Brewing Up a Storm: Investigating British Tea Prices from 1690-1914

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With one of the highest tea per capita consumption rates in the world, tea has long been associated with the British national identity. In this essay, Féidhlim McGowan provides a thoroughly enjoyable discussion of tea prices in Britain between 1690 and 1914 and proposes a rigorous framework to investigate the impact of shocks on these prices during this period. He concludes by diligently considering the most suitable econometric approach and finds that an ARCH model is likely to be most appropriate.

Introduction

"I did send for a cup of tee, a China drink, of which I never had drunk before".
(Pepys, 1660)

As the global economy becomes ever more interconnected, it is instructive to examine how unpredictable events – or 'shocks' in economics parlance – can have important effects on the prices of factors of production and commodities. This paper aims to provide a framework through which the growth of tea as a commodity can be tracked, with specific emphasis on Britain from 1650 to 1914, and to identify the shocks that led to noticeable price changes during this time period. A priori, given the rise in popularity of tea it can be expected that most of these shocks will drive the price downwards. However, there have always been gains to be made from digging deeper into what appears at first glance to be self-evident. Was there a pattern to these shocks, and if so, what can they tell us about current trends in commodity flows?

Why tea? Since it was introduced to Mr. Pepys and Company in the mid-17th century, tea has been inextricably linked to revolutions, both military and industrial, and so it is intriguing to examine why such seemingly innocuous leaves from the Camellia sinensis plant brewed up such a storm. Hyperbole aside, there are at least three good reasons why studying the evolution of a specific commodity such as tea is a worthwhile exercise for economists today. Firstly, it may act as an instrument for policymakers. For

example, a lack of diversification in the supply of a staple good or service can be at best foolhardy, and at worst disastrous[1]. The prudent response is to ensure, whenever possible, a variety of suppliers for necessary goods. Further reason to study commodity flows is that the unintended consequences of such flows are a perennial source of fascination to historians and economists alike. How did the discovery of vast quantities of silver in the New World influence Euro-Asian trade patterns? Indeed, did the booming spice trade actually act as a catalyst for the discovery of the New World? Furthermore, for developing economies especially, the importance of commodity price changes cannot be overstated as fluctuations can have large effects on real output, the balance of payments, and the government budgetary position.

Finally, by virtue of the fact that tea was the natural complement to sugar, by examining the tea trade one may also gain insight into why the sugar industry, and the slavery that sustained it, evolved as it did. To this extent this proposed framework may have increasing returns to scale. As an aside, given the volume of the tea trade and its inter-linkages to sugar, it is a slight puzzle why the tea trade has received relatively little attention from economic historians. A final aim of this paper is to provide a slight redress of this imbalance.

A Brief History of the Tea Trade

This section deals with the existing work on the evolution of the British tea trade. The seminal work to date on British tea prices was carried out by Clark (2004) and Allen (2001). Both studies record a dramatic price decline for tea. The Clark series falls from a peak of 614 pence per pound in 1690 to 54 pence per pound in 1850 - a price drop of 91 per cent. The Allen paper starts at a later date (1760) but as evident in Figure 1 - taken from Hersch and Voth (2009) - it shows a high degree of correlation (0.89) with Clark's results. However, both of these papers are concerned with numerous commodities, and subsequently neither dwells on the specific reasons for this steep price decline.

Rich data on consumption patterns can be assembled in a patchwork fashion using three sources: Forrest (1973) for 1700-1770, Davis (1979) for 1784-86 and Moykr (1988) for 1794-1854. In aggregate, these papers document a secular rise in the quantity of tea consumed from 1690 for approximately 100 years. Some researchers posit that to gain a holistic view of the British tea trade one must examine the records of illegal imports or smuggling. A reference point in this area is "Smuggling and the British Tea Trade before 1784" by Hoh-Cheung and Mui. The authors begin by reminding the reader that when Adam Smith wrote that a highly taxed article, if in strong demand, would find a way of evading the additional charges, that tea was his primary evidence. The authors proceed to

1. One need look no further than the Irish potato crop and the then ubiquitous 'lumper' strain, which never failed – that is, until it did.

describe in minute detail why the smugglers could operate as they did until 1784. This data will be incorporated into the econometric model in section five.

A novel approach to the impact of tea in British life is provided by Hersh and Voth (2009) who raise the question of how the introduction of tea, coffee and sugar improved welfare in Britain. Using the Greenwood-Kopecky (2009) method, they find that the average Briton in 1850 would have been willing to give up 15 per cent of his income to retain access to tea and sugar. More pertinent to the thrust of this paper, the authors also incorporate the incentive to smuggle (i.e., the tariff rate) in a robustness check for the quantity of tea imported. As the authors explain:

> *"We hold the tariff rate constant at the period average to predict tea demand in the absence of tariff changes. This effectively reduces the rate of growth in the British demand for tea. Overall, the variability of the new, predicted series is lower than of the official imports"*

To conduct a robust analysis it is necessary to control for real income changes. Fortunately, Clark (2005) created a highly detailed real wage index which tracks many items, making it less volatile. This index shows that not until 1850 was the average real wage higher than in 1500. The price of tea and the real wage are intertwined through the elasticity of demand for tea, thus it is necessary to include real wages in the specified model.

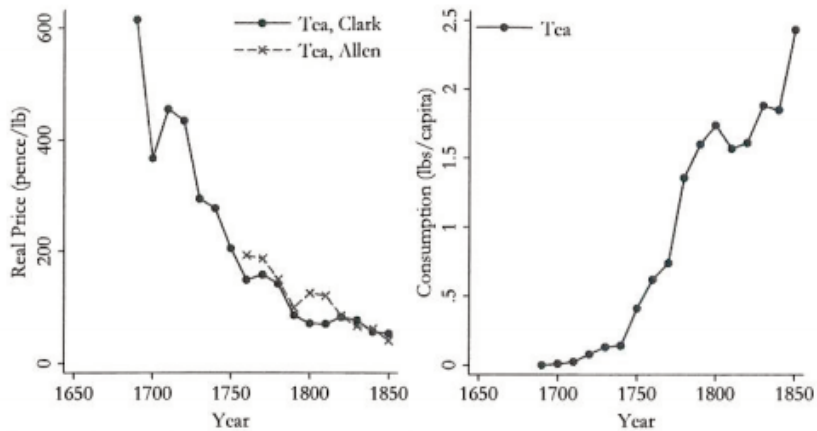

Figure 1: Tea Prices (Source: Hersch and Voth, 2009)

Possible Shocks to the Price of Tea

The Boston Tea Party, 1773: Apart from the minor incident of setting in motion a war of independence, the act of throwing crates of tea into Boston harbour also culminated in

legislation that abolished tariffs placed on tea in both the colonies and domestically[2].

The Opium Wars, 1839–42, 1859-1860: Along with silk and porcelain, a strong demand for tea developed in Britain from 1650 onwards. However, only silver was accepted in payment by China, which was self-sufficient and not particularly interested in purchasing any Western goods. Eventually the British figured out that instigating an influx of opium into China (despite the best efforts of the Chinese government) would be a deviously effective way of eliminating the trade deficit. This policy worked remarkably well, resulting in the Treaty of Nanking.

Tea Arrives in India, 1851: Despite strict Chinese restrictions on the movements of European merchants in the interior, Robert Fortune, a Scottish botanist, smuggled the Camellia sinensis plant out of the country to India[3], thus ending the Chinese monopoly on tea production. In addition to the plant, Fortune brought a team of expert Chinese botanists to foster the growth of tea in India[4]. Within a generation India was a world leader in tea production.

The Clipper Cometh, 1843: Tea was one of the few commodities that was valuable enough to command a speed premium in transit[5]. A Smithsonian article described the incentive thusly:

> *"In the middle of the 19th century, demand for fresh tea was such that the first vessel home from Fuzhou or Shanghai could command a premium of at least 10 per cent for her wares, and a clipper ship that cost perhaps £12,000 or £15,000 to build might bring home a cargo worth almost £3,000 on her first voyage".*

Tea and Typhoid

As a slight aside, this section briefly reviews the literature which implicates tea consumption as a causal factor in the successful build-up of large urban centres during the Industrial Revolution in Britain. Firstly, sweetened tea provided a convenient source of calories which facilitated longer working hours. This is a partial explanation for the 'British Food Puzzle' whereby, despite a substantial increase in real income per head, domestic demand for foodstuffs stagnated or declined from 1770-1850[6]. In fact, by 1900 one fifth of British calories came from sugar, mainly through the medium of tea[7].

The more substantive reason why some postulate that tea was vital for the Industrial Revolution is its role in making the nation healthier. For a start, tea has mild an-

2. Cole (1958) - duty on tea decreased from a high of 125 percent of net cost in 1736-40 to only 12.5 percent in 1787-91.
3. Rose (2011).
4. When choosing his team of botanists, it is said that Fortune favoured the brave.
5. Evans (1964).
6. Clark, Huberman and Lindert (1995).
7. Mintz (1985): Sweetness and Power.

tiseptic properties[8] which can be passed on through breastfeeding from mother to baby. Secondly, and perhaps more importantly, water is boiled in the tea making process, thus killing lots of nasty bacteria that cause illnesses such as dysentery and typhoid.

A possible rebuttal to this viewpoint is that a higher real wage meant the general population benefitted from improved nutrition, in quality if not in quantity, as the Industrial Revolution progressed. However, this argument does not hold given that studies investigating average height have found that physical well being actually declined during the Industrial Revolution[9]. Directly testing this theory about the health benefits of tea is unfortunately beyond the scope of this paper. However, to do so one could examine the incidence rate of waterborne disease and tea consumption in different cities before and during and after the Industrial Revolution. A preliminary hypothesis would be that the cities that were quicker to take up drinking tea would also record an earlier drop-off in the rates of these diseases. A well-specified regression with appropriate controls could be highly informative in this regard.

Empirical Approach

The nature of this proposal means it is impossible to avoid a certain element of deductive reasoning. The price changes in tea have been well documented (see Figure 1), and to simply replicate these findings using a simple linear regression would not add anything to the corpus of knowledge in this field. Ideally, the proposed research would lend empirical findings to what is at present just a hunch, or else debunk what is currently a persistent myth.

The most appropriate way to approach this research question is through the use of a time series analysis. However, one must proceed with caution when using such a tool and be aware of the many pitfalls such as spurious correlation and omitted variable bias that may be lurking in the data. Sufficient controls must be included to ensure the robustness of the results.

The table below summarises the data sources for this proposal. The main data source is the Clark database on commodity prices.

Variable	Source	Geographic Coverage	Period Covered
Price of Tea	Clarke (2005)	Britain	1200-1913
Income	Allen	Britain	1200-1913
Consumption	Forrest (1973), Davis (1979), Moykr (1988)	Britain	1700-1850
Tariffs	Cole (1958)	Britain	1726-1829
Clipper Speed	Clark (1910)	USA, Britain	1843-1869
Price of Substitutes	Clarke(2005)	Britain	1200 - 1913

Table 1: Data Sources

8. Chan et al (2011).
9. Komlos (1998).

The coefficients of the above independent variables are estimated to be as follows:

X_1: Income: The coefficient is expected to be positive, as a higher real wage will lead to more disposable income for tea and this increased demand will increase the price.

X_2: Consumption: This is analogous to demand. By construction the coefficient should be positive.

X_3: Tariffs: The coefficient expected to be positive, as higher tariffs should obviously increase the price of tea. It is necessary to include an interaction term for how tariffs negatively affects official consumption (i.e., the smuggling confound – see X_{10}).

X_4: Clipper speed: This is a proxy for transport costs, as the fewer days at sea means a smaller wage bill for deckhands etc. However, the expected coefficient sign is ambiguous as quicker transport means the tea arrives in better condition and could therefore command a higher price.

X_5: Price of substitutes: Coffee is the main substitute for tea. Standard economic theory suggests that price declines in coffee would, ceteris paribus, lead to decreased consumption of tea as people switch to the cheaper alternative. The decrease in demand should reduce the price, thus the expected coefficient is positive.

$X_6 – X_9$: In addition to the variables in the above table, dummy variables will be included to see whether certain events (outlined above) may be considered "shocks". A significant coefficient on these terms would add weight to the notion they were events of consequence for the price evolution of tea.

$X_{6,t-1} – X_{9,t-1}$, etc: To allow for the impact of shocks not becoming apparent immediately, lagged dummy variables will also be included in the model.

X_{10} : Smuggling interaction term (basically X_3*X_4).

And the dependent variable is:

Y_t: Price of Tea

Two possible approaches are as follows:

1. Dummy Variable Approach

$$Y_t = \beta 0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \ldots + \beta_9 X_9 + \beta_{6,t-1} X_{6,t-1} + \ldots + \beta_{9,t-1} X_{9,t-1} + \beta_{10} X_{10} + \varepsilon_t$$

This econometric model will aim to isolate the impact of possible shocks using a host of control variables and dummy variables. In essence this reduces to a study of outliers. There are two types of outliers to consider in this analysis – additive outliers and innovational outliers. Additive outliers are essentially errors in observations, for example if the price of tea in a particular year was wrongly transcribed by a clerk. These errors arise in many areas of economics but are particularly relevant in economic history. The pragmatic way to get around additive outliers is to use multiple data sources. Innovational outliers are different in that they affect subsequent observations. This type of outlier is central to the proposed model as their effect on prices is what the model attempts to isolate.

2. ARCH Approach

Myers (1992) suggests an Autoregressive Integrated Moving Average (ARlMA) methodology for modelling commodity price series. Myers writes that the accurate job ARIMA does of modelling "is consistent with the idea that commodity prices are made up of a stochastic trend and stationary deviations around trend". Krishnarani (2013) used ARIMA to model tea prices, but a major caveat is that he included no explanatory variables. This means that while still useful to consult, replicating this model using the above data would not achieve the desired goal.

An alternative, and probably superior method, is the use of an Autoregressive Conditional Heteroskedasticity (ARCH) model, which has the benefit of the error terms accounting for the time series element, i.e. that the series are correlated through time. This approach necessitates the vectorisation of the independent variables, which can be easily implemented in statistical pakage such as Stata. Next, lag tests are performed to choose the appropriate p and q[10] for the ARMA component, based on information criteria like AIC or BIC[11].

Then, the standard ARCH model is specified as follows:

$$y_t = x_t \beta + ARMA(p,q) + \varepsilon_t$$

$$Var(\varepsilon_t) = \sigma_t^2 = \gamma_0 + A(\sigma,\varepsilon) + B(\sigma,\varepsilon)^2$$

The advantage of an ARCH model lies in its ability to capture the time varying stochastic conditional volatility of the series and this can help in gaining an understanding of the

10. p = number of Autoregressive lags, q = number of moving average lags.
11. Khan and Asghar (2010).

process. In other words, it will give a better representation of how the explanatory variables and the movements in the price of tea are related. For example, the ARCH model could show the marginal effect of tariff changes on price.

Conclusion

To reiterate, this proposed framework sets out to accomplish quite an ambitious task – to explain why the price of tea changed with reference to specific shocks, rather than just how it changed. It is clear that the principles of this approach can be easily transposed to any other commodity. Although ARCH is probably the best econometric option available, it is advisable to keep one's hopes in check when attempting to achieve the goal set out at the beginning of this paper given the ominous warning: "what commodity prices lack in trend, they make up for in variance"[12].

12. Deaton (1999), quoted in Cashin and McDermott (2002).

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