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ARTICLE

The high wage economy and the industrial revolution: a restatement[†]

Robert C. Allen

Abstract

This article responds to Humphries's critique of Allen's assessment of the high wage economy of eighteenth-century Britain and its importance for explaining the industrial revolution. New evidence is presented to show that women and children participated in the high wage economy. It is also shown that the high wage economy provides a good explanation of why the industrial revolution happened in the eighteenth century by showing that increases of women's wages around 1700

greatly increased the profitability of using spinning machinery. The relationship between the high wage economy of the eighteenth century and the inequality and poverty in Britain in the nineteenth century is explored.

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The relationship between technical change and the income of workers during the industrial revolution has been an overarching question since the eighteenth century. The 'modern' debate was kicked off by the famous exchange between Hartwell and Hobsbawm in the 1960s.[1] After hundreds of books and articles, the debate subsided with Feinstein's publication of an economy-wide average wage index that increased during the industrial revolution but less rapidly than output per worker—so optimists and pessimists could each claim a partial victory.[2]

The fundamental question is again coming to the fore, however, in recent works by Humphries and myself.[3] In her critique, Humphries raises many important issues about my 'high wage economy' interpretation of the industrial revolution.[4] In this response, I focus on the most important. She is right on one important matter; namely, that the budgets underlying the price deflator should contain more calories than I allowed. While this provides a better underpinning for the calculations, it does not, in fact, lead to different conclusions on important historical questions. She also asks how the high wage view of the industrial revolution interfaces with the debate about the standard of living in the first half of the nineteenth century. This is an important question that I have not previously addressed, and I take it up at the end of this reply. In addition, she advances theses about the well-being of women and children and the incentives underlying the invention of the cotton mill. I do not find her views in these matters persuasive, as I will explain.

Humphries's view of the industrial revolution is different from mine. Her ideas are rooted in the classic view that sees the industrial revolution intimately connected to a low wage economy. Her claims include the following: that poverty was widespread among the working class during the industrial revolution; that women and children suffered even more than men; and that mechanized factories were invented in response to the abundant supply of low wage female and child labour. Humphries develops these ideas with modern methodologies. She has compiled a database of more than 600 working-class autobiographies, which provide systematic evidence for the quantitative analysis of children's lives. These life stories provide moving narratives that communicate the statistical findings.

In contrast, I argue that the industrial revolution was the result of Britain's high wage economy in the eighteenth centuries: that British workers were among the most highly paid in the world before the industrial revolution and many (but not all) continued to earn high wages as it unfolded; that British women and children enjoyed one of the highest standards of living in the world during the eighteenth century; and that mechanized factories were invented to cut production costs by substituting cheap energy and capital for expensive British labour.

Humphries notes that our different views reflect differences in 'perspective and methodology'. Perspective is certainly important. My perspective is global: I contend that it is impossible to understand why the industrial revolution was British without comparing Britain to other countries at the

time. To understand the industrial revolution, Britain must be seen from a global perspective. Humphries's perspective is that of social critics during and after the industrial revolution. They compared the standard of living of British workers to the consumption of the middle and upper classes and concluded that the workers were unfairly treated and deserved a higher income. Humphries's recent *Childhood and child labour in the British industrial revolution* is a masterpiece of economic history that analyses the lives of British children—from that perspective. A global perspective, however, leads to different conclusions.

The importance of the global perspective is clear in the story of the Ealing gardener. Humphries quotes at length from Sir Frederick Eden's summary of his finances. A reconstruction is in table 1. What does she learn from these details? He worked long hours and received some of his income in kind. The family did not eat as much as she thinks they should have. She is struck by how little was spent on clothing: 'The clothing budget is hugely problematic'. Also, the gardener complained that prices were high and he needed a raise to make ends meet. Humphries presents the gardener's circumstances in detail to make it clear that he and his family could not possibly be considered members of a 'high wage economy'.

Table 1. The Ealing gardener's annual budget

Income	
Husband's earnings per year	£37 12s. 0d.
Wife's earnings per year	£1 0s. 0d.
Total family income	£38 12s. 0d.

Expenses and consumption					
	Units/week	**Unit**	**Cal/day**	**Price (d./unit)**	**Expense/year**
Bread	33⅓	lb	4,820	2.3	£15 3s. 4d.
Meat	3½	lb	1,040	6.0	£4 11s. 0d.
Beer	4	qt	206	1.5	£1 6s. 0d.
Cheese	1	lb	243	5.0	£1 1s. 0d.
Tea	⅛	lb	0	48.0	£1 6s. 0d.
Sugar	2	lb	493	9.0	£3 18s. 0d.

Food provided by employer

Skim milk	7	qt	308	
Potatoes	35	lb	1,589	
Beans	2	lb	442	

Other expenses

Soap	½	lb	9.0	£0 19s. 6d.
Candles	⅓	lb	7.0	£0 10s. 0d.
Clothing				£3 10s. 0d.
Coal	½	bushel	18.0	£1 19s. 0d.
School fees				£1 6s. 0d.
Rent				£3 18s. 0d.
Totals			9,141	£39 4s. 4d.

Note: A few prices have been added to those reported by Eden and the arithmetic very slightly altered so that price times quantity equals expenditure. Eden states that the gardener could take 'from his master's garden, what potatoes and other vegetables he has occasion for'. I have inserted quantities that are plausible in view of other budgets, but they are obviously uncertain.

Source: Eden , *State of the poor* , vol. II, pp. 433–5. Calories from USDA , *National Nutrient Database* .

I once thought so, too. I believed that the lifestyle of the Ealing gardener, like that of English agricultural labourers in general, typified the poverty of the pre-industrial world. When I started teaching economic history I made a handout of the budget of a farm labourer (based on the gardener's expenditures), so that my students could see what life was like before it was transformed by modern economic growth. One day, a development economist from India asked me what the classical economists meant by the 'subsistence wage'. I was pleased to show him my handout, which I thought answered the question. My friend looked at the budget, tut-tutted, wagged his finger, and said, 'These people are not poor. Look at all that meat they ate, look at all that cheese, look at that beer. These people were not poor—they were very rich'. Had I listened to my colleague, I would have learned something important, but I dismissed him as just another uninformed economist. Now I know he was right. The world's poor people today (those who make up Collier 's *Bottom billion*), as in the past, derived most of their calories from the cheapest available grain. Sometimes it was boiled to make a soup, pudding, or porridge.[5] At other times, it was ground to coarse flour and fried as a tortilla or chapati. Poor people also ate legumes and some sort of fat. There was little or no meat in the diet, and alcohol was generally absent. In the early seventeenth century, Francisco Pelsaert observed that people in north India 'have nothing but a little kitchery [kedgeree] made of green pulse mixed with rice

… eaten with butter in the evening, in the day time they munch a little parched pulse or other grain'.[6] The world's poor could not (and still cannot) afford to buy the bread, beer, and beef that the Ealing gardener consumed. They took their calories from cheaper sources.

Indeed, the Ealing gardener could have saved a lot of money by buying the sort of food that a Mexican peon or an Italian farm labourer, or a Chinese coolie could afford. Sir Frederick Eden realized that the Ealing gardener had a very expensive lifestyle. Eden did not have a global perspective, but he did compare the south of England with the north. He reckoned that 'a Cumberland labourer, who was as well supplied with vegetables, would make himself many a palatable dish, with onions, potatoes, and milk, and not expend above £15 a year in housekeeping' (less than half what the gardener spent). What Eden was describing was a diet similar to a French peasant's. Eden found it astonishing that this family should consume so large a quantity of the best wheaten bread. This is however considered to be so essential a part of the diet of a labourer in the southern parts of England 'that any farmer, who attempted to vary the diet of his men, by the introduction of various palatable and nutritious soups and puddings, would be considered as a very hard-hearted fellow'.[7] Eden concluded that:

> half their income might be laid by, and their family as well fed as it is at present, upon a diet not less wholesome, and what, I think, (from the variety of dishes that might be prepared,) would soon prove more palatable, than bread for dinner, six days in the week, and a small piece of plain roast beef on a Sunday.[8]

Eden was right that the gardener could have saved a lot of money on food without sacrificing nutrition. If the bread, meat, beer, cheese, and sugar had been replaced with enough oatmeal to supply the same amount of calories, the family could have saved £17 17s. 3d. or about half their annual income. He could have cut back even further—the cost of the bare bones basket was only about £10 per year. The reason this was possible is that the foods the gardener consumed were expensive sources of calories. Bread cost 2d. per 1,000 calories, meat and cheese were 3d., while beer and sugar reached 4d. and 5d., respectively. In contrast, oatmeal cost less than one penny per thousand calories. Of course, a mainly oatmeal diet would have been boring. Who would want to eat that?[9] Apparently not the Ealing gardener or his wife. Fortunately, they did not have to: the gardener's wages were high enough to buy white bread, Sunday roast, and pints of beer—even if he complained about the 'hardness of the times'.[10] Workers in other parts of the world were not so fortunate—they did not earn enough to buy the Ealing gardener's standard of living. That is the sense in which England was a high wage economy.

II

I have developed a procedure for comparing real wages across time and space. The measure is called a welfare ratio or a subsistence ratio and equals a family's income divided by the cost of maintaining it at a specified level of consumption.[11] In work to date, I have usually taken the family income to be that of the husband. The family's consumption is computed by first specifying the annual consumption pattern for a man and then multiplying its cost by three to obtain the subsistence income of the family

on the grounds that a family consisted of three adult male equivalents (a man, a woman, and two children). The first consumption pattern that I specified was the 'respectability basket' that included bread, beef, and beer. Initially, it was set to provide approximately 1,940 calories per day, but this was increased to 2,500 calories.[12] In addition, 'subsistence' baskets based on the cheapest available grain were defined since most people in the world outside north-western Europe could not afford the respectability basket. These subsistence baskets also provided about 1,940 calories per day. Evidently, the procedure is stylized as not all families are the same, but standardization is necessary to compare real wages across countries and centuries. When the welfare ratio equalled one, the worker earned just enough to keep a family at the baseline standard of living, while higher values indicate more discretionary income. The Ealing gardener, as we have seen, could have supported himself and his family on a lot less money: indeed, his earnings were about four times the subsistence standard of living. He had a large surplus above subsistence, most of which was expended in buying foods that were expensive sources of calories.

Humphries objects that these baskets do not provide enough calories. She has a point. Per capita calorie consumption is only 1,455 calories per day when the adult male gets 1,940 calories and we assume a family consisted of four people and three adult male equivalents (1,455 = 1,940 * 3/4): 1,455 calories places the family in the bottom decile of the Indian income distribution, which may be appropriate in defining subsistence.[13] However, 1,455 calories is not consistent with modern food security and poverty lines, nor does it provide the man with enough calories to do a labourer's job. A better procedure that is consistent with modern measures is to set the calorie level of the diet at 2,100 calories per person per day.[14] Requiring each person (rather than each adult male equivalent) to receive 2,100 calories implies that the family's annual subsistence cost was four times the cost of the annual basket rather than three times.[15] The implication is that the male received 3,160 calories per day when he worked (and so could do his job), while the woman received 2,057 (and so could spin, for instance).[16] The children also received nutritional levels consistent with World Health Organization standards for 'active' lives. Table 2 shows consumption patterns defined in terms of this norm.

Table 2. Baskets of goods (new definitions)

	A	B
	Respectability	Bare bones subsistence
	Quantity per person per year	Quantity per person per year
Oatmeal/grain		170 kg
Bread	182 kg	
Beans/peas	34 kg	20 kg
Meat	26 kg	5 kg
Butter/oil	5.2 kg	3 kg

Cheese	5.2 kg	
Eggs	52 each	
Beer	182 l	
Soap	2.6 kg	1.3 kg
Linen/cotton	5 m	3 m
Candles	2.6 kg	1.3 kg
Lamp oil	2.6 kg	1.3 kg
Fuel	5.0 M BTU	2.0 M BTU

Note: Each basket provides 2,100 calories per day. The cheapest varieties of bread, meat, oil, cheese, alcohol, and cloth in each locality are used in the respectability basket. The bare bones subsistence basket is modified to include the cheapest available carbohydrate. Its quantity is adjusted to yield the same calorie content.

The change raises the cost of subsistence everywhere since all baskets have more calories and since each family gets more baskets. The upshot of this is that international comparisons are virtually unaffected, and England's status as a high wage economy in the eighteenth century is confirmed. Figure 1 shows the subsistence ratio (computed on the new basis) for six cities that I have used previously to compare labourers' living standards.[17] The geometry of the two graphs is the same. London and Amsterdam are the high wage cities with fairly constant real wages across the early modern period. Florence and Vienna also had high wages in the fifteenth century. Their subsistence ratios then slipped to one or even lower in the eighteenth century. Beijing and Delhi had similarly low real earnings at the time. England is a high wage economy using the higher calorie standard just as it was earlier.
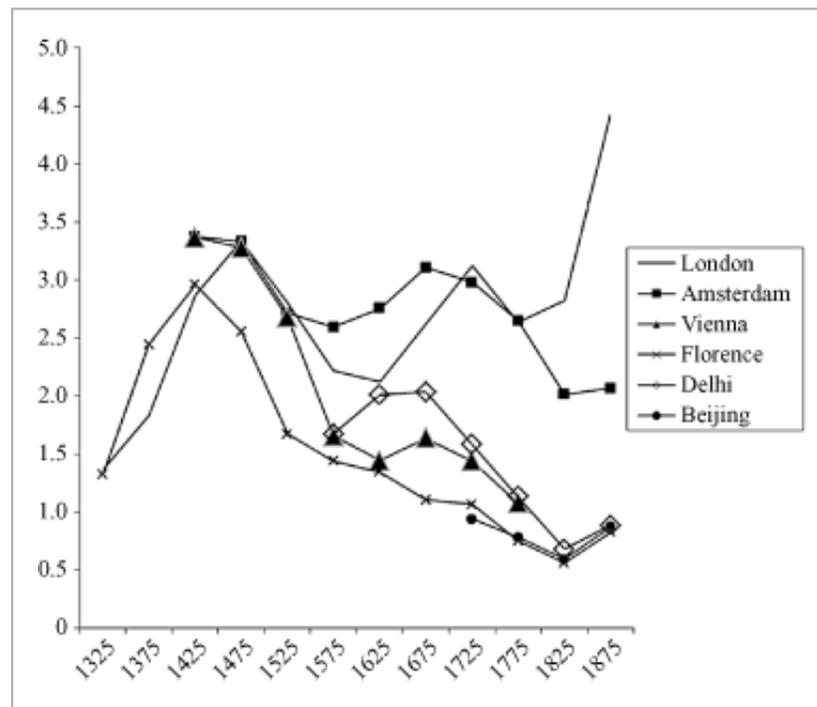
Figure 1.

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Subsistence ratio for labourers' income

Note: These ratios were calculated as the ratio of full-time, full-year earnings (generally reckoned at 250 days per year) relative to the cost of a supporting a family for a year (reckoned at four times the cost of the basket shown in tab. 2 plus 5% of that cost for rent). The wage rates are those of labourers and not carpenters, bricklayers, masons, or other skilled artisans.

Sources: See **Allen, Bassino, Ma, Moll-Murata, and van Zanden**, 'Wages, prices and living standards'.

Humphries objects to additional features of this procedure. The issues she raises, however, do not change the conclusion that Britain was a high wage economy. The rest of this section examines three of her objections.

First, Humphries argues that the procedure is patriarchal. The procedure's calculations are based on a 'male breadwinner family (MBWF)', which Humphries contends is ahistorical. She correctly observes that there has always been a variety of family arrangements, and men were sometimes absent. Indeed, many children were orphans. Furthermore, the earnings of women and children are ignored. So a model assuming that a man supports a wife and their children is an inappropriate starting point for the analysis—according to Humphries.

Or is it? Since there are always a lot of family arrangements, the question is what is the predominant type? The best evidence for the industrial revolution is in Humphries's *Childhood and child labour in*

the British industrial revolution . In her sample of biographies, 433 out of 584 boys grew up in families with fathers present.[18] That is 74 per cent. As Horrell and Humphries show, most of the income of working class families came from the earnings of the male head. 'In general male earnings comprised … usually around 70 to 80 percent' of family income, while 'women's and children's earnings made up … usually around 20 percent' of the total with almost all of this coming from the children. Women contributed very little.[19] That is why Humphries remarks 'on the cardinal importance of the father's economic role'.[20] Since most children lived in a male breadwinner family and depended on their father's earnings for their well-being, the MBWF is the sensible framework to begin research.

A further objection by Humphries is that the analysis is based on London wages, and they overstate the income of many workers. Figure 2 shows the real wages of building labourers in different parts of England from 1700 to 1850. The wages are expressed as welfare ratios where annual earnings are deflated by the cost of maintaining four people at 2,100 calories per day using the subsistence basket in table 2. The real wage of building labourers in northern Italy is also expressed in the same metric to provide perspective.
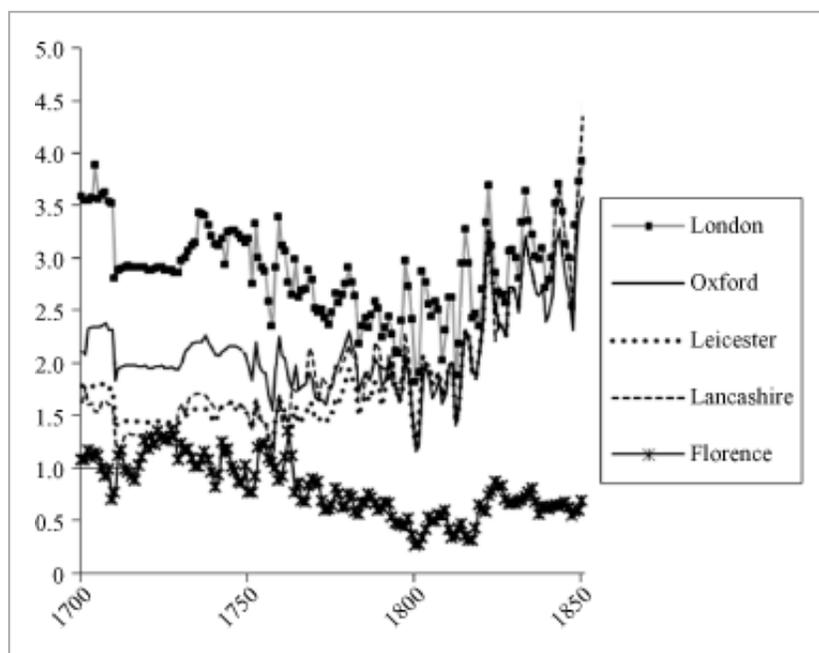

Figure 2.

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Subsistence ratios for building labourers across England and in northern Italy

Sources: London: **Schwarz** , 'Standard of living', pp. 36–8. Florence: **de Maddalena** , *Prezzi* , p. 420. Oxford: **Phelps Brown and Hopkins** , 'Seven centuries', pp. 205–6. Leicester: **Page** , ed., *Victoria history* , p. 185. Lancashire: 1700–94: **Gilboy** , *Wages* , pp. 280–2; 1810–25: *Tables of the Revenue* (P.P. 1833, XLI), p. 165; 1839–1900: **Bowley** , 'Part VI, wages in the building trades', pp. 310–11.

The pattern is simple. From 1700 to 1760, Italian labourers were at the bottom with a wage at bare

bones subsistence. London labourers earned three times that wage, labourers elsewhere in southern England earned twice that wage, and labourers in northern England earned 50 per cent more than subsistence. Between 1760 and 1850, Italian real wages slumped even lower (these were very difficult times for Italians as well as for most people in southern and central Europe and in many parts of Asia), London wages sagged to two-and-a-half times subsistence, while real wages throughout the rest of England slowly advanced. By 1820, convergence was complete, and building labourers throughout England earned about two-and-a-half times subsistence. By 1850 they earned at least three times subsistence.

The experience of other workers also needs to be considered. Indeed it should be remembered that building labourers were at the bottom end of the urban wage distribution. Craftsmen, shop keepers, farmers, and many other workers earned more. Humphries thinks that 'agricultural labourers constitute a sensible comparator since they remained the largest single occupational grouping and one known to have fared less well over the course of the industrial revolution'.[21] I will review the evidence for women spinners, handloom weavers, and farm workers. They all did well before 1770, but then their experiences diverged. An important finding is that the earnings of spinners advanced earlier than the wages of the northern labourers shown in figure 2, as we will see.

Third, Humphries claims that the well-being of women and children is overestimated since no attention is paid to the father's power to shift the intra-familial allocation of consumption in his favour. Humphries spends many pages showing that if a family's income is at bare bones subsistence, then the survival of the women and children is threatened if the man consumes the 2,500 calories per day that she thinks he requires. This is true and shows the terrible choices that arise at bare bones subsistence. She implies that this has important implications for English workers. Generally, however, it does not, since their earnings were several multiples of subsistence. They could buy many more calories than people at subsistence, so they could side-step the trade-offs that concern her. The Ealing gardener's family consumed more calories than were specified in any of the baskets.

Nonetheless, the issue of the intra-familial allocation of income is an important one, and it is not directly addressed by the real wages I have computed. Did this issue have enough negative ramifications to threaten the conclusion that English children, for instance, benefited from the high wage economy? Fortunately, there is a way to answer that question.

III

I consider the question of children's (and to a lesser extent women's) welfare in a broader context. The United Nations Human Development Index aggregates three aspects of experience—income, health, and education—to gauge well-being. How did the lives of English women and children stack up on these dimensions?

I begin with income. In the eighteenth century, the real wages of male labourers in Britain were higher than those of their counterparts in Europe (outside of the Low Countries), Asia, and Latin America. The only parts of the world with comparably high male real wages were the settlements on the east coast of North America that became the US.[22]

Two issues complicate similar comparisons in the cases of women and children. The first pertains to

the way they were paid. While women and children have often worked, they have rarely been paid with a daily cash wage. Often they have been paid according to a piece rate (for example, spinners), or they received much of their remuneration in kind (servants), or they accrued income in a family business (farmers' wives and children helping their parents). The piece rates, in particular, are informative, and much more work needs to be done on the global scale to collect and interpret this information. In this reply, I restrict myself to comparisons between England and France.

In the pre-industrial economy, spinning was one of the most common jobs for women. During the 1780s, Arthur Young collected information on the daily earnings of women in both countries. He found that a woman who spent a full day spinning could earn 6.25d. per day in England and 9 sou tournois in France. Taking account of prices in the two countries implies that spinners in England received a real wage that was a third greater than their counterparts in France.[23]

As factory production spread in the nineteenth century, wage labour became more common, and data availability increases. A French inquiry in the early 1830s reported average earnings as 2.13 francs per day for men, 1 franc for women, and 0.62 francs for children.[24] Boot and Maindonald have exhaustively studied wages in British cotton mills, and average earnings in 1833 came to 210d. per week for men, 96.79d. for women, and 59.55d. for children.[25] Similar relative earnings prevailed in the two countries, which implies that generalizations of real wages based on male earnings apply to women and children as well. Table 3 summarizes the data and shows that the real earnings of all classes of British workers were 40 to 45 per cent higher than those of their French counterparts. Women and children participated in the high wage economy just as men did.

Table 3. British and French real wages, 1833

	British wage	French wage	British wage	French wage	British/French
	d./day	francs/day	Real	Real	
Men	35.1	2.13	7.61	5.12	1.49
Women	16.5	1.00	3.58	2.40	1.49
Children	9.9	0.62	2.15	1.49	1.44

 Note: The average earnings of British children were 8.9d. per day if no adjustment is made for the differences in hours worked per week for children of different ages. In that case, the real wage of British children is 1.93, which exceeds the French real wage by 30%.

 Sources:

 British wages: **Boot and Maindonald** , 'New estimates', pp. 383, 407–8. The daily wages for men and women are the weekly earnings for males and females aged 18–60 years, divided by 6. For children, an average weekly wage on a 69-hour basis was calculated by weighting the wages for children under 13, boys aged 13–17, and girls aged 13–

17 by percentages of the workforce. Employees aged 13 and over worked a 69-hour week, while children under 13 worked a 48-hour week, and that difference explains much of the difference in their weekly earnings. To put earnings on the same time basis, the earnings of children under 13 were multiplied by 69/48. Weighted average earnings of children computed in this way were divided by 6 to calculate daily earnings.

 French wages: **Levasseur** , *Histoire des classes ouvrières* , vol. II, p. 253.

Real wages: The daily wages were divided by the consumer price indices in pence and francs for 1833 to compute the purchasing power of the wages. The consumer prices indices in local currency were taken from spreadsheets labelled 'London' and 'Strasbourg' on Allen's homepage at http://www.nuffield.ox.ac.uk following links. The values of the indices were 4.6134 for England and 0.4164 for France. Deflating the nominal wages in this way indicates the number of units of a composite consumer good that could be purchased where the composite good is defined according to budget A in tab. 1.

'British/French' is the ratio of the British real wage to the corresponding French real wage.

In principle, these comparisons could be extended to more countries and pushed back in time, but the research will require ingenuity and resourcefulness in view of the limited availability of wage data. Even a complete set of earnings data, however, will leave unresolved the question of the intra-familial distribution of earnings. Did the high real wages of English children translate into better life experiences or did they simply subsidize their fathers' drinking?

The history of adult heights provides an answer to this question, as well as providing evidence on the health of children.[26] The mean height of a group of adults is usually interpreted as a measure of their standard of living, but it is not equivalent to real wages or GDP. Height and income are correlated but only imperfectly, so something else is involved. In the usual formulation, an adult's height depends on his or her 'net nutritional status' during childhood, that is on gross food consumption less the demands for energy and other nutrients arising from basal metabolism, work, and illness. Children have some ability to offset deficiencies in food in some years with surpluses in later years.[27] These considerations can be summarized by saying that adult height is nature's aggregator, combining many features of childhood into a summary statistic. It looks like a purpose built indicator to measure children's quality of life in its nutritional and health dimensions.

Anthropometric historians have accumulated a vast amount of evidence about the completed heights of men, which allow international comparisons of the standard of living of English boys. These data are not without their problems: most datasets are measurements of military recruits. Generally, they were volunteers—so they may not have been a random sample of the population—and there were often minimum height requirements for service, so the samples are truncated. Other datasets include prisoners or indentured servants, which raise parallel questions of selection. Anthropometric historians have shown great ingenuity in tackling the problems.

In the pre-industrial world, the tallest men were more than 170 cm in height, while the shortest were about 150. White males in the future US were the tallest and averaged 172–3 cm.[28] These men also earned the highest real wages in the world. The second tallest men lived in northern Europe. Dutch soldiers averaged about 165 cm tall in the early nineteenth century, while Swedes and Norwegians were about 166 cm tall.[29] The height of French soldiers, who averaged only 162 cm in the seventeenth century, increased to 168 cm in the 1740s and then slumped to 165 cm in the 1760s and slid below 164 cm in the 1780s and 1790s.[30] Bavarian soldiers were similar.[31] The mean height of north Italian recruits in the Austrian army dropped from 168 cm in the 1730s to 164 in the early nineteenth century.[32] Further east and south, men were shorter. Heights fell dramatically in central Europe between 1730 and 1790: in Bohemia from 165 to 161 cm, in Hungary from 167 to 163, in Galicia from 171 to 163, and in Austria from 169 to 161.[33] In southern Spain male soldiers averaged 163 cm in the eighteenth century, and similar or shorter heights are reported for Madrid and its hinterland from the 1830s onward.[34] Outside of Europe, people were shorter still. Adult working-class men emigrating from

south China averaged 163–4 cm in the early nineteenth century.[35] Japanese military recruits in the late Tokogawa period averaged 157 cm.[36] The height of Mexican soldiers slid from 164 cm to 160 cm between 1740 and 1835. Argentine recruits in 1785 averaged 158 cm. Peasants and indigenous peoples in Latin America more recently return heights of 153–9 cm.[37]

How does England fit into this pattern? Floud, Wachter, and Gregory collected very large samples of heights of recruits in the British Army and Royal Marines, and carried out the first analysis of these data.[38] A recent comparison of their results with the heights of other (mainly northern) Europeans shows that the British (at 169 cm) were the tallest European men in the last quarter of the eighteenth century.[39] The conclusions of Floud, Wachter, and Gregory have been controversial, and the data have been reanalysed several times. A principal point of contention is whether, or in what way, the Royal Marine data should be included in the analysis. Komlos and Cinnirella contend that these data are censored from both above and below, which renders them unsatisfactory for estimating the height distribution.[40] Cinnirella, consequently, excluded them from his analysis and reached two conclusions.[41] First, British working-class heights averaged 172 cm in the late eighteenth century, which was as tall as the Americans. On this reading of the evidence, British boys tied with American boys in having the highest standard of living in the world in the eighteenth century.

An important corollary of this finding is that the intra-family allocation of income was not—in general— biased towards drunken, gluttonous men. Rather, food was distributed to the boys, at least, in the male breadwinner family in a way that allowed them to flourish. Life was harder for children in female headed families and probably hardest of all for children growing up in orphanages or other institutional settings. These boys were shortest of all.

Cinnirella's second conclusion was that the standard of living slipped during the second quarter of the nineteenth century, for the heights of men born in that period dropped. Why this happened is not entirely clear. There are three possibilities.[42] First, although the average real wage rose in Britain in the first half of the nineteenth century, the dispersion of earnings also increased, as wages rose for employees in expanding activities, while they fell for people working in hand trades that were being driven out of business by factory production. The average height could have fallen if the negative effects of lower earnings on a child's growth were more substantial than the positive impact of high earnings. Second, exposure to pollution and disease increased for children as the population moved into large cities, placing greater nutritional demands on children.[43] Third, the intra-familial distribution of income may have shifted against children. The industrial revolution saw sharp reductions in the prices of manufactured goods such as cloth, shoes, hats, stockings, and other clothing. Perhaps the granddaughter of the Ealing gardener decided to rectify the clothing deficiency once and for all—at the expense of her children's nutrition.

Whatever the explanation, the decline in heights in the nineteenth century is too late to undermine the role of high wages in explaining the technological breakthroughs in the eighteenth. The economic implications of declining heights came in the later Victorian period. The British workforce of the 1880s and 1890s was shorter than the workforce of the 1780s and 1790s. Perhaps intellectual development was also adversely affected. The decline in the quality of the workforce may have contributed to Britain's poor productivity performance in the late nineteenth century.

Education is the third component of the Human Development Index. There are not adequate statistics to measure schooling, but the ability to sign one's name is a widely available indicator of literacy and

'age heaping' has been taken to measure numeracy. At the end of the eighteenth century, the geographical distribution of these attributes was not dissimilar to that of height.[44] The highest levels of literacy and numeracy were reached in Britain, the US, and the Low Countries. They were followed by north-eastern France, western Germany, and Scandinavia. Central and southern Europe lagged behind, as did Latin America and much of Asia. Japan is an important anomaly, for literacy was high even though the people were short. While there were many deficiencies in the quality and quantity of British schools, an unusually high proportion of British children nonetheless acquired basic intellectual skills as they grew up.

Wages, height, and literacy point to an important conclusion: the quality of childhood in eighteenth-century Britain was high in comparison to that in most other parts of the world. Indeed, the high quality of British childhood was one of the building blocks of the industrial revolution, for it meant that adults were physically strong and possessed skills required for technological progress and commercial success. The industrial revolution was an outcome of many successful childhoods.

IV

Humphries does not see it that way. In the final section of her article, she takes up the challenge of explaining the inventions of the industrial revolution. In her view, Britain had an abundant supply of women and children, and the factories of the industrial revolution were invented to exploit those resources. Since women and children were low wage workers, the industrial revolution should be seen as the response to low wages rather than to high wages.[45]

These claims have a few problematic features that alert us to underlying problems. The first cotton spinning factories, which were the principal examples of machine technology before the power loom came into general use in the 1830s, did *not* involve the substitution of female labour for male labour. The spinning machines in general use in the 1770s and 1780s were Hargreaves's jenny and Arkwright's water frame. Both substituted women and children using machines for women and children using hand processes in cottages. Beginning in the late 1780s, Crompton's mule became the preferred technology. It substituted male spinners for female spinners.[46] The principal change in technology that changed the sexual division of labour was actually the reverse of the 'stylized fact' that Humphries assumes. It is no surprise, therefore, that her explanation for the invention of machinery is unsound.

Second, Humphries never analyses the British labour supply from an international perspective. This is essential since the question of explaining why machines were invented *in Britain* is fundamentally comparative. Was the supply of women and children really greater in Britain than elsewhere? The answer must be 'No'. Wages are a measure of labour scarcity, and the real wages of British women and children were higher than those of their French counterparts—not lower as Humphries's explanation requires. It is, therefore, unpersuasive to say that the factory was invented in Britain rather than in France because Britain had a more abundant supply of female and child labour.

Third, the calculations which I have previously done to show that early spinning jennies and Arkwright mills were profitable in England but not in France used *female* wages (not male wages). My development of the idea that high wages induced labour-saving technical change in Britain has already incorporated the relative scarcity of women.

Humphries's claim that machines were profitable because they allowed the substitution of cheap women and children for expensive men is not an alternative to my analysis of the high wage economy; rather, Humphries is simply specifying one channel by which high wages might have induced mechanization. To be more precise, it was only worthwhile for a business to install a machine to substitute female and child labour for male labour when male wages were high. The machine cost money, and the investment was justified by reducing labour costs. If male wages were low, so were the cost savings. Machines made sense only in a high wage economy.

We can gain valuable insights into technical change by analysing the timing of invention. Why were the spinning machines invented in Britain in the eighteenth century rather than the seventeenth or the nineteenth? The answer throws light on themes that are important to Humphries such as the rise of the male breadwinner family and poverty during the industrial revolution.

My analysis of the timing of invention elaborates my earlier explanations of why the inventions were made in Britain.[47] The short answer is that it would not have paid to use spinning machines before the eighteenth century: hence, they were not invented earlier. The analysis of profitability turns on the history of women's wages relative to the cost of spinning machinery.

I do not draw a sharp distinction between cotton, which was the first fibre to be successfully spun by machine, and wool, worsted, or linen. Evidently, the mechanization of the cotton industry would have been impossible before the advent of cotton manufacture late in the seventeenth century. However, the early history of wool and linen production is relevant for three reasons. First, the earliest attempts to spin with machines were carried out with these fibres.[48] Second, by the late eighteenth century, worsted was being spun by machines, and wool and linen followed in the early nineteenth century. Third, spinners shifted their time between fibres in response to anticipated earnings, so the wage earned by cotton spinners was effectively set by conditions in the wool and worsted industries. Those are known, so we can analyse what the profits would have been to mechanize spinning in cotton had the possibility arisen in the seventeenth century. My argument is that it would not have been profitable to mechanize cotton before the eighteenth century even if the fibre were widely available. It was changes in the wool industry that tipped the balance of advantage in cotton production.

Muldrew reviewed the history of earnings of spinners from the end of the sixteenth century to the middle of the eighteenth.[49] The data are not easy to interpret since women differed among themselves in productivity as well as in the time they devoted to spinning, but Muldrew has worked through these problems to achieve a consistent series. We can extend his series using Feinstein's estimates of spinners' earnings during the early industrial revolution.[50] Figure 3 shows the earnings of a spinner from 1588 to 1803 divided by the wage of a building labourer in northern England. A woman earned one-third as much as a man at the end of the sixteenth century or in the first half of the seventeenth. By 1750 her earnings jumped to two-thirds of male earnings. These earnings were very high compared to those in other countries. Indeed, not only were women participating in the high wage economy, they were its advanced guard, for women's earnings were leading the way upward in northern England. This is an important example of why Humphries is right that a correct understanding of the industrial revolution must give full weight to women's experience. Women's earnings stayed at a high level for a generation, but then they slumped as machine spinning replaced hand spinning.

Figure 3.

Open in figure viewer

Earnings of a spinner relative to a building labourer

Sources: Spinners' wage from **Muldrew** , ' "Th'ancient distaff" ', pp. 504–11, 519.
Labourers' wage from **Woodward** , *Men at work* , pp. 274–5; **Gilboy** , *Wages* , pp. 280–2.

The rise in spinners' earnings was the result of the expansion of wool and linen production. Following Muldrew, table 4 shows the number of 'married women equivalents' required by the wool industry from 1500 to 1770. The number increased 14-fold. This was much greater than the increase in the number of adult women in the period. The ratio of 'married women equivalents' required to spin the country's wool and the number of adult women in the population is a rough indicator of the balance of labour demand and supply—rough because not all adult women were spinners and because younger women also spun. Nonetheless, the calculation shows that the ratio rose from 18 per cent in 1500 to 62 per cent in 1770. Towards the beginning of the eighteenth century, the market for spinners was becoming tight, and their earnings were rising.

Table 4. Spinning and the female population

	Wool spun	Spinners required	Female population aged 25–59	Ratio of spinners required to female population, age 25–59
1500	14.0	88,889	487,500	18%
1590	35.5	225,083	770,480	29%
1615	48.0	338,427	889,120	38%
1640	44.7	342,299	1,062,134	32%

1700	57.0	495,974	1,106,688	46%
1750	71.6	651,038	1,194,601	54%
1770	86.4	785,627	1,270,542	62%

Sources: Wool spun: **Muldrew** , ' "Th'ancient distaff" ', p. 518. Female population aged 25–9: **Wrigley and Schofield** , *Population history* , pp. 527–35. Wool production in 1500: **Broadberry, Campbell, Klein, Overton, and van Leeuwen** , 'British economic growth', p. 32. Spinners required in 1500: computed with Muldrew's procedure (Muldrew, ' "Th'ancient distaff" ', pp. 510, 517); that is, each spinner worked 35 weeks per year and spun 4.5 pounds per week for a total of 157.5 pounds per year.

The rise in wages in the wool industry was noticed by contemporary observers. In 1724, Defoe attributed the rise to the 'Encrease of Trade': 'The rate for spinning, weaving, and all other Manufacturing-Work, I mean in WOOL, is so risen, that the Poor all over England, can now earn or gain near twice as much in a Day, and in some Places, more than twice as much as they could get' previously. The high earnings of spinners pulled labour out of agriculture: 'the Farmers Wives can get no Dairy-Maids … and what's the matter? Truly the Wenches answer, they won't go to Service at 12d to 18d a Week, while they can get 7 s to 8 s a Week at spinning'.[51]

The rise in spinners' earnings increased the attractiveness of using machines. We can analyse both jennies and water frames. The jenny was the first spinning machine to come into general use. Initially, it was purchased by women spinning in their homes.[52] They used the machine to increase the yarn they could make each week and, hence, the income they received from the putting out merchant who supplied them with materials. Figure 4 plots rates of return realized by a woman who (hypothetically) bought a jenny at different dates between 1588 and 1784. Before 1700, the profit rate was always less than 3 per cent. In 1700, it jumped to 20 per cent and it reached about 33 per cent by the middle of the eighteenth century. The increase was driven by the rise in women's wages which made it profitable for women to buy machines to augment their labour. These profit rates are returns to fixed capital, and a return of 15 per cent, computed on that basis, was necessary to induce investment. That threshold was crossed in the eighteenth century, and mechanical spinning became attractive. We can repeat the analysis for Arkwright's water frame with similar results. The rate of return to installing an Arkwright mill would have been less than 3 per cent in the seventeenth century but jumped to 20 per cent by the mid-eighteenth (figure 4). That is when it became profitable to use—and hence to invent—roller spinning.
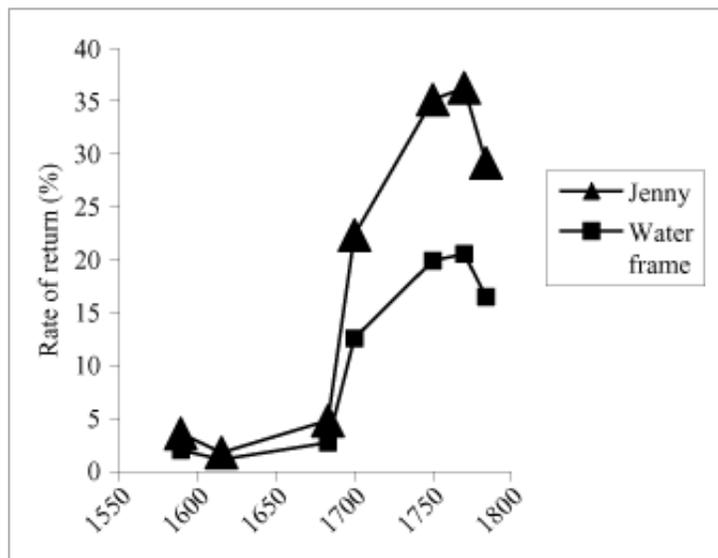
Figure 4.

Open in figure viewer

Rates of return to spinning machinery installed in England at different dates

Sources: See text. The rates of return to the jenny and the water frame were calculated using the methods described in **Allen** , *British industrial revolution* , pp. 213–16; however, the rate of return formula for the jenny was modified following **Allen** , 'Spinning jenny', pp. 462–3, so that the spinner was assumed to continue to work the same time with the jenny as she had with the spinning wheel. The cost of buying a jenny or erecting a water frame for years before 1784 was estimated from the acquisition costs of the machinery and mills in 1784 by multiplying those costs by an index of the price of capital goods. This was calculated as a geometric average of the wage rate of building labourers and the prices of building materials.

The best way to understand why the famous inventions of the industrial revolution were invented in Britain in the eighteenth century is to analyse the profitability of using the equipment since there was no point going to the expense of inventing something that would not be used. Britain was a high wage economy in the eighteenth century, and those high wages increased the incentive to invent labour-saving machinery. This conclusion does not depend on comparisons of male wages alone since women and children also participated in the high wage economy.

V

Underlying all of her criticisms of the high wage economy is Humphries's view that living standards for many people were low during the industrial revolution.[53] How under those circumstances, can one speak of a high wage economy? This is an important question. The answer is that the high wage

economy was not a permanent feature of English life. It was the result of the economic expansion that began at the end of the Tudor period and continued until the industrial revolution. The growth of cities, rural manufacturing, and agricultural productivity led to rising levels of prosperity throughout the country. Wages in London were high in the sixteenth century and remained so. Male wages converged upwards towards the London standard. This process began in southern England in the seventeenth century and extended to northern England in the eighteenth. The gains were not confined to men, as the evidence of spinners' wages shows. Children also gained as indicated by the heights of men.

This prosperity, however, contained the seeds of its own destruction even as it led ultimately to higher living standards generally. As wages rose in the eighteenth century, the incentives to mechanize production increased in order to economize on the more expensive labour. The result was the invention of the cotton mill and eventually the spread of machine technology across the whole economy. As industry was mechanized, there was technological unemployment and falling wages for those who remained in the handicraft sector. The 'standard of living question' was the result of the liquidation of the traditional sectors that were responsible for the prosperity of the eighteenth century. The standard of living problem was big because these sectors were large.[54]

Spinners were the first casualties in this struggle, and there were many of them. While hand spinners could earn 12d. per day in 1770, their earnings dropped to 5d. by 1795.[55] This bears on Humphries's concern with family income, for the loss of female earnings had noticeable consequences. Male farm labourers rarely earned enough to keep their families at the respectable standard of living, so the family had to subsist on cheaper sources of calories if men were the sole providers. This is shown in figure 5, where the earnings of a southern agricultural labourer, assumed to work full-year, full-time, are plotted. In the sixteenth and seventeenth centuries, his earnings were too low to purchase the respectability standard of living, and his wife's were not substantial enough to close the gap. This is clear in figure 5, where the wife's earnings have been added to the man's to show the combined total.[56] The situation changed between 1700 and 1775 due to the rise in spinners' wages. In this 'golden age' the family earned 20 per cent more than necessary to purchase the respectability standard. After 1775, this favourable situation reverted to the earlier pattern of insufficiency, as the wife's earnings collapsed. The political discourse of the time focused on the plight of the agricultural labourer, since his earnings were not sufficient to keep his family at the respectable standard of living. The immediate cause of the problem lay not in agriculture, however, but in the collapse of cottage spinning.
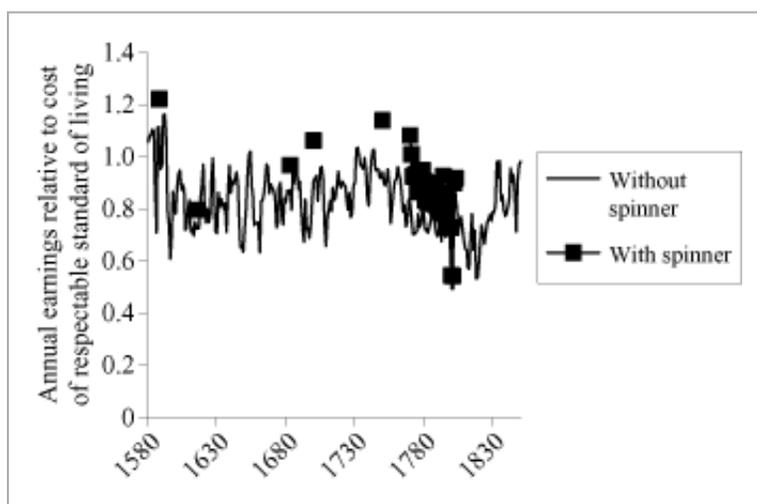
Figure 5.

Family earnings for a southern agricultural labourer and a spinner

Sources: The cost of a 'respectable' standard of living was discussed in section II. A male agricultural labourer was assumed to work 300 days per year at daily wages discussed in Allen, *Enclosure*, p. 330. A spinner was assumed to work 120 days per year (40% of full time) at rates used in fig. 3.

The technological unemployment resulting from machine spinning was a foretaste of more problems in the nineteenth century. A full analysis of gains and losses during the industrial revolution is beyond the scope of this article, but figure 6 shows how the general prosperity of the high wage economy of the eighteenth century gave way to enormous inequality as the industrial revolution unfolded. I focus on building and agricultural labourers in Lancashire and worsted hand loom weavers. Figure 6 shows their annual earnings deflated by the cost of the subsistence basket of 2,100 calories and on the assumption that they had to support four people. In 1770, the difference in earnings among these groups was small: the building labourers, who received the highest wage, earned only about one-quarter more than the handloom weavers, who had the lowest. The handloom weavers enjoyed a brief golden age in the first quarter of the nineteenth century but their incomes slumped to bare bones subsistence after 1830. By 1840 the labourers were earning three times what the handloom weavers took in. The farm labourers occupied an intermediate position and realized a small increase in the real wage over the period. The clear winners were the building labourers whose real earnings doubled by 1850.
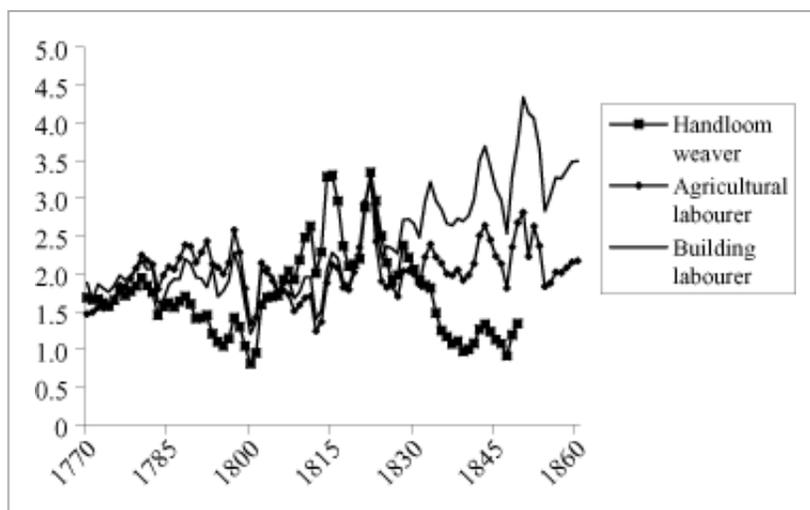

Figure 6.

Subsistence ratios in northern England, 1770–1850

Sources: Worsted handloom weaver: Feinstein's index based on Bowley and Palgrave as described in **Feinstein** , 'Wage-earnings', p. 191. Agricultural labourer: **Bowley** , 'Part I, agricultural wages', p. 720 (wages implied by Bowley's index numbers). Building labourer: see sources for fig. 2.

This explosion in wage inequality was obscured in Feinstein's work, for he averaged the low earnings of handloom weavers with the high earnings of mule spinners to compute average earnings in the cotton industry, for instance, which was the first step in computing the economy-wide average as the average of industrial averages. Had the first step been to compute the average earnings of hand workers and the average earnings of factory workers irrespective of industry, the increase in wage inequality would have been apparent, and losers in the industrial revolution would have been highlighted at the same time.

VI

There is a deeply ingrained tradition among British historians that emphasizes the poverty of the working class during the industrial revolution. This was a theme of social critics of the period and was incorporated into economic theory by the classical economists who thought wages were at 'subsistence'. While Ricardo, Malthus, and Marx subscribed to this view, it is worth remembering that Adam Smith had a far more nuanced understanding of the world.[57] He thought that the English and Dutch workers had the world's highest real wages, followed by other Europeans, and then by the Chinese and Indians. Indeed, Friedrich Engels's description of working-class diets contradicted his own theory, for it showed that all but the poorest strata ate expensive foods such as bread, cheese, and meat.[58] The average Italian or Indian labourer could not afford to eat so well. Unless we base our theories of the industrial revolution on comparative analysis that recognizes the relatively high standard of living achieved by eighteenth-century Britain, we will never understand why the industrial revolution happened when and where it did.

Footnotes

1   **Hartwell** , 'Rising standard of living'; idem, 'Standard of living'; **Hobsbawm** , 'British standard of living'; idem, 'Standard of living during the industrial revolution'.

2   **Feinstein** , 'Pessimism perpetuated'.

3   **Humphries** , *Childhood* ; eadem, 'Children who built Victorian Britain'; eadem, 'Childhood and child labour'; **Allen** , *British industrial revolution* ; idem, *Global economic history* ; idem, 'Industrial revolution in miniature'; idem, 'Spinning jenny'.

4   **Humphries** , 'Lure of aggregates'.

5   **Collier** , *Bottom billion.*

6   **Pelsaert** , *Remonstrantie* , pp. 60–1.

7   **Eden** , *State of the poor* , vol. II, pp. 434–5.

8   Ibid., vol. II, p. 435.

9   Perhaps the Scots: **Gibson and Smout** , *Prices* , pp. 231–2.

10   **Eden** , *State of the poor* , vol. II, p. 434.

11   For most places annual earnings equal the man's daily wage rate multiplied by a work year of 250 days.

12   **Allen** , 'Great divergence in European wages', p. 421; idem, *British industrial revolution* , p. 36.

13   **Suryanarayana** , 'Nutritional norms', p. 35.

14   **Allen** , 'Poverty lines', explains the procedures mentioned here in more detail.

15   Adult males comprised about 25% of the population. We can summarize this by saying that an average family consisted of a man, a woman, and two children.
Floud, Fogel, Harris, and Hong , *Changing body* , pp. 165–7, have performed extensive calculations to determine the ratio of adult male equivalents (AMEs) to the English population, and they concluded the ratio was very close to three AMEs to four people—which was my assumption. Humphries suggests that the ratio was higher for the working class, but the evidence she presents does not establish the point. For instance, she argues that working-class women had more than four children, on average. However, not all of these children were living with their parents and supported by their income since some of the children died and others were grown up or lived elsewhere; **Schneider** , 'Real wages'. Moreover, Humphries would have to show that English working-class families were larger than their counterparts in other countries if she wants to argue that my assumptions lead to an overestimate of the relative standard of living in England. She has not done that, and the case, in any event, is doubtful.

16   **Allen** , 'Poverty lines', pp. 3–6.

17   **Allen** , *British industrial revolution* , p. 40. The male building wages discussed in this article are those of building labourers and not those of carpenters, masons, bricklayers, or other skilled artisans.

18   **Humphries** , *Childhood* , p. 62.

19   **Horrell and Humphries** , 'Old questions', p. 858, n. 31.

20   **Humphries** , *Childhood* , p. 88.

21   **Humphries** , 'Lure of aggregates', p. 697.

22   **Allen, Bassino, Ma, Moll-Murata, and van Zanden** , 'Wages, prices, and living standards';
      Allen, Murphy, and Schneider , 'Colonial origins'.

23   **Young** , *Travels* , vol. II, pp. 316–33. In terms of silver, the English wage was 2.9 grams per
      day and the French wage was 2.1 grams per day. Between 1780 and 1786, consumer prices
      averaged 4% more in England than in France when prices are also expressed in silver. Price
      data is from the spreadsheet labourers.xls, columns X and Z on my web page on
      http://www.nuffield.ox.ac.uk. Other price indices give similar results.

24   **Levasseur** , *Histoire des classes ouvrières* , vol. II, p. 253. The 1840–5 industrial census
      reported very similar earnings outside of Paris (2.09 fr. for men, 1.03 for women, and 0.73 for
      children) and for the textile industries (2.04 for men, 1.05 for women, and 0.73 for children);
      ibid., vol. II, pp. 237–8.

25   **Boot and Maindonald** , 'New estimates', pp. 383, 407–8.

26   The following have debated whether the intra-household allocation of resources disadvantaged
      women and children: **Nicholas and Oxley** , 'Living standards of women';
      Johnson and Nicholas , 'Male and female living standards'; eisdem, 'Health and welfare of
      women'; **Harris** , 'Gender, height and mortality'; idem, 'Gender, health, and welfare'; idem,
      'Anthoprometric history'.

27   **Steckel** , 'Stature', pp. 1910–11; **Floud et al.** , *Changing body* , p. 11.

28   **Costa and Steckel** , 'Long-term trends', p. 51.

29   **Steckel** , 'Stature', p. 1919.

30   **Komlos** , 'Anthropometric history', p. 168; **Weir** , 'Economic welfare', p. 191.

31   **Baten** , 'Climate'; **Baten and Murray** , 'Heights'.

32   **A'Hearn** , 'Anthropometric evidence', pp. 370–1.

33   **Komlos** , *Nutrition and economic development* , p. 57.

34   **Cámara** , 'Long-term trends', p. 67; **Montero** , 'Madrid rural', p. 107.

35   **Baten, Ma, Morgan, and Wang** , 'Evolution', p. 351.

36   **Akira, Osamu, and Toby** , eds., *Emergence of economic society* , pp. 235–8.

37   **Challú** , 'Great decline', p. 89; **Ríos and Bogin** , 'Anthropometric perspective', p. 291.

38   **Floud, Wachter, and Gregory** , *Height, health and history* .

39   **Floud et al.** , *Changing body* , p. 69.

40   **Komlos** , 'Secular trend'; **Cinnirella** , 'Optimists or pessimists?'.

41   **Cinnirella** , 'Optimists or pessimists?'. **Komlos and Küchenhoff** , 'Diminution', have proposed a weighting procedure for combining the Army and Royal Marine data. They find that the British were as tall as the Americans in the middle of the eighteenth century and that their height dropped during the industrial revolution by more than Cinnirella found. The decline also started in the late eighteenth century.

42   **Komlos** , 'Shrinking'.

43   **Kirby** , *Child workers* , pp. 110–26, reviews contemporary evidence on the relationship between children's heights and their ages, locations, and occupations. He concludes that working in a large city or a coal mine retarded the growth of children.

44   **A'Hearn, Baten, and Crayen** , 'Quantifying'; **Baten and Crayen** , 'Global trends'.

45   **Humphries** , 'Lure of aggregates', pp. 708–12.

46   **Kirby** , *Child labour* , pp. 71–2, makes these points.

47   **Allen** , *British industrial revolution* ; idem, 'Industrial revolution in miniature'; idem, 'Spinning jenny'.

48   **Kerridge** , *Textile manufactures* , pp. 169–70; **Wadsworth and Mann** , *Cotton* , pp. 411–15.

49   **Muldrew** , ' "Th'ancient distaff" '.

50   **Feinstein** , 'Wage-earnings', p. 190.

51   **Defoe** , *Great law* , p. 83.

52   **Pinchbeck** , *Women workers* , p. 148.

53   **Humphries** , 'Lure of aggregates'.

54   **Humphries** , *Childhood* , pp. 42–7, also raises these possibilities.

55   **Feinstein** , 'Wage-earnings', p. 190.

56   The wife is assumed to work 40% of full time, as indicated by **Eden** , *State of the poor* , vol. 3, p. 796.

57   **Smith** , *Wealth of nations* , pp. 74–5, 91, 187, 206.

58   **Engels** , *Condition of the working class* , p. 85.

Footnote references

Official publications