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The Difficulties In Estimating Real Wage Series

Seminar: Unified Growth Theory

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Abstract

This paper examine the difficulties which appear in the estimation of real wages series, when going more than one century back time. Based on an article from Clark (2005) the method used to calculate real wage series are shown and in minor degree compared to other scholars. Some general limitations and difficulties are described. In the end a critic from Hersch and Voth (2009), about the lack of consumer price series to adopt new goods is explored. This led to the conclusion that more that research is needed, especially if new consumer price series can incorporate new goods.

1. Introduction

One of the main building blocks of Unified Growth Theory is the Malthusian Trap, which is indicated by the fact that the real wage per person has stagnated for more than a millennium. This view is broadly accepted by most who work in this field and the data collected mostly supports this conclusion. But there are some serious deficiencies when estimation historical real wage series. The most pronounced problem relates to lack of data, and then to the availability of suitable substitutions when the needed data series are lacking. But there are other important limitations such as incorporating new goods into the consumer price indexes. This is important because real wage series are calculated from the nominal wage divided by consumer price so reliable data on both wages and consumer prices are need.

This paper will give an overview of the many limitations which occur when estimating real wage series and then conclude upon the reliability of these series. Before this an understanding of how real wage series are calculated are needed. For this purpose Gregory Clark article from 2005 are chosen, because it is one of the lasted in this field and Hersch and Voth (2009) use his estimation in their article. To a miner extent Clark's (2005) estimations of the real wage will be compared to Phelps Brown, Henry and Sheila V. Hopkins (1981) estimations, this will be covered in the Second section. Some of the general limitations about the estimation of both normal wage series and consumer price series will be covered in the third section. The shortfall which is derived from new goods not being incorporated into the consumer price series, and therefore not taking account of the improved consumer welfare from these changes in consumption patterns, will be discussed in section four.

2. Calculation of real wage

Clark (2005) improved the real wage index by adding new information, compared to previous work. He uses more than 46,000 quotes of day wages, 90,000 quotes of prices of 49 commodities and 20.000 quotes of housing rent. The new data changes both the wage series and price index. In comparisons the real wage index by Phelps Brown and Hopkins (1981)[1], is more volatile since they index tracks fewer items. In the coming subsections Clark's (2005) calculation of nominal wage and consumer price index and some of the important assumptions behind these will be covered.

[1] See figure 1 on page 4.

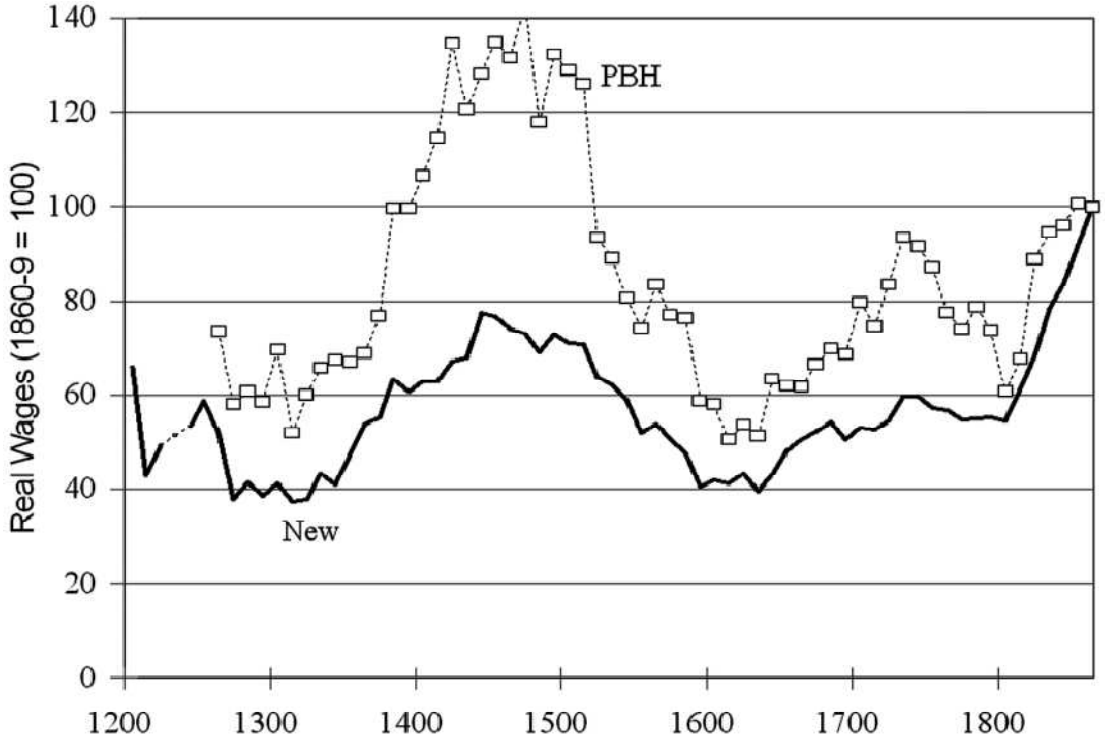

Figure 1 — Real wages, 1200–1869, Phelps Brown and Hopkins (1981) vs. Clark (2005). In both series, 1860–69 has been set to 100[2].

2.1. Wage

The wage series is calculated from data on building workers' and use an average of five regional series in the years before 1915, the regions being London, the Southeast, the Southwest, the Midlands and the North. Around 1860 there was a change in how wages were quoted, before most wages were quoted for 'a day' or 'half a day' with length of a day unspecified. Thereafter wages began to be quoted hourly, with a period between 1720-1869 where wages sometime were quoted both by the day and by the hour. Clark uses these data to calculate the implied hours per day. He finds that after 1810s the workday is about 10 hours, but from the 1750s to the 1810s the work day seemingly declined from 11 to 10 hours[3]. By assuming a standard workday of 10 hours for all day wages quotes before 1810, the wages after 1869 is therefore converted into a wage for notional 10-hour day.

Clark calculates the annual day wages for 'craftsmen' and 'labourers and assistants' before 1915. He does this by estimating the coefficients of a regression on the following form:

[2] Clark, Gregory (2005) "The Condition of the Working Class in England, 1209-2004" Page 1311.
[3] Table A1 in Clark, Gregory (2005) "The Condition of the Working Class in England, 1209-2004."

$$\ln(W_{it}) = \alpha_i + \sum_{j=1}^{29} \gamma_j \,\text{Craft}_j + \sum_{i=1}^{12} \eta_j \text{Joint}_k \; + \sum_{l=1}^{4} \sum_{m=1}^{13} \theta_{lm} \,\text{Region}_l \text{Period}_m + \sum_t \phi_t D_t + \epsilon ijt \qquad \textbf{(2.1)}$$

Where W_{it} is the average wage in location i of a craftsman in year t, α_i is a fixed wage premium for each location i, Craft_i is a set of 29 indicator variables for different crafts[4], Joint_k is an indicator variable for a joint wage of a craftsman and his servant or assistant for 13 periods[5], Region_l is an indicator variable for each of the four regions and London is the omitted category. Period_m is an indicator for each of the periods[6], and D_m is and indicator for each of 672 years with a wage observation. From 1209 to 1914 there are 23,524 observations of craftsmen's wages, with the average of each craft at each location in each time period treated as one observation. Of these observations, 2,164 pertained to the joint wage of a craftsman and a helper and 42 years was without an observation.

The calculation of day wages for labourers and assistants is regressed on the following form:

$$\ln(W_{it}) = \alpha_i + \beta \text{Joint}_{<1350} + \sum_{l=1}^{4} \sum_{m=1}^{13} \theta_{lm} \,\text{Region}_l \text{Period}_m + \sum_t \phi_t D_t + \epsilon_{ijt} \qquad \textbf{(2.2)}$$

Where W_{it} now is the average wage in location i of a labourers in year t, beside that the variable definitions are similar to the previous equation. By the equation Clark assumes that laborer's wages did not vary across craft. He only uses joint wages for the years before 1350 ($\text{Joint}_{<1350}$), because wage observation on helpers alone are scarce. In this regression there are 11,988 observations available, of which 572 were joint observation of the wage of a craftsman and a helper before 1350.

From 1914 to 2004 these series for nominal day wages were extended using a variety of reliable sources. A comparison of the nominal wage estimated by Phelps Brown and Hopkins (1981) and Clark (2005) is shown in figure 1 in the appendix. In the figure nominal wages are shown relative to Clark's estimations. In individual decades the wage estimates deviate by as much as 23 percent, and there is little pattern to these deviations. This difference explains some of the much higher real wage found by Phelps Brown and Hopkins (1981) seen in figure 1 on page 4.

[4] Such as bricklayer and mason, the omitted category is carpenter.
[5] 1200-1299, 1300-1349,……., 1800-1849 and 1850-1869.
[6] 1200-1299, 1300-1349,……., 1850-1899 and 1900-1914.

2.2. Consumer price series

The cost-of-living index (as Clark writes it) for 1209-1869 was formed as a geometric index of prices of each component, with expenditure shares used as weights. It thus assumes constant shares of expenditure on each item as relative prices change. That is, if p_{it} is the price index for each commodity i in year t and a_i is the expenditure share of commodity i, then the overall price level in each year p_t is calculated as:

$$p_t = \prod_i p_{it}^{a_i} \qquad \textbf{(2.3)}$$

The individual price series were derived as the estimated parameters on year indicators of regressions of the form:

$$\ln(p_{it}) = \sum_k \beta_k DTYPE_k + \sum_t \phi_t D_t + \epsilon_{ikt} \qquad \textbf{(2.4)}$$

Where p_{it} is the price index for each commodity i in year t and DTYPE is a dummy variable for each type of a product, with type defined by location, purchaser, characteristics, and measuring unit. In this regression Clark try to control for variations in the size of units across sources and in the quality.

The weight for expenditures are derived mainly from studies of manual workers' expenditures collected in the years 1786-1854, by Horrell (1996)[7] and Vanderlint (1784)[8]. From 1200 to 1869 Clark uses the same set of weights for major categories of expenditure. In the interests of economy of space, he uses the same cost-of-living for craftsmen and labourers. Because the different movements in their cost of living are not huge enough to justify the extra space that would be required to treat them separately. There is used a maximum of 49 items to calculate the cost-of-living index, in contrast Phelps Brown and Hopkins (1981) used at their maximum only 20 goods.

Bread was up until 1869 the single most important item of consumption for workers. The available prices of bread before 1816 are mainly from London, but the prices were regulated by law before 1815. To overcome this problem the bread prices are estimated from a regression of the wheat prices. Meat prices by the pound can be found only after 1540, before this meat was quoted by the live animal or a part of the animal and not by weight. Clark approximate meat prices using an

[7] Horrell, Sara. 1996. "Home Demand and British Industrialization." *J. Econ. Hist.*56 (September): 561–604.
[8] Vanderlint, Jacob. 1734. *Money Answers All Things*. London: T. Cox.

average of the animal product that was sold by the pound, such as egg prices and the price of fish.[9] A major difference in comparisons to Phelps Brown and Hopkins (1981) index is the inclusion of housing rental cost, which Clark estimates to be 8 percent of the expenditure of worker. For the years before 1540, there are only two major sources of housing rents. After this the range of sources becomes greater.

3. Limitations

The main problem in generating long-run series of nominal wages and consumer prices are the lack of reliable data. In the cases where data are available, these series are more often than not incomplete, and therefore have to be approximated as seen in the previous section. Some series are missing altogether, like the case of bread. The series logically also becomes more inconsistent the further back in time they goes, because of more lacks in the data.

3.1. Wage series

Problems relate to the fact that wage (nominal and real) data refers to a single worker, and in early sub periods the worker is generally an adult male. Yet consumer price series usually pertain to household expenditure. It is reasonable, from the standpoint of standard of living that the focal point be the household rather than individual worker. Therefore earnings incorporating contributions of all household members (both spouse and children), are perhaps an analytically superior alternative to single-worker earnings. But such data are limited and insufficient to construct the desired series.

Even if the real wage is considered a measure of the standard of living for a household, it neglect other sources of earnings, such as gleaning after harvest, foraging on commons and woods, the Church, charity and household production. Household productions such as home made cloths and most labours in the earlier period held a plot of land capable of furnishing them with a part of what they needed to live.

Wage series involve the assumption of full employment, because the estimates attempt to measure the change in wage for a worker in full-time employment. Unemployment of any kind (seasonal,

[9] A proxy of meat prices using price of whole animals before 1540, are not used because farm animals seem to have been much larger in the nineteenth century that the medieval period.

cyclical, structural or voluntary) is not reflected in the wage series[10]. Some scholars have tried to adjust an earnings series so that it incorporates unemployment, but data on unemployment are limited or non-existent prior to the 20th century.

The preferred type of price for calculating consumer prices indexes is retail prices, since these prices are the rates at which consumers directly transact their purchases. But as mentioned above such data are rare, and generally data on retail prices do not exist prior to the 20th century. In estimating historical consumer price series it is therefore necessary to draw on other types of prices. The most commonly utilized alternatives are wholesale prices, contract prices, and export and import unit values[11].

3.2. Consumer price series

Wholesale prices are generally more available than retail prices in earlier centuries. The disadvantage hereby is that wholesales prices move differently from retail prices. Another problem is that wholesale prices typically are for the raw materials which constitute the consumer goods instead of the actual consumer goods. For instants the price of wool may proxy that of clothing.

Contract prices (or "institutional prices") are a substantial amount of the available data. These prices are for the purchases of institutions such as hospitals, schools, the military and other government departments. The dilemmas hereby are that institution purchase large quantities at favourable prices, compared to the small quantities and lack of market power of the normal consumer. In addition contract prices are generally established for long periods and therefore tend to be rigid, compared to the normal consumer market. Both wholesale and contract prices generally are specific to London or occasionally some other location.

Export and import unit values are computed from official trade statistic as the ratio of the value to physical quantity of an exported or imported commodity. These unit-value series have the problem of change in quality, as the composition of the export or import commodity category changes over time. In spite of these problems, some historians are sanguine about the use of the alternative price

[10] Voluntary unemployment may reflect a preference for more leisure in the face of a rising earning rate. Dyer, Christopher (1989) "*Standards of Living in the Later Middle Ages: Social Change in England c. 1200-1520*" views such voluntary unemployment as "plausible" for the later-medieval workers, who "set themselves goals in cash or consumption needs, and worked until they had achieved their aims."

[11] Officer, Lawrence H.

categories in place of retail prices[12]. Furthermore the use of wholesale prices when retail prices are lacking has been defended for analysis covering many decades because 'in the long run retail prices must move in sympathy with wholesale prices'[13].

3.3. Laspeyres price index VS. Geometric index

When Clark estimates the price index he uses a geometric index, where most other scholars (among them Phelps Brown and Hopkins (1981)) use the Laspeyres price index. The Laspeyres index is computed as:

$$p_t = \sum \left(\frac{P_{i,t+1}}{P_{it}}\right) a_{it} \qquad \textbf{(3.1)}$$

Where p_t is the change in price level, p_{it} is the price index for each commodity i in year t and a_i is the expenditure share of commodity i. A Laspeyres index has fixed quantity weights derived from a base period (in Phelps Brown and Hopkins (1981) index the base period is 1451-75), an index of 1 would state that an agent in the current period can afford to buy the same bundle as he consumed in the previous period, given that income has not changed.

A limitation of the Laspeyres price index is that as relative price change, physical quantities purchased nevertheless remain fixed. This means that there is no substitution of a relatively cheaper for a relatively dearer commodity as prices change over time. The cost of living is therefore overestimated compared to base period[14]. In contrast the geometric price index of Clark incorporates genuine constant expenditure-share weights. This means that a uniform identical elasticity of demand is implicitly assumed for all commodities *i,* this elasticity varying with total expenditure in current period and equalling unity for total expenditure unchanged from the base period. Therefore there is a response, although limited, of quantity to relative price changes, but not a response of expenditure share to relative price changes.

Another deficiency related to both indexes is that consumer price series do not incorporate changes in quality of goods. Normally goods improve in quality over time and therefore increase the consumer's utility from a given quantity. Textile is a good example of this, since the product in 1830 was not only cheaper than in 1750 but was also of a better quality.

[12] They have to be sanguine, for there are in most cases no alternative to retail prices.
[13] Officer, Lawrence H.
[14] Clark (2005), he uses this as the explanation for using a geometric price index.

In conjunction with the previous an additional problem arises when new goods are introduced into a consumer price index, it is normally solved by chain linkage. This requires extremely detailed budget information that is not available for the early modern period. Sugar has been included in some estimations, but its addition does not affect the overall conclusion.[15]

4. Gains from diversity

As mentioned earlier one of the serious deficiencies are how to incorporate new goods into a consumer price index. The Authors Jonathan Hersh and Hans-Joachim Voth examine this in their article "Sweet diversity: Colonial goods and the rise of European living standards after 1492" from 2009. They argue that the discovery for the new World improved European living standard directly trough gains from new goods. Hersh and Voth adopt a model for the value of new good[16] and derive welfare gains from a calibration exercise. They focus on England from 1600 to 1850 using historical data on the price and consumption of increasingly affordable colonial goods, to estimate welfare gains from their introduction. Tea, sugar and coffee are chosen as the goods to be valued, because these goods from around 1600 increasingly were consumed in all part of English society. During the 1790s, a period of unusually high prices and severe downward pressure on lower-class living standard, as much as 7 percent of household income (roughly 10 percent of a household's food budget) was spent on tea, coffee, sugar and treacle by poor working-class household[17]. This illustrates the high value assigned to these new commodities, despite economic distress. In appendix table 1, the consumption of some colonial luxuries in Europe are shown. The results suggest that by 1850 Englishmen's welfare had increased by at least 15 percent as a result of the availability of these goods alone.

Regarding the data Hersh and Voth use daily workers' wages from Clark (2005) for income. For price data they primary use Clark (2004)[18], since his series extend back to the medieval period and tracks a larger number of products. The consumption data comes from five different sources[19].

[15] Allen, Robert C. (2001)

[16] Greenwood, Jeremy and Kopecky, Karen A. (2009).

[17] Feinstein, Charles H. (1998). "Pessimism Perpetuated: Real Wages and the Standard of Living in Britain during and after the Industrial Revolution." *Journal of EconomicHistory* 58(3): 625-58.

[18] Clark, Gregory (2004). "The Price History of English Agriculture, 1209-1914." *Research in Economic History* 22: 41-124.

[19] Mitchell, B. R. and P. Deane (1962), Mokyr, Joel (1988), Cole, W. A. (1958) Davis, Ralph (1979) and Deerr, Noel (1950).

4.1. Model

Greenwood and Kopecky (2009) introduce a method that makes less stringent demands of the data. Their approach is more macroeconomic and requires aggregate data on prices and take-up rates of a new consumption item. For working with historical data this is an advantage. This is why their model is chosen. It is a modified model of consumer demand where initial marginal utility of new good consumption is bounded, allowing gains in consumer surplus to be calculated.

Let the consumer's tastes be described by:

$$\theta U(c) + (1-\theta)V(n), \text{with } 0 < \theta < 1 \qquad \textbf{(5.1)}$$

Where $U(c)$ describes the utility derived from the "old good", $V(n)$ describes the utility derived from the "new good" and the parameter θ is the share of expenditure on the goods. Take the utility function for the consumption of old goods to be of the standard constant-relative-risk-aversion variety, so that $U(c)$ can be written as:

$$U(c) = \frac{c^{1-\rho}}{1-\rho}, \text{with } \rho \geq 0 \qquad \textbf{(5.2)}$$

The parameter ρ is the coefficient of relative risk aversion. This equation ensures that the marginal utility of the first item of a new good is not infinitely large. The utility function for the consumption of the new good can be written as:

$$V(n) = \frac{(n+v)^{1-\rho}}{1-\rho}, \text{with } 0 < v < \infty \qquad \textbf{(5.3)}$$

$$\text{and with } V(0) = \frac{v^{1-\rho}}{1-\rho} > -\infty \quad \text{and} \quad V_1(0) = v^{-\rho} \qquad \textbf{(5.4)}$$

The last two conditions ensure that at zero consumption of the new good. The parameter v is a utility shift parameter that corresponds to the marginal utility of zero new good consumption, given by $v^{-\rho}$. Since $\rho \geq 0$ the magnitude of the elasticity of demand for the new good is unrestricted. The consumer's static maximization problem is:

$$\omega \equiv W(y,p) = \max_{c,n}[\theta U(c) + (1-\theta)V(n)] \qquad \textbf{(5.5)}$$

Subject to his budget and the non-negativity constraints,

$$c + pn = y, \text{with } c, n \geq 0 \qquad \textbf{(5.6)}$$

W(*y,p*) represents the consumer's indirect utility function, which gives him maximal level of welfare at the income level *y* when he faces the price for the new good *p*. This leads to a threshold price *P'*(*y*), such that the optimal expenditure on the new good will be zero whenever $p \geq P'(y)$, and $P'(y) = \frac{1-\theta}{\theta} v^{-\rho} y^{\rho}$. Greenwood and Kopecky show that below the threshold price consumption of the new good is given by:

$$n' = \frac{y+pv}{p+[(1-\theta)/\theta]^{-1/\rho} p^{1/\rho}} - v \qquad \textbf{(5.7)}$$

Welfare changes are calculated from the indirect utility functions with and without access to the new good. Greenwood and Kopecky (2009) define two measures of the welfare gain from the new good –equivalent variation (EV) and compensating variation (CV). The equivalent variation is the increase in income needed to give the consumer without access to the new good the same level of utility as a consumer with access. This can be written as:

$$W\big((1+\lambda_{EV})y_2, \infty\big) = W(y_2, p_2) \qquad \textbf{(5.8)}$$

Compensating variation is defined as the amount of income a consumer would be willing to lose, provided he kept access to the new good. We can think of this as the amount of income a consumer would be willing to forego in order to maintain access to the price p_2 as opposed to facing an infinite new good price. This can be written as:

$$W\big((1+\lambda_{CV})y_2, p_2\big) = W(y_2, \infty) \qquad \textbf{(5.9)}$$

4.2. Results

The welfare measures for introduction of new goods can be calculated by using observed data on income (y), prices (p) and new good consumption (n) to calculate the preference parameter (θ, ρ and v). Hersh and Voth do this by using a two-step procedure. The utility functions predict a mapping of income and price of old and new goods to quantities consumed, for any set of values for $p, y, v, \theta,$ and ρ. Using equation (5.7) to calculate n', they calibrate $v, \theta,$ and ρ to minimize the sum of squares of differences between observed new goods n and the predicted new goods n'. Hersh and Voth constrain consumption in the beginning of the period to zero. Due to the nonconvex nature of the equation (5.7), a Nelder-Mead nonlinear optimization algorithm is used for the sum of squares minimization[20].

The results are shown in table 1, with shows both a jointly-calibrated value for ρ (Panel A) and a separately-calibrated value for ρ (Panel B). But there is little reason to assume that consumers should have different rate of time preference in the context of these different overseas luxuries. As seen in the table welfare estimates are large, a total equivalent variation of 17.3 percent. The compensating variation is of a similar magnitude (16.4 percent). Said differently consumers would have had to receive an extra 17.3 percent in income if they lost these goods in 1850. Consumers in 1850 would have been willing to have their income cut by 16.4 percent to preserve access to sugar, tea and coffee. This suggests that the introduction of these three goods had big consequences for the welfare of the English population.

Hersh and Voth also examine the robustness of their results by using alternative data series, correcting for smuggling[21] and altogether using different method. They find that their initial results are plausible or perhaps even conservative. Compared to Greenwood and Kopecky (2009) who estimated the impact of personal computer to have a welfare gain at 3.5-4 percent, Hersh and Voth estimations could seem high. But in the past introducing a new good mattered more, so there were bigger welfare gain, because the pre-existing range of goods was smaller than it is today.

Hersh and Voth results for tea sugar and coffee constitute a lower bound on the new goods introduced in the period. Other products such as tomatoes, potatoes, exotic spices and tobacco became available on the Europe market in this period. If the rise in consumption of all these goods was measured accurately, welfare gain for European consumers would have been even larger, than the suggested findings[22].

[20] Hersh and Voth (2009)
[21] Tea were especially smuggled compared to sugar and coffee.
[22] Hersh and Voth (2009)

Table 1 - Welfare gains from sugar, tea, and coffee, England (1600-1850)

New Good	Year Range	EV	CV	ν	ρ	θ	R^2
Panel A. Results with ρ calibrated at 0.9395							
Sugar	1600–1850	8.0%	7.6%	0.0993	0.9395	0.9435	0.8517
Tea	1690–1850	7.9%	7.3%	0.0572	0.9395	0.9590	0.7718
Coffee	1690–1850	1.5%	1.5%	0.1255	0.9395	0.9875	0.8508
Welfare Gain		17.3%	16.4%				
Panel B. Results with $0<\rho \leq 2$							
Sugar	1600–1850	6.4%	6.2%	0.0590	0.7216	0.9268	0.8596
Tea	1690–1850	13.6%	11.3%	0.1550	1.4894	0.9711	0.8066
Coffee	1690–1850	2.9%	3.0%	0.3857	2	0.9991	0.8871
Welfare Gain		22.9%	20.40%				

5. Conclusion

This paper highlights some of the problems and deficiencies, when calculating historical real wage price series. As seen from the comparison between Clark (2005) and Phelps Brown and Hopkins (1981), scholars do not agree on how to estimate data. Especially Clark's way of indexing his series raises some debate. As seen in the first part of the paper the main problem with real wages series are the surprisingly little and in some cases imprecise data. Both of these issues raise some serious doubts about the estimations. In the last section Hersh and Voth calculations shows that real wages series generally are underestimated, because of their lack of incorporating new consumer goods into the consumer price series. Alone by adding sugar, tea and coffee to the English consumption there was a welfare gain by at least 15 percent from 1600 to 1850. Their exact results and they methods can be discussed (which I haven't find room for in this paper), but they point out a serious problem in the real wages series.

To conclude that that the real wage series are unreliable would be to over interpret. Therefore more research in the field is needed and if possible new data, but it seems unlikely that new data should appear. A better way to incorporate new consumption possibilities into the consumer price series is much needed.

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Officer, Lawrence H. "What Were the U.K. Earnings Rate and Consumer Price Index Then? A Data Study"

Appendix

Figure 1

Nominal wages in Phelps Brown and Hopkins (1981) relative to Clark (2005). Clark, Gregory (2005)

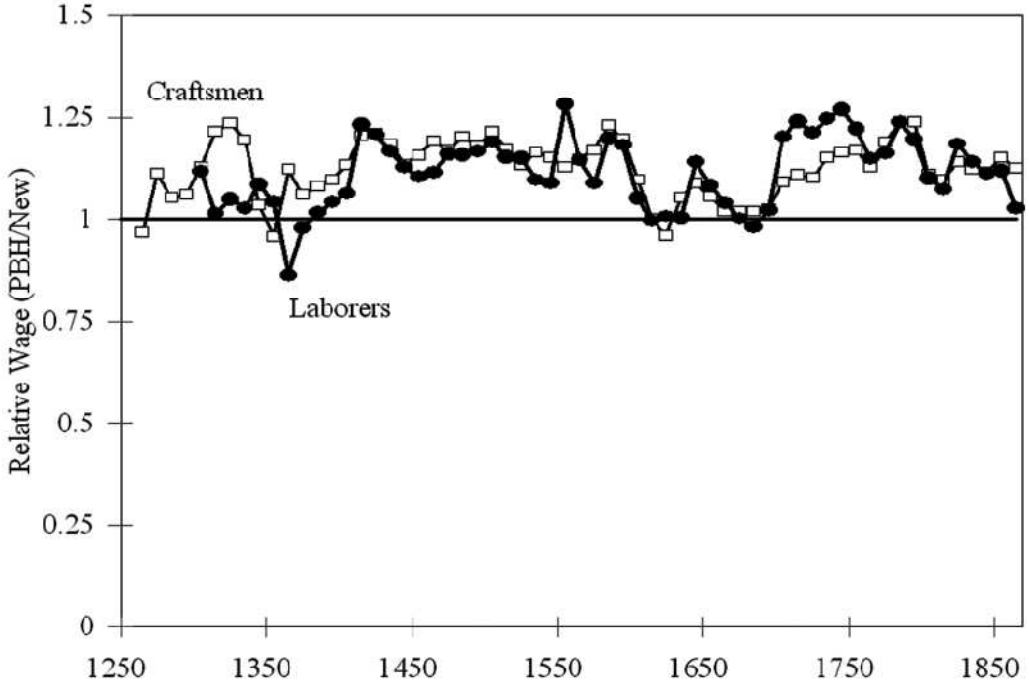

Table 1:

Consumption of colonial luxuries in Europe, early modern period (lbs per head and year). Hersch and Voth (2009).

	Sugar		Coffee		Tea	
England	1670s	2.2	1699-1701	0.1	1722	0.6
	1700-9	5.7	1749-51	0.1	1750-9	1.1
	1750-9	11.0	1801	0.1	1804-6	1.7
	1770-9	23.1	1841	0.5	1844-6	1.8
Belgium	1800	3.6	1790	0.1	1720 9	0.1
	1850-4	6.6	1850-4	8.8	1850-4	0.02
France	1730-4	1.0	1781-9	0.5		
	1788-90	2.1	1815-24	0.5	1825-34	0.1
	1830	4.4	1825-35	0.6	1835-44	0.1
Austria	1780	0.3	1780	0.1		
	1800	0.9	1800	0.1		
	1830	2.2				

Source: adapted from DeVries (2008)