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Learning From Ricardo and Thompson: Machinery and Labor in the Early Industrial Revolution and in the Age of Artificial Intelligence

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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.

1. INTRODUCTION

> The jenny simply multiplied human hands while the water-frame was a substitute for human skill
>
> —Chapman (1904, p. 53)
>
> [T]he Jennyes are in the Hands of the Poor and the Patent Machines are generally in the Hands of the Rich
>
> —Hammond & Hammond (1919, p. 56)[1]

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

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]

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[1]This statement was made by cotton spinners to a Parliamentary Committee, which reported in 1780. It is quoted by Hammond & 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.

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

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 a lack 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 & 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 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

[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 quantities of factors of production and thus raises average labor productivity. Demand for labor, as well as employment and wages, is 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 (see Acemoglu & Restrepo 2018, 2019 for discussion).

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 & 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 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.

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[7]Because automation reduces costs, sectors adopting automation technologies may expand employment and thus increase hiring in nonautomated tasks (Acemoglu & 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 & 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 & 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 & 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). Pissarides (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 & Newman 2002). In addition, in models where employers have access to coercive capabilities or other ways of shifting quasi-rents away from workers, an increase in productivity can be associated with lower wages (see, e.g., Acemoglu & 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 & Johnson 2023, chapter 5).

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 **Supplemental Appendix** reviews the wage and price data from early 1800s Britain in more detail.

Supplemental Material >

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 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

[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.

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]

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 & Davis 1997).

Hammond & 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 (pp. 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, pp. 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 & 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.

[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 to higher saving and eventually rising demand for labor."

[14] Hayek (1941, p. 424), Sotiroff (1952, p. 94), Gourvitch (1966, pp. 58–59), Henderson & Davis (1997, pp. 576, 579), and Schumpeter (2006, pp. 650–51) 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, pp. 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**.

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." (Readers are referred to the discussion in Henderson & Davis 1997, pp. 577–79.)

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 **Supplemental Appendix**.

Supplemental Material >

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 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

[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, 18), and Allen (2018).

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 handloom 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 of handloom weavers 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–e) used primary sources to compile series for wages and employment in the cotton industry through the nineteenth century. Wood's series include separate estimates for workers in factories and for handloom weavers. His full series runs from 1806 to 1862 and is available annually (Wood 1910e, pp. 598–99, 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.)

[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 & Johnson 2023, chapter 4; Baptist 2014; Beckert 2014). **Supplemental 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 [2015 (1835), pp. 235–37], Chapman (1904, p. 28), and Hammond & Hammond (1919, p. 72) (see also Landes 2003). Baines [2015 (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.

Supplemental Material >

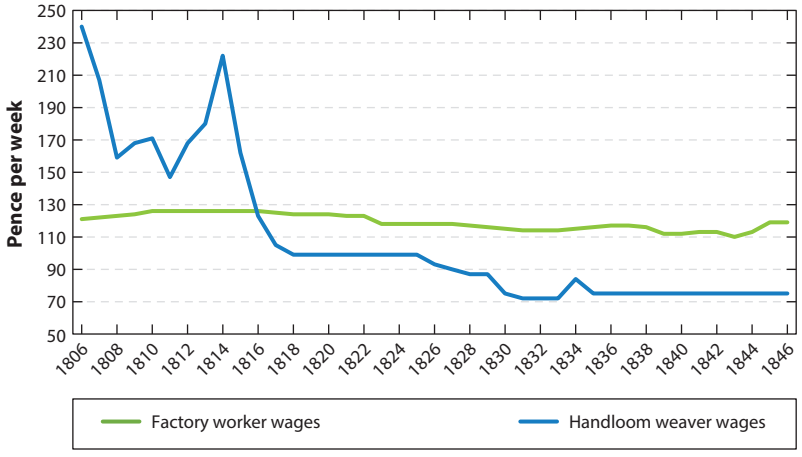

Figure 1

Handloom weaver and factory worker nominal wages. Nominal wages are from Wood (1910e). Factory workers include spinners and weavers.

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 & 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

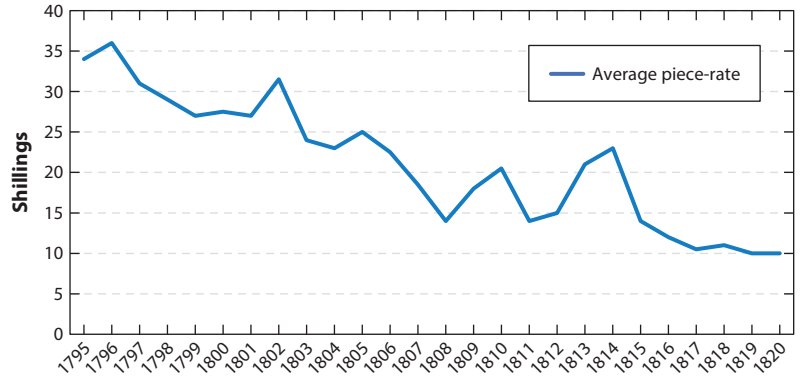

Figure 2

Piece-rate for muslin weaving at Bolton, 1795–1820. Price reflects the rate for 60-reed cambric muslin. Data are from Bythell (1969, table 2).

[22] Muslin is a loosely woven cotton cloth.

Table 1 Nominal earnings and expenses of handloom weavers in Lancashire, 1814–1833[a]

	Near Colne				Near Oldham		
Year	(1) A family could earn[b] (shillings)	(2) Repair of looms, rent, etc. (shillings)	(3) Leaving for other costs[c] (shillings)	(4) Yearly income (£)	(5) Wage (shillings)	(6) 63-hour wage (shillings)	(7) Expenses[d] (shillings)
1814	52.00	5.25	46.75	135.20	2.29	13.75	3.63
1815	34.17	5.25	28.92	88.83	1.96	11.75	3.27
1816	26.83	5.25	21.58	69.77	1.50	9.00	2.79
1817	24.17	5.25	18.92	62.83	1.08	6.50	2.35
1818	28.83	5.25	23.58	74.97	1.46	8.75	2.71
1819	25.00	5.25	19.75	65.00	1.67	10.00	2.92
1820	23.33	5.25	18.08	60.67	1.50	9.00	2.73
1821	28.31	5.25	23.06	73.61	1.42	8.50	2.63
1822	22.88	5.25	17.63	59.48	1.50	9.00	2.69
1823	21.00	5.25	15.75	54.60	1.58	9.50	2.75
1824	19.13	5.25	13.88	49.73	1.58	9.50	2.73
1825	19.13	5.25	13.88	49.73	1.46	8.75	2.58
1826	11.83	4.25	7.58	30.71	1.08	6.50	2.13
1827	14.63	4.25	10.38	38.03	1.08	6.50	2.19
1828	14.63	4.25	10.38	38.03	1.17	7.00	2.25
1829	10.50	4.25	6.25	27.03	1.00	6.00	2.06
1830	13.50	4.25	9.25	35.11	0.83	5.00	1.88
1831	14.83	4.25	10.58	35.11	0.83	5.00	1.88
1832	12.00	4.25	7.75	30.71	0.79	4.50	1.77
1833	12.00	4.25	7.75	31.20	0.79	4.50	1.75

Table adapted from Wood (1910d, table 34).

[a]Earnings and expenses represent weekly values unless otherwise indicated. All columns have been converted into a single denomination from the original table. Conversion factors used were 1£ = 20s = 240d.

[b]This is for a family of 6 persons including 3 children.

[c]Other costs are food, clothing, etc.

[d]Expenses are rent, fuel, etc.

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]

[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 (1910e, 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

Hammond & 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 (G.B. Parliam. 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 & 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, pp. 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 **Supplemental 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).

Supplemental Material >

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 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

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.

[25] Readers may consult, for example, G.B. Parliam. (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 **Supplemental Appendix**. We use Clark's latest available index in all figures that refer to Clark (2010).

[28] As discussed in the **Supplemental 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.

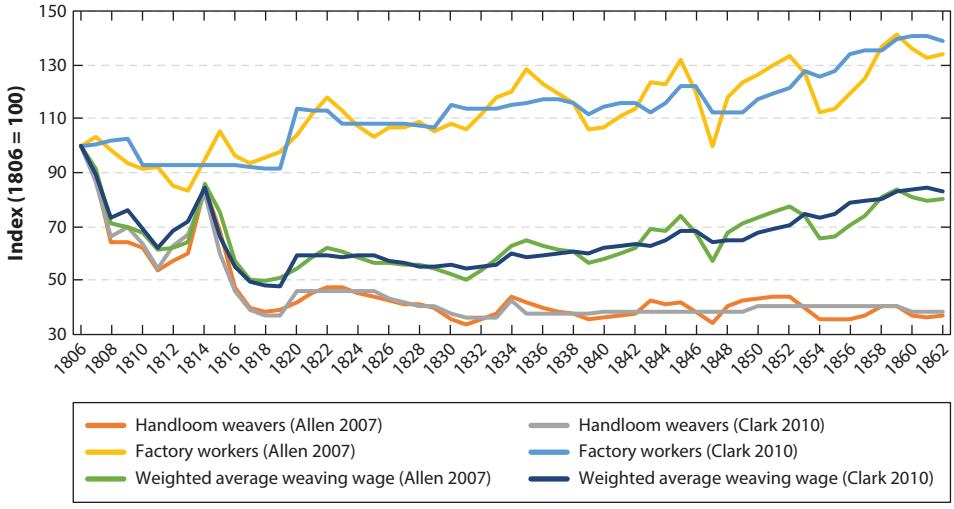

Figure 3

Real weekly wages of textile workers, by cost-of-living index (1806 = 100), 1806–1862, according to Allen's (2007) and Clark's (2010) cost-of-living indices. Textile worker wages are from Wood (1910e, table 41). Weighted average is the average of handloom and factory worker wages, weighted by employment.

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. (G.B. Parliam. 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 **Supplemental Appendix** provides further corroborating details from more standard and comprehensive consumer price indices.)

Supplemental Material >

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 worked either in their homes or in small

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

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

Abbreviation: ND, no data. Table adapted from Wood (1910e, table 40).

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 2015 (1835)] writes, "[W]here, in the first decade of the century, the machine worked hardly faster than the traditional handloom, the

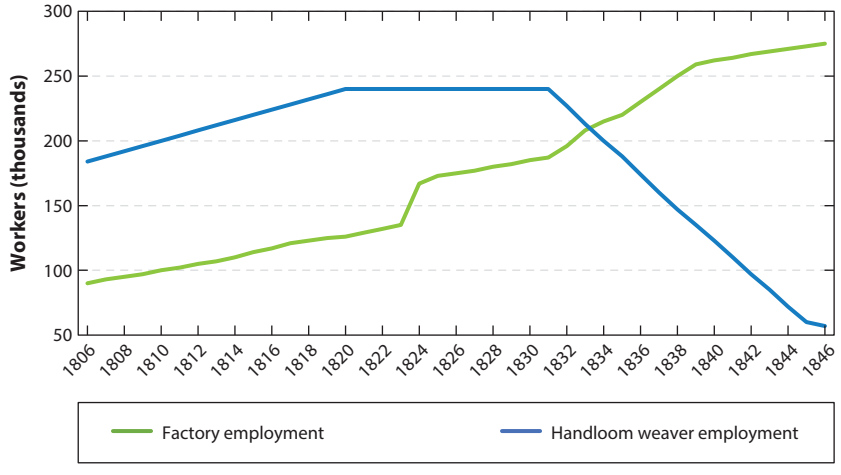

Figure 4

Handloom weaver and factory worker employment. Employment data are from Wood (1910e). Factory workers include spinners and weavers.

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

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 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, 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

[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 (1910e, 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 [2015 (1835)] and Wood (1910a–e). Hammond & 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).

[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.

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 **Supplemental 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.

Supplemental Material >

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]

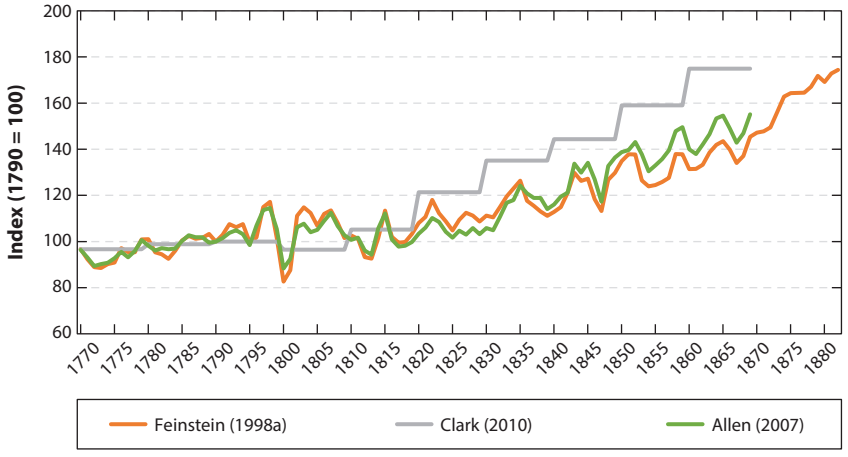

Figure 5

Economy-wide real wages (1790 = 100), 1770–1882. The figure shows economy-wide wages weighted by occupation and population. Feinstein (1998a) bases his nominal wage series largely on the work of Bowley (1898) and Wood (1910a–e). Allen uses Feinstein's nominal wages. Clark constructs his own series from Clark (2001, 2005, 2007), drawing on archival sources including Bowley and Wood. Figure adapted with permission from Allen (2007).

[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.

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 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]

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[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 wages was 8% (using Allen prices) or 13% (using Clark prices). However, over the same period, the increase in real wages was 21% if we use Feinstein's 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.

[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 & Johnson 2023, chapter 5).

[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

Table 3 Nominal daily earnings of coal workers, 1800–1835[a]

Year	Northumberland (shillings)	Durham (shillings)	Yorkshire (shillings)		Lancashire and Cheshire (shillings)	East Midlands (shillings)	Staffordshire (shillings)		South Wales (shillings)	Scotland (shillings)
			South	West			North	South		
1800–1802	2.75	2.75	2.93	2.80	4.27	2.67	2.51	ND	3.10	2.99
1804–1806	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
1813–1814	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

Abbreviation: ND, no data. Table adapted from Mitchell (1984, table 7.1).

[a]The table represents shift earnings of coal hewers. Index values have been converted to currency using values found in Mitchell (1984, table 7.1, note ii). All columns have been converted to a single denomination using the following conversion factors: 1£ = 20s = 240d.

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

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

Note that real wages fluctuated significantly as nominal wages were sticky and prices moved a great deal. The evaluation of change in real wages is affected by end points (e.g., real wages in 1821 were above 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 **Supplemental 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]

Supplemental Material >

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.

[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 **Supplemental 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.

Table 4 Builders' and agricultural workers' wages, 1710–1859

Decade	Builders[a]			Agricultural workers[b]	
	Craftsman's day wage (pence)	Helper's day wage (pence)	Relative wage	Raw average day wage (pence)	Estimated average day wage (pence)
1710–1719	19.7	12.1	1.63	10.5	9.9
1720–1729	20.0	12.4	1.62	10.1	9.6
1730–1739	20.3	12.6	1.62	10.2	10.8
1740–1749	20.6	12.6	1.63	11.1	10.8
1750–1759	20.5	13.1	1.57	12.2	10.9
1760–1769	21.3	13.9	1.53	11.2	11.7
1770–1779	22.3	15.1	1.48	11.4	12.5
1780–1789	23.4	15.3	1.53	11.8	13.2
1790–1799	26.8	17.9	1.50	14.5	15.6
1800–1809	35.9	23.9	1.51	19.1	19.0
1810–1819	43.8	29.8	1.47	23.2	23.0
1820–1829	42.1	27.0	1.56	22.2	20.6
1830–1839	42.7	28.0	1.53	21.3	20.3
1840–1849	43.3	29.0	1.50	22.5	21.2
1850–1859	45.6	30.1	1.52	22.4	21.9

[a]Columns regarding builders are from Clark (2005, table A2).
[b]Columns regarding agricultural workers are from Clark (2007, table 1).

4.5. Assessment

The data discussed above suggest 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.

Supplemental Material >

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 **Supplemental 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 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 & 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).

[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.

In *Industry and Empire*, Hobsbawm (1999, p. 65) 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.

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 & 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 & Autor 2011; Acemoglu & 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 & Johnson 2023).

[43] For detailed discussion of living conditions in early English industrial cities, readers are referred to Engels (1845).

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 & Restrepo 2018; Acemoglu & 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 & Johnson 2023), these changes were the result of innovations that prioritized increasing the marginal productivity of labor, most importantly by introducing new tasks for workers. For example, new technologies in railways and heavy industry introduced novel activities and capabilities for workers. American technologies that emphasized boosting the productivity of unskilled labor by standardizing parts and processes introduced new technical tasks for laborers and spread throughout Europe, including the United Kingdom. Modern manufacturing started employing more workers including in design, repair, maintenance, and clerical tasks. These technological trends laid the foundation for more shared prosperity, where wage growth went hand in hand with higher profits for businesses. Critically, this type of sharing was also undergirded by a changing balance between capital and labor, as voting rights expanded and trade unions were empowered to negotiate wages and working conditions. Factories were now everywhere, but they no longer subjected workers to the same horrendous conditions for longer hours, nor could they employ and exploit very young children.

The importance of choice in the direction of technology may be even more central today, to understand how AI could affect labor markets, than it was in the Industrial Revolution. One promise of AI is its capability to provide much better information to humans for problem-solving tasks and decision-making. If such a path for AI 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

[44]For literature on the endogenous direction of technological change, readers are referred to Acemoglu (1998, 2002) as well as Acemoglu & Restrepo (2018) in the context of automation versus new tasks. For the endogenous evolution of institutions impacting how gains from new technologies are shared, readers may consult Acemoglu & Johnson (2023, chapters 1, 8).

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 & 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 (OECD 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 & Restrepo 2020, 2022). In the meantime, AI and other new tools are also intensifying surveillance and shifting the balance of power from labor to capital (Acemoglu & Johnson 2023).

Following Ricardo, this may be a time for us to rethink how machinery (and algorithms) impacts 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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