves disembarked. Even then, the relationship is weak (adjusted r-square of only around 0.07) although the slaves disembarked variable is statistically significant at 5% alpha, and the two variables are cointegrated. Whether looking at total military spending or just the army or just spending on ordinances, the adjusted r-squared values are lower, although the slaves variables is statistically significant and the variables are cointegrated. Similar weak results are obtained when military spending is used as a portion of total government spending or as a portion of GDP.

Figure 26 is submitted as an illustration of how the slave trade correlates with the inflation adjusted values of economic surplus per capita. The slave trade variable has a moderate association with the economic surplus per capita (adjusted r-square = 0.40), and it is statistically significant at $\alpha < 0.05$ and is cointegrated with economic surplus per capita. It appears that the slave trade is correlated with profitability in the nation. The slaves disembarked variable is not cointegrated with the Baran Ratio (amount of domestic investment as a portion of the surplus) and yields an adjusted r-squared of only around 0.20 in looking at the values from 1563 to 1809. Figure 27 displays the estimated portion of the value of slaves as a portion of the balance of trade from 1697 to 1775 (Mitchell 2011) by multiplying West Indies slave auction values (US Census Bureau 2015) by the total number of slaves disembarked under the British flag. Only time series values for 1697 to 1775 can be found in doing research for this paper. As can be seen, investment in slaves is as high as nearly 85% of the balance of trade so that a significant portion of capital outflows from Britain can be assumed to be going for slave "investments." The -247% comes from 1600 when the balance of trade was a small but negative 28,000 £ according to calculations from the Mitchell (2011) book. This figure, then is basically an outlier since it is very small when compared to other balance of trade values (average = 2,125,582 £). And although the Baran Ratio does not work very well with the slaves disembarked variable, the slaves variable does have a weak but statistically significant association with the decadal values of real investment in Britain from 1570 to 1810 (Lambert 2020 and 2023) as shown in Figure 28. The two variables are cointegrated, and there appears to be a link, albeit not a strong one, between domestic real investment and the number of slaves disembarked from 1570 to 1810 (adjusted r-squared = 0.202).[13] Contrary to what some claim (Niemietz 2024), the value and numbers of slaves appear to be linked to domestic investment somewhat during the 16th thorough the 18th Centuries.

A Simple Multivariate Model

(Insert Tables 1 and 2 around here)

This paper has discussed various factors that could have influenced the British economy form the 16th to the 19th Centuries. Two simple multivariate model are offered to see if some or all of these factors are correlated with Clark's (2009) measurement of real NNI per capita or with the Broadberry, et al estimates of real GDP per capita over these centuries. The two models are created in such a way to avoid problems of multicollinearity, serial correlation, and non-stationarity. It is admitted, however, that the "independent variables" used in the models are not completely exogenous. Endogeneity exists because while each factor can influence real NNI or real GDP per capita, greater levels of income and output can affect these factors. Table 1 displays a model

[13] Clark's (2009) conjectures are only on domestic output and income, and there is no data on direct foreign investment or capital flows back to Britain from overseas profits. One can infer as others have done that probably the increased output from slave sales and production have indirectly boosted investment in industries that have arisen due largely to the growth of sugar and other slave related products.

wherein real economic surplus per worker[14], the natural log of the estimated public investment per capita (Lambert 2024b), and the natural log of the real economic surplus per total disembarked slave (zero for years when there is none disembarked), and the natural log of the number of horses per 1,000 population in Britain over the centuries (Clark 2009) are used in a model to see if they are associated with the log of the real NNI per capita from 1547 to 1859.

Ln Real NNI per Capita = f{Real Economic Surplus per Worker, Ln Est. Public Investment per Capita, Ln Real Economic Surplus per Disembarked Slave, Ln Number of Horses per 1,000 Population)

(1)

Each of the four variables is statistically significant at the 5 or 10% alpha level and are cointegrated with real NNI per capita at either the 5 or 10% alpha level. The four variables explain about 74% of the variation in real NNI per capita and show that a one Pound increase in surplus per worker is associated with an approximate 0.06% increase in real NNI per capita; a 1% increase in public investment per capita is associated with a 0.0035% increase in real NNI per capita; a 1% increase in surplus per slave is correlated with a 0.012% rise in real NNI per capita; and a 1% increase in horses per 1000 of population is associated with a 0.22% rise in real NNI per capita.

For the Broadberry, et al data of Real GDP per capita, the independent variables used in Table 1 do not work as well even when trying different ways of respecifying them. Because of problems of non-stationarity, the variables of public investment and slaves disembarked cannot be used. Table 2 presents a model wherein

Real GDP per Capita = f(Real Economic Surplus per Worker, Horses in Millions) (2)

[14] Using population numbers from Clark (2009) and Broadberry, et all (2015, Chapters 6 and 8), the working population is estimated as approximately half of the population numbers estimated by Clark and adjusting these numbers by Broadberry, et al numbers.

The two variables explain around 92% of the variation in real GDP per capita and are statistically significant and cointegrated at $\alpha < 0.05$. A one GBP increase in economic surplus per worker is associated with a £2.33 increase in real GDP per capita, and an increase of 1 million horses is associated with around a £111 increase in real GDP per capita. There is a strong implication that human and animal exploitation have made a difference in surplus generation.

Conclusion

This paper/research note has endeavored to illustrate the linkages among different data sources that could give some ideas about the transition debate from feudalism to capitalism and from one form of capitalism to a more advanced one as in the Industrial Revolution. The results are limited by the fact that they rely upon conjectures on past centuries developed by economists in modern times. There is also the problem of endogeneity and feedback loops among the variables in the models examined. More research can be done to refine backward looking estimates and to develop new ones, and this is paramount to scholarly explorations and investigations into economic history. Finally, even though the Engle-Granger test is used to control for non-stationarity and possible spurious relationships, it is admitted that there can be underlying variables in the models that could link the "independent" variables with the "dependent" variables, although the main goal of the models is to show some type of correlation and not causation.

At the same time, many of the claims made by Maurice Dobb, Robert Brenner, and Eric Williams have received at least partial and implicit support by the results of the data analyses in this paper. Dobb's notion of class conflict playing a major role in the transition from feudalism to capitalism is illustrated by how wage workers gain a greater share of national income at the expense of the upper classes after the Black Death but then lose this beginning in the 16th Century as the economic surplus going to the upper class increases. That is, exploitation goes down after the

Black Death and for several centuries subsequently, but with the Baran Ratio beginning to go up in the 16th Century and with agricultural output rising thanks at least partially to the enclosure movement, which in turn benefits landowners, the economic surplus (rents and capital income) to the upper classes begins to rise with the greater exploitation.

Horses and their contributions can be seen as somewhat supporting Brenner. If Langdon is correct, then by yeoman farmers putting horses to greater usage than during previous centuries and also by buying out smaller, less successful farms to become larger enterprises and landowners as competition caused an industry shakeout of smaller less competent farms, we see a key agricultural innovation that is made possible by agriculture moving from a feudalistic to capitalistic mode of production with economies of scale, economies of scope, and greater levels of production and investment. The horse, underutilized in feudalistic times as a draught animal, plays an important role in this.

The notion that the slave trade has had broader than regional economic effects is also partially supported by this note. Williams' claim of a connection between slavery and capitalism gain support as does the research of Heblich, Redding, and Voth (2022). Most, although not all, of the macroeconomic variables examined point to national effects of the slave trade on the British economy up to and including the period of the Industrial Revolution. This is despite the fact that the Broadberry, et al and Clark datasets are estimates of British domestic activity and that the slave trade plays its largest role in exports and imports, items for which they do not provide conjectures. This paper has tried to show that slave trade values make up a significant portion of the Mitchell data on the balance of trade.

With these things in mind, what lessons can we draw for the present? If human exploitation has been central to capitalism, whether in serf, peasant, and/or slave form, should so much of the economic surplus be siphoned to a ruling class which has relied upon limiting the rights and privileges of so many of their fellow humans? Jason Hickel:(2019) estimates of slave reparations of $97 trillion in US alone, and in today's dollars, Britain paying slave owners in 1834 around 20 million Pounds would be worth $300 billion in today's money. Slaves got nothing of this "settlement" money, and reparations to their descendants in Britain, the US, and other nations are still debated. Incidentally, Hickel credits the slave trade with the production of items in the new world which freed up agricultural land and other resources in Britian which led to its greater economic development. Additionally, if animals have certain rights and are worth more than a piece of machinery because they are sentient beings (Benton 1993, Foster and Clark 2018), what then is owed to the equine species and other draught animals due to their contributions to human advancement? Agricultural production and distribution and transportation are dramatically improved by horses beginning in the 16th Century and in following centuries in Britain. Periods of famine begin to disappear. After World War II and especially in the US, the tractor becomes the dominant form of farm equipment in most nations, when it comes to agricultural output, and horses and donkeys begin to be associated with other industries such as rodeos, circuses, eventing shows, and most of all, horse racing. Tragically, the use of these animals in meat products continues to this day even though it is becoming more and more controversial (Crnkovic 2022). Horse racing is a sport that is in decline in the US and elsewhere (Lambert 2021), and attempts to have greater regulation of racing to prevent the excessive drugging and abuse of racehorses have been met with resistance by horse owners, farms, and race tracks (Block and Amundson 2024). Such is the current state of a species that has helped humanity overcome famine and transportation challenges. Given climate change and arguments for a more and greater emphasis on organic farming, which relies on little if any petroleum products and the close proximity of farms to urban centers so as to avoid long hauls of produce and goods by semitruck in order to reduce carbon emissions, one can envision the return of the plow horse as a key factor in reducing some of the reliance on combustion engine tractors and huge combines (Mulhall, Leavy, and Conlon 2023, Lambert 2023b). Protecting horses and other draught animals and redeploying them in large numbers to help humanity again, this time to help combat climate change, could be similar to their use in helping humankind to achieve a higher standard of living from feudalism to capitalism.

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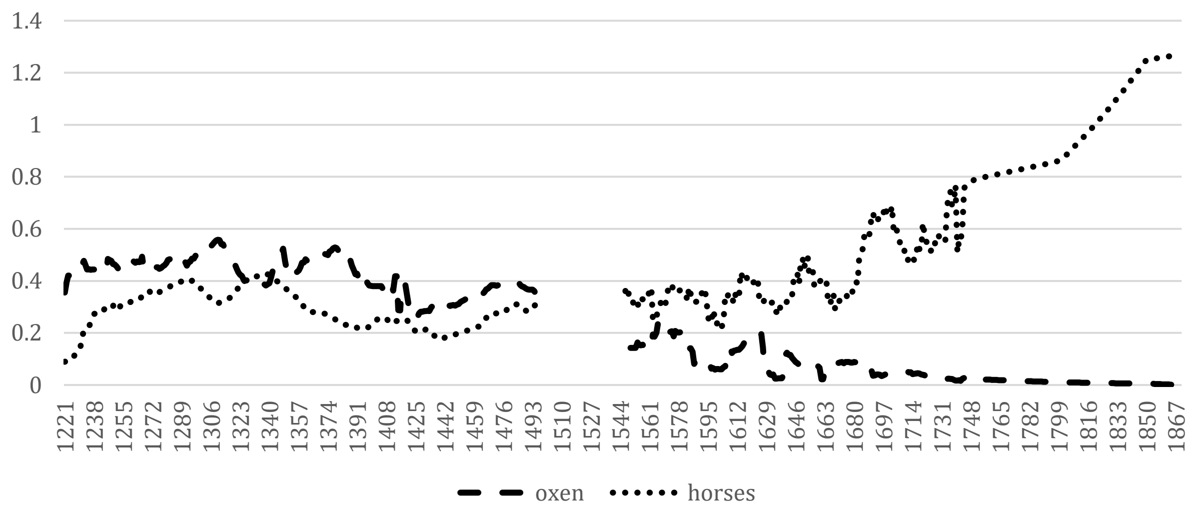
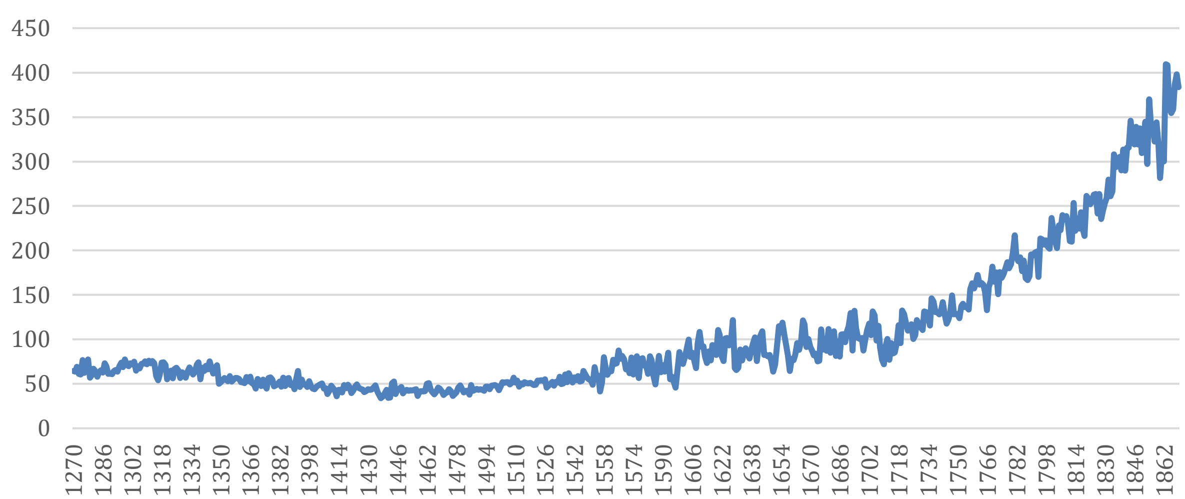
Fig. 1: Number of Horses and Oxen in Millions, Britain, 1221 to 1870

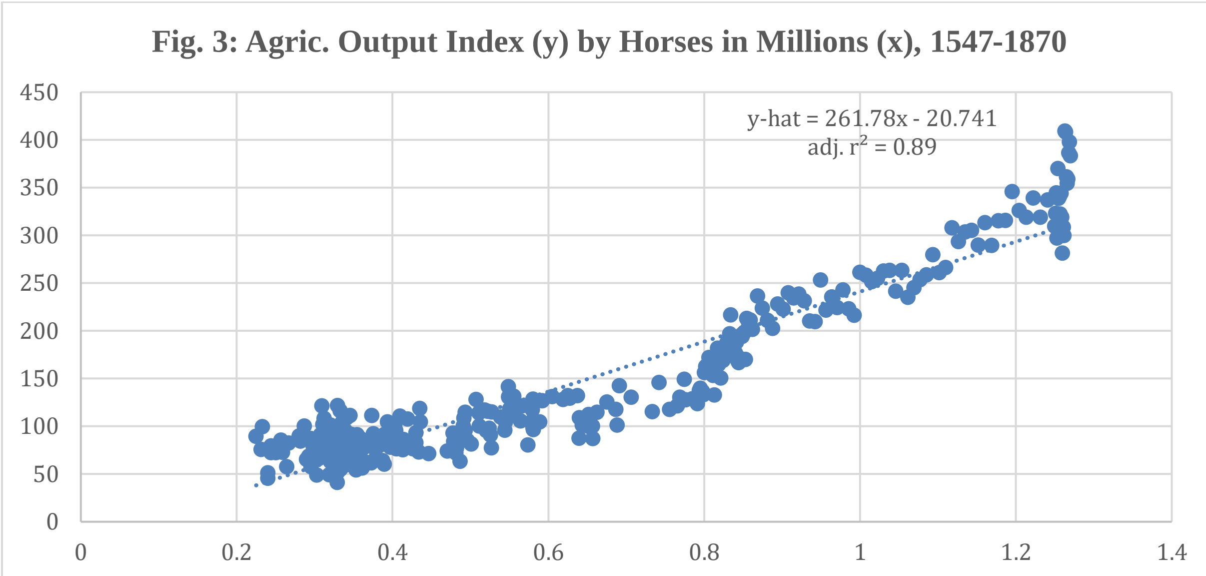


Source: Broadberry, et al (2015)

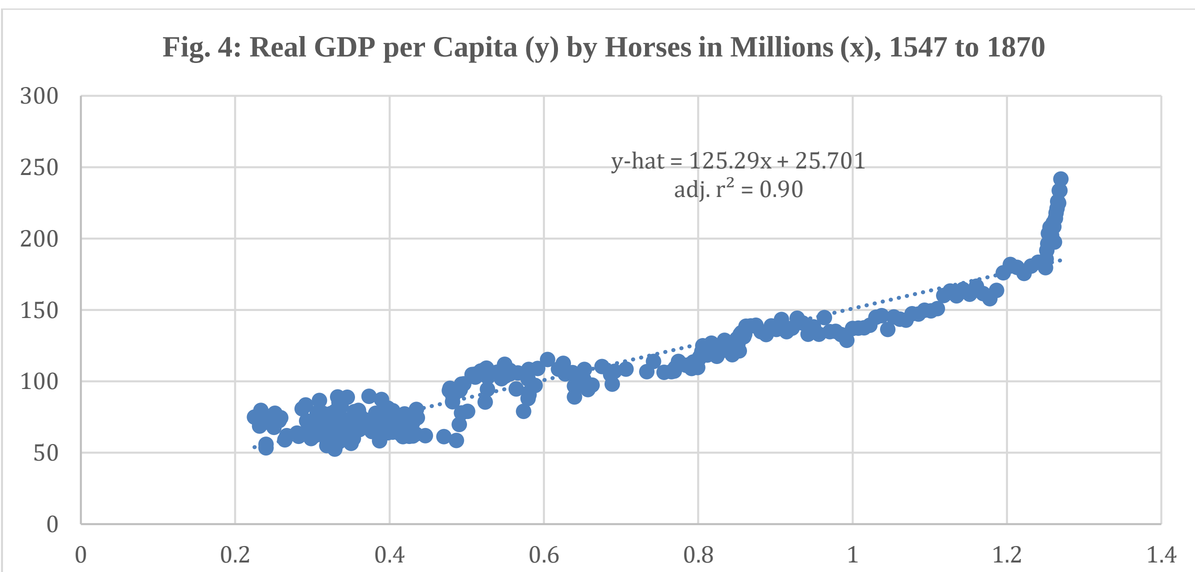
Fig. 2: Agricultural Output Index, 1700 Base Yr =100



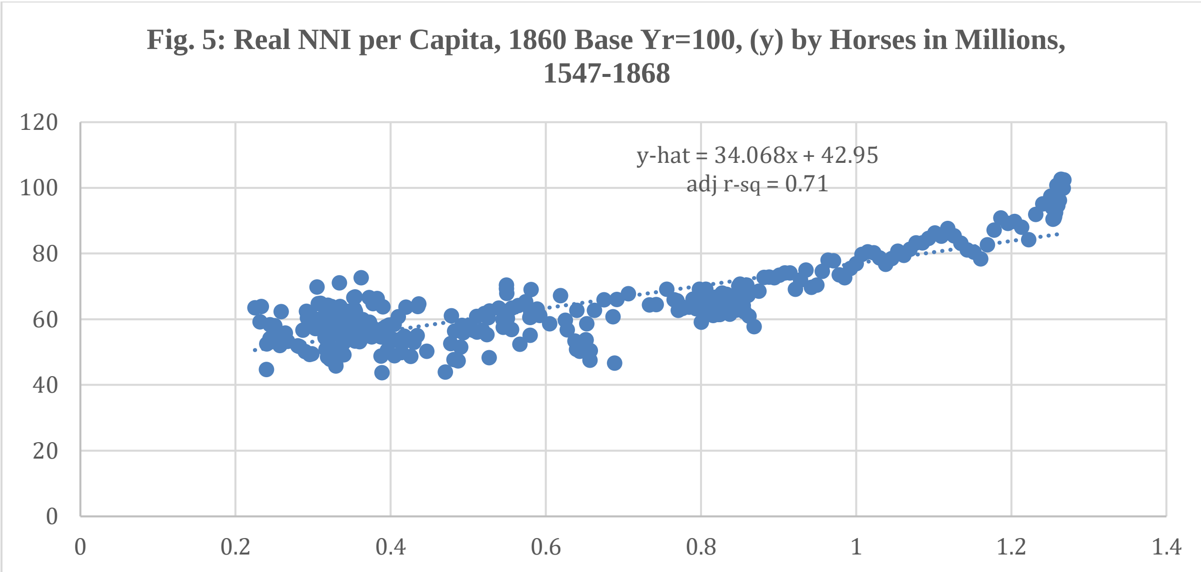
Source: Broadberry, et al (2015)



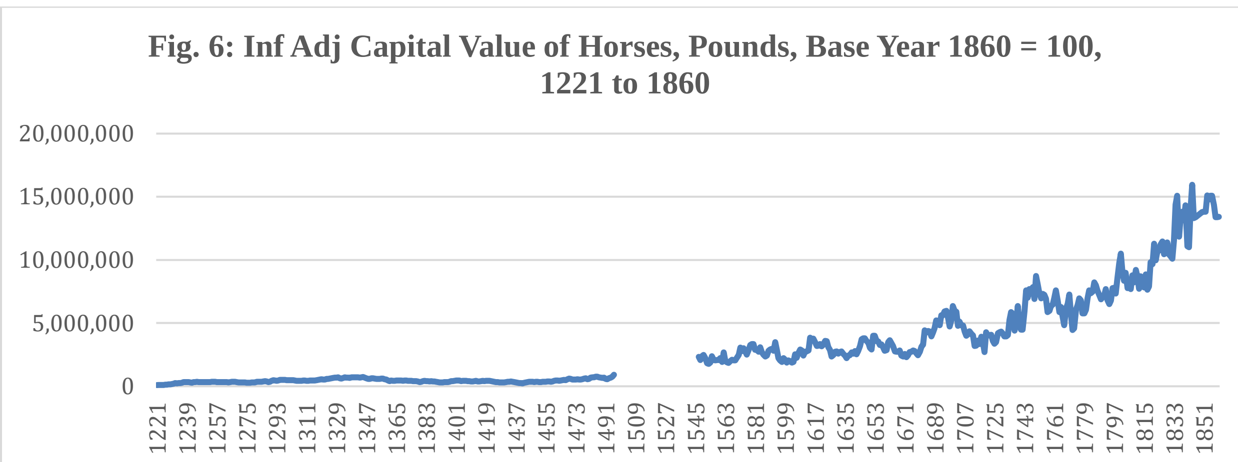
E-G Test: Tau-stat = -6.4, p-value < 0.01, co-integrated. Source: Broadberry, et al (2015)



E-G Test: Tau-stat = -4.2, p-value < 0.01, co-integrated. Source: Broadberry, et al (2015)

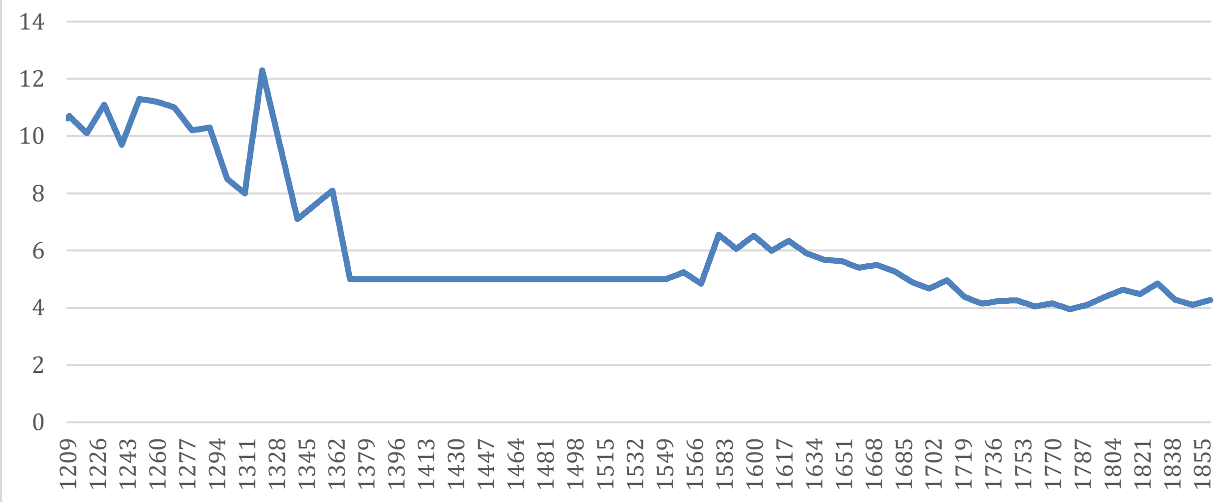


E-G Test: Tau-stat = -5.8, p-value < 0.01, co-integrated. Sources: Broadberry, et al (2015) and Clark (2007, 2009, and 2010).



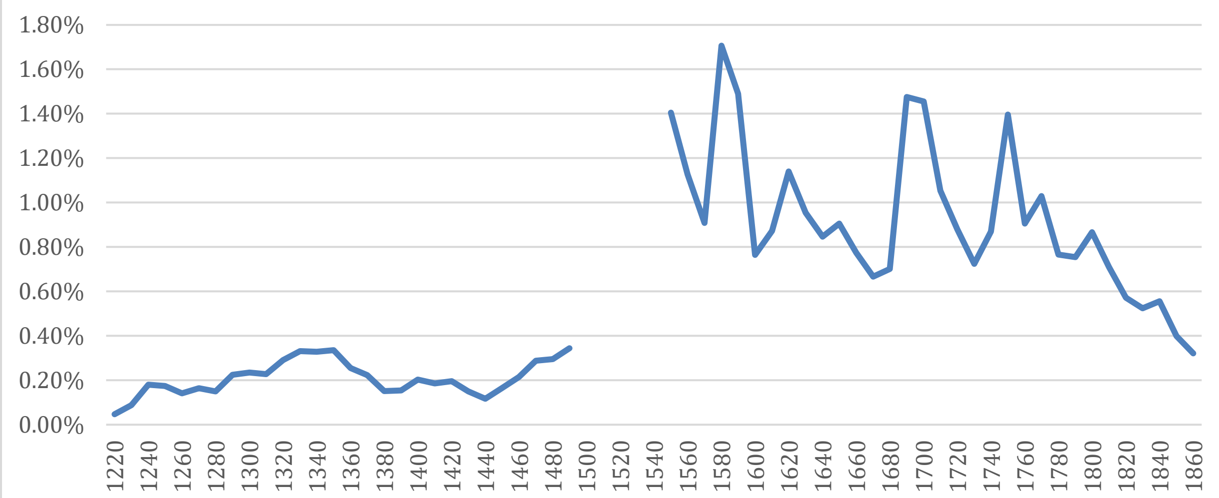
Sources: Broadberry, et al (2015) and Clark (2009)

Fig. 7: Estimated Return to Capital and Land, 1209 to 1860

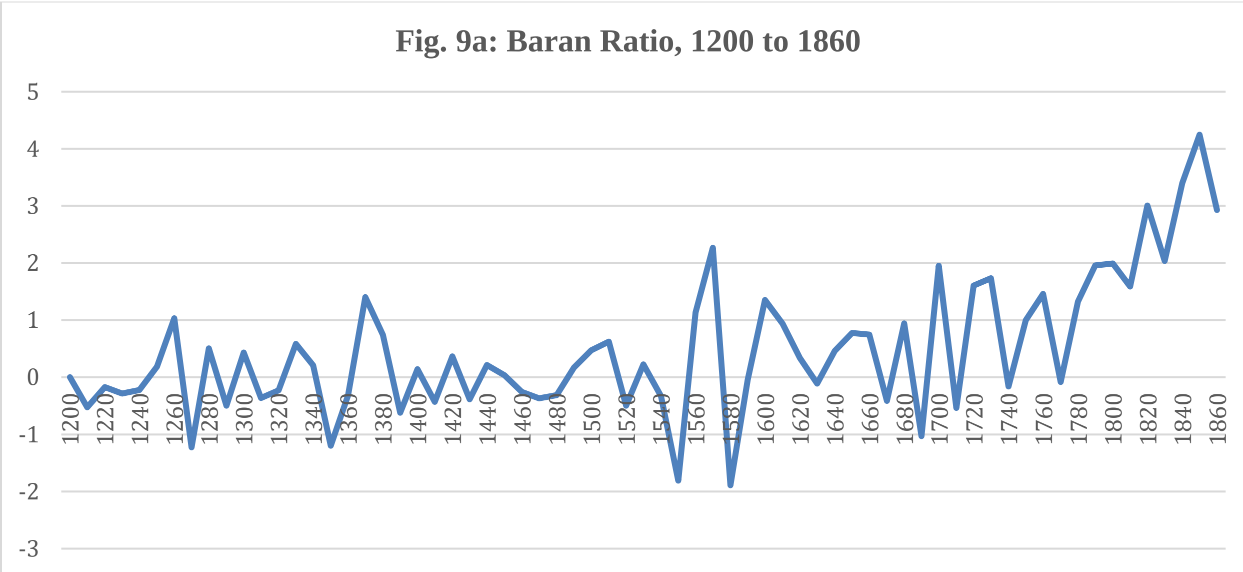


Source: Based on Clark's data (2009).

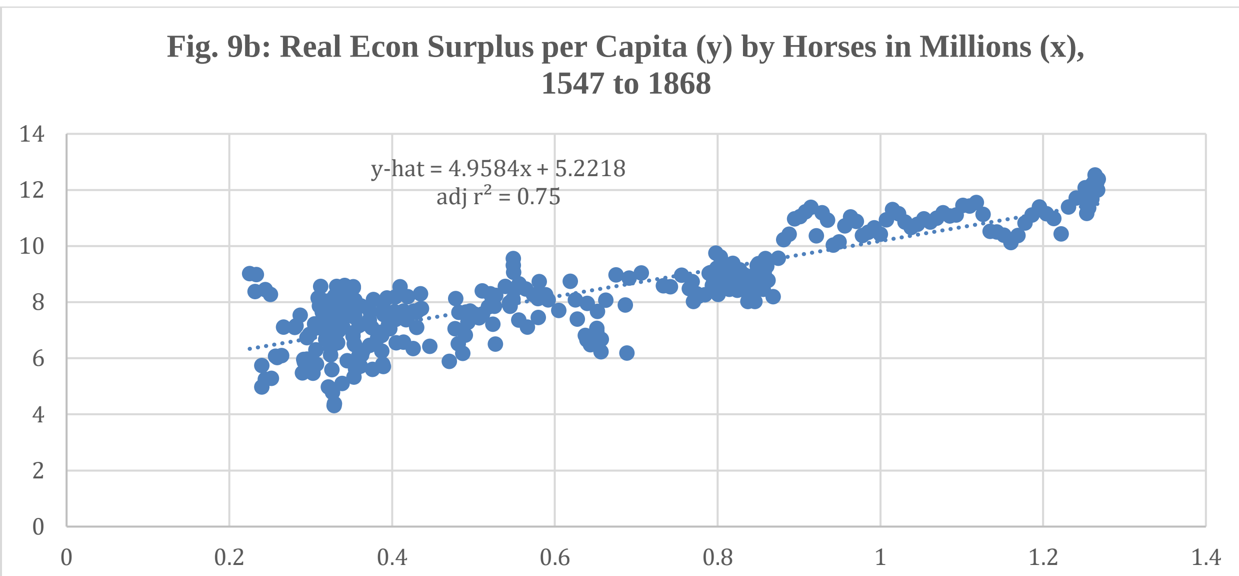
Fig. 8: Horse Capital Stock of Total Capital Stock Pct



Source: Based on data from Broadberry, et al (2015), Clark (2009), and Lambert (2020b and 2023).

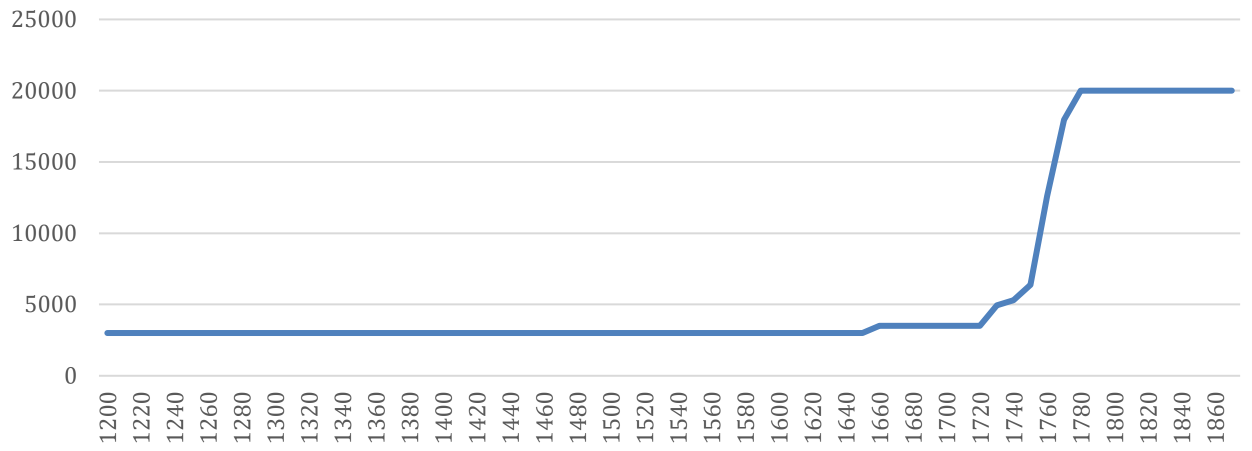


Source: Lambert (2020 and 2023).



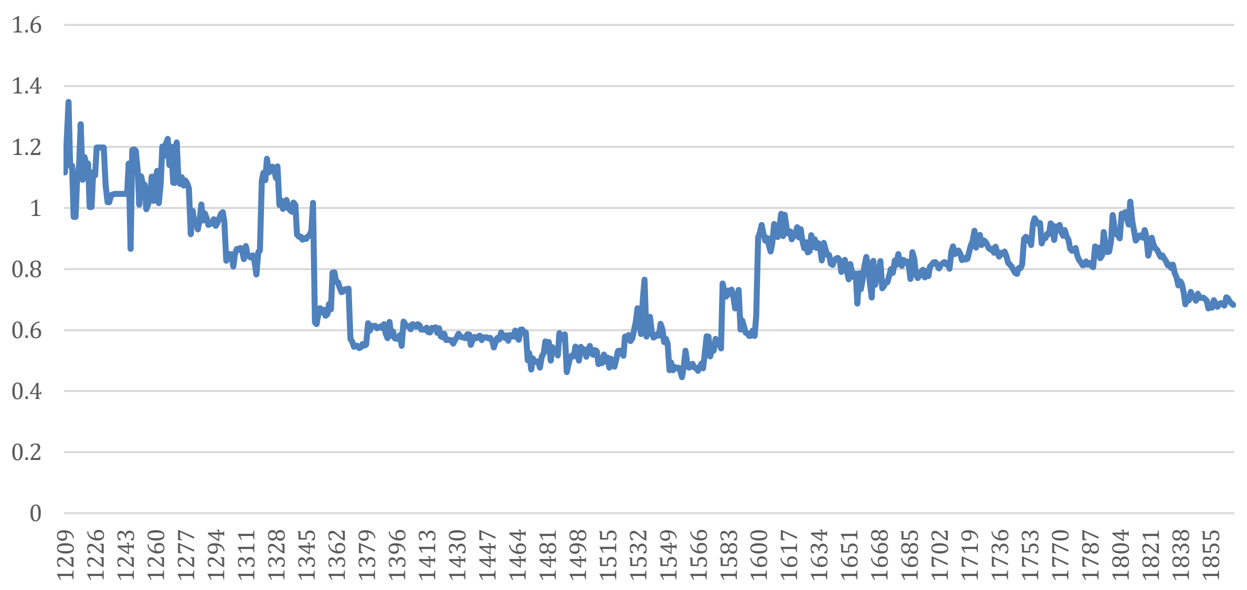
E-G Test: Tau-stat = -5.7, p-value < 0.01, co-integrated. Sources: Clark (2009) and Broadberry, et al (2015).

Fig. 10: Estimates of Mileage of Roads and Turnpikes



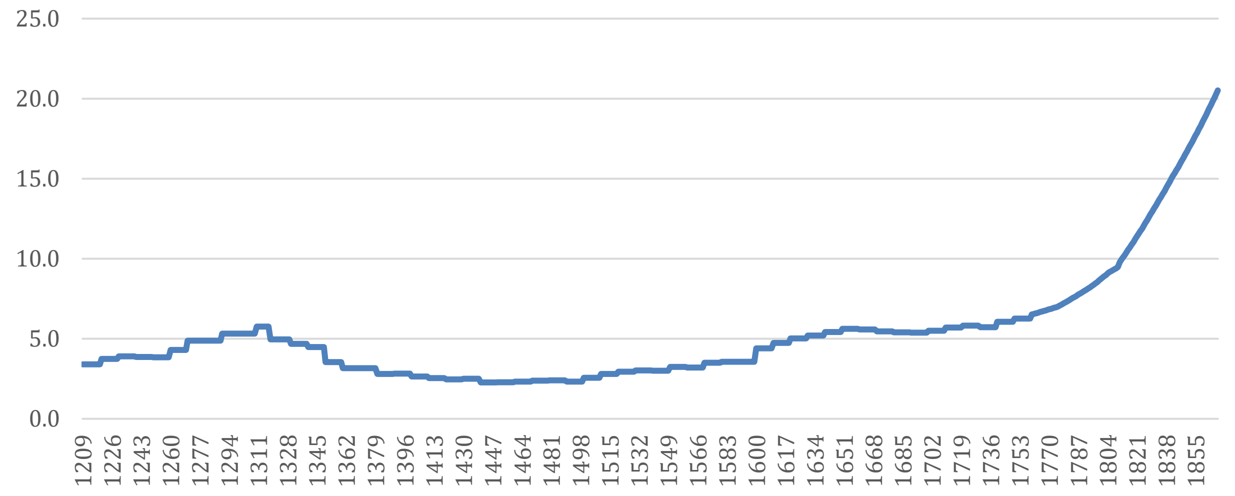
Source: Lambert (2024a and 2024b)

Fig. 11: Rate of Exploitation, S/V, or Economic Surplus to Wages Pct, 1209 to 1860



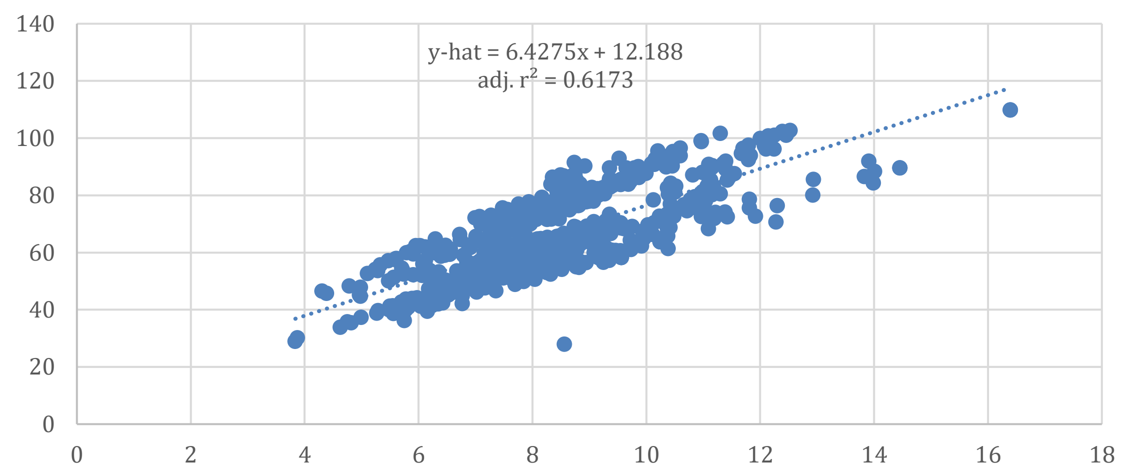
Source: Author’s use of Clark (2009) data.

Fig. 12: Estimated Population of England, 1209 to 1868

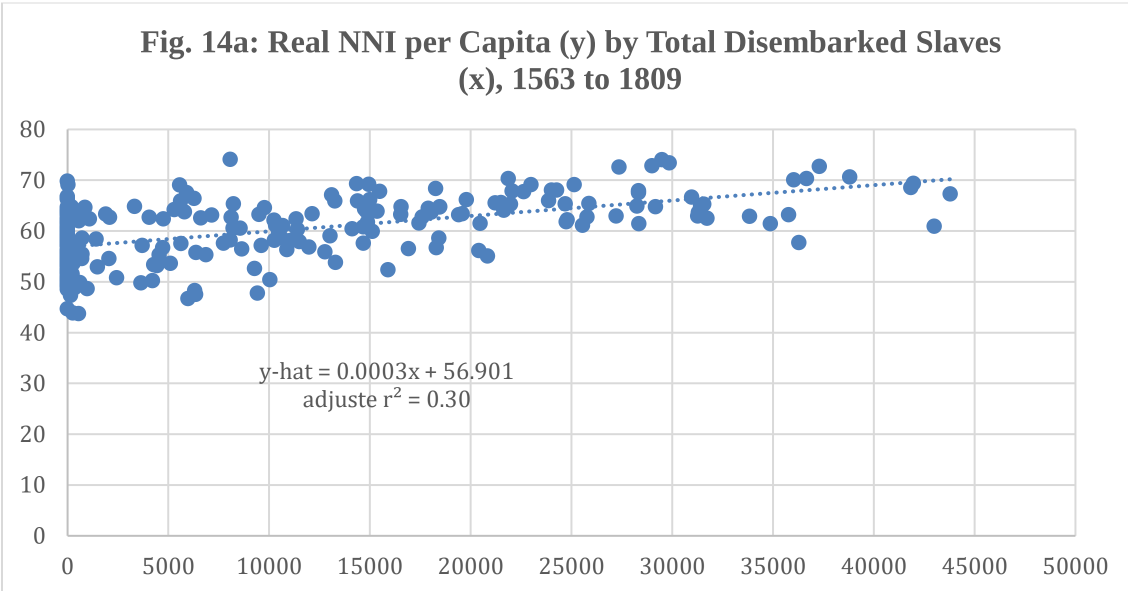


Source: Author's use of Clark (2009) data.

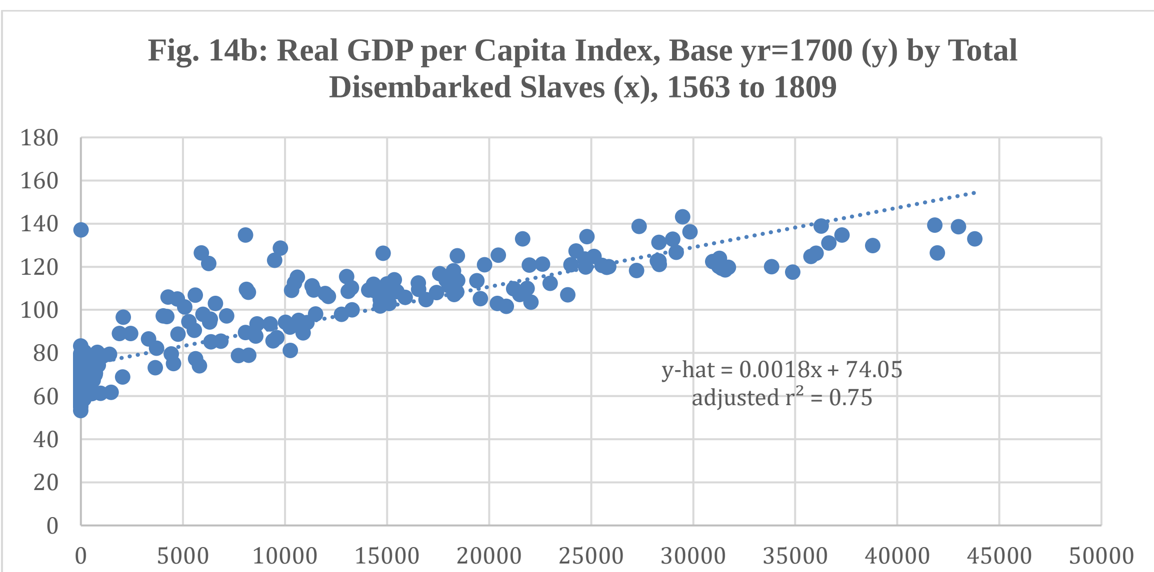
Fig. 13: Real NNI per Capita (y), Base 1860=100, by Real Economic Surplus per Capita (x)



E-G Test: Tau-stat = -4.05, p-value < 0.01, co-integrated. Source: Author's use of Clark (2009) data.

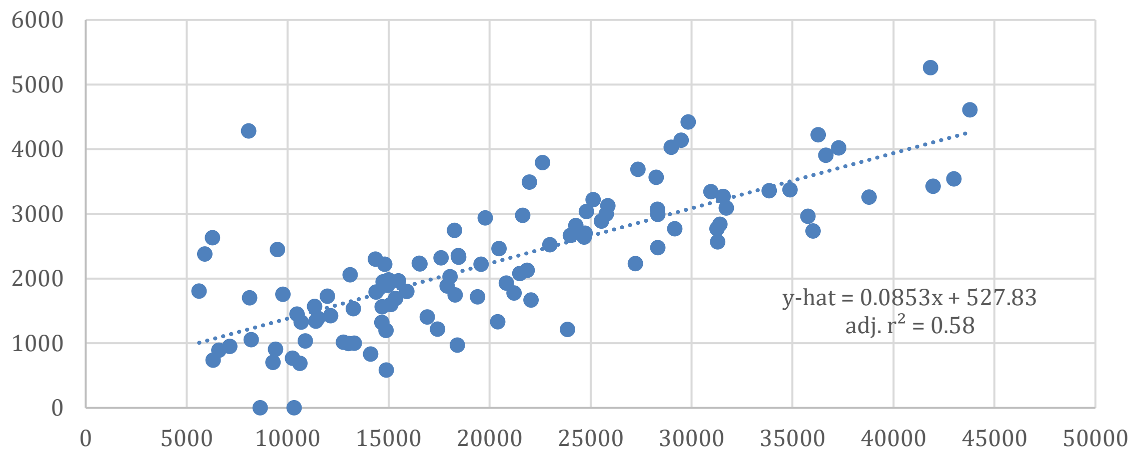


E-G Test: Tau-stat = -4.2, p-value < 0.01, co-integrated. Source: Author's use of Clark (2009) data and Slave Voyage (2021).



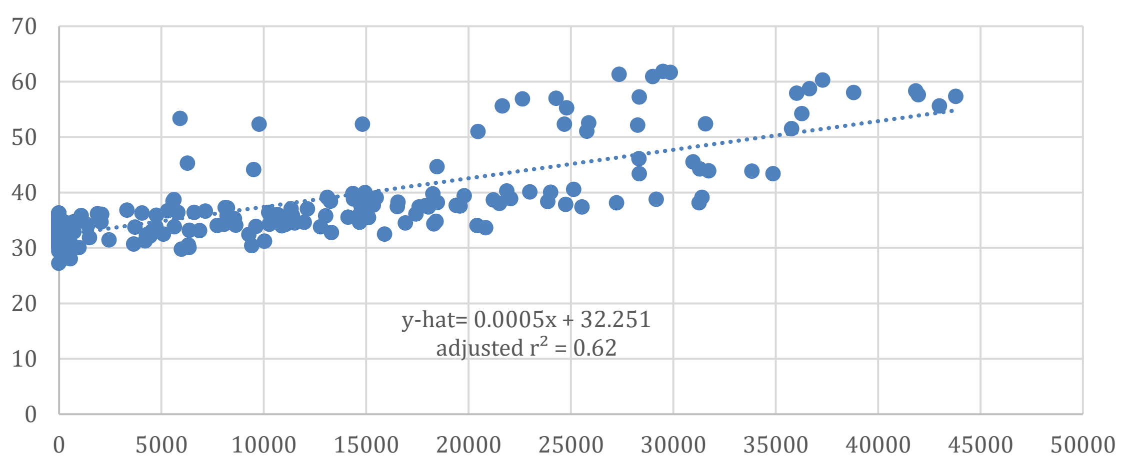
E-G Test: Tau-stat = -4.6, p-value < 0.01, co-integrated. Source: Author's use of Broadberry, et al (2015) data and Slave Voyage (2021) data.

Fig. 15: Inf Adjusted Sugar Imports Thousands GBPs (y) by Disembarked Slaves (x), 1700 to 1808

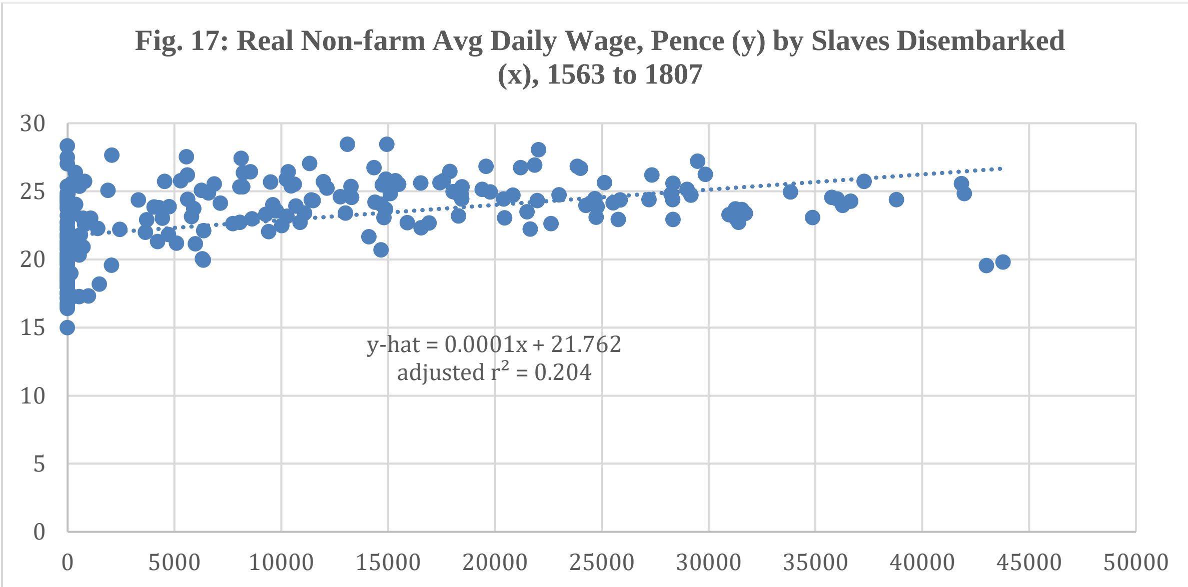


E-G Test: Tau-stat = -4.6, p-value < 0.01, co-integrated. Source: Author’s use of Mitchell (2021) data and Slave Voyage (2021) data.

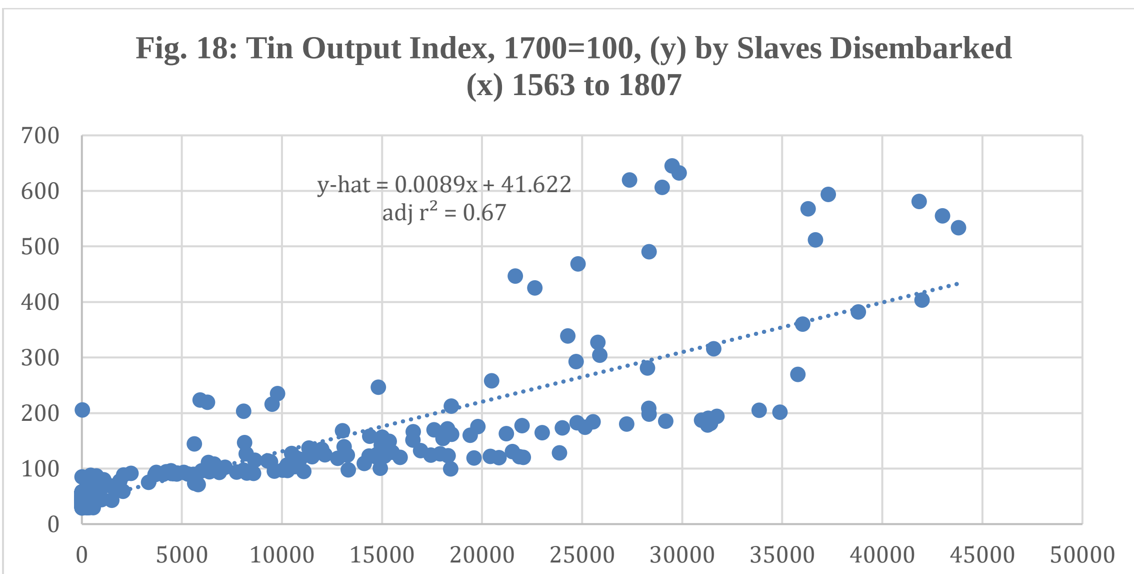
Fig. 16: Pct Males Nonfarm Sector (y) by Disembarked Slaves (x) , 1563 to 1807



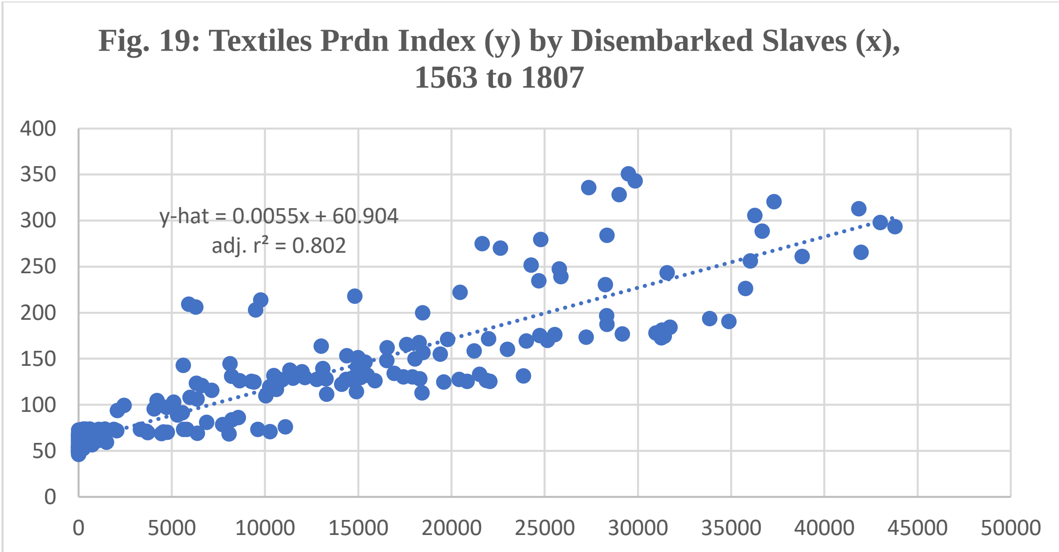
E-G Test: Tau-stat = -3.4, p-value < 0.05, co-integrated. Source: Author’s use of Clark (2009) data and Slave Voyage (2021) data.



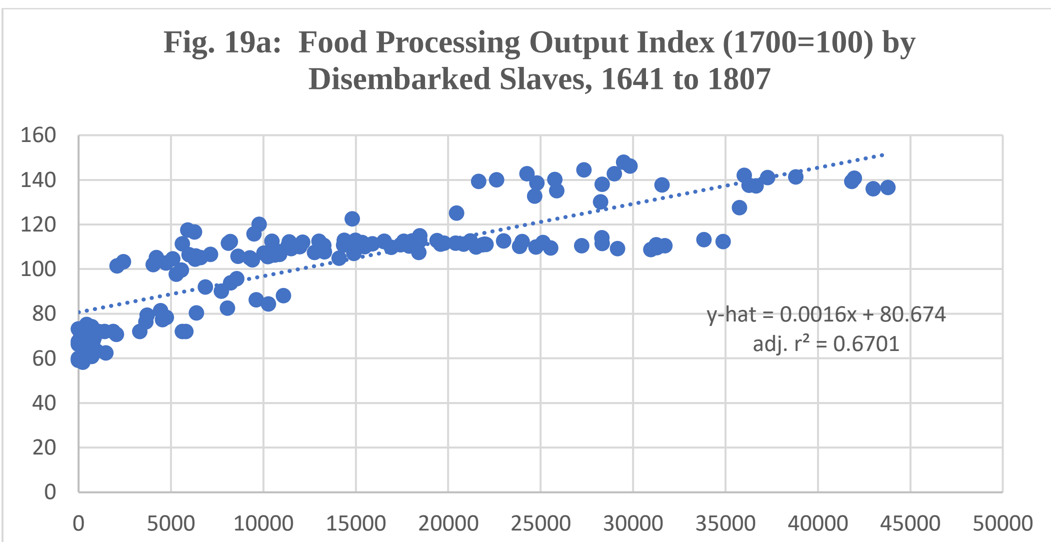
E-G Test: Tau-stat = -5.08, p-value < 0.01, co-integrated. Source: Author's use of Clark (2009) data and Slave Voyage (2021) data.



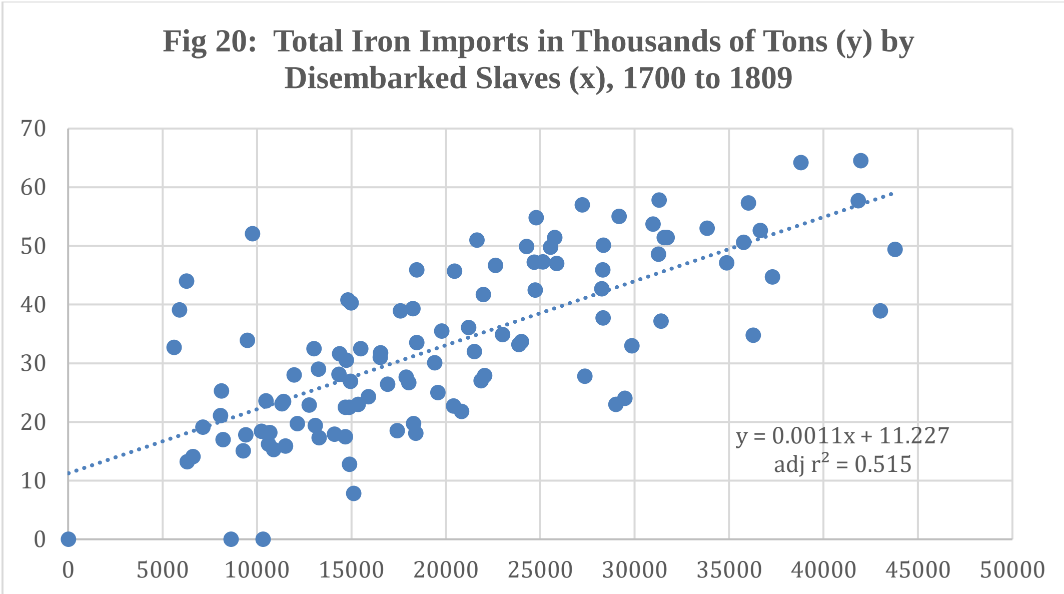
E-G Test: Tau-stat = -3.58, p-value < 0.05, co-integrated. Source: Author's use of Broadberry, et al (2015) data and Slave Voyage (2021) data.



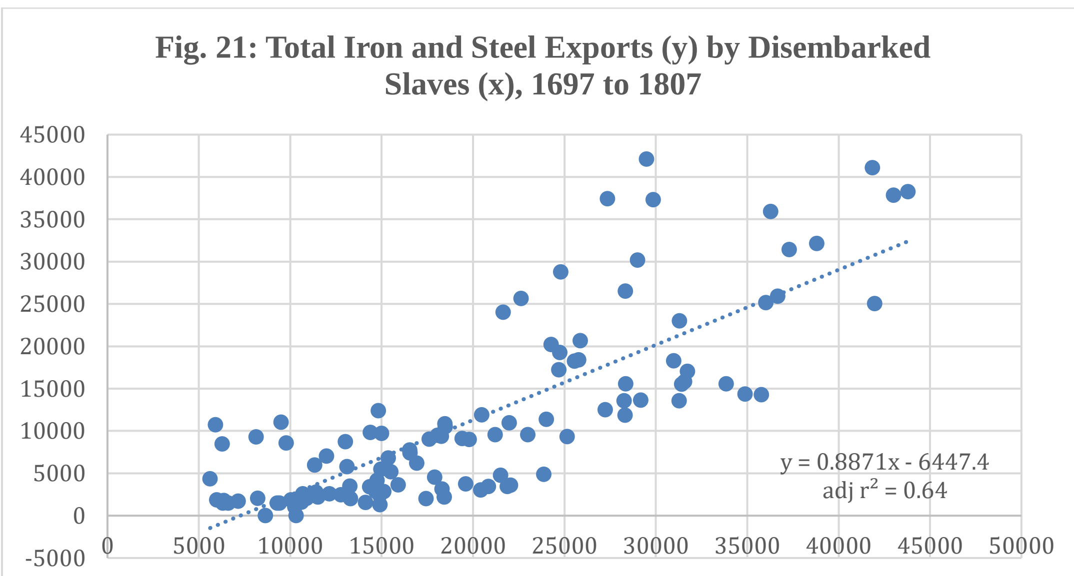
E-G Test: Tau-stat = -4.2, p-value < 0.01, co-integrated. Source: Author's use of Broadberry, et al (2015) data and Slave Voyage (2021) data.



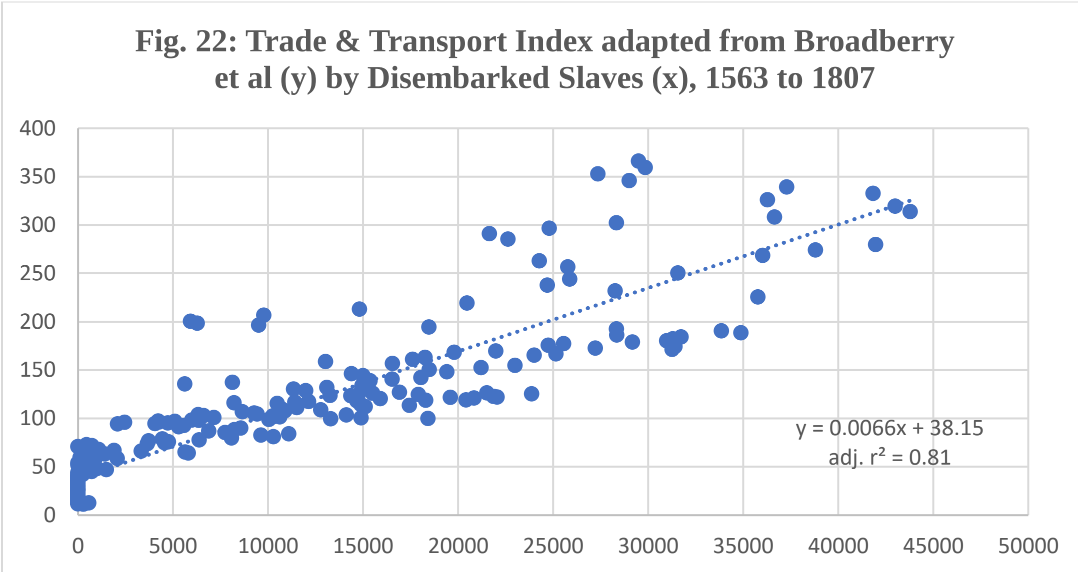
E-G Test: Tau-stat = -3.65, p-value < 0.025, co-integrated. Source: Author's use of Broadberry, et al (2015) data and Slave Voyage (2021) data.



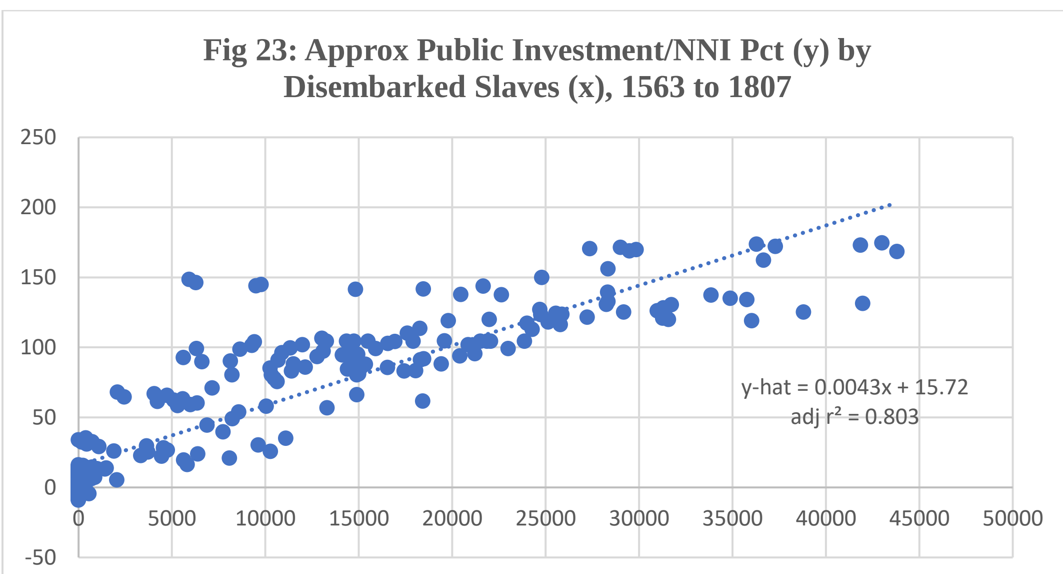
E-G Test: Tau-stat = -4.7, p-value < 0.01, co-integrated. Source: Author's use of Mitchell (2011) data and Slave Voyage (2021) data



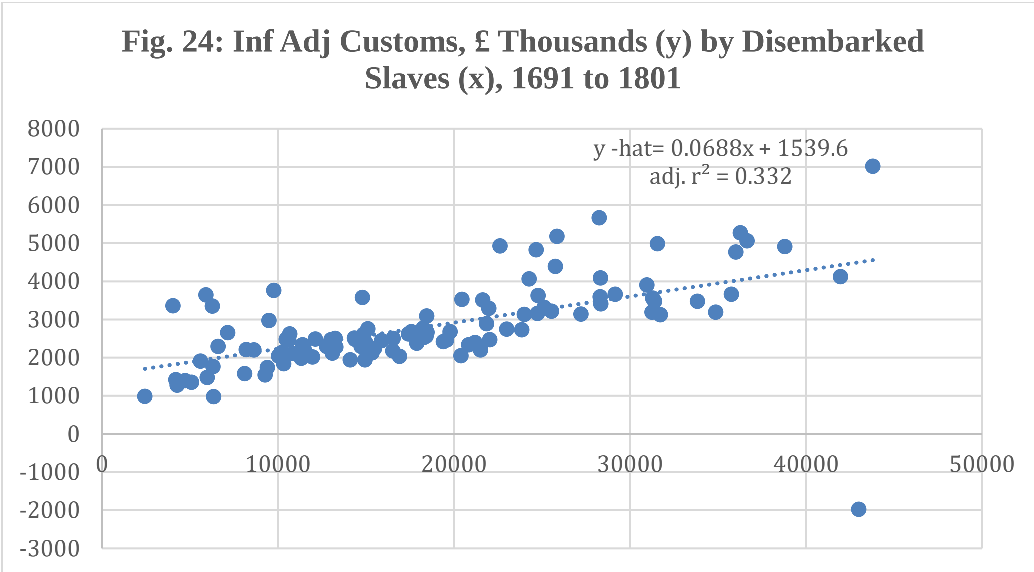
E-G Test: Tau-stat = -3.6, p-value < 0.05, co-integrated. Source: Author's use of Mitchell (2011) data and Slave Voyage (2021) data



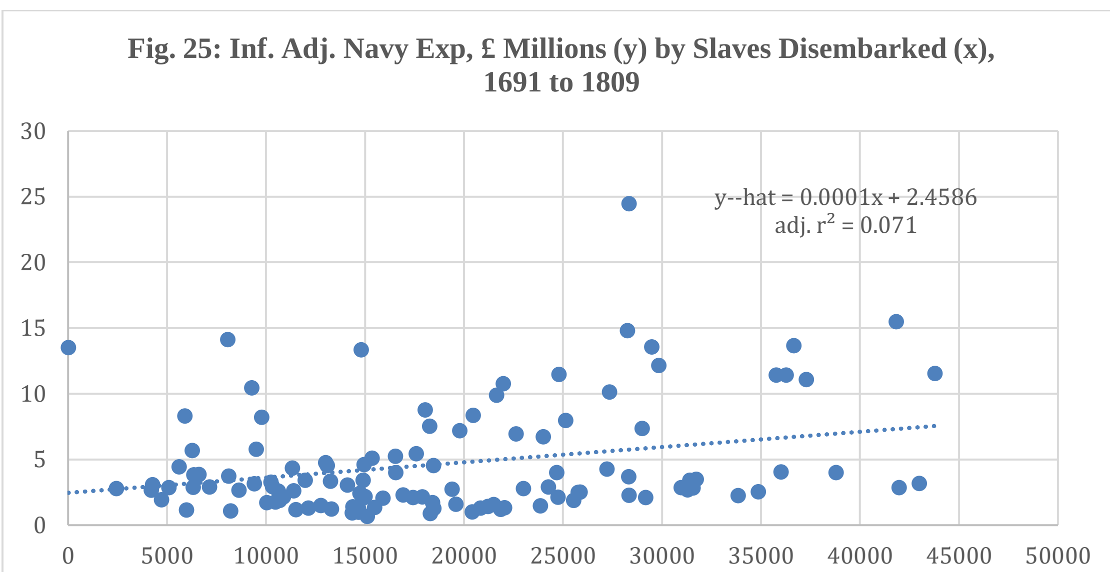
E-G Test: Tau-stat = -4.5, p-value < 0.01, co-integrated. Source: Author's use of Broadberry, et al (2015) data and Slave Voyage (2021) data.



E-G Test: Tau-stat = -5.04, p-value < 0.01, co-integrated. Source: Author's use of Lambert (2024), Clark (2009), data and Slave Voyage (2021) data.

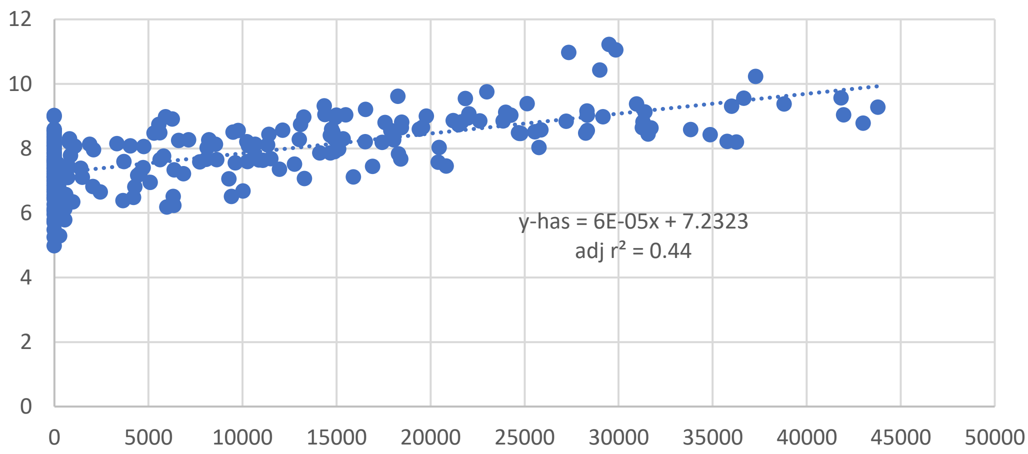


E-G Test: Tau-stat = -9.8, p-value < 0.01, co-integrated. Source: Mitchell (2011) and Slave Voyage (2021) databases.



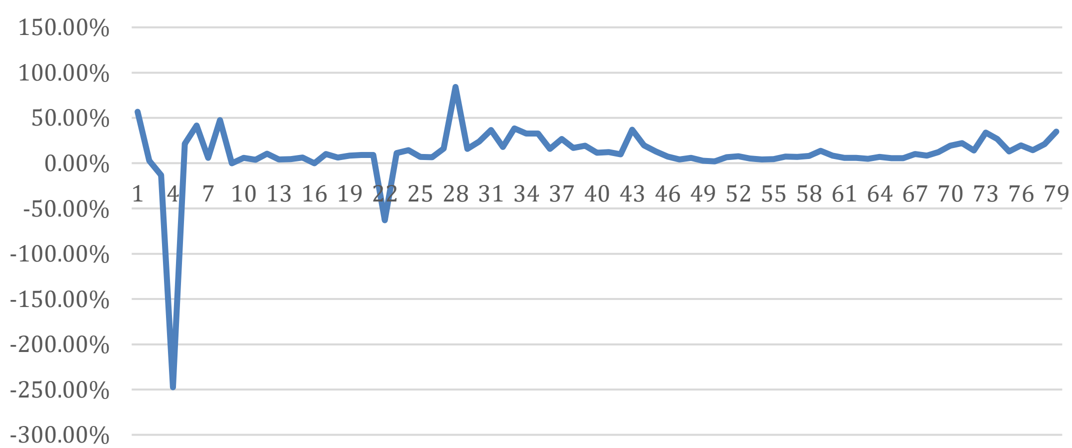
E-G Test: Tau-stat = -4.06, p-value < 0.01, co-integrated. Source: Mitchell (2011, pages 578-580) and Slave Voyage (2021) databases.

Fig. 26: Surplus per Capita (y) by Disembarked Slaves (x), 1563 to 1807

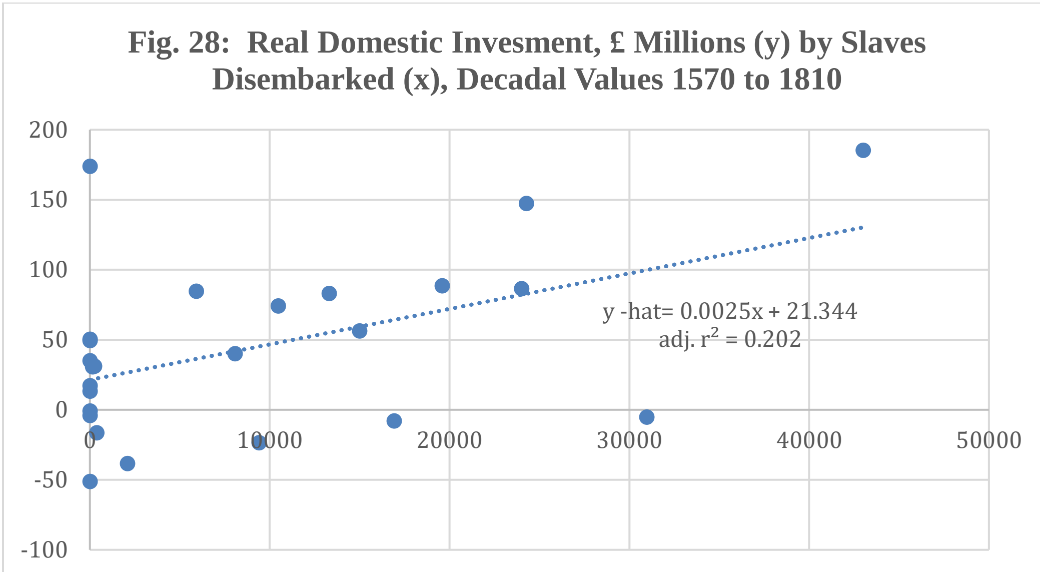


E-G Test: Tau-stat = -5.06, p-value < 0.01, co-integrated. Source: Clark (2009) and Slave Voyage (2021) databases.

Fig. 27: Value of Slaves Disembarked as Pct of Balance of Trade, 1697 to 1775



Source: US Census Bureau (2015) and Slave Voyage (2021) databases.



E-G Test: Tau-stat = -3.6, p-value < 0.5, co-integrated. Source: Lambert (2020b and 2023) and Slave Voyage (2021) databases.

<u>Table 1</u>

Dependent Variable: Ln Real NNI per Capita, 1547 to 1860

Independent Variables:

	b (NWSE)	**ADF Tau-stat**	**E-G Test Tau-stat**
Intercept	2.20** (0.12)		
Econ Surplus per Worker	0.06** (0.004)	-0.31	-3.38**
Ln Est. Public Investment per Capita	0.0035* (0.002)	-0.37	-3.72**

Ln Real Economic Surplus per Disembarked Slave	0.012** (0.003)	-1.73	-3.40**
Ln Horses per 1000 Population	0.22** (0.023)	-0.58	-3.26*

Adjusted r-squared = 0.74
n = 313
average VIF = 1.44

**p < 0.05
*p < 0.10

Table 2

Dependent Variable: Real GDP per Capita, 1547 to 1868

Independent Variables:

	b (NWSE)	**ADF Tau-stat**	**E-G Test Tau-stat**
Intercept	-1.59 (4.58)		
Econ Surplus per Worker	2.33** (0.036)	-0.19	-3.59**
Horses in Millions	111.25**	1.70	-3.49**

(2.89)

Adjusted r-squared = 0.92
n = 322
average VIF = 1.79

**p < 0.05
*p < 0.10

Appendix

1. Output for Fig. 3

ADF Tests

	X var	Y var	X diff	Y diff
tau-stat	1.4953361	0.3710468	-19.232163	-25.94992
tau-crit	-1.9418601	-1.9418601	-1.9418629	-1.9418629
stationary	no	no	yes	yes
aic	-4.1160556	8.6069045	-4.1134109	8.4756003
bic	-4.1043601	8.6186	-4.1016887	8.4873225
lags	0	0	0	0
coeff	0.0036281	0.0021862	-1.0694745	-1.3553229
p-value	> .1	> .1	< .01	< .01

Engle-Granger Test

alpha	0.05
type	0
max lags	0
criteria	none

tau-stat	-6.3983227
tau-crit	-3.3550533
cointegrated	yes
lags	0

p-value	< .01

Breusch-Godfrey Test

Lags	1
LM*	429.19
df1	1
df2	321
p-value	4E-61

LM	185.36
p-value	3E-42

Regression Analysis

OVERALL FIT	
Multiple R	0.945
R Square	0.893
Adjusted R Square	0.892
Standard Error	28.31
Observations	324

AIC	2168.4
AICc	2168.4
SBC	2175.9

ANOVA				Alpha	0.05	
	df	*SS*	*MS*	*F*	*p-value*	*sig*
Regression	1	2E+06	2E+06	2675.9	5E-158	yes
Residual	322	258051	801.4			
Total	323	2E+06				

ols	*Coeff*	*std err*	*t stat*	*p-value*	*lower*	*upper*
Intercept	-20.74	3.5929	-5.77	2E-08	-27.81	-13.7
Group 1	261.8	5.0605	51.73	5E-158	251.8	271.7

newey-west	*Coeff*	*std err*	*t stat*	*p-value*
Intercept	-20.74	4.8084	-4.31	2E-05
Group 1	261.8	7.8962	33.15	8E-106

2. Output for Figure 4

ADF Tests

	X var	Y var	X diff	Y diff
tau-stat	1.49534	1.754	-19.23	-23.772585
tau-crit	-1.9419	-1.942	-1.942	-1.9418629
stationary	no	no	yes	yes
aic	-4.1161	6.3794	-4.113	6.3109921
bic	-4.1044	6.3911	-4.102	6.3227143
lags	0	0	0	0
coeff	0.00363	0.0051	-1.069	-1.2779164
p-value	> .1	> .1	< .01	< .01

Engle-Granger Test

alpha	0.05
type	0
max lags	0
criteria	none

tau-stat	-4.2238913
tau-crit	-3.3550533
cointegrated	yes
lags	0
p-value	< .01

Breusch-Godfrey Test

Lags	1
LM*	768.77467
df1	1
df2	321
p-value	3.35E-87

LM	228.56376
p-value	1.226E-51

Regression Analysis

OVERALL FIT	
Multiple R	0.951655
R Square	0.9056473
Adjusted R Square	0.9053543
Standard Error	12.606915
Observations	324

AIC	1644.2
AICc	1644.3
SBC	1651.7

ANOVA — Alpha 0.05

	df	*SS*	*MS*	*F*	*p-value*	*sig*
Regression	1	491223	491223	3090.7	4E-167	yes
Residual	322	51176.8	158.93			
Total	323	542399				

ols	*coeff*	*std err*	*t stat*	*p-value*	*lower*	*upper*
Intercept	25.700703	1.60003	16.063	5E-43	22.553	28.84853
Horses in Millions	125.28854	2.25362	55.594	4E-167	120.85	129.7222

newey-west	*coeff*	*std err*	*t stat*	*p-value*
Intercept	25.700703	2.48898	10.326	9E-22
Horses in Millions	125.28854	4.40415	28.448	7E-90

3. Output for Fig. 5

ADF Tests

	X var	Y var	X diff	Y diff
tau-stat	1.49925	-0.00575	-19.1723	-18.974
tau-crit	-1.94187	-1.94187	-1.94187	-1.9419
stationary	no	no	yes	yes
aic	-4.10989	5.63965	-4.10715	5.63859
bic	-4.09814	5.6514	-4.09537	5.65037
lags	0	0	0	0
coeff	0.003686	-2E-05	-1.06948	-1.0608
p-value	> .1	> .1	< .01	< .01

Engle-Granger Test

alpha	0.05
type	0
max lags	0
criteria	none

tau-stat	-5.8403
tau-crit	-3.3552
cointegrated	yes
lags	0

p-value	< .01

Breusch-Godfrey Test

Lags	1
LM*	570.46
df1	1
df2	319
p-value	5E-73
LM	206.52
p-value	8E-47

Regression Analysis

OVERALL FIT			
Multiple R	0.84291	AIC	1228.19
R Square	0.7105	AICc	1228.26
Adjusted R Square	0.70959	SBC	1235.73
Standard Error	6.71286		
Observations	322		

ANOVA Alpha 0.05

	df	*SS*	*MS*	*F*	*p-value*	*sig*
Regression	1	35389.3	35389.306	785.339	4E-88	yes
Residual	320	14420	45.062442			
Total	321	49809.3				

ols	*coeff*	*std err*	*t stat*	*p-value*	*lower*	*upper*
Intercept	42.9498	0.85719	50.105389	2E-153	41.26	44.636
Horses in Millions	34.0677	1.21567	28.023905	3.9E-88	31.68	36.459

newey-west	*Coeff*	*std err*	*t stat*	*p-value*
Intercept	42.9498	1.2067	35.592679	3E-113
Horses in Millions	34.0677	1.891	18.015681	1.4E-50

4. Output for Figure 9a

ADF Tests

	X var	Y var	X diff	Y diff
tau-stat	1.4992	0.0488	-19.17229218	-17.35
tau-crit	-1.942	-1.942	-1.941868473	-1.942
stationary	no	no	yes	yes
aic	-4.11	1.5045	-4.107149068	1.5068
bic	-4.098	1.5163	-4.095373065	1.5186
lags	0	0	0	0
coeff	0.0037	0.0002	-1.069481547	-0.972
p-value	> .1	> .1	< .01	< .01

Engle-Granger Test

alpha	0.05
type	0
max lags	0
criteria	none
tau-stat	-5.692
tau-crit	-3.355
cointegrated	yes
lags	0

p-value	< .01

Breusch-Godfrey Test

Lags	1
LM*	627.31
df1	1
df2	319
p-value	3E-77

LM	213.45
p-value	2E-48

Regression Analysis

OVERALL FIT	
Multiple R	0.8685
R Square	0.7543
Adjusted R Square	0.7535
Standard Error	0.8736
Observations	322

AIC	-85.02
AICc	-84.95
SBC	-77.47

ANOVA — Alpha 0.05

	df	*SS*	*MS*	*F*	*p-value*	*sig*
Regression	1	749.66	749.6626622	982.26	2E-99	Yes
Residual	320	244.22	0.763199106			
Total	321	993.89				

ols	*coeff*	*std err*	*t stat*	*p-value*	*Lower*	*upper*
Intercept	5.2218	0.1116	46.8089891	3E-145	5.0023	5.4412
Horses Millions	4.9584	0.1582	31.34108403	2E-99	4.6471	5.2696

newey-west	*coeff*	*std err*	*t stat*	*p-value*
Intercept	5.2218	0.1647	31.70543729	9E-101
Horses Millions	4.9584	0.2032	24.40348396	5E-75

5. Output for Figure 13

ADF Tests

	X var	Y var	X diff	Y diff
tau-stat	-1.25261	-1.1105	-27.907	-30.295
tau-crit	-1.94141	-1.9414	-1.9414	-1.94142
stationary	no	no	yes	yes
aic	2.297491	6.5989	2.29408	6.57434
bic	2.304306	6.6058	2.30091	6.58116
lags	0	0	0	0
coeff	-0.00433	-0.0042	-1.085	-1.16562
p-value	> .1	> .1	< .01	< .01

Engle-Granger Test

alpha	0.05
type	0
max lags	0
criteria	none

tau-stat	-4.0531
tau-crit	-3.3454
cointegrated	yes
lags	0

p-value	< .01

Breusch-Godfrey Test

Lags	1
LM*	6262.2015
df1	1
df2	657
p-value	0

LM	597.33092
p-value	6.37E-132

Regression Analysis

OVERALL FIT				
Multiple R	0.7857		AIC	2905.2
R Square	0.6173		AICc	2905.23
Adjusted R Square	0.6167		SBC	2914.18
Standard Error	9.0196			
Observations	660			

ANOVA				Alpha	0.05	
	df	*SS*	*MS*	*F*	*p-value*	*sig*
Regression	1	86350	86350.02	1061.43	2.25E-139	yes
Residual	658	53529.8	81.35229			
Total	659	139880				

ols	*coeff*	*std err*	*t stat*	*p-value*	*lower*	*upper*
Intercept	12.188	1.69644	7.184299	1.8E-12	8.8566219	15.518783
SurplusPerCapita	6.4275	0.19728	32.57964	2E-139	6.0400865	6.814854

newey-west	*coeff*	*std err*	*t stat*	*p-value*
Intercept	12.188	2.31209	5.271299	1.8E-07
SurplusPerCapita	6.4275	0.28363	22.66165	1.8E-84

6. Output for Figure 14

ADF Tests

	X var	Y var	X diff	Y diff
tau-stat	-0.2762	-1.9651	-16.5767	-14.805
tau-crit	-1.9421	-1.9421	-1.94215	-1.94215
stationary	no	yes	yes	yes
aic	5.63818	19.289	5.63867	19.3068
bic	5.65243	19.303	5.65296	19.3211
lags	0	0	0	0
coeff	-0.0012	-0.031	-1.06241	-0.95589
p-value	> .1	0.048	< .01	< .01

Engle-Granger Test

alpha	0.05
type	0
max lags	0
criteria	none

tau-stat	-4.162
tau-crit	-3.361
cointegrated	yes
lags	0

p-value	< .01

Regression Analysis

OVERALL FIT	
Multiple R	0.553526
R Square	0.306391
Adjusted R Square	0.3035599
Standard Error	5.2452908
Observations	247

AIC	820.71321
AICc	820.81198
SBC	827.73199

ANOVA Alpha 0.05

	df	*SS*	*MS*	*F*	*p-value*	*sig*
Regression	1	2977.6011	2977.6011	108.22495	3.136E-21	yes
Residual	245	6740.7035	27.513075			
Total	246	9718.3046				

ols	*coeff*	*std err*	*t stat*	*p-value*	*lower*	*upper*
Intercept	56.900605	0.4381209	129.87421	6.35E-228	56.037641	57.763569
Totals Disembarked	0.0003035	2.917E-05	10.403122	3.136E-21	0.000246	0.0003609

newey-west	*coeff*	*std err*	*t stat*	*p-value*
Intercept	56.900605	0.6012486	94.637402	6.52E-195
Totals Disembarked	0.0003035	3.467E-05	8.7526126	3.453E-16

7. Output for Figure 14a

ADF Tests

	X var	Y var	X diff	Y diff
tau-stat	-2.063	0.6867	-11.64	-16.64
tau-crit	-1.942	-1.942	-1.942	-1.942
stationary	yes	no	yes	yes
aic	19.298	6.2695	19.301	6.1977
bic	19.326	6.2981	19.33	6.2264
lags	1	1	1	1
coeff	-0.033	0.0026	-1.102	-1.666
p-value	0.0394	> .1	< .01	< .01

Engle-Granger Test

alpha	0.05
type	0
max lags	1
criteria	non e

tau-stat	-4.605
tau-crit	-3.361
cointegrated	yes
lags	1

p-value	< .01

Breusch-Godfrey Test

Lags	1
LM*	299.13
df1	1
df2	244
p-value	3E-44
LM	136.04
p-value	2E-31

Regression Analysis

OVERALL FIT	
Multiple R	0.8671
R Square	0.7519
Adjusted R Square	0.7509
Standard Error	12.091
Observations	247

AIC	1233.2789
AICc	1233.3777
SBC	1240.2977

ANOVA — Alpha 0.05

	df	*SS*	*MS*	*F*	*p-value*	*sig*
Regression	1	108566.4	108566.4	742.59395	4.029E-76	yes
Residual	245	35818.726	146.19888			
Total	246	144385.13				

ols	*coeff*	*std err*	*t stat*	*p-value*	*lower*	*upper*
Intercept	74.05	1.009942	73.320748	1.09E-168	72.060424	76.038977
Totals Disembarked	0.0018	6.724E-05	27.250577	4.029E-76	0.0017	0.0019649

newey-west	*coeff*	*std err*	*t stat*	*p-value*
Intercept	74.05	1.3224679	55.99357	1.26E-141
Totals Disembarked	0.0018	8.3E-05	22.076991	3.436E-60

8. Output for Figure 15.

ADF Tests

	X var	Y var	X diff	Y diff
tau-stat	-1.3132787	-0.3927841	-9.674045	-15.108777
tau-crit	-1.9437233	-1.9437233	-1.943751	-1.9437507
stationary	no	no	yes	yes
aic	20.053166	15.304914	20.07039	15.171958
bic	20.078	15.329749	20.09537	15.196938
lags	0	0	0	0
coeff	-0.0306647	-0.0077732	-1.010303	-1.366161
p-value	> .1	> .1	< .01	< .01

Engle-Granger Test

alpha	0.05
type	0
max lags	0
criteria	none
tau-stat	-4.5884317
tau-crit	-3.3927602
cointegrated	yes
lags	0

p-value	< .01

Breusch-Godfrey Test

Lags	1
LM*	40.474116
df1	1
df2	106
p-value	5.17E-09

LM	30.119169
p-value	4.063E-08

Regression Analysis

OVERALL FIT			
Multiple R	0.7661687	AIC	1423.5976
R Square	0.5870145	AICc	1423.8261
Adjusted R Square	0.5831548	SBC	1428.9803
Standard Error	679.37615		
Observations	109		

ANOVA — Alpha 0.05

	df	*SS*	*MS*	*F*	*p-value*	*sig*
Regression	1	7E+07	70196968	152.08899	2.829E-22	yes
Residual	107	4.9E+07	461551.95			
Total	108	1.2E+08				

ols	*coeff*	*std err*	*t stat*	*p-value*	*lower*	*upper*
Intercept	527.82689	154.635	3.4133836	0.000907	221.28201	834.37177
Total Disembarked	0.0852785	0.00691	12.332436	2.829E-22	0.0715703	0.0989866

newey-west	*coeff*	*std err*	*t stat*	*p-value*
Intercept	527.82689	219.855	2.4007923	0.0180853
Total Disembarked	0.0852785	0.00901	9.4696782	8.102E-16

9. Output for Figure 16

ADF Tests

	X var	Y var	X diff	Y diff
tau-stat	-1.2735329	0.9761943	-15.719048	-15.344886
tau-crit	-1.9421503	-1.9421503	-1.9421552	-1.9421552
stationary	no	no	yes	yes
aic	19.142055	3.9206743	19.152713	3.9285422
bic	19.156388	3.935007	19.167088	3.9429169
lags	0	0	0	0
coeff	-0.0188457	0.002827	-1.0104125	-0.9863407
p-value	> .1	> .1	< .01	< .01

Engle-Granger Test

alpha	0.05
type	0
max lags	0
criteria	none

tau-stat	-3.4210507
tau-crit	-3.3611829
cointegrated	yes
lags	0

p-value	0.0442688

Breusch-Godfrey Test

Lags	1
LM*	774.86437
df1	1
df2	242
p-value	2.142E-77

LM	186.69331
p-value	1.675E-42

Regression Analysis

OVERALL FIT	
Multiple R	0.7871703
R Square	0.6196371
Adjusted R Square	0.6180719
Standard Error	4.650504
Observations	245

AIC	755.10983
AICc	755.20942
SBC	762.11235

ANOVA				Alpha	0.05	
	df	*SS*	*MS*	*F*	*p-value*	*sig*
Regression	1	8561.4	8561.4166	395.86362	6.392E-53	yes
Residual	243	5255.4	21.627187			
Total	244	13817				

ols	*coeff*	*std err*	*t stat*	*p-value*	*lower*	*upper*
Intercept	32.250945	0.3904	82.613411	7.55E-180	31.481977	33.019913
Totals Disembarked	0.0005154	3E-05	19.896322	6.392E-53	0.0004643	0.0005664

newey-west	*coeff*	*std err*	*t stat*	*p-value*
Intercept	32.250945	0.3313	97.34053	1.19E-196
Totals Disembarked	0.0005154	4E-05	11.643718	3.421E-25

10. Output for Figure 17

ADF Tests

	X var	Y var	X diff	Y diff
tau-stat	-1.9650917	-0.463	-14.804982	-17.204961
tau-crit	-1.9421405	-1.942	-1.9421454	-1.9421454
stationary	yes	no	yes	yes
aic	19.289015	3.721	19.306826	3.6959465
bic	19.303264	3.736	19.321117	3.7102374
lags	0	0	0	0
coeff	-0.0310333	-0.002	-0.9558929	-1.0850088

Engle-Granger Test

alpha	0.05
type	0
max lags	0
criteria	none

tau-stat	-5.0817424
tau-crit	-3.3609791
cointegrated	yes

p-value	0.0479848	> .1	< .01	< .01

lags	0
p-value	< .01

Breusch-Godfrey Test

Lags	1
LM*	445.66652
df1	1
df2	244
p-value	5.614E-57

LM	159.61284
p-value	1.375E-36

Regression Analysis

OVERALL FIT	
Multiple R	0.455548
R Square	0.2075239
Adjusted R Square	0.2042894
Standard Error	2.5173073
Observations	247

AIC	458.04762
AICc	458.14638
SBC	465.06639

ANOVA — Alpha 0.05

	df	*SS*	*MS*	*F*	*p-value*	*sig*
Regression	1	406.55623	406.55623	64.157607	4.653E-14	yes
Residual	245	1552.5248	6.336836			
Total	246	1959.081				

ols	*coeff*	*std err*	*t stat*	*p-value*	*lower*	*upper*
Intercept	21.761944	0.2102619	103.49922	3.33E-204	21.347793	22.176096
Totals Disembarked	0.0001121	1.4E-05	8.0098444	4.653E-14	8.456E-05	0.0001397

newey-west	*coeff*	*std err*	*t stat*	*p-value*
Intercept	21.761944	0.3159399	68.88001	2.39E-162
Totals Disembarked	0.0001121	2.011E-05	5.5754922	6.503E-08

11. Output for Figure 18

ADF Tests

	X var	Y var	X diff	Y diff
tau-stat	-1.96509	-0.9997	-14.80498201	-15.556318
tau-crit	-1.94214	-1.9421	-1.942145378	-1.9421454
stationary	yes	no	yes	yes
aic	19.28901	9.5567	19.30682648	9.5649034
bic	19.30326	9.571	19.32111733	9.5791942
lags	0	0	0	0

Engle-Granger Test

alpha	0.05
type	0
max lags	0
criteria	none

tau-stat	-3.5779953
tau-crit	-3.3609791

coeff	-0.03103	-0.0102	-0.955892924	-0.9958934
p-value	0.047985	> .1	< .01	< .01

cointegrated	yes
lags	0
p-value	0.0292191

Breusch-Godfrey Test

Lags	1
LM*	851.5725
df1	1
df2	244
p-value	1.54E-81

LM	191.9895
p-value	1.17E-43

Regression Analysis

OVERALL FIT	
Multiple R	0.8164225
R Square	0.6665456
Adjusted R Square	0.6651846
Standard Error	72.603443
Observations	247

AIC	2118.788
AICc	2118.8867
SBC	2125.8067

ANOVA — Alpha 0.05

	df	*SS*	*MS*	*F*	*p-value*	*sig*
Regression	1	258151	2581511	489.7332	2.323E-60	yes
Residual	245	129145	5271.26			
Total	246	387297				

ols	*coeff*	*std err*	*t stat*	*p-value*	*lower*	*upper*
Intercept	41.62227	6.06431	6.86347	5.474E-11	29.67743	53.56711
Totals Disembarked	0.0089355	0.0004	22.1299	2.323E-60	0.008140	0.009730

newey-west	*coeff*	*std err*	*t stat*	*p-value*
Intercept	41.62227	4.36158	9.542942	1.484E-18
Totals Disembarked	0.0089355	0.0009	9.894778	1.226E-19

12. Output for Figure 19

ADF Tests

	X var	Y var	X diff	Y diff
tau-stat	-1.2735329	21.778391	-15.719048	-0.1189746
tau-crit	-1.9421503	-1.9421503	-1.9421552	-1.9421552
stationary	no	no	yes	no
aic	19.142055	3.3702598	19.152713	1.4497142
bic	19.156388	3.3845924	19.167088	1.464089
lags	0	0	0	0

Engle-Granger Test

alpha	0.05
type	0
max lags	0
criteria	none

tau-stat	-4.2207002
tau-crit	-3.3611829

coeff	-0.0188457	0.0135959	-1.0104125	-0.0017419
p-value	> .1	> .1	< .01	> .1

cointegrated	yes
lags	0
p-value	< .01

Breusch-Godfrey Test

Lags	1
LM*	451.58612
df1	1
df2	242
p-value	2.953E-57

LM	159.51674
p-value	1.443E-36

Regression Analysis

OVERALL FIT	
Multiple R	0.8963421
R Square	0.8034292
Adj. R Square	0.8026203
Standard Error	31.55994
Observations	245

AIC	1693.4172
AICc	1693.5168
SBC	1700.4197

ANOVA — Alpha 0.05

	df	*SS*	*MS*	*F*	*p-value*	*sig*
Regression	1	989252.68	989252.68	993.19584	8.286E-88	yes
Residual	243	242035.25	996.02983			
Total	244	1231287.9				

ols	*coeff*	*std err*	*t stat*	*p-value*	*lower*	*upper*
Intercept	60.904029	2.6492811	22.988889	6.771E-63	55.685543	66.122515
Group 1	0.0055397	0.0001758	31.51501	8.286E-88	0.0051935	0.005886

newey-west	*coeff*	*std err*	*t stat*	*p-value*
Intercept	60.904029	2.0951253	29.069397	4.596E-81
Group 1	0.0055397	0.0002986	18.55365	1.835E-48

13. Output for Figure 20

ADF Tests

	X var	Y var	X diff	Y diff
tau-stat	-1.3570567	-1.2139131	-9.8332794	-14.558707
tau-crit	-1.9436965	-1.9436965	-1.9437233	-1.9437233
stationary	no	no	yes	yes
aic	20.062781	7.0265388	20.079117	6.9187087

Engle-Granger Test

alpha	0.05
type	0
max lags	0
criteria	none

bic	20.087473	7.05123	20.103952	6.9435433
lags	0	0	0	0
coeff	-0.0318219	-0.02584	-0.9553655	-1.3614143
p-value	> .1	> .1	< .01	< .01

tau-stat	-4.7410399
tau-crit	-3.3922402
cointegrated	yes
lags	0
p-value	< .01

Breusch-Godfrey Test

Lags	1
LM*	78.856765
df1	1
df2	107
p-value	1.73E-14

LM	46.671662
p-value	8.393E-12

Regression Analysis

OVERALL FIT	
Multiple R	0.7209706
R Square	0.5197986
Adjusted R Square	0.5153523
Standard Error	10.130902
Observations	110

AIC	511.41147
AICc	511.63789
SBC	516.81243

ANOVA — Alpha 0.05

	df	*SS*	*MS*	*F*	*p-value*	*sig*
Regression	1	11998.631	11998.631	116.90565	6.601E-19	yes
Residual	108	11084.599	102.63517			
Total	109	23083.23				

ols	*coeff*	*std err*	*t stat*	*p-value*	*lower*	*upper*
Intercept	11.227223	2.2484939	4.9932191	2.295E-06	6.7703179	15.684128
Totals Disembarked	0.0010921	0.000101	10.812291	6.601E-19	0.0008919	0.0012924

newey-west	*coeff*	*std err*	*t stat*	*p-value*
Intercept	11.227223	3.2245176	3.4818302	0.0007199
Totals Disembarked	0.0010921	0.0001414	7.722008	6.191E-12

14. Output for Figure 21

ADF Tests

	X var	Y var	X diff	Y diff
tau-stat	-0.8400754	1.0788325	-10.42115	-12.784601
tau-crit	-1.9436701	-1.9436701	-1.9436965	-1.9436965

Engle-Granger Test

alpha	0.05
type	0
max lags	0

stationary	no	no	yes	yes	criteria	none
aic	19.9005184	18.6883751	19.9162143	18.6608288		
bic	19.9250683	18.7129249	19.9409055	18.6855201	tau-stat	-3.5606811
lags	0	0	0	0	tau-crit	-3.3917297
coeff	-0.0182924	0.01887633	-1.0027699	-1.218335	cointegrated	yes
p-value	> .1	> .1	< .01	< .01	lags	0
					p-value	0.03449088

Breusch-Godfrey Test

Lags	1
LM*	105.116358
df1	1
df2	108
p-value	1.2397E-17
LM	54.7490386
p-value	1.3695E-13

Regression Analysis

OVERALL FIT			
Multiple R	0.80067436	AIC	1946.13396
R Square	0.64107943	AICc	1946.35826
Adjusted R Square	0.63778658	SBC	1951.55302
Standard Error	6357.8296		
Observations	111		

ANOVA — Alpha 0.05

	df	*SS*	*MS*	*F*	*p-value*	*sig*
Regression	1	7869692528	7869692528	194.688364	5.2969E-26	yes
Residual	109	4405997700	40421997.2			
Total	110	12275690228				

ols	*coeff*	*std err*	*t stat*	*p-value*	*lower*	*upper*
Intercept	-6447.4463	1410.266839	-4.5717917	1.2832E-05	-9242.5493	-3652.3433
Disembarked Slaves	0.88707243	0.063575397	13.9530772	5.2969E-26	0.76106806	1.0130768

newey-west	*coeff*	*std err*	*t stat*	*p-value*
Intercept	-6447.4463	1521.816887	-4.2366768	4.761E-05
Disembarked Slaves	0.88707243	0.085610492	10.3617256	6.3463E-18

15. Output for Figure 22

ADF Tests

	X var	Y var	X diff	Y diff
tau-stat	-1.2735329	37.14372	-15.719048	0.9501788
tau-crit	-1.9421503	-1.9421503	-1.9421552	-1.9421552
stationary	no	No	yes	no

Engle-Granger Test

alpha	0.05
type	0
max lags	0
criteria	none

Aic	19.142055	2.5830535	19.152713	0.5149415
Bic	19.156388	2.5973861	19.167088	0.5293162
Lags	0	0	0	0
Coeff	-0.0188457	0.0160566	-1.0104125	0.0085396
p-value	> .1	> .1	< .01	> .1

tau-stat	-4.5312514
tau-crit	-3.3611829
cointegrated	yes
lags	0
p-value	< .01

Breusch-Godfrey Test

Lags	1
LM*	420.07049
df1	1
df2	242
p-value	8.31E-55

LM	155.4476
p-value	1.118E-35

Regression Analysis

OVERALL FIT	
Multiple R	0.9021535
R Square	0.8138809
Adjusted R Square	0.813115
Standard Error	36.115329
Observations	245

AIC	1759.4833
AICc	1759.5829
SBC	1766.4858

ANOVA — Alpha 0.05

	df	*SS*	*MS*	*F*	*p-value*
Regression	1	1385987.4	1385987.392	1062.6154	1.078E-90
Residual	243	316949.03	1304.317008		
Total	244	1702936.4			

ols	*coeff*	*std err*	*t stat*	*p-value*	*lower*
Intercept	38.150086	3.0316806	12.58380772	2.696E-28	32.178359
Totals Disembarked British Ships	0.0065572	0.0002012	32.59778275	1.078E-90	0.0061609

newey-west	*coeff*	*std err*	*t stat*	*p-value*
Intercept	38.150086	2.729116	13.97891703	5.555E-33
Totals Disembarked	0.0065572	0.0003428	19.13093887	2.182E-50

16. Output for Table 23

ADF Tests

	X var	Y var	X diff	Y diff

Engle-Granger Test

alpha	0.05

tau-stat	-1.2735329	4.4738909	-15.719048	-4.5093521
tau-crit	-1.9421503	-1.9421503	-1.9421552	-1.9421552
stationary	no	no	yes	yes
aic	19.142055	4.6312773	19.152713	3.459536
bic	19.156388	4.64561	19.167088	3.4739107
lags	0	0	0	0
coeff	-0.0188457	0.0088795	-1.0104125	-0.1547993
p-value	> .1	> .1	< .01	< .01

type	0
max lags	0
criteria	none

tau-stat	-5.0397186
tau-crit	-3.3611829
cointegrated	yes
lags	0
p-value	< .01

Breusch-Godfrey Test

Lags	1
LM*	457.71688
df1	1
df2	242
p-value	1.016E-57

LM	160.26573
p-value	9.899E-37

Regression Analysis

OVERALL FIT	
Multiple R	0.8967791
R Square	0.8042128
Adjusted R Square	0.8034071
Standard Error	24.340397
Observations	245

AIC	1566.1391
AICc	1566.2387
SBC	1573.1416

ANOVA — Alpha 0.05

	df	*SS*	*MS*	*F*	*p-value*	*sig*
Regression	1	591355.12	591355.12	998.14366	5.097E-88	yes
Residual	243	143966.55	592.45492			
Total	244	735321.67				

ols	*coeff*	*std err*	*t stat*	*p-value*	*lower*	*upper*
Intercept	15.720096	2.0432407	7.6937076	3.567E-13	11.695373	19.744819
Totals Disembarked	0.0042831	0.0001356	31.593412	5.097E-88	0.0040161	0.0045502

newey-west	*coeff*	*std err*	*t stat*	*p-value*
Intercept	15.720096	2.5077391	6.2686331	1.649E-09
Totals Disembarked	0.0042831	0.0001774	24.14984	1.614E-66

17. Output for Figure 24

ADF Tests

	X var	Y var	X diff	Y diff

Engle-Granger Test

alpha	0.05

tau-stat	-0.6442397	-1.9029286	-10.301477	-20.666726
tau-crit	-1.9436701	-1.9436701	-1.9436965	-1.9436965
stationary	no	no	yes	yes
aic	19.861409	17.00744	19.874336	16.448477
bic	19.885959	17.03199	19.899027	16.473169
lags	0	0	0	0
coeff	-0.014724	-0.0717467	-0.9996404	-1.7986934
p-value	> .1	0.0561909	< .01	< .01

type	0
max lags	0
criteria	none

tau-stat	-9.805112
tau-crit	-3.3917297
cointegrated	yes
lags	0
p-value	< .01

Breusch-Godfrey Test

Lags	1
LM*	0.4273405
df1	1
df2	108
p-value	0.5146863

LM	0.43748
p-value	0.5083413

Regression Analysis

OVERALL FIT	
Multiple R	0.5819778
R Square	0.3386982
Adjusted R Square	0.3326312
Standard Error	928.86307
Observations	111

AIC	1519.1212
AICc	1519.3455
SBC	1524.5402

ANOVA — Alpha 0.05

	df	*SS*	*MS*	*F*	*p-value*	*sig*
Regression	1	48166274	48166274	55.826404	2.098E-11	yes
Residual	109	94043740	862786.61			
Total	110	1.42E+08				

ols	*coeff*	*std err*	*t stat*	*p-value*	*lower*	*upper*
Intercept	1539.637	191.9748	8.0199936	1.299E-12	1159.1491	1920.1249
Slaves Disembarked	0.0688094	0.009209	7.4717069	2.098E-11	0.0505568	0.0870619

newey-west	*coeff*	*std err*	*t stat*	*p-value*
Intercept	1539.637	254.3988	6.0520612	2.061E-08
Slaves Disembarked	0.0688094	0.015326	4.4896056	1.78E-05

18. Output for Figure 25

ADF Tests

Engle-Granger Test

	X var	Y var	X diff	Y diff
tau-stat	-1.3479464	-2.1953912	-10.099211	-14.166989
tau-crit	-1.9434989	-1.9434989	-1.943522	-1.943522
stationary	no	yes	yes	yes
aic	20.004701	4.9893182	20.0248575	4.9615863
bic	20.02831	5.0129266	20.0485953	4.9853241
lags	0	0	0	0
coeff	-0.0306381	-0.0965222	-0.9491072	-1.2713073
p-value	> .1	0.0281837	< .01	< .01

alpha	0.05
type	0
max lags	0
criteria	none

tau-stat	-4.0642381
tau-crit	-3.3884005
cointegrated	yes
lags	0
p-value	< .01

Breusch-Godfrey Test

Lags	1
LM*	108.11714
df1	1
df2	115
p-value	2.976E-18

LM	57.179929
p-value	3.977E-14

Regression Analysis

OVERALL FIT	
Multiple R	0.2804637
R Square	0.0786599
Adjusted R Square	0.0707173
Standard Error	3.9950815
Observations	118

AIC	328.85796
AICc	329.06848
SBC	334.39933

ANOVA — Alpha 0.05

	df	*SS*	*MS*	*F*	*p-value*	*sig*
Regression	1	158.06746	158.06746	9.9035565	0.0020968	yes
Residual	116	1851.4384	15.960676			
Total	117	2009.5059				

ols	*coeff*	*std err*	*t stat*	*p-value*	*lower*	*upper*
Intercept	2.4586337	0.7954951	3.0906962	0.0025005	0.8830554	4.034212
Slaves Disembarked	0.0001162	3.692E-05	3.1469917	0.0020968	4.306E-05	0.0001893

newey-west	*coeff*	*std err*	*t stat*	*p-value*
Intercept	2.4586337	0.9606741	2.5592796	0.0117753
Slaves Disembarked	0.0001162	5.262E-05	2.2080484	0.0292076

19. Output for Figure 26

ADF Tests

Engle-Granger Test

	X var	Y var	X diff	Y diff
tau-stat	-1.9650917	0.0853878	-14.804982	-15.07195
tau-crit	-1.9421405	-1.9421405	-1.9421454	-1.9421454
stationary	yes	no	yes	yes
aic	19.289015	1.5634006	19.306826	1.5667433
bic	19.303264	1.57765	19.321117	1.5810342
lags	0	0	0	0
coeff	-0.0310333	0.0003626	-0.9558929	-0.972006
p-value	0.0479848	> .1	< .01	< .01

alpha	0.05
type	0
max lags	0
criteria	none

tau-stat	-5.0564014
tau-crit	-3.3609791
cointegrated	yes
lags	0
p-value	< .01

Breusch-Godfrey Test

Lags	1
LM*	362.15997
df1	1
df2	244
p-value	4.021E-50

LM	147.5741
p-value	5.878E-34

Regression Analysis

OVERALL FIT	
Multiple R	0.6328485
R Square	0.4004972
Adjusted R Square	0.3980503
Standard Error	0.8490629
Observations	247

AIC	-78.837388
AICc	-78.738623
SBC	-71.818612

ANOVA — Alpha 0.05

	df	*SS*	*MS*	*F*	*p-value*	*sig*
Regression	1	117.99244	117.99244	163.67201	4.813E-29	yes
Residual	245	176.62243	0.7209079			
Total	246	294.61488				

ols	*coeff*	*std err*	*t stat*	*p-value*	*lower*	*upper*
Intercept	7.2707175	0.0709193	102.52104	3.23E-203	7.1310282	7.4104068
Disembarked Slaves	6.041E-05	4.722E-06	12.793436	4.813E-29	5.111E-05	6.971E-05

newey-west	*coeff*	*std err*	*t stat*	*p-value*
Intercept	7.2707175	0.0991223	73.351007	9.9E-169
Disembarked Slaves	6.041E-05	6.056E-06	9.9759182	6.864E-20

20. Output for Figure 28

ADF Tests

Engle-Granger Test

	X var	Y var	X diff	Y diff
tau-stat	-2.1663229	-1.77818	-6.3159517	-8.7395457
tau-crit	-1.9551297	-1.9551297	-1.9557751	-1.9557751
stationary	yes	no	yes	yes
aic	21.568859	11.134334	21.53788	10.874763
bic	21.617944	11.18342	21.58725	10.924133
lags	0	0	0	0
coeff	-0.3389277	-0.3335891	-1.6868495	-1.5003314
p-value	0.0333774	0.0755549	< .01	< .01

alpha	0.05
type	0
max lags	0
criteria	none

tau-stat	-3.6044901
tau-crit	-3.5914508
cointegrated	yes
lags	0
p-value	0.0490702

Breusch-Godfrey Test

Lags	1
LM*	0.0534316
df1	1
df2	22
p-value	0.8193323

LM	0.0605707
p-value	0.8055962

Regression Analysis

OVERALL FIT	
Multiple R	0.4850637
R Square	0.2352868
Adjusted R Square	0.2020384
Standard Error	55.066316
Observations	25

AIC	202.34237
AICc	203.48523
SBC	204.78012

ANOVA Alpha 0.05

	df	*SS*	*MS*	*F*	*p-value*	*sig*
Regression	1	21458	21458.471	7.076634	0.0139837	yes
Residual	23	69743	3032.2991			
Total	24	91201				

ols	*coeff*	*std err*	*t stat*	*p-value*	*lower*	*upper*
Intercept	21.344343	13.927	1.5326231	0.1390096	-7.4651785	50.153865
Disembarked Slaves	0.0025327	0.001	2.6601944	0.0139837	0.0005632	0.0045023

newey-west	*coeff*	*std err*	*t stat*	*p-value*
Intercept	21.344343	12.534	1.702885	0.1020677
Disembarked Slaves	0.0025327	0.0011	2.3152654	0.0298698

21. Output for Table 1

a. Economic Surplus per Worker

ADF Tests

Engle-Granger Test

	X var	Y var	X diff	Y diff
tau-stat	-0.3055902	0.1375289	-17.800154	-18.928927
tau-crit	-1.9418915	-1.9418915	-1.9418944	-1.9418944
stationary	no	no	yes	yes
aic	2.9114325	-2.4903256	2.9147521	-2.4926104
bic	2.9234293	-2.4783288	2.9267771	-2.4805854
lags	0	0	0	0
coeff	-0.001168	0.0001308	-1.0108771	-1.0723044
p-value	> .1	> .1	< .01	< .01

alpha	0.05
type	0
max lags	0
criteria	none

tau-stat	-3.378136
tau-crit	-3.3557207
cointegrated	yes
lags	0
p-value	0.0478378

b. Ln Public Investment per Capita

ADF Tests

	X var	Y var	X diff	Y diff
tau-stat	-0.3692377	0.1375289	-15.218895	-18.928927
tau-crit	-1.9418915	-1.9418915	-1.9418944	-1.9418944
stationary	no	no	yes	yes
aic	3.197127	-2.4903256	3.1794879	-2.4926104
bic	3.2091238	-2.4783288	3.1915129	-2.4805854
lags	0	0	0	0
coeff	-0.0017011	0.0001308	-0.8552153	-1.0723044
p-value	> .1	> .1	< .01	< .01

Engle-Granger Test

alpha	0.05
type	0
max lags	0
criteria	none

tau-stat	-3.7206783
tau-crit	-3.3557207
cointegrated	yes
lags	0
p-value	0.0199907

c. Ln Real Economic Surplus per Disembarked Slave

ADF Tests

	X var	Y var	X diff	Y diff
tau-stat	-1.7321608	0.1375289	-26.041861	-18.928927
tau-crit	-1.9418915	-1.9418915	-1.9418944	-1.9418944
stationary	no	no	yes	yes
aic	2.2556618	-2.4903256	2.1190444	-2.4926104
bic	2.2676586	-2.4783288	2.1310695	-2.4805854
lags	0	0	0	0
coeff	-0.0191107	0.0001308	-1.372583	-1.0723044
p-value	0.0821778	> .1	< .01	< .01

Engle-Granger Test

alpha	0.05
type	0
max lags	0
criteria	none

tau-stat	-3.3990216
tau-crit	-3.3557207
cointegrated	yes
lags	0
p-value	0.0458232

d. Ln Horses per 1000 Population

ADF Tests

Engle-Granger Test

	X var	Y var	X diff	Y diff
tau-stat	-0.5775231	0.1375289	-18.534257	-18.928927
tau-crit	-1.9418915	-1.9418915	-1.9418944	-1.9418944
stationary	no	no	yes	yes
aic	-2.3120993	-2.4903256	-2.3138738	-2.4926104
bic	-2.3001025	-2.4783288	-2.3018488	-2.4805854
lags	0	0	0	0
coeff	-0.0005521	0.0001308	-1.0495143	-1.0723044
p-value	> .1	> .1	< .01	< .01

alpha	0.05
type	0
max lags	0
criteria	none

tau-stat	-3.2553538
tau-crit	-3.3557207
cointegrated	no
lags	0
p-value	0.0668575

e. Regression Model

Regression Analysis

OVERALL FIT	
Multiple R	0.86165194
R Square	0.74244406
Adjusted R Square	0.73909918
Standard Error	0.08438088
Observations	313

AIC	-1542.771771
AICc	-1542.497261
SBC	-1524.040755

ANOVA — Alpha 0.05

	df	SS	MS	F	p-value	sig
Regression	4	6.32165852	1.58041463	221.9641772	2.16864E-89	yes
Residual	308	2.19300119	0.00712013			
Total	312	8.51465971				

ols	*coeff*	*std err*	*t stat*	*p-value*	*lower*	*upper*	*vif*
Intercept	2.20384239	0.11475681	19.2044578	1.35766E-54	1.978035862	2.42964891	
RealEconSurplusPerWorker	0.06232736	0.00248166	25.1152237	1.60454E-76	0.057444215	0.06721051	1.24648967
LnApproxPub Inv per Capita	0.00347038	0.00110934	3.12834079	0.001926096	0.001287545	0.00565322	1.47891009
Ln Real Econ Surplus per Total Disembarked	0.01161978	0.00228006	5.09626234	6.05519E-07	0.007133314	0.01610624	1.66695635
LnHorsesPer1000Population	0.2157301	0.02381452	9.05876516	1.55978E-17	0.168870375	0.26258983	1.36995846

newey-west	*coeff*	*std err*	*t stat*	*p-value*
Intercept	2.20384239	0.12070021	18.2588115	5.47915E-51
RealEconSurplusPerWorker	0.06232736	0.00371045	16.7977957	2.10292E-45
LnApproxPub Inv per Capita	0.00347038	0.00196593	1.76526452	0.078510204

Ln Real Econ Surplus per Total Disembarked	0.01161978	0.00280493	4.14262503	4.44011E-05
LnHorsesPer1000Population	0.2157301	0.02322076	9.29039952	2.88314E-18

22. Output for Table 2

a. Economic Surplus per Workers

ADF Tests

	X var	Y var	X diff	Y diff
tau-stat	-0.1897942	2.4318487	-14.72822	-18.000462
tau-crit	-1.9418657	-1.9418657	-1.9418685	-1.9418685
stationary	no	no	yes	yes
aic	2.9012331	6.2981848	2.8643177	6.263302
bic	2.9247851	6.3217368	2.8879239	6.2869082
lags	1	1	1	1
coeff	-0.0007038	0.0069109	-1.1545409	-1.5771297
p-value	> .1	> .1	< .01	< .01

Engle-Granger Test

alpha	0.05
type	0
max lags	1
criteria	none

tau-stat	-3.5892183
tau-crit	-3.3551713
cointegrated	yes
lags	1
p-value	0.0274063

b. Horses in Millions

ADF Tests

	X var	Y var	X diff	Y diff
tau-stat	1.7015181	2.4318487	-13.843366	-18.000462
tau-crit	-1.9418657	-1.9418657	-1.9418685	-1.9418685
stationary	no	no	yes	yes
aic	-4.1099622	6.2981848	-4.1026005	6.263302
bic	-4.0864102	6.3217368	-4.0789942	6.2869082
lags	1	1	1	1
coeff	0.0042123	0.0069109	-1.1337043	-1.5771297
p-value	> .1	> .1	< .01	< .01

Engle-Granger Test

alpha	0.05
type	0
max lags	1
criteria	none

tau-stat	-3.4913106
tau-crit	-3.3551713
cointegrated	yes
lags	1
p-value	0.0368578

c. Regression Model

Regression Analysis

OVERALL FIT	
Multiple R	0.9597485
R Square	0.92111719
Adjusted R Square	0.92062262
Standard Error	11.2002703

AIC	1558.849952
AICc	1558.976135
SBC	1570.173607

Observations	322

ANOVA				Alpha	0.05	
	df	*SS*	*MS*	*F*	*p-value*	*sig*
Regression	2	467283.214	233641.607	1862.486689	1.1714E-176	yes
Residual	319	40017.2914	125.446055			
Total	321	507300.506				

ols	*coeff*	*std err*	*t stat*	*p-value*	*lower*	*upper*	*vif*
Intercept	-1.5927898	4.57568638	-0.3480986	0.727995762	-10.5951251	7.40954544	
RealEconSurplusPerWorker	2.33196341	0.35734986	6.52571525	2.65851E-10	1.628903154	3.03502366	1.79874478
horses (millions)	111.254182	2.72032384	40.8974037	6.5965E-129	105.9021398	116.606225	1.79874478

newey-west	*coeff*	*std err*	*t stat*	*p-value*
Intercept	-1.5927898	7.58693387	-0.2099385	0.833849659
RealEconSurplusPerWorker	2.33196341	0.51381124	4.5385605	8.03426E-06
horses (millions)	111.254182	2.8900835	38.4951445	6.2617E-122