# Horses, Serfs, Slaves and Transitions

Lambert, Thomas

University of Louisville

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Thomas Lambert, PhD[1]
Applied Economist
College of Business, University of Louisville
Louisville, KY 40292 USA
Contact: 1-502-852-7838 and Thomas.Lambert@Louisvillle.edu

**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.

**Keywords**: Baran ratio, economic surplus, investment, slave trade, slavery, serfs, horses, long waves, Great Britain
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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 paper. Both variables have trends that are non-stationary according to an Augmented Dickey-Fuller

[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.

(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 16$^{th}$ 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 enhancing ways (e.g., better healthcare, better educational systems) or "wasted" on things such as

[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.

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 Lambert (2024a and 2024b) based on the work of other historians, and these show an increase in

[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).

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 whether these are from ships under the British flag or the flag of other nations. Therefore, annual

[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.

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 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.

[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.

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.[12] 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 and tobacco production also yields

[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.

substandard results. Many economic historians credit these industries developing thanks to the slave trade and at least at the local and regional level in Britain, yet no substantive correlations for these are found at the aggregate level unlike some of the other findings in this paper.

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

[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.

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 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

[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.

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)

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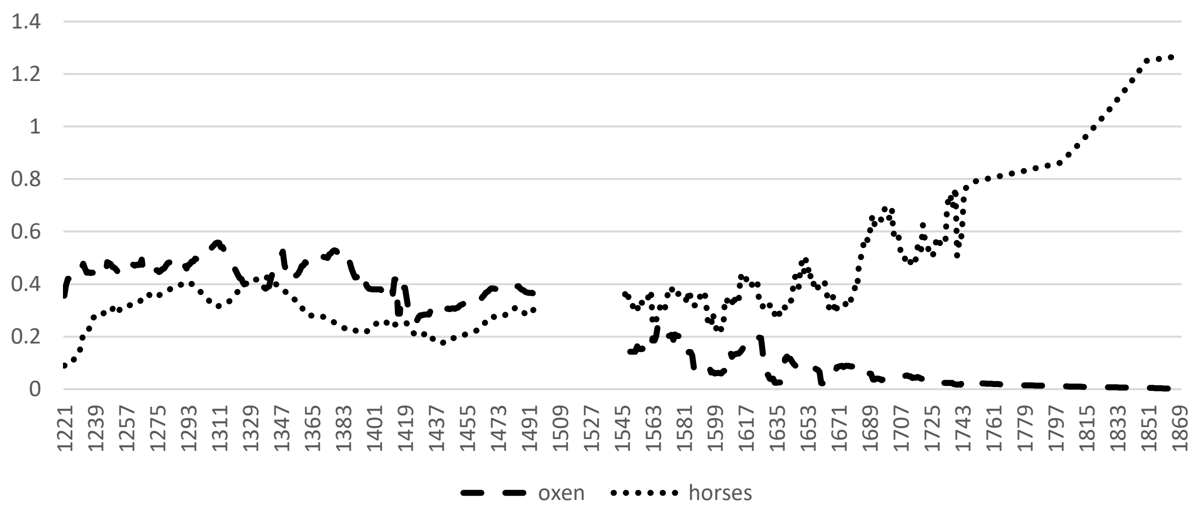
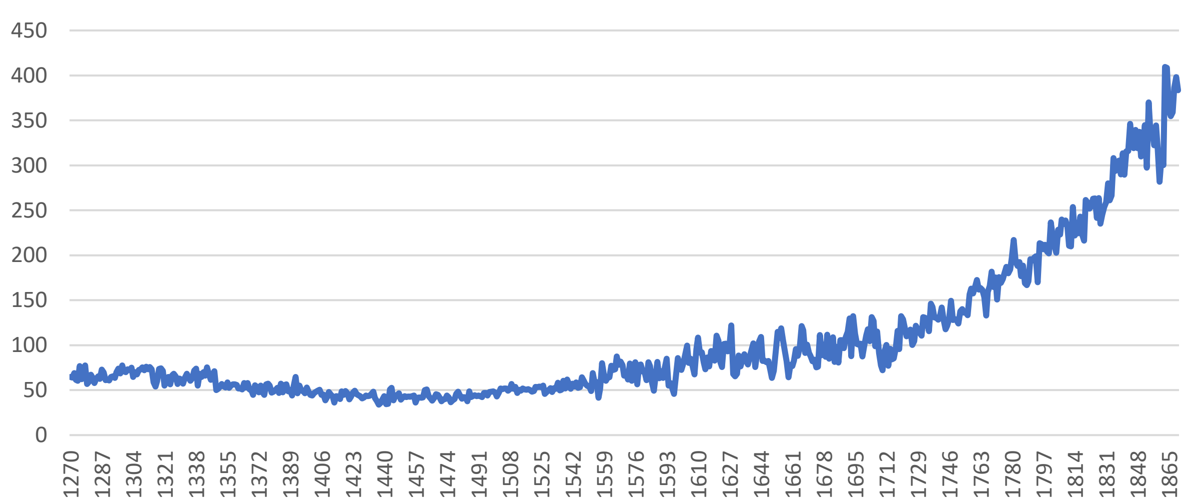
**Fig. 1: Number of Horses and Oxen in Millions, Britain, 1221 to 1870**

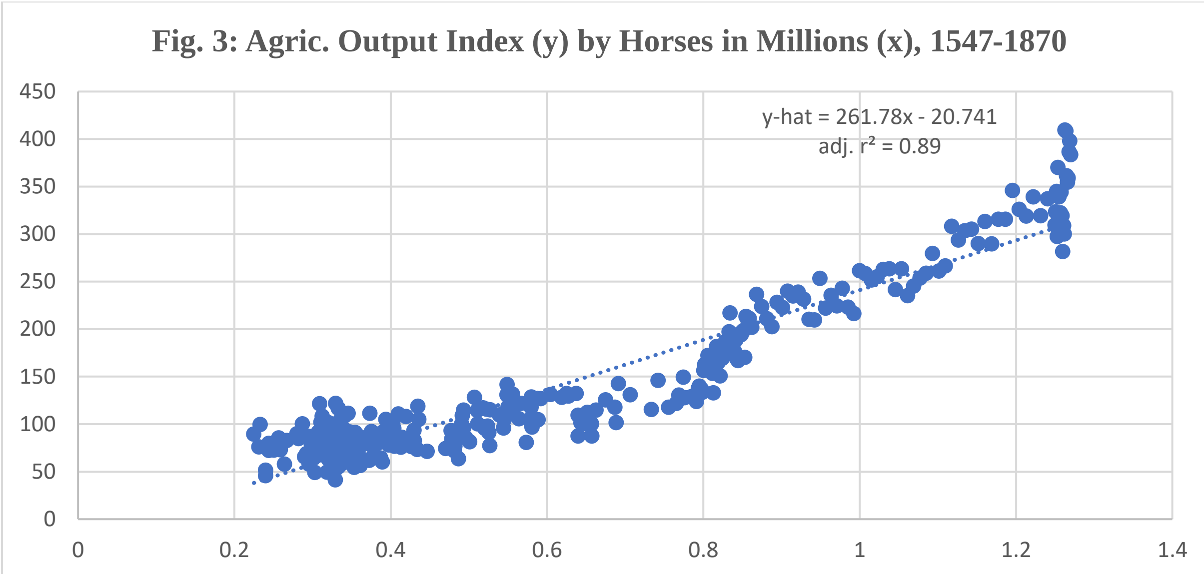



Source: Broadberry, et al (2015)

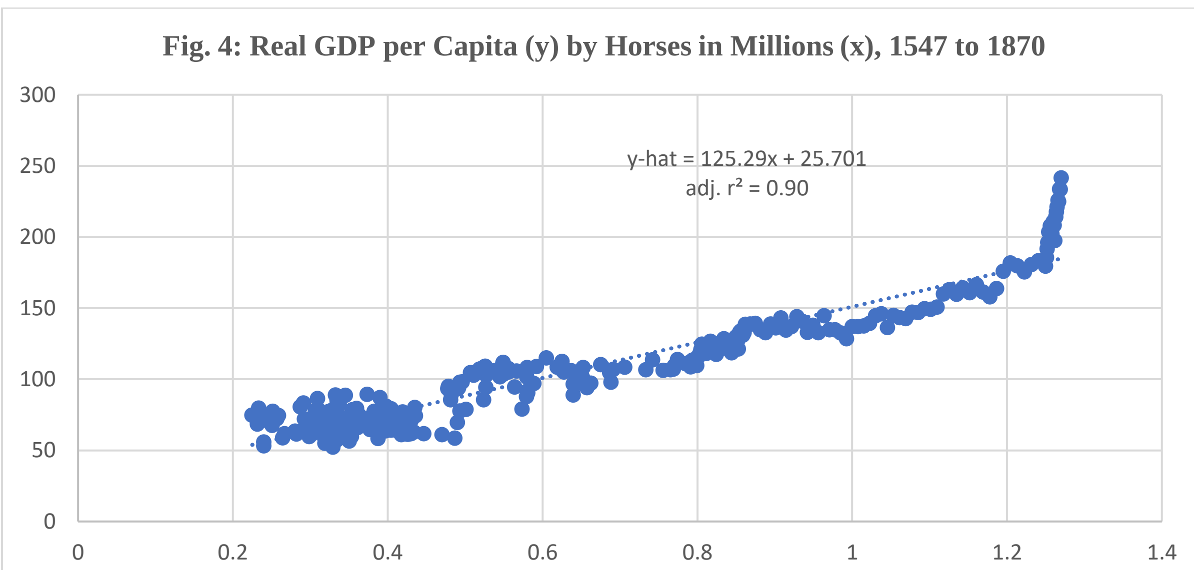
**Fig. 2: Agricultural Output Index, 1700 Base Yr =100**




Source: Broadberry, et al (2015)

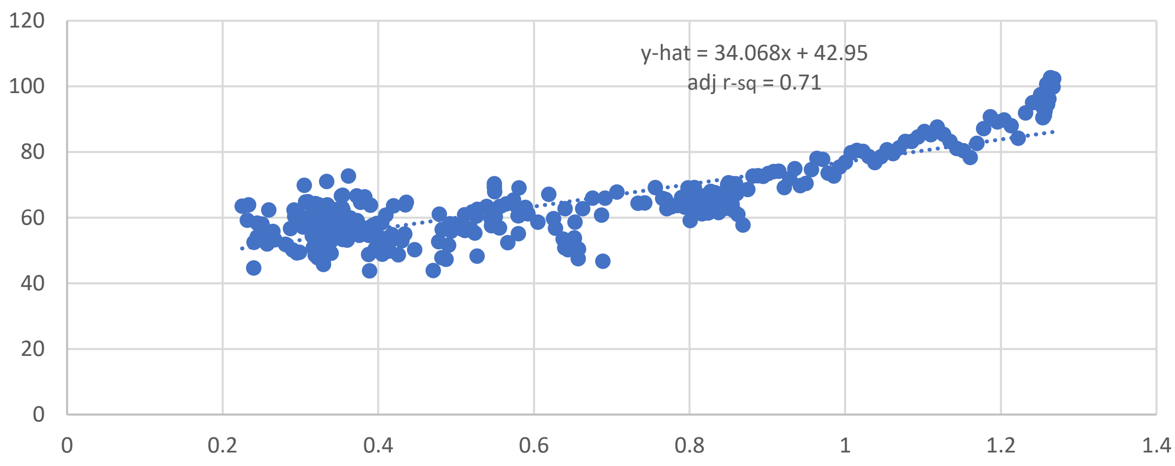



E-G Test: Tau-stat = -6.4, p-value < 0.01, co-integrated. Source: Broadberry, et al (2015)



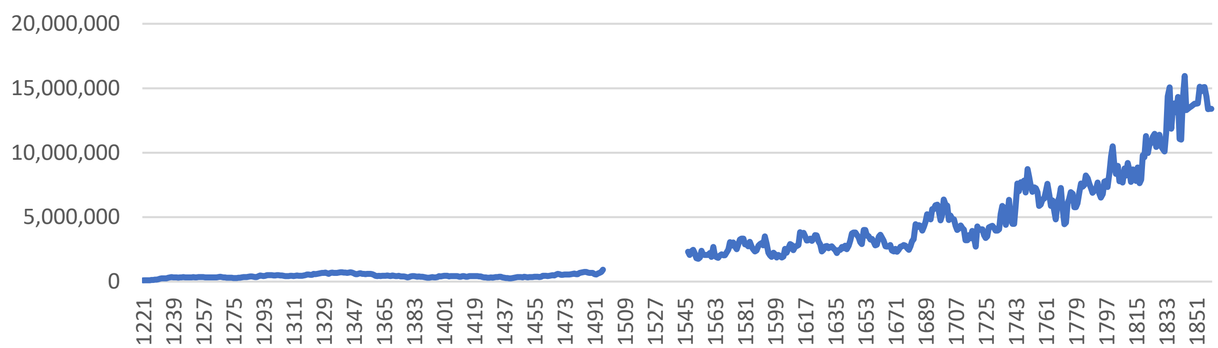

E-G Test: Tau-stat = -4.2, p-value < 0.01, co-integrated. Source: Broadberry, et al (2015)

**Fig. 5: Real NNI per Capita, 1860 Base Yr=100, (y) by Horses in Millions, 1547-1868**



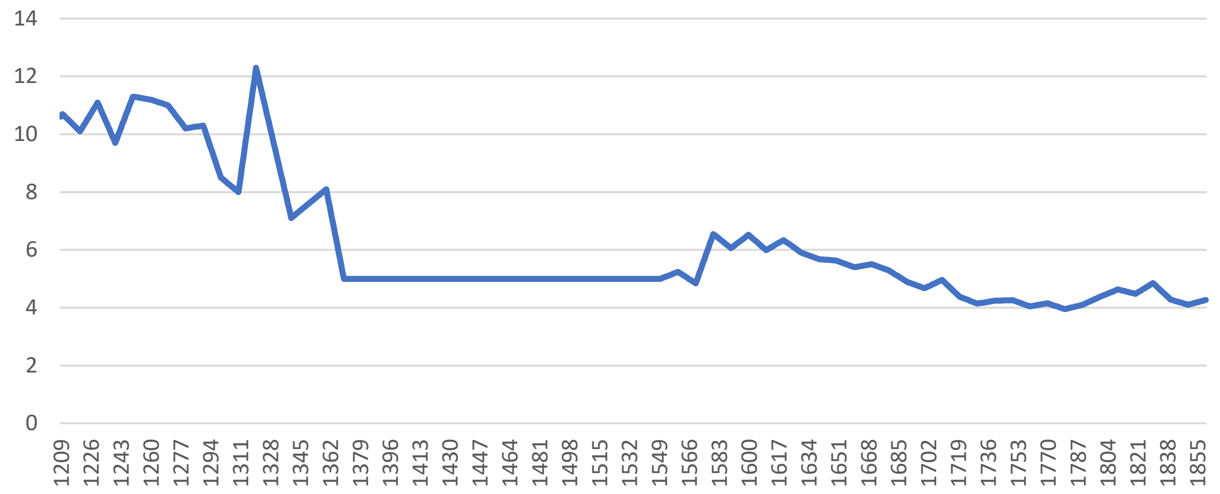

E-G Test: Tau-stat = -5.8, p-value < 0.01, co-integrated. Sources: Broadberry, et al (2015) and Clark (2007, 2009, and 2010).

**Fig. 6: Inf Adj Capital Value of Horses, Pounds, Base Year 1860 = 100, 1221 to 1860**



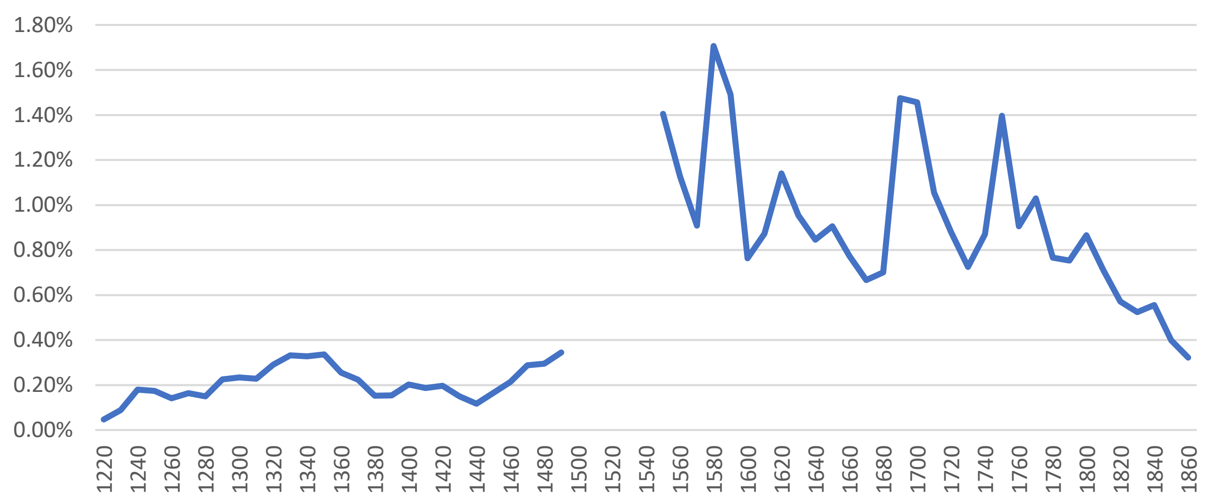

Sources: Broadberry, et al (2015) and Clark (2009)

**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).

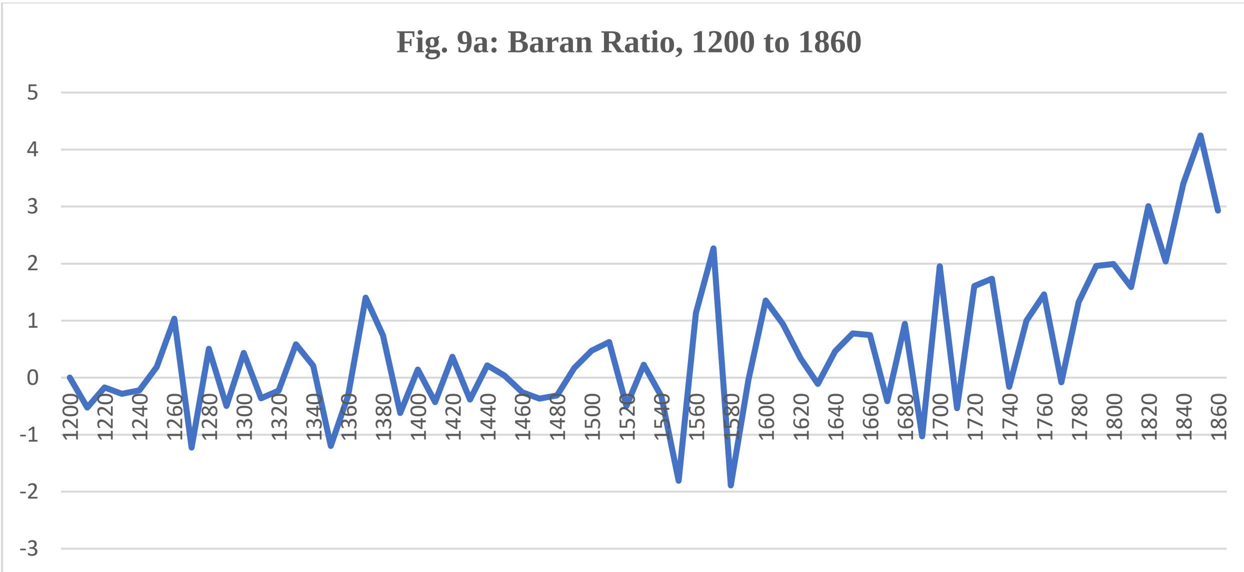



**Fig. 9a: Baran Ratio, 1200 to 1860**

Source: Lambert (2020 and 2023).

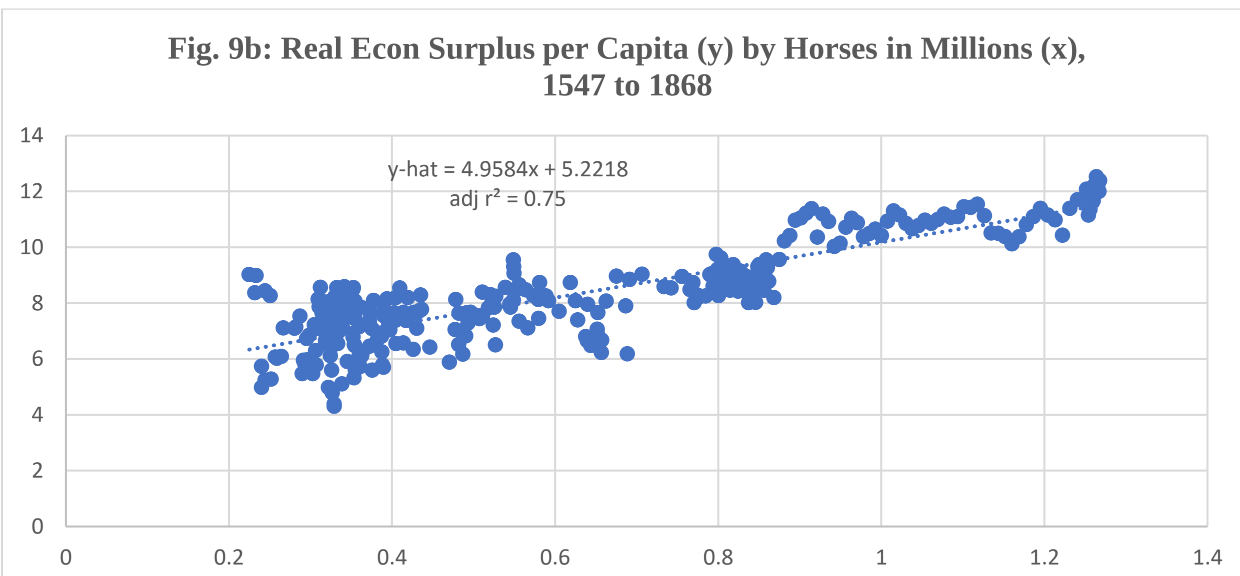
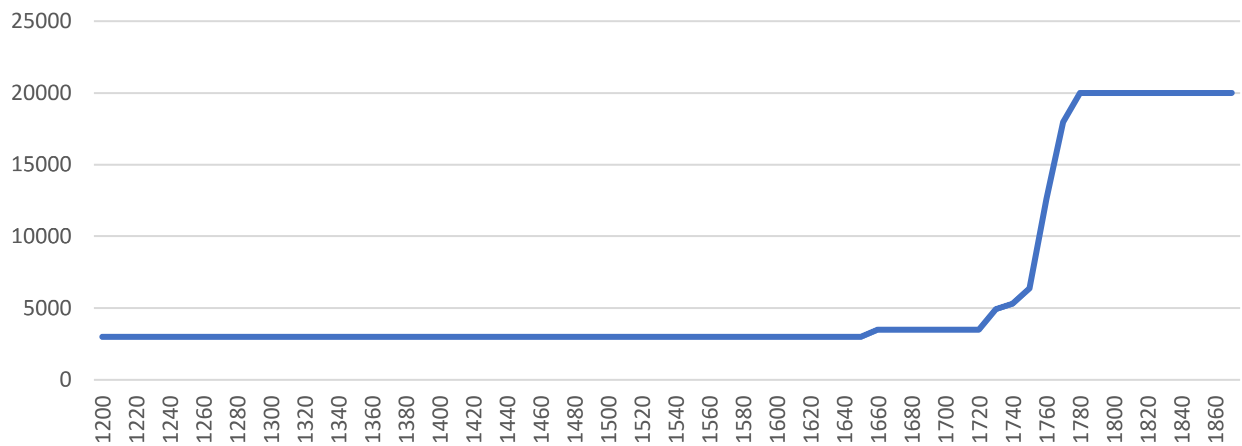



**Fig. 9b: Real Econ Surplus per Capita (y) by Horses in Millions (x), 1547 to 1868**

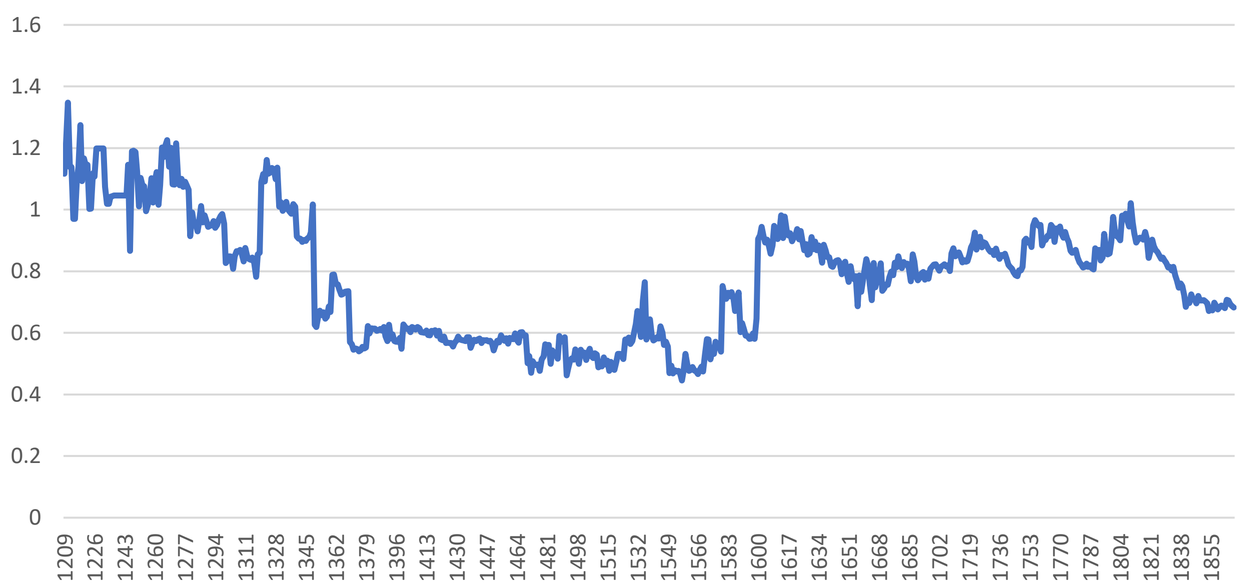
E-G Test: Tau-stat = -5.7, p-value < 0.01, co-integrated. Sources: Clark (2009) and Broadberry, et al (2015).

**Fig. 10: Estimates of Mileage of Roads and Turnpikes**



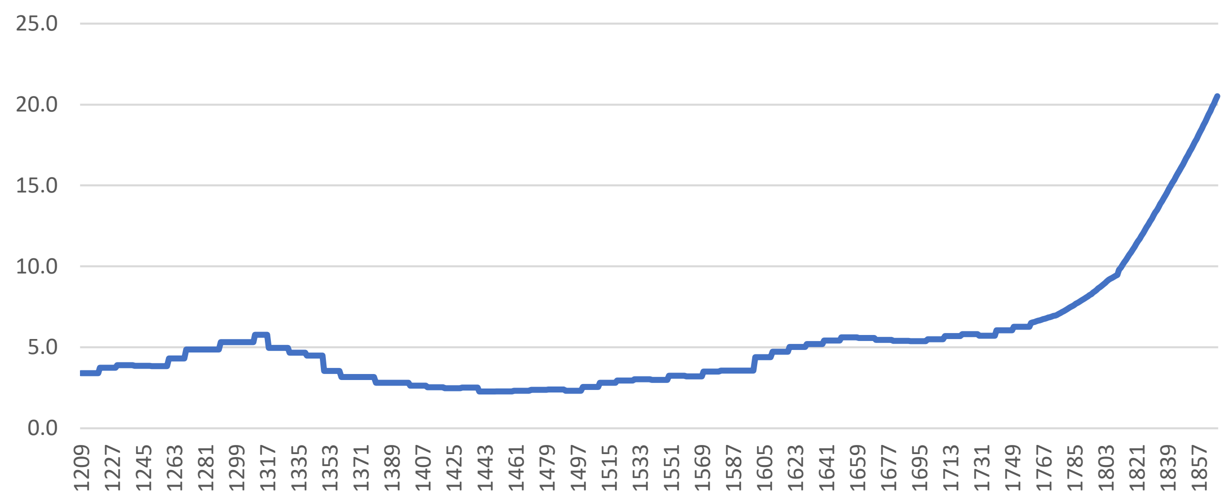

Source: Lambert (2024a and 2024b)

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



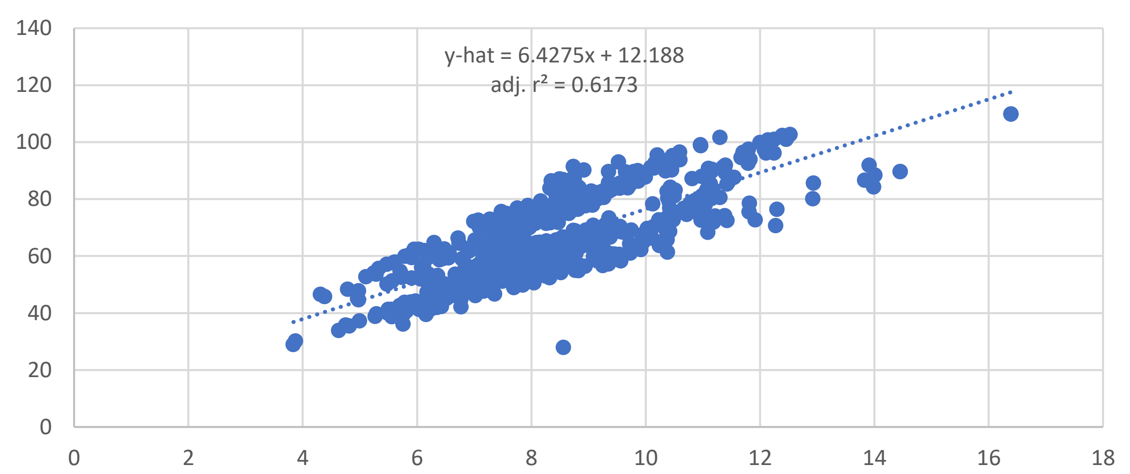

Source: Author's use of Clark (2009) data.

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

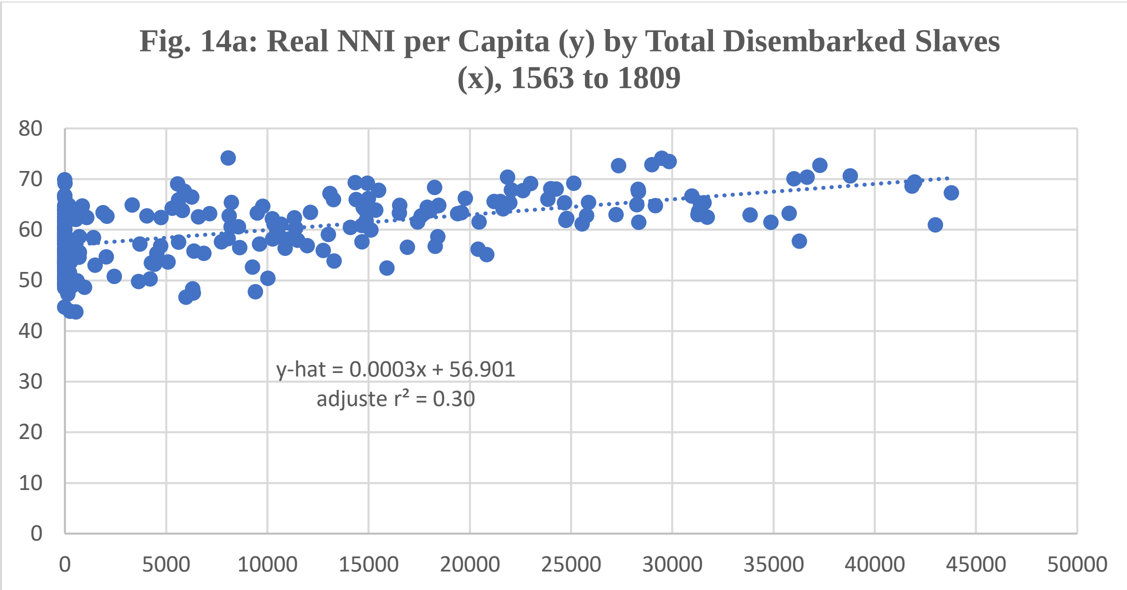



Source: Author's use of Clark (2009) data.

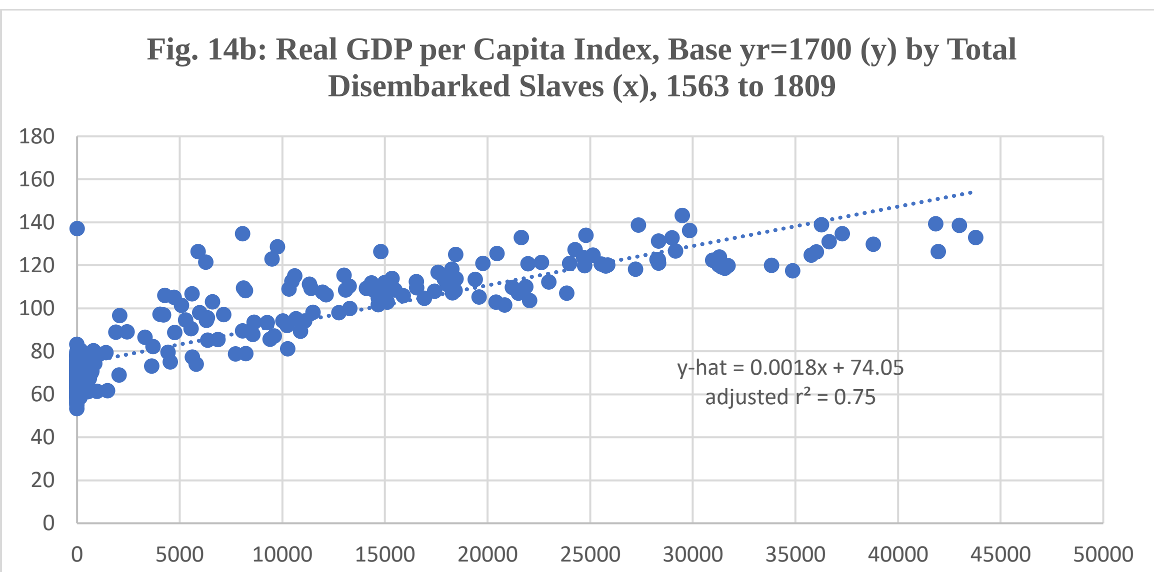
**Fig. 13: Real NNI per Capita (y), Base 1860=100, by Real Economic Surplus per Capita (x)**



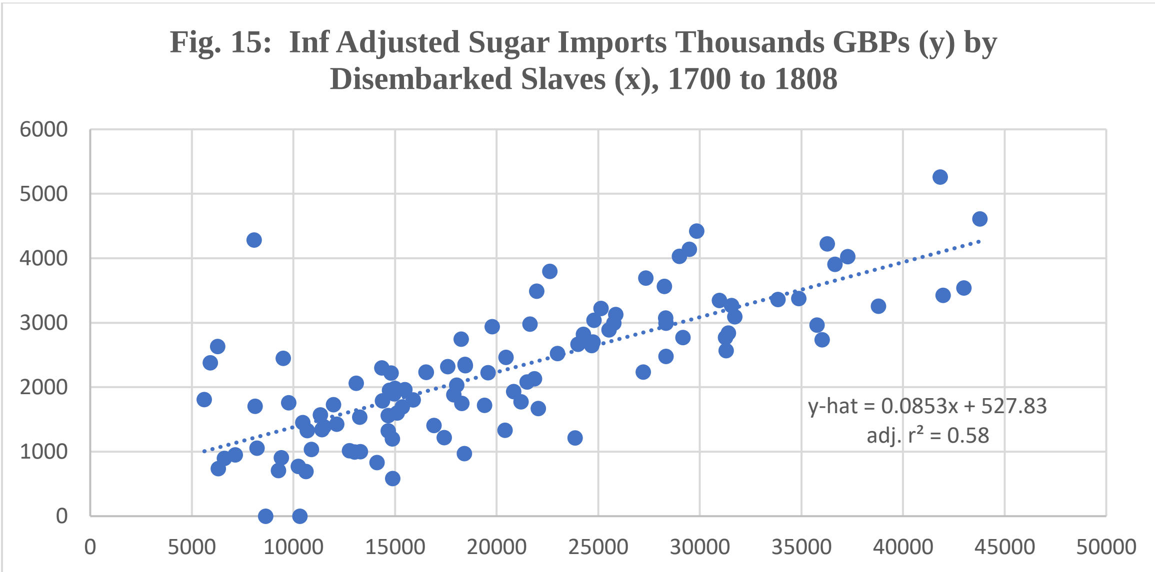

E-G Test: Tau-stat = -4.05, p-value < 0.01, co-integrated. Source: Author's use of Clark (2009) data.



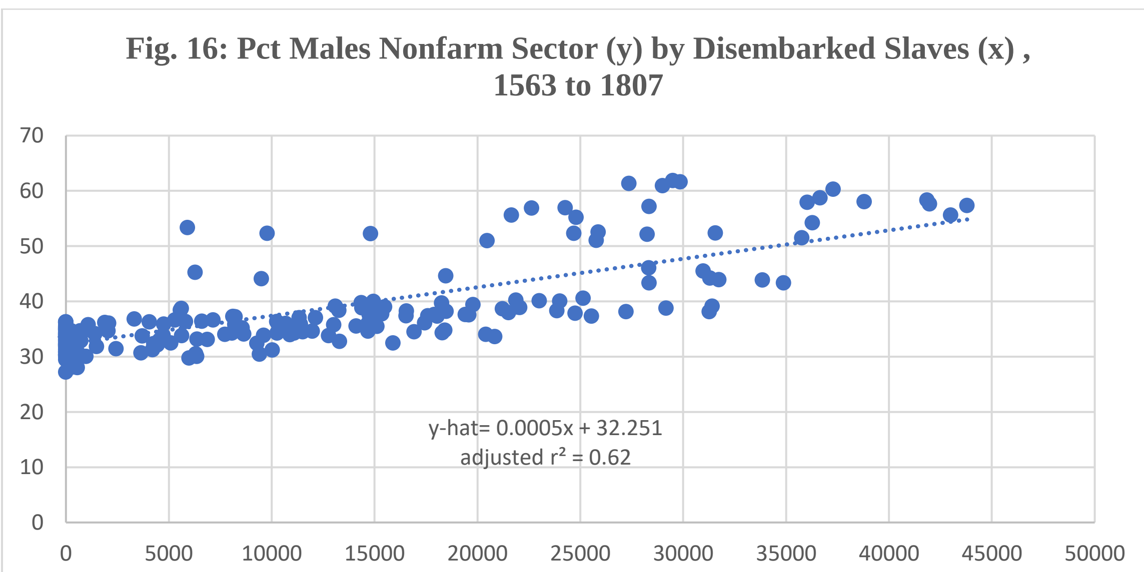

E-G Test: Tau-stat = -4.2, p-value < 0.01, co-integrated. Source: Author's use of Clark (2009) data and Slave Voyage (2021).




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.

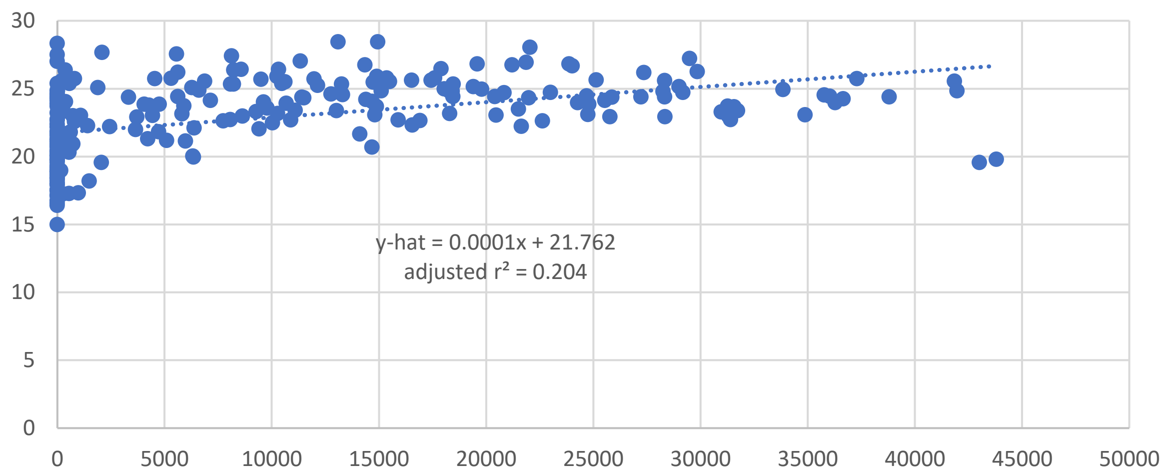



E-G Test: Tau-stat = -4.6, p-value < 0.01, co-integrated. Source: Author's use of Mitchell (2021) data and Slave Voyage (2021) data.



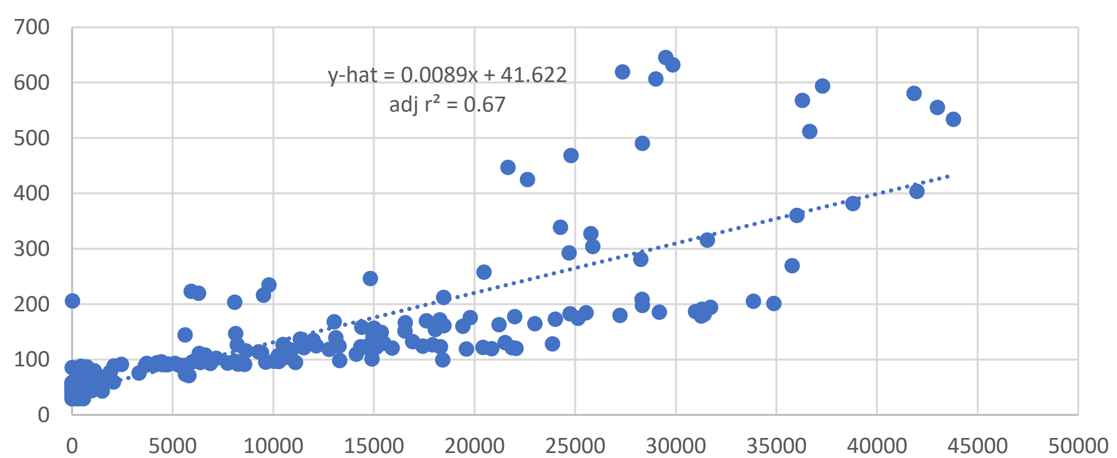

E-G Test: Tau-stat = -3.4, p-value < 0.05, co-integrated. Source: Author's use of Clark (2009) data and Slave Voyage (2021) data.

**Fig. 17: Real Non-farm Avg Daily Wage, Pence (y) by Slaves Disembarked (x), 1563 to 1807**

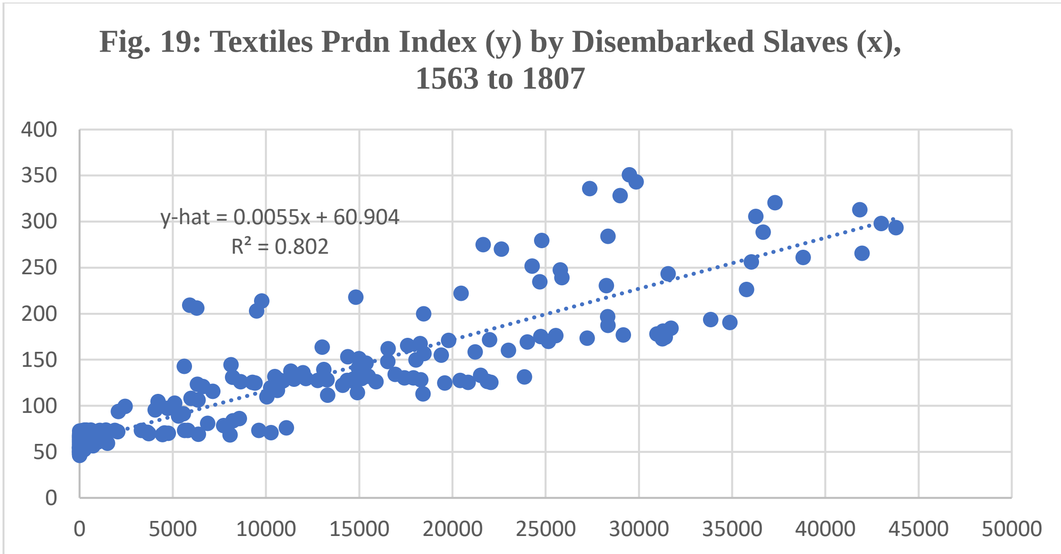



E-G Test: Tau-stat = -5.08, p-value < 0.01, co-integrated. Source: Author's use of Clark (2009) data and Slave Voyage (2021) data.

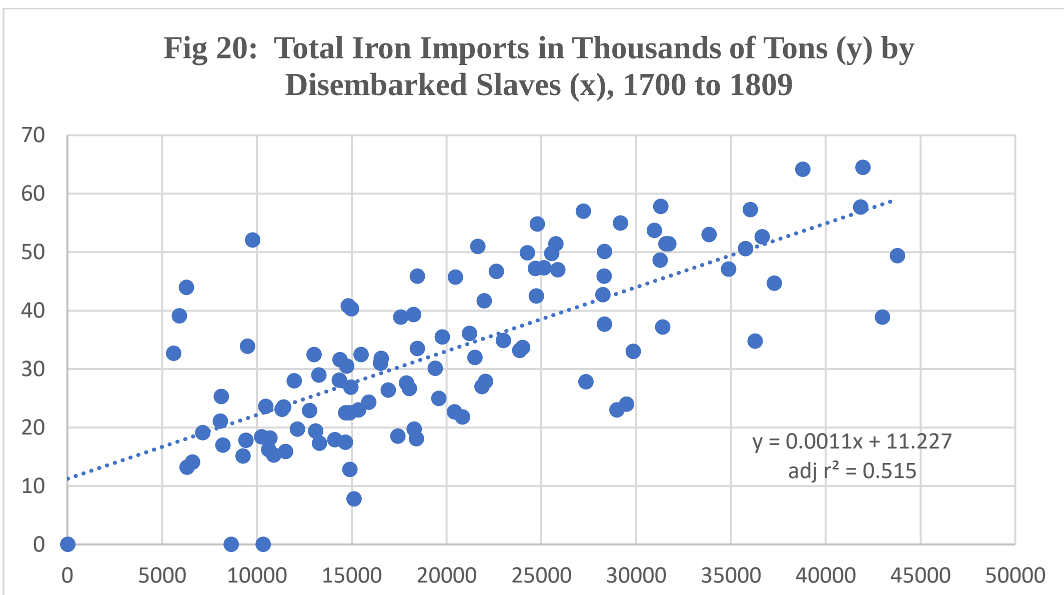
**Fig. 18: Tin Output Index, 1700=100, (y) by Slaves Disembarked (x) 1563 to 1807**



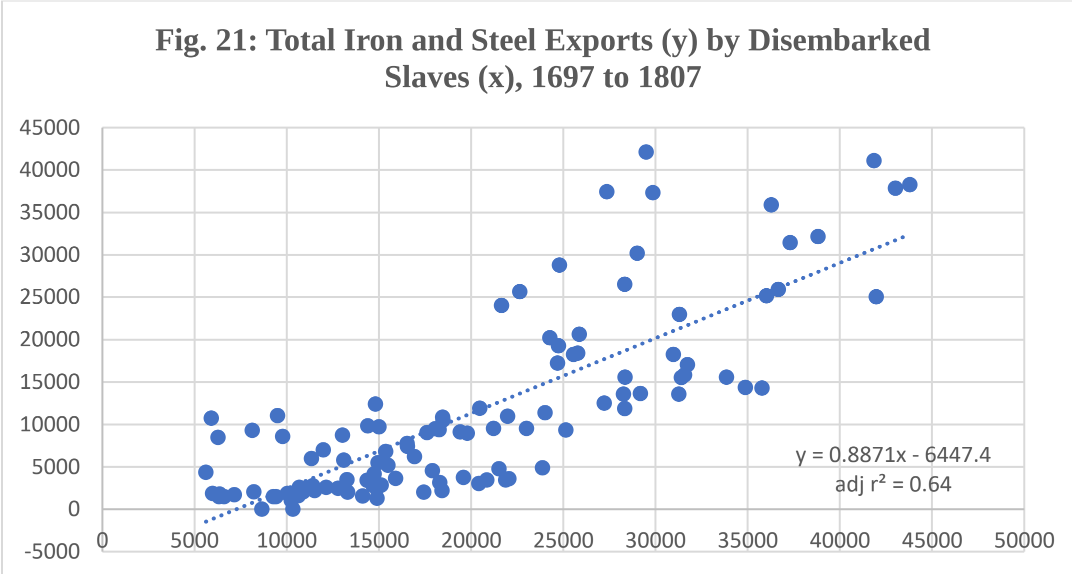

E-G Test: Tau-stat = -3.58, p-value < 0.05, co-integrated. Source: Author's use of Broadberry, et al (2015) data and Slave Voyage (2021) data.



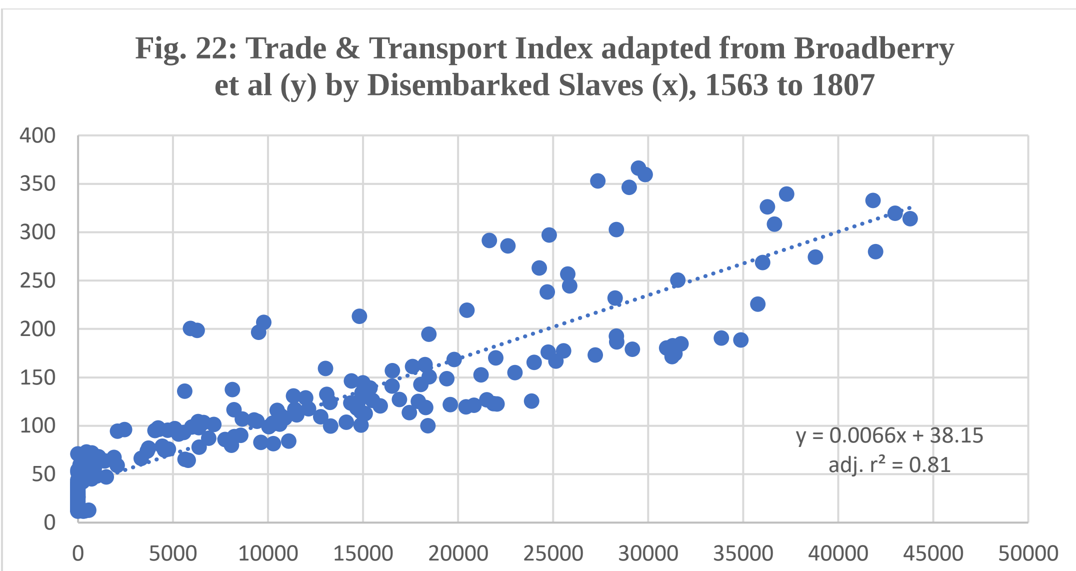

E-G Test: Tau-stat = -4.2, p-value < 0.01, co-integrated. Source: Author's use of Broadberry, et al (2015) data and Slave Voyage (2021) data.



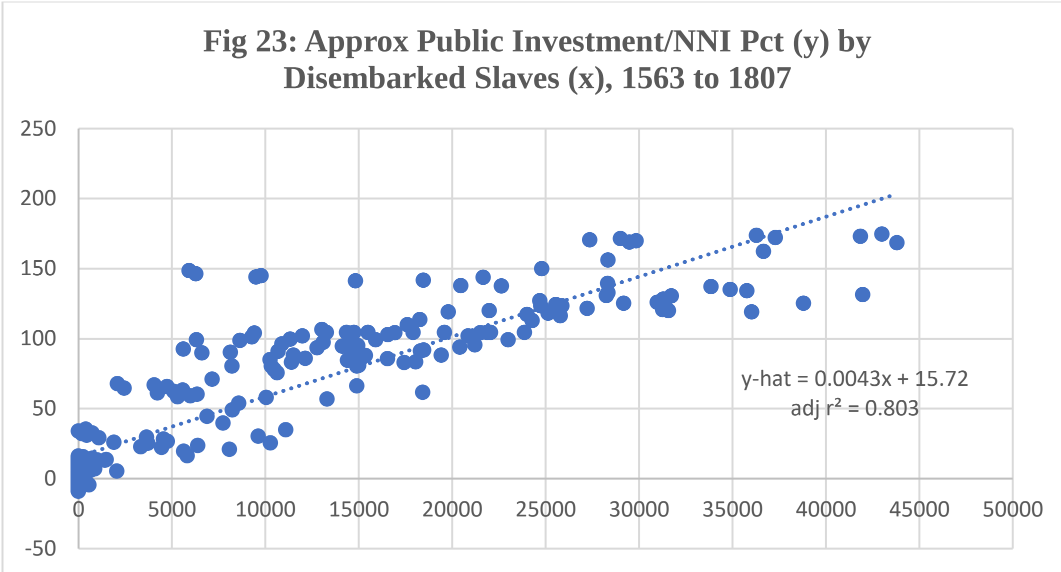

E-G Test: Tau-stat = -4.7, p-value < 0.01, co-integrated. Source: Author's use of Mitchell (2011) data and Slave Voyage (2021) data



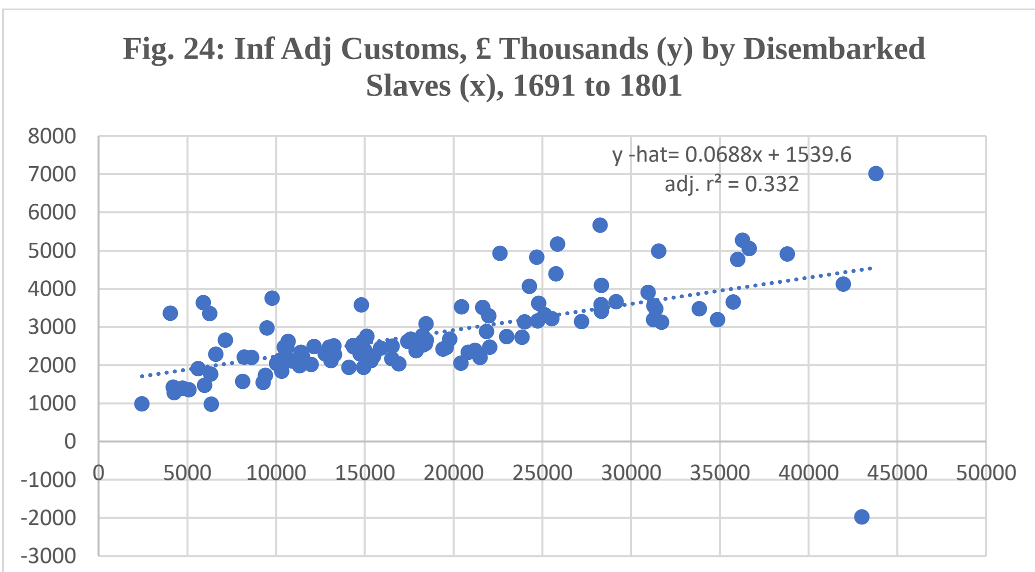

E-G Test: Tau-stat = -3.6, p-value < 0.05, co-integrated. Source: Author's use of Mitchell (2011) data and Slave Voyage (2021) data




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.

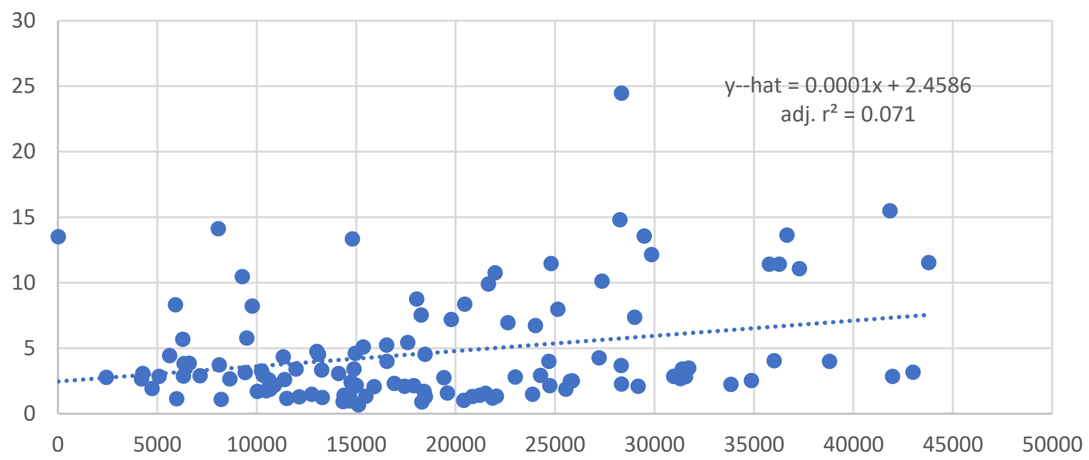



E-G Test: Tau-stat = -5.04, p-value < 0.01, co-integrated. Source: Author's use of Lambert (2024), Clark (2009), data and Slave Voyage (2021) data.



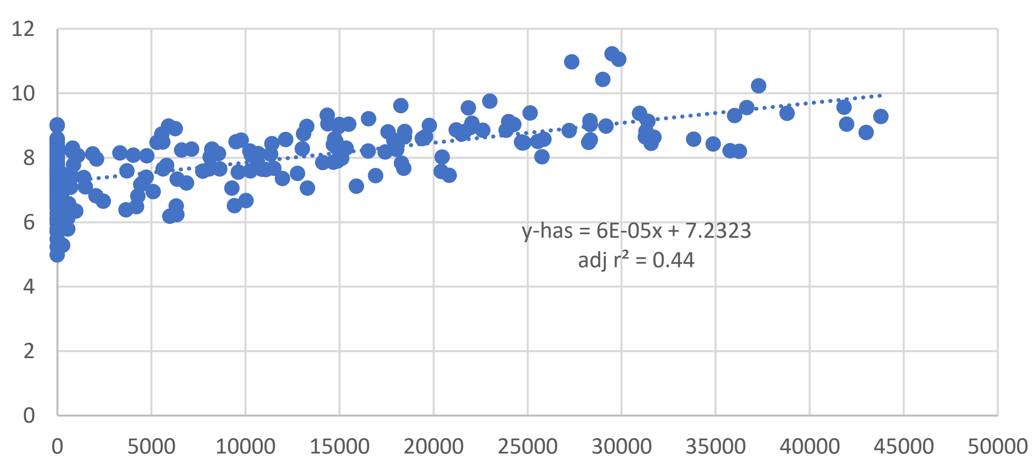

E-G Test: Tau-stat = -9.8, p-value < 0.01, co-integrated. Source: Mitchell (2011) and Slave Voyage (2021) databases.

**Fig. 25: Inf. Adj. Navy Exp, £ Millions (y) by Slaves Disembarked (x), 1691 to 1809**



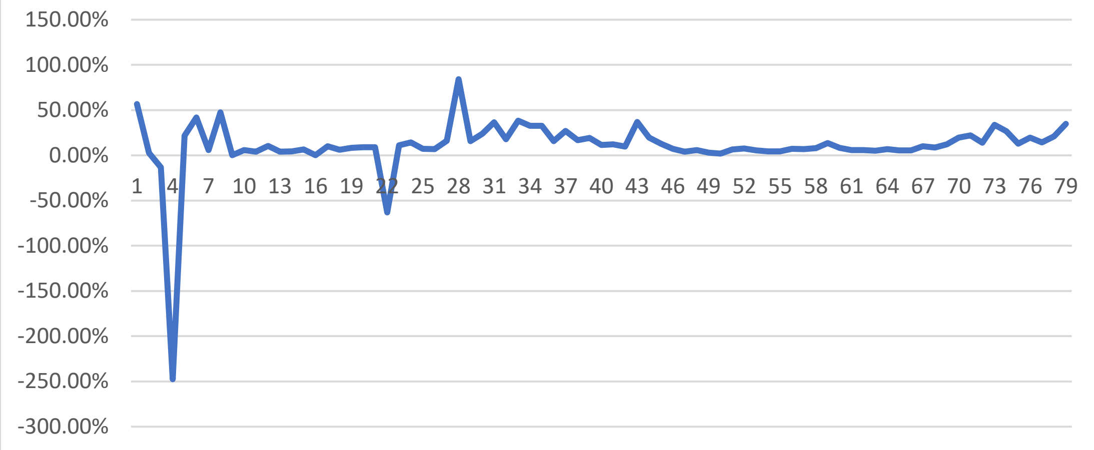

E-G Test: Tau-stat = -4.06, p-value < 0.01, co-integrated. Source: Mitchell (2011, pages 578-580) and Slave Voyage (2021) databases.

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



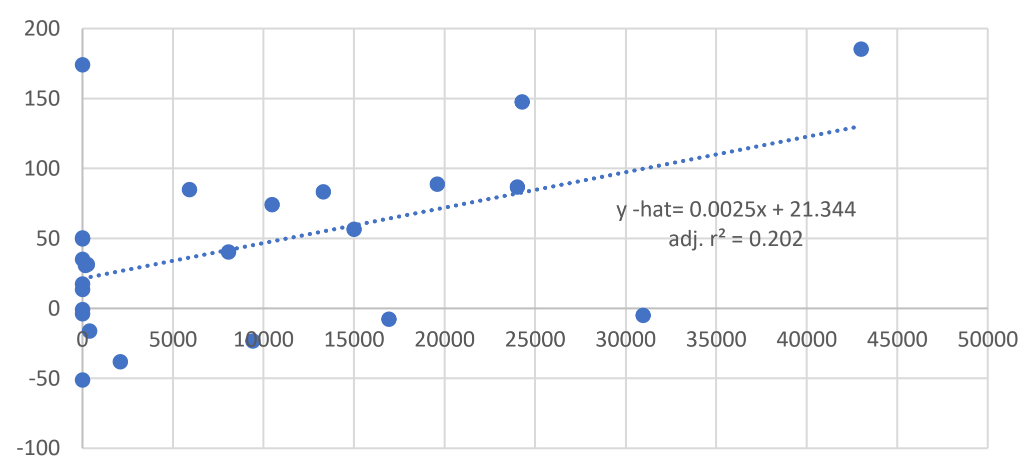

E-G Test: Tau-stat = -5.06, p-value < 0.01, co-integrated. Source: Clark (2009) and Slave Voyage (2021) databases.

**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.

**Fig. 28: Real Domestic Invesment, £ Millions (y) by Slaves Disembarked (x), Decadal Values 1570 to 1810**




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

**Table 1**

*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** (2.89) | 1.70 | -3.49** |

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 |
| R Square | 0.6173 |
| Adjusted R Square | 0.6167 |
| Standard Error | 9.0196 |
| Observations | 660 |

| | |
|---|---|
| AIC | 2905.2 |
| AICc | 2905.23 |
| SBC | 2914.18 |

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 | none |

| | |
|---|---|
| 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 |
| R Square | 0.5870145 |
| Adjusted R Square | 0.5831548 |
| Standard Error | 679.37615 |
| Observations | 109 |

| | |
|---|---|
| AIC | 1423.5976 |
| AICc | 1423.8261 |
| SBC | 1428.9803 |

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

**Engle-Granger Test**

| | |
|---|---|
| alpha | 0.05 |
| type | 0 |
| max lags | 0 |
| criteria | none |

| | |
|---|---|
| tau-stat | -5.0817424 |
| tau-crit | -3.3609791 |
| cointegrated | yes |
| 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 |
| coeff | -0.03103 | -0.0102 | -0.955892924 | -0.9958934 |
| p-value | 0.047985 | > .1 | < .01 | < .01 |

**Engle-Granger Test**

| | |
|---|---|
| alpha | 0.05 |
| type | 0 |
| max lags | 0 |
| criteria | none |

| | |
|---|---|
| tau-stat | -3.5779953 |
| tau-crit | -3.3609791 |
| 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 | 2581511 | 2581511 | 489.7332 | 2.323E-60 | yes |
| Residual | 245 | 1291459 | 5271.26 | | | |
| Total | 246 | 3872970 | | | | |

| ols | coeff | std err | t stat | p-value | lower | upper |
|---|---|---|---|---|---|---|
| Intercept | 41.62227 | 6.06431 | 6.863477 | 5.474E-11 | 29.67743 | 53.567111 |
| Totals Disembarked | 0.0089355 | 0.0004 | 22.12992 | 2.323E-60 | 0.0081401 | 0.0097308 |

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

**Engle-Granger Test**

| | |
|---|---|
| alpha | 0.05 |
| type | 0 |
| max lags | 0 |
| criteria | none |

| | |
|---|---|
| tau-stat | -4.2207002 |
| tau-crit | -3.3611829 |
| 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 |
| 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 |

**Engle-Granger Test**

| | |
|---|---|
| alpha | 0.05 |
| type | 0 |
| max lags | 0 |
| criteria | none |
| 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 |
| stationary | no | no | yes | yes |
| aic | 19.9005184 | 18.6883751 | 19.9162143 | 18.6608288 |
| bic | 19.9250683 | 18.7129249 | 19.9409055 | 18.6855201 |
| lags | 0 | 0 | 0 | 0 |
| coeff | -0.0182924 | 0.01887633 | -1.0027699 | -1.218335 |
| p-value | > .1 | > .1 | < .01 | < .01 |

**Engle-Granger Test**

| | |
|---|---|
| alpha | 0.05 |
| type | 0 |
| max lags | 0 |
| criteria | none |

| | |
|---|---|
| tau-stat | -3.5606811 |
| tau-crit | -3.3917297 |
| cointegrated | yes |
| 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 |
| R Square | 0.64107943 |
| Adjusted R Square | 0.63778658 |
| Standard Error | 6357.8296 |
| Observations | 111 |

| | |
|---|---|
| AIC | 1946.13396 |
| AICc | 1946.35826 |
| SBC | 1951.55302 |

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 |
| 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 |

Engle-Granger Test

| | |
|---|---|
| alpha | 0.05 |
| type | 0 |
| max lags | 0 |
| criteria | none |

| | |
|---|---|
| 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 |
|---|---|---|---|---|
| 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 |

**Engle-Granger Test**

| | |
|---|---|
| alpha | 0.05 |
| 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 |
|---|---|---|---|---|
| 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 |

**Engle-Granger Test**

| | |
|---|---|
| alpha | 0.05 |
| 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**

| | 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 |

**Engle-Granger Test**

| | |
|---|---|
| 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**

| | 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 |

**Engle-Granger Test**

| | |
|---|---|
| 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**

| | 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 |

**Engle-Granger Test**

| | |
|---|---|
| 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**

| | 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 |

**Engle-Granger Test**

| | |
|---|---|
| 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

Engle-Granger Test

| | 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 |

| | |
|---|---|
| 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

| | 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 |

Engle-Granger Test

| | |
|---|---|
| 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 |

Engle-Granger Test

| | |
|---|---|
| alpha | 0.05 |
| type | 0 |
| max lags | 1 |
| criteria | none |

| | | | | |
|---|---|---|---|---|
| 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 |

| | |
|---|---|
| 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 |
| Observations | 322 |

| | |
|---|---|
| AIC | 1558.849952 |
| AICc | 1558.976135 |
| SBC | 1570.173607 |

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 |