For Want of a Cup: The Rise of Tea in England and the Impact of Water Quality on Economic Development *

Francisca M. Antman†
Department of Economics, *University of Colorado Boulder*
Preliminary and Incomplete

June 15, 2015

Abstract

While it is now well accepted that access to clean water plays an important role in public health and economic development, there is less historical evidence for the role that clean water played in the development of the now-rich world. I investigate this question by exploiting a natural experiment on the effects of water quality on mortality—the advent of tea consumption in 18th century England. The custom of tea drinking spread rapidly throughout England, even among lower classes, and resulted in an unintentional increase in consumption of boiled water which reduced mortality rates. This hypothesis is supported by preliminary results suggesting that areas with lower initial water quality had larger declines in mortality rates after tea drinking became widespread. A similar pattern of results holds in years following larger volumes of tea imports. Finally, I use cause-specific death data to show that higher volumes of tea imports were associated with fewer deaths from water-borne diseases, while the same is not true for non-water-borne diseases. This supports the idea that the mechanism behind the tea-mortality relationship was in fact boiled water.

JEL classification: N33, Q25, Q56, I150
Keywords: tea, water quality, mortality, Industrial Revolution

*I thank Tania Barham, Howard Bodenhorn, Brian Cadena, Ann Carlos, Gregory Clark, Melissa Dell, Andrew Foster, Timothy Guinnane, Jonathan Hughes, Trevon Logan, Wolfgang Keller, Victor H. Mair, Craig McIntosh, Terra McKinnish, Nathan Nunn, Nancy Qian, Matthew Ruther, Carol Shiue, Jeffrey Zax, and Shuang Zhang for helpful feedback. Tim Larsen, Peter Graca, Isaac Kaplan, and Priti Kalsi provided excellent research assistance. Seminar and conference participants at the Ohio State University, Case Western Reserve University, University of New Mexico, Broom Center for Demography Workshop, Northeast Universities Development Consortium Conference, Population Association of America annual meeting, and Western Economic Association International meeting also offered useful feedback.

†Contact: francisca.antman@colorado.edu, Department of Economics, University of Colorado Boulder, 256 UCB, Boulder, CO 80309.

1 Introduction

The importance of access to clean water for economic development has recently received considerable attention with policymakers raising the issue as a priority worthy of inclusion in the United Nations' Millennium Development Goals. While U.N. leaders now say the world has met the global target of expanding access to safe drinking water, an estimated 780 million people still lack access to an improved drinking water source (WHO/UNICEF 2012). The fact that the majority of these people live in the developing world has stimulated substantial research in developing countries to estimate the impact of water interventions on health, mortality, and quality of life (Kremer et al. 2011, Galiani et al. 2005, Devoto et al. 2012). Although these studies highlight the role that access to clean water can play in economic development today, much less is known about the importance of clean water in the development of the now-rich world. Historical approaches in this area, though substantial, have largely focused on the U.S. experience, and in particular, the impacts of public health interventions targeted at improving drinking water sources and sewage systems in the late 19th and early 20th centuries (Alsan and Goldin 2015; Beach et al. 2014; Ferrie and Troesken 2008; Cutler and Miller 2005; Troesken 2004). By this time period, however, as with the water impact studies that take place today, clean water and sanitation are widely understood to have a direct impact on health, thus raising the possibility that treatment estimates may suffer from endogeneity bias and be confounded with correlated effects (Currie et al. 2013). In contrast, this paper adds to this burgeoning literature by exploiting a natural experiment into the effects of water quality on mortality that occurred prior to the understanding that water contamination could compromise health, namely, the advent of tea consumption in

18th century England. Since brewing tea would have required boiling water, and boiling water is a method of water purification, the rise of tea consumption in 18th century England would have resulted in an accidental improvement in the relatively poor quality of water available at the time. To what extent can this explain the drop in mortality rates seen over this period? While the link between increased tea consumption, population, and growth has been hypothesized by other authors (MacFarlane 1997; Mair and Hoh 2009; Standage 2006), to my knowledge this is the first paper to provide quantitative evidence on this relationship.

I put forth two identification strategies to estimate the causal relationship between tea consumption and mortality rates in England. The first is a differences-in-differences model that compares the period before and after the widespread adoption of tea in England across areas that vary in their initial levels of water quality. This is similar to the approach used by Nunn and Qian (2011), who exploit regional variation in the suitability of land for potato cultivation to estimate the impact of the potato on population. The second model employed here uses actual tea import data at the national level interacted with measures of water quality that vary across England. Thus, I investigate whether positive shocks to tea imports resulted in larger declines in mortality rates in areas where water quality was initially worse. As expected, preliminary results suggest that the introduction of tea resulted in larger declines in mortality rates in areas that had worse water quality to begin with. Areas with lower initial water quality also appear to have had larger declines in mortality rates in years following relatively high tea imports. I provide further support for the boiled water mechanism with analyses of cause-specific death data that show increased tea imports resulted in fewer contemporaneous deaths from water-borne diseases, but no similar decline in contemporaneous deaths from non-water-borne diseases.

The remainder of this paper is organized as follows. Section 2 provides some background on the historical context surrounding the introduction of tea to England. Section 3 presents the empirical strategy including the two identification strategies described above. Section 4 describes the data used in the analysis. Section 5 presents preliminary results, robustness checks, and empirical support for the mechanism using cause-specific mortality data. Section 6 concludes.

2 Historical Background

Tea was first imported to England from China in 1689 (Mair and Hoh, 2009) and like most newly imported goods, at the outset, tea was regarded as a luxury good enjoyed by the elite. By the end of the 18th century, however, a consumer revolution was taking place in which broad social groups were able to purchase newly available goods, such as tea (Allen 2009, p.49-50). As such, historical evidence indicates that even the humblest peasant drank tea twice a day (MacFarlane p.144-48). The rapid and wide acceptance of tea throughout the population was likely due to the distinct properties of tea that made it accessible to all social classes. In particular, only a few leaves are necessary to make a decent pot and tea leaves can be reused, such that boiling water can be poured over already-used tea leaves (MacFarlane and MacFarlane 2003), thus decoupling the link between income and tea consumption. While this production process would have produced weaker tea, it also suggests that the main health improvement associated with tea would be related to the properties of boiled water, as opposed to any particular property of the tea leaf itself.

Why then did tea emerge as the English national beverage? One important factor is the prominent role of the English East India Company (EIC) which had a long-running monopoly over trade with the Far East until 1834. Through its dominance in international markets, the EIC was able to bring so much tea into England that it was able to push other beverages such as coffee, out of the market by 1730 (Mair and Hoh 2009, p.176). Another cultural feature that helped solidify England as a nation of tea drinkers was the advent of tea houses, where, unlike all-male coffee houses, women could purchase their own tea. This ensured that tea would become a more accessible beverage, available to a wider population, and thus solidify its dominance as the country's national beverage. Tea gardens, which could be enjoyed by men, women, and families together, also enshrined tea as a cultural custom, as did the worker's tea break (Mair and Hoh 2009 p.186, MacFarlane and MacFarlane, p.80-94).

The relative cost of tea, further diminished by the ability to reuse tea leaves, was also an important feature in establishing tea's dominance over alternative beverages. For instance, the consumption of alcoholic beverages, such as ale and beer, had a long history in England prior to the introduction of tea. While these beverages would have also been a relative improvement over plain water, they were costly in comparison, in part due to the high costs of inputs involved in producing them, as well as the malt tax which further raised consumption costs. Thus, while "small beer" was at one point the usual beverage in England, by 1680, the malt tax had risen so considerably that it became necessary to find an alternative beverage (MacFarlane, p.151; Clark 1998, ch.1). Like beer, alternative beverages that may have provided an improvement in water quality, such as coffee, chocolate, wine, and whiskey, would also have been less suitable as a national beverage due to the high costs of inputs involved in production and unpleasant side effects from large-scale consumption (MacFarlane and MacFarlane, p.283). Raw milk, on the other hand, would have been contaminated with bacteria until pasteurization began around 1890 (MacFarlane 125-26). In contrast, tea was a relatively cheap, accessible, and safe beverage that was mild enough to be drunk throughout the day by the entire population (MacFarlane and MacFarlane p.31-39).

At the time that tea was sweeping across England, the methods for disposing human waste in England were still very primitive. Far too few privies existed and householders were known to accumulate their excrement and dispose of them in streets and rivers (MacFarlane 1997, p176). This made cities, with rising population densities, particularly dangerous, and may explain why urban men were substantially shorter than rural men over this period of rapid urbanization (Steckel 2005). At this time, however, the critical importance of separating human excrement from drinking water sources was not understood and thus typhoid and later cholera outbreaks were common. This may have been in part due to the fact that the germ theory of disease was in its very infancy and unknown to more than a handful of people worldwide. Prevailing views on the causes of mortality crises focused on miasmas, clouds of noxious gases that moved indiscriminately across the population spreading illness and death. It was not until the 1840s that William Budd (MacFarlane p.110) and John Snow (Johnson 2006, p. 74) argued that typhoid and cholera were spread through contaminated water, and their hypotheses continued to be hotly debated until John Snow's pioneering epidemiological study of the London cholera outbreak of 1854 publicly demonstrated the link between water and disease (Johnson 2006). This discovery spurred the public health movement that emphasized the need to separate drinking water sources and sewage infrastructure culminating in the first Public Health Act of 1848. Nevertheless, the act was poorly funded and it was not until the late 19th and early 20th centuries, well beyond the period studied here, that significant improvements were made in public sanitation and environmental health (Harris et al. 2010). Thus, the fact that people were ignorant of the dangers of contaminated water during the rise of tea consumption, coupled with evidence that people were not motivated to drink tea for its health benefits (MacFarlane 1997, p.149) and actually debated the merits of tea-drinking, (Mair and Hoh p.178-80), all suggest that tea drinking was likely to be independent of the types of unobserved variables that might present a challenge for identification.

While some might be concerned that estimating the relationship between tea and mortality over this period is actually a spurious correlation driven by rising wages, there is considerable evidence to suggest that although English wages were high relative to other countries, they rose very little over the course of the Industrial Revolution (Allen, 2009, p.41-42). Others have also suggested that however much real wages rose over this period, living standards did not rise (Mokyr 1993). What then can explain the dramatic drop in mortality seen over this period that has continued to be the subject of considerable historical debate (Johnson 1993)? While some have argued that it stemmed from nutritional improvements which allowed for a reduced incidence of infectious disease (McKeown 1983; Fogel 1989), still others have disputed this hypothesis (Schofield 1984; Lee 1981), and others have argued that nutrition actually declined over at least part of this period (MacFarlane 1997, ch.21). The decline of beer in the late 17th century owing to the high malt tax would certainly have meant a decline in nutritional quality of beverages, as tea is less nutritionally useful than beer. Thus the paradox of why England experienced a decline in mortality over this period without an increase in wages, living standards, or nutrition can be explained by the widespread adoption of tea as the national beverage and the commensurate increased consumption of boiled water (MacFarlane 1997, p. 150).

While this paper represents the first quantitative examination of this hypothesis, it should be noted that several historians have suggested that the custom of tea drinking was instrumental in curbing deaths from water-borne diseases and thus sowing the seeds for economic growth. MacFarlane (1997) draws comparisons between the experiences of England and Japan in this respect, concluding that "tea caused boiled water to be used, which caused dysentery to be minimized" (MacFarlane 1997, p.379). Mair and Hoh (2009, p.198) write that without "boiled beverages such as tea, the crowding together in immense cities...would have unleashed devastating epidemics." Similarly, Standage (2006, p.201) writes that the popularity of tea "allowed the workforce to be more densely packed in their living quarters around factories in the industrial cities... without risk of disease." This view is echoed by Johnson (2006, p. 95), who writes that "largely freed from waterborne disease agents, the tea-drinking population began to swell in number, ultimately supplying a larger labor pool to the emerging factory towns...."

3 Empirical Methods

3.1 First Identification Strategy

To measure the effect of tea drinking on mortality rates in England, I begin by comparing the mortality rates across areas that varied in initial water quality before and after tea consumption became popular. This is estimated via the following regression model:

$$Deaths_{it} = a_1 + \gamma_1 WaterQuality_i \times PostTea_t + X_{it}\beta_1 + \mu_i + \delta_t + \varepsilon_{it} \ , \qquad (1)$$

where the dependent variable is the natural log of the number of deaths in parish i in year t. The independent variable of interest, $WaterQuality_i \times PostTea_t$, is an interaction term between the initial water quality in parish i and a dummy variable indicating the period is after tea drinking was widespread among the broader population of England. As discussed above, although tea first came to England just prior to 1700, Figure 1 shows very little imported tea at the beginning of the series in 1761. Thus, it is unlikely that tea drinking was widespread at the beginning of the century and could not have had an appreciable effect on death rates at that time. From Figure 1, it appears that the volume of tea imports does not noticeably take off until after 1784, which coincides with the Tea and Window Act which reduced the tea tax from 119 to 12.5 percent at one stroke (Mair and Hoh, p.187-88). In light of this, I define $PostTea_t$ to be an indicator for years 1785 or later. In subsequent specifications, I also introduce lead indicators for the periods immediately preceding 1785 interacted with water quality measures to show that the results are robust to concerns regarding pre-existing trends prior to 1785.

All regressions also include parish fixed effects (μ_i) and year fixed effects (δ_t). X_{it} includes controls for other parish characteristics that vary over time, such as population measures which will be discussed below. Since very few time-varying controls are available for parishes over this period, the remaining components of X_{it} come largely from the interaction of other parish characteristics (e.g. the distance to a market town and the proximity to the coast) interacted with time period indicators. Standard errors are clustered at the parish level. Equation (1) is estimated on the years 1700-1839 to more closely surround the rise of widespread tea consumption in England.

3.2 Second Identification Strategy

To provide further evidence of the impact that tea consumption had on mortality rates, I utilize actual tea import data to compare the impact of national tea imports on mortality rates in areas that varied in their level of initial water quality:

$$Deaths_{it} = a_2 + \gamma_2 WaterQuality_i \times Tea\operatorname{Im}ports_{t-1} + X_{it}\beta_2 + \mu_i + \delta_t + \varepsilon_{it} \ , \qquad (2)$$

where the independent variable of interest, $WaterQuality_i \times Tea\operatorname{Im}ports_{t-1}$, is the interaction term between initial water quality in parish i and national-level tea imports in year t-1. The use of lagged tea imports reflects the fact that tea imports arriving in London may not have reached the final consumer until the following year. All remaining variables are as specified above. As a robustness check to ensure that the estimated effects are not simply driven by variation in incomes, I use data on other imported goods to show that the impact of tea imports on mortality rates survives the inclusion of miscellaneous imported goods, a proxy for income. This adds weight to the causal interpretation for the special role that tea played in decreasing mortality.

3.3 Support for the Mechanism via Cause-Specific Deaths

To further bolster the evidence that the mechanism behind these results was the improvement in water quality, I also use cause-specific death rates over this time period available in Marshall (1832) to show that higher tea imports curbed deaths from water-borne diseases such as dysentery, commonly described as flux or bloody flux (Wrigley and Schofield 1981). At the same time, falsification tests show that shocks to tea imports did not significantly affect contemporaneous deaths from air-borne diseases such as tuberculosis and smallpox. Unfortunately, cause-specific death rates are only available for London prior to the middle of the19th century, and thus the identification strategy here relies on linking variation in tea imports with variation in cause-specific deaths:

$$CAUSE\_Specific\_Deaths_{it} = a_3 + \gamma_3 Tea\,\mathrm{Im}ports_t + \theta_3 t + \phi_3 t^2 + \varepsilon_{it} \ , \qquad (3)$$

where current year's tea imports are included in the specification due to the fact that London would have been the main port of entry and also the site of the mortality measurements in this specification. A linear and quadratic time trend are also included as controls. As an extension, I also use data on infant and child mortality rates from London available in Marshall (1832) to run a similar specification to investigate whether infant and child deaths can be linked to variation in tea consumption. This is similar to the approach used by Galiani et al. (2005), with the obvious drawback that cause-specific mortality rates are not available across parishes, thus eliminating the possibility of a difference-in-differences strategy. In this context, however, the empirical prediction is somewhat less clear, as infants and children may have been less likely to consume tea, but because infants and children are more sensitive to water-borne diseases, they may have indirectly benefited from lower incidence of these diseases among the tea-drinking population (MacFarlane 1997).

4 Data Sources

4.1 Mortality Data

The mortality rates and parish characteristics used in the analysis are constructed from Schofield and Wrigley's (2003) collection of records on burials, baptisms, and marriages for 404 English parishes over the years 1538-1849. To limit the focus to the years in which tea was introduced, this paper focuses on the sample starting in 1700. While Wrigley and Schofield (1981) use these data to recover population estimates for England as a whole, they do not provide population estimates for the parishes individually. This is in part due to concerns about migration rates across parishes which are not available. Since it is important to scale deaths by the relative size of the parishes, I follow Wachter (1998) in constructing the following measure of population based on a weighted average of past measures of parish-specific burials, baptisms, and marriages:

$$Population_{it} = 0.4 \times \frac{smooth(Baptisms_{it})}{0.03} + 0.4 \times \frac{smooth(Burials_{it})}{0.025} + 0.2 \times \frac{smooth(Marriages_{it})}{0.008}, \tag{4}$$

where $Population_{it}$ is the constructed measure of population for parish i in year t and smooth(x_{it}) is the average of x_{it} over the past 20 years. As there may be some concern over the use of this constructed measure and the degree of measurement error it may include, I report specifications with the natural log of $Population_{it}$ on the right-hand side, as opposed to scaling the dependent variable by the constructed population measure. For comparison, I also present results with the measure of births ($Baptisms_{it}$) and marriages ($Marriages_{it}$), as well as marriages alone on the right-hand side instead of the constructed population measure.

4.2 Water Quality Measures

The water quality measures used in the analysis are based on parish altitude, slope, and initial population density in the parish at a point in time prior to the rise of tea consumption. It is believed that parish altitude should be positively correlated with water quality because parishes at higher elevation would have been less likely to be subjected to water contamination from surrounding areas. Similarly, a steeper terrain would have meant that water would be less likely to pool or stand and thus provide fewer sources for contamination. The measures of the average altitude (in meters) and average slope (in degrees) in the parish are constructed from NASA Shuttle Radar Topography images based on historical parish boundaries. The correlation between initial population density and water quality, however, is thought to be negative, as a denser parish would have posed greater challenges for disposing of human waste and thus provided greater sources for contamination. This is particularly true for this period prior to the widespread acceptance of the germ theory of disease and the public health movement that began later in the 19th century (Johnson 2006).

4.3 Tea Imports

The data on national-level tea imports come from the East India Company records available from Bowen (2007) and cover the years 1761-1834. Unfortunately, the data on tea are not available at the parish level, thus requiring the more subtle empirical strategy discussed above. Preliminary results show a negative correlation between tea imports and national mortality rates provided by Wrigley and Schofield (1981, p.531-534). This relationship is illustrated in Figure 1, which shows a dramatic rise in Chinese tea imports over the years 1761-1834, going from around 5 tons at the beginning of the period to well over 30 tons at the end.[1] Over the same period, mortality rates fell from around 29 to 24 deaths per 1,000 people. At the same time, there is substantial year-to-year variation in tea imports and mortality rates. Tying these phenomena together will prove useful in the proposed identification strategy below.

4.4 Descriptive statistics

Table 1 presents descriptive statistics for the data sources used in the analysis. Panel A includes mean and standard deviations for the three measures of water quality used below: parish altitude, slope, and parish population density in 1700. Table 1, Panel B describes the demographic data that vary over time which are used in the first identification strategy over the years 1700-1839. Finally, Table 1, Panel C describes the data on tea imports for the years 1761-1834 which are used in the second identification strategy outlined above.

The descriptive statistics might better illustrate the spirit of the identification strategy in graphical form. To this end, Figures 2 through 4 graph death rates against tea imports for the three measures of water quality used in the analysis. Figure 2 graphs the death rates against tea imports distinguished by whether the parishes were in high altitude (better water quality) versus low altitude (worse water quality) areas. The fitted line for the low water quality areas appears to be steeper than that for high water quality areas, suggesting that

[1] In response to increased competition, the East India Company began to shift production and exportation of tea to India, but not until the late 1830s (Mair and Hoh, p.212-13).

increased tea consumption had a bigger impact on lowering mortality rates in areas where water quality was worse. A similar relationship between tea and mortality is observed in Figure 3, where the fitted line for parishes with lower slopes (worse water quality) is steeper than for parishes with higher slopes (better water quality). In Figure 4, where population density in 1700 is used as the measure of water quality, worse water quality (higher population density) again appears to be linked with a bigger decline in death rates relative to areas with better water quality (lower population density), and thus produces a steeper fitted line for higher density parishes.

5 Preliminary Results

5.1 First Identification Strategy

5.1.1 Main Results

Tables 2A through 2C present the main results using the first identification strategy relying on the interaction between parish water quality and an indicator for the post-tea-drinking era which coincided with the dramatic drop in the tea tariff in 1785 (equation 1). Table 2A shows the results with the constructed population measure as a control whereas births and marriages are used as controls in Table 2B, and marriages alone are used as a control for the parish population in Table 2C. Across all three tables, the coefficients of interest on the interaction between the post-1785 indicator and the water quality variables all have the anticipated signs. The coefficients on the interaction terms positively correlated with water quality (altitude and slope) are positive, suggesting that a lower altitude or lower slope (worse water quality) was associated with a bigger decline in deaths after tea drinking became widespread. The coefficients on the slope and altitude interaction terms (columns 1 and 2 across Tables 2A through 2C) are also similar in magnitude ranging from 0.02 to 0.05, suggesting that they are measuring similar phenomena. Although the coefficients on the interaction between initial population density and the post-tea indicator (column 3 across Tables 2A through 2C) are not statistically significant in these specifications, their signs are nevertheless consistent with the above interpretation. While the coefficients are negative, they also suggest that worse water quality (a rise in population density) is associated with a drop in mortality after tea drinking became widespread.

5.1.2 Robustness

One common feature of difference-in-difference strategies is the parallel trends assumption that requires one to believe that the treated and control groups would have maintained parallel trends in the absence of treatment. While this assumption is ultimately untestable, a common method of bolstering the case for this assumption is to show that there were no pre-existing trends prior to treatment. Thus, to demonstrate the robustness of the first identification strategy, Tables 3A through 3C present the analogous results from equation (1) after including two pre-trend indicators interacted with the water quality measure. These include lead variables for the post-1760 era as well as the post-1770 era. As can be seen from the tables, most coefficients on interaction terms with the lead variables are small and statistically insignificant, with a few exceptions on the interactions with the 1760 indicator in tables 3A and 3B. The latter estimates, however, are in the opposite direction of the coefficient on the water quality variable interacted with post-1785, the treatment period thought to coincide with the widespread adoption of tea as the national drinking custom. In Table 3C, where the lead analysis is conducted with marriages as the population control, all coefficients on lead indicators interacted with water quality are statistically insignificant. At the same time, it should be noted that in all specifications in Tables 3A through 3C, the coefficient of interest on the interaction between the 1785 indicator and the water quality measure remains statistically significant and has the anticipated sign. This evidence mitigates concerns over whether pre-existing changes in mortality rates are driving the effects of interest and supports the notion that areas with worse water quality had greater declines in mortality after tea drinking became widespread in 1785.

5.2 Second Identification Strategy

5.2.1 Main Results

Tables 4A through 4C present the main results using the second identification strategy relying on actual shocks to tea imports (equation 2), with the constructed population measure as a control (Table 4A), births and marriages as controls (Table 4B), and marriages alone as a control for the parish population (Table 4C). In each table, Columns (1), (2), and (3) show the results with the altitude, slope, and initial population density measure as indicators of water quality, respectively. The coefficient on the interaction terms between water quality and lagged tea imports suggest the same pattern that was observed in Figures 2-4. First, the interaction term between tea imports and altitude has a positive coefficient (column 1 in Tables 4A through 4C). This suggests that lower altitude areas (with worse water quality) had relatively larger declines in mortality rates when England experienced a positive shock to tea imports. A similar pattern is true for the slope coefficient in column 2 of Tables 4A through 4C, which is also positively correlated with water quality. The interaction term between population density and tea imports (column 3 in Tables 4A through 4C) shows a negative coefficient, but a similar pattern of results, since population density is negatively correlated with water quality. The similarity of coefficient estimates across all tables also suggests that it makes little difference whether the population control is the constructed measure or the combinations of controls for marriages and births. These results validate those from the first identification strategy and point to tea shocks reducing mortality rates more in areas with worse initial water quality.

5.2.2 Robustness

Tables 5A through 5C address concerns over whether the coefficients of interest are picking up correlations between the variables of interest and some unobserved variables that are actually driving the results. For instance, one might be concerned that the measures of water quality are actually picking up some underlying wealth distributions or proximity to trade routes that are actually driving the correlation with mortality rates. To purge the coefficient of interest of these sources of variation, I include other parish characteristics interacted with the tea imports such as the distance to the nearest market town in 1700 (in km) and a variable indicating that the parish is within 10 km of the coast. A related concern is that the tea import data might be reflecting changes in income over time across parishes and these changes simply had a differential impact on mortality across different types of parishes. To address this, I make use of the East India Company's records on other (miscellaneous) imports and interact them with the measures of water quality used for identification. While the coefficient on the distance to market town interaction term is statistically significant across all specifications, none of the interaction terms between miscellaneous imports and the water quality measures are statistically significant. More importantly, Tables 5A through 5C show that the inclusion of these additional controls makes very little difference to the magnitudes or statistical significance of the original estimates using altitude and slope as the water quality measures from Tables 4A through 4C. This is true regardless of whether the population control used is the constructed measure (Table 5A), births and marriages (Table 5B), or marriages alone (Table 5C). Again, these results point to larger declines in mortality in areas with worse water quality following years with higher tea imports.

5.3 Support for the Mechanism via Cause-Specific Deaths

Finally, Table 6 shows the results from equation (3), that is, the investigation of whether variation in tea imports can explain variation in cause-specific mortality rates and infant and child mortality rates. Columns (1) and (2) show that higher tea volumes are associated with lower deaths from flux and bloody flux, two diseases most clearly identified with dysentery and diarrhea specifically. First, it should be noted that the average number of deaths due to both flux and bloody flux look small, particularly in comparison with those due to smallpox and consumption (tuberculosis). This is likely due to the difficulty in classifying cause of death during this period of time prior to modern medicine. In particular, it is likely that diarrheal diseases were misclassified, owing to symptoms such as fevers and abdominal pains that may have been confused with other diseases. Thus, although deaths due to intestinal infections are found to account for 8% of all deaths around the mid-19th century, it is reasonable to presume that actual rates were higher (Wrigley and Schofield 1981, p. 659). Thus, while we can conclude from columns (1) and (2) of Table 6 that higher tea volumes are associated with fewer deaths from flux and bloody flux (coefficient estimates -.282 and -.561, respectively), we should be more cautious in interpreting the relative impact implied by these estimates. Nevertheless, we can compare the sign and absolute magnitude of these results with those suggested by falsification tests where contemporaneous non-water-borne related deaths are used as dependent variables (columns 3 and 4). The choice of consumption and smallpox are used in light of the greater likelihood that these diseases would not have been confused with dysentery, in particular smallpox which was "clearly recognizable" (Wrigley and Schofield 1981, p.688). Columns (3) and (4) show that the coefficients on smallpox and consumption are positive in sign and statistically insignificant, with much larger magnitudes (1.735 and 2.791, respectively), in part owing to the much larger number of deaths due to these diseases over this period. This suggests that while tea drinking was associated with a decline in water-borne diseases, no similar decline in non-water-borne diseases was observed. This adds credence to the hypothesis that the mechanism by which tea reduced mortality was through the boiling of water.

As mentioned above, it is less clear whether tea should have had a noticeable impact on the mortality rates of infants and children, since children are more susceptible to water-borne diseases and may have benefited indirectly from a lower incidence of these diseases among the tea-drinking population. In any case, the evidence here does not point to any statistically significant relationship between tea imports and either infant (under 2 years old) or child (2 to 5 years old) deaths. Estimates are also small in magnitude (-6.74 and 2.138, respectively) relative to the large average number of deaths per year for these age groups (7189 and 2038, respectively). This may reflect the possibility that infants and children were less likely to drink tea, implying they did not see as much benefit to increases in tea volumes.

6 Conclusion

Preliminary results on the link between tea and mortality rates suggest that the rise of tea consumption in 18th century England resulted in larger declines in mortality rates in areas that had worse water quality to begin with. Areas with lower initial water quality also appear to have experienced larger declines in mortality rates in years following relatively high tea imports. While the magnitudes of the effects may seem small, it is important to note that they are most certainly underestimates, because tea likely played a role in reducing mortality rates in parishes with relatively good water quality over this period as well.

Although the broader impact of tea consumption on mortality rates at the dawn of the Industrial Revolution has been hypothesized by the historians noted above, to my knowledge this paper provides the first quantitative evidence on this relationship. Consequently, the empirical relationship uncovered here has the potential to make a significant contribution to the literature on the origins of the Industrial Revolution as well as the field of economic development which has recently seen a surge in attention devoted to improvements in water quality in currently developing countries. While that literature has primarily focused on evaluations of policy interventions and randomized trials, this paper is an important exception. Here, I present a case in which water quality was improved without design or concerted intervention, but instead through a change in culture and custom that ultimately may have proved critical for long-run economic development.

References

Allen, Robert C. 2009. *The British Industrial Revolution in Global Perspective.* New York: Cambridge University Press.

Alsan, Marcella and Claudia Goldin. 2015. "Watersheds in Infant Mortality: The Role of Effective Water and Sewerage Infrastructure, 1880 to 1915." NBER Working Paper No. 21263.

Beach, Brian, Joseph Ferrie, Martin Saavedra and Werner Troesken. 2014. "Typhoid Fever, Water Quality and Human Capital Formation." NBER Working Paper No. 20279.

Bowen, H.. 2007. East India Company: Trade and Domestic Financial Statistics, 1755-1838 [computer file]. Colchester, Essex: UK Data Archive [distributor], September 2007. SN: 5690, http://dx.doi.org/10.5255/UKDA-SN-5690-1.

Clark, Christine. 1998. *The British Malt-making Industry Since 1830.* London: The Hambledon Press.

Currie, Janet, Joshua S. Graff Zivin, Katherine Meckel, Matthew J. Neidell, and Wolfram Schlenker. 2013. "Something in the Water: Contaminated Drinking Water and Infant Health." NBER Working Paper No. 18876.

Cutler, David and Grant Miller. 2005. "The Role of Public Health Improvements in Health Advances: The Twentieth-Century United States." *Demography,* 42 (1): 1-22.

Devoto, Florencia, Esther Duflo, Pascaline Dupas, William Parienté, and Vincent Pons. 2012. "Happiness on Tap: Piped Water Adoption in Urban Morocco." *American Economic Journal: Economic Policy*, 4(4): 68–99.

Ferrie, Joseph P. and Werner Troesken. 2008. "Water and Chicago's Mortality Transition, 1850-1925," *Explorations in Economic History*, 45:1-16.

Fogel, R. 1989. "Second thoughts on the European escape from hunger: famines, price elasticities, entitlements, chronic malnutrition, and mortality rates." NBER Working Paper Series on Historical Factors in Long-Run Growth.

Galiani, Sebastian, Paul Gertler and Ernesto Schargrodsky. 2005. "Water for Life: The Impact of Privatization of Water Services on Child Mortality." *The Journal of Political Economy*, 113(1): 83-120.

Harris, Bernard, Roderick Floud, Robert W. Fogel, and Sok Chul Hong. 2010. "Diet, Health, and Work Intensity in England and Wales, 1700-1914." NBER Working Paper No. 15875.

Johnson, Steven. 2006. *The Ghost Map.* New York: Penguin Group.

Kremer, Michael, Jessica Leino, Edward Miguel, and Alix Peterson Zwane. 2011. "Spring Cleaning: Rural Water Impacts, Valuation, and Property Rights Institutions." *The Quarterly Journal of Economics*, 126(1): 145-205.

Lee, Ronald. 1981. "Short-term variation: Vital Rates, Prices, and Weather" In: *The Population History of England 1541-1871: A Reconstruction.* By E.A. Wrigley and R.S. Schofield.

Mair, Victor H. and Erling Hoh. 2009. *The True History of Tea.* London: Thames and Hudson.

MacFarlane, Alan. 1997. *The Savage Wars of Peace: England, Japan, and the Malthusian Trap.* Cambridge, MA: Blackwell.

MacFarlane, Alan and Iris MacFarlane. 2003. *The Empire of Tea: The Remarkable History of the Plant that Overtook the World.* New York: The Overlook Press.

Marshall, J. 1832. *Mortality of the Metropolis.* London: J. Haddon.

Mokyr, Joel. 1993. "Editor's Introduction: The New Economic History and the Industrial Revolution" in *The British Industrial Revolution: An Economic Perspective.* Ed. Joel

Mokyr. Boulder, CO: Westview Press.

McKeown, Thomas. 1983. "Food, Infection, and Population." *The Journal of Interdisciplinary History* 14(2): 227-47.

Nunn, Nathan and Nancy Qian. 2011. "The Potato's Contribution to Population and Urbanization: Evidence from a Historical Experiment." *The Quarterly Journal of Economics*, 126(2): 593-650.

Schofield, Roger. 1994. 2nd edition. "British Population Change, 1700-1871" In: *The Economic History of Britain Since 1700.* Eds. Roderick Floud and Donald McCloskey. 2nd ed.

Schofield, R.S. and Wrigley, E.A. 2003. Parish Register Aggregate Analyses, 1662-1811; 404 Data [computer file]. Colchester, Essex: UK Data Archive [distributor], April 2003. SN: 4491, http://dx.doi.org/10.5255/UKDA-SN-4491-1.

Standage, Tom. 2006. *A History of the World in Six Glasses.* New York: Walker Publishing.

Steckel, Richard H. 2005. "Health and Nutrition in the Pre-Industrial Era: Insights from a Millennium of Average Heights in Northern Europe." In: *Living Standards in the Past: New Perspectives on Well-being in Asia and Europe.* New York: Oxford University Press.

Stevenson, John. 1993. "Social Aspects of the Industrial Revolution." In: *The Industrial Revolution and British Society.* Eds. Patrick O'Brien and Roland Quinault. (ch.10). New York: Cambridge University Press.

Troesken, Werner. 2004. *Water, Race and Disease.* NBER Series on Long-term Factors in Economic Development. Massachusetts Institute of Technology.

WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation. 2012. "Progress on Drinking Water and Sanitation: 2012 Update." UNICEF and World Health Organization.

Wachter, Kenneth. 1998. "Levels of Demographic Randomness: Evidence from the Wrigley and Schofield Parish Series." University of California Berkeley.

Wrigley, E.A. and R.S. Schofield. 1981. *The Population History of England, 1541-1871: A Reconstruction*. Cambridge, MA: Harvard University Press.

Table 1: Descriptive Statistics

Panel A: Parish Characteristics	Mean	Std Dev	Median	N
Parish on coast or within 10 km of coast	0.267	0.443	0	404
Distance to Nearest Market Town in 1700 (km)	4.433	3.534	4	404
Area (acres)	5750.579	5348.921	4237	394
Population Density in 1700 (Pop_Constructed_1700/Area)	1.916	19.367	0.144	394
Parish altitude (meters)	83.502	60.246	76.6166	402
ln(Altitude)	4.112	0.907	4.33881	402
Parish slope (degrees)	2.407	1.579	1.924	402
ln(Slope)	0.702	0.591	0.654	402

Panel B: Parish-year characteristics, 1700-1839	Mean	Std Dev	Median	N
Deaths (burials)	31.438	43.998	20	52516
ln(Deaths)	2.963	0.993	2.996	52516
Births (baptisms)	41.029	60.276	27	52637
ln(Births)	3.253	0.958	3.296	52637
Marriages	11.558	20.553	7	50662
ln(Marriages)	1.911	0.997	1.946	50662
Population (Constructed Measure)	1247.764	1648.759	839.614	52849
ln(Population, Constructed)	6.735	0.852	6.733	52849

Panel C: Annual Imports, 1761-1834	Mean	Std Dev	Median	N
East India Company Tea Imports, millions of pounds, lagge	18.005	11.778	17.324	74
ln(Tea), lagged	2.590	0.878	2.851	74

Table 2A: The Impact of Tea Adoption on Mortality, Controlling for Constructed Population Measure

	(1)	(2)	(3)
	ln(Deaths)	ln(Deaths)	ln(Deaths)
Post1785*ln(Altitude)	0.0194***		
	(0.00696)		
Post1785*ln(Slope)		0.0203*	
		(0.0109)	
Post1785*ln(1700PopDensity)			-0.00730
			(0.00608)
ln(Population)	0.807***	0.808***	0.817***
	(0.0440)	(0.0441)	(0.0451)
Parish FEs	YES	YES	YES
Year FEs	YES	YES	YES
Observations	52,223	52,223	51,163

Robust standard errors clustered at parish level in parentheses below point estimates

*** p<0.01, ** p<0.05, * p<0.1

Table 2B: The Impact of Tea Adoption on Mortality, Controlling for Births and Marriages

	(1)	(2)	(3)
	ln(Deaths)	ln(Deaths)	ln(Deaths)
Post1785*ln(Altitude)	0.0502***		
	(0.0120)		
Post1785*ln(Slope)		0.0478**	
		(0.0188)	
Post1785*ln(1700PopDensity)			-0.0138
			(0.0127)
ln(Births)	0.287***	0.284***	0.285***
	(0.0176)	(0.0175)	(0.0182)
ln(Marriages)	0.0639***	0.0647***	0.0654***
	(0.00622)	(0.00640)	(0.00655)
Parish FEs	YES	YES	YES
Year FEs	YES	YES	YES
Observations	49,965	49,965	48,926

Robust standard errors clustered at parish level in parentheses below point estimates

*** p<0.01, ** p<0.05, * p<0.1

Table 2C: The Impact of Tea Adoption on Mortality, Controlling for Marriages

	(7)	(8)	(9)
	ln(Deaths)	ln(Deaths)	ln(Deaths)
Post1785*ln(Altitude)	0.0404***		
	(0.0150)		
Post1785*ln(Slope)		0.0459**	
		(0.0233)	
Post1785*ln(1700PopDensity)			-0.0207
			(0.0155)
ln(Marriages)	0.0923***	0.0926***	0.0936***
	(0.00830)	(0.00840)	(0.00871)
Parish FEs	YES	YES	YES
Year FEs	YES	YES	YES
Observations	50,102	50,102	49,063

Robust standard errors clustered at parish level in parentheses below point estimates

*** p<0.01, ** p<0.05, * p<0.1

Table 3A: The Impact of Tea Adoption on Mortality, Controlling for Leads and Constructed Population

	(1)	(2)	(3)
	ln(Deaths)	ln(Deaths)	ln(Deaths)
Post1760*ln(Altitude)	-0.00901		
	(0.0128)		
Post1770*ln(Altitude)	0.00370		
	(0.0117)		
Post1785*ln(Altitude)	0.0227***		
	(0.00774)		
Post1760*ln(Slope)		-0.0378**	
		(0.0164)	
Post1770*ln(Slope)		0.0133	
		(0.0171)	
Post1785*ln(Slope)		0.0359***	
		(0.0119)	
Post1760*ln(1700PopDensity)			0.0132**
			(0.00599)
Post1770*ln(1700PopDensity)			-0.000172
			(0.00633)
Post1785*ln(1700PopDensity)			-0.0165***
			(0.00575)
ln(Population)	0.808***	0.810***	0.818***
	(0.0444)	(0.0443)	(0.0451)
Parish FEs	YES	YES	YES
Year FEs	YES	YES	YES
Observations	52,223	52,223	51,163

Robust standard errors clustered at parish level in parentheses below point estimates

*** p<0.01, ** p<0.05, * p<0.1

Table 3B: The Impact of Tea Adoption on Mortality, Controlling for Leads, Births and Marriages

	(1)	(2)	(3)
	ln(Deaths)	ln(Deaths)	ln(Deaths)
Post1760*ln(Altitude)	0.0121		
	(0.0113)		
Post1770*ln(Altitude)	0.00961		
	(0.00975)		
Post1785*ln(Altitude)	0.0339***		
	(0.00988)		
Post1760*ln(Slope)		-0.0277*	
		(0.0166)	
Post1770*ln(Slope)		0.0223	
		(0.0147)	
Post1785*ln(Slope)		0.0489***	
		(0.0143)	
Post1760*ln(1700PopDensity)			0.0129*
			(0.00704)
Post1770*ln(1700PopDensity)			0.00242
			(0.00602)
Post1785*ln(1700PopDensity)			-0.0248***
			(0.00910)
ln(Births)	0.287***	0.284***	0.286***
	(0.0175)	(0.0175)	(0.0182)
ln(Marriages)	0.0635***	0.0647***	0.0653***
	(0.00622)	(0.00640)	(0.00653)
Parish FEs	YES	YES	YES
Year FEs	YES	YES	YES
Observations	49,965	49,965	48,926

Robust standard errors clustered at parish level in parentheses below point estimates

*** p<0.01, ** p<0.05, * p<0.1

Table 3C: The Impact of Tea Adoption on Mortality, Controlling for Leads and Marriages

	(1)	(2)	(3)
	ln(Deaths)	ln(Deaths)	ln(Deaths)
Post1760*ln(Altitude)	0.0185		
	(0.0129)		
Post1770*ln(Altitude)	0.00853		
	(0.0102)		
Post1785*ln(Altitude)	0.0205*		
	(0.0118)		
Post1760*ln(Slope)		-0.0153	
		(0.0190)	
Post1770*ln(Slope)		0.0143	
		(0.0160)	
Post1785*ln(Slope)		0.0449***	
		(0.0169)	
Post1760*ln(1700PopDensity)			0.00476
			(0.00807)
Post1770*ln(1700PopDensity)			0.00170
			(0.00667)
Post1785*ln(1700PopDensity)			-0.0255**
			(0.0107)
ln(Marriages)	0.0918***	0.0926***	0.0936***
	(0.00827)	(0.00839)	(0.00871)
Parish FEs	YES	YES	YES
Year FEs	YES	YES	YES
Observations	50,102	50,102	49,063

Robust standard errors clustered at parish level in parentheses below point estimates

*** p<0.01, ** p<0.05, * p<0.1

Table 4A: The Impact of Tea Imports on Mortality, Controlling for Constructed Population

	(1)	(2)	(3)
	ln(Deaths)	ln(Deaths)	ln(Deaths)
ln(Tea)*ln(Altitude)	0.0107***		
	(0.00327)		
ln(Tea)*ln(Slope)		0.0178***	
		(0.00489)	
ln(Tea)*ln(PopDensity_1700)			-0.00601**
			(0.00246)
ln(Population)	0.720***	0.717***	0.722***
	(0.0537)	(0.0534)	(0.0543)
Parish FEs	YES	YES	YES
Year FEs	YES	YES	YES
Observations	26,745	26,745	26,199

Robust standard errors clustered at parish level in parentheses below point estimates

*** p<0.01, ** p<0.05, * p<0.1

Table 4B: The Impact of Tea Imports on Mortality, Controlling for Births and Marriages

	(1)	(2)	(3)
	ln(Deaths)	ln(Deaths)	ln(Deaths)
ln(Tea)*ln(Altitude)	0.0130***		
	(0.00438)		
ln(Tea)*ln(Slope)		0.0230***	
		(0.00618)	
ln(Tea)*ln(PopDensity_1700)			-0.0104**
			(0.00404)
ln(Births)	0.233***	0.232***	0.230***
	(0.0166)	(0.0165)	(0.0168)
ln(Marriages)	0.0439***	0.0437***	0.0443***
	(0.00674)	(0.00675)	(0.00690)
Parish FEs	YES	YES	YES
Year FEs	YES	YES	YES
Observations	25,986	25,986	25,446

Robust standard errors clustered at parish level in parentheses below point estimates

*** p<0.01, ** p<0.05, * p<0.1

Table 4C: The Impact of Tea Imports on Mortality, Controlling for Marriages

	(1)	(2)	(3)
	ln(Deaths)	ln(Deaths)	ln(Deaths)
ln(Tea)*ln(Altitude)	0.00778		
	(0.00513)		
ln(Tea)*ln(Slope)		0.0202***	
		(0.00734)	
ln(Tea)*ln(PopDensity_1700)			-0.00997**
			(0.00456)
ln(Marriages)	0.0608***	0.0606***	0.0606***
	(0.00763)	(0.00760)	(0.00779)
Constant	2.904***	2.937***	2.929***
Year FEs	YES	YES	YES
Observations	26,086	26,086	25,546

Robust standard errors clustered at parish level in parentheses below point estimates

*** p<0.01, ** p<0.05, * p<0.1

Table 5A: The Impact of Tea Imports on Mortality with Additional Controls, Controlling for Constructed Population

	(1)	(2)	(3)
	ln(Deaths)	ln(Deaths)	ln(Deaths)
ln(Tea)*ln(Altitude)	0.00908**		
	(0.00425)		
ln(MiscImports)*ln(Altitude)	0.00496		
	(0.00660)		
ln(Tea)*ln(Slope)		0.0163***	
		(0.00623)	
ln(MiscImports)*ln(Slope)		0.00918	
		(0.00970)	
ln(Tea)*ln(PopDensity_1700)			-0.000801
			(0.00256)
ln(MiscImports)*ln(PopDensity_1700)			-0.00719
			(0.00458)
ln(Tea)*NearCoast	-0.000552	-0.00944	-0.00701
	(0.00717)	(0.00674)	(0.00686)
ln(Tea)*DistanceToMarket	0.00269***	0.00293***	0.00181*
	(0.000842)	(0.000844)	(0.000947)
ln(Population)	0.718***	0.716***	0.722***
	(0.0532)	(0.0527)	(0.0538)
Parish FEs	YES	YES	YES
Year FEs	YES	YES	YES
Observations	26,745	26,745	26,199

Robust standard errors clustered at parish level in parentheses below point estimates

*** p<0.01, ** p<0.05, * p<0.1

Table 5B: The Impact of Tea Imports on Mortality with Additional Controls, Controlling for Marriages and Births

	(1)	(2)	(3)
	ln(Deaths)	ln(Deaths)	ln(Deaths)
ln(Tea)*ln(Altitude)	0.0122***		
	(0.00455)		
ln(MiscImports)*ln(Altitude)	0.00737		
	(0.00609)		
ln(Tea)*ln(Slope)		0.0213***	
		(0.00623)	
ln(MiscImports)*ln(Slope)		0.0122	
		(0.00976)	
ln(Tea)*ln(PopDensity_1700)			-0.00299
			(0.00319)
ln(MiscImports)*ln(PopDensity_1700)			-0.00987*
			(0.00568)
ln(Tea)*NearCoast	0.00789	-0.00440	-0.00190
	(0.00981)	(0.00935)	(0.00941)
ln(Tea)*DistanceToMarket	0.00399***	0.00430***	0.00275**
	(0.00122)	(0.00123)	(0.00135)
ln(Marriages)	0.0445***	0.0443***	0.0445***
	(0.00673)	(0.00672)	(0.00689)
ln(Births)	0.233***	0.232***	0.230***
	(0.0164)	(0.0163)	(0.0166)
Parish FEs	YES	YES	YES
Year FEs	YES	YES	YES
Observations	25,986	25,986	25,446

Robust standard errors clustered at parish level in parentheses below point estimates
*** p<0.01, ** p<0.05, * p<0.1

Table 5C: The Impact of Tea Imports on Mortality with Additional Controls, Controlling for Marriages

	(1) ln(Deaths)	(2) ln(Deaths)	(3) ln(Deaths)
ln(Tea)*ln(Altitude)	0.00877*		
	(0.00497)		
ln(MiscImports)*ln(Altitude)	0.00514		
	(0.00663)		
ln(Tea)*ln(Slope)		0.0193***	
		(0.00676)	
ln(MiscImports)*ln(Slope)		0.0104	
		(0.0111)	
ln(Tea)*ln(PopDensity_1700)			-0.00242
			(0.00359)
ln(MiscImports)*ln(PopDensity_1700)			-0.00972
			(0.00616)
ln(Tea)*NearCoast	0.0118	0.00307	0.00582
	(0.0114)	(0.0109)	(0.0109)
ln(Tea)*DistanceToMarket	0.00406***	0.00437***	0.00296*
	(0.00147)	(0.00148)	(0.00160)
ln(Marriages)	0.0613***	0.0612***	0.0609***
	(0.00763)	(0.00759)	(0.00780)
Parish FEs	YES	YES	YES
Year FEs	YES	YES	YES
Observations	26,086	26,086	25,546

Robust standard errors clustered at parish level in parentheses below point estimates

*** p<0.01, ** p<0.05, * p<0.1

Table 6: The Impact of Tea Imports on Cause-Specific Deaths, Infant, and Child Mortality in London

Dependent Variable: Number of deaths due to…

	(1)	(2)	(3)	(4)	(5)	(6)
	water-borne		non-water-borne			
	flux	bloody flux	smallpox	consumption	under 2 mortality	age 2-5 mortality
Tea (volume)	-0.282**	-0.561**	1.735	2.791	-6.473	2.138
	(0.133)	(0.264)	(6.914)	(7.473)	(8.612)	(4.391)
Observations	71	29	71	71	70	70
Mean of dep var	14.49	83.03	1487.73	3838.62	7188.50	2038.31

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes: Other control variables include a linear and quadratic time trend

Sources: Author's calculations based on mortality data from Marshall (1832) and tea import data from English East India Company records (Bowen 2007)

Figure 1: Tea Imports from China and the English Crude Death Rate

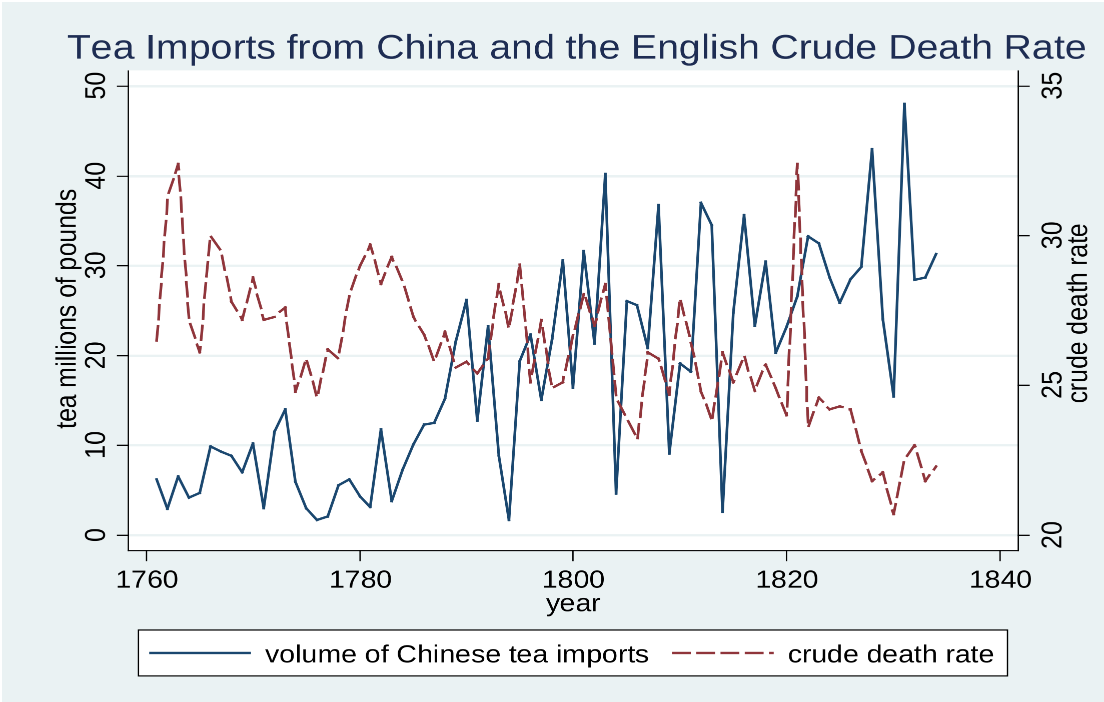

Figure 2: Average Parish Death Rates by Altitude and Lagged Tea Imports

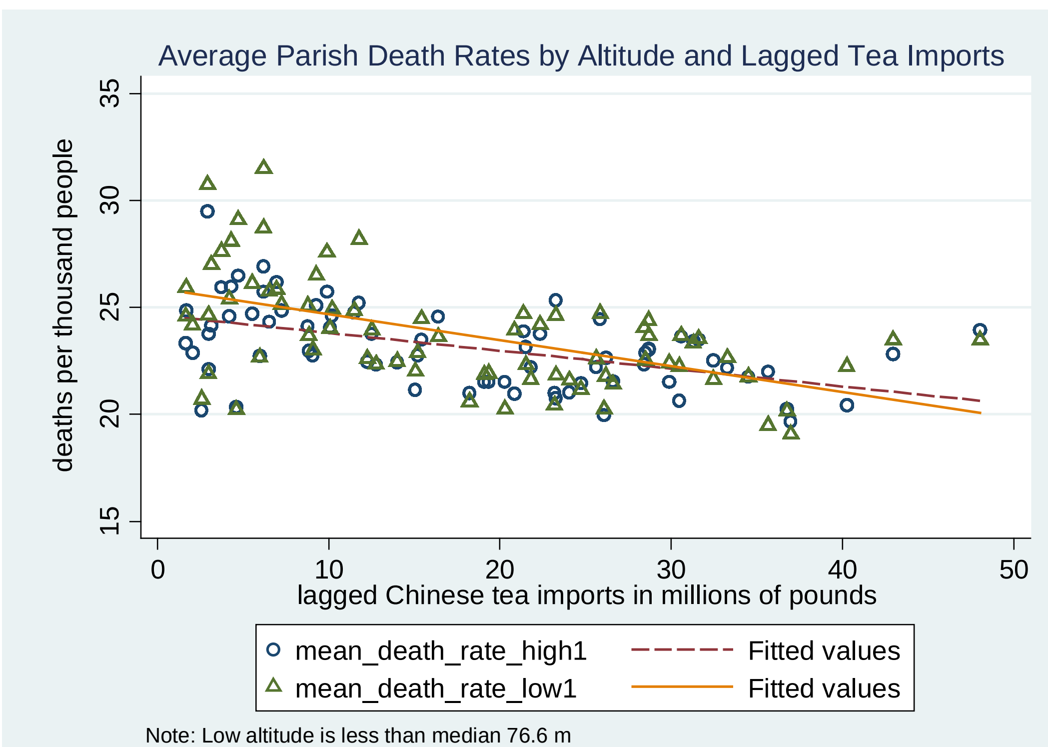

Figure 3: Average Parish Death Rates by Slope and Lagged Tea Imports

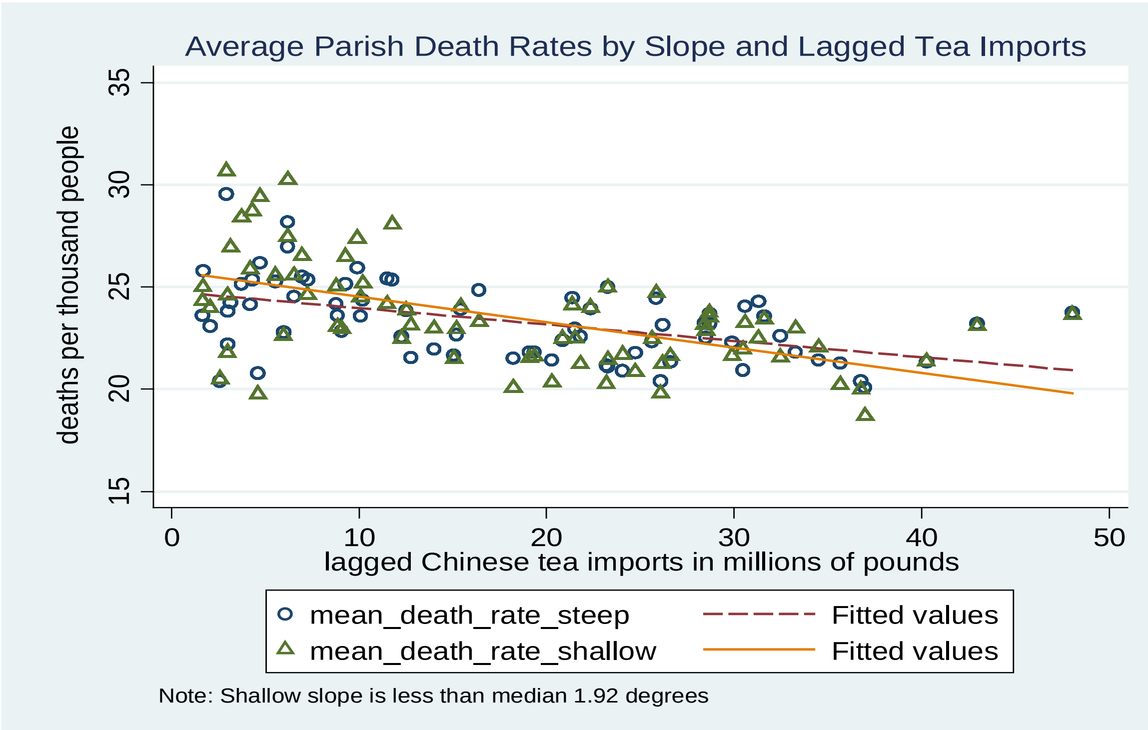

Figure 4: Average Parish Death Rates by Population Density in 1700 and Lagged Tea Imports