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 Jennyes 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. 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.[2] This notion of a productivity bandwagon appears frequently today in discussions about the potential distributional impacts of developments in artificial intelligence (AI).

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-loom workers who received a lower wage while enduring dangerous working conditions. With few outside options, and an inability to adapt to these unprecedented changes, handloom 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 handloom 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 (Ricardo, 1817). In a much-quoted line, Ricardo told the House of Commons in 1819 that "machinery did not lessen the demand for labor." This fit his broader view, again frequently referenced over the generations, that the spread of factories and large-scale production would necessarily benefit workers.

[1] This statement was made by cotton spinners to a Parliamentary Committee, which reported in 1780. It is quoted by Hammond and Hammond (1919, p. 56), who call this "a significant complaint that marks the rise of the new order of capitalism." Jennys 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 et al. (2015, p. 38) 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."

[3] The best available data suggest 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.

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 labor now does, there would be no demand for labor."[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 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—that is, how technology influences worker productivity and, via this channel, its impact on wages and employment opportunities. The questions 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 was articulated by E.P. Thompson, most notably in *The Making of the English Working Class* (Thompson, 1966).

Writing in the early 1960s and drawing on a wide range of sources from the early 1800s, Thompson (and other historians in the Marxist tradition, such as Eric Hobsbawm) 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 previous work (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 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

[4]Sraffa (1951, Vol. VIII, p. 399-400), letter dated June 30, 1821

[5]As put by Mokyr et al. (2015, p. 35) "The problem with the factories was not in the low quantity of work they offered, but the low quality of work in the mills."

[6]The short version of how this can happen is as follows. A technological improvement increases output for given

performed by workers—displaces workers and can reduce, rather than increase, the demand for labor. This is what happened to handloom 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 nonautomated 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 handloom 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]

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 will 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

quantities of factors of production, and thus it raises average labor productivity. Demand for labor, as well as 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 be 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. In general, however, there is no such guarantee, and automation—defined as machines taking over tasks previously performed by labor—expands the wedge between average and marginal productivity of labor (for further discussion, see Acemoglu and Restrepo, 2018, 2019).

[7]Because automation reduces costs, sectors adopting automation technologies may expand employment and thus increase hiring in nonautomated 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 increases incomes and demand for other goods, so that other industries may start hiring more (Acemoglu and Restrepo, 2019; Aghion et al., 2019). Via both channels, automation may end up increasing the demand for labor and thus equilibrium wages, but there is no guarantee that it 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 of workers would lead to most of the gains from new technology being captured by firms (or dissipated by additional firm entry). Pissaridēs (2000) provides 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 F. Newman, 2002). In addition, in models where employers have access to coercive capabilities or

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]

Both the technological and political pillars of shared prosperity remain important today, including in debates about the potential impact of AI. 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 handloom 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 handloom weavers, in terms of nominal wages, real wages, and employment and of how long it took for offsetting positive developments in other parts of the economy to emerge. Section 5 incorporates ideas highlighted by E.P. Thompson, which further emphasize the ways in which automation made many handloom 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 on whether new technologies automate work or create new tasks for labor, whether new technologies monitor or empower workers, and how institutions evolve to share productivity gains (or not). Section 7 concludes. Our Appendix reviews the wage and price data from early 1800s Britain in more detail.

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 of the sector's transformation. Broadly, the production of cotton textiles begins with 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

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% 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 directly in confrontation with worker interests than was the aristocracy (see the discussion in Acemoglu and Johnson, 2023, chapter 5).

machines to spin cotton greatly increased labor productivity.[11]

In the early 1700s, it took over 50,000 person hours to spin (i.e., 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, 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.[12]

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 handloom 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 handloom weavers' wages, Ricardo's views changed.

3 Ricardo's Pivot

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 the third edition of the work, which appeared that year.[13]

[11] 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.

[12] 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.

[13] We should point out there are various plausible views on what Ricardo meant by adding this chapter. In the reading of Mokyr et al. (2015, p. 33) for example, Ricardo felt "that in the long run higher productivity would lead higher saving and eventually rising demand for labor."

One possibility is that Ricardo was swayed by John Barton's (1817) *Observations on the Circumstances Which Influence the Condition of the Labouring Classes of Society.*[14] 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.[15]

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 handloom 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 1818–1819 (p. 112–18). Concerns about wages and frustration regarding the lack of parliamentary response increasingly led to demands for reform, meaning expanded representation in the 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. The so-called Peterloo Massacre shook the country; the link to handloom worker discontent was evident (Hernon, 2006, p. 22-24).[16]

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 labor 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 labor 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; see Sraffa 1951, Vol. VII, p. 159): "[T]here is no new creation of machinery which entirely supersedes the use of the labor of man" (see the discussion in Henderson and Davis 1997, p. 577-79).

[14] Hayek (1941, p. 424), Sotiroff (1952, p. 94), Gourvitch (1966, p. 58-59), Henderson and Davis (1997, p. 576, 579), and Schumpeter (2006, p. 650-651) all note the similarity of Ricardo's reasoning in "On Machinery" to Barton's argument in *Observations*.

[15] 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, p. 156-59).

[16] 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, readers are referred to https://www.peterloomassacre.org/history.html

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 "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 confirms that Ricardo's concerns were well warranted: Handloom weavers suffered greatly with the adoption of power looms, and unlike the case of 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 handloom weavers as the power loom was adopted.[17] 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 handloom 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 handloom 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 way 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.

4.1 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

[17] 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).

about 1% of British GDP), rising to 4–5% in 1805–1807 and to 7–8% in 1811–1813 (Chapman, 1987, p. 55). There was a matching, and dramatic, increase in the UK annual import of raw cotton from 26m pounds in 1791–1795 to 300m pounds in 1831–1835 (Chapman, 1904, p. 144).[18] Cotton manufacture was the booming industrial sector of the early 1800s in Britain.[19]

Cotton goods became a major export from Britain. In 1784–1786, total British exports were worth 12.7m pounds, and cotton exports were valued at 0.8m pounds (6% of total exports). By 1814–1816, total exports were 44.4m pounds and cotton exports were 18.7m pounds, making up 42.1% 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 employed only about 10,000 workers in weaving.[20] 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.[21] The rise and fall of hand-loom weavers was a well-known and much discussed feature of the early British cotton industry.

4.2 What Happened to Handloom Weavers?

Facing new competition in the form of mechanized weaving, how did the handloom weavers fare? The best available evidence indicates that wages steadily declined in both nominal and real terms. Despite real wages falling to nearly a quarter of their golden age peak, hundreds of thousands remained in the occupation, and struggled to survive.

4.2.1 Nominal wages

As part of his work on the statistics of wages in the nineteenth century, Wood (1910a,b,c,d,e) used primary sources to compile series for wages and employment in the cotton industry through

[18] According to Chapman (1987, p. 36) "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. . . . 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." 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; Baptist 2014; Beckert 2014). Appendix Table A3 has a slightly different series from the one used by Mitchell (1984) for total imports of raw cotton, but the trend is the same.

[19] Other transformations were underway, including in coal mining, the working of metals (ferrous and nonferrous), and steam engines. However, 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).

[20] The power loom came into much wider use "in the 1820s" (Bythell, 1969, p. 103).

[21] These numbers are frequently quoted and seem to originate from the reports of the handloom weavers commission, specifically those produced in 1840. They are also reported by Baines (1835, p. 235-237), 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 handloom weavers, their numbers rising from 240,000 in 1820 to 250,000 in 1834.

the nineteenth century. Wood's series include separate estimates for workers in factories and for handloom weavers. His full series runs from 1806 to 1862 and is available annually Wood (1910a, p. 598-599, Table 41). Wood finds that nominal weekly wages for handloom 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, handloom 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 as well as between regions (transportation costs were high before railways). However, the series in Figure 2 for muslin cloth at Bolton (north of Manchester) in 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).[22] 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 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.[23]

Table 1 depicts estimated family earnings for handloom weavers in two Lancashire towns, starting in 1814. This series shows shillings per week alongside two measures of cost: the cost of keeping looms in good repair and household expenses (food, clothing, and rent). Column 1 shows that from 1814 to 1819, nominal weekly earnings for a family of six fell by half. Column 3 ("Leaving for other costs") clearly shows the squeeze on handloom worker nominal earnings from 1814 to 1820 and confirms that this measure of earnings continued to fall through the 1820s and into the 1830s (see the next section for more details on real wages).[24]

Hammond and Hammond (1919), among others, were confident that handloom 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

[22] Muslin is a loosely woven cotton cloth.

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

[24] Even on the most positive interpretation, this period of wage decline for handloom workers is on the upper end of "an average working lifetime," the transition period suggested by Mokyr et al. (2015) for higher productivity to be reflected in higher wages for laborers. On the other hand, it is possible that economy-wide wages turned upward a bit earlier; the precise timing of changing real wages in the 1830s for other parts of the economy is harder to discern.

(Parlimentary Committee, 1835).

A third reason to interpret the data series with caution is that 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 Hammond (1919) provide corroborating evidence from a wide range of people, including some not at all sympathetic to the workers.[25]

In Bythell's (1969, p. 106-7) summary, "the decline in money wage rates for handloom weaving between the 1790s and the 1830s was spectacular."[26]

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

4.2.2 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 it 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, Allen (2007, 2009) offers a sensible reconciliation of the plausible alternative views, favoring an index that is close to the work of Feinstein (1998a,b), but with some modifications suggested by Clark (2005).[27] Consumer prices (for a basket of typical working-class consumption) rose by about 10% between the early 1800s and the early- to mid-1820s (Allen, 2007).

Consequently, real wages for handloom weavers fell in this period, likely declining to around 25% of their peak golden-age level—and then slumped further (Figure 3).[28]

Supporting evidence on this point comes from the 1835 Parliamentary 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

[25] See, for example, Parlimentary Committee (1835)

[26] 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 handloom 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" Hunt (1981, p. 64).

[27] Clark makes some updates to his index (Clark, 2007, 2010) but does not address important detailed critiques by 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).

[28] 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.

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, an 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. (Parlimentary Committee, 1835, p. xiii). By 1818–1825 this sum had more than halved to only 103 lbs. This confirms that the purchasing power of handloom 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 handloom workers move to other income-earning opportunities, for example, in cotton factories? Landes (2003, p. 86) comments that the slow decline in the number of handloom 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 handloom 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 handloom workers. The most complementary activity to weaving, spinning, was already mechanized to a significant degree. As Bythell (1969, p. 107) puts it, "until the great expansion of all kinds of factory work in the cotton districts from the 1820s," movement out of the handloom sector was slow.[29]

4.2.3 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 handloom weavers (Table 2), most of whom either worked either 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, p.86) (based on Baines (1835)) writes, "[W]here, in the first decade of the century, the machine worked hardly faster than the traditional handloom, the technical advantage had risen by the mid-1820's to as much as $7\frac{1}{2}$ to 1, and one boy on two looms could do up to fifteen times as much as the cottage artisan."

As shown in Table 2, by 1820, the cotton industry employed 115,000 workers in spinning jobs and 11,000 in weaving jobs in factories. Total employment in the cotton industry (factory operatives

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

plus handloom workers) rose from 168,000 in 1788 to 274,000 in 1806 and to 336,000 in 1820.[30] This change in the structure of employment is consistent with data showing steady investment in British cotton-spinning mills during this period (Chapman, 1987, p. 29, Table 3).

In 1815, there were perhaps 200,000 handloom weavers, rising to 240,000 in 1820.[31] There were still 200,000–250,000 handloom weavers in the early 1830s, according to various sources, including testimony to the 1835 Parliamentary Select Committee on weaving.[32]

Power-loom weaving never employed anywhere near as many workers as did handloom 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 factory operatives in 1813 compared with 212,000 handloom weavers. By 1819–1821, the total number of factory operatives was around 120,000, while the number of handloom weavers is estimated to have increased to 240,000.[33]

Employment of handloom weavers perhaps was not 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 handloom weavers during the first two decades of the nineteenth century, as discussed above.

4.3 Factory operatives

As shown in Figure 3, from 1806 to 1818–1820 the real wages of cotton workers in factories barely increased, while there was a modest increase in employment in this activity. In 1806, 90,000 factory operatives 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 handloom weavers earned roughly double (240d.) what cotton factory workers were paid. Up until 1815, handloom weavers earned more than factory operatives, but then this changed quite dramatically. By 1820, handloom weavers earned more than 25% 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,

[30] Bythell (1969, p. 54) cautions on early data quality; however, he also notes that "figures of the order of 200,000 to 250,000 will not over-represent the total number of hand-loom weavers when the labor force was at its peak" (p. 57).

[31] The number of handloom weavers rose steadily from 1788 to 1820; 240,000 was peak employment, a level that was maintained until 1831 according to Wood (1910a, p. 596, Table 40).

[32] While the available data do not reach modern standards of quality, this industry was investigated repeatedly by parliamentary committees. These investigations are the source for much of the information used by Baines (1835) and Wood (1910a,b,c,d,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.

[33] There may have been another 50,000 people employed as auxiliaries to handloom weavers Chapman (1987, p. 51).

falling to 150d in 1815, and to only 108d in 1820.[34] Over the same decade and a half, productivity gains, including with the spread of steam power, continued to be remarkable. The population of some textile towns in the Greater Manchester area more than doubled between 1801 and 1831.[35]

In real terms, using Allen's (2007) consumer price index for reasons discussed in the Appendix, earnings fell significantly (by more than half) for handloom workers between 1806 and 1820, but real wages also declined (by about 10%) for cotton factory operatives.[36] The weighted average wage in this highly productive and rapidly innovating sector fell by about 50% from 1806 to 1820. Compared to the golden age that ended around 1800, earnings for handloom weavers fell to about one-quarter of their previous level.[37] 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 had grown elsewhere in the economy. While the evidence is not perfect, the data strongly suggest that 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).[38]

4.4 Prominent Sectors and Economy-Wide Wages

The positive effect of productivity increases on wages may 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—indeed, 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

[34] We calculate the weighted average wage as (number of factory operatives × factory wage) + (number of handloom weavers × handloom earnings), divided by the total number of workers in this sector for that year.

[35] The population of Bradford rose from 29,000 to 77,000, while Huddersfield increased from 15,000 to 34,000 residents, 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.

[36] Handloom 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.

[37] 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.

[38] 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% (using Allen (2007) prices) or 13% (using Clark (2010) prices). However, over the same period, the increase in real wages was 21% if we use Feinstein (1998a) economy-wide wage estimate or 40% 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.

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.[39] 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 1813–1814, 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.

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, 2007). There was not much increase through the mid-1750s, but clearly some increase in nominal wages appeared 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, 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.[40]

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.

[39] 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)

[40] This is consistent with work by 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 a series of 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.

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 their 1819 level, due to lower prices). However, 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, 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 et al. (2023).[41]

4.5 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 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. However, the number of new jobs created in weaving did not match the displacement of opportunity for human handloom workers.

The main complementary activity, spinning, was already highly mechanized. 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 handloom workers fell sharply, and the average real wage for the cotton industry (weighted across handloom 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

[41] 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 et al. (2023) have a similar view of economy-wide wages based on Clark's price index and wage data from Hunt (1986), which are 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 et al. (2023) find that agricultural wages rose in the north relative to the south when comparing 1770 to 1860.

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 Hobsbawm (1999) notes in *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 (Thompson, 1966). Multiple original sources agree that handloom 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 not only was 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 (see Hammond and Hammond 1919 for further discussion). Of course, this also meant that they had less say in the determination of their pay.

Thompson (1966, p. 306) put it this way:

> "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.[42] Thompson also noted that "[t]here 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*, Hobsbawm agrees with this perspective, writing that "the city destroyed society." Industrial life not only forced workers to trade workplace autonomy for the regularity of factories but 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.[43]

Hobsbawm concludes that the social change accompanying industrialization was so intolerable to preindustrial workers that tens of thousands accepted starvation wages in handloom 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. Handloom weavers were among the first victims of modern creative destruction; their social and economic way of life was effectively destroyed in a few short decades (Mokyr, 2020).

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 AI.

[42] These rapid changes had differential consequences for women and children in comparison to men, impacting labor force composition and family dynamics. Lyons (1989) details how families responded to deteriorating wages in the weaving industry, and how women and children comprised the majority of the early factory labor force. Humphries (2013) documents the upsurge in child labor among children born between 1791 and 1850, especially in factory and mining work. Griffin (2018) discusses how even rising male wages did not necessarily translate to greater family well-being until cultural and social norms of 'breadwinning' became more common. She stresses that hunger was common in rural and industrializing districts alike.

[43] For detailed discussion of living conditions in early English industrial cities see Engels (1845).

6.1 Labor Demand and Working Conditions in the Age of Artificial Intelligence

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 et al., 2019).

However, 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 AI 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 et al., 2022).

Thompson's perspective is also highly relevant to current debates. In *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 AI 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 work in less safe conditions (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.

6.2 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.[44] However, 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, 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 onward.

As we have explained elsewhere (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-

[44] 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 (see 2023, chapters 1 and 8).

solving tasks and decision-making. If such a path for AI was feasible (which we believe it is, as we argue in Acemoglu et al. 2023; see also Acemoglu 2023) and if it was prioritized, we could move to a different phase of modern economic growth than the nonshared variant ushered in by the digital and robotic technologies of the last four decades.

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, as argued, for example, 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 AI potentially accelerating these technological trends and disruptions.

Expecting that new digital tools would not only boost productivity but also raise employment and wages has been a natural conjecture for many economists and policymakers. However, 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; Acemoglu et al., 2022). In the meantime, AI 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.

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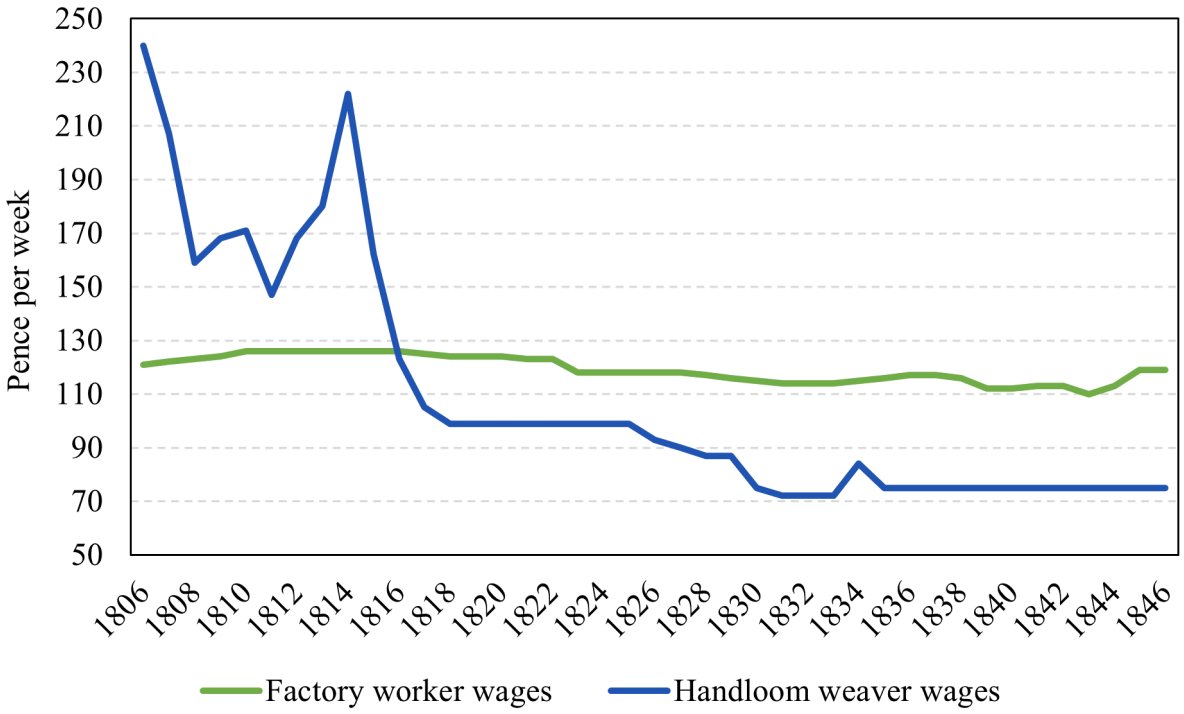
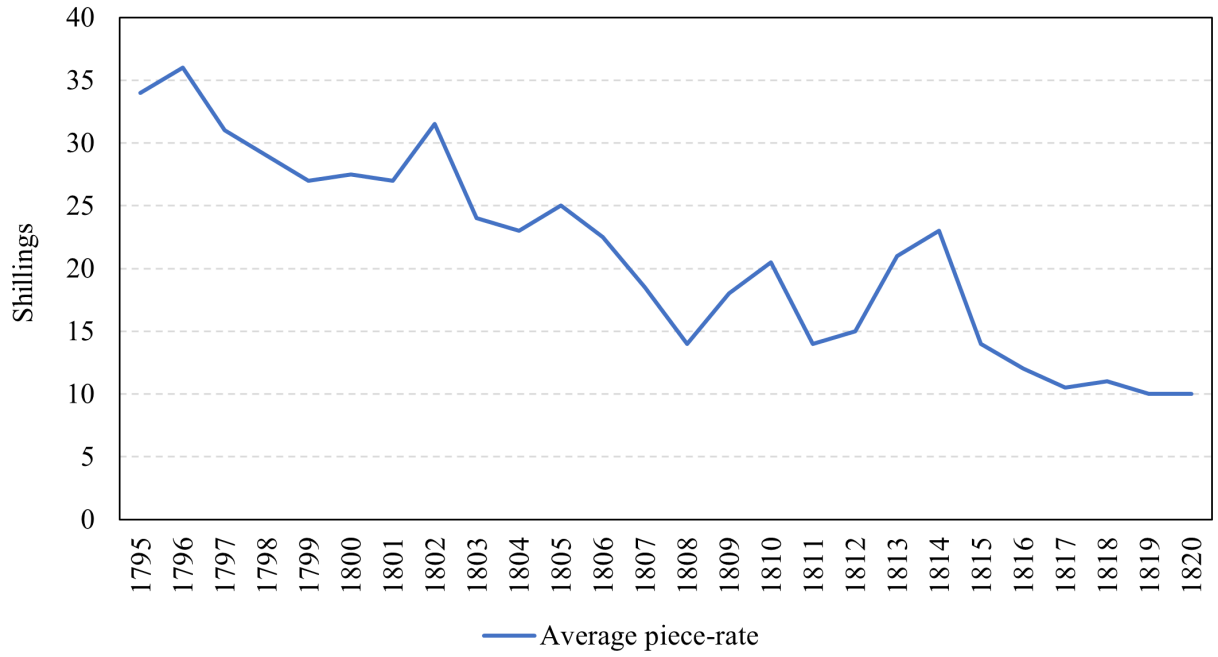
Figure 1: Handloom weaver and factory worker nominal wages



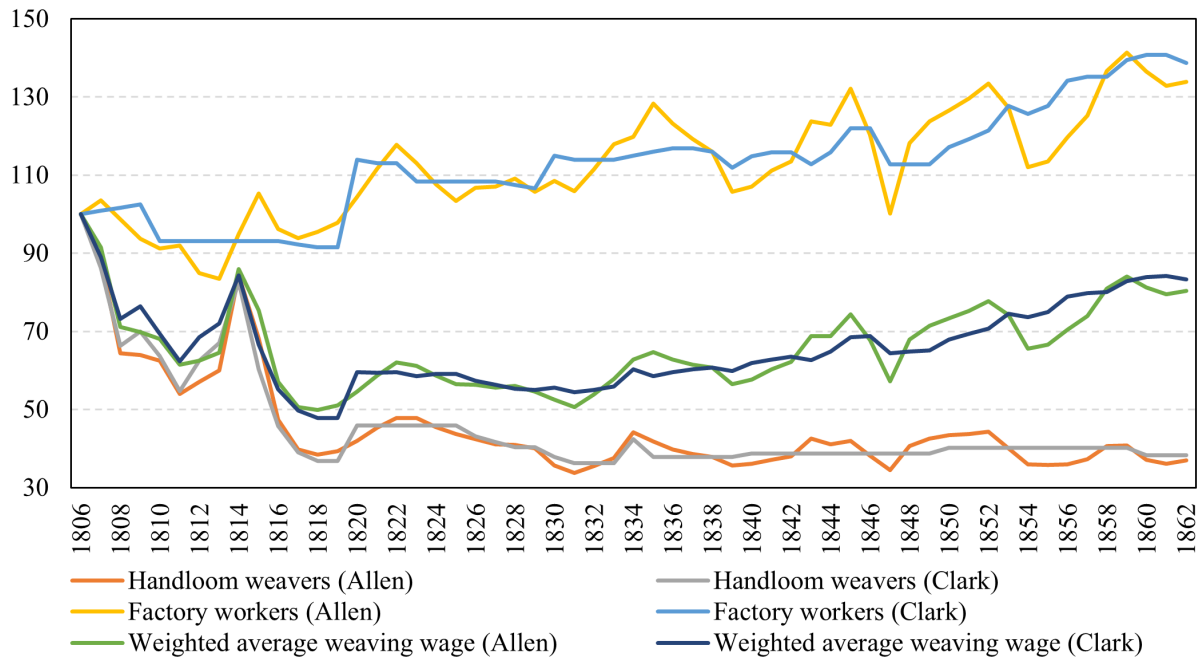
Note: Nominal wages are from Wood (1910a). Factory workers include spinners and weavers.

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



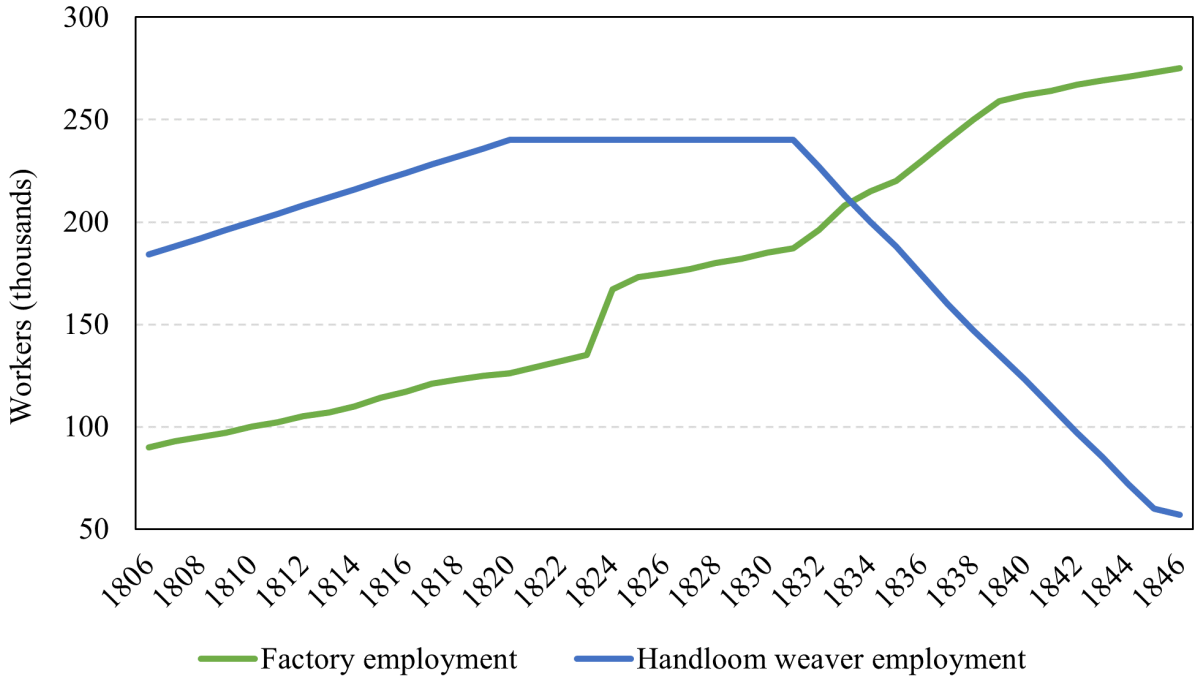
Note: Price reflects the rate for 60-reed cambric muslin. Produced from Table 2 in Bythell (1969, p. 99)

Figure 3: Real weekly wages of textile workers, by cost-of-living index (1806 = 100), 1806-1862, according to Allen's (2007) and Clark's (2010) indices



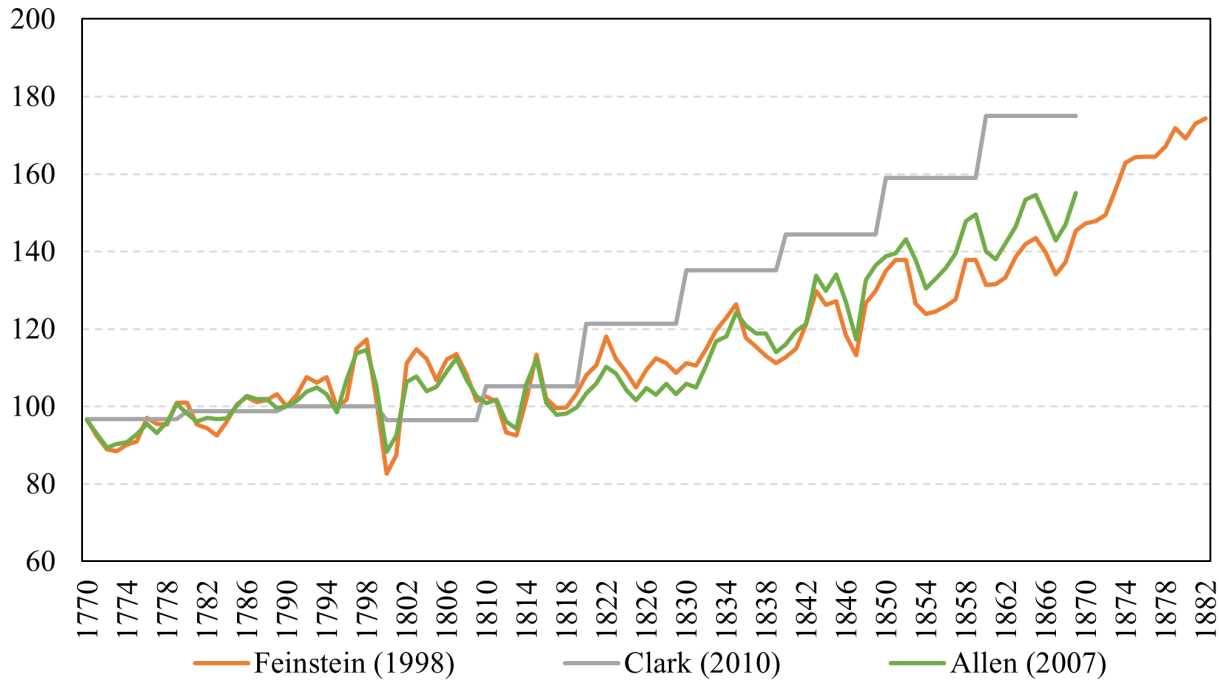
Note: Textile worker wages are from Wood (1910a, Table 41). Weighted average is the average of handloom and factory worker wages, weighted by employment.

Figure 4: Handloom weaver and factory worker employment



Note: Employment is from Wood (1910a). Factory workers include spinners and weavers.

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



Note: 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 his work in Clark (2001, 2005, 2007), drawing on archival sources including Bowley and Wood.

Table 1: Nominal earnings and expenses of handloom weavers in Lancashire, 1814-1833

Year	Near Colne				Near Oldham		
	A family could earn (shillings)	Repair of looms, rent, etc. (shillings)	Leaving for other costs (shillings)	Yearly income (£)	Wage (shillings)	63 hours wage (shillings)	Expenses (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

Note: Table adapted from Wood (1910e, Table 34). Earnings and expenses throughout the table 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. "A family" was assumed to be 6 persons including 3 children. "Other costs" include food, clothing, etc. "Expenses" include rent, 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

Note: Table reproduced from Wood (1910a, Table 40) ND indicates 'no data'.

Table 3: Nominal daily earnings of coal workers in shillings, 1800-1835

Year	North-umberland	Durham	Yorkshire		Lancashire & Cheshire	East Midlands	Staffordshire		South Wales	Scotland
			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

Note: Table adapted from Mitchell (1984, Table 7.1) ND indicates 'no data'. Values represent 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 shillings using the following conversion factors: 1£ = 20s = 240d.

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

Decade	Builders		Agricultural workers		
	Craftsmen's day wage (pence)	Helper's day wage (pence)	Relative wage	Raw average day wage (pence)	Estimated avg 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

Note: Columns regarding builders wages are from Clark (2005, Table A2). Columns regarding agricultural workers are from Clark (2007, Table 1).

Appendix: 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" (p. 11-12). This optimistic view of real wage growth was effectively challenged by Feinstein (1998a), 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 (1998a) more realistic account of real wage growth has become widely accepted (Allen, 2009; Crafts and Mills, 2022). However, recent work (notably Clark 2005, 2007, 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 (1998a,b), Clark (2005, 2007, 2010), and Allen (2007, 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 (1998a) 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 (1998a) 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 (1998a) 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 (1998a) 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, 2010) made minor modifications to his index, but many of Allen's original critiques still apply. 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

[45] For his estimates of real wages, Allen (2007, 2009) simply accepts Feinstein's (1998a) series of nominal wages.
[46] Feinstein (1998b) also relies on Horrell (1996) to inform his weightings.

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 (1998a) and Allen's (2007) weightings of around 30% for bread and flour combined (See Table A2).

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, 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). 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, 2007, p. 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

[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.

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

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 (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 (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 byFeinstein (1998a). 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 (1910a) 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.

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

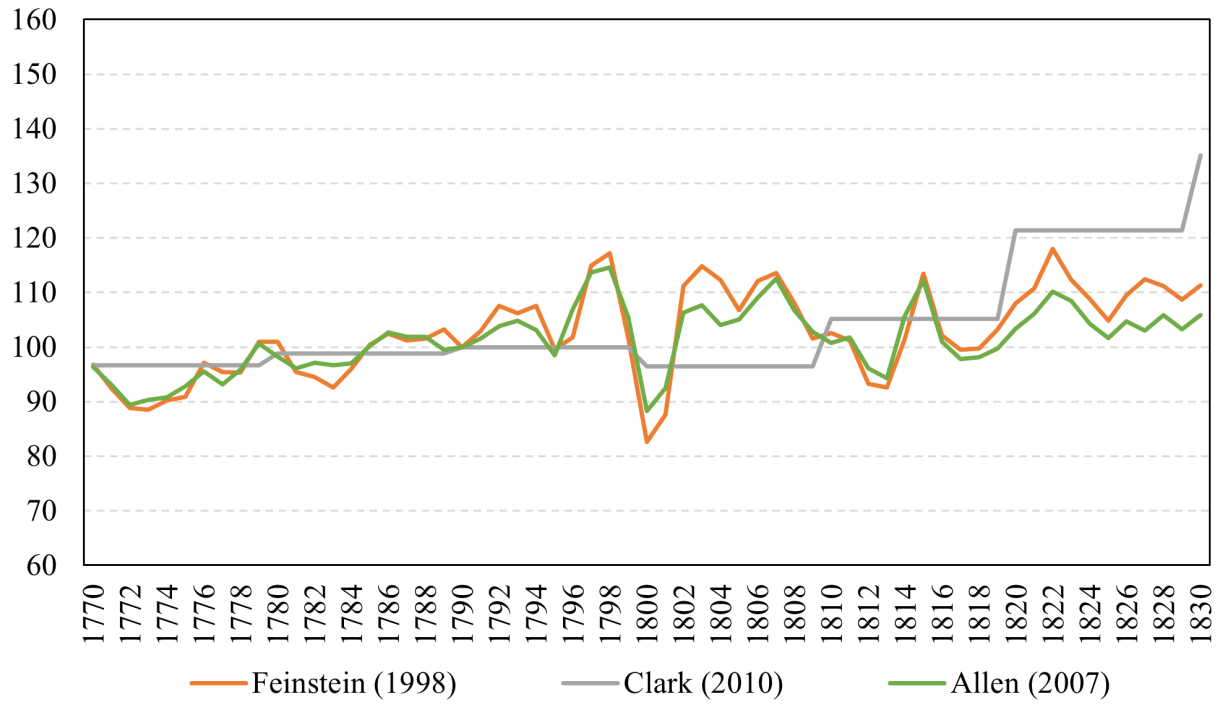
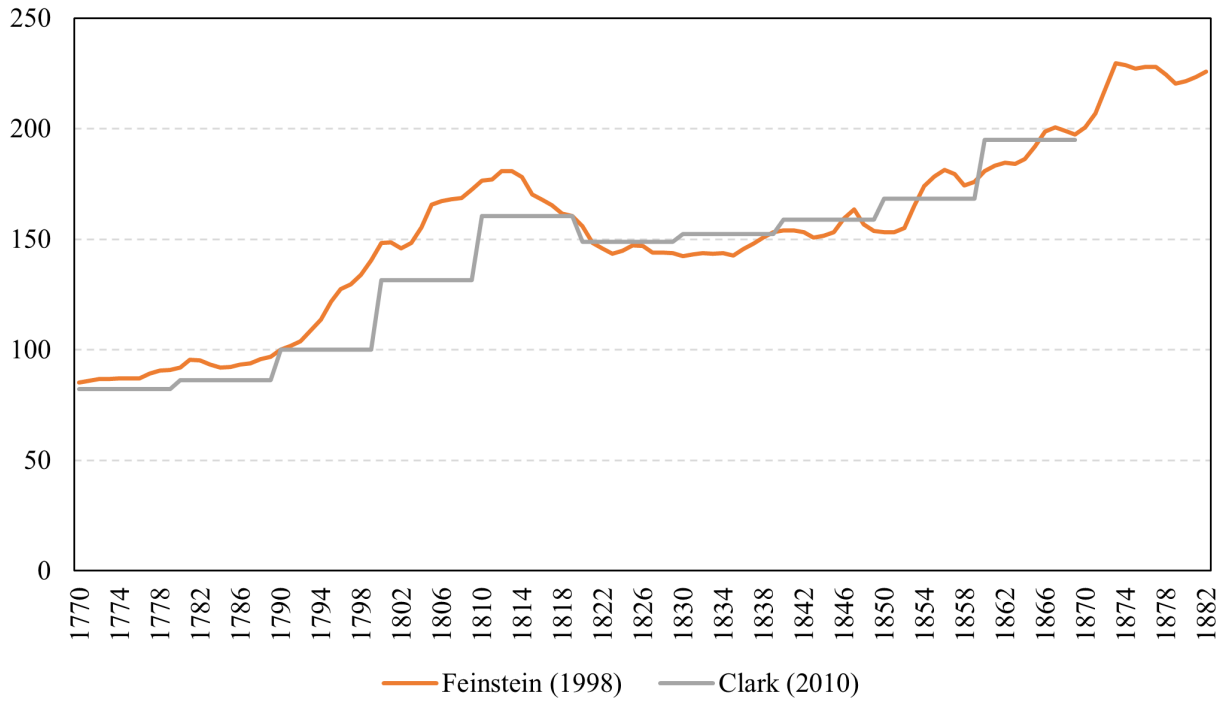


Figure A2: Economy-wide nominal wages (1790 = 100), 1770-1882



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

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

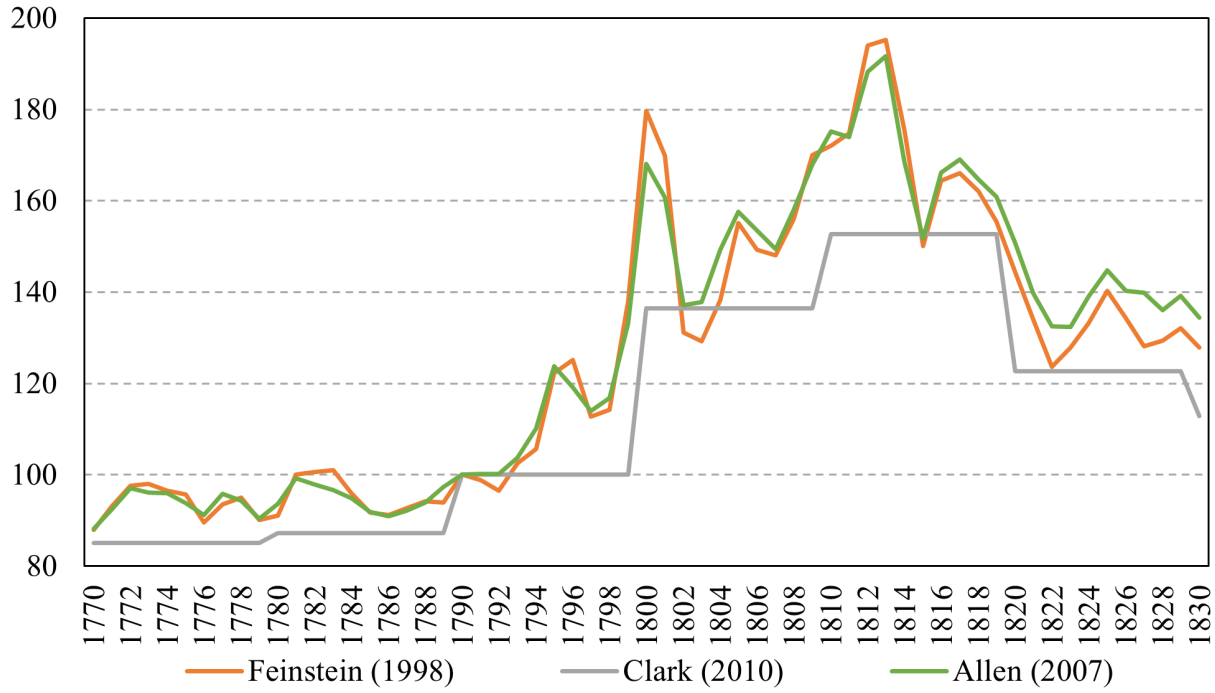


Figure A4: Economy-wide real wages (1790 = 100), 1790-1850

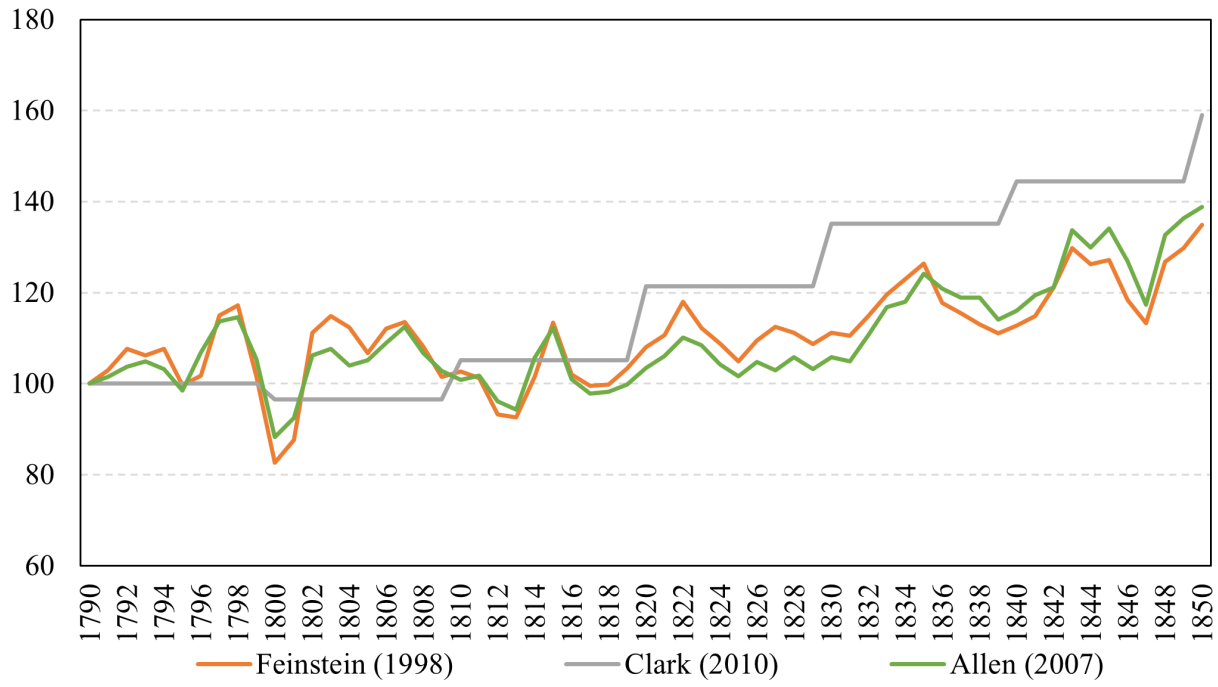


Table A1: CPI weighting comparison across alternative estimates

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

Note: 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

Note: 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

Note: Table from Mitchell (1984). ND indicates 'no data'.