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**LEARNING FROM RICARDO AND THOMPSON:
MACHINERY AND LABOR IN THE EARLY INDUSTRIAL REVOLUTION
– AND IN THE AGE OF AI**

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Abstract

David Ricardo initially believed machinery would help workers but revised his opinion, likely based on the impact of automation in the textile industry. Despite cotton textiles becoming one of the largest sectors in the British economy, real wages for cotton weavers did not rise for decades. As E.P. Thompson emphasized, automation forced workers into unhealthy factories with close surveillance and little autonomy. Automation can increase wages, but only when accompanied by new tasks that raise the marginal productivity of labor and/or when there is sufficient additional hiring in complementary sectors. Wages are unlikely to rise when workers cannot push for their share of productivity growth. Today, artificial intelligence may boost average productivity, but it also may replace many workers while degrading job quality for those who remain employed. As in Ricardo's time, the impact of automation on workers today is more complex than an automatic linkage from higher productivity to better wages.

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“The jenny simply multiplied human hands while the water-frame was a substitute for human skill.” (Chapman 1904, p. 53)

“...the Jennies are in the Hands of the Poor and the Patent Machines are generally in the Hands of the Rich.” (Hammond and Hammond 1919, p. 56)¹

1. Introduction

According to conventional wisdom, any increase in total productivity is ultimately good for workers, at least on average.² In this long-established view among economists, technological change – including various forms of automation – always has the net effect of raising wages and generating more opportunity, creating an engine that pulls everyone along and leading directly to shared prosperity. This notion of a “productivity bandwagon” appears frequently today in discussions about the potential distributional impacts of developments in artificial intelligence.

Wages, consumption, and overall standards of living have certainly improved since the Industrial Revolution. Technological innovation has created new jobs, opportunities, and wealth. However, taking such a long view ignores the struggles of workers to secure their fair share of the prosperity made possible by new machinery. The fate of cotton workers in the early Industrial Revolution provides an illustrative example. In only a few decades, several hundred thousand skilled and well-compensated artisan weavers were displaced by a smaller number of power

¹ Statement made by cotton spinners to a Parliamentary Committee, which reported in 1780. Quoted in Hammond and Hammond (1919, p. 56), who call this “a significant complaint that marks the rise of the new order of capitalism.” Jennies were small spinning machines, which could be operated in people’s homes or small workshops. “Patent machines” and “water-frames” refer to machinery that was operated in factories.

² The precise empirical meaning of “ultimately” is important here. As Mokyr, Vickers, and Ziebarth (2015) write about the early Industrial Revolution, “It is true that, in the long run, wages for laborers increased to reflect dramatically increased productivity. It is also true that, for the Industrial Revolution, by many estimates it took longer than an average working lifetime to do so, and in the long run, we are all dead” (p.38).

loom workers who received a lower wage while enduring dangerous working conditions. With few outside options, and unable to adapt to these unprecedented changes, hand-loom weavers suffered a precipitous fall in their real wages. Though economic historians have debated the precise course of economy-wide real wages during the early Industrial Revolution, the collapse of wages in weaving is incontrovertible.³ All the data suggest that real wages for hand-loom weavers more than halved between 1806 and 1820.

David Ricardo, a founder of modern economics, was an early and influential proponent of the productivity bandwagon. In a much-quoted line, Ricardo told the House of Commons in 1819 that “machinery did not lessen the demand for labour.” This fit his broader view, again frequently referenced over the generations, that the spread of factories and large-scale production would necessarily benefit workers.

Shortly after 1819, however, Ricardo revised his thinking on this key point. For the third edition of *On the Principles of Political Economy and Taxation* in 1821, he added a chapter, “On Machinery,” in which he wrote: “It is more incumbent on me to declare my opinion on this question, because they have, on further reflection, undergone a considerable change” (Ricardo 1821, p. 282). In a private letter written in the same year, he further added, “If machinery could do all the work that labour now does, there would be no demand for labour.”⁴

Understanding the context within which Ricardo shifted his thinking provides insight into why the productivity bandwagon can so easily break down. As a member of Parliament on the Select Committee on the Poor Laws, Ricardo witnessed first-hand the consequences of power looms in

³ The best available data suggests that conditions (including wages, consumption, and public health) in highly innovative places such as Manchester were appalling in the 1830s. Prosperity was more widely shared later -- likely after about 1850.

⁴ Sraffa (1951, 8:399–400), letter dated June 30, 1821.

the cotton industry. These observations likely influenced his revised view of the impact of machinery on labor demand.

Despite this substantial update to his worldview, Ricardo remained firmly focused on narrowly defined economic factors – i.e., how technology influences worker productivity and, via this channel, the impact on wages and employment opportunities. The question of who had power in factories, the value of worker autonomy, and working conditions more broadly did not feature significantly in Ricardo’s writings or speeches. The importance of these issues during the Industrial Revolution were articulated by E.P. Thompson, most notably in *The Making of the English Working Class*.

Writing in the early 1960s and drawing on a wide range of sources from the early 1800s, Thompson argued that the spread of the factory system did not improve the lives of workers in the innovating sectors (such as cotton) and had only limited positive effects on workers in other sectors. For Thompson, the movement of workers into factories shifted the balance of power between workers and capital, and consequently working conditions deteriorated. Specifically, workers lost autonomy over their lives; they were increasingly forced, because of viable alternative sources of income, to work long, monotonous hours in unhealthy conditions, while also living in overcrowded and highly unsanitary cities.⁵ All of this was made possible by government coercion which actively prevented workers from “combining” (i.e., bargaining collectively) to push for higher wages, better working conditions or political reform.

In Acemoglu and Johnson (2023), we propose a framework that blends Ricardo’s and Thompson’s ideas to clarify when new technologies improve the lot of workers. For the benefits

⁵ As put by Mokyr, Vickers, and Ziebarth (2015), “The problem with the factories was not in the low quantity of work they offered, but the low quality of work in the mills” (p.35).

of growth to be shared, the right combination of technological and political conditions must exist.

New technologies can reduce the value of marginal productivity for workers even as they raise average productivity.⁶ Most saliently, automation – the substitution of machinery for tasks previously performed by workers – displaces workers and can reduce, rather than increase, the demand for labor. This is what happened to hand-loom weavers.

Automation does not necessarily mean the impoverishment of labor, however. First, when automation significantly increases productivity in some sectors, it can benefit labor. This could be either because automating sectors themselves grow sufficiently and demand for labor in non-automated tasks increases, or because other industries producing complementary products expand their hiring. This is what took place in the last decades of the eighteenth century as various tasks in spinning were mechanized, and this automation process triggered a massive expansion in hand-loom weaving. Even in such cases, however, automation tends to reduce labor's share of industry value added and, more broadly, labor's share of national income, so the productivity increase benefits capital more than labor.⁷

⁶ The short version of how this can happen is as follows. A technological improvement increases output for given quantities of factors of production, and thus raises *average* labor productivity. The demand for labor, employment, and wages are determined by labor's *marginal productivity* (or more precisely by the *value of the marginal product of labor*). The general presumption is that average and marginal productivity of labor should move together, but there is no theoretical guarantee for this. They do so when the aggregate production function of the economy can be approximated by a Cobb-Douglas function, which imposes that these two quantities are proportional to each other. The same conclusion also applies when the aggregate production function exhibits constant returns to scale and the cost of capital remains constant even as the demand for capital increases. But in general, there is no such guarantee, and automation – the substitution of machines for tasks previously performed by labor – expands the wedge between average and marginal productivity of labor. See Acemoglu and Restrepo (2018, 2019) for discussion.

⁷ Because automation reduces costs, sectors adopting automation technologies may expand employment and thus increase hiring in non-automated tasks (Acemoglu and Restrepo 2019). Whether they do so or not will depend on the demand elasticity for their product. Additionally, automation in one sector

Second, and more powerfully, automation can be coupled with the creation of new tasks, which raise the marginal productivity of labor in new activities and overall labor demand.⁸ Although such new tasks were important in the second half of the nineteenth century, they were not a central feature of industrialization until at least the beginning of the railway age in the 1830s and were not widespread until after about 1850 (Acemoglu and Johnson 2023).

In line with Thompson’s emphasis, even technological developments that favor labor are not sufficient to guarantee that workers benefit. Whether workers gain or not depends on who has power. When political power is in the hands of a narrow elite and workers lack the ability to bargain collectively, their wages and working conditions may not improve.⁹ The fact that British workers lacked both political voice and the legal right to bargain collectively is critical to understanding why they did not benefit from productivity gains during the early stages of the Industrial Revolution.¹⁰

increases incomes and demand for other goods, which may start hiring more (Acemoglu and Restrepo 2019, Aghion, Jones, and Jones 2019). Via both channels, automation *may* end up increasing the demand for labor and thus equilibrium wages. But there is no guarantee that automation will do so. Acemoglu and Restrepo (2019) provide a simple decomposition of the full effects of technological changes, including sectoral reallocation of labor, on overall labor demand in the economy.

⁸ While automation reduces the labor share of national income and increases in the physical productivity of labor have ambiguous and generally small effects on the labor share, new labor-intensive tasks increase the labor share, as well as wages and employment, because they *reinstate* labor centrally into the production process. See Acemoglu and Restrepo (2018, 2019).

⁹ In settings where wages are determined via bargaining, low bargaining power for workers would lead to most of the gains from new technology being captured by firms (or dissipated by additional firm entry). See, for example, Pissarides (2000) for a textbook treatment of search and bargaining models. More interestingly, some types of technologies, such as those that facilitate monitoring, may shift bargaining power or “quasi-rents” from workers to firms (see, e.g., Acemoglu and Newman 2002). In addition, in models where employers have access to coercive capabilities or other ways of shifting quasi-rents away from workers, an increase in productivity can be associated with lower wages (see, e.g., Acemoglu and Wolitzky 2011).

¹⁰ Less than 10 percent of the British adult male population was allowed to vote before 1832. The political system of the eighteenth century was dominated by landowners and protecting property was a primary goal for the political system (Williams 1939). This changed with the rise of manufacturing in the North of England, but initially only so far as increasing the economic power – and then the political voice – of the people who owned factories. For most of the nineteenth century, these owners of capital were more

Both technological and political pillars of shared prosperity remain important today, including in debates about the potential impact of artificial intelligence. For this reason, understanding why Ricardo may have changed his mind remains highly relevant today. In the early 1820s, Ricardo reconsidered the productivity bandwagon after witnessing first-hand, and over at least a decade, the consequences of the first Industrial Revolution. In the 2020s, we should be able to learn from history and apply relevant lessons more effectively. It is not unreasonable to want to do better than Ricardo's generation in terms of ensuring that potential prosperity through innovation is more equally shared.

This article explores the rise and fall of hand-loom weaving, based on the best available evidence regarding how relevant measures of real wages changed in this early phase of British industrialization. Section 2 sets the scene with the rise of cotton as a large part of the British economy after 1780. Section 3 reviews what is known about when exactly Ricardo changed his view on machinery. Section 4 contains our analysis of what happened to hand-loom weavers, in terms of nominal wages, real wages, and employment, and how long it took for offsetting positive developments in other parts of the economy to emerge.¹¹ Section 5 incorporates ideas highlighted by E.P. Thompson, which further emphasize the ways in which automation made many hand-loom workers (and others) worse off, at least until industrialization significantly boosted the demand for labor. Section 6 links these historical developments to what we are likely to experience in the age of AI and emphasizes the importance of choices: whether new technologies automate work or create new tasks for labor; whether new technologies monitor or

directly in confrontation with worker interests than were the aristocracy. See the discussion in Acemoglu and Johnson (2023, Chapter 5).

¹¹ Our historical discussion draws directly on the best available data sources, most of which have already been used effectively by leading researchers such as Hunt (1981), Mokyr (2009, Chapters 7 and 18), and Allen (2018). There is not much disagreement on the basic facts.

empower workers; and how institutions evolve to share productivity gains (or not).¹² Section 7 concludes. Our online Appendix reviews the wage and price data from early 1800s Britain in more detail. (The list of references includes work cited in both the main text and the online appendix.)

2. The Rise of Cotton

Most narrative histories of the Industrial Revolution emphasize the importance of the British cotton industry as one of the first to see widescale adoption of machinery in factories. The development of spinning machines in the 1770s signaled the beginning the sector's transformation. Broadly, the production of cotton textiles begins with first spinning raw cotton into yarn, which then must be woven into fabric. The dominant industrial fact of the late eighteenth century was that the use of machines to spin cotton greatly increased labor productivity.¹³

In the early 1700s, it took over 50,000 person hours to “spin” (turn raw cotton into yarn that could be woven) 100 pounds of cotton. Indian spinners were regarded as the most productive in the world, and they produced the best quality product. From 1760, however, this labor requirement fell quickly as machines were invented and quickly improved. Labor required was 2,000 hours per 100 pounds of cotton after the introduction of Samuel Crompton's mule in 1780,

¹² For literature on the endogenous direction of technological change, see Acemoglu (1998, 2002), and Acemoglu and Restrepo (2018) in the context of automation versus new tasks. For the endogenous evolution of institutions impacting how gains from new technologies are shared, see Acemoglu and Johnson (2023), Chapters 1 and 8.

¹³ The backstory is slightly more complicated. In the early eighteenth century, raw cotton was imported from India and other colonies, in part because trade restrictions limited the import of cotton cloth or clothing – at the behest of the more established British wool and silk industries. The first significant technological improvements were in weaving, which boosted the demand for yarn and encouraged the development of machines for spinning. However, those early weaving machines were what became known as “handlooms”; they were worked by one person, often with assistants (typically family members) and at home.

1,000 hours after the introduction of the 100-spindle mule around 1790, and just 300 hours with the arrival of “power-assisted mules” around 1795 (Chapman 1987, p. 20). These machines represented a significant capital cost, and all were deployed in what were then large factories, initially with several hundred workers, rising quickly in some cases to between 1,000 and 1,500 employees (Freeman 2018). Putting machines in factories allowed owners to control who had access to the machines and to determine working conditions.¹⁴

While the industrialization of spinning displaced some proto-industrial spinners, the explosion of cheap yarn in need of weaving created new and lucrative employment in hand-loom weaving. Prior to around 1820, weaving remained a cottage industry, primarily performed by men, women, and children in the home. A trade that was easily learned, could be performed in the home, and required minimal upfront investment, weaving attracted thousands, including many former spinners (Bythell, 1969). It was in the context of this ‘golden age of weaving’ from around 1780 to 1800 that Ricardo likely formed his early views on automation and labor. However, coinciding with the growing adoption of power looms during the 1810s and the accompanying collapse in hand-loom weavers’ wages, Ricardo’s views changed.

3. Ricardo’s Pivot

¹⁴ Not all the inventors prospered. This was a highly competitive industry, and the big profits fell into the hands of those who could grab market share and defend their intellectual property rights. Richard Arkwright became fabulously wealthy from his efforts in the spinning industry. Crompton died poor. Hobsbawm (1996, Chapter 2) has a good discussion of profits and entrepreneurs.

In 1817 the first edition of Ricardo's *Principles* made no mention of the potential ill-effects of machinery on workers. By 1821, however, Ricardo had apparently changed his mind on this point – hence the chapter *On Machinery* in his third edition, which appeared that year.¹⁵

One possibility is that Ricardo was swayed by John Barton's *Observations on the Circumstances which influence the Condition of the Labouring Classes of Society*.¹⁶ However, Ricardo had considered and rejected Barton's argument in 1817 when drafting the first edition of *Principles*, so his change of opinion is more likely to have been spurred by events.¹⁷

Ricardo became a member of Parliament in 1819, and while no one has spotted a particular “aha” moment, it seems likely that current political conditions played a role in Ricardo's change of mind, including repeated expressions of anger and frustration by hand-loom weavers (Henderson and Davis 1997).

Hammond and Hammond (1919) provide a detailed narrative history of cotton workers' grievances and protests. These complaints were not new in the late 1810s, but they reached something of a crescendo in 1818-19 (pp. 112-118). Concerns about wages and frustration regarding the lack of Parliamentary response increasingly led to demands for “reform,” meaning expanded representation in Parliament. This push for democracy was seen as threatening by many members of the elite. A major demonstration, with perhaps 60,000 people expressing support for political reform, was broken up by force in Manchester in August 1819 – this

¹⁵ We should point out there are various plausible views on “whatever did he mean by that” with regard to this added chapter. In the reading of Mokyr, Vickers, and Ziebarth (2015), for example, Ricardo felt “that in the long run higher productivity would lead higher saving and eventually rising demand for labour” (p.33).

¹⁶ Gourvitch (1986, pp. 58-59), Hayek (1941, p. 424), Schumpeter (2006, pp. 650-651), Sotiropoulos (1952, p. 94), and Henderson and Davis (1997, pp. 576 and 579) all note the similarity of Ricardo's reasoning in “On Machinery” to Barton's argument in *Observations*.

¹⁷ Barton wrote to Ricardo directly arguing that machinery could reduce labor demand. Ricardo rejected this argument in his response dated May 20, 1817 (Sraffa 1951, Vol. VII, pp. 156-159).

“Peterloo Massacre” shook the country. The link to hand-loom worker discontent was evident (Hernon 2006, pp. 22-24).¹⁸

In contrast to the intense and repeated debates about power looms for weaving, earlier protests against spinning machinery had not proved long lasting. Hammond and Hammond (1919, p. 56) point out:

“After these riots in 1779 the workers made no more attempts to check the introduction of machinery for spinning. The reason no doubt lies in the fact that whenever any labour was displaced by the introduction of any particular species of machinery for spinning, it was soon absorbed by an expansion of trade. Many of the economists of the day, with this example before them, came to think that the introduction of machinery would be a similarly painless process in every case. The weaving trade offered employment to any surplus labour from spinning.”

This relatively positive experience with spinning machinery helps explain Ricardo’s first take on the issue, for example, as expressed directly to Barton (in a letter on May 20, 1817; Sraffa 1951, Vol. VII, p. 159):¹⁹

“...there is no new creation of machinery which entirely supersedes the use of the labour of man.”

From 1819, Ricardo was a member of the Parliamentary Select Committee on the Poor Laws. In this capacity he was undoubtedly aware of the overwhelming evidence that a large number of workers struggled to earn a living. In his maiden speech, on March 25, 1819, he acknowledged

¹⁸ The Peterloo Massacre took place on St. Peter’s Field, Manchester. “Peterloo” is an ironic reference to the Battle of Waterloo in 1815. For further details, see <https://www.peterloomassacre.org/history.html>.

¹⁹ Sraffa (1951), p. 159. See the discussion in Henderson and Davis (1997), pp. 577-9.

“the inadequacy of the wages to the support of the labouring classes” as one of “two great evils for which it was desirable to provide a remedy” (Cannan 1894, p. 414).

By 1820, as we discuss below, Ricardo had good reason to think that the introduction of improved weaving machinery, specifically the power loom in factories, would not necessarily – or any time soon – lead to widely shared prosperity. To better understand this critical period of economic upheaval, we now turn to the best available evidence on wages and inflation, which confirm that Ricardo’s concerns were well warranted: hand-loom weavers suffered greatly with the adoption of power looms, and unlike the spinners before them, there was little compensatory wage or employment growth elsewhere in the economy.

4. Labor Demand and Wages in the Early Industrial Revolution

We start with the wages and employment of hand-loom weavers as the power loom was adopted. As discussed in the Introduction, the impact of automation can always extend beyond the tasks that are automated and broader effects can manifest in various ways. Moreover, as we have already emphasized and as illustrated by the example of the early cotton spinners, automation can trigger the creation of new tasks or even new opportunities in related – upstream or downstream – sectors.

After hand-loom weavers, we turn to data on other cotton workers (“factory operatives”), and then to other sectors for which there are good data (mining, building, and agriculture). Finally, we assess the best available series for “economy-wide wages.” Drawing on this evidence, we find that real wages for hand-loom weavers collapsed between 1800 and the early 1820s. Despite real wages nearly halving, hundreds of thousands of people (mostly adult men) remained in the

profession. With economy-wide real wages stagnating until at least the 1820s, we find little evidence for offsetting employment or wage gains in other industries.

For all wage developments, we discuss the nominal numbers first, with a preference for series in shillings and pence (the most transparent and easiest to compare across sectors), and then convert them into real terms. Over the decades, there has been some debate about the best consumer price indices to use, but this has now settled down, as we review in the Appendix.

A. The Cotton Boom

The productivity boom in spinning converted cotton from a modest cottage industry to a major sector in the British economy. In the early 1780s, the cotton industry was small (accounting for about 1 percent of British GDP), rising to 4-5 percent in 1805-07, and to 7-8 percent in 1811-13 (Chapman 1987, p. 55). There was a matching, and dramatic, increase in the UK annual import of raw cotton from 26m pounds in 1791-5 to 300m pounds in 1831-35 (Chapman 1904, p. 144).²⁰ Cotton manufacture was the booming industrial sector of the early 1800s in Britain.²¹

²⁰ According to Chapman (1987), “the United States cotton crop rose from 2 million lbs. in 1791 to 182 million lbs. in 1821, becoming the major source of Lancashire’s supply at the turn of the century” (p.36). Chapman (1987) further says, “The high elasticity of the supply of cotton, due primarily to the responsiveness of the American planters and the adoption of Whitney’s cotton gin, was clearly a crucial factor in the phenomenal growth of the British cotton industry in these years” (p. 36). Like a number of other economic historians of this period, he makes no mention of the increasing intensity of slavery, the forced migration of enslaved people across the Deep South or the long-lasting ill-effects of slave plantation cotton agriculture on political institutions and social development (see for example Acemoglu and Johnson, 2023, Chapter 4; Beckert 2014; and Baptist 2014). Appendix Table A3 (included in the online Appendix) has a slightly different series from Mitchell (1984) for total imports of raw cotton, but the trend is the same.

²¹ Other transformations were underway, including in coal mining, the working of metals (ferrous and non-ferrous), and steam engines. But in the decades under consideration, widespread adoption of factory-based machines – and the consequent displacement of labor in more artisanal production – was a central feature only in the cotton industry. See Mokyr (2009), p.452.

Cotton goods became a major export from Britain. In 1784-86, total British exports were worth 12.7m pounds, and cotton exports were valued at 0.8m pounds (6 percent of total exports). By 1814-16, total exports were 44.4m pounds and cotton exports were 18.7m pounds, making up 42.1 percent of total exports, by value (Davis 1979, p. 15).

Almost all cotton weaving in Britain was done on handlooms until at least 1806. There was some employment in power-loom factories from 1813, but by 1820 cotton factories still only employed about 10,000 workers in weaving.²² The total number of power looms was estimated at 2,400 in 1813 and 14,150 in 1820. We do not have an annual series, but the evidence suggests an acceleration of adoption during the time Ricardo was rethinking his views.²³ The rise and fall of hand-loom weavers was a well-known and much discussed feature of the early British cotton industry.

²² The power loom came into much wider use “in the 1820s” (Bythell 1969, p. 103).

²³ These numbers are frequently quoted and seem to originate from the reports of the hand-loom weavers commission, specifically those produced in 1840. They are also reported in Baines (1835, pp. 235-7), Chapman (1904, p. 28), and Hammond and Hammond (1919, p. 72); see also Landes (2003). Baines (1835) provides some additional commentary and context regarding this increase. He notes that by 1833 there were at least 100,000 power looms in operation in Britain, and the years of 1824 and 1825 were those of the greatest rise. Despite this increase in power looms, there remained many hand-loom weavers, their numbers rising from 240,000 in 1820 to 250,000 in 1834.

B. What Happened to Hand-Loom Weavers?

Nominal Wages

As part of his work on the statistics of wages in the nineteenth century, Wood (1910a-e) used primary sources to compile series for wages and employment in the cotton industry through the nineteenth century. Wood's series include separate estimates for workers in factories and for hand-loom weavers. His full series runs from 1806-1862 and is available annually (Wood 1910e, pp. 598-599, Table 41). Wood finds that nominal weekly wages for hand-loom weavers fell steadily from 240d. (old pence) in 1806 to 99d. in 1820. In the same period, wages for factory workers remained stable at around 120d. (The change in relative wages can be seen clearly in Figure 1, which shows these series in nominal terms.)

These headline numbers need to be interpreted with care, for the following reasons.

First, hand-loom workers were paid on a piece-rate basis. Those rates are known, but output (i.e., productivity) varied by worker, so total income varied a great deal across people (Bythell 1969). The piece-rate data show considerable variation during the year and across years, and between regions (transportation costs were high before railways). However, the series in Figure 2, for muslin cloth at Bolton (north of Manchester), 1795-1820, is consistent with the broader picture painted by modern authorities, such as Bythell (1969), as well as historians with access to a full range of evidence, most notably Hammond and Hammond (1919).²⁴ These prices are in nominal terms and show an unmistakable decline after 1800.

Second, as piece-rates fell, it is possible that output per worker increased, as the qualitative evidence suggests they worked harder (Bythell 1969, p. 116). It has been suggested that in their

²⁴ Muslin is a loosely woven cotton cloth.

“golden age” (1780-1800), weavers worked 4 days per week and earned 40 shillings; by the 1830s, the general perception is that they were working harder, perhaps 14-16 hours per day for 6 days per week and earning a lot less money per week or month or year.²⁵

Table 1 depicts estimated family earnings for hand-loom weavers in two Lancashire towns, starting in 1814. This series shows shillings per week alongside two measures of costs: to keep looms in good repair; and household expenses (food, clothing, and rent). The first column shows that from 1814-1819, nominal weekly earnings for a family of six fell by half. The third column (“Leaving for other costs”) clearly shows the squeeze on hand-loom worker nominal earnings from 1814-20 and confirms that this measure of earnings continued to fall through the 1820s and into the 1830s.²⁶ (See the next section for more details on real wages).

Hammond and Hammond (1919), among others, were confident that hand-loom weavers lived well at the end of the 1700s and that most people engaged in the same occupation were quite poor in the 1830s (and likely by 1820). This is also the overwhelming assessment of various Parliamentary investigations, including the highly informative 1835 Parliamentary Select Committee report (Parliamentary Committee 1835).

Third, the 1835 Parliamentary report and other official investigations arose because weavers were petitioning for government action in their favor, so there may have been some natural inclination to exaggerate their difficulties (Bythell 1969, p. 114). However, Hammond and

²⁵ Bythell (1969, p. 116) does not give a weekly earnings number for the 1830s – but the weekly wage for hand-loom weavers was 240d. (or 20 shillings) in 1806 and only 75d. in 1830, according to Wood (1910e), Table 41, cited above.

²⁶ Even on the most positive interpretation, this period of wage decline for hand-loom workers is on the upper end of “an average working lifetime” (the transition period suggested by from Mokyr, Vickers, and Ziebarth (2015) for higher productivity to be reflected in higher wages for laborers). On the other hand, it is possible that economy-wide wages turned upwards a bit earlier – the precise timing of changing real wages in the 1830s for other parts of the economy is harder to discern.

Hammond (1919) provide corroborating evidence from a wide range of people, including some not at all sympathetic to the workers.²⁷

In Bythell's summary, "the decline in money wage rates for hand-loom weaving between the 1790s and the 1830s was spectacular" (1969, pp. 106-107).²⁸

In sum, there is considerable evidence consistent with Wood's wage series, showing a decline in nominal wages for hand-loom workers in the cotton industry, with little offset in the form of new opportunities in factories.

Real Wages

The evolution of consumer prices in this period has central importance to the broader question of how economy-wide real wages evolved in this time, and has been contentiously debated for decades. As discussed in the Appendix, this debate has settled down (at least until any new data make an appearance). While there have been several twists and turns, Robert Allen (2007, 2009) offers a sensible reconciliation of the plausible alternative views, favoring an index that is close to the work of Charles Feinstein (1998), but with some modifications suggested by Gregory

²⁷ See, for example, Parliamentary Papers 1835, Select Committee, 1 July 1835.

²⁸ Hunt (1981) has a more positive view of wages during the early Industrial Revolution than the more recently available data suggest. Nevertheless, our view on what happened to hand-loom weavers aligns with his: "But it was the mechanization of cotton spinning and the increased output of machine-spun yarn that had initially raised hand-loom weavers' earnings to as much as 40s a week and persuaded large numbers to take up the loom, and it was effective mechanization of weaving after 1820 that most decisively forced down wages" (p. 64).

Clark (2005).²⁹ Consumer prices (for a basket of typical working-class consumption) rose by about 10 percent between the early 1800s and the early- to mid-1820s (Allen 2007).

Consequently, real wages for hand-loom weavers fell in this period – likely declining to around 25 percent of their peak “golden age” level – and then slumped further (Figure 3).³⁰

Supporting evidence on this point comes from the 1835 Select Committee. The committee interviewed and received testimony from various weavers, manufacturers, and others with direct experience in the textile industry. These sources report consistently poor and deteriorating living conditions among weavers throughout Britain. They confirm wages fell since at least 1800 and summarize the increased poverty in terms of the basket of goods that weavers could afford.

The units, pounds of food (flour, oatmeal, potatoes, and “butcher’s meat”) that could be afforded, are not standard in modern economics. They are nonetheless highly informative. For example, income of nearly 27 shillings per week in 1797-1804 could purchase 100 lbs. of flour, 142 lbs. of oatmeal, 826 lbs. of potatoes, or 55 lbs. of butchers’ meat, which yields an average of 281 lbs. (pp. xiii). By 1818-1825 this sum had more than halved, to only 103 lbs. This confirms that the purchasing power of hand-loom weavers collapsed immediately before and during the time when Ricardo was revising his views on machinery. (The Appendix provides further corroborating details from more standard and comprehensive consumer price indices.)

When it was clear that their earnings had fallen and would not recover, why didn’t hand-loom workers move to other income-earning opportunities, for example in cotton factories? Landes

²⁹ Clark makes some updates to his index in Clark (2007) and Clark (2010), but they do not address important detailed critiques in Allen (2007). Details of Allen’s arguments are covered in the Appendix. We use Clark’s latest available index in all figures that refer to Clark (2010).

³⁰ As discussed in the Appendix, Allen and Clark offer the two leading consumer price indices for this period, with some differences between them. However, our core statements about what happened to the real wages of cotton workers are robust to the choice between these two price indices.

(2003, p. 86) comments that the slow decline in the number of hand-loom weavers “testified to the obstinacy and tenacity of men who were unwilling to trade their independence for the better-paid discipline of the sheds.” This may have been part of the explanation, but other opportunities were mostly lacking in Lancashire, where a disproportionate number of hand-loom workers were located, and even elsewhere in the country. There was no other booming sector, and in the first two decades of the nineteenth century, cotton factories did not expand fast enough to employ a large number of hand-loom workers. The most complementary activity to weaving, spinning, was already mechanized to a significant degree. As Bythell (1969) puts it, “until the great expansion of all kinds of factory work in the cotton districts from the 1820s” (p. 107), movement out of the hand-loom sector was slow.³¹

Employment

In 1788, there were 60,000 people employed in spinning factories; there was no large-scale factory employment of weavers. There were, however, 108,000 people employed as hand-loom weavers (Table 2), most of whom either worked in their homes or in small workshops. In 1806, there were still “few” workers in cotton factory-based weaving, but this number reached 3,000 by 1813 and 10,000 by 1817. (See Figure 4 for the best available series.)

Of the power loom, Landes (2003, based on Baines 1835) writes, “... where, in the first decade of the century, the machine worked hardly faster than the traditional hand-loom, the technical

³¹ Presumably it was difficult to move back to agriculture, in part because enclosures had limited the amount of common land available.

advantage had risen by the mid-1820's to as much as 7 ½ to 1, and one boy on two looms could do up to fifteen times as much as the cottage artisan" (p. 86).

As shown in Table 2, by 1820, the cotton industry employed 115,000 in spinning jobs and 11,000 in weaving jobs in factories. Total employment in the cotton industry (factory operatives plus hand-loom workers) rose from 168,000 in 1788 to 274,000 in 1806 and to 336,000 in 1820.³² This change in the structure of employment is consistent with data showing steady investment in "British Cotton-spinning Mills" during this period (Chapman 1987, Table III, p. 29).

In 1815, there were perhaps 200,000 hand-loom weavers, rising to 240,000 in 1820.³³ There were still 200,000-250,000 in the early 1830s, according to various sources – including testimony to the 1835 Parliamentary Select Committee on weaving.³⁴

Power loom weaving never employed anywhere near as many workers as did hand-loom weaving at its peak. There were perhaps 10,000 power loom workers in factories in 1817 and only 11,000 in 1820.

There were 107,000 "all factory operatives" in 1813 compared with 212,000 "hand-loom weavers." By 1819-21, "all factory operatives" was around 120,000 workers while "hand-loom weavers" is estimated to have increased to 240,000.³⁵

³² Bythell (1969, p. 54) cautions on early data quality. On p. 57, however, he says "figures of the order of 200,000 to 250,000 will not over-represent the total number of hand-loom weavers when the labour force was at its peak."

³³ The number of hand-loom weavers rose steadily from 1788 to 1820; 240,000 was peak employment, a level that was maintained until 1831 according to Wood (1910e, Table 40, p. 596).

³⁴ While the available data is not at modern quality standards, this industry was investigated repeatedly by Parliamentary committees. These investigations are the source for much of the information in Baines (1835) and Wood (1910a-e). Hammond and Hammond (1919) used a wider range of materials, mostly communications between the government (in London) and local informants and magistrates. Thus, even though the data are far from perfect, several independent sources confirm the basic patterns.

³⁵ There may have been another 50,000 people employed as "auxiliaries" to hand-loom weavers (Chapman 1987, p. 51).

Headline employment of hand-loom weavers was not perhaps the issue that attracted most attention. This was a sector with relatively low barriers to entry, and which generally did not need a great deal of skill or established expertise. Much more of the concern (including in the run-up to and aftermath from Peterloo) was about the steady decline in earnings and the standard of living for hand-loom weavers during the first two decades of the nineteenth century, as discussed above.

C. Factory Operatives

As shown in Figure 3, from 1806 to 1818-20, real wages of cotton workers in factories barely increased while there was a modest increase in employment in this activity. In 1806, 90,000 “operatives in factories” earned a weekly wage of 121d. while in 1820, 126,000 workers earned 124d.

In 1806, at the start of the available series, 184,000 hand-loom weavers earned roughly double (240d.) what cotton factory workers were paid. Up until 1815, hand-loom weavers earned more than factory operatives, but this then changed quite dramatically. By 1820, hand-loom weavers earned more than 25 percent less than factory operatives – and this gap only grew over time.

Taking a weighted average across the cotton industry, “all workpeople” earned 200d. per week in 1806, falling to 150d. in 1815, and to only 108d. in 1820.³⁶ Over the same decade and a half, productivity gains – including with the spread of steam power – continued to be remarkable. The

³⁶ We calculate the weighted average wage as (number of factory operatives x factory wage) + (number of hand-loom weavers x hand-loom earnings); all divided by the total number of workers in this sector for that year.

population of some textile towns in the Greater Manchester area more than doubled between 1801 and 1831.³⁷

In real terms, using Allen's (2007) consumer price index for reasons discussed in the Appendix, earnings fell significantly (by more than half) for hand-loom workers between 1806 and 1820, but real wages also declined (by about 10 percent) for cotton factory operatives.³⁸ The weighted average wage in this highly productive and rapidly innovating sector fell by about 50 percent from 1806 to 1820. Compared to the golden age that ended around 1800, earnings for hand-loom weavers fell to about one-quarter of their previous level.³⁹ Despite being a highly productive, modern, and growing industry, manufacturing cotton by 1820 was significantly less remunerative for its labor force than had been the case 20-30 years earlier.

This would be less of a concern, perhaps, if real wages and employment grew elsewhere in the economy. While the evidence is not perfect, the data strongly suggest economy-wide real wages were largely flat from the end of the 1700s to 1820, and in fact, real wages declined in sectors where productivity rose most notably. This continued well into the 1820s, and likely did not turn around until sometime in the 1830s (the leading economy-wide wage series are shown in Figure 5).⁴⁰

³⁷ The population of Bradford rose from 29,000 to 77,000, while Huddersfield increased from 15,000 to 34,000, and Leeds from 53,000 to 123,000 (Finer, 2017). Sanitation did not keep pace and the public health consequences were dire. "There were parts of Manchester where thirty-three privies had to supply 7,095 persons" (Finer, 2017, p. 215). Mortality rate (deaths per 1,000) increased from the 1820s.

³⁸ Hand-loom workers were paid piece-rates, which varied considerably from year to year. Factory operatives were paid a fixed nominal wage, with no indexation or adjustment for inflation – so their standard of living was squeezed whenever the price level rose. As shown in Figure 3, our findings are robust across choice of price index.

³⁹ In contrast, many employers did well. There is no complete series on profits, but Hobsbawm (1996) provides some convincing numbers and details on this point.

⁴⁰ Kelly et al (2023) propose an economy-wide measure based on agricultural wages, adjusted for changes in population by county. For 1770 to 1833 (the dates they specify), the increase in real wage was 8 percent (using Allen prices) or 13 percent (using Clark prices). However, over the same period, the

D. Prominent Sectors and Economy-Wide Wages

It is possible for the positive effect of productivity increases on wages to be apparent outside of the sector where technological progress is most concentrated. This could be because the innovating sector provides cheaper goods to the rest of the economy – and the price of cotton clothing did fall. If the labor market is competitive and the cost of mobility across occupations and geographies is low, wages should also tend to equilibrate.

Coal mining was a relatively well-developed sector by 1800, including with the use of steam engines to pump water from great depths.⁴¹ We also have a great deal of regional data on miners' wages. Table 3 shows that nominal daily miner wages in Northumberland, for example, were under 3 shillings in 1800-1802, rising above 3 shillings in 1813-14, but then falling back to (or below) the 1800 level by 1822. There is a similar pattern in other regions, including in Lancashire and Cheshire which had important coal fields at this time. A miner earned the same nominal wage in 1800 and in 1822, according to this series.

increase in real wages was 21 percent if we use Feinstein's economy-wide wage estimate or 40 percent using Clark's economy-wide wage series – as shown in Figure 5. This long-difference calculation is interesting but does not highlight a major point of agreement – there was little if any increase in economy-wide real wages until well into the 1810s (Clark's version) or even the mid-late 1820s (using the Feinstein or Allen series). We should note that there is also widespread agreement, or perhaps even a consensus, that real wages grew steadily from the mid- or late-1830s. However, as Mokyr (2009) emphasizes, living conditions in cities were bad and perhaps even worsened (e.g., with cholera, typhus and other disease burdens increasing) until at least the 1850s.

⁴¹ The coal industry was developed primarily to supply fuel to households. The London area was substantially deforested by the 1600s and bringing wood to the city was expensive. By 1800, there were some industrial uses, but the spread of steam engines started to have major effects – including by allowing large urban agglomerations to develop – only after that date. By the time Ricardo was writing, commercially viable steam locomotion on iron railways still seemed to be a pipe dream. The Rainhill trials of 1829 and the success of the Liverpool and Manchester railway, which opened in 1830, changed everything (Acemoglu and Johnson 2023, Chapter 5).

Table 4 confirms this account with decadal averages for builders' wages, broken down by Craftsmen (more skilled workers) and Helpers (less skilled) from Clark (2005 and 2007). There was not much increase through the mid-1750s, but clearly some increase in nominal wages after 1779. The decadal average nature of this series makes it hard to see the precise timing, but it seems clear that nominal wages for both categories of builders increased in the first two decades of the nineteenth century.

Table 4 confirms a similar pattern for agricultural wages, also from Clark (2005 and 2007). In real terms these rose and fell with harvest and trade conditions, but only roughly kept up with inflation during the early Industrial Revolution.

Some sectors, including coal mining, expanded rapidly in the early nineteenth century but, like cotton weaving, relied on low-wage labor from children and women. The macro picture for the British economy during this era is one in which output and employment increased across a wide range of sectors, and there was no mass unemployment. The percentage of people employed in agriculture fell, as workers were absorbed into expanding sectors. Nevertheless, until the railway system began to develop in the 1830s, sectors that were developing and introducing new machinery most rapidly, such as the cotton industry and coal mining, did not pay commensurately high wages.⁴²

⁴² This is consistent with Mokyr (1988), who finds only slow consumption growth (under half a percent per year) from 1815 to 1849, roughly, with most of the growth occurring later in this period. For the broader context, see Mokyr (2009), particularly Chapter 18. Mokyr emphasizes that there were negative shocks to living standards at this time, including in the short-run from the Napoleonic Wars' impact on grain prices and from bad weather, and in the longer-run from the unprecedented increase in population.

Consistent with the evidence from individual industries, economy-wide real wages stagnated through the early nineteenth century. Figure 5 shows the best available overall real wage series and the effects of using alternative price indices.

Using Allen's preferred index (or anything close to it), economy-wide real wages did not rise much, if at all, in the early 1800s. In cotton textiles, the most rapidly innovating sector, real wages declined sharply.

Note that real wages fluctuated significantly as nominal wages were sticky and prices moved a great deal. The evaluation of change in real wages is affected by end points (e.g., real wages in 1821 were above 1819, due to lower prices). But real wages did not significantly break with their previous trend until well into the 1830s, according to Allen and Feinstein.

As we discuss in the Appendix, Clark (2005, 2007, and 2010) offers an alternative price series for the early 1800s. Using this index, the implications for economy-wide wages are more positive, as recently emphasized by Kelly, Mokyr, and Ó Gráda (2023).⁴³

E. Assessment

The data discussed above suggests that Ricardo had good reason to become more cautious about the effects of machinery on labor. Like spinning machinery previously, the power loom boosted

⁴³ Clark (2001) reaches a more positive assessment of real wages in the early industrial revolution when he uses his price index and his own agricultural wage series, which is available for four regions. Kelly, Mokyr, and Ó Gráda (2023) have a similar view of economy-wide wages based on Clark's price index and wage data from Hunt (1986), which is based on Bowley (1898). We prefer Allen's price index for the detailed reasons given in the appendix, but the door is always open to new data that may speak to this issue. Kelly, Mokyr, and Ó Gráda (2023) find that agricultural wages rose in the north relative to the south when comparing 1770 to 1860.

productivity in weaving. As new machines replaced people in weaving tasks, some additional jobs were created – for example tending to those machines, including repairing them as needed. But the number of new jobs created in weaving did not match the displacement of opportunity for human hand-loom workers.

The main complementary activity, spinning, was already highly mechanized. And other sectors were not stimulated enough, either directly by the lower cost of woven cloth, or indirectly through gains to consumers (for whom clothing was a small part of their spending; see the Appendix.)

In a modern industrialized economy, we expect more innovative sectors (such as software or biotech today) to pay high wages. The reality in Lancashire in the early 1800s was more complex. Real wages for hand-loom workers fell sharply, and the average real wage for the cotton industry (weighted across hand-loom factory workers) did not rise for many decades (Figure 3). Successful entrepreneurs earned huge profits from applying new machines, but this prosperity was barely shared with any workers – even cotton factory workers saw little increase in their real wage from around 1820 until about 1850.

Productivity gains due to new machinery in cotton were not shared with the workers in textile production, nor were there compensatory gains in other sectors of employment. Economy-wide real wages rose little or stagnated (depending on the dates chosen for comparisons), and there is little evidence of growth in other low-skilled occupations such as building, farming, or mining.

Although the issue of earnings is crucial, it partly misses how industrialization upended the social lives of workers. As Eric Hobsbawm notes in his book *Industry and Empire*, the Industrial Revolution was just as much a social revolution as it was an economic one. Understanding the

consequences of this social upheaval is central to the question of how new technologies impacted laborers' lives.

5. Working and Living Conditions

Ricardo was primarily focused on the efficiency improvements of adopting machines. He and other leading early economists tended to neglect or play down other considerations, including the issue of power in the workplace – which is important in its own right, but also influences whether workers get a fair share.

E.P. Thompson's *The Making of the English Working Class*, with its emphasis on working conditions, offers a helpful corrective. Multiple original sources agree that hand-loom workers had considerable control over when and how hard they worked on particular days or during the year. All of this disappeared as tasks were taken over by weaving machines. This was not only impoverishing, as Ricardo came to understand, but also fundamentally changed the balance of power between employers and workers.

We should not idealize what came before large factories. Nevertheless, it seems clear that some weavers had much greater autonomy and control over their schedule and craft in the mid- or even late-1700s. In fact, in some ways they were more like independent businesspeople than workers. They were referred to as selling their cloth, not their labor (Chapman 1904). And even when they worked at home for large merchants, who would supply cloth and rent machines, there were alternatives. In contrast, contemporary sources report that there was a de facto “combination” by factory owners, with an agreement not to hire workers who quit other employers in the same area. There was no government enforcement of “combination” laws when it came to employers.

As weaving became automated, “deskilling” accompanied disempowerment of the workers. Machines effectively replaced skilled and experienced adult men with women and children, who had less skill and who were also cheaper and easier to control. This reinforced the significantly declining ability of weavers to have a say in their working conditions or the discipline to which they were subjected, and consequently, control over daily life passed into the hands of employers.⁴⁴ Of course, this also meant that they had less say in the determination of their pay.

Thompson put it this way (p. 306):

“Weaving had offered an employment to the whole family, even when spinning was withdrawn from the home. The young children winding bobbins, older children watching for faults, picking over the cloth, or helping to throw the shuttle in the broad-loom; adolescents working a second or third loom; the wife taking a turn at weaving in and among her domestic employments. The family was together, and however poor meals were, at least they could sit down at chosen times. A whole pattern of family and community life had grown up around the loom-shops; work did not prevent conversation or singing.”

In Thompson’s view, the power loom sheds “were resisted until poverty broke down all defences,” (p. 307) because working in a factory meant giving up most vestiges of independence and freedom.

⁴⁴ See Hammond & Hammond (1919) for more discussion.

“There had been a time when factories had been thought of as kinds of workhouses for pauper children; and even when this prejudice passed, to enter the mill was to fall in status from a self-motivated man, however poor, to a servant or a ‘hand.’” (p. 306)

In *Industry and Empire*, Eric Hobsbawm agrees with this perspective, writing “the city destroyed society.” Industrial life not only forced workers to trade workplace autonomy for the regularity of factories, it also forced them into unsafe factories and unsanitary housing. Cities across Britain swelled, with Manchester quadrupling in population between 1801 and 1851 (Douglas et al., 2002).

Without amenities such as adequate sewers and clean water, new residents faced epidemics (including cholera and typhoid), endemic tuberculosis, and further health damage from pollution.

Hobsbawm concludes that the social change accompanying industrialization was so intolerable to pre-industrial workers that tens of thousands accepted starvation wages in hand-loom weaving *despite* relatively higher wages in factories (see Figures 1 and 4). The quality of life for these workers almost certainly deteriorated with the arrival of factory-based power looms.

6. The Relevance of Ricardo and Thompson Today

The lessons that David Ricardo and E.P. Thompson learned remain important today, for we are in the midst of a potentially rapid transformation of work due to digital technologies and artificial intelligence.

A. Labor Demand and Working Conditions in the Age of AI

One perspective is that automation, because it increases average productivity by substituting cheaper and more reliable machines and algorithms for human labor, will ultimately be good for workers. According to this view, the economy may need fewer blue-collar and office workers as these tasks are automated, but as firms and consumers are enriched by the rising productivity, there will be demand for workers in other sectors (e.g., Aghion, Jones, and Jones 2019).

But Ricardo's concerns remain relevant today. We now also have evidence that automation significantly reduces the share of labor in national income and can depress labor demand, employment, and wages (e.g., Acemoglu and Restrepo 2020, 2022). The debate is not settled, but there is growing evidence that during the period of rapid automation, essentially since 1980, wages have not risen much and a significant fraction of the US labor force has experienced declining real wages (e.g., Acemoglu and Autor 2011; Acemoglu and Restrepo 2020, 2022).

It remains to be seen how artificial intelligence will alter this picture – exacerbating some of the existing trends but also potentially creating new opportunities for workers. Despite the powerful and diverse capabilities of new AI tools, there is already some evidence that this suite of technologies has primarily been used for more automation (Acemoglu, Autor, Hazell, and Restrepo 2022).

Thompson's perspective is also highly relevant to current debates. In *The Age of the Smart Machine*, Zuboff (1988) pointed out that the advance of digital technology potentially has a dark side for workers. Lowering the cost of monitoring has encouraged employers to become more

intrusive and allowed them to watch their employees more closely. Rapid recent increases in the capabilities of artificial intelligence have the potential to push further in this same direction.

The modern version of Thompson's dystopia would include control over the workday and what happens in the workplace, minute by minute, for all kinds of workers. Some of this might be used to improve workplace safety and protect employees (e.g., against harassment), but there is already evidence that technology is being used to drive workers harder and even encourage them to cut corners and become less safe (Acemoglu and Johnson 2023).

Overall, should we expect that productivity gains from AI will be shared with workers?

Ricardo's insights suggest there is no guarantee that they will be if automation is the only focus of new AI technologies. If AI is used to create new tasks and increase human capabilities, the benefits would be more likely shared with labor. Thompson's insights add another major caveat: if AI is used extensively for surveillance and worker control, it will shift the balance of power between workers and managers, making it less likely that labor will capture much of the productivity gains.

B. The Direction of Technological Change

Combining Ricardo's revised thinking about machines and Thompson's ideas about the balance of power in factories provides an enriched account of the effects of the early Industrial Revolution on labor. But missing from both of their accounts is another important element – the centrality of technological choices.

It was not preordained by advances in technology, engineering, or business organization that improved machinery would reduce the demand for labor in the early decades of the nineteenth

century, or that the factory system would disempower workers and push them into much harsher working conditions. These were choices.

The direction of technology is highly malleable and responds to economic incentives, as well as the political and bargaining power of different parties affected by the technology (Acemoglu 2001; Acemoglu 2002; Acemoglu and Restrepo 2018; Acemoglu and Johnson 2023). The same is doubly true for organizational choices – after all, modern factories could be set up without such long hours or such harsh conditions for working people.

Recognizing the essential role of choice over the direction of technology and organizational forms is not only relevant for understanding the early decades of the Industrial Revolution. It is also critical to appreciate how and why things started changing from around 1850 onwards.

As we explain in Acemoglu and Johnson (2023), these changes were the result of innovations that prioritized increasing the marginal productivity of labor, most importantly by introducing new tasks for workers. For example, new technologies in railways and heavy industry introduced novel activities and capabilities for workers. American technologies that emphasized boosting the productivity of unskilled labor by standardizing parts and processes introduced new technical tasks for laborers and spread throughout Europe, including the United Kingdom. Modern manufacturing started employing more workers including in design, repair, maintenance, and clerical tasks. These technological trends laid the foundation for more shared prosperity, where wage growth went hand in hand with higher profits for businesses. Critically, this type of sharing was also undergirded by a changing balance between capital and labor, as voting rights expanded and trade unions were empowered to negotiate wages and working conditions. Factories were now everywhere, but they no longer subjected workers to the same horrendous conditions for longer hours, nor could they employ and exploit very young children.

The importance of choice in the direction of technology may be even more central today, to understand how AI could affect labor markets, than it was in the Industrial Revolution.

One promise of AI is its capability to provide much better information to humans for problem-solving tasks and decision-making. If such a path for AI were feasible (which we believe it is, as we argue in Acemoglu, Autor, and Johnson 2023; see also Acemoglu 2021) and if it were prioritized, we could move to a different phase of modern economic growth than the non-shared variant ushered in by the digital and robotic technologies of the last four decades.

But critically, this is a choice. The evidence we have briefly discussed suggests we may be heading down a different path, with much less favorable implications for labor. If AI amplifies automation and surveillance, its impact on labor could be as bad as, or even worse than, what Ricardo and Thompson were concerned about in the early stages of the Industrial Revolution.

7. Conclusion

Despite rapid improvements in the productivity of cotton manufacturing, the early decades of the nineteenth century were not buoyant times for British workers. Skilled artisans, especially handloom cotton weavers, lost their relatively high pay and autonomy, while average real wages for all workers were stagnant or declining, even as productivity in the economy rose. It was presumably these developments that made David Ricardo, a founder of modern economics, change his mind about the question of machinery. While Ricardo had previously assumed that new machinery that raised average productivity would also mean greater demand for labor, more employment, and higher wages, he had good reason to revise his thinking on this critical question in the early 1820s.

We have much to learn from Ricardo's openness to new ideas and new ways of thinking about economics as he observed very different effects of machinery on labor than he had previously presumed.

Going one step further, we suggest that Ricardo's productive thinking on this question may need to be combined with ideas about how new technologies and organizational forms fundamentally change the balance of power between capital and labor, for example as argued by the historian E.P. Thompson. Thompson's work, drawing on a large body of original sources and research by other historians, demonstrates that the new factory system also subjected workers to greater discipline, more intense monitoring, and a regimen with much less autonomy and arguably less specialized, skilled work.

Learning from Ricardo and Thompson is particularly important today because we are in a similarly transformative and disruptive process of technological change. The machinery in question is no longer the factory system and textile equipment, but rather advanced digital machinery and algorithms. On the horizon, we have artificial intelligence potentially accelerating these technological trends and disruptions.

Expecting that new digital tools would not just boost productivity but also raise employment and wages has been a natural conjecture for many economists and policymakers. But we now know that the impact of digital technology has been more complex and less positive for many working people in the industrialized world. Since 1980, inequality has increased at a staggering rate in the United States and less educated workers have experienced significant declines in their real wages (Acemoglu and Autor 2011; Autor 2019). Although the precise experiences of other countries vary, the general pattern of increasing inequality since the 1980s has been the norm (Organisation for Economic Co-operation and Development 2015). Recent evidence also shows

that new digital technologies, including robotics, automated equipment, and office automation, have led to declines in the real earnings and employment of workers who used to specialize in tasks that are now being performed by machinery and algorithms (Acemoglu and Restrepo 2020, 2022). In the meantime, artificial intelligence and other new tools are also intensifying surveillance and shifting the balance of power from labor to capital (Acemoglu and Johnson 2023).

Following Ricardo, this may be a time for us to rethink how machinery (and algorithms) impact labor, and how we can make choices about the direction of technology and policy to ensure that workers with diverse skills also benefit from new technologies.

References

- Acemoglu D. 1998. Why do new technologies complement skills? Directed technical change and wage inequality. *The Quarterly Journal of Economics*. 113(4):1055–89
- Acemoglu D. 2001. Good jobs versus bad jobs. *Journal of Labor Economics*. 19(1):1–21
- Acemoglu D. 2002. Directed technical change. *The Review of Economics Studies*. 69(4):781–809
- Acemoglu D, Autor D. 2011. Skills, tasks and technologies: implications for employment and earnings. In *Handbook of Labor Economics*, Vol. 4, pp. 1043–1171
- Acemoglu D. 2021. Harms of AI. Forthcoming in *The Oxford Handbook of AI Governance*, edited by Bullock JB. et al.
- Acemoglu D, Autor D, Hazell J, Restrepo P. 2022. Artificial Intelligence and jobs: evidence from online vacancies. *Journal of Labor Economics*. 40(S1):S293–340
- Acemoglu D, Johnson S. 2023. *Power and Progress: Our Thousand-Year Struggle over Technology and Prosperity*. New York: PublicAffairs
- Acemoglu D, Johnson S, Autor D. 2023. Can we have pro-worker AI? Choosing a path of machines in service of minds. MIT Shaping the Future of Work Initiative, MIT.
- Acemoglu D, F. Newman A. 2002. The labor market and corporate structure. *European Economic Review*. 46(10):1733–56
- Acemoglu D, Restrepo P. 2018. The race between man and machine: implications of technology for growth, factor shares, and employment. *American Economic Review*. 108(6):1488–1542
- Acemoglu D, Restrepo P. 2019. Automation and new tasks: how technology displaces and reinstates labor. *Journal of Economic Perspectives*. 33(2):3–30

- Acemoglu D, Restrepo P. 2020. Robots and jobs: evidence from US labor markets. *Journal of Political Economy*. 128(6):2188–2244
- Acemoglu D, Restrepo P. 2022. Tasks, automation, and the rise in U.S. wage inequality. *ECTA*. 90(5):1973–2016
- Acemoglu D, Wolitzky A. 2011. The economics of labor coercion. *Econometrica*. 79(2):555–600
- Aghion P, Jones B, Jones C. 2019. Chapter 9: Artificial Intelligence and economic growth. In *The Economics of Artificial Intelligence: An Agenda*, pp. 237–82. University of Chicago Press
- Allen RC. 2007. Pessimism preserved: real wages in the British Industrial Revolution. Discussion Paper Series 314, University of Oxford, Department of Economics
- Allen RC. 2009. Engels' Pause: Technical change, capital accumulation, and inequality in the British Industrial Revolution. *Explorations in Economic History*. 46(4):418–35
- Allen RC. 2018. The hand-loom weaver and the power loom: a Schumpeterian perspective. *European Review of Economic History*. 22(4):381–402
- Autor DH. 2019. Work of the past, work of the future. *AEA Papers and Proceedings*. 109:1–32
- Baines E. 1835. *History of the Cotton Manufacture in Great Britain*. H. Fisher, R. Fisher, and P. Jackson
- Baptist EE. 2014. *The Half Has Never Been Told: Slavery and the Making of American Capitalism*. New York: Basic Books
- Barton J. 1817. *Observations on the Labouring Classes of Society*. John and Arthur Arch

- Beckert S. 2014. *Empire of Cotton: A Global History*. New York: Alfred A. Knopf.
- Bowley AL. 1989. The statistics of wages in the United Kingdom during the last hundred years.
(Part I.) agricultural wages. December. Vol. 61, No. 4.
- Bythell Duncan. 1969. *The Hand-loom Weavers: A Study in the English Cotton Industry during the Industrial Revolution*. London: Cambridge University Press
- Cannan E. 1894. Ricardo in Parliament. *The Economic Journal*. 4(15):409–23
- Chapman SD. 1987. *The Cotton Industry in the Industrial Revolution*. London: Macmillan Education UK.
- Chapman SJ. 1904. *The Lancashire Cotton Industry: A Study in Economic Development*.
Manchester University Press
- Clark G. 2001. Farm wages and living standards in the Industrial Revolution: England, 1670-1869. *The Economic History Review*. 54(3):477–505
- Clark G. 2002. Shelter from the storm: housing and the Industrial Revolution, 1550-1909. *The Journal of Economic History*. 62(2):489–511
- Clark G. 2005. The condition of the working class in England, 1209–2004. *Journal of Political Economy*. 113(6):1307–40
- Clark G. 2007. The long march of history: farm wages, population, and economic growth, England 1209-1869. *The Economic History Review*. 60(1):97–135
- Clark G. 2010. The macroeconomic aggregates for England, 1209–2008. In *Research in Economic History*, Vol. 27, ed. AJ Field, pp. 51–140. Emerald Group Publishing Limited

- Crafts N, Mills TC. 2022. Considering the counterfactual: real wages in the first Industrial Revolution. *The Economic Journal*. 132(645):1994–2006
- Davis R. 1979. *The Industrial Revolution and British Overseas Trade*. Leicester University Press
- Douglas I, Hodgson R, Lawson N. 2002. Industry, environment, and health through 200 years in Manchester. *Ecological Economics*. 41(2):235–55
- Feinstein CH. 1998. Wage-earnings in Great Britain during the Industrial Revolution. In *Applied Economics and Public Policy*, eds. B Henry, I Begg, pp. 181–208. Cambridge University Press
- Finer SE. 2017. *The Life and Times of Sir Edwin Chadwick*. Abingdon, Oxon: Routledge
- Freeman JB. 2018. *Behemoth: A History of the Factory and the Making of the Modern World*. New York: W. W. Norton & Company.
- Gourvitch A. 1966. *Survey of Economic Theory on Technological Change & Employment*. New York: A. M. Kelley
- Hammond JL, Hammond BB. 1919. *The Skilled Labourer, 1760-1832*. Longmans, Green and Co.
- Hayek F. 1941. *The Pure Theory of Capital*. London: Macmillan and Co., Limited
- Henderson JP, Davis JB. 1997. *The Life and Economics of David Ricardo*. Boston, MA: Springer US
- Hernon I. 2006. *Riot! Civil Insurrection from Peterloo to the Present Day*. London; Ann Arbor, MI: Pluto

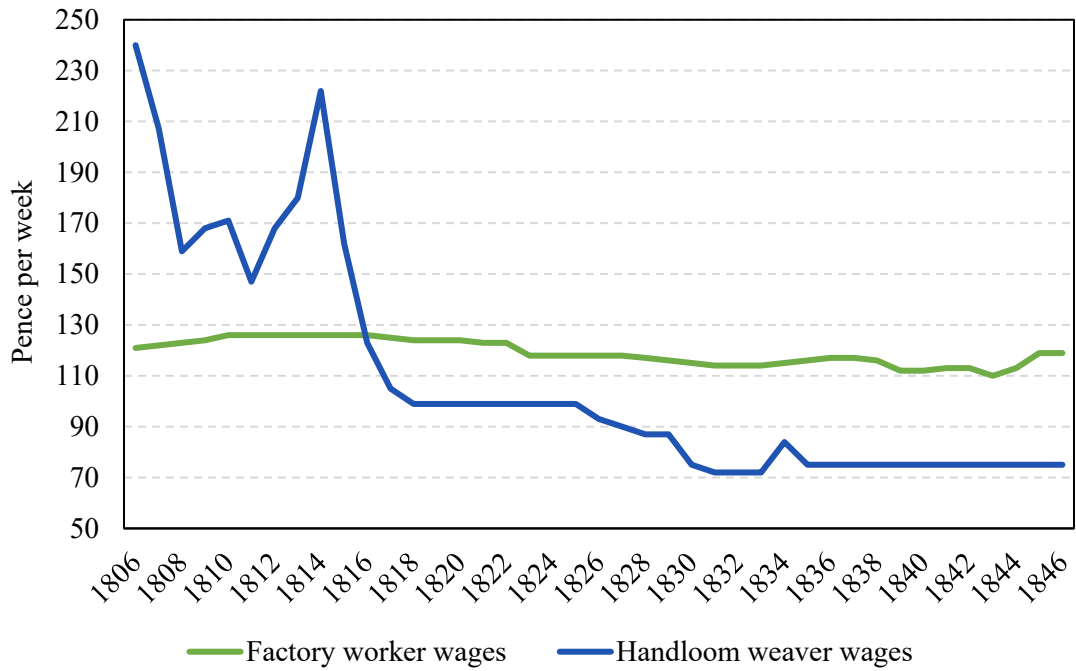
- Hobsbawm EJ. 1996. *The Age of Revolution 1789-1848*. New York: Vintage Books
- Hobsbawm EJ, Wrigley C. 1999. *Industry and Empire: From 1750 to the Present Day*. London: Penguin Books
- Horrell S. 1996. Home demand and British industrialization. *The Journal of Economic History*. 56(3):561–604
- Hunt EH. 1981. *British Labour History, 1815-1914*. London: Weidenfeld and Nicolson.
- Hunt EH. 1986. Industrialization and regional inequality: wages in Britain, 1760-1914. *The Journal of Economic History*. 46(4):935–66
- Kelly M, Mokyr J, Ó Gráda C. 2023. The mechanics of the Industrial Revolution. *Journal of Political Economy*. 131(1):59–94
- Landes DS. 2003. *The Unbound Prometheus: Technological Change and Industrial Development in Western Europe from 1750 to the Present*. Cambridge, UK: Cambridge University Press.
- Lindert PH, Williamson JG. 1983. English workers' living standards during the Industrial Revolution: a new look. *The Economic History Review*. 36(1):1
- Mitchell BR. 1984. *Economic Development of the British Coal Industry 1800-1914*. Cambridge: Cambridge University Press
- Mokyr J. 1988. Is there still life in the pessimistic case? Consumption During the Industrial Revolution, 1790-1850. *Journal of Economic History*. 48(1): 69-92.
- Mokyr J. 2009. *The Enlightened Economy: An Economic History of Britain, 1700-1850*. New Haven: Yale University Press.

- Mokyr J, Vickers C, Ziebarth NL. 2015. The history of technological anxiety and the future of economic growth: is this time different? *Journal of Economic Perspectives*. 29(3):31–50
- Organisation for Economic Co-operation and Development. 2015. *In It Together: Why Less Inequality Benefits All*. Organisation for Economic Co-operation and Development
- Parliamentary Committee. 1835. *Report from Select Committee on Hand-Loom Weavers' Petitions: With the Minutes of Evidence and Index: Ordered, by the House of Commons, to Be Printed, 1 July 1835*. London
- Petersen C. 1995. *Bread and the British Economy, 1770-1870*. Routledge
- Pissarides CA. 2000. *Equilibrium Unemployment Theory*. Cambridge, Massachusetts: The MIT Press.
- Ricardo D. 1821. *On the Principles of Political Economy and Taxation*. McMaster University Archive for the History of Economic Thought. 3rd ed.
- Schumpeter JA. 2006. *History of Economic Analysis*. Taylor & Francis
- Sotiropoulos G. 1952. John Barton (1789-1852). *The Economic Journal*. 62(245):87
- Sraffa P. 1951. *The Works and Correspondence of David Ricardo*. Cambridge: University Press for the Royal Economic Society
- Thompson EP. 1966. *The Making of the English Working Class*. New York: Vintage Books
- Tucker RS. 1936. Real wages of artisans in London, 1729-1935. *Journal of the American Statistical Association*. 31(193):73
- Vanderlint J. 1734. *Money Answers All Things*. London

- Williams B. 1939. *The Whig Supremacy: 1714-1760*. Oxford: Clarendon Press.
- Wood GH. 1910a. The statistics of wages in the United Kingdom during the nineteenth century.
(Part XV.) The cotton industry. *Journal of the Royal Statistical Society*. 73(1):39
- Wood GH. 1910b. The statistics of wages in the United Kingdom during the nineteenth century.
(Part XV.) The cotton industry. *Journal of the Royal Statistical Society*. 73(2):128–63
- Wood GH. 1910c. The statistics of wages in the United Kingdom during the nineteenth century.
(Part XVII.) The cotton industry. *Journal of the Royal Statistical Society*. 73(3):283
- Wood GH. 1910d. The statistics of wages in the United Kingdom during the nineteenth century.
(Part XVIII.) The cotton industry. *Journal of the Royal Statistical Society*. 73(4):411
- Wood GH. 1910e. The statistics of wages in the United Kingdom during the nineteenth century.
(Part XIX.) The cotton industry. Section V. Changes in the average wage of all employed,
with some account of the forces operating to accelerate or retard the progress of industry.
Journal of the Royal Statistical Society. 73(6/7):585
- Zuboff S. 1988. *In the Age of the Smart Machine: The Future of Work and Power*. New York:
Basic Books

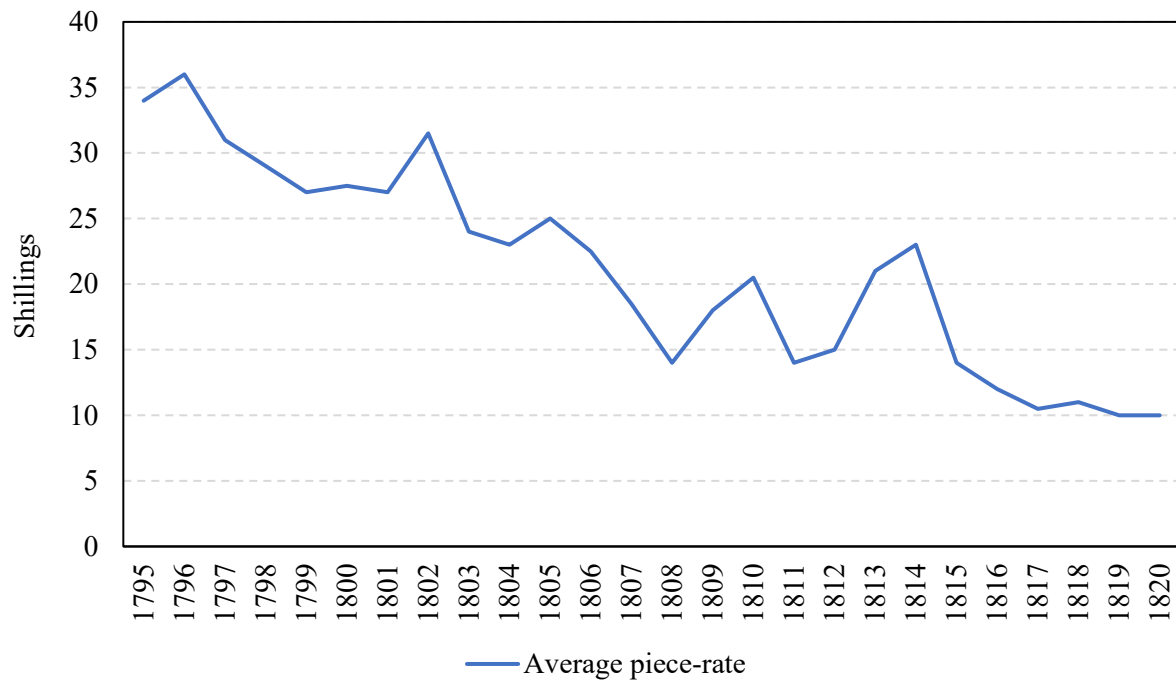
Figures

Figure 1: Handloom weaver and factory worker nominal wages



Nominal wages are from Wood (1910e). Factory workers include spinners and weavers.

Figure 2: Piece-rate for muslin weaving at Bolton, 1795-1820



Price reflects the rate for 60-reed cambric muslin. Produced from table in Bythell (1969, pp. 99)

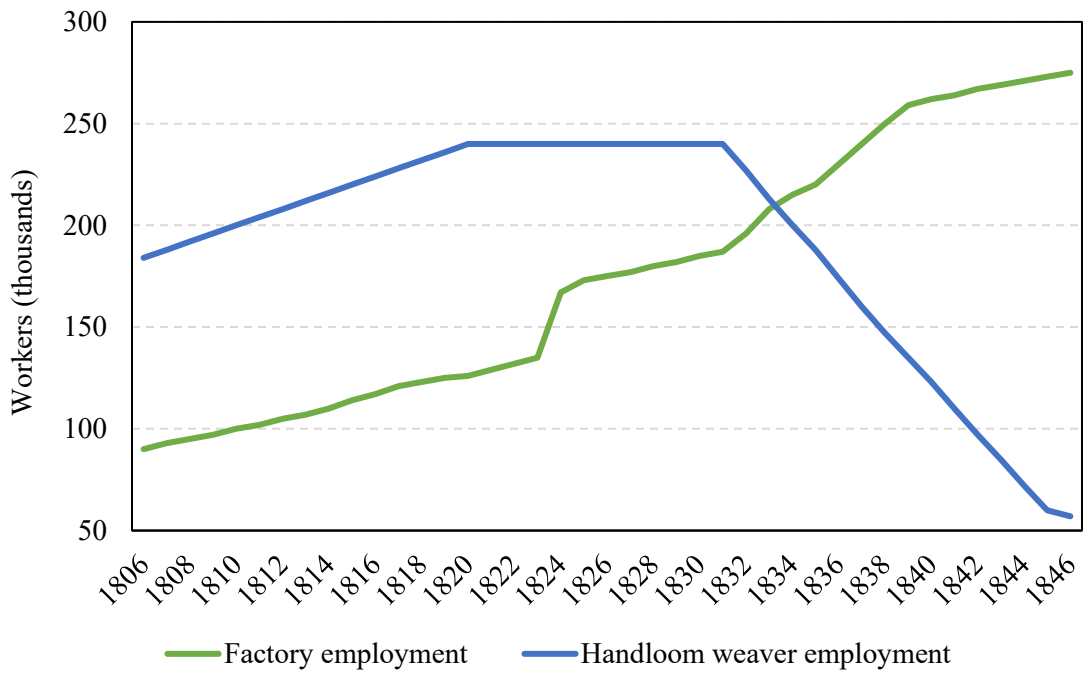
Figure 3: Real weekly wages of textile workers, by cost-of-living index (1806 = 100), 1806-1862



Textile worker wages are from Wood (1910e) Table 41.

Weighted average is the average of handloom and factory worker wages, weighted by employment.

Figure 4: Handloom weaver and factory worker employment



Employment is from Wood (1910e). Factory workers include spinners and weavers

Figure 5: Economy-wide real wages (1790 = 100), 1770-1882

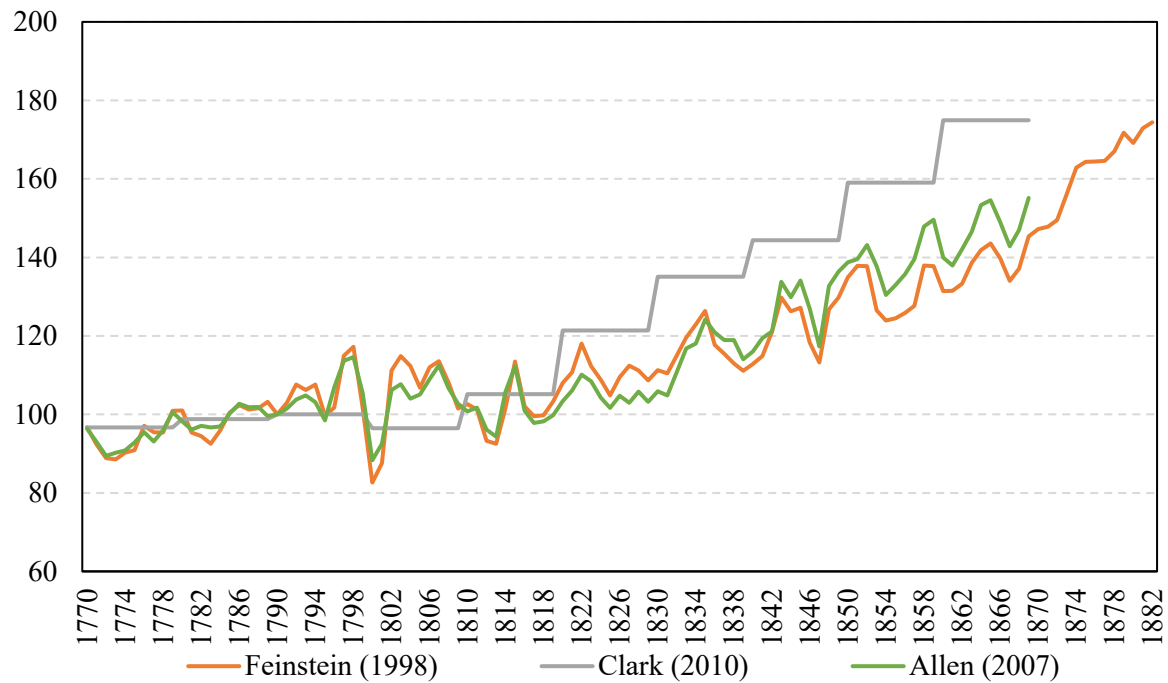


Figure shows economy-wide wages weighted by occupation and population.

Feinstein bases his nominal wage series largely on the work of A.L. Bowley and G.H. Wood.

Allen uses Feinstein's nominal wages. Clark constructs his own series from work in Clark (2001, 2005, and 2007), drawing on archival sources including Bowley and Wood.

Tables

Table 1: Earnings and expenses of handloom weavers in Lancashire, 1814-1833^a

Year	Near Colne				Near Oldham		
	A family could earn ^b (shillings)	Repair of looms, rent, etc. (shillings)	Leaving for other costs ^c (shillings)	Yearly income (£)	Wage (shillings)	63 hours wage (shillings)	Expenses ^d (shillings)
1814	52.00	5.25	46.75	135.20	2.29	13.75	3.63
1815	34.17	5.25	28.92	88.83	1.96	11.75	3.27
1816	26.83	5.25	21.58	69.77	1.50	9.00	2.79
1817	24.17	5.25	18.92	62.83	1.08	6.50	2.35
1818	28.83	5.25	23.58	74.97	1.46	8.75	2.71
1819	25.00	5.25	19.75	65.00	1.67	10.00	2.92
1820	23.33	5.25	18.08	60.67	1.50	9.00	2.73
1821	28.31	5.25	23.06	73.61	1.42	8.50	2.63
1822	22.88	5.25	17.63	59.48	1.50	9.00	2.69
1823	21.00	5.25	15.75	54.60	1.58	9.50	2.75
1824	19.13	5.25	13.88	49.73	1.58	9.50	2.73
1825	19.13	5.25	13.88	49.73	1.46	8.75	2.58
1826	11.83	4.25	7.58	30.71	1.08	6.50	2.13
1827	14.63	4.25	10.38	38.03	1.08	6.50	2.19
1828	14.63	4.25	10.38	38.03	1.17	7.00	2.25
1829	10.50	4.25	6.25	27.03	1.00	6.00	2.06
1830	13.50	4.25	9.25	35.11	0.83	5.00	1.88
1831	14.83	4.25	10.58	35.11	0.83	5.00	1.88
1832	12.00	4.25	7.75	30.71	0.79	4.50	1.77
1833	12.00	4.25	7.75	31.20	0.79	4.50	1.75

Table adapted from Wood (1910d), Table 34

^aEarnings and expenses represent weekly values unless otherwise indicated.

All columns have been converted into a single denomination from the original table.

Conversion factors used were: 1£ = 20s = 240d.

^b6 persons including 3 children.

^cFood and clothing, etc.

^dRent, fuel, etc.

Table 2: Employment in the British cotton industry, 1788-1862

Year	Factory employment (thousands)			Handloom weavers (thousands)
	Spinning	Weaving	Total	
1788	60	ND	60	108
1801	83	ND	83	164
1806	90	Few	90	184
1813	104	3	107	212
1817	111	10	121	228
1820	115	11	126	240
1823	120	15	135	240
1824	122	45	167	240
1825	124	49	173	240
1831	131	56	187	240
1832	132	64	196	227
1833	133	75	208	213
1835	ND	ND	220	188
1839	ND	ND	259	135
1847	ND	ND	277	53
1850	ND	ND	331	40
1856	ND	ND	379	23
1862	ND	ND	452	3

ND indicates 'no data'. Table reproduced from Wood (1910e), Table 40.

Table 3: Daily earnings of coal workers, 1800-1835^a

Year	Northumberland (shillings)	Durham (shillings)	Yorkshire (shillings)		Lancashire & Cheshire (shillings)	East Midlands (shillings)	Staffordshire (shillings)		South Wales (shillings)	Scotland (shillings)
			South	West			North	South		
1800/2	2.75	2.75	2.93	2.80	4.27	2.67	2.51	ND	3.10	2.99
1804/6	ND	ND	ND	ND	ND	3.52	2.76	ND	ND	3.49
1811	ND	ND	ND	ND	ND	ND	ND	ND	5.02	ND
1813/14	3.37	3.31	3.09	2.95	4.48	3.52	ND	ND	3.34	3.32
1818	2.70	2.80	ND	ND	ND	ND	ND	ND	ND	ND
1819	2.49	2.52	2.61	2.50	4.00	ND	ND	ND	2.90	3.24
1822	2.70	2.80	2.88	2.75	4.27	2.99	ND	ND	3.00	3.75
1825	3.89	3.78	3.41	3.30	4.59	3.41	ND	ND	4.23	5.01
1826	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.50
1827	2.70	2.80	ND	ND	ND	ND	ND	ND	4.23	4.00
1828	2.70	2.80	ND	ND	ND	ND	ND	ND	ND	4.00
1829	2.49	2.52	2.93	2.80	4.27	2.88	3.00	4.00	3.74	4.00
1830	2.70	2.80	2.93	2.80	4.27	2.93	3.19	4.00	3.93	4.00
1831	3.79	3.73	2.93	2.80	4.27	2.93	3.38	4.00	4.23	4.00
1832	3.48	3.50	2.93	2.80	4.27	2.93	3.38	4.00	3.98	4.00
1833	3.37	3.13	2.93	2.80	4.53	2.93	3.38	4.00	3.93	4.00
1834	3.37	3.13	3.20	3.05	4.80	3.20	4.01	4.00	3.98	4.00
1835	3.37	3.13	3.47	3.35	4.80	3.52	4.16	4.00	4.23	4.00

ND indicates 'no data'. Table adapted from Mitchell (1984), Table 7.1.

^aTable represents shift earnings of coal hewers.

Index values have been converted to currency using values found in table note ii.

All columns have been converted to a single denomination using the following conversion factors: 1£ = 20s = 240d.

Table 4: Builders' and agricultural workers' wages, 1710-1859

Decade	Builders ^a			Agricultural workers ^b	
	Craftsmen's day wage (pence)	Helper's day wage (pence)	Relative wage	Raw average day wage (pence)	Estimated average day wage (pence)
1710-19	19.7	12.1	1.63	10.5	9.9
1720-29	20.0	12.4	1.62	10.1	9.6
1730-39	20.3	12.6	1.62	10.2	10.8
1740-49	20.6	12.6	1.63	11.1	10.8
1750-59	20.5	13.1	1.57	12.2	10.9
1760-69	21.3	13.9	1.53	11.2	11.7
1770-79	22.3	15.1	1.48	11.4	12.5
1780-89	23.4	15.3	1.53	11.8	13.2
1790-99	26.8	17.9	1.50	14.5	15.6
1800-09	35.9	23.9	1.51	19.1	19.0
1810-19	43.8	29.8	1.47	23.2	23.0
1820-29	42.1	27.0	1.56	22.2	20.6
1830-39	42.7	28.0	1.53	21.3	20.3
1840-49	43.3	29.0	1.50	22.5	21.2
1850-59	45.6	30.1	1.52	22.4	21.9

^aColumns regarding builders are from Clark (2005), Table A2.

^bColumns regarding agricultural workers are from Clark (2007), Table 1

**ONLINE APPENDIX TO “LEARNING FROM RICARDO AND THOMPSON”:
MEASURING THE COST OF LIVING IN THE EARLY INDUSTRIAL REVOLUTION**

The question of how living standards evolved throughout the early Industrial Revolution has been of interest to economic historians for decades. Core to this debate is the measurement of the trend of real wages. A seminal effort came from Lindert and Williamson (1983) who argued that real wages “nearly doubled” from 1820 to 1850, and claimed this was large enough of an increase to “resolve most of the debate over whether real wages improved during the Industrial Revolution” (pp. 11-12). This optimistic view of real wage growth was effectively challenged by Feinstein (1998), who found only a 12% increase in real wages from 1780 and 1840, far behind the rate of increase in productivity. With more detailed household expenditure shares along with new and improved estimates of prices, Feinstein’s (1998) more realistic account of real wage growth has become widely accepted (Allen 2009, Crafts and Mills 2022). However, recent work (notably by Clark 2005, 2007, and 2010) has challenged this view, and offered evidence to support a more optimistic case. It is thus worth considering the question of real wage trends carefully and examining what drives the differences between these accounts.

Comparing the evidence offered by Feinstein (1998), Clark (2005, 2007, and 2010), and Allen (2007 and 2009), differences in real wages boil down to disagreement regarding consumer prices, particularly during the critical years after 1815. Overall, we find Allen’s series, which combines the most persuasive elements of Feinstein’s and Clark’s offerings, to be the most compelling. The choice of consumer price series is crucial to determining if real wages stagnated or grew during the early Industrial Revolution (i.e., from the 1770s into the 1830s or even to

1850). However, the core arguments presented in this article, regarding the wages of workers in the textile industry, are robust across all price indices (as shown in Figure 3).

Prior to the end of the Napoleonic Wars in 1815 there is general consensus between Feinstein, Clark, and Allen that real wages were stagnant (see Figure A1). Only in the post-1815 period do major discrepancies emerge. From 1815-1851 Clark (2010) finds a 51% increase in real wages, far more than the 21% and 25% found by Feinstein (1998) and Allen (2007). An intriguing feature of the living standards debate is the general alignment of the literature regarding economy-wide nominal wages. As shown in Figure A2, estimates of nominal wages from Feinstein (1998) and Clark (2010) are remarkably similar.⁴⁵ Indeed, as Allen (2007) observes, the substantive discrepancies between the real wage series come down to differences in the price index. Feinstein (1998) and Allen (2007) all reach similar peaks in prices around 1815. Using decadal averages, Clark (2010) estimates a far smaller peak in prices, with a rapid fall after 1820. Thus, to understand the differences underlying these estimates of real wage it is sensible to focus primarily on differences in estimates of the price index, paying special attention to how prices evolved in the post-Napoleonic War period.

Allen (2007) conducts a detailed review comparing Clark's (2005) novel consumer price index with Feinstein (1998) with the goal of constructing his own series, based on the best of each contribution. Ultimately, Allen (2007) makes a compelling case that many of Clark's new contributions "degrade" the quality of Clark's index relative to Feinstein's. As a result, Allen's 'best of both' index is much closer Feinstein's than Clark's. More recently, Clark (2007 and 2010) made minor modifications to his index, but many of Allen's original critiques still apply.

⁴⁵ For his estimates of real wages, Allen (2007 and 2009) simply accepts Feinstein's (1998) series of nominal wages.

Therefore, despite Clark's updates (more on those below), we still prefer Allen (2007) as the best cost of living index available.

Allen first notes the discrepancy between Clark's (2005) weighting of carbohydrates in comparison to Feinstein. While Feinstein weights bread and flour at roughly 30% of the working-class budget, Clark only gives them a share of 18.5%. To reach this lower value, Clark presents budget share estimates from Horrell (1996) as well as Vanderlint (1734). Allen favors using Horrell (1996), whom Clark cites as yielding a budget share of 37.8% for 1787-96 and 29.7% for 1840-54.⁴⁶ However, Allen objects to the inclusion of Vanderlint (1734), whose outlying estimate of 12.5% pulls down Clark's weighting (see Table A1 for the full set of weights). Allen (2007) notes that Vanderlint (1734) published his estimates in a politically motivated pamphlet, which cannot be relied on as a serious estimate of household expenditure.

Clark seems to have acknowledged this fact, as he excludes Vanderlint in his estimation of spending share in Clark (2007), instead relying only on Horrell (1996). In this series, he assumes a much higher proportion of spending (40%) went towards wheat. Similarly, bread and wheat make up a larger proportion (roughly 30% on average from 1760-1840) of the cost-of-living index presented in Clark (2010).⁴⁷ Therefore, with respect to weighting of carbohydrates, Clark seems to have accepted Allen's criticism. His revised weightings now align more closely with Feinstein (1998) and Allen's (2007) weightings of around 30% for bread and flour combined (See Table A2).

⁴⁶ Feinstein also relies on Horrell (1996) to inform his weightings.

⁴⁷ The discrepancy between Clark (2007) and Clark (2010) is due to the differences in the budget Clark was hoping to represent. Clark (2007) looks at agricultural workers, whereas Clark (2010) is focused on the average worker. Average weighting of wheat is calculated from Tables 16, 29, and 30 in Clark (2010). See Table A2 for details.

Allen offers evidence supporting his choice of weighting for wheat. Extrapolating from each share's estimate, Allen compares implied aggregate wheat consumption from Clark and Feinstein's spending shares and compares this with evidence regarding available wheat supply. This exercise finds that Clark's (2005) estimates of wheat demand fall far below the supply, while Feinstein's (based on a 29.9% spending share) implies excessive demand. Following this logic, Clark's (2007) revised shares, which are closer to 40%, would imply much too high levels of demand. Based on this information, we prefer Allen's chosen weighting of 28.5%.

Aside from weighting, Allen also takes issue with several of Clark's novel price series, especially those regarding food. Here, Allen's criticism of Clark (2005) is still relevant, as Clark (2007 and 2010) simply refers to the earlier article for these price indices. The most significant disagreement is with regard to the price of bread.⁴⁸

As a heavily weighted food product, the price of bread is of crucial importance to the overall consumer price index. Clark interpolates the price of bread from the price of wheat, rejecting "abundant" evidence regarding actual retail prices of bread (Allen 2007, p. 10).⁴⁹ Citing concerns of changing quality, Clark takes the cost of wheat as an indicator of the price of bread of constant quality. However, Allen points out that the bread prices available in contemporary sources like Petersen (1995) reflect the price for a legally defined standard loaf of known and constant quality. In addition to this legal standard, contemporary accounts suggest that bread quality did not decline during the early Industrial Revolution, and if anything improved in quality (Allen

⁴⁸ Aside from the pricing of bread, Allen rejects Clark's series for dairy and beer prices, preferring those offered by Feinstein (1998).

2007, 11). Customers were sensitive to low quality breads and could easily avoid loaves of inferior quality.

To substantiate his fears of declining quality of bread, Clark cites no direct evidence. He rather argues that bread and wheat prices ought to have moved in fixed proportion. Since they did not, he concludes that the quality of bread must have deteriorated. Allen offers several competing explanations for the disconnect between wheat and bread prices. First, Clark cites the Navy's costs in turning wheat into bread to suggest that 92% of the costs came from wheat. However, Allen points out that the Navy's "costs" excluded capital costs, which were substantial for the small, high-cost bakeries which most English consumers patronized. Second, technical improvements in milling and increased competition drove down the price of flour with respect to wheat. This resulted in a low ratio of flour to wheat prices, and in turn a low ratio of the price of bread to the price of wheat. Third, according to Allen, legal reform after 1757 ended a golden age of rent-seeking in baking, causing the ratio of the price of bread to the price of wheat to fall. From 1709-1757, local magistrates were allowed to determine the mark-up on a standard loaf of bread, which led to a period of high prices. Reform in 1757 ended this.

Taken together, we can conclude that bread prices in the 1770s and 1780s were low not because the quality was low. Rather, they reflected other factors. Allen (2007) concludes that consumers could buy quality bread at prices for which we have good evidence. He thus reasonably uses those prices in his price index. Clark (2010) acknowledges Allen's criticisms but fails to refute them effectively. Clark offers no response to the direct evidence of constant-quality bread and several historical examples substantiating the disconnection between wheat prices and bread prices. Rather, he doubles down on the indirect evidence, showing that even accounting for capital and other costs, the price of bread cannot be predicted by its inputs. From this he

concludes that the bread could not be of constant quality. However, given the strength of Allen's direct evidence and plausible explanations for this disconnect, we prefer Allen's series. This is a substantial difference. Table 1 in Allen's (2007) shows that substituting Clark's grain series for Allen's preferred series makes a large difference in Clark's (2005) consumer price index. The effect of this series is obviously even greater for Clark (2010), which weights bread almost twice as heavily.

In contrast to his food price indices, Allen has a much more favorable view of Clark's contributions to estimating rent, clothing, and fuel costs. Regarding rent, Clark (2002) assembles a series based on actual rents paid for housing owned by charities throughout Britain. This is the most comprehensive series of actual rents paid in this time and is consistent with political events which would have likely impacted rent. Allen therefore accepts Clark's rent series as an improvement over Feinstein. Similarly, Clark's measures of clothing prices are closely aligned with data collected by Tucker (1936) regarding actual prices paid for various articles of clothing in hospitals. Clark's series is also based on actual prices paid, an improvement over Feinstein's series which relies on inputs like wool and cotton cloth to estimate prices of clothing. Preferring to use actual prices, Allen chooses Tucker's series, which aligns closely with Clark's. Finally, for fuel, Allen constructs his own series based on the weighted average of the prices per BTU of coal and charcoal in London and Northern England. This series moves in sympathy with Clark, and starkly contrasts Feinstein's.

In sum, Allen (2007) raises valid concerns about Clark's (2005) cost-of-living series, and most of Allen's points also apply to Clark's subsequent updates. Allen quite reasonably combines the best of Clark's contributions with the well-respected series provided by Feinstein (1998). The resulting series relies more on evidence of actual prices paid than either Clark or Feinstein alone

and is well reasoned in its construction. Because of this, we prefer Allen's cost-of-living and real wage series for this article. As Allen observes, his series is far closer to Feinstein than Clark, and it is thus not surprising that the resulting real wage series supports Feinstein's pessimism more than Clark's optimism.

However, even if we were to accept Clark's more optimistic price series, the interpretation presented in this article is unlikely to be overturned. Figure 3 shows real wages of workers in the cotton industry from Wood (1910e) taking both Clark's and Allen's CPI. In either case, hand-loom weavers saw a large fall in wages from 1806-1820, while factory workers only realized small gains. The weighted average cotton industry wage fell sharply from 1806 (the start of this series) to 1820, and only slowly recovered thereafter.

Figures

Figure A1: Economy-wide real wage (1790 = 100), 1770-1830

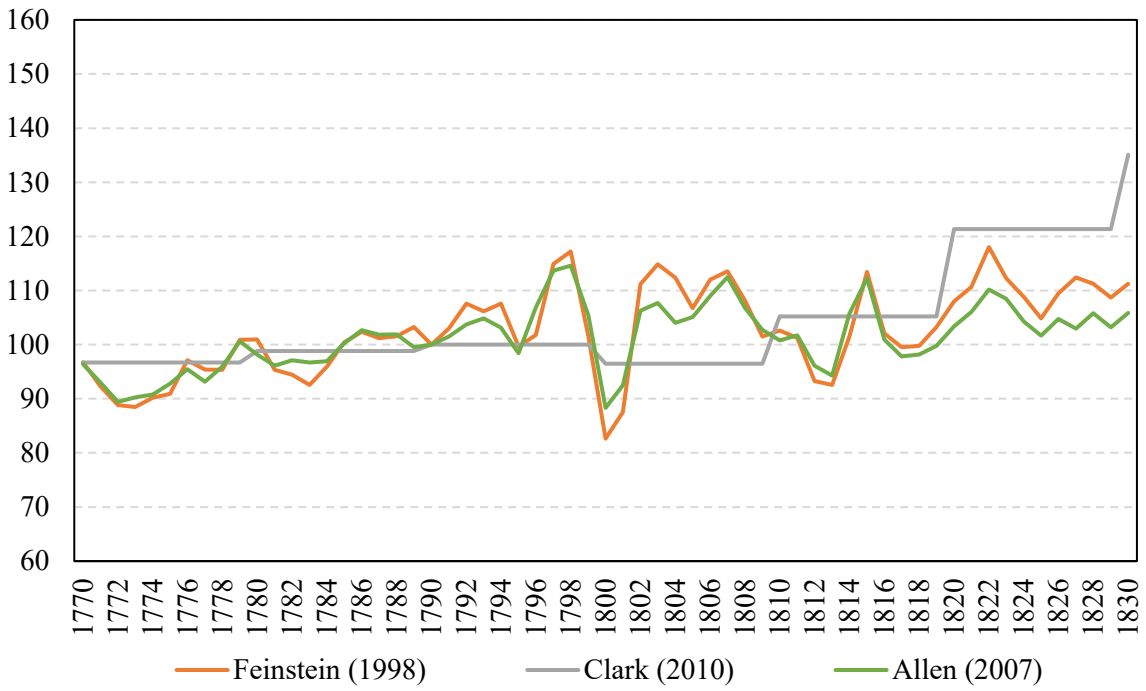
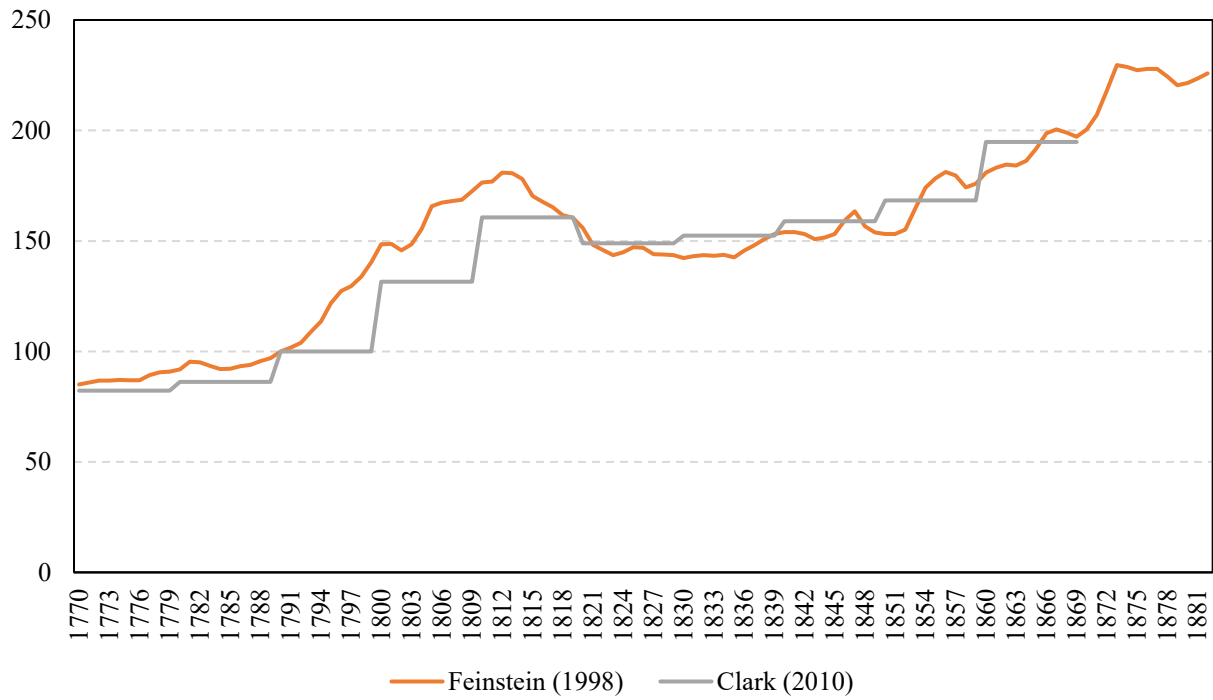


Figure A2: Economy-wide nominal wages (1790 = 100), 1770-1882



Note, Allen (2007) uses Feinstein's series for national nominal wages

Figure A3: Consumer price index (1790 = 100), 1770-1830

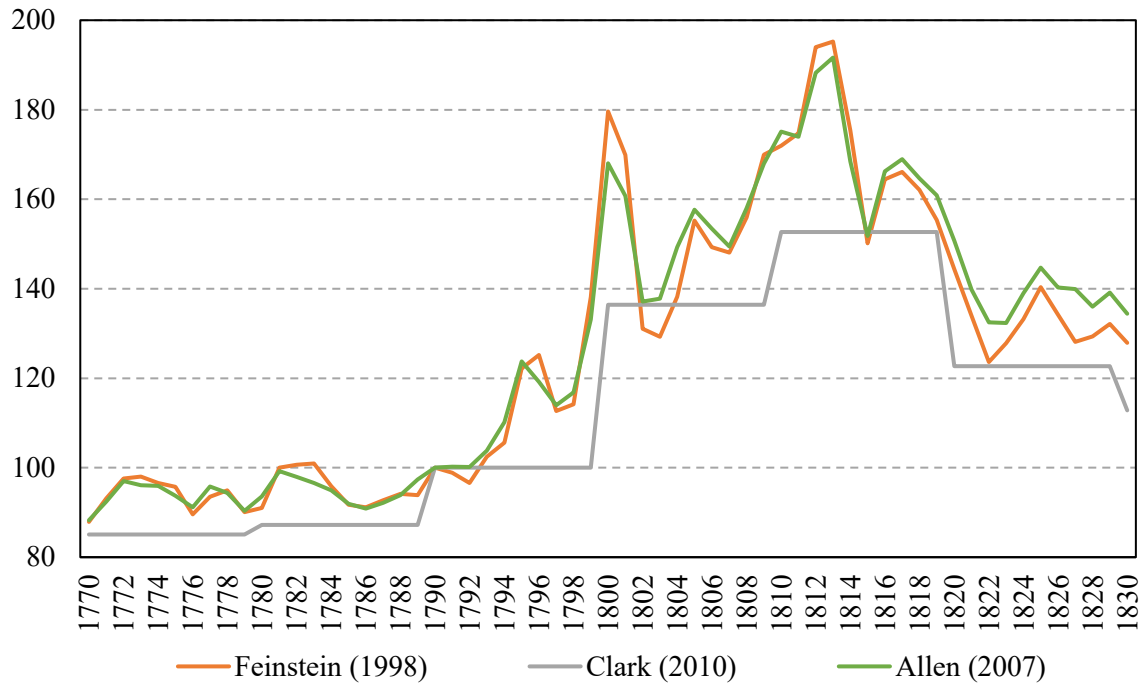


Figure A4: Economy-wide real wages (1790 = 100), 1790-1850

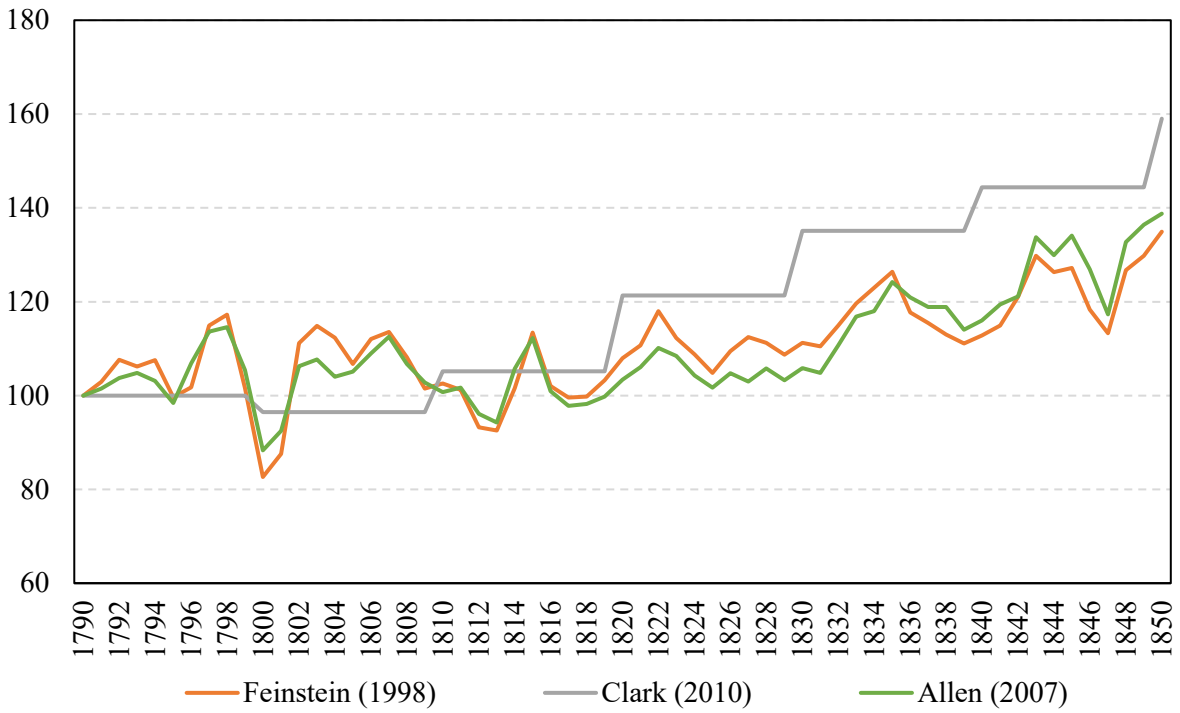


Table A1: CPI weighting comparison across alternative estimates

Product	Feinstein (1998)				Clark (2005)	Allen (2007)
	1788/92	1828/32	1858/62	Average		
Bread	13.80	16.25	18.30	16.12	18.50	19.00
Flour	18.63	13.65	9.15	13.81	0.00	9.50
Oatmeal	8.97	4.55	1.83	5.12	2.00	4.00
Barley	0.00	0.00	0.00	0.00	1.00	0.00
Pease	0.00	0.00	0.00	0.00	1.00	0.50
Potato	3.45	4.55	6.10	4.70	4.00	4.00
Rice	0.00	0.00	0.00	0.00	0.50	0.00
Beef	2.07	2.60	3.05	2.57	11.00	2.60
Mutton	2.07	2.60	2.44	2.37	0.00	2.60
Pork	4.83	5.20	4.88	4.97	0.00	5.20
Fish	0.00	0.00	0.00	0.00	0.50	0.00
Eggs	0.00	0.00	0.00	0.00	0.50	0.00
Milk	3.45	4.55	4.27	4.09	4.00	4.55
Butter	2.76	2.60	3.05	2.80	5.00	2.60
Cheese	2.07	1.95	1.83	1.95	2.50	1.95
Sugar	4.83	4.55	4.27	4.55	4.50	4.00
Tea/Coffee	2.07	1.95	1.83	1.95	3.50	2.00
Salt	0.00	0.00	0.00	0.00	1.00	0.00
Spices	0.00	0.00	0.00	0.00	1.00	0.00
Beer	10.00	11.00	12.00	11.00	6.50	11.00
Food Total	79.00	76.00	73.00	76.00	67.00	73.50
Tobacco	0.00	0.00	0.00	0.00	1.00	0.00
Fuel	4.00	4.00	4.00	4.00	5.00	4.00
Light/soap	1.00	1.00	1.00	1.00	4.50	1.00
Clothing	6.00	8.00	9.00	7.67	12.00	8.00
Rent	10.00	11.00	13.00	11.33	8.00	11.00
Services	0.00	0.00	0.00	0.00	2.50	2.50

Table adapted from Allen (2007), Table 2

Table A2: CPI weighting comparison across alternative estimates

Product	Clark (2005)	Clark (2010)			Allen (2007)
		1760/89	1790/1819	1820/39	
Bread	18.50	34.56	32.40	24.69	19.00
Flour	0.00	0.00	0.00	0.00	9.50
Oatmeal	2.00	2.16	2.16	1.11	4.00
Barley	1.00	1.30	0.86	0.74	0.00
Peas	1.00	2.16	2.16	1.11	0.50
Potatoes	4.00	2.16	4.32	7.37	4.00
Rice	0.50	0.86	1.30	1.84	0.00
Meat	11.00	7.20	7.37	7.37	10.40
Fish	0.50	2.16	2.01	2.01	0.00
Dairy	7.00	7.20	7.37	7.37	6.50
Fats	5.00	2.16	2.01	2.01	2.60
Sugar	4.50	2.16	3.35	3.35	4.00
Drinks	10.00	6.48	6.70	6.70	13.00
Salt	1.00	0.72	0.67	0.67	0.00
Spices	1.00	0.72	0.67	0.67	0.00
Food Total	67.00	72.00	67.00	67.00	73.50
Tobacco	1.00	0.00	1.00	1.00	0.00
Fuel	5.00	5.00	5.00	5.00	4.00
Light/soap	4.50	4.50	4.50	4.50	1.00
Clothing	12.00	12.00	12.00	12.00	8.00
Rent	8.00	4.50	7.50	7.50	11.00
Services	2.50	2.00	3.00	3.00	2.50

Clark (2005) and Allen (2007) columns adapted from Allen (2007), Table 2

Clark (2010) columns calculated from weights in Tables 16, 29, and 30 in Clark (2010)

Table A3: Supply of raw cotton, imports into the UK, 1815-1830

Year	Total Imports (millions of lbs)	Imports from the USA (millions of lbs)	Re-exports (millions of lbs)
1815	101	54	ND
1816	95	51	ND
1817	126	61	ND
1818	179	68	ND
1819	151	62	ND
1820	152	90	6
1821	133	93	15
1822	143	101	18
1823	191	143	9
1824	149	92	13
1825	228	140	18
1826	178	131	24
1827	272	217	18
1828	228	152	17
1829	223	157	30
1830	264	211	9

ND indicates 'no data'. Table from Mitchell (1988)