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Sweet diversity: Colonial goods and the welfare gains from global trade after 1492☆

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ABSTRACT

When did overseas trade start to matter for living standards? Traditional real-wage indices suggest that living standards in Europe stagnated before 1800. In this paper, we argue that welfare may have actually risen substantially, but surreptitiously, because of an influx of new goods. Colonial "luxuries" such as tea, coffee, and sugar became highly coveted. Together with more simple household staples such as potatoes and tomatoes, overseas goods transformed European diets after the discovery of America and the rounding of the Cape of Good Hope. They became household items in many countries by the end of the 18th century. We apply two standard methods to calculate broad orders of magnitude of the resulting welfare gains. While they cannot be assessed precisely, gains from greater variety may well have been big enough to boost European real incomes by 10% or more (depending on the assumptions used).

1. Introduction

Before the Industrial Revolution, living standards stagnated for millennia: In the long run, in a Malthusian world, population increases always nullified the effects of productivity gains (Malthus 1803, Hansen and Prescott 2002, Galor 2005). Estimated living standards confirm this assessment: According to most real wage series, in most European countries, life in 1800 was no better than it had been in the Middle Ages.[1] Clark (2007) even argued that Englishmen in 1800 were no better off than their ancestors had been on the African savannahs.

In this paper, we argue that living standards prior to the Industrial Revolution may well have improved substantially, and that these gains were largely overlooked because gains from variety were key: Trade with overseas regions after 1500 may have increased European living standards, reducing the monotony of diets. In addition to colonial "luxury" goods such as sugar, tea, and coffee household staples, European diets began to include new food items such as potatoes and tomatoes (Qian and Nunn 2010). The rise of hot, sweetened beverages transformed meals (Braudel 1988; Cowan 2005). Other goods, such as tobacco, increased the range of

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[1] Clark (2005). Allen (2001) showed that in many European countries, real wages fell during the early modern period.

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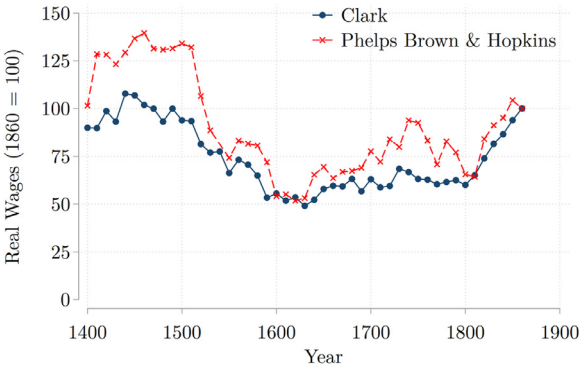

Fig. 1. Real wages in England, 1400-1860.

available consumer products. However, standard real wage indices fail to capture changes in welfare from the introduction of new goods (Boskin et al. 1998). Traditional real wage indices for early modern Europe are dominated by bread, wheat, and beer, and use consumption baskets with fixed weights (Phelps-Brown and Hopkins 1981; Allen 2001).[2] Mismeasurement is substantial because early modern consumers increasingly voted with their pocketbooks in favour of sugar, tea, and coffee.[3] Starting either from zero (for tea, tobacco, and coffee) or from very low levels of consumption (sugar), English imports per head surged to 23 pounds of sugar, 2 pounds of tea, 1 pound of tobacco, and 0.1 pound of coffee by 1804-06.[4] By 1800, nearly ten percent of the budget of English working-class households was spent on sugar, tea, and coffee (Feinstein 1998).[5]

Focusing on England during the period 1600 to 1800, we use detailed historical data on the price and consumption of increasingly affordable colonial goods to estimate welfare gains from their introduction. To put a value on new goods requires data on both prices and quantities consumed (Hausman 1996). We compile a comprehensive data set on the adoption on tea, sugar, and coffee, and use two techniques for analysing welfare gains from new products. We adapt the methods of Hausman (1999) and Greenwood and Kopecky (2013) to our historical data, exploiting both short- and long-run variations. The results suggest that by 1800, English welfare had increased substantially. While the magnitude of changes is hard to pin down precisely, gains may well have been in the order of 10% or more of per capital income. These findings lend further support to the argument that trade boosts living standards through gains from variety (Broda and Weinstein 2006).[6]

2. Historical background and context

2.1. Living standards in England before 1800

Real wages broadly suggest stagnation until 1800.[7] Fig. 1 presents two real wage series for the period of this study, by Phelps-Brown and Hopkins (1981) and Clark (2005). Phelps-Brown and Hopkins used a Laspeyres index for the seven centuries covered by their index, with a weight of 70% for food. Grain prices are the single biggest determinant of the Phelps-Brown Hopkins index. According to it, Englishmen saw their living standards surge by almost 200% after the Black Death. After 1500, a long period of decline set in. By 1800, real wages were no higher than in 1700 – and some 25%-50% lower than they had been in 1450.[8]

None of the existing indices of living standards during the early modern period incorporate the value of new goods. Loschky (1980) changed the weight for manufactured goods by using a different definition of the consumption basket. Feinstein

[2] Clark (2005) uses periodic updating of expenditure weights. For reasons that are well-known, this will still understate gains from variety to an important extent (Hausman 2003).

[3] Nordhaus (1996) makes a related argument, looking at the history of lighting to suggest that cost of living indices have vastly underestimated the decline in the cost of many goods over the last 200 years. Hulten (1996) questions Nordhaus's result.

[4] Mokyr (1988).

[5] A "Malthusian response" was not forthcoming since greater availability of colonial luxuries did not stimulate population growth: it neither reduced death rates nor raised birth rates.

[6] They recently investigated the issue empirically, and concluded that between 1970 and 2000, variety growth alone added 2.2-2.6 percent to US real income. Feenstra (1994) and Romer (1994) had earlier suggested that trade liberalizations may be welfare enhancing because they raise the range of goods available.

[7] According to Maddison (2001), English GDP per capita rose at a rate of less than 0.3% between 1500 and 1700.

[8] Loschky (1980) reworked the Phelps-Brown and Hopkins series, using Paasche and chain weighted price indices. His findings are more optimistic, showing a smaller decline during the early modern period. This is mainly due to changes in the relative price of manufactured goods, which became cheaper. For example, his Paasche index recovers its post-Plague peak by the middle of the 18th century, a full 100 years before the date indicated by the Phelps-Brown and Hopkins series.

used separate weights in his Laspeyres indices for three sub periods between 1770 and 1870.[9] Clark employed a geometric index of the price of consumer goods, using constant expenditure shares as weights. Since he bases his index on expenditure shares from the 1790s, his index captures some of the benefit that consumers derived from the declining prices of colonial goods. The reasons why the value of new goods is not captured in any of the existing price indices – even if budget shares are updated – are well-known.[10] As a result, the welfare implications of the radical transformation of consumption patterns and diets between 1500 and 1800 have largely been overlooked.

2.2. The adoption of colonial goods after 1492

Sugar can be derived from a variety of sources—sugarcane, sugar beets, roses, sorghum, honey, and other products. Early forms of sugar were available in small quantities at prohibitive prices. Europe's first taste of sugar derived from sugarcane came courtesy of Arab conquerors. Sugarcane production had reached Valencia and Sicily by the 10th century (Mintz, 1985). The Crusaders are said to have encountered Egyptian sugar when they advanced into Syria. From there, cultivation of sugarcane spread to Cyprus. From the twelfth century onwards, medieval court records show that English kings consumed sugar.[11] It was also grown in the Azores, the Canary Islands and on Madeira before reaching Brazil in the 1520s (Braudel, 1988). By 1572, a French observer commented that "people devour it out of gluttony… What used to be a medicine is nowadays eaten as a food."[12]

The availability of hot drinks also transformed eating habits. Over the course of the early modern period, breakfast changed profoundly. It went from a relatively heavy meal, often consisting of porridge or other grains, with some cold cuts, combined with wine or beer, to the modern-style, often light meal. Tea and coffee, more likely than not sugared, were combined with bread or pastry. As an English observer in 1722 noted: "before the use of tea, breakfasts were more substantial; milk in various shapes, ale and beer, with roast cold meat…".[13] In France, a Parisian observer noted the change in consumption amongst all classes by the eighteenth century:

> "Consumption [of coffee] has tripled in France; there is no bourgeois household where you are not offered coffee, no shopkeeper, no cook, no chambermaid who does not breakfast on coffee with milk in the morning. In public markets and in certain streets and alleys in the capital, women have set themselves up selling what they call *café au lait* to the populace."[14]

By the end of the 18th century, even the lowest ranks of society in England drank tea frequently. What had once been luxury goods, enjoyed by the few, was being consumed *en masse*. In 1800, the European continent as a whole imported 120 m. pounds of coffee, 125 m. pounds of tobacco, 40 m. pounds of tea, and 13 m. pounds of chocolate (Braudel, 1988). In combination, the introduction of coffee, tea, and sugar transformed European consumption habits.

3. Data

In calculating welfare gains for colonial luxuries, we use three types of data: quantities consumed, prices, and income.[15] For price data we rely mainly on Clark (2004), who computed detailed series for the period. Since sugar, tea and coffee cannot be grown in the British Isles, we use retained imports (imports less re-exports) per capita as a measure of consumption (Schumpeter, 1960; Sheridan, 2000). Finally, we use daily (nominal) workers' wages from Clark (2005) for income.

. Figure A.1 presents the Clark series for the real price of sugar. We convert from nominal to real (relative) prices using the CPI provided by Clark (2005). The real price of sugar declined dramatically over a relatively short period. It fell from a high of over 32 pence per pound in 1600 to less than 15 by the 1650s, before declining to 8.3 pence per pound in 1800. We obtain per capita consumption by dividing total retained imports by population.[16] Our sugar consumption data combines two series: Sheridan (2000) for the 17th century and Schumpeter (1960) for the 18th century. Sheridan estimates 2.13 lbs. of sugar were consumed per capita per year in 1663-1669. This grows to 4.01 lbs per capita in 1690-1699. Sugar consumption takes off in the 18th century, ending at 23 lbs. per capita in 1790-9 as measured by Schumpeter. We set an initial point of zero consumption of sugar at 1600, and interpolate between 1600 and 1700.[17]

Similar declines in prices and rise in consumption are apparent for both tea and coffee. Appendix figures A.1 and A.2 show the evolution over time. Tea experienced an even more dramatic price decline than sugar. The Clark series falls from a high of over

[9] He uses expenditure shares similar that are similar to Horrell (1996). However, since his analysis starts in 1770, it cannot capture changes in living standards before then as a result of the arrival of new goods.

[10] Cf. the report of the Boskin Commission to the Senate Finance Committee (1996). The committee recommended that even with a speedy introduction of new goods prices into the CPI it would be necessary to either extend backward their price history or incorporate a welfare adjustment measure similar to Hausman's.

[11] It is mentioned in the pipe rolls of Henry II (1154-89). Cf. Mintz (1985).

[12] Cit. acc. to Braudel (1988).

[13] Cit. acc. to Goodman (1995).

[14] Braudel (1988).

[15] All data and replication files can be accessed on openicpsr (https://doi.org/10.3886/E172801V1).

[16] Population figures are from appendix tables A5.2, A5.3 and A6.1 in Wrigley et al. (1997).

[17] We experimented with different assumptions about the year to which we attribute zero consumption, and with leaving out interpolated values in our welfare calculations. Results are broadly unchanged (available upon request).

830 pence per pound in 1690 to 72 pence in 1800, a price decline of 91%. Beginning at very low levels of consumption in the late 17th century, tea consumption grew to 2 lbs. per capita by the late 18th century. We assume that tea consumption was zero in 1690. Qualitative evidence such as the existence of London tea houses from as early as the 1660s (Forrest, 1973) and Samuel Pepys's diary suggest there was some consumption before that period. However, the earliest data on retained imports (from 1700) show that per capita consumption was still very low. This makes 1690 a conservative starting point.[18] The price of coffee declined from a high of nearly 140 pence per pound in 1710 to a low of 55 pence per pound in 1800. Per capita consumption grew from very low levels in 1700 to 0.279 lbs. per capita in 1790-9. As a percentage of household budgets, coffee never reached the importance of tea. By 1800, the English consumed almost ten times more tea than coffee by weight. We assume zero consumption of coffee in 1690.

4. Methods and results

As new goods become available, consumers switch some of their expenditure away from old goods. The extent to which they do so reflects their relative attractiveness. As prices fall, consumption normally goes up. To assess gain in consumer surplus from the introduction of new goods, we need to estimate the price at which consumption would be zero – the "shadow" reservation price of the new good. Welfare gains from giving consumers access to a new good are then approximated by the area under the demand curve between the "shadow" reservation price and the actual price paid by consumers, scaled by the quantity consumed. If demand is highly elastic (say, $\frac{\delta Q/Q}{\delta p/p} = \infty$), it will evaporate at the slightest price increase; in this case, consumers would not miss a new good much.[19]

The standard challenge in estimating welfare gains from new goods is that, most of the time, they are suddenly added to the choice set of consumers, at a given price – and are then available at volume. That means that the price at which consumer demand is zero is rarely observed, and needs to be estimated by sophisticated econometric methods. For example, when assessing the welfare gains from the introduction of Apple Cheerio cereal, Hausman (1996) estimated the price elasticity of demand using data on all breakfast cereals sales and prices over time. Apple Cheerios went from not available at all to being available, on average, at $3.48. Hausman's estimation implied a reservation price of $7.00, suggesting sizeable gains in consumer welfare. The consumer surplus can then be approximated by the area under the demand curve.

Here, we use two complementary perspectives to estimate the consumer surplus generated by new goods. One uses short-term fluctuations in prices and quantities imported; the other, the entire time path of price and consumption changes over two centuries. While results do not coincide exactly, both broad approaches strongly suggest substantial gains in consumer welfare.

4.1. Welfare gains from price elasticities and short-term fluctuations – results using hausman method

If we have a measure of the price elasticity of demand, welfare gains can be estimated relatively easily. The main measure of welfare gain we use is compensating variation (CV) – the amount of income that could be taken from consumers who have access to the new good, to make their welfare constant relative to consumers without access. Hausman (1996) shows that CV can be approximated by

$$CV \approx \frac{1}{2} S\eta^{-1}$$

where η is the price elasticity of demand, and S is the budget share of new goods. Estimates of price elasticities in modern studies of consumer surplus normally come from estimating demand systems using short-term price and quantity fluctuations (Petrin, 2002).

The challenge is to estimate price elasticities that shed light on English consumer preferences during the early modern period. Earlier scholars have already estimated such elasticities from consumer budgets during our period (Horrell, 1996), and from aggregate price and quantity series (Mokyr 1985). We also estimate elasticities from historical data directly, using prices and quantities of new goods. To identify coefficients, we use an instrumental variable design, derived from the logic of maritime warfare during the long 18th century.[20] The estimated elasticities for sugar range from -0.068 to -0.398, and for tea and coffee, from -0.17 to -0.644.[21]

Table 1 presents welfare gains using the Hausman method. Horrell's elasticities imply welfare gains for tea and coffee of 8.6% (6.4%) for 1801 (1759), and of 8.8% (7.2%) in 1801 (1759) for sugar when we use the price elasticity estimate for tea and coffee. Mokyr's elasticity estimates imply a smaller effect for tea and coffee, and a markedly bigger one for sugar. According to his tea elasticities, the welfare gain from coffee and tea in 1759 equalled 2.5-3%, rising to 3.3.4% forty years later. For sugar, his figures imply gains of 18-26.5% in 1759, rising to 22-32%.

Our own estimates yield values closer to those implied by Horrell's analysis. Using OLS estimates, we arrive at combined welfare gains of 13.8-17.8%, compared with her 13.6-17.3%. When we estimate using seemingly unrelated regressions, this declines to 10.2-

[18] For the Greenwood and Kopecky method it is necessary to set an initial point of zero consumption. This initial point has no implication for other methods of welfare estimation used.
[19] Details on the Hausman theoretical methodology for calculating welfare gains are presented in the Appendix.
[20] The appendix details the estimation strategy.
[21] I abstract from Horrell's (1996) of a price elasticity of 0.38 for sugar, as well as the IV result for sugar, since the coefficients are positive.

Table 1
Main welfare estimates, using Hausman method

Source of η	Commodity	η	estimation period method		CV circa 1759	CV circa 1801
			Panel A: Earlier Studies			
Mokyr 1988	sugar	-0.099	1855-1900	time series OLS	18.2%	22.1%
		-0.068	1855-1900	time series OLS	26.5%	32.2%
	tea and coffee	-0.644	1855-1900	time series OLS	2.5%	3.3%
		-0.54	1855-1900	time series OLS	3.0%	4.0%
				sum range	**20.7%-29.5%**	**25.3-36.2%**
Horrell 1996	sugar	0.48	1787-1854	AIDS		
	sugar	-0.25	1787-1854	AIDS	7.2%	8.8%
	tea and coffee	-0.25	1787-1854	AIDS	6.4%	8.6%
				sum	**13.6%**	**17.3%**
			Panel B: Authors' Estimates			
authors	sugar	-0.398	1700-1850	time-series OLS	4.5%	5.5%
	tea	-0.17	1700-1850	time-series OLS	8.2%	9.1%
	coffee	-0.186	1700-1850	time-series OLS	1.1%	3.2%
				sum	**13.8%**	**17.8%**
	sugar	-0.48	1700-1850	SUR	3.8%	4.6%
	tea	-0.253	1700-1850	SUR	5.5%	6.1%
	coffee	-0.213	1700-1850	SUR	1.0%	2.8%
				sum	**10.2%**	**13.5%**
	sugar	0.285	1700-1850	IV		
	sugar	-0.488	1700-1850	IV	4%	4.5%
	tea	-0.381	1700-1850	IV	3.7%	4.1%
	coffee	-0.595	1700-1850	IV	0.3%	1.0%
				sum	**7.7%**	**9.6%**

13.5%. Our IV estimates have the problem that the estimated elasticity for sugar is positive (as is Horrell's). If we use the average of the elasticity estimates for coffee and tea for sugar, we obtain aggregate gains of 7.7-9.6%. While each historical estimate produces different welfare gains, all results show that new goods added to the welfare of Britons – and that gains may well have been substantial, exceeding 10% of per capita expenditure by 1800 in all cases.[22]

Modern-day estimates of the demand elasticities provide a sanity check for this conclusion. Gemmill (1980), in a comprehensive survey of data from 73 countries, estimates the price elasticity of demand for sugar to be between -0.25 and -0.38 in the short run. This is close to the -0.398 to -0.48 we estimate, and the -0.25 we used from Horrell; it is larger in absolute size than the estimates in Mokyr (1985). Kanayama et al. (1999) estimate the demand elasticity for sugar to be between -0.13 and -0.16, closer to the values derived by Mokyr.

4.2. Consumer Surplus and Long-term Price Changes – Welfare Gains Using the Greenwood and Kopecky Method

Instead of using demand estimation based on short-term fluctuations of prices and quantities, we can use the time path of prices and quantities of new colonial goods directly, exploiting import statistics over more than two centuries. Greenwood and Kopecky (2013) estimate welfare gains from the introduction of computers, using annual data on the value and price of computers sold. In both the case of colonial goods and of computers, consumption surged as prices fell precipitously (Fig. 2). In both cases, supply shocks – technological progress in the case of one, new cultivation methods and increasing exploitation of slave labour on Caribbean plantations on the other – allow us to trace out demand curves. Greenwood and Kopecky's method uses information on budget shares and prices of new goods to calibrate a model describing the take-up of new goods over time. It jointly estimates preferences for the new good and the "reservation price," ensuring that marginal utility is finite for zero rates of initial consumption. Details on the Greenwood and Kopecky method are presented in the Appendix, and include information on model calibration and fit.

Welfare gains using this method are presented in Table 2. We find welfare gains of 4-5.7% from sugar, and 2.8-3.1% from tea. Coffee adds around 0.5%.[23] While the optimization is unproblematic for coffee and tea at decade frequencies, the estimates only converges for sugar if we provide guesses of $\rho>0.2$, and model fit is poor. The estimator does not converge for annual coffee data. Since coffee had the smallest share in overall consumption of the three "colonial luxuries", the ratio of data to noise in our time series is arguably particularly high. Using annual data, we find a slightly higher value for sugar and a markedly lower one for tea. The estimator for coffee does not converge. In combination, the Greenwood-Kopecky method suggests welfare gains from colonial goods of 7-9%, compared with a range of 10-14% from the Hausman method. While the estimates for each commodity vary, the aggregate effects implied by these estimates are greater than 5% consistently, and may well have been close to 10%.

[22] In Table A.2, we use examine the effect of estimation uncertainty, using 95% confidence intervals to assess the robustness of our findings. Even when using the estimates suggesting the most elastic response to price changes, we derive CVs of 8.1-10.1%, which we discuss further below.
[23] In this case, the algorithm has difficulty finding the optimum solution. We present results for the case of restricting the search to $\rho>0.2$.

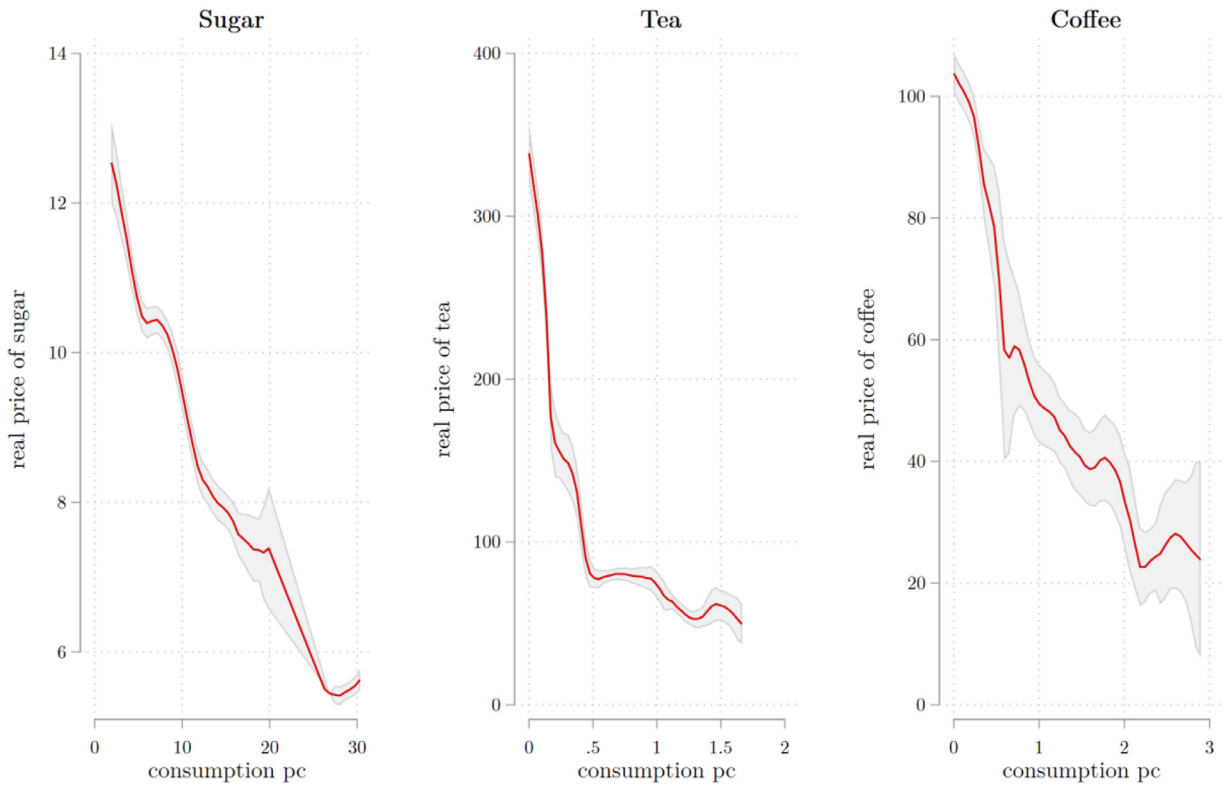

Fig. 2. Real Commodity Prices and Consumption Per Capita in England, 1600-1800 Note: Prices in pence per pound, relative to Clark's (2005) aggregate price index. Consumption in pounds per head, as discussed in the Appendix.

Table 2
Main welfare estimates, using Greenwood and Kopecky method

Commodity	Years	Sum of Errors	CV	ν	ρ	θ	R^2
			Panel A: decade data				
sugar	1600-1800	0.49	5.8%	5.02	0.702	0.725	0.52
tea	1690-1800	3.9	2.8%	0.0187	0.56	0.49	0.88
coffee	1690-1800	6.9	0.5%	0.019	0.33	0.20	0.54
Sum			**9%**				
			Panel B: yearly data				
sugar	1600-1800	8.1	4.0%	0.725	0.4349	0.4771	0.78
tea	1690-1800	71.6	3.1%	0.0031	0.3581	0.1468	0.59
Sum			**7.1%**				

Note: Estimated parameters include ν, the new goods utility shift at zero consumption, ρ the parameter governing the taste for the new good, and θ, the consumption share of old goods. Compensating variation (CV) measures the welfare gain, expressed as a fraction of income.

4.3. Discussion

Estimates of welfare gains from new goods cluster in the range around 10%, using two different methods and a range of price elasticities. However, they do not agree exactly on the magnitudes involved – and underlying elasticities are estimated with an error. What can we conclude with confidence from our results?

Table A.2 in the Appendix shows the range of plausible estimates, given the confidence intervals for estimates of price elasticities. At 95% confidence, the upper limit often includes zero; since price elasticities of demand above zero are generally not observed (except in the case of Giffen goods), we do not use these for calculating welfare gains. However, as Table A.1 shows, using upper bounds still results in quantitatively similar results even if entire categories of commodities are ignored. For example, under OLS, the mean estimate of the price elasticity of demand for sugar is -0.398; the upper bound is -0.171, which implies a compensating variation of 12.8%. Similarly, under SUR, for the upper bound we "lose" the estimate for coffee, but two estimates for sugar and tea become very large, suggesting a CV of 27.9%. Lower bound estimates of elasticities all lead to defined CVs, and are between 2/3

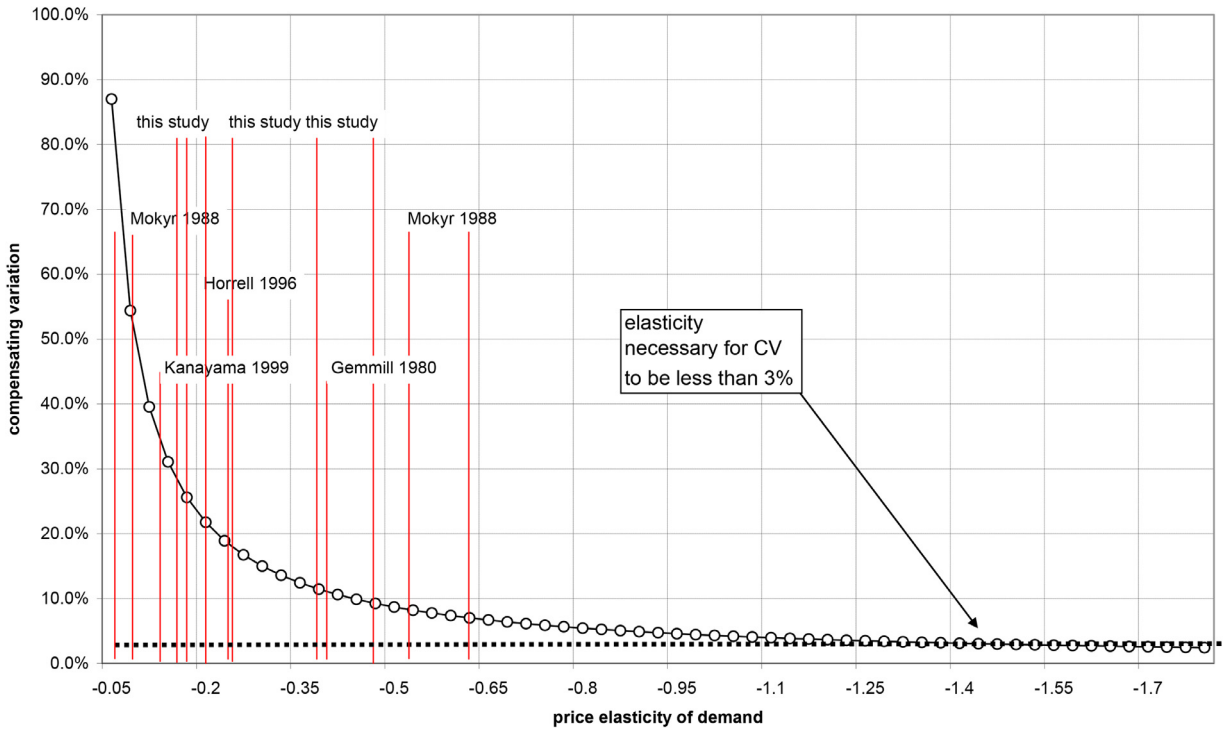

Fig. 3. Price Elasticities and Compensating Variation Note: The x-axis shows η, the price elasticity of demand. For any given value of η, we use the Hausman (2009) method to calculate a measure of welfare gains from new goods, the compensating variation, using $CV \approx 0.5S\eta^{-1}$ with the budget share of new goods S in 1801 (shown on the y-axis). Red lines indicate the price elasticities estimated by different studies. The graph also shows at which value of the price elasticity of demand implies CV < 3%, i.e. new goods would have only had a small effect on English welfare by 1801: -1.43.

and half of the mean estimates. Under IV, because it implies a negative price elasticity for sugar, the sum of lower-bound estimates suggests substantial gains, of 10.1%, mainly driven by sugar. The main result of our sensitivity analysis is that, even if we use the most pessimistic estimates throughout, we should add 8-10% to welfare in 1801.[24]

Consumer surplus is typically estimated from consumer expenditure surveys, combined with price information. Here, the conceptual basis is simple – given the behaviour of a consumer in, say, 1800, what is the gain in welfare from having access to good X? The closest analogy to this are our estimates based Horrell's budget surveys, implying CVs of approximately 12% in 1801. Data from longer time series is conceptually less appealing since consumer preferences may shift over the course of centuries. The (long-run) time series evidence by Mokyr implies markedly higher welfare gains, of 21-29%, mainly because of the low elasticities for sugar, whereas the short-term price and volume variation used to estimate coefficients in this paper suggests somewhat gains in the 10-14% range. Compared with that, the long-run time series used in the Greenwood-Kopecky method suggest estimates in the 7-9% range.

How elastic would demand have to be for new goods to add little to English welfare? In Fig. 3, we present such an analysis. We define "neglible" as 3% or less in 1801. Given the budget share of all new goods (tea, sugar, coffee) of 8.7%, we plot compensating variation as a function of possible elasticities. Red lines indicate estimated elasticities, from this study as well as Mokyr (1985), Horrell (1996), Kanayama (1999), and Gemmill (1980). For a welfare gain of 3% or less, the price elasticity of demand for "new goods" would have to be -1.43 or smaller. This is many times higher than even the most "pessimistic" elasticities estimates found in this study, or, indeed, in modern-day analyses of consumer behaviour. Similarly, Figure A.8-A.10 show implied values of welfare gains for combinations of ρ and θ, and plot the estimates obtained from the Greenwood-Kopecky method. For actual welfare gains to be equal to 0%, indicated by the red line, the parameter governing the utility of new goods (ρ) would have to shift down substantially, and the budget share for the old goods (θ) would have to rise by half.[25]

The Greenwood-Kopecky method leads to lower estimates of welfare gains overall. One interpretation could be as follows: the Greenwood-Kopecky method uses the entire history of new good consumption to assess the taste for new goods. However, as these new goods became available, consumer habits adapted; the underlying assumption of stable demand may not be entirely correct. If there was habit-formation, then prices did not fall as much as they should have done (consumers in 1801 liked their tea, in 1600, they

[24] Note that the probability of all three true values of the elasticity being at the 95% level in each estimation is not 5%, but 0.013% (0.05^3).
[25] Because of the challenges of calibrating the model for coffee, we do not present the results here.

Table 3
Impact of New Goods on Welfare, Contemporary vs. Historical

Good	Welfare Gain (CV)	Year	Source
	Modern Goods		
Apple Cinnamon Cheerios	0.002%	1992	Hausman (1996)
Personal computers	3.5-4%	2004	Greenwood & Kopecky (2009)
minivans	0.03%	1988	Petrin (2002)
Satellite TV	0.04-0.06%	2001	Goolsbee and Petrin, 2004
Internet	2-3%	2005	Goolsbee & Klenow (2006)
Mobile phones	0.46-0.9%	1996	Hausman (1999)
Foreign varieties	2.2-2.6%	2001	Broda & Weinstein (2006)
	Colonial Luxuries, 1800		
Sugar	4.0-32.2%	1600-1800	This study
Tea and Coffee	3.3-12.3%	1690-1800	This study
Tobacco	4.5-4.7%	1690-1800	This study (Appendix)

may not have been used to it). This will bias estimates if consumer preferences for new goods downwards (because of an outward shift of the demand curve).

5. Conclusions

When did globalization begin to matter for living standards? According to the prevailing consensus, the answer is – not before the 19th century. O'Rourke and Williamson (2002) analysed traditional wage indices to show that trade across the Atlantic did not change real incomes before the 1830s. This paper argues that global trade quickly began to matter for living standards. As Europeans rounded the Cape of Good Hope, they brought back tea; from the New World, they brought tobacco, chocolate, and potatoes. In the Caribbean and other tropical colonies, Europeans set up a production system for sugar, tea, and coffee that transformed the supply of these goods. By the eighteenth century at the latest, consumption habits had undergone a profound transformation. New consumption goods offered variety where monotony had once reigned: hot, sweet caffeinated beverages replaced water and ale, and by revealed preference, consumers favoured tea, sugar, and coffee. Sugar also helped to reduce the culinary monotony of winter: it facilitated the making of jam and marmalade, preserving fruit flavours throughout the winter.

The welfare gains from access to new goods can be assessed by asking a counterfactual question – how much would incomes have to go up to compensate for a particular consumer item no longer being available? We use two different methods, pioneered by Hausman and Greenwood and Kopecky, to gauge orders of magnitude. Results are broadly similar. Most estimates, even under pessimistic assumptions, suggest that colonial luxuries made consumers better off by about one tenth of final-period consumption – and perhaps more. We cannot confirm these results using highly granular data on individual demand curves as modern-day studies can, but the closest historical analogues also imply welfare gains of 10% or more.

Our quantitative results for tea, sugar, and coffee may well constitute a lower bound on the discoveries' overall effect. An even wider range of 'new goods' arrived on European shores as a result of overseas expansion (Nunn and Qian, 2010). The addition of tomatoes, potatoes, chocolate, exotic spices, polenta, and tobacco transformed consumption habits in even more fundamental ways than sugar, tea, and coffee. If data tracking the rise in consumption of all of these colonial goods were available, welfare increases for European consumers after 1492 as a result of growing variety could be even larger than our findings suggest.

Compared to the gains from new goods today, the welfare increases from introducing sugar, tea, and coffee in the past appear large. In Table 3, we compare the impact of recently invented new goods with our results, including welfare gains from tobacco estimated in the Appendix. Even for the contemporary new goods with the biggest impacts, such as personal computers and the internet, welfare gains pale in magnitude compared with those for colonial goods. Goolsbee and Klenow (2006) calculate a gain of approximately 2% for the internet. Our findings suggest welfare gains that are up to an order of magnitude larger (except when compared with personal computers).[26] Other studies of modern-day gains from trade through increasing variety also show smaller increases than the ones we derive. Broda and Weinstein (2006) find welfare gains of 2.2-2.6%, approximately 1/4 of our "best-guess" improvement of 10% from sugar, tea, and coffee alone.

Relatively large gains in the more distant past make sense intuitively: Introducing a new good matters more when the pre-existing range of goods is small. Put another way – adding Apple Cheerios to the range of choices for breakfast cereals has (some) value. However, being able to replace beer soup, porridge and cold cuts with milky, sugary coffee and bread with jam was much nicer, as evidenced by rising budget shares of colonial goods. Exotic new products from the Americas and the Far East – pepper and nutmeg, tea and sugar, coffee and tobacco, chocolate and cloves – improved living standards by far more than modern consumers, sated by an ever-expanding range of new goods, can readily appreciate. The reason why seemingly mundane goods like sugar, coffee and tea probably made a big difference to living standards is that life was not just 'nasty, brutish, and short' in Hobbes' phrase, at their time of introduction – it was also (in culinary terms) boring and bland.

[26] In a similar vein, the findings in Nordhaus (1996) and Leunig (2006) also suggest large welfare gains from new goods introduced in the past.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.eeh.2022.101468.

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Online Appendix - Sweet Diversity: Colonial Goods and the Welfare Gains from Global Trade after 1492

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I. Notes on Data Series

Details on Income Data

Income data comes from three series in Clark (2007). Clark provides daily wages for 'farm', 'craft', and 'building laborer' in pence per day[1]. We calculate income as follows: We know the prices and per capita consumption of sugar and tea. From these, we can calculate total expenditure on these goods. Contemporary budget surveys give an idea of the share of spending devoted to these goods. This in turn gives us an implied annual income. We translate Clark's daily wages into annual per capita incomes by adjusting the days of work per year such that the implied expenditure shares for sugar and tea match the budget surveys. This method suggests an average of 180 days of work per year.[2] Feinstein (1998) shows sugar accounted for 4.8% of a household's budget in 1788-92. Using consumption per capita of sugar from retained imports, our estimated incomes show sugar to be 4.4% of income in 1790. With regard to tea, in 1800 using our income estimates we calculate the expenditure share of tea at 3.1%, close to Horrell's estimate of 3.6% for 1801.

Details on New Goods Consumption Data

Data on consumption of new goods in Britain is derived from official import statistics. These will underestimate true consumption if goods arrived via illegal channels. At various times, smuggling was rife in Britain during the early modern period. Tariffs and excise taxes were high, especially for tea and tobacco. A standard way to smuggle goods into the country was to

[1] We use as a raw wage series the arithmetic mean of the three series. Weighting is not an issue, as the income level is set by the number of days worked per year.

[2] The number for adult males was probably much higher (Clark and van der Werf 1998, Voth 1998, 2001). Note that we are estimating the number of working days per Englishman, including small children and the elderly, in adult male wage equivalents.

officially 're-export' colonial goods, and then land them illegally.[3] Tea and tobacco were easy to smuggle. Sugar and coffee were affected much less because the weight/value ratio was less favorable.[4] Mokyr (1988) estimated that between half to over 90 percent of all tobacco consumed in Great Britain had been smuggled.

Standard statistics on retained imports deduct re-exports fully from the import figures, some of which may have returned as smuggled goods to Great Britain. This is particularly problematic since the incentive to smuggle varied over time. For example, duty on tea fell from a high of 125 percent of net cost in 1736-40 to a mere 12.5 percent in 1787-91 (Cole 1958). The incentive to smuggle therefore declined markedly over time (though by the 1820s, tea duty had returned to 100 percent of net cost); the share of smuggled goods in final consumption probably fell.[5] Since the Greenwood and Kopecky welfare estimates depend on how quickly the consumption of new goods rises, the legal import figures may paint too optimistic a figure – real consumption may have risen much less during the periods of tariff reductions. The extent to which one can correct for smuggling in British import statistics is controversial (Cole 1958, Hoh-Cheung and Mui 1975, Cole 1975). In the main section, we will use the 'official' statistics on retained imports.

We use a variety of sources to track the price of tobacco and the volume consumed. For the early years, 1630-1693, we rely on Rogers (1887).[6] At the beginning of our period, there is confusion in the price series about the quality for which prices are being quoted. Spanish tobacco was several times dearer than colonial tobacco. Price fluctuations may be driven by overall

[3] This required forging the landing documents from a foreign port, or bribing an official to provide them (Hoh-Cheung and Mui 1975).
[4] Mokyr (1988).
[5] In figure A5 in the appendix, we plot legal imports and the tariff rate side-by-side.
[6] For the interval 1700-1740, there is data in Clemens (1980). It is for colonial America, and the price trend is different from the one in the UK. We decided not to use it in our estimation procedure since there is no direct way of matching Clemens' data with the Rogers and Clark series.

changes in the price of tobacco, or by its origin. To sidestep the issue, we adjust the prices of Spanish tobacco by the average price difference between both types.

II. Theoretical Methods

Hausman Method

Hausman (1999) suggested a simple method for estimating welfare gains from the introduction of new goods. This method can be applied to any standard utility function:

$$CV \approx \frac{1}{2} S \eta^{-1}$$

Where CV is compensating variation, S is the share of the new good in expenditure, and η is the price elasticity of demand. Effectively, the Hausman method estimates the welfare gain as the area of a triangle in a demand diagram with price and quantity on the y- and x-axis. The triangle is formed by the area between the price-quantity combination, the y-axis, and the tangent to the (compensated) demand curve. The lower the price elasticity of demand, the greater the windfall for consumers from the introduction of a new good.

Greenwood-Kopecky method

An alternative approach for valuing new goods is Greenwood and Kopecky (2013). They use a standard CRRA function, but shift the marginal utility from the initial consumption of a new good so that it is bounded. From this, they derive estimates of welfare gains CV and EV. In the Greenwood and Kopecky model, utility is fully separable between new and old goods. Consumers derive utility $V(n)$ from consuming quantity n of new goods, and utility $U(c)$ and from quantity c of old goods. Both the consumption of new and old goods follow standard CRRA preferences, with one important qualification in the case of new goods:

$$U(c) = \frac{c^{1-\rho}}{1-\rho}, \text{ with } \rho \geq 0$$

and

$$V(n) = \frac{(n+\nu)^{1-\rho}}{1-\rho}, \text{ with } V(0) = \frac{\nu^{1-\rho}}{1-\rho} > -\infty \text{ and } V_1(0) = \nu^{-\rho}$$

Where ρ is the degree of risk aversion, and 1/ρ is intertemporal elasticity of substitution, which captures the marginal benefits from the new good. Adding ν to the CRRA preferences shifts the standard utility function so that the marginal utility of the first item of a new good is finite. At zero consumption of the new good, marginal utility of the first unit is $\nu^{-\rho}$. This leads to a threshold price, $\hat{p}$ for the new good where $\hat{p} \geq \hat{P}(y)$ and $\hat{P}(y) = \frac{1-\theta}{\theta}\nu^{-\rho}y^{\rho}$. If the price of the new good is higher that this threshold ("reservation") price, consumption of the new good will be zero. Welfare gains are calculated from the indirect utility functions with and without access to the new good.

Consumer maximize overall utility

$$W(y,p) = \max_{c,n}\left[\theta U(c) + (1-\theta)V(n)\right]$$

with $0 < \theta < 1$; $c, n \geq 0$; and subject to the budget constraint $c+pn=y$

Utility maximization generates a demand function for new goods of the form

$$\hat{n} = \frac{y+p}{p + [(1-\theta)/\theta]^{-1/\rho}\, p^{1/\rho}} - \nu$$

which is greater than zero as long as price is below the threshold price, $\hat{p}$, otherwise $\hat{n} = 0$. Here, θ is the utility weight on the old good, and (1-θ) the utility weight of the new good, c serves as a numeraire, p is the relative price of new goods, and y is income.

Welfare gains can be expressed using two measures – compensating variation and equivalent variation. Suppose there are two states of the world: In state 2, consumers have access to the good; in state 1, they do not. State 1 can be considered as a special case of state 2 where the price of the new good is infinitely high. The equivalent variation (EV) is the increase in income needed (λ) to give the consumer in state 1 (without access to the new good) the same level of utility as a consumer in state 2 (with access). This can be written as

$W((1+\lambda_{EV})y_2, \infty) = W(y_2, p_2)$

where $W(y_t, p_t)$ is the indirect utility function which has as inputs current prices p_t and income y_t. EV is expressed in percent of income in state 2, i.e. it is the increase λ in consumption of the "old goods" that would make a consumer indifferent between having no access to the new good, and consuming the actual quantities of the new good at actual prices.

$$W((1+\lambda_{EV})y_2, \infty) = \frac{\theta((1+\lambda_{EV})y_2)^{(1-\rho)}}{1-\rho} + \frac{(1-\theta)\nu^{1-\rho)}}{1-\rho}$$

which yields

$$\lambda_{EV} = \frac{[(1-\rho)W(y_2,p_2)]-(1-\theta)\nu^{\frac{1}{1-\rho}}}{(\theta^{\frac{1}{1-\rho}}y_2)-1}$$

Similarly, compensating variation (CV) is defined as the amount of *income* a consumer would be willing to lose, provided he retained access to the new good. Formally, this implies

$W((1-\lambda_{CV})y_2, p_2) = W(y_2, \infty)$

CV is expressed as a percentage of income in state 2. There is no closed-form solution to calculating CV in the Greenwood-Kopecky model. It has to be calculated using numerical methods. With quasi-linear preferences, the results for both will be identical, which is why we focus on compensating variation (as this is the same outcome as in the Hausman method).

To perform this calculation, observed data on income (y), prices (p) and new good consumption (n) are used to calibrate the preference parameters: the intertemporal elasticity of substitution ($1/\rho$), the weight on utility of non-new good consumption (θ), and the utility shift parameter (ν). Using the method by Greenwood and Kopecky (2013), we calibrate ν, θ, and ρ to minimize the sum of squares of differences between observed new goods, n, and the predicted new goods, $\hat{n}$.[7]

III. Calibration and Empirical Estimation of Price Elasticities for New Goods

The Hausman method requires values for the price elasticity of demand η and for S, the budget share of new goods. Budget shares can be obtained from estimates of import values and expenditure. Massie (1760) presented figures for annual sugar consumption for 51 different groups in English society – from the highest ranks of the nobility to the lowest rungs of the social ladder. He estimates that in aggregate, spending on sugar amounted to 3.4% of all expenditure. For 1800, we have estimates from Horrell (1996) for both working-class spending and England as a whole. She finds expenditure shares for workers of 2.6% for tea and coffee and of 3.6% for sugar and treacle. At the national level, this rises to 3.2% and 6%, because non-workers consumed more of these goods.

One attempt to estimate η for sugar and tea from historical data is Mokyr (1988). Using time-series data from the period 1855 to 1900 and an inverse-log specification, he obtains own-price elasticities of -0.54 to -0.64 for tea, and of -0.068 to -0.099 for sugar. The data used in this estimation comes from the period after 1800, and may not be well-suited to our purposes. One

[7] As in Greenwood and Kopecky, we constrain consumption in the beginning of the period to zero. Due to the nonconvex nature of the equation (10), a simplex nonlinear optimization algorithm is used for the sum of squares minimization.

alternative way of obtaining estimates of η is to use micro-data.[8] Horrell (1996) does so, analysing working-class expenditure patterns to estimate an almost ideal demand system (AIDS). She finds an own-price elasticity of -0.25 for tea and coffee, and of 0.4 for sugar. While the first estimate is similar to the ones obtained by Mokyr, the latter, positive one is difficult to rationalize – there is little reason to think that sugar was a Giffen good.

To calculate our own empirical elasticities, we start by estimating a model of the form:

$$ln(Imppc_{i,t}) = C + \eta_i ln(rp_{i,t}) + \epsilon_{i,t}$$

where $Imppc_{i,t}$ is the consumption of commodity in year t, which we regress on its real price *rp*. To control for the secular downward trend in prices we transform imports per capita by using the residuals of imports per capita against a time trend. That is our dependent variable in the above equation -- the residual from the equation $imports\ pc_t = \beta_0 + \beta_1 * year_t$. The results from estimating these elasticities are presented in table A1. The results in columns 1-3 show the results of simple time-series OLS. As is common in other implementations of demand estimation (Ozuna and Gomez 1994), we can also use seemingly unrelated regressions (SUR) to estimate a set of η jointly, taking into account that the error terms in eq. (1) are not uncorrelated.

Finally, we use historical time-series data combined with an instrument for prices – periods of naval war involving Britain – in order to estimate the price elasticities for sugar, tea and coffee. Since these goods were imported, naval wars tended to have a negative effect on imports.[9] The eighteenth-century saw Britain involved in numerous conflicts. Most of them led to naval warfare in the North Atlantic. Privateers attacked Britain's merchant ships, increasing shipping costs and seizing cargo (Mokyr and Savin 1976). As a result, imported commodities were, on average, more expensive in years of war. For example, tea was, on average, 18% dearer

[8] For the restrictions that are necessary to identify η see Bresnahan (1997).
[9] The exercise is similar in spirit to Angrist, Graddy and Imbens (2000).

during war-years between 1700 and 1850; sugar price rose by an average 15% relative to trend.[10] We proxy naval warfare with both war itself and the number of men employed in the navy. For tea, we also use the tariff on tea. We obtain a strong first stage

Appendix table A1 shows the OLS, SUR and 2SLS estimates of the price elasticity for sugar, tea, and coffee. We de-trend the dependent variables.[11] We then regress the log of consumption on the log of the real price. Under OLS, we obtain elasticity estimates of -0.398 for sugar, -0.17 for tea, -0.186 for coffee, and -0.134 for sugar and tea estimated as a joint composite good. Sugar and the sugar-tea composite good are significant at the 0.05 level, and tea is significant at the 0.1 level. Using 2SLS, we instrument the real price of the commodities with a war dummy and the size of the British navy.[12] For tea and coffee we obtain negative coefficients that are statistically significant. For sugar, we find a positive, insignificant coefficient. Most of the coefficients under instrumental variable estimation are larger in absolute value than the ones obtained under OLS. This could indicate measurement error of prices, or different LATE – price shifts brought on by war changing quantities by more than variation in peacetime, perhaps because of shipping disruptions adding quantity to price shocks. We remain agnostic about the need for instrumentation. While demand shifts may have played some role in setting prices of colonial goods in the UK, it is clear that the overwhelming identifying variation comes from the short-term impact of hurricanes, shipping disasters, and war as well as the long-term effects of massively growing supply.

[10] The overall price trend is downwards for both commodities. If we detrend the data by deriving the residuals from a linear regression of price on a year trend, we still find large and statistically significant differences.
[11] We do so by regressing the log of consumption on a linear trend, and using the residuals in the specification. The time trend is estimated over the whole time series. Results are available from the authors on request.
[12] For the latter, we use establishment figures, not actual men in the navy provided by Floud, Gregory, Wachter (1990). This should capture the size of the threat faced on the seas by Britain at least as well as actual manpower, which was constrained by difficulties of empressment, etc. We use as an additional instrument for tea the log of the tea duty rate.

IV. Extensions and Qualifications

Tobacco

Europeans first encountered tobacco during the voyages of discovery. Columbus noted the smoking of tobacco by Native Americans on Cuba in November 1492. Afterwards, it took almost a century for consumption to grow significantly. The plant was largely treated as a botanical curiosity. It was only in the 1570s that the medical writings of Nicolas Monardes, who produced a compendium on the plants of the New World, gave a push to tobacco use. Europeans consumed it as snuff, as chewing tobacco, and in pipes. The use of cigarettes first became common in Spain, and then spread to other countries. Initially produced by Native Americans, Spanish settlers in the New World eventually learned to make it themselves.

Tobacco was cultivated in Spain from the 1550s, and then spread to Italy, the Balkans, Java, the Philippines, and India. However, production in the North American colony of Virginia overtook all other sources of tobacco. By 1700, almost all European imports came from either Virginia or Brazil. England imported it on a vast scale, only to re-export it to the continent. By the early 18th century, Virginia tobacco exports alone filled 200 boatloads per year (Braudel 1988). As early as 1690s, consumption reached over two pounds per capita according to Shammas (1990).

Tobacco is similar to the other new goods – it arrived in Europe from overseas, it has no close substitute amongst native plants, the import price fell rapidly, and consumption became a mass phenomenon. We nonetheless do not treat it on par with the other goods because of its addictive properties. Tobacco in some ways is not a “good”, but a “bad” – the health effects can be strongly negative, even if life expectancy was perhaps too low for the full carcinogenic effects to make themselves felt. Becker and Murphy (1988) define a good as addictive if tolerance

increases over time, users find it ever harder to stop consuming it, and suffer from unpleasant feelings ranging from cravings to withdrawal symptoms. By this definition, sugar, tea, and coffee are probably not addictive in the strict sense, while tobacco clearly is.[13]

Estimating welfare gains for tobacco is complicated by the issue of smuggling. Existing estimates of tobacco imports show a puzzling decline in absolute per capita consumption after 1700. We test the sensitivity of our findings by examining welfare results for take-up between 1630 and 1700 as well as 1630 to 1800.

Table A3 gives the results for tobacco using the Greenwood-Kopecky method. If we allow ρ for the Greenwood-Kopecky method to be determined by tobacco consumption itself, we obtain a reasonable fit. The marginal value of the first unit of tobacco is reasonable, too. The equivalent and compensating variations in 1700 equal 7-8%. If we take results up to 1800, we find welfare gains of 4.5%. These gains are higher or on par with the welfare gains from sugar and tea. Using the Hausman method, we find similar results. Both IV and OLS results suggest that the price elasticity of demand was close to -0.35. This implies a welfare gain of around 4.5%, almost identical with the results from the Greenwood and Kopecky method using the estimate from 1630-1800.

13 This could be a problem for our method because we implicitly assume time separable utility. Because the pleasure of consuming an addictive good today depends on the history of personal consumption, this is not strictly correct. However, we analyse tobacco use over a long period in which several generations of users are born and die. This allows us to abstract from the non-separability of utility for each of them, and apply the basic method for estimating welfare gains.

Leisure lost

Some authors have argued that the length of the working day increased after 1750 (Voth 1998, 2001). This has been interpreted as a sign that backward-bending labor supply curves declined (DeVries 2008) – people worked more as more consumer goods became available. It could be argued that the introduction of new goods led to a decline in leisure. This would imply that while utility from the new goods increased, our calculations might be upward-biased because we fail to account for the negative effects of longer hours.

Correcting for changes in leisure would be mistaken, in our view. First, the evidence that hours increased is controversial (Clark and Van der Werf 1998). Second, many of the gains in consumer welfare from new goods materialized long before work intensification became (potentially) an issue – by 1750, take-up rates were high. Third, as long as households supply labor hours via utility maximization, their revealed preference in the early, low-hours period was for leisure. This implies that the shadow value of time was low. If the availability of new goods by 1800 lead households to supply more labor, this suggests that that working was now worthwhile because the shadow value of time increased.[14] Deducting the value of leisure lost – when it was clearly of low value initially – would be inappropriate.

Health implications

Many of the new goods that Europeans started to enjoy after 1600 were initially considered to have medicinal qualities. Nicolas Monardes' 1571 tract on medical plants from the New World argued that 36 health problems could be cured by tobacco. Today, we know that most of this advice was misguided. Smoking causes cancer, and excessive sugar consumption leads to diabetes, obesity and dental decay. Both longitudinal studies and cross-country evidence suggest

[14] This is the approach favored by Usher (1980).

that increases in sucrose levels in the diet directly increased the prevalence of caries (Newbrun 1982). Caffeine in tea and sugar may increase coronary disease. The argument is articulated in extreme form by Thomas and Bean (1974):

> "The only group of clear gainers from the British trans-Atlantic slave trade, and even these gains were small, were the European consumers of sugar and tobacco and other plantation crops. They were given the chance to purchase dental decay and lung cancer at somewhat lower prices than would have been the case without the slave trade."

Should we adjust the estimated welfare gains to take changes in health into account? Most of the health issues that could arise are not of major concern for our time period. Life expectancy in England was low – in the range of 30-35 years. Even heavy smoking must have resulted in few additional deaths, as many people would have died too early to be affected by cancer. Also, diabetes and obesity cannot have been major health concerns, given the low overall nutrient intake.

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Appendix Figures

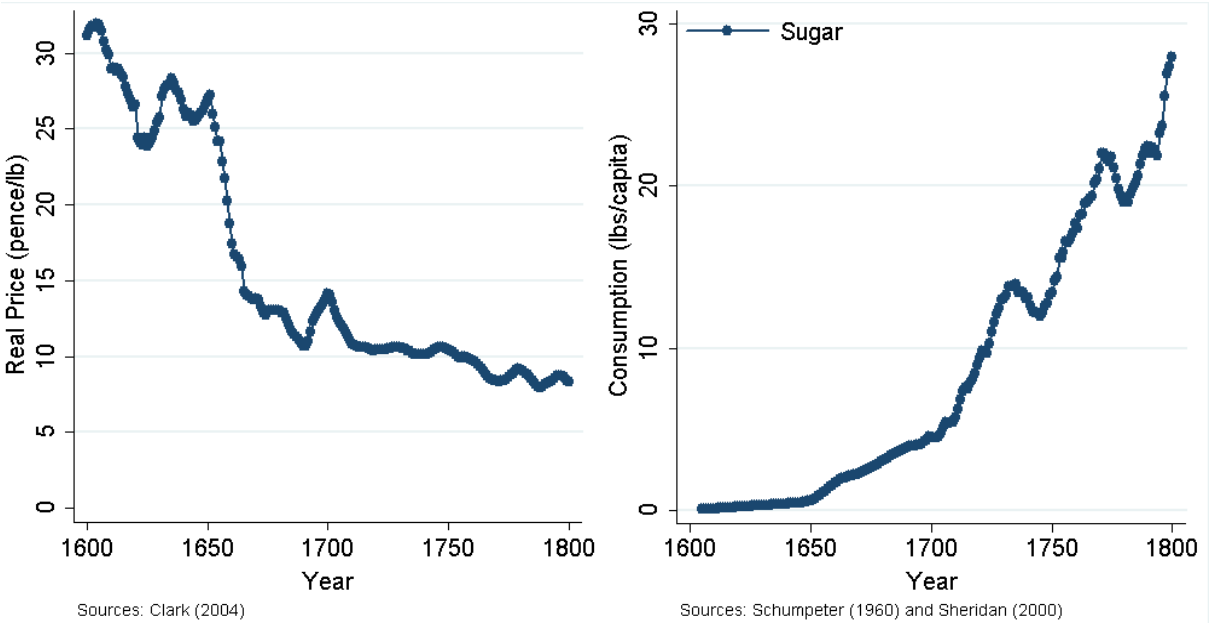


Figure A1: Real Sugar Prices and Consumption Per Capita in England, 1600-1800

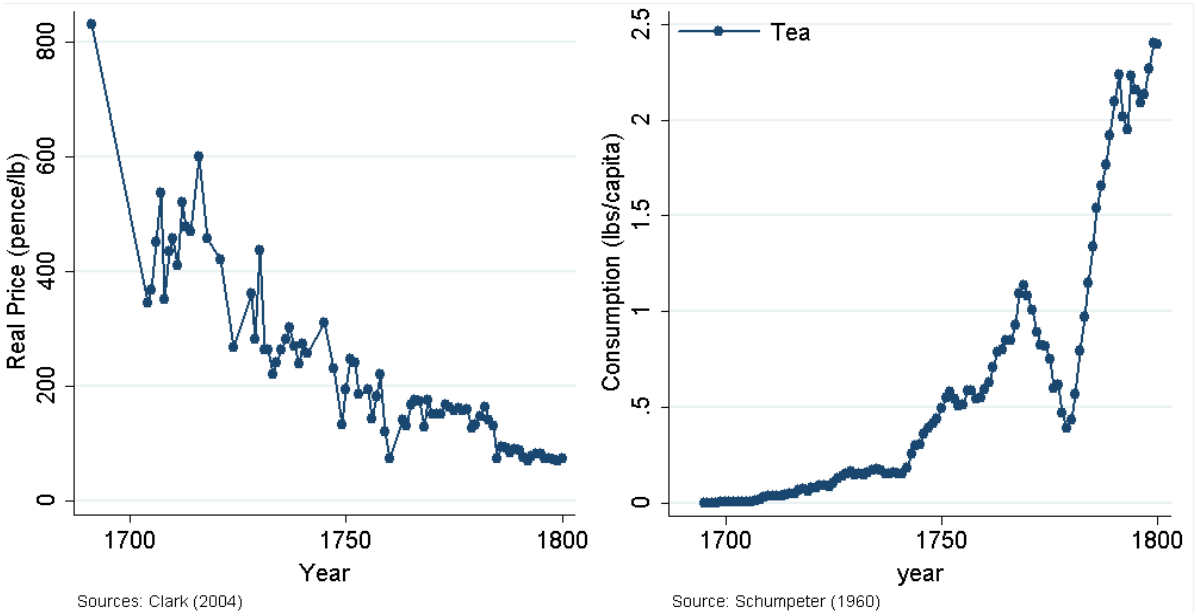


Figure A2: Real Tea Prices and Consumption Per Capita in England, 1600-1800

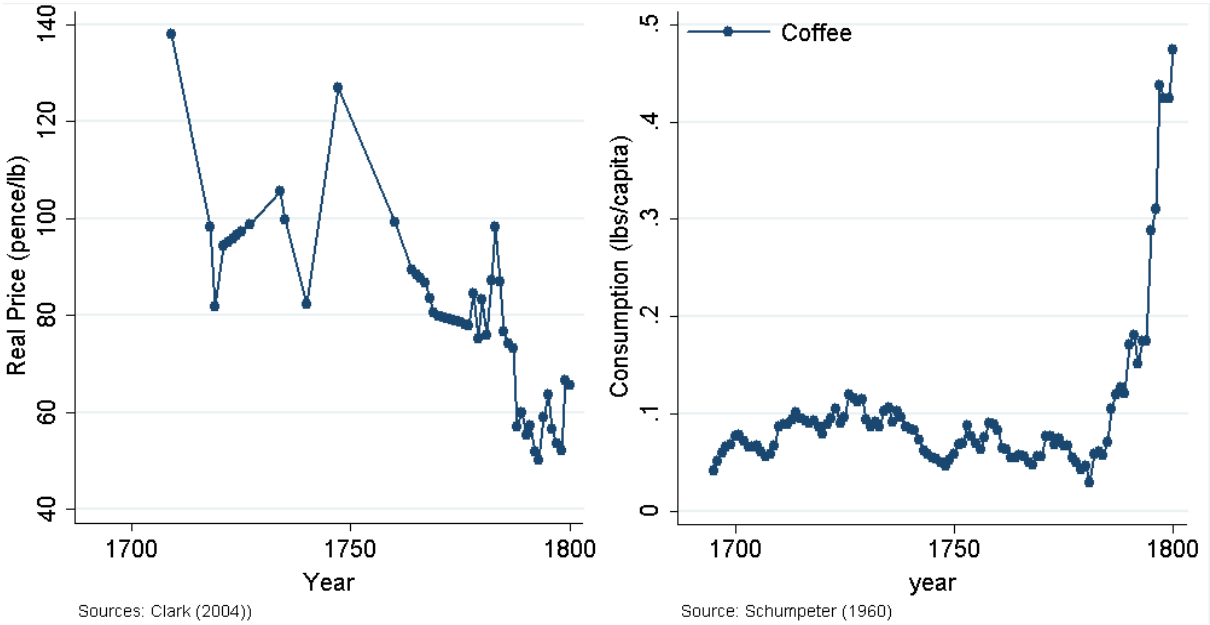


Figure A3: Real Coffee Price and Consumption Per Capita in England, 1600-1800

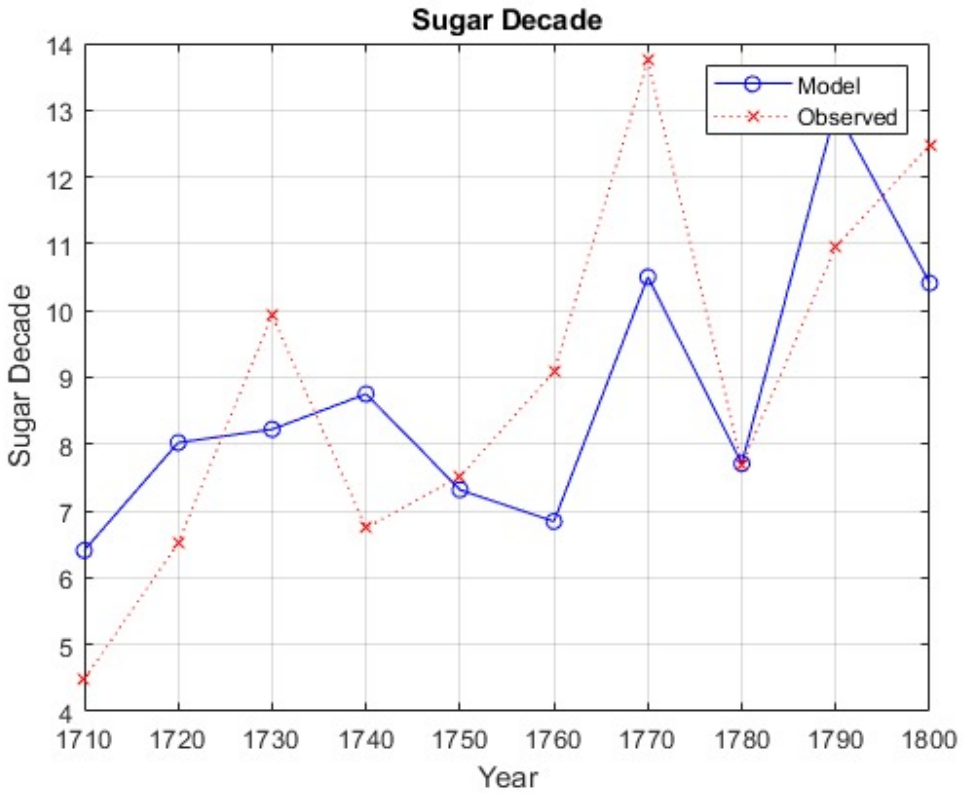


Figure A4: Greenwood-Kopecky method estimated sugar consumption vs. observed consumption, 1600-1850

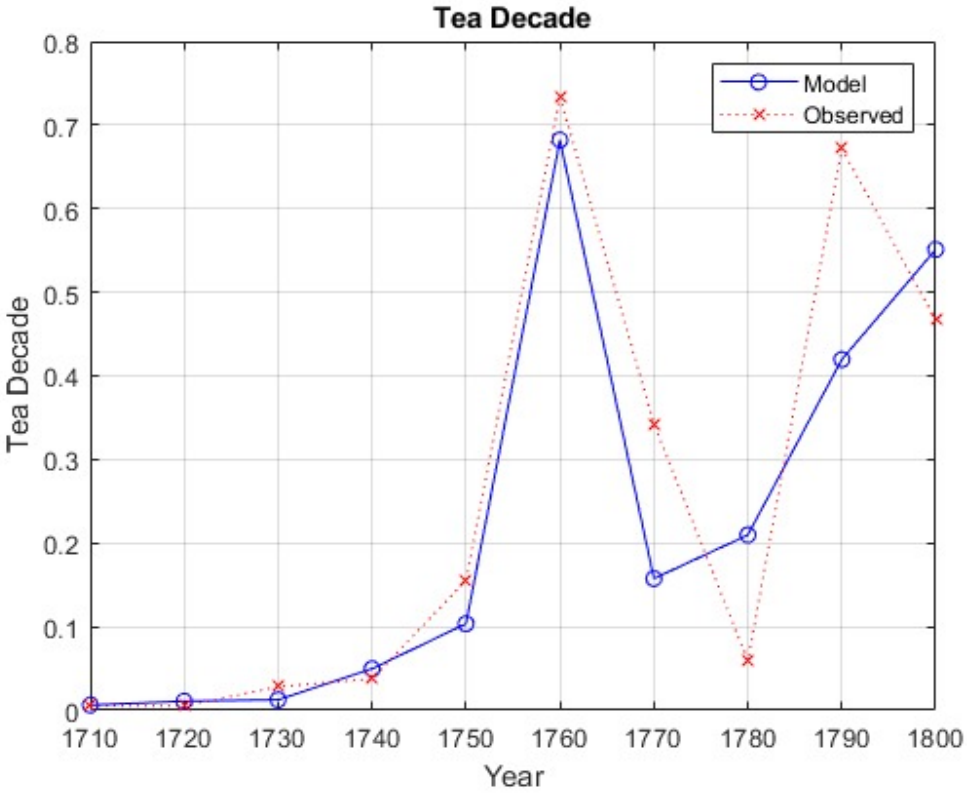


Figure A5: Greenwood-Kopecky method estimated tea consumption vs. observed consumption, 1600-1850

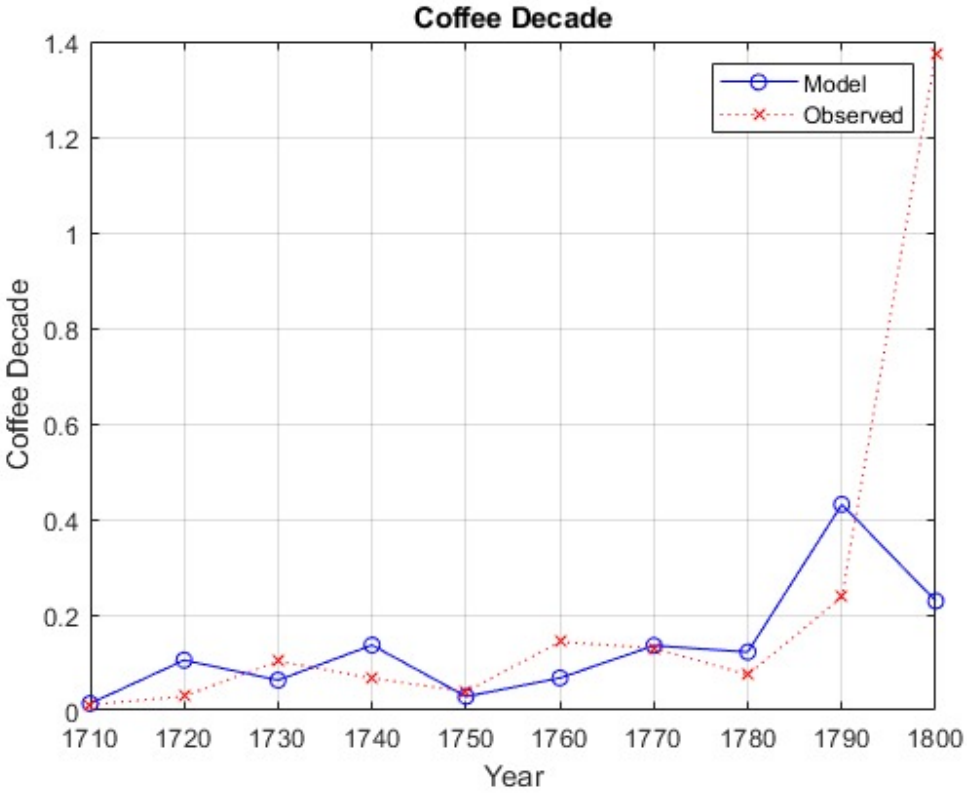
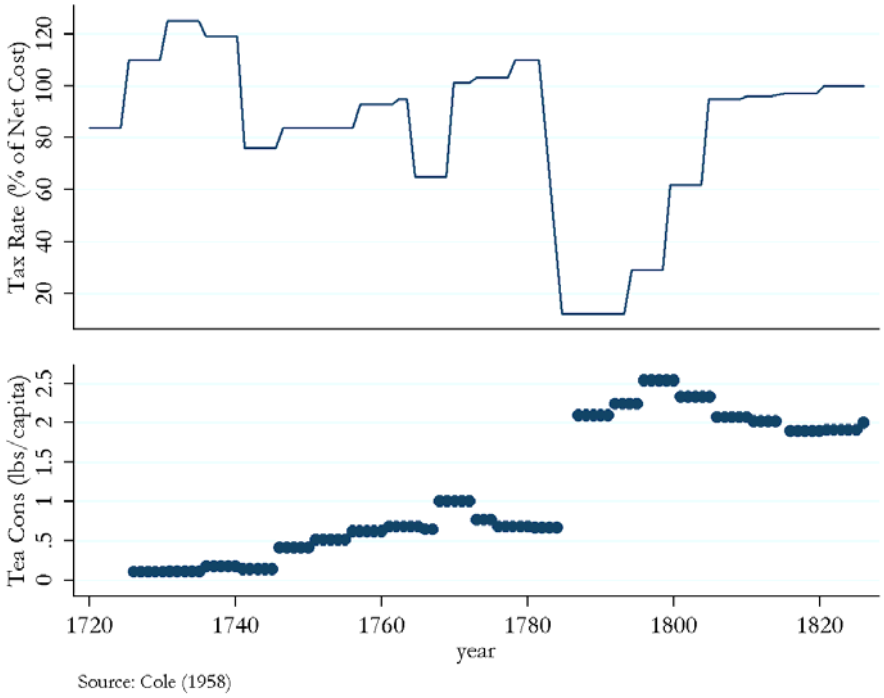


Figure A6: Greenwood-Kopecky method estimated coffee consumption vs. observed consumption, 1600-1850



Source: Cole (1958)

Figure A7: Tea consumption and tax rate

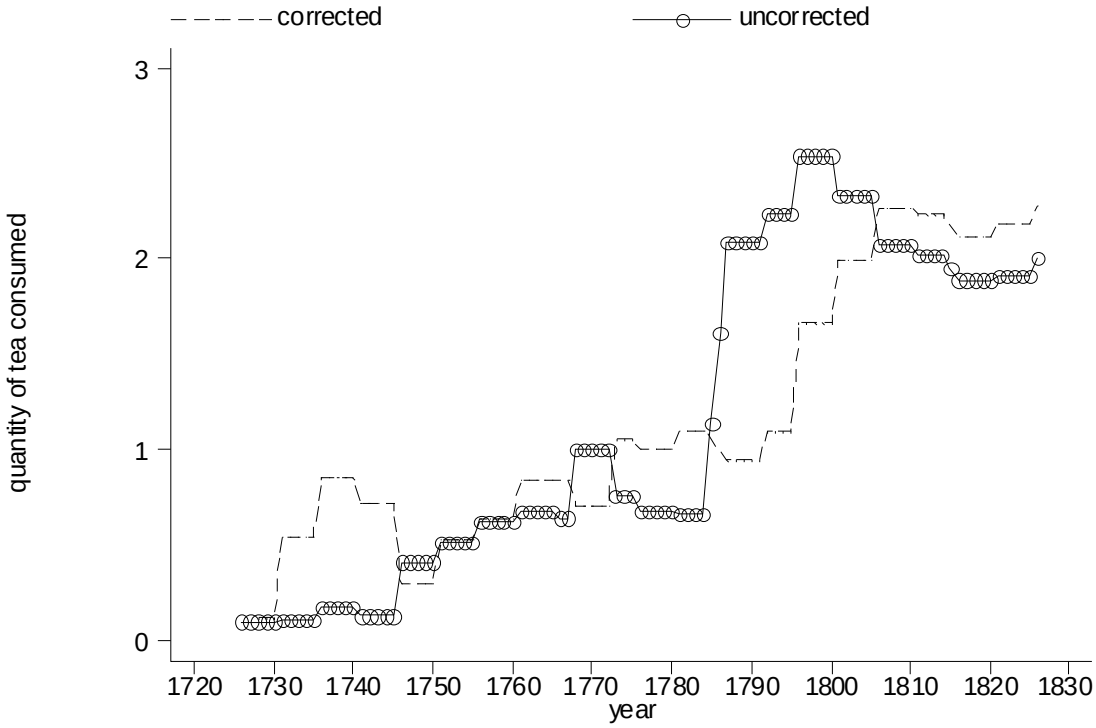


Figure A8: Smuggling-Corrected and Raw Tea Consumpion

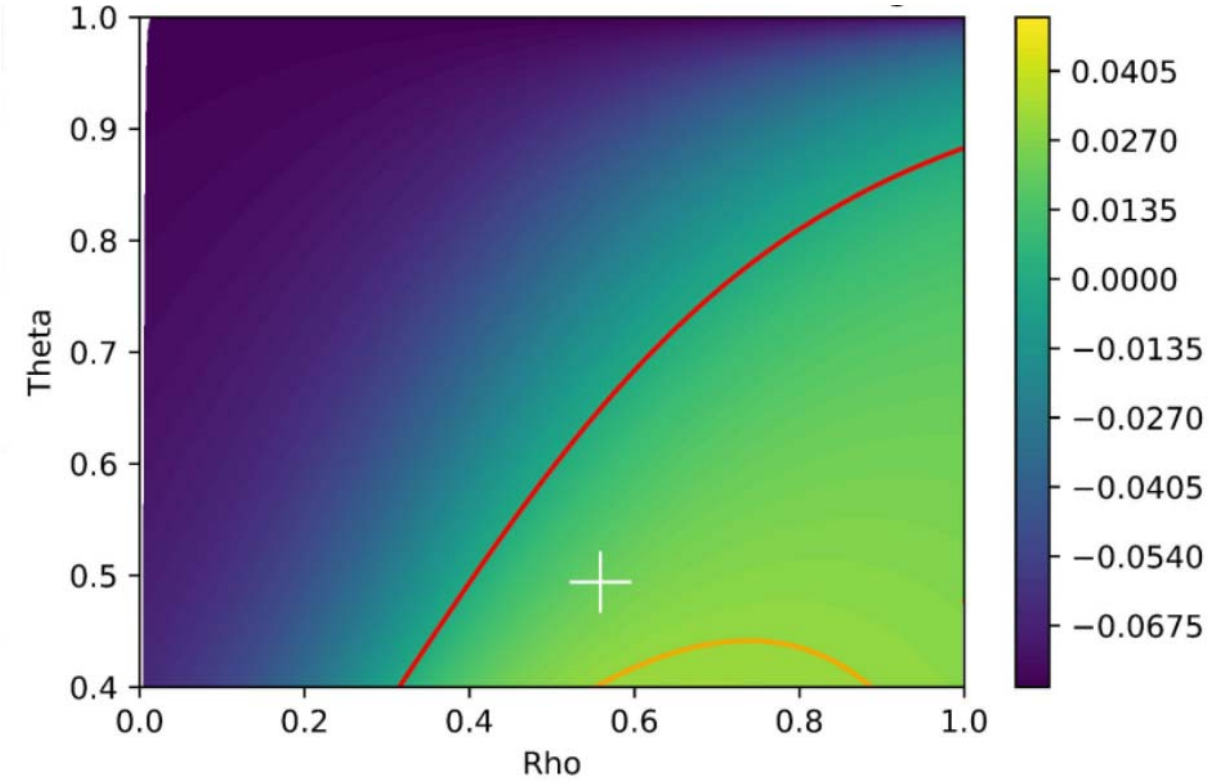


Figure A9: CV implied by combinations of θ and ρ - sugar, 1801

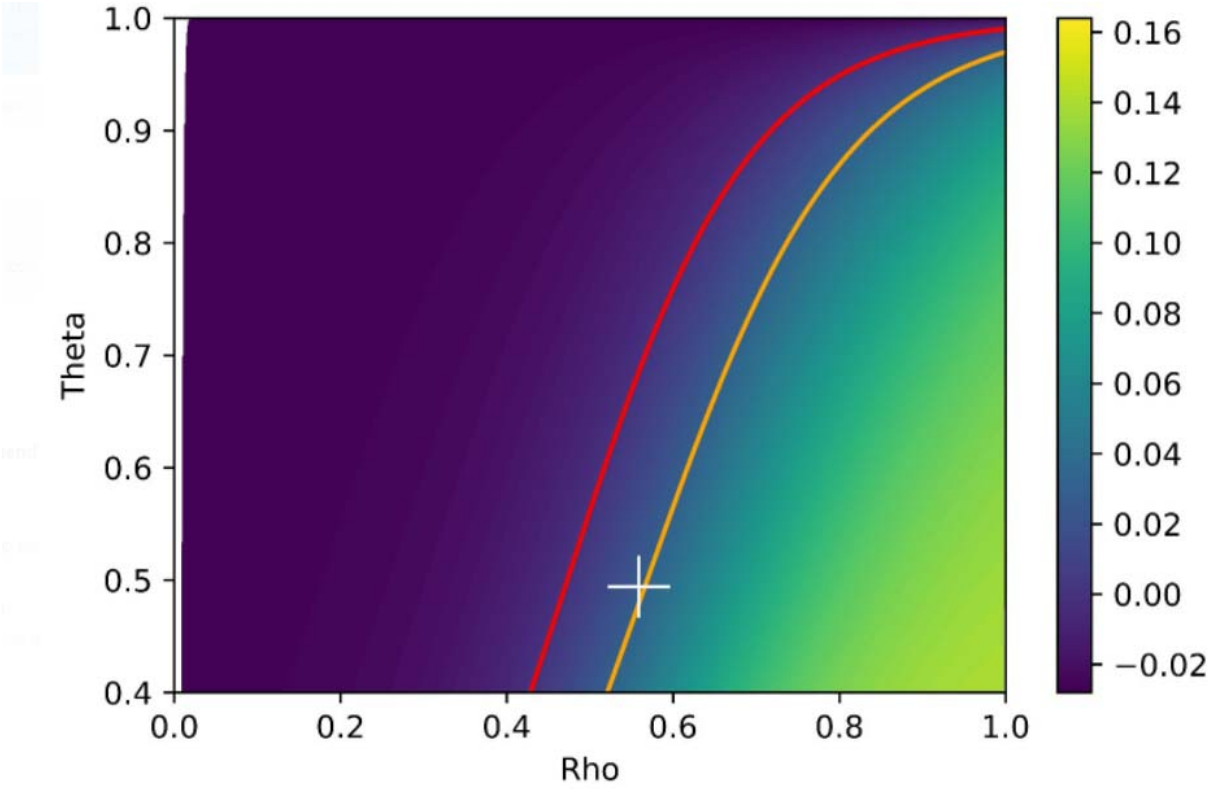


Figure A10: CV implied by combinations of θ and ρ - tea 1801

Tables

Table A.1: Price elasticity estimation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		OLS			SUR			IV	
commodity	sugar	tea	coffee	sugar	tea	coffee	sugar	tea	coffee
log(real sugar price)	-0.398***			-0.483***			0.285		
	(0.115)			(0.112)			(0.295)		
log(real tea price)		-0.170*			-0.253***			-0.381*	
		(0.0912)			(0.0886)			(0.205)	
log(real coffee price)			-0.186			-0.213*			-0.595**
			(0.126)			(0.125)			(0.263)
Constant	0.884***	0.845*	0.790	1.071***	1.262***	0.905*	-0.580	2.141**	2.416**
	(0.255)	(0.459)	(0.539)	(0.248)	(0.447)	(0.535)	(0.644)	(1.010)	(1.097)
Observations	151	151	151	151	151	151	129	96	129
R-squared	0.075	0.023	0.014	0.071	0.017	0.014	-0.048	-0.022	0.028
Andersen-Rubin F							6.5***	9.2***	11.9***

Notes: *, **, and *** indicate significance at the 90%, 95% and 99% levels, respectively. Standard errors in parentheses. We instrument commodity prices with a war dummy, and naval manpower in columns 7 and 9, and additionally, with tea import tariffs in column 8. Anderson-Rubin F-statistics for the significance of the first stage are reported for the IV-results.

Table A.2: Sensitivity tests: 95% confidence intervals of price elasticities and corresponding welfare gains

		Main estimates			Sensitivity analysis			
		budget share			95% confidence interval			
estimation	commodity	1801	elasticity	CV	highest	CV	lowest	CV
OLS	Sugar	0.044	-0.398	0.055	-0.171	0.128	-0.625	0.035
	Tea	0.031	-0.17	0.091	0.011		-0.35	0.044
	Coffee	0.012	-0.186	0.032	0.063		-0.44	0.014
	Sum			**0.178**		**0.128**		**0.093**
SUR	Sugar	0.044	-0.48	0.046	-0.264	0.083	-0.7	0.031
	Tea	0.031	-0.253	0.061	-0.079	0.196	-0.426	0.036
	Coffee	0.012	-0.213	0.028	0.03		-0.458	0.013
	Sum			**0.135**		**0.279**		**0.081**
IV	Sugar	0.044	0.285		0.86		-0.29	0.076
	Tea	0.031	-0.381	0.041	0.021		-0.78	0.020
	Coffee	0.012	-0.595	0.010	-0.079	0.075	-1.11	0.005
	Sum			**0.051**		**0.075**		**0.101**

Table A.3: Welfare gains from tobacco – Greenwood-Kopecky method

New Good	Start	End	N	Sum of Error	Compensating Variation (CV)	υ	ρ	θ	R^2
Tobacco	1630	1700	7	0.0591	7.16%	0.5482	2.4964	0.995	0.9312
Tobacco	1630	1800	14	0.3633	4.73%	0.9834	4.4605	0.9996	0.8282