Inequality

The IFS Deaton Review

Technical change, globalisation and the labour market: British and American experience since 1620

Bob Allen

An IFS initiative funded by the Nuffield Foundation

IFS Institute for Fiscal Studies

Nuffield Foundation

Technical change, globalisation and the labour market: British and American experience since 1620

Robert C. Allen (NYU Abu Dhabi)[1]

Executive summary

- The history of the last four centuries in the UK and US divides into four phases. Output per worker grew in all of them. Real wages grew on average from 1620 to 1770 and from 1840 to the 1970s. During the Industrial Revolution (1770–1840) and the post-1970 Service Revolution, however, the average real wage was flat and wage inequality increased.

- Rising real wages led to labour-saving technical change in Britain during the Industrial Revolution and to the invention of mass production in the US in the twentieth century.

- Employment in manufacturing has collapsed in the US and UK since the 1960s as routinised jobs created by mass production technology have been replaced by robots and computerised systems. The employment declines have also been conditioned by a shift in demand from manufactures to services and by rising imports of manufactures from China and other countries as they have industrialised.

- The lost production jobs in manufacturing offered high pay. Many of the new jobs in services require advanced education and training and pay well; many others require little training and pay badly. The result has been a shift of income from labour to capital and an increase in inequality.

- Productivity and incomes in all UK regions were at the top of the West European league table until the 1970s when growth outside greater London stagnated. Now, most UK regions lie at the bottom of the West European table, along with the former East Germany.

- The UK's regional problem encompassing most of the country is really a national productivity failure.

[1] I thank the following people for helpful comments and discussions: Alberto Bisin, Jonathan Chapman, Angus Deaton, Giovanni Federico, David Green, Jeff Jensen, Paul Johnson, Suresh Naidu, Patrick O'Brien, Jón Steinsson and Peter Temin, as well as the participants in seminars and workshops at New York University Abu Dhabi and New York, the Institute for Fiscal Studies, and the Centre for Economic Policy Research.

1. Introduction

The UK economy is not performing well. GDP is growing slowly. Labour productivity lags behind most of western Europe. Inequality is also rising, real wages have been growing less rapidly than output per worker, and labour's share of the national income has dropped substantially. In addition, regional inequality has become extreme. Only London performs well in a European context, while most of the country has sunk to central European levels of income and performance. How has the country that pioneered the first Industrial Revolution come to such a pass?

This chapter addresses that question by tracing the history of wages, technology and globalisation over the past four centuries. Today is not the first time that inequality has increased and become a great social problem. The Industrial Revolution is another example. Other periods have witnessed more favourable outcomes.

For the last four centuries, technology and wage rates have evolved together. Over the long term, productivity has risen, and wages have increased. The interplay between technology and wages has not been smooth, however: periods when growth was 'successful' with wages and productivity rising together have alternated with periods in which that synchronisation has broken down, the average wage has fallen behind productivity, and the dispersion of wages among workers has increased. The first aim of this chapter is to block out these phases over the past four centuries. A second aim is then to explore how technology has affected the labour market, and how the labour market, in turn, has affected the evolution of technology.

Other factors, of course, have been involved in the evolution of technology and wages. The development of science has contributed to the development of technology, both by discovering new knowledge of the natural world as well as by promoting the idea that the collection of facts and the development of theories can help us understand the world around us (Mokyr, 1990, 2002, 2009, 2017). Globalisation has also affected labour markets, although it needs to be recognised that globalisation, in part, is the creation of technology. Finally, political and social institutions have influenced both technology and the labour market.

The history of the labour market bears on another issue of great importance – that is, inequality. Piketty (2014), who has done much to advance our knowledge of the subject, has argued that inequality increases when the return on capital exceeds the growth in national income because the former (if re-invested) governs the growth in total capital and the income from it, while the latter equals the growth in incomes overall. But what determines the return on capital? When output per worker grows faster than the average wage, then the share of profits in the economy rises and, with it, the return on capital. What is happening in the labour market, therefore, affects the overall degree of inequality. Technological change and globalisation are important determinants of the critical balance between productivity and wages and, hence, of overall inequality[2].

Historically, the feedback between wages and technology has been a slow process, so it is best grasped by surveying a long time frame. I consider the last four centuries, and I divide them into four periods. The focus is always on the leading economy of the period. In the first two periods it is Britain, and in the last two it is the United States, but I also continue the discussion of Britain to

[2] Critiques of Piketty and the endogeneity of his explanatory variables include Acemoglu and Robinson (2015) and Ray (2015).

the present. In all periods, output per worker has risen, but the periods differ greatly in their distributional stories. The periods are as follows (all dates are approximate).

- **Phase 1: the pre-Industrial Revolution, 1620–1770**. Agricultural employment declined as a fraction of the British work force, and employment in urban and rural handicraft manufacturing expanded as exports of these goods surged to supply European and then imperial markets in the future United States of America (hereafter US), the Caribbean, and other possessions. Manufacturing still meant 'working by hand', and the typical worker was a man or woman working in the family's cottage rather than in a centralised factory. By the end of the eighteenth century, labour markets were tight, and English wages were amongst the highest in the world. With output per worker and most wages rising, this was a successful outcome for the economy.

- **Phase 2: the Industrial Revolution, 1770–1867**. High wages in Great Britain made it profitable to invent machines to save labour, and the result was the factory mode of production. The shift to factories meant that output per worker in the economy increased. However, competition between the new factories and the established handicraft producers meant that some workers lost while others gained, with the result that the average wage was flat while output per worker expanded and inequality rose.

- **Phase 3: the Age of Manufactures, 1867–1973**. Except for cyclical fluctuations, manufacturing output and employment expanded continuously, and real wages as well as output per worker increased. Rising real wages induced the invention of capital-intensive, high-output technologies. Product innovation sustained the growth of manufacturing by creating new goods that kept consumers buying more and more manufactures. In addition, the US had the West to settle, and Britain an empire to supply, and these seemingly limitless markets underpinned the expansion.

- **Phase 4: the Service Revolution, 1973–2020**. Demand shifted away from manufactures towards services as technical change created more products dispensed through the service sector and more demand for its products. Output growth in manufacturing slackened. Growing imports of manufactures from newly developing countries, notably China, also made a contribution but one of secondary importance. High wages in the immediate post-war period created an incentive to substitute capital for labour, and the more recent fall in information technology (IT) prices created further incentives in that direction. As a result, manufacturing employment has collapsed, and the service sector has expanded. Services offer many low-wage jobs (as well as high-salary jobs), so wage dispersion has increased. There has been only a negligible rise in the average income of employees in the US since 1973. The average real wage increased in Great Britain during the 1970s and 1980s, but since then real wage growth has petered out.

Capitalism worked well in the first and third phases in the sense that the incomes of the majority rose in step with overall labour productivity. In the second and fourth phases, that synchronisation came unstuck. Why? The common feature of Phases 2 and 4 is that a new economic system was replacing the pre-existing one. In 1800, the factory replaced the cottage; in 2000, the hospital or restaurant replaced the factory. Schumpeter (1994, pp. 84, 87, 88) told us that capitalism progresses through a 'perennial gale of creative destruction'. Sometimes, this gale was exceptionally strong and blew away the existing structures, destroying many livelihoods in the process. At other times, it was more like a gentle breeze, and most people prospered.

2. The framework of analysis

I approach these issues from the perspective of the dynamics of economic growth that emphasises the same themes as endogenous growth theories. Two generations ago, Solow (1956) formulated his growth model that was hegemonic in economics and economic history for many years. In important respects, however, it is not consistent with the facts of the last four centuries, and it fails to address key features of capitalist development, so a different approach is needed. Anything less than an endogenous growth model is useless. In this chapter, I follow a path blazed by Romer (1986, 1990), Lucas (1988), Grossman and Helpman (1991) and Aghion and Howitt (1992). My approach to technical change, which is a key part of the story, follows the recent work of Acemoglu (2002) and Acemoglu and Restrepo (2018, 2019). The following are some important features.

- **Production function**. The Solow model posits a neoclassical production function in which GDP depends on the labour force and capital stock. Instead, we think of the available technology as a set of discrete input–output coefficients. These describe the actual ways in which production can take place. This approach is akin to Acemoglu and Restrepo's use of a task-based model of production.

- **Technical change**. The Solow model assumes labour augmenting technical change, in which case, output per worker and the real wage increase at the same rate. This is meant to model the 'stylised fact' that the two increase in tandem in historical data (Kaldor, 1957). However, this 'fact' is a generalisation of what happened between the middle of the nineteenth century and the 1970s (i.e., Phase 3 in my schema). It does not describe the Industrial Revolution or the past 50 years. Something is wrong.

  There are other difficulties. A prediction of the Solow model with labour augmenting technical change is that output per worker rises at the same rate at all capital–labour ratios. This has not occurred. Long-run macro data show that output per worker has, indeed, risen at the high capital–labour ratios in rich countries. However, at low capital–labour ratios such as those found in poor countries today and in today's rich countries at the beginning of the nineteenth century, there has been no increase in output per worker for two centuries. In addition, the output–capital ratio has been declining over time, although the Solow model implies it should remain constant (Allen, 2012).

  Finally, on the theoretical plane, a neoclassical production function and any kind of factor augmenting technical change has the implication that the production function shifts inward at every capital–labour ratio; that is, at every value of the ratio of the wage to the price of capital. This set-up precludes finding that the factor price ratio guides the invention of new technology (Acemoglu and Restrepo, 2018, 2019). Indeed, Solow treated the evolution of technology as exogenous.

  Instead, of this representation of technical change, it is more useful to think of it as the invention of a technique with a new set of input–output coefficients. With this approach, it is easy to see that factor prices affect the evolution of technology.

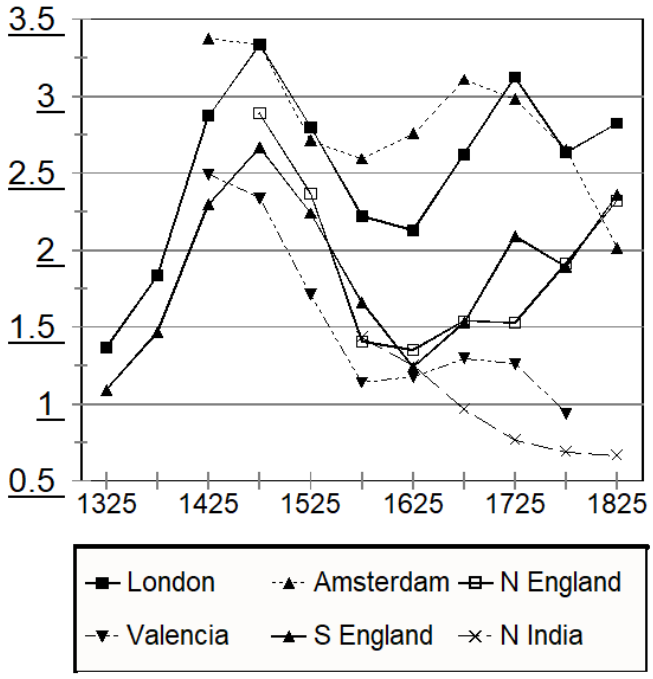
- **Wage evolution**. Because the Solow model assumes a neoclassical production function, the relation between wages and output per worker can be analysed with standard marginal productivity theory in an aggregate framework. Instead, we take a disaggregated and historically specific approach to wage determination. In the Industrial Revolution, for instance,

there was competition between new factories and old-fashioned handicraft producers. The late nineteenth century looks much more like Solow-in-action, but even then the impact of immigration of the labour market must be analysed to understand the evolution of the US labour market.

3. Phase I: pre-industrial economic growth, 1620–1770

The pre-Industrial Revolution ran from roughly 1620 to 1770, when the Industrial Revolution began. This is the period when sustained economic development began in Britain, and it was marked both by a 50% rise in output per worker (Broadberry et al., 2015) and a general increase in real wages. This was a marked break from the usual Malthusian pattern that characterised pre-industrial economies. In such economies, wages were normally at subsistence. Demographic shocks such as plagues caused wages to rise, but they then gravitated back to subsistence. Across Europe, real wages rose after the Black Death in the mid-fourteenth century, and in most places fell back to subsistence as populations rebounded. The major exceptions were the maritime cities on the North Sea such as Antwerp, Amsterdam and London. Real wages in London dropped slightly in the fifteenth century, but they quickly reverted to a high level and stayed there through the Industrial Revolution. In the rest of Britain, wages fell to subsistence, as they did elsewhere in Europe. By the seventeenth century, however, wages in southern England began rising to the London level and by the eighteenth century this dynamism had spread to northern England (see Figure 1; Gilboy, 1934; Allen, 2001; Clark, 2005; Humphries and Weisdorf, 2019). Women's earnings rose relative to men's (Humphries and Weisdorf, 2015). These trends meant that British real wages were amongst the highest in the world in the mid-eighteenth century (Allen et al., 2011). These wage increases occurred at the same time that the population was rising. The Malthusian pattern was broken (North and Thomas, 1973; Clark, 2007).

Figure 1. Real wages in England, Europe and Asia



Source: Allen et al. (2011) and Allen (2015, p. 8).

The wage patterns were a consequence of the shift of manufacturing from the Mediterranean to the North Sea that took place between 1500 and 1750. In 1500, at the end of the middle ages, Italy and Spain were the most urbanised countries and Europe's manufacturing power houses. The only comparably developed parts of northern Europe were the Low Countries (modern-day Belgium and the Netherlands). Otherwise, the continent was largely rural and agricultural. In 1500, the agricultural population made up three-quarters of the total in England and the large continental countries. (This is the same proportion that was observed in less-developed countries such as China and India early in the twentieth century.) The percentage was 55%–65% in Italy, Spain and the Low Countries. The Netherlands and Belgium had correspondingly larger urban populations, and that was important as most manufacturing took place in cities. The rural non-agricultural populations comprised a similar fraction of the population (14%–19%) in all of the European countries in 1500, and consisted of servants in country houses, priests, workers in transportation, and village craftsmen satisfying local needs (Allen, 2017, pp. 19–20).

By the eve of the Industrial Revolution, the centre of manufacturing in Europe had shifted to the North Sea. The English economy was the most transformed. The agricultural share of the population had dropped to 45%, while the urban share jumped to 23%, and the rural non-agricultural share leaped to 32% – the highest percentage in Europe. London grew from 50,000 people in 1500 to one million in 1800, when it became the largest city on the continent. Some of the growth in the urban share was due to an expansion in manufacturing (e.g., furniture making and book publishing in London, metal working in Birmingham, and so forth), but much of it was due to the growth of commerce and shipping.

The growth of manufacturing was most apparent in the increase in the rural, non-agricultural share. In the seventeenth century, the wool and linen industries, like many others, expanded in the countryside. Merchants signed up men and women to spin yarn, weave fabrics and knit stockings in their homes. The merchant brought the raw material to the workers, collected the finished articles, and paid the spinners and weavers for their effort. These rural industries were geographically concentrated, and their products were sold across Europe and, indeed, around the world. England was a leader in this so-called 'proto-industrial' revolution.

The Dutch and the Belgians were not far behind. Indeed, the Dutch economy was the most modern, if not the most transformed, by the end of the seventeenth century. The Netherlands was the most urbanised and had the smallest share of its population in agriculture. The great question in early modern political economy was how to catch up with the Dutch. Britain did it with the Industrial Revolution.

The other countries in Europe were transformed to a much lesser degree. There was a small decline in the agricultural share of the workforce in the big continental countries and a corresponding increase in rural manufacturing, but the cities remained small. These were not the economic leaders.

The economies of Italy and Spain were the least transformed of all. The stasis is somewhat deceptive – the constancy in the Spanish urban share encompasses the huge growth of Madrid and the collapse of the old manufacturing cities. Nonetheless, Italy and Spain had slipped from first to last place in European economic performance.

Why were the economies of England and the Low Countries so radically transformed? The answer lies in the evolution of the international economy and the imperial and military policies of the governments of Europe. In the middle ages, pepper, cinnamon, nutmeg and other spices were

exported from India and south-east Asia to Europe via the Middle East. In the fifteenth century, the invention of the square rigged ship allowed Europeans to sail around Africa to Asia. Vasco da Gama reached India in 1498, and his success led to the establishment of a Portuguese empire in Asia, Africa and Brazil. Success was short-lived, however, for many of the Asian colonies were seized by the Dutch in the sixteenth century. Some years before Vasco da Gama's voyage, Christopher Columbus convinced King Ferdinand and Queen Isabella of Spain to fund his attempt to reach Asia by sailing west across the Atlantic, and he reached the Bahamas in 1492. The 'discovery' of America (the Grand Banks of Canada had been frequented by European fishermen for centuries) led to a scramble for colonies in which Spain looked the early winner, for the conquest of Mexico and Peru gave her vast quantities of silver. This treasure proved counterproductive for the economy, however, because it led to inflation that rendered Spanish agriculture and manufacturing uncompetitive. By the seventeenth century, England, France and other powers were seizing colonies in the Caribbean, where fortunes were made in sugar plantations manned with African slaves. The English also established a string of colonies along the east coast of North America. These markets were large; by 1770, the colonies of the future US had a population of 2.4 million, about one-third of England's. Incomes were as high as, or higher than, those in England (Allen, Murphy and Schneider, 2012; Lindert and Williamson, 2016), and most manufactures were imported. This was a big market for English goods. Bengal was conquered by the British East India Company in 1757. The Dutch and the French also founded colonies in India, the Caribbean and North America, but they were defeated by the British who took many of their colonies from them. The British and the French followed 'mercantilist' economic policies and used tariffs and other trade restrictions to secure their colonial markets for themselves. As the British Empire expanded, so did the market for British manufactured goods, and this led to the great expansion of rural manufacturing and urban employment.

The expansion in manufacturing employment had important knock-on effects. One was tight labour markets that led to high wages. Others included the agricultural revolution and the development of the British coal mining industry (Allen, 2009a). Cheap coal was an important reason that the metal-working industries could compete internationally even though they paid higher wages than their competitors. High wages may have induced some labour-saving technical change before 1770, but the big impact was after 1770 when the textile industry was mechanised.

4. Phase 2: Industrial Revolution, 1770–1867

Wages affected technology

This period is the classic Industrial Revolution. It was driven by technological change. The Industrial Revolution saw momentous technological inventions such as factory spinning, power loom weaving, a coal-based iron industry, steamships and railways. Invention in this period was focused mainly on cutting the cost of manufacturing existing products rather than creating new products. The textile inventions are emblematic, and they lowered the cost of producing yarn and cloth that were already being made by hand or that were very close substitutes for them. For a century, the steam engine's sole contribution to progress was to reduce the cost of pumping water out of mines.

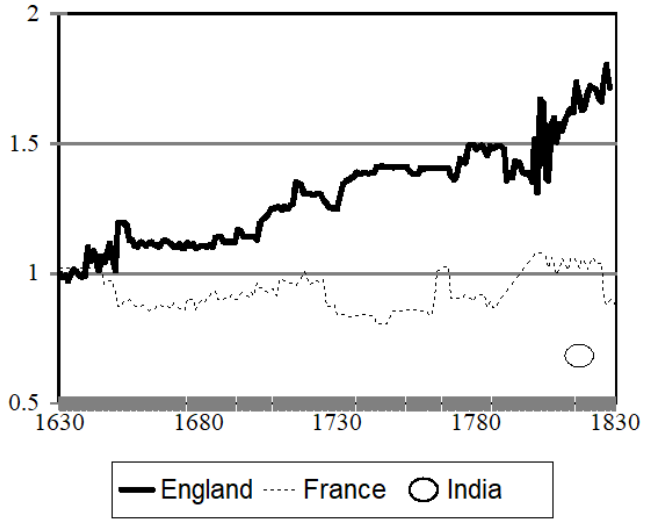
Invention in this period was not conducted in research laboratories but was rather the work of individuals following their own ideas. They did not always operate alone, however. At the highest level, the Royal Society heard papers on atmospheric pressure and was alive to possibilities of using that force for power generation. More prosaically, inventors met in local groups, shared

ideas, and learned from each other (Mokyr, 2009). It was not uncommon for inventors to share information so that they could learn from each other's experiences and push new design ideas forward. A good example of this sort of 'collective invention' was the perfection of Cornish pump engines in the first half of the nineteenth century (Allen, 1983; Nuvolari, 2004). The aim of inventors was generally to find a device they could either exploit themselves, or sell or license to someone else who would do so.

The search for better devices was a sensible response to Britain's economic expansion between 1600 and 1770, for it created a unique wage and price environment that made the new machines of the Industrial Revolution profitable. British wages were high relative to the price of consumer goods and, more to the point, relative to the price of capital services. (Figure 2 plots this ratio for northern England, France and India.)

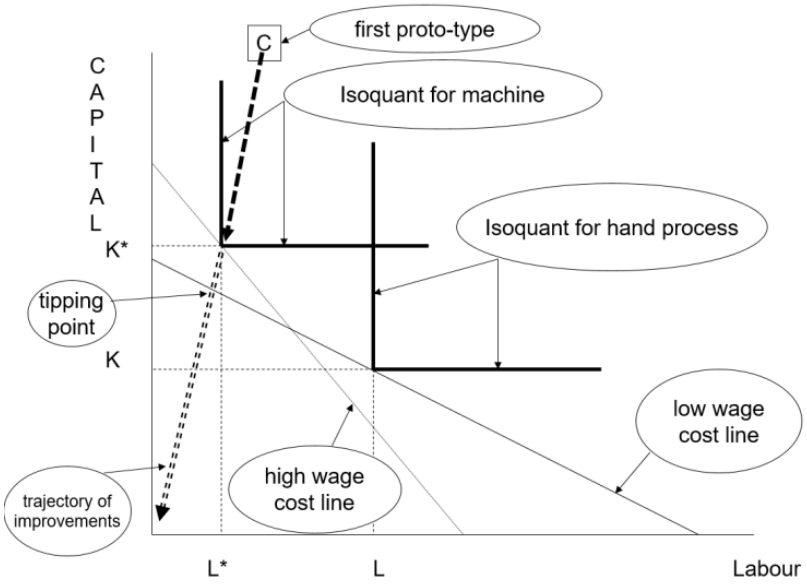
The impact of high wages on invention is clearer if we think about technical change as the invention of new techniques represented by single points in capital–labour space rather than as shifts in a standard production function. Figure 3 illustrates this point using spinning as an example. Two techniques are shown for spinning cotton yarn. The spinning wheel had a low capital–labour ratio, while the spinning jenny had a higher ratio. England in 1770 was characterised by the 'high-wage cost line,' while the rest of the world (and England in 1600) had the 'low-wage cost line'. Before 1770, the spinning wheel was the only technology available for making coarse cotton yarn, and it was used worldwide, whatever the relative factor prices. In 1770, the spinning jenny was only profitable in England, so this was the only place it was used and, indeed, the only place where it was worth inventing it.

Figure 2. Wages relative to the user cost of capital



Source: Allen (2017, p. 72).

Figure 3. Production model of mechanisation

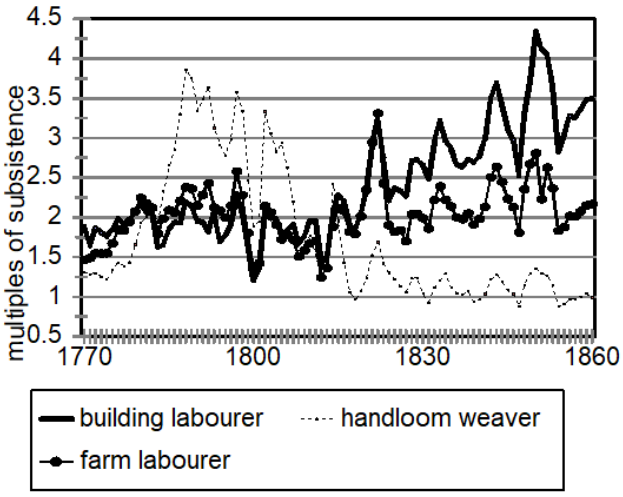


Note: Both isoquants assume the same output level.

Mechanical spinning was continuously improved from the 1760s into the nineteenth century. Hargreave's first machine was followed by Arkwright's water frame (plus associated machines to make the first cotton mill), Crompton's mule, Robert's self-acting mule, and so forth. This trajectory of improvements is indicated on the diagram. Point C represents Hargreaves' first attempt at making a jenny. It was too inefficient to be used commercially. The thick dotted line represents the improvements Hargreaves made during the R&D phase of the project, which turned it into a commercially successful technology. The double dotted line to the 'tipping point' represents improvements to mechanical spinning after the jenny entered commercial service. At the 'tipping point', machine spinning became profitable in low-wage economies. This is when the Industrial Revolution jumped to the continent, and it did so through the adoption of the most advanced technology because it was the only technology that paid where labour was cheap. The double dotted line towards the origin indicates subsequent improvements.

The mechanisation of spinning was followed by the invention of power loom weaving, and similar incentives were in play. In the 1780s, thousands of spinning jennies were installed in cottages and workshops, and hundreds of Arkwright mills were constructed. Output of cheap cotton yarn surged. This yarn had to be woven into cloth, and the result was a large expansion in the handloom weaving sector. The weavers were mainly men. As the sector expanded, weavers' wages, which had been similar to those of building labourers and farm workers in the 1770s, rose sharply (Figure 4). The late eighteenth and early nineteenth century has come to be known as the 'golden age of the handloom worker' (Hammond and Hammond, 1919). Their high wages, however, became a target of inventors who sought to perfect the power loom to cut labour costs. This story was repeated in other handicraft trades.

Figure 4. Lancashire male labour market real earnings, pence per week



Source: Allen (2017, p. 72).

Technology affected wages

The technological innovations of the Industrial Revolution had a dramatic impact on the labour market. The 'standard of living debate' dominates much discussion of the first half of the nineteenth century.[3] How could the high-wage economy of the eighteenth century have given rise to apparently widespread poverty in the nineteenth century? Figure 4 shows the explosion in wage inequality in the Lancashire labour market. The 'golden age of the handloom weaver' around 1800 was followed by a collapse in their earnings as the power loom slashed the margin between yarn and cloth prices. Farm wages remained steady. The real wages of building workers rose consistently as did the wages of men employed in cotton mills, after an initial dip during the French Wars. Eventually, handloom weavers were forced to give up the trade, and many redeployed to the remaining hand trades, putting further downward pressure on wages.

In 1820, handloom weavers amounted to 10% of the male workforce, so their fate was of considerable consequence in its own right. But they were not alone. Again and again, we encounter the same story: machinery was invented to do the work that a skilled artisan had previously done by hand. People with those skills continued in their trade (it was, after all, what they could do) even as their earnings dropped under the competitive pressure of increasingly efficient machinery. They sank into poverty, and eventually the trade disappeared. Framework knitting and pillow lace weaving are examples.

In 1589, William Lee invented a machine to knit stockings. It was powered by the operator and had more moving parts than the early spinning machines. It was impressively complicated. A narrow frame could make a dozen pairs of stockings per week, while a wide frame could produce that many in a day. In 1844, there were almost 50,000 knitting frames in Great Britain. Many improvements had been made to the frame, which enabled it to knit more and more complicated patterns.

[3] The matter has always been contentious. An intense debate on the question with many contributions raged between the exchanges between Hobsbawm (1957) and Hartwell (1961) through Feinstein (1998a, b), which brought that controversy to a close.

Pillow lace knitting was a separate industry. The lace knitters made a square of lace, called a mesh, by sticking pins in the pillow and using them as anchors to weave the pattern with thread, bobbins and crochet hooks. This was a domestic industry carried out in the knitters' homes, and it supported many thousands of women.

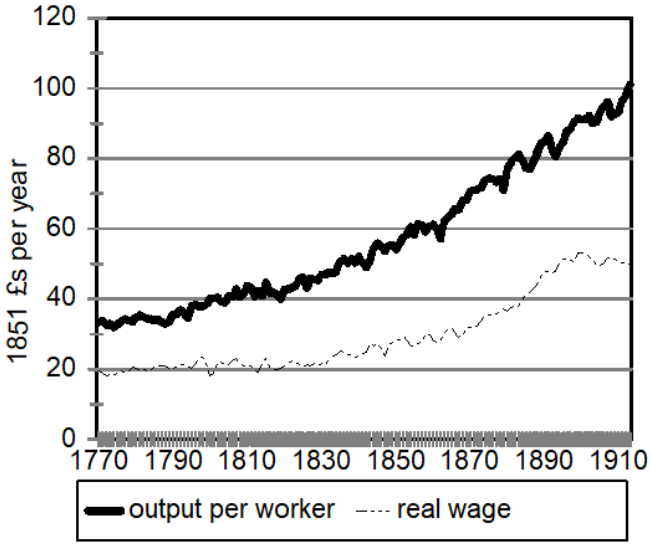
The industries were originally distinct, but their fates became entangled, as inventors contrived to improve the stocking frame, so it could knit lace. It was a difficult problem and was only solved by John Heathcote in 1809. At first, the machine-wrought lace was crude but, over time, the process was improved so finer qualities of lace could be knit at lower and lower cost. At the beginning of the nineteenth century, women could make five meshes of plain net per minute on their cushions, and lace cost 100 shillings per square yard. The steam-powered machinery of the 1850s knit 40,000 meshes per minute, and the price of lace had dropped to 6d per square yard. In the face of this competition, the incomes of the pillow lace knitters collapsed, and eventually it became pointless for even the poorest woman to compete against the machinery. By 1860, 90% of the lace machines were steam-powered. They were operated by men who had formed a trade union and earned high wages. The women who made lace in their cottages were gone.

The fate of the men who knit stockings and machine lace was also unfortunate. It was not difficult to learn to operate a knitting frame, so men who were forced out of other jobs such as handloom weaving flowed into the stocking and lace industries, depressing earnings there. By the 1840s, poverty was endemic. The situation only improved when steam factories replaced the old knitting frames. Marc Isambard Brunel patented a steam-powered knitting machine in 1816, but it was not successful. Circular machines were developed in the 1830s and became commercially viable after Matthew Townshend invented the latch needle in 1847. William Cotton's first patent was in 1846 and followed by half a dozen others in the next 25 years. He opened a factory in 1853 and sold knit fabrics and knitting machines. Steam-powered factories proliferated. Productivity was much higher than in hand work, and wages rose. Modern collective bargaining also developed in the 1860s.

As one activity after another was mechanised, hand workers experienced falling earnings either because their own industry was mechanised, or because another was, and workers in it were driven into theirs. Hand workers as a whole suffered falling incomes. The average wage of the working class did not rise until the handicraft sector was replaced by factories. The fate of the handloom weaver prefigures some developments of the present day.

The combination of rising real wages in expanding trades with the falling wages in the hand trades meant that the average wage level remained unchanged even as output per worker rose (Figure 5). The first half of the nineteenth century when this was occurring was the time when all social commentators (e.g., Malthus, Ricardo, Marx) thought that real wages would remain at subsistence no matter how much economic growth took place; this period has been dubbed 'Engels' pause' in recognition of Friedrich Engels' (1845) description of Manchester at this time (Allen, 2009b).

Figure 5. Output per worker and the real wage in Britain



Source: Allen (2017, p. 8).

5. Phase 3: the Age of Manufactures, 1867–1973

Wages affected technology in the US

By the middle of the nineteenth century, as Britain was progressing beyond the Industrial Revolution, modern manufacturing and transport technology was being adopted in western Europe and North America. The US was a leader in this advance, and it marked the beginning of the US's Age of Manufactures and the country's rise to economic hegemony.

At the outset, the US was not a mature industrial nation. In 1869, 53% of the workforce was in agriculture and only 19% in manufacturing, but the latter were much more productive as manufacturing accounted for 15% of GDP versus agriculture's 22%. Manufacturing output grew rapidly thereafter and peaked in the early 1950s at 32% of GDP and 24% of employment.[4] The service sector's share did not change much, so the decline of agriculture was matched by the increase in manufacturing.

What determined the evolution of technology in this period, and how did it affect the labour market? The first issue to consider is the development of technology and its determinants, which include the evolution of factor prices.

In the mid-nineteenth century, US innovation was organised along the same lines as those of innovation in Britain during the Industrial Revolution. New technology was developed by inventors working on their own, who aimed to profit from it by exploiting it in their own businesses or selling the right to use it to other entrepreneurs (Khan and Sokoloff, 1993). However, as the period progressed, invention became more institutionalised. In 1876, Thomas Edison expanded his inventive capacity by founding the first industrial laboratory with about 60–80 employees. Many of the large US manufacturing firms produced by the mergers of the late nineteenth and early twentieth centuries quickly established industrial research laboratories

[4] Historical Statistics of the United States, series D167, D170, D174, F251 and F254, https://hsus.cambridge.org/.

(Chandler, 1977, p. 375). These firms had more resources than many of the individuals who preceded them. They also had commercial objectives that conditioned the course of R&D.

Much of this private R&D was aimed at product innovation. Inventions, such as the railway, that transformed the lives of ordinary people made their first appearance towards the end of the Industrial Revolution. Even the poor were affected. The Duke of Wellington, for instance, objected to Brunel's Great Western Railway because 'it will only encourage the lower classes to move about'.[5] The same thing happened in India. When railways were built, sales of third-class tickets boomed, and the 'poor moved about'. By the late nineteenth century, developments such as electric power, automobiles, petroleum, modern chemicals and aircraft began to transform life on a greater scale. Modern living quarters with their modern conveniences were invented (Gordon, 2016). Product innovation was crucial in the growth process, for it sustained the continuous rise in demand for manufactures throughout this period; had the consumption choices remained as they were in 1850, for instance, demand for manufactures would have been sated early on, and the economy would have evolved in a very different direction from that which actually followed.

Government-funded research also became important for the first time. In 1862, the Morrill Act provided for federally assisted land grant colleges in each state whose objectives included developing agriculture and engineering. In the same year, the US Department of Agriculture (USDA) was established. In 1887, the federal government began to fund agricultural experiment stations in every state and, in 1914, extension services to teach modern agriculture. In 1879, the US Geological Survey (USGS) was established to survey and map the mineral resources of the country and promote their exploitation. These were scientific research organisations established to promote the settlement and economic development of the West. Their aim was not so much to promote the substitution of capital for labour as in Figure 3, but rather to raise the value of land and natural resources. The USDA and USGS are early examples of 'mission-oriented R&D'. This type of organisation has played an increasingly important role in guiding invention in the twentieth century and broadening the range of objectives it serves.

There is a fundamental economic reason for the state to fund basic research: new knowledge is a public good. In this context, a 'private good' is anything like an apple: only one person can eat it, and once that has happened, it is gone. In contrast, a 'public good' is one that can be consumed by an unlimited number of people; the Pythagorean theorem has been used in technical applications repeatedly for two and a half millennia without losing its power. Private goods can be effectively produced by the market system, but public goods such as new knowledge are underproduced as their creators cannot capture all of the benefits of their work. Pythagoras certainly did not receive much of the return from his theorem. Patents are a very imperfect device to deal with this problem over a limited time frame. Basic research is a public good. As a result, basic research is undertaken in universities or research institutes supported by public funds or charities. This support extends into basic technology. Hybrid corn, for instance, was developed in the US in the first decades of the twentieth century. The underlying biology was worked out by investigators at Michigan State University, the University of Illinois and Harvard University. It was directed to practical ends by state experiment stations and the USDA. Only then did private seed companies begin to produce and market seed; commercial production was first undertaken by a firm that was established by a USDA investigator.[6] Likewise, the federal government in the twentieth century began funding basic research in medicine through the National Institutes of Health,

[5] http://www.bbc.co.uk/history/british/victorians/brunel_isambard_01.shtml.

[6] https://tdaynard.com/2019/10/25/a-brief-history-of-the-hybrid-corn-industry/.

which conducts its own research and funds many other projects. Sometimes pharmaceutical companies develop new drugs, but often they only produce and market drugs developed by research institutions funded by governments and charities. Only when drugs are developed do pharmaceutical companies enter the picture to market them. This has been the story with COVID-19 vaccines such as the Oxford–AstraZeneca and Pfizer–BioNTech products.

Nevertheless, although product innovation and land value augmentation were important, much of the thrust of technological change in the period was aimed at cost reduction. In general, new technology was created with ever higher capital–labour ratios that produced ever more output per worker. We can study the evolution of this technology at both the industry and the macro level, and the same patterns emerge.

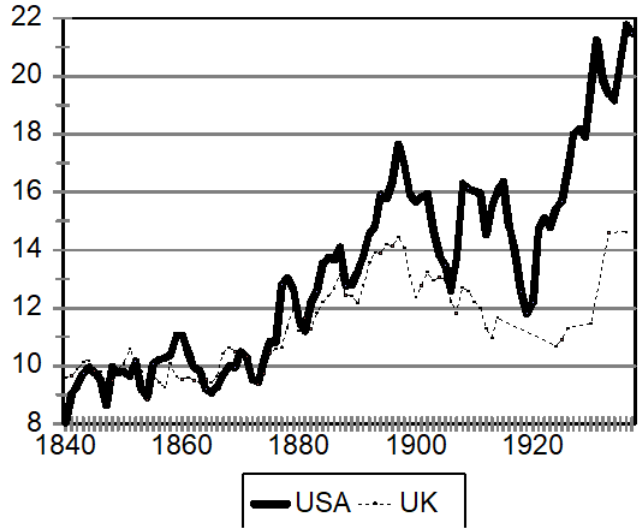
In his history of American management, Chandler (1977, pp. 240–83) explained that the main objective in designing new plants between 1870 and World War I was to increase 'throughput', that is, output per factory. This was not done by increasing employment per factory, rather by increasing the capital in the plant, so that the work force could produce more per day. The iron smelting industry is a classic example. A key new technology was 'fast driving', which meant blowing much higher volumes of air into the base of the blast furnace to increase production (Temin, 1964). The results show up in the statistics for the industry: the number of workers per blast furnace establishment only increased from 122 to 183 between 1879 and 1914. Over the same period, horsepower per establishment increased tenfold from about 793 to 7,639, while output per establishment jumped fifteen fold from 5,552 tons per year to 81,363 tons per year. Technology evolved similarly in industries as diverse as flour milling, cigarette rolling, petroleum refining, and distilling.

This pattern described by Chandler corresponds to the same pattern as technical change in the British textile industry during the Industrial Revolution: new technology raised capital per worker and pushed up output per worker by an even greater amount. Macro data for the nineteenth and twentieth centuries show the same pattern (Allen, 2012).

Why did technology develop in this way? The answer is that economic development led to higher wages in rich countries, and the higher wages in turn made it profitable to develop technology with even higher capital–labour and capital–output ratios. It is important in this regard to distinguish between skilled and unskilled wages. Industries differed greatly in their mix of workers. In 1910, for instance, 48% of the workforce in the iron and steel industry were unskilled workers as opposed to 14% in the automobile industry. Skilled and unskilled workers presented different challenges but, in the US at least, the movement of factor prices induced the substitution of capital for labour in both cases.

The incentives to mechanise depended on wages relative to capital prices, and Figure 6 shows this ratio for unskilled labourers. It was rising in the US and also in Britain. Machines were invented to save unskilled labour. In the iron industry in the middle of the nineteenth century, for instance, the ore, coke and limestone to be charged into a blast furnace were first raised to the top of the furnace stack with a lift. The materials were transferred to wheelbarrows, and labourers pushed them across a gantry to the top of the stack where they were dumped into the furnace. US iron firms replaced this system in the early twentieth century with 'skip chargers'. These were containers that were filled at the base of the furnace with raw materials and then hoisted up a track to the top of the furnace where they were automatically tipped and their contents dumped into the furnace stack. The labour of the top loaders was dispensed with and the savings on their wages paid for the skip charger (Allen, 1977; Temin, 1964, pp. 162–3).

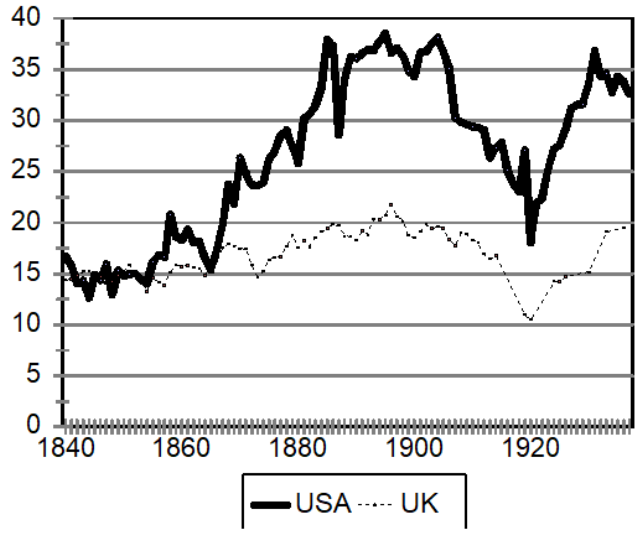
Figure 6. Unskilled wages relative to user cost of capital



Note: User cost of capital: index equals (interest rate + depreciation rate) * index of cost of capital goods.

Source: Nominal wages as described in Figure 11. Interest rate: US, New England municipal bonds (Homer and Sylla, 1996, pp. 287–8, 342, 350); UK, yield on long-term government bonds (Homer and Sylla, 1996, pp. 196–7, 444–5).The depreciation rate is assumed to be 5%. The index of cost of capital goods = geometric average of building labour wage rate and arithmetic average of prices of bar iron, copper, soft wood building lumber and bricks. Sources of prices of bar iron, copper and lumber have already been given (with the addition that the US bar iron price was extrapolated to 1937 using the price of steel rails). Bricks: US, New York, 1849–1933 (US Census Bureau, Historical Statistics of the United States, online, Table Cc264); UK, Glasgow, 1863–1902 (UK Board of Trade, Report on Wholesale and Retail Prices in the United Kingdom in 1902, with comparative statistical tables for a series of years; House of Commons Parliamentary Papers, 1903, Vol. 68, p. 199). Softwood construction lumber: New York Hemlock, 1890–1920 (US Department of Labor, Bureau of Labor Statistics, 1922. p. 184, Table 9), 'New York Market, average price per M feet'; 1840–90, extrapolated with Aldrich (1893, Vol. I, p. 46), 'one inch first quality hemlock boards not planed'; 1921–39, extrapolated with Potter and Christy (1962, p. 244, series L). UK Baltic, 1840–60, extrapolated with Economist series of price of Canadian yellow pine from Aldrich (1893, Vol. I, pp. 213-4); 1861–1937 UK Board of Trade, Statistical Abstract for the United Kingdom, London, HMSO, various years and Sauerbeck (1886, 1907), unit value of imported timber, sawn or split, shillings per load of 50 cubic feet. Copper: US, 1840–1891, Aldrich (1893, Vol. I, p. 40) copper ingots; 1892–1939, US Census Bureau, Historical Statistics of the United States, online, Table Cc255-Cc257; UK, 1846–91, Aldrich (1893, Vol. I, p.234), Saurbeck's prices of copper bars from Chile; 1892–1937, Sauerbeck (1886, 1907), Editor of the 'Statist' (1918, 1938). Iron: US, bar iron, Philadelphia, best refined bar iron, US Department of Commerce, Bureau of the Census, Statistical Abstract of the United States, Washington, DC, Government Printing Office, various years (series extended forward with price of open hearth steel rails in US Census Bureau, Historical Statistics of the United States, online, Table Cc245); UK, bar iron, common bars, Mitchell and Deane (1971, pp.493–4).

Figure 7. Skilled wages relative to user cost of capital



Source: Same as Figure 6.

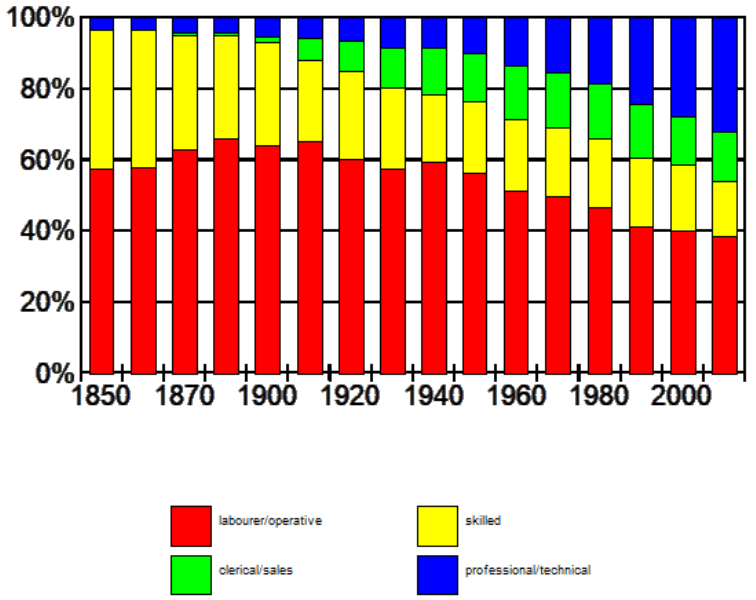
The incentives to invent machinery to save skilled labour were even greater in the New World, for skilled wages there rose much more with respect to the cost of capital (Figure 7). This played out in industries such as automobile manufacture, which employed a high proportion of skilled labour. Henry Ford's Highland Park plant is the preeminent example. It was opened in 1910 to produce model T Fords, and it is most famous for being the site of the first moving assembly line in 1913. This invention accelerated throughput and displaced labourers. The bigger challenge, however, was to reduce the employment of high-wage skilled machinists. This was accomplished through jigs, fixtures and stops. General purpose machine tools that could perform many different tasks – and thus required the machinist to set the guides that controlled cutting and the depths to which drills would bore – were replaced with custom-designed machines in which pre-set jigs, fixtures and stops controlled operation without the operator having to set them. Custom machines cost more than general purpose machines because a different design was required at every work station. This increase in capital intensity, however, allowed skilled machinists to be replaced by new immigrants from central Europe who had no machining experience (Meyer, 1981, pp. 24–26, 44–53).

> 'The old time tool hardener was an expert. He had to judge the heating temperatures…The wonder is that he hit it so often…We introduced a system by which the man at the furnace has nothing at all to do with the heat. He does not see the pyrometer–the instrument which registers the temperature. Coloured electric lights give him his signals.' (Ford, 1922, chapter 6).

Conceptualisation (for instance, the ability to lay out the work and locate the jigs and set the stops) was separated from execution – merely pushing the metal through the machine (Braverman, 1974). The 'semi-skilled' worker was born.

The Highland Park plant was a trend setter and not an isolated case. It epitomised mass production. The manufacturing sector as a whole shows the same patterns. The share of skilled workers dropped from about 40% in 1850 to about 15% in 2010 with most of that drop occurring before 1940 (Figure 8). There was at first a small rise and then a fall in the share of labourers/operatives. What is also striking, however, is the rise in white collar jobs.

Figure 8. Occupation distribution of US manufacturing labour force



Source: Katz and Margo (2014, pp. 37, 45–6).

There are several reasons for the rise in white-collar work. With respect to the manufacturing sector, the decline in skilled work required a compensating increase in managerial and clerical activity as management assumed the conceptualisation function that skilled workers had performed. Also, skilled workers had often hired their assistants and subordinates, and these tasks were assumed by expanded personnel departments. Managers were also required to monitor and supervise the work of the semi-skilled workforce. In addition, the scale of business became larger to take advantage of the high throughput of advanced technology as well as to take advantage of the large national market created by the national rail system. The control of large organisations led to planning and cost accounting, which entailed many office jobs.

Structural shifts in the economy also contributed to the growth in white-collar employment. The rise of government with its tax systems and social welfare programmes has entailed many clerical, managerial and professional jobs. Higher incomes led to shifts in consumer spending away from manufactured goods towards services such as education and medical care, both of which required many professional employees.

Large numbers of well-paid clerical workers created an incentive to invent machines to save office labour. Typewriters and dictating machines were early examples. A particularly interesting case is Herman Hollerith's invention of the electrical tabulating machine. It was first used to compile vital statistics in Baltimore in 1887 but its great breakthrough came when it was selected to compile the 1890 US Census (Truesdell, 1965; Austrian, 1982). It is portentous in many ways, including the fact that Hollerith's company became the core of IBM. Some European statistical agencies quickly took up the electrical tabulator, as well as some American railway companies. An interesting case of non-adoption, however, is the Indian census. Baines (1900, pp. 50–1), the director, remarked to the Royal Statistical Society that there was no point using the electrical tabulator when Indian labour was so cheap. The economics of Hollerith's tabulator were much the same as Hargreave's jenny.

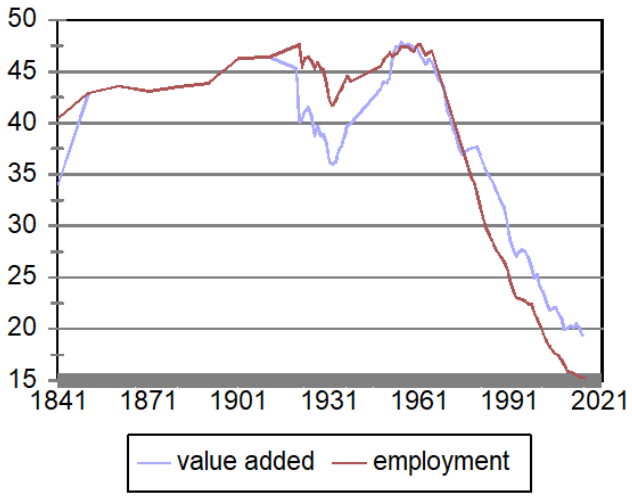
Wages affected technology in the UK

The period from the Industrial Revolution until the 1960s also was Britain's Industrial Age. In the mid-nineteenth century, Britain was already a mature industrial nation, and the distribution of economic activity across sectors was stable whether it is measured in value added or employment (Figure 9). About 45% was 'industrial', which includes mining, manufacturing, construction and utilities. Depressed conditions aside, manufacturing itself accounted for about 35% of national income. At the outset in 1841, agriculture amounted to one-quarter of the economy, but its share fell over the nineteenth century, and the service sector expanded accordingly. The situation changed dramatically after 1960, when the manufacturing share went into freefall, and services grew at its expense – but that is a theme for later.

While the whole period from the end of the Industrial Revolution to the 1960s is united by the industrial structure that characterised it, there is a notable break around World War I. Before the war, many of the indicators such as trade volumes and industrial output rose in the long term. After the war, they stagnated or began to decline. For most of the pre-war period, Britain was a world leader in industrial technology. From the early twentieth century onwards, the US had overtaken the UK. I begin with the pre-war period.

Technology evolved and improved in Britain before World War I. The course of evolution differed between the countries, however. Britain had a more abundant supply of skilled labour than the US, and this reduced the incentive to mechanise in Britain. This abundance was a legacy of the Industrial Revolution and was also due to the absence of the mass immigration of unskilled farm workers that continually diluted the supply of skilled labour in the US. Britain developed industries and techniques that utilised its skilled labour.

Figure 9. Shares of valued added and employment in industry, UK, 1841–2016



Source: Bank of England, 'A Millennium of Macroeconomic Data for the UK', Version 3.1, Sections A16 and A53 (https://www.bankofengland.co.uk/statistics/research-datasets).

Abundant skilled labour was a product of the Industrial Revolution, but it had to be constantly renewed, and this was achieved through a widespread system of industrial apprenticeships. These were common in the construction and engineering trades. Boys (by the late nineteenth century, they were school leavers) were hired as apprentices for a period that was most often five years. During this time, they were paid a low but rising wage and given on-the-job training. At the end of the five years, their wages were doubled, or more, to the level of skilled workers. They

had no obligation to remain with the same employer, although they generally remained in the same region. The system worked in part because the skilled workers were organised in unions and bargained collectively with all of the employers in the region. The craft unions monitored the system to ensure the apprentices were trained and not simply exploited as low-wage employees. The US had no comparable system, the usual explanation being that labour was far too mobile, so employers had little chance of recouping their investment in training (Elbaum, 1989).

A second factor that influenced the evolution of technology was differences in the institutional arrangements for invention. Britain was a follower, not a leader, in establishing state-sponsored research institutions such as the USGS or the German Physikalisch-Technische Reichsanstalt (Cahan, 1989). Nor did British universities provide technological support for industry like their German and US counterparts. Technological advance was usually the result of individual inventors or talented individuals, often studying and perfecting the technology of the industry in which they worked. Professional associations were important in bringing together engineers and entrepreneurs from the firms in an industry, so that they could share information and build on each other's progress. So long as industries were expanding and new capacity was being constructed, technical advance occurred in existing industries through collective invention (although this was obviously not a system adapted to advancing technology in new industries).

For much of the period, Britain managed to enlarge its economy without diversifying its industrial structure. It did so by expanding the output of the industries in which it had achieved world leadership during the Industrial Revolution: cotton and wool, iron and steel, mechanical and railway engineering. Only shipbuilding was added to the list, but this was not much of a diversification as the ships were built in the existing centres of heavy industry and drew on the steel they produced and the engineering skills they fostered. The situation was different in the US, for instance, where the industrial market would have been saturated had the products of the Industrial Revolution been the only ones on offer. Britain finessed this issue by creating its vast formal and informal empire in which it had privileged access and into which its factories could expand sales at the expense of local handicraft producers.

Britain's trading empire consisted of countries in a range of political relations with the UK. The most tightly controlled places were those in the formal empire – preeminently India and the other colonial possessions administered by the UK. Before World War I, Lancashire producers were successful in preventing India and Egypt, for instance, from imposing taxes that in any way privileged their cotton industries in relation to Lancashire. The self-governing dominions such as Australia and Canada had more autonomy but remained loyal subjects of Her Majesty in the commercial realm. Then there were the formally independent nations whose commercial options were severely constrained by trade treaties. The Ottoman Empire, the Persian Empire, China, Japan and Thailand were all in virtually free trade arrangements with Britain due to what the Chinese referred to as 'unequal treaties'. These treaties all set limits to tariffs imposed on British goods (usually 5% or less) as well as removing the obligation to pay many internal duties that the nationals of the country had to bear and allowing Britain the right to appoint consuls who could adjudicate legal disputes between their citizens and local nationals. The specifics varied from treaty to treaty, but all of them ruled out the use of protective tariffs to promote factory production, thereby creating the legal basis for the domination of the local market by imports. Other western countries often forced similar concessions, but Britain had an ascendant position.

The consequence was a vast expansion of British exports to world markets during the nineteenth century. In 1750, Britain produced about 2% of the world's manufactures – a figure in line with its share of world population. Around 1880, Britain's share of world manufactures peaked at about

23% and remained high into the twentieth century (Allen, 2017, p. 107). The surge in British exports of cloth and iron goods de-industrialised China, India and many other countries, turning them into classic 'underdeveloped' economies focused on agriculture. As Marx wrote (quoting Lord William Bentinck, the Governor General of India, in 1835): the 'bones of the cotton weavers are bleaching the plains of India'.[7]

Britain's export performance was impressive, but it was narrowly based. Table 1 summarises the results of the 1907 Census of Production. The British manufacturing sector as a whole (including coal mining) exported 12% of its production net of imports. Importantly, the sector subdivided into two parts. The so-called Victorian staples – cotton, wool, coal, iron and steel, engineering – were highly competitive internationally. This group exported (net) 45% of production and the ratio ranged from a low of 31% (shipbuilding) to a high of 72% (cotton textiles). The rest of the manufacturing sector was a net importer – at 10% of production. The 'rest of manufacturing' included sectors that are rarely major exporters, such as food processing, but also important so-called 'new industries' such as electrical products, motor vehicles and chemicals. The electrical products industry had a net export ratio of 5%, while motor vehicles and chemicals were net imports at 15% and 18%. Britain's lack of success in the 'new industries' did not, however, prefigure the post-war experience, as is often assumed.

Table 1. UK production, exports and imports, 1907 (millions £s)

	Production	Exports	Imports	Net exports	Net exports/ production
Victorian staples	119.6	40.2	0.02	40.1	34%
Coal mining	87.8	45.7	7.2	38.5	44%
Iron and steel	86.0	28.9	0.07	28.9	34%
Mechanical engineering	32.0	10.0	0.027	10.0	31%
Ship building	32.0	10.0	0.027	10.0	31%
RR engineering	16.9	8.3	0.024	8.3	49%
Cotton	132.0	104.6	9.8	94.8	72%
Wool	65.5	32.2	10.4	21.8	33%
Staples subtotal	539.7	269.9	27.5	242.4	45%
Other manufacturing	816.3	130.0	215.3	–85.3	–10%
Total	1,356.0	399.9	242.8	157.1	12%

Source: Census of Production, 1907.

[7] Marx (1867, Vol. I, chapter 15, 'Machinery and Modern Industry,' p. 289).

Britain's comparative advantage in the industries in which it dominated the world rested on three factors: (i) cheap natural resources – coal, in particular, but also iron ore, which was usually found close to the coal needed to smelt it; (ii) the skills of its work force; and (iii) the efficiency of its technology – at least at the outset. Once the Americans invented mass production in response to their high wages, Britain had lost its technological superiority (Broadberry, 1997; Allen, 2014). The performance of British industry has been a recurring policy issue ever since.

World War I and its aftermath ended Britain's export success that had marked the pre-war period. An immediate cause was the decision in 1925 to return to the gold standard at the pre-war – by then, overvalued – exchange rate. This priced Britain's exports out of world markets. Long-run factors worked in the background as well, namely, the economic development of Germany, Japan and the US. The growth of the iron, steel and engineering industries in Germany and the US meant that they were bound to take the market share from Britain at some point. In the case of iron and steel, this had already begun in the 1890s. The economic development of Japan, pushed forward by the isolation provided by the war itself, meant that Britain's vast Asian cotton markets were under threat from a new competitor. Finally, the development of the petroleum industry undermined the supremacy of coal as a fuel. Churchill's decision in 1913 to convert Britain's destroyer fleet to oil was a harbinger of things to come.

The high ratios of exports and net exports to production that Britain's leading industries had achieved before World War I disappeared in the 1920s. Steel was the most successful industry. Exports remained strong through the 1920s, but imports rose dramatically. From 1926 onwards, Britain rarely ran an export surplus in steel. Coal exports peaked in 1923 and then went into slow but irreversible decline. Finally, cotton textiles, which had been exporting most of its output before World War I, saw its exports of cloth drop from a peak of seven million yards in 1913 to less than one million in 1940, never to rise again.

The loss of export markets meant that the sales of textiles, steel and coal were limited to the growth in the British market, and that potential was limited. Britain's share of world manufactures collapsed and output of the leading Victorian industries stagnated or shrank. The steel industry did best, but success was slow in coming. It only regained its 1917 level of production (almost 10 million tons) just before World War II. Production continued to expand after the war, and output peaked at about 25 million tons per year in the 1960s. Mechanical engineering was probably as successful: we lack a measure of its output though the 1960s, but it doubled between 1913 and 1948 (Feinstein, 1972, Table T115). Shipbuilding maintained a trendless and highly variable level of output through the 1960s. Coal production peaked at 287 million tons in 1913 and then went into a slow slide, finally slipping below 200 million tons in 1960 when it entered terminal decline. Cotton production peaked in 1913 when 2,178 million pounds of raw cotton were consumed. Consumption had dropped by three-quarters in the 1960s. Some of this loss was made up by the increased weaving of synthetic fibres in Lancashire, but the textile industry was far smaller.[8]

The setbacks to the Victorian staples had an impact on the labour market but not as substantial as one might expect (Table 2). Between 1911 and 1971, employment in Britain expanded by almost five million jobs overall. Some industries shed workers. Mining lost three-quarters of a million jobs. These were mainly coal miners, and the fall in numbers was due to the fall in output as well

[8] Industrial statistics for the UK, from the UK Board of Trade, Statistical Abstract for the United Kingdom (various years) and the UK Office of National Statistics, Annual Abstract of Statistics (various years).

Table 2. Distribution of employment between broad sectors, 1911 and 1971 (thousands of workers)

	London		South-East and East		Other regions		Great Britain	
	1911	1971	1911	1971	1911	1971	1911	1971
Agriculture, forestry, fishing	8	5	435	177	1,048	453	1,491	635
Mining	0	5	5	11	1,138	376	1,144	391
Manufacturing	628	1,093	697	1,384	4,434	5,659	5,759	8,136
Utilities	12	62	21	71	54	229	86	362
Construction	131	250	281	358	727	1,062	1,139	1,669
Transportation	265	303	324	193	1,029	628	1,619	1,124
Distribution	242	548	366	586	1,068	1,882	1,675	3,016
Financial and business services	41	498	61	235	141	659	242	1,392
Education and health	108	507	191	639	431	1,755	731	2,901
Other services	669	499	1,063	554	2,295	1,482	4,027	2,534
Public administration	68	316	173	364	197	892	438	1,572
Total	2,174	4,086	3,616	4,571	12,561	15,076	18,351	23,733
Manufacturing share	29%	27%	19%	30%	35%	38%	31%	34%
Industry share	36%	35%	40%	44%	59%	52%	52%	47%

Source: Lee (1979).

as technical improvements that raised labour productivity. Agriculture lost even more. However, manufacturing gained almost two and a half million jobs, and gains were also large in service industries such as distribution, finance, education, health and public administration. Overall, manufacturing increased its share of employment from 31% to 34%, while 'industry', including mining, utilities and construction, saw a small decline from 52% to 47% because of the loss of jobs in mining.

There were some important developments at the regional level.[9] All regions gained population with the highest rate of increase being in London. The greatest change in economic structure, however, was in the East and South-East. In 1911, there were big differences between regions in the share of employment in manufacturing ranging from a low of 19% in the East and South-East to a high of 35% in the North (that is, the rest of the country).[10] By 1971, the share of the North had risen to 38%, while the share of the East and South-East had jumped up to 30%. The industrialisation of the East and South-East almost eliminated regional disparities in manufacturing employment between 1911 and 1971.

Employment grew in manufacturing in all regions because of job creation in some 'old industries' but especially in 'new industries' (Table 3). Two industries experienced very large job losses between 1911 and 1971. One was textiles – no surprise there, given its fall in output – and the other was clothing. Among the 'old industries', there were substantial job gains in metal manufacturing (mainly iron and steel) and especially mechanical engineering, where employment more than doubled. There was also a small increase in employment in ship building. Most of the job gains, however, were in 'new industries'. These included motor vehicles (three-quarters of a million additional jobs), electrical equipment (another three-quarters of a million jobs) and chemicals (half a million new jobs). While there has always been a 'chemical' industry, its output in 1971 was mainly new products produced in novel ways. Whatever weakness there had been in the 'new industries' before World War I, it did not prevent these industries from growing to very large size in Britain after the war. Moreover, expansion was not confined to these industries. There was substantial employment creation in food and beverages, paper and publishing, and 'other' manufacturing industries. Real wages were rising in all regions in this period, as will be documented later, and the nationwide transformation of industry undoubtedly contributed to this.

Job creation in the 'new industries' was the result of product innovation. Before World War I, Britain's manufacturing sector could grow without diversifying the product range, because the imperial arrangements allowed its textile, iron, steel and engineering industries to expand throughout the world. However, this opportunity ended with the war, and manufacturing expansion required expansion of the product range. As in the US, it was the 'new industries' that enlarged consumer desires and prevented stagnation of demand, which would likely have

[9] My analysis of regions is based on the data compiled by Rosés and Wolf (2019) for benchmark years from 1900 to 2010. They employ a consistent subnational classification scheme based on NUTS1 and NUTS2 regions. The British NUTS2 regions correspond to standard British statistical regions. However, because of boundary shifts in the twentieth century, they combine the North-West and North-East regions in the UK into the North and the South-East and East regions into a region I refer to as East/South-East. In addition to the publicly available data sets for GDP and population, Rosés and Wolf kindly gave me their regional employment data set. For this I am very grateful. I reworked the regional GDP data by replacing the national GDP series underpinning them (and produced by the Maddison Project) with Penn World Table v. 9 GDP estimates for 1950–2010 (Feenstra, Inklar and Timmer, 2015). I used the Maddison GDP data in Rosés and Wolf, however, to extend the Penn World Table data back to 1900.

[10] The North is a slightly inaccurate designation for the 'rest of the country' as it includes the South-West as well as everything from Wales and the Midlands to John o' Groats.

Table 3. Manufacturing employment in Britain, 1911 and 1971 (thousands of workers)

	1911	1971
Mining	1,143.893	391.46
Food, beverages, tobacco	333.855	738.44
Coal and petroleum products	0	58.95
Chemicals	122.628	458.68
Metal manufacture	360.19	550.79
Mechanical engineering	516.326	1,124.85
Instruments	38.578	145.26
Electrical engineering	101.245	843.92
Shipbuilding	155.885	180.42
Vehicles	192.738	788.83
Metal fabrication	494.515	585.98
Textiles	1,298.051	591.48
Leather, fur	89.749	52.85
Clothing, footwear	1,143.559	470.05
Bricks, pottery, glass, cement	194.62	305.76
Timber, furniture	276.191	302.2
Paper, printing, publishing	335.657	612.38
Other manufacturing	105.659	324.95
Total	18,351	23,733
Old industries	3,474	2,839
	50%	33%
New industries	417	2,091
	6%	25%

Source: Lee (1979).

occurred had the menu of consumption options remained as it was in 1850. This was a question of technical change leading to product innovation rather than process innovation. Examples range from bicycles, automobiles, modern chemicals and pharmaceuticals, aircraft, electrical and electronic devices to indoor plumbing and modern kitchens.

Another feature of the new industries was that many were related to developments in the natural sciences. Countries with strong university programmes in these areas reaped economic benefits. Germany is the preeminent example before the 1930s. Its physicists and chemists won many Nobel Prizes. Key technical personnel in industry were trained in universities, and their academic staff made important discoveries that improved industrial processes and led to new products. Fritz Haber's discovery of the process to convert atmospheric nitrogen to ammonia, made when

he was at the University of Karlsruhe and for which he received a Nobel Prize, is one of the most famous but far from unique.

Much of this activity took place outside of Britain – in contrast to the Industrial Revolution when Britain led the world. The spread of invention to other countries was to be expected as they industrialised, but there were two aspects of the process that aroused concern in Britain. The first related to product innovation: Britain seemed to be successful in inventing new products, but not in commercialising them. The second related to process innovation. When new production technology was invented abroad, it was created to respond to local conditions, and this meant that it was not necessarily suitable for British conditions. Britain had become a kind of backward country trying to catch up to the world technology frontier. Economists speak rather glibly of the 'advantages of backwardness', which include the chance for poor countries to quickly catch up to their advance countries by adopting their technology. The rub is that the advance technology, which may have been intended to save labour by using more capital, may not pay when labour is cheap. This is the kind of 'poverty trap' that Britain slipped into as the US leapt ahead by building labour-saving systems such as Ford's mass production techniques.

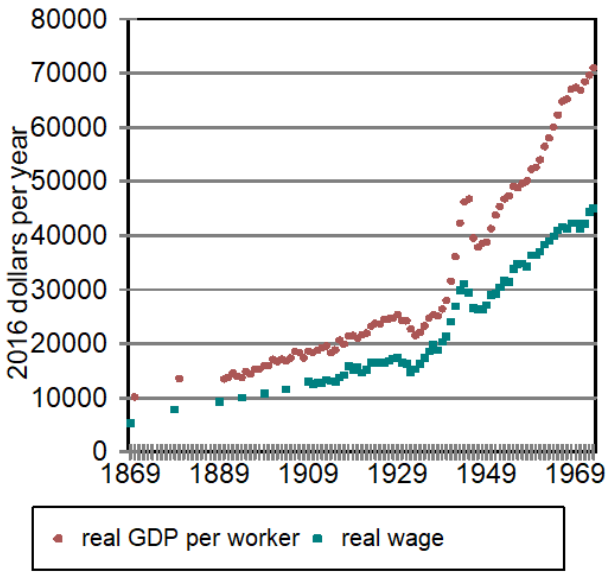
Technology and globalisation influenced wages in the US

Despite – indeed, in part because of – the efforts of inventors to save money by inventing machines to substitute capital for labour, real wages rose rather than fell between the mid-nineteenth century and 1973. Figure 10 shows that real average earnings per person in the labour force rose at the same rate as real GDP per worker from 1869 to about 1950. Both continued to grow thereafter, but the real wage rose somewhat less rapidly. The 'stylised fact' that wages and output per worker grow at the same rate is a generalisation of the history of this period in the US and also in Britain, as we shall see.

The process was, of course, more complex when examined in detail. It is important to distinguish skilled from unskilled labour. Figure 11 shows unskilled wages expressed in 1905 British pence in the US and UK. The wages rates of unskilled workers in the UK and US were strikingly similar until World War I. Skilled wages in the two countries were also similar in the ante bellum period. However, after the Civil War, skilled wages rose more rapidly in the US, and a large gap emerged by the end of the nineteenth century (Figure 12).

Another notable development occurred after World War I. British wages stagnated, while US wages leapt ahead. By 1940, US factory operatives and unskilled workers were making 25%–50% more than British skilled workers (Figure 13). (US skilled workers were making even more than that.) This marked the birth of the so-called 'American middle class'. Their wage gains continued after World War II and only ceased in 1973. Henry Ford (1922, chapter 5) summarised the impact of the new technology as follows: 'I have heard it said, in fact I believe that it's quite a current thought, that we have taken skill out of work. We have not. We have put a higher skill into planning, management, and tool building, and the results of that skill are enjoyed by the man who is not skilled.'

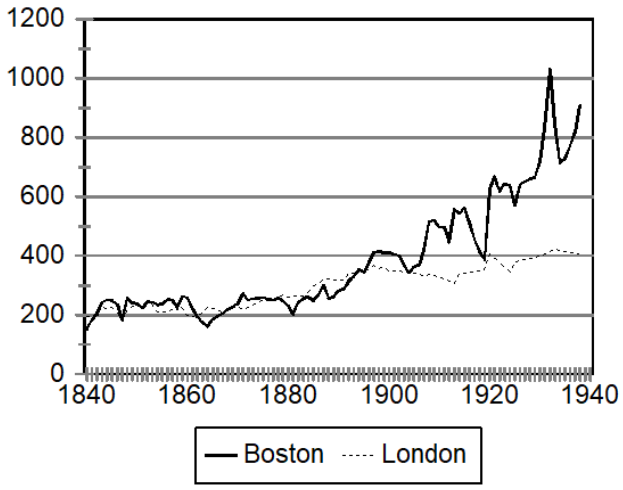
Figure 10. Real output per worker and average labour income per employed person in the US, 1869–1973



Note: 'Real wage' includes the self-employed as well as all employed workers. In this graph, the income of the self-employed is set equal to the average wage and salary of all employed workers.. Various alternatives were explored and gave similar results.

Source: GDP in billions of chained 2009 dollars from https://www.bea.gov.national/index.htm#gdp. Total workers: 1929–90, total employed civilian labour force, US Census Bureau, Historical Statistics of the United States, online, Table Ba471; 1991–2016, Current Population Survey, Labor Force Statistics, series LNS 12000000. Total wage and salary income of all employed workers from US Bureau of Economic Analysis, Table 2.1, Personal Income and Its Disposition, 1929–2019 (https://apps.bea.gov/iTable/iTable.cfm?reqid=19&step=2#reqid=19&step=2&isuri=1&1921=survey). For 'production and non-supervisory workers', total earnings, total number and earnings per worker were computed as follows. 1909–65, US Census Bureau, Historical Statistics of the United States, online, Tables Ba4361 and Ba4362, 'Hourly and weekly earnings of production workers in manufacturing, 1909–1965' and 'Hours worked per week calculated as the ratio'. 1874–1909, productivity and average wage extrapolated backward from 1909 using Budd (1960, p. 398). 1964–2016, Federal Reserve Bank of St Louis, FRED economic data, average hourly earnings of production and non-supervisory employees, total private from https://fred.stlouisfed.org/series/CEU0500000008 and total number from Federal Reserve Bank of St Louis, FRED economic data, production and non-supervisory employees, total private, from https://fred.stlouisfed.org/series/CES0500000006. Total earnings computed as hourly earnings multiplied by 40 hours per week multiplied by number of workers. 40 hours per week is consistent with corresponding data for 1909–65.For 'non-production and supervisory' total earnings, number of workers and earnings per worker were computed as the totals of all employed workers minus the totals for 'production and non-supervisory workers'.

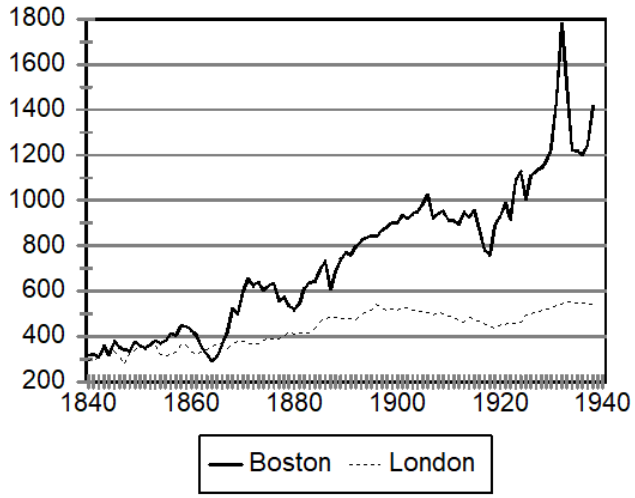
Figure 11. Unskilled real wages in 1905 British pence



Note: Nominal weekly earnings divided by a consumer price index that (in the case of Boston) was converted to sterling using a PPP exchange rate.

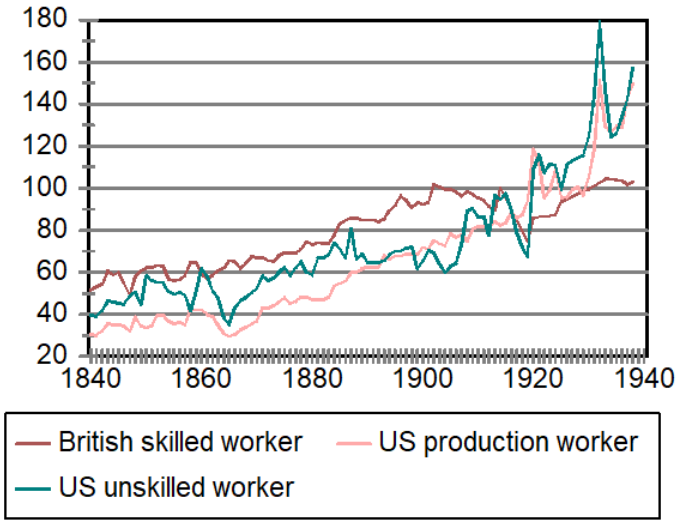
Source: Nominal weekly earnings for Boston: 1840-60, Margo (2000, Table 3A.5, Northeast); 1861–98, Bulletin of the United States Bureau of Labor Statistics, No. 604, pp. 253–60; 1900–28, Bulletin of the United States Bureau of Labor Statistics, No. 604, p. 185 (wage per hour multiplied by hours per week). Nominal weekly earnings for London: 1840–1860, Schwartz (1985, pp.36-8); 1861–1938, Bowley (1937, pp. 10, 15) and UK Department of Employment and Productivity (1971, p. 30, 32). Missing values interpolated. Consumer prices indices for the US from Officer and Williamson (2020) and for the UK from Allen (2007), Feinstein (1998a, pp. 652–3), Feinstein (1972, p. T140) and Bank of England, 'A millennium of macroeconomic data for the UK', Version 3.1, A47 Wages and Prices, Column BY (https://www.bankofengland.co.uk/statistics/research-datasets). The PPP exchange rate for 1905 was constructed using the retail prices of 15 fuels, coal, kerosene and house rent in the two countries. Prices and expenditure patterns are taken from UK Board of Trade (1911, pp. xxii, xxix–xlvii). Although the US data were collected in 1909, the Board of Trade (1911, p. iii) concluded that they could be compared to the UK data collected in 1905 without impairing the comparison.

Figure 12. Skilled real wages in 1905 British pence



Source: See Figure 11.

Figure 13. Creation of US 'middle class' (1905 British £s per year)



Source: For nominal wages of British skilled workers and US unskilled workers and for price indices, see sources for Figure 11. For nominal wages of US production workers, see sources for Figure 17.

Ford was right that technical change played an important role in explaining the course of US wages, but other factors were also at play. Some affected the demand for labour and others the supply.

On the demand side, an important factor that sustained rising wages was the expansion of the US population as the continent was settled. Between 1850 and 1950, the population grew from 23 million to 152 million. Globalisation played a role in this expansion. The international (read British) demand for US grain and beef was buoyant throughout the century. For it to have been profitable to have settled the West, the price of wheat or cattle at the point of production on the frontier had to be high enough to induce labour to give up the chance of earning high wages in the east of the country and move west. The construction of ever more railways meant that more and more homesteads met this condition. Even after the frontier was closed, the West was not fully settled, and the population and economy continued to drift westwards well into the twentieth century. World War II gave a further boost to the great American boom, and the country enjoyed several decades of economic ascendancy in the post-war era.

The effect of the continual rise in population at high and rising wages combined with waves of product innovation was the fastest growing consumer demand in the world. Manufacturing expanded to meet it, and employment of production workers grew almost continuously from 1850 to 1979. The depression of the 1930s, of course, disrupted this expansion, and there was small cyclical fluctuation around the trend, but, in general, the trajectory was ever upward.

Technical progress also contributed to rising wages throughout the period 1867–1973. The replacement of skilled jobs by semi-skilled jobs might appear to be a counter example, but the rapid expansion of the manufacturing sector meant that the demand for skilled labour was rising in the twentieth century, albeit at a lower rate than manufacturing employment as a whole. In addition, the elimination of labouring jobs as material transport was mechanised in conjunction with the creation of new semi-skilled jobs and this meant that skill level overall was rising. As factory labour became more productive, competition among firms for workers led to rises in real wages.

The supply of labour also affected the evolution of wages. Supply changed after World War I because immigration policy changed. Before World War I, there was no restriction on immigration from Europe. As the West was settled and the manufacturing sector expanded, the demand for both skilled and unskilled labour increased. As we noted earlier, the US lacked the system of industrial apprenticeships that sustained Britain's supply of skilled workers. It is hard to escape the conclusion that the supply of unskilled labour from the farms of eastern and southern Europe was much more elastic than the supply of skilled labour from the US itself – even with some assistance of immigrants from the UK and north-western Europe (Goldin, 1994; O'Rourke, 2019).[11] As a result, the rising demand for labour caused the wages of skilled workers to rise, while the immigration of farm labourers dampened any corresponding increase among the unskilled. This 'open door' immigration policy changed after 1921. Immigration no longer put a lid on the wages of unskilled and semi-skilled wages, and they rose, closing the gap with skilled wages.[12] Thus began the 'great compression' of the 1930s and 1940s (Goldin and Margo, 1992).

Labour unions also contributed to the great compression. Unskilled workers in the manufacturing sector were unionised during the 1930s. Previously, unions had often been weak and generally involved only skilled craftsmen. New Deal labour legislation created a favourable environment for organisation, and the Congress of Industrial Organizations succeeded in unionising most manufacturing workers. Wage negotiations tended to reduce wage inequality within the sector.

A final factor to consider is education. In their influential analysis of the race between education and technology, Goldin and Katz (2008) maintain that technical change throughout the twentieth century has increased the demand for educated labour. Their evidence for this claim is that production workers with more schooling earned higher wages than those with less schooling early in the twentieth century. They contend that wage inequality decreases when the supply of educated workers increases. The spread of high schools in the US during the early twentieth century was rapid enough to explain the fall in the skill premium. For emphasis, they dubbed the twentieth century the 'human capital century'.

It is difficult on the face of it to reconcile the Goldin–Katz view of the twentieth century with the de-skilling view of mass production advanced here. It is true that the educational level of the US work force has risen substantially, and conventional growth accounting attributes a lot of productivity growth to the rising educational level of the work force (Denison, 1962; Jorgenson and Griliches, 1967). However, most accounts of factory work emphasise that increases in mechanisation made work more boring (Chinoy, 1955; Bright, 1958a, b; Meyer, 1981). One of the complex aspects of a craftsman's job was laying out the work. Knowledge of geometry and mathematics helped to do that quickly and well. A craftsman could have made use on the job of the Euclidean geometry he had learned in high school. When the layout, however, was built into a machine, the need for that knowledge evaporated. Perhaps Bowles and Gintis (1976) got it right when they argued that what high school really taught students was how to follow instructions and fit into a routine.

Technology and globalisation influenced wages in the UK

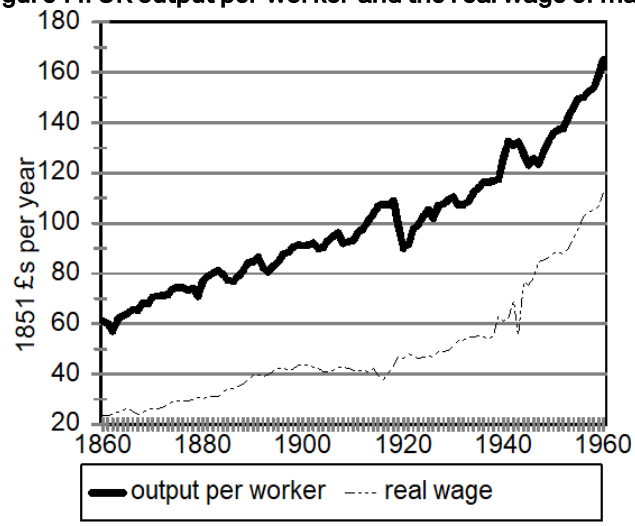
Technological change and globalisation also affected wages in Britain. According to the Solow growth model, the rate of technical progress determines both the growth rate of output per

[11] This view has been contested, for example, by Goldin and Katz (2008).

[12] The end of the mass immigration of European farmers created the opportunity for African–Americans to leave their farms in the South and move to factory work in the North (Collins, 1997).

worker and the growth rate of the real wage. Over the period 1860–1960, this prediction was substantially born out. Figure 14 plots the two series, and, in the long term, they grew in tandem. Indeed, after World War II, the growth of the real wage accelerated with respect to the growth in output per worker.

Figure 14. UK output per worker and the real wage of manual workers, 1860–1960



Source: Bank of England, 'A millennium of macroeconomic data for the UK', Version 3.1 https://www.bankofengland.co.uk/statistics/research-datasets; Allen (2009b).

How does Britain's performance compare to that of other countries? Table 4 shows GDP per head in 2011 US$. In 1850, per capita income was higher in Britain than in any other country in the table. In 1899, however, the US overtook the UK by these figures and has remained above it ever since. By 1910, Switzerland had also overtaken Britain, and by 1950 Sweden and Denmark had pulled ahead. The table, however, makes the important point that, as late as 1960, Britain was otherwise at the top of the European table.

Table 4. GDP per head in leading countries, 1850–1960 (2011 US$ per person)

1850		1900		1910		1925		1938		1950		1960	
UK	**3,189**	**USA**	**6,270**	**USA**	**7,608**	**USA**	**9,629**	Switzerland	9,521	**USA**	**14,655**	Switzerland	19,151
USA	**2,768**	**UK**	**6,146**	Switzerland	6,535	Switzerland	7,842	**USA**	**9,390**	Switzerland	13,681	**USA**	**17,600**
Netherlands	2,371	Switzerland	5,785	**UK**	**6,363**	**UK**	**6,896**	**UK**	**8,456**	Sweden	9,970	Sweden	13,454
Belgium	1,847	Belgium	5,517	Belgium	6,101	Belgium	6,791	Sweden	7,850	Denmark	9,453	Denmark	12,523
Denmark	1,767	Denmark	4,624	Denmark	5,286	Netherlands	6,467	Denmark	7,847	**UK**	**9,242**	**UK**	**11,937**
Austria	1,650	Netherlands	4,405	Netherlands	4,891	Denmark	6,046	Belgium	7,190	Norway	8,850	Norway	11,535
France	1,597	Austria	4,155	Austria	4,744	France	5,732	Norway	7,006	Belgium	8,098	Netherlands	11,496
Switzerland	1,488	France	4,043	France	4,184	Sweden	5,068	Netherlands	6,746	Netherlands	7,796	France	10,517
Germany	1,428	Ireland	4,023	Sweden	4,088	Austria	4,880	France	6,075	France	7,025	Belgium	10,492
Italy	1,350	Germany	3,411	Germany	4,049	Norway	4,708	Germany	6,002	Finland	5,942	Germany	10,215
Sweden	1,289	Sweden	3,254	Ireland	3,882	Germany	4,360	Finland	5,587	Austria	5,371	Austria	9,369
Norway	1,188	Norway	3,058	Norway	3,566	Spain	3,919	Austria	5,099	Ireland	5,123	Finland	9,245
Spain	1,079	Spain	2,873	Spain	3,042	Finland	3,776	Ireland	4,475	Germany	4,669	Italy	7,275
Portugal	923	Finland	2,557	Finland	3,026	Italy	3,706	Italy	4,247	Italy	4,319	Ireland	6,478
Finland	911	Italy	2,231	Italy	2,949	Ireland	3,624	Spain	2,910	Spain	3,551	Spain	5,798
Ireland	834	Portugal	1,869	Portugal	1,638	Portugal	1,821	Portugal	2,270	Portugal	2,785	Portugal	4,383

Source: GDP (2011 US$) divided by population as given by Rosés and Wolf (2019) data base and Maddison (2006) for 1850. GDP (2011 US$) for 1950–2010 from Penn World Table, version 9.0 (Feenstra et al., 2015). GDP extended back to 1900 using real GDP data in Rosés and Wolf (2019). 1900 GDP extended back to 1850 using real GDP series in Maddison (2006).

Table 5. Regional GDP per worker relative to the European mean regions, 1900–60

	1900		1910		1925		1938		1950		1960
London C	2.23	Belg-grea	2.20	London C	1.87	London C	2.13	Switzerlar	2.14	Luxembo	2.11
Belg-grea	1.95	Belg-Wall	2.05	Belg-grea	1.83	Wales	1.70	Luxembo	1.91	Switzerlar	1.87
Belg-Wall	1.88	Luxembo	2.01	Neth-W	1.80	Belg-grea	1.68	Isle-de-fra	1.80	Hamburg	1.72
Luxembo	1.86	London C	1.99	Isle-de-fra	1.73	Rest of Sc	1.65	Belg-grea	1.75	Isle-de-fra	1.65
Isle-de-fra	1.77	Belg-Flan	1.78	Madrid	1.68	Luxembo	1.61	Swed-eas	1.69	Neth-W	1.58
Rest of Sc	1.73	Rest of Sc	1.78	Rest of Sc	1.63	West Mid	1.60	London C	1.68	Belg-grea	1.54
SouthWes	1.57	Neth-W	1.52	Belg-Flan	1.59	Switzerlar	1.60	Swed-sou	1.58	Swed-eas	1.50
Belg-Flan	1.57	Switzerlar	1.51	Belg-Wall	1.54	Neth-W	1.52	Neth-W	1.58	Swed--no	1.44
North	1.56	North	1.50	Switzerlar	1.54	Swed-eas	1.52	Swed--no	1.56	Bremen	1.38
East Midl	1.55	SouthWes	1.49	Luxembo	1.50	Belg-Flan	1.47	Belg-Flan	1.50	Neth-S	1.37
Neth-W	1.55	East Midl	1.45	SouthWes	1.43	SouthWes	1.46	Belg-Wall	1.48	London C	1.36
Madrid	1.50	Scotland	1.41	North	1.35	Yorks & H	1.39	Rest of Sc	1.46	Swed-sou	1.32
Scotland	1.47	Isle-de-fra	1.40	Wales	1.34	Belg-Wall	1.36	West Mid	1.44	Neth-N	1.29
Switzerlar	1.45	Yorks & H	1.37	Spain-E	1.33	Scotland	1.34	North	1.43	Neth-E	1.26
Yorks & H	1.43	West Mid	1.35	East Midl	1.32	Swed-sou	1.28	Neth-S	1.42	Belg-Wall	1.26
Wales	1.42	Wales	1.33	Neth-E	1.32	Berlin	1.27	Wales	1.41	Belg-Flan	1.25
West Mid	1.39	Berlin	1.33	West Mid	1.31	North	1.25	SouthWes	1.41	Rest of Sc	1.22
Hamburg	1.36	Swed-eas	1.30	Scotland	1.30	East Midl	1.24	East Midl	1.41	Wales	1.21
Berlin	1.36	Madrid	1.29	Mediterra	1.27	Isle-de-fra	1.23	Yorks & H	1.40	Nordrheir	1.17
Bremen	1.33	Hamburg	1.27	Neth-N	1.26	Neth-N	1.23	Scotland	1.37	Centre-es	1.17
Finland	1.28	Bremen	1.23	Yorks & H	1.26	Swed--no	1.21	Denmark	1.36	Est	1.17
Spain-E	1.20	Aust-east	1.22	Swed-eas	1.22	Norway	1.21	Neth-N	1.31	West Mid	1.17
Nord	1.17	Saarland	1.22	Spain-NE	1.20	Neth-E	1.18	Neth-E	1.30	Nord	1.16
Aust-east	1.16	Est	1.20	Neth-S	1.18	Bremen	1.16	Mediterra	1.14	SouthWes	1.15
Ireland	1.10	Spain-E	1.19	Nord	1.12	Hamburg	1.15	Nord	1.10	North	1.14
Neth-N	1.10	Neth-N	1.17	Aust-east	1.12	Mediterra	1.10	Northern	1.09	Scotland	1.14
Saarland	1.10	Nordrheir	1.17	Hamburg	1.12	Neth-S	1.10	Est	1.08	East Midl	1.13
Mediterra	1.09	Neth-S	1.16	Bremen	1.10	Aust-east	1.06	Centre-es	1.07	Yorks & H	1.11
Nordrheir	1.09	Swed-sou	1.13	Berlin	1.08	Sachsen	1.03	Bassin par	1.00	Saarland	1.09
Neth-E	1.08	Neth-E	1.10	Est	1.07	Madrid	1.03	Italy-NW	1.00	Bassin par	1.07
Est	1.08	Swed--no	1.10	Swed-sou	1.05	Saarland	1.03	Hamburg	0.96	Mediterra	1.07
Northern	1.05	Ireland	1.03	Northern	1.02	Nordrheir	1.01	Aust-east	0.94	Hessen	1.03
Swed-eas	1.05	Spain-NE	1.02	Swed--no	1.02	Italy-NW	0.95	Finland	0.92	Baden-W	1.00
Spain-NE	1.03	Mediterra	1.02	Centre-es	1.01	Sachsen-A	0.94	Madrid	0.91	Finland	0.98
Neth-S	1.03	Hessen	1.00	Norway	1.01	Finland	0.93	Nordrheir	0.88	Italy-NW	0.97
Swed--no	1.00	Northern	0.98	Bassin par	1.00	Northern	0.89	Ireland	0.87	Aust-east	0.97
Bassin par	0.94	Sachsen	0.97	Saarland	0.99	Thuringer	0.89	Bremen	0.86	Niedersac	0.97
Sachsen	0.93	Rheinlanc	0.96	Nordrheir	0.94	Rheinlanc	0.89	Sud-ouest	0.84	Berlin	0.94
Schleswig	0.92	Nord	0.95	Sud-ouest	0.85	Nord	0.88	Baden-W	0.80	Schleswig	0.94
Hessen	0.91	Baden-W	0.91	Italy-NW	0.85	Schleswig	0.86	Hessen	0.80	Northern	0.93
Rheinlanc	0.88	Brandenb	0.88	Sachsen	0.83	Hessen	0.85	Ouest	0.77	Sud-ouest	0.92
Centre-es	0.85	Finland	0.87	Ireland	0.82	Brandenb	0.85	Italy-NE	0.75	Madrid	0.91
Swed-sou	0.85	Schleswig	0.86	Canaries	0.81	Ireland	0.85	Spain-E	0.75	Bavaria	0.88
Baden-W	0.83	Spain-S	0.86	Ouest	0.80	Centre-es	0.84	Spain-NE	0.74	Aust-Wes	0.86
Niedersac	0.83	Thuringer	0.84	Spain-S	0.79	Baden-W	0.83	Bavaria	0.73	Meckelnb	0.83
Brandenb	0.80	Bassin par	0.83	Italy-cent	0.78	Est	0.83	Schleswig	0.72	Italy-cent	0.81
Sachsen-A	0.79	Aust-Wes	0.83	Finland	0.78	Bassin par	0.82	Italy-cent	0.72	Brandenb	0.81
Aust-Wes	0.78	Centre-es	0.80	Rheinlanc	0.77	Niedersac	0.80	Rheinlanc	0.71	Ouest	0.81
Spain-S	0.77	Sud-ouest	0.77	Aust-Wes	0.76	Aust-Wes	0.77	Saarland	0.71	Sachsen-A	0.80
Thuringer	0.76	Italy-NW	0.77	Spain-Cer	0.74	Spain-E	0.77	Niedersac	0.70	Thuringer	0.80
Sud-ouest	0.75	Niedersac	0.75	Italy-NE	0.72	Italy-cent	0.76	Norway	0.70	Rheinlanc	0.80
Bavaria	0.71	Sachsen-A	0.74	Hessen	0.72	Meckelnb	0.74	Berlin	0.69	Aust-sout	0.79
Meckelnb	0.70	Italy-islan	0.74	Italy-islan	0.70	Bavaria	0.73	Aust-Wes	0.68	Italy-NE	0.78
Spain-Cer	0.69	Bavaria	0.73	Schleswig	0.68	Aust-sout	0.71	Meckelnb	0.64	Spain-E	0.78
Ouest	0.69	Meckelnb	0.73	Thuringer	0.68	Sud-ouest	0.71	Aust-sout	0.63	Ireland	0.78
Aust-sout	0.68	Spain-Cer	0.73	Aust-sout	0.67	Italy-NE	0.70	Brandenb	0.59	Spain-NE	0.78
Italy-NW	0.60	Aust-sout	0.72	Sachsen-A	0.66	Italy-islan	0.70	Thuringer	0.57	Sachsen	0.77
Denmark	0.58	Italy-cent	0.71	Spain-NW	0.66	Spain-NE	0.69	Sachsen-A	0.56	Denmark	0.65
Italy-islan	0.58	Ouest	0.67	Baden-W	0.65	Ouest	0.66	Canaries	0.55	Italy-islan	0.59
Italy-cent	0.55	Italy-NE	0.65	Italy-S	0.63	Denmark	0.61	Italy-islan	0.53	Norway	0.59
Canaries	0.52	Canaries	0.62	Niedersac	0.63	Italy-S	0.57	Sachsen	0.52	Italy-S	0.58
Italy-NE	0.50	Italy-S	0.58	Bavaria	0.60	Spain-S	0.52	Spain-NW	0.52	Canaries	0.56
Portugal	0.45	Spain-NW	0.53	Brandenb	0.58	Portugal	0.50	Portugal	0.52	Spain-S	0.53
Italy-S	0.44	Norway	0.45	Meckelnb	0.51	Spain-NW	0.44	Spain-Cer	0.52	Portugal	0.53
Spain-NW	0.44	Portugal	0.43	Portugal	0.45	Spain-Cer	0.43	Spain-S	0.52	Spain-Cer	0.51
Norway	0.40	Denmark	0.30	Denmark	0.41	Canaries	0.42	Italy-S	0.48	Spain-NW	0.51

Source: Regional GDP divided by regional employment and normalized to the mean. GDP for countries (Table 4) apportioned to regions using shares from the database of Rosés and Wolf (2019), who kindly provided me with their estimates of employment by region, for which I am very grateful.

It is important to appreciate that throughout this period, all of the UK's regions shared in its prosperity. The graphic in Table 5 shifts the metric to output per worker to put the information firmly on a productivity basis, and displays the data for NUTS1 and NUTS2 regions across Europe.[13] Regions in leading countries have been colour-coded to facilitate comparison. The UK is red.

The UK performance is impressive by this measure. The ranking in 1900 shows the prosperity achieved by the UK's early industrialisation: all of the UK regions were at the top of the league table. It is no surprise that London leads the table given its role in international trade and finance. The other regions are near the top in view of their highly productive industrial sectors. Other top ranked regions include Paris, another great financial centre, Belgium, which was the continent's first industrialiser, Switzerland and Luxembourg, whose performance is probably overstated given its small size and commuters from neighbouring countries. Both Northern Ireland and the Republic of Ireland, which was part of the UK at the time, had incomes above the European average. The situation in 1910 was slightly less favourable, the major change being the downward slippage of both parts of Ireland. But still the situation before World War I is a testament to British economic performance.

British success continued across the period. World War I did not dislodge it, and, on the eve of World War II, Britain was still western Europe's leading economic power. This state of affairs continued until 1960. Economic development on the continent was underway, of course, and it shows up in the upward movement of Scandinavia, the Netherlands and some German districts, which pushed British districts downwards. Despite the blows inflicted on the Victorian staple industries by the overvalued exchange rate and the loss of so many export markets, GDP per worker in all UK regions remained above the west European average. Northern Ireland is the exception to these generalisations.

Britain's lead in labour productivity led to high real wages. I begin with the situation in 1870. At that date, the real wage of unskilled workers in the UK was about the same as in the US, but UK skilled workers lagged behind their US counterparts. In comparison with Europe, however, the UK was doing very much better. Table 6 shows rankings of the average real wage of unskilled workers in European countries around 1872, 1905 and 1933. The average real wage of manufacturing workers in 1960 is also shown.[14] In this table, the real wage is computed as the ratio of the weekly wage divided by the cost of maintaining an average size family at the consumption standard of a German skilled worker in 1906–7.[15] The source for 1960 reports a national average; in all of the other years, the national figures shown are averages of cities in the countries concerned.

[13] The UK Office of National Statistics has produced a series of reports comparing GDP per worker in regions of the UK, Germany, Italy, France, Spain and the Netherlands for recent years (see, for example, https://www.ons.gov.uk/economy/nationalaccounts/uksectoraccounts/compendium/economicreview/april2018/regionalandsubregionalproductivitycomparisonsukandselectedeucountries2014). In this commentary, I broaden the range of countries and extend the comparisons back to 1900 to study their historical evolution. My results for recent years are consistent with the ONS estimates for the same period.

[14] In this endeavour I follow the pioneering comparisons of Williamson (1995) for 1905–11, 1931–3 and 1960. I have shifted the years, however, to broaden the comparisons where possible, refined the PPP exchange rate calculations, and aligned the exercise with the periods adopted here.

[15] Based on Budgets in the UK Board of Trade, 'Report of an Enquiry by the Board of Trade into Working Class Rents, Housing and Retail Prices Together with the Rates of Wages in Certain Occupations in the Principal Industrial Towns of the German Empire', Parliamentary Papers, cd. 4032, 1908, Vol. CVIII, p. xx, class 25–30 shillings per week.

Table 6. Real wages across Europe, 1872–2011

1872		1905		1933		1960		2011	
Gt Britain	**0.89**	**Gt Britain**	**0.92**	Denmark	1.79	**Gt Britain**	**1.94**	Switzerland	6.63
Denmark	0.75	Ireland	0.84	Netherlands	1.57	Sweden	1.77	Denmark	6.60
Netherlands	0.63	Denmark	0.83	Norway	1.54	Norway	1.64	Norway	6.55
Latvia	0.61	Sweden	0.81	Sweden	1.45	Netherlands	1.57	Sweden	5.15
Germany	0.55	Germany	0.80	**Gt Britain**	**1.34**	Germany	1.36	Finland	5.09
Belgium	0.55	Belgium	0.79	Germany	1.17	Finland	1.23	Ireland	5.01
Switzerland	0.53	Norway	0.72	Switzerland	1.06	Switzerland	1.18	Belgium	4.98
Russia	0.50	France	0.70	Ireland	1.02	Ireland	1.13	Spain	4.79
Sweden	0.45	Netherlands	0.67	Belgium	0.91	Belgium	1.07	Germany	4.74
Norway	0.41	Spain	0.44	Austria	0.78	France	0.99	Netherlands	4.55
Greece	0.38	Italy	0.40	France	0.74	Austria	0.92	Austria	4.35
France	0.35	Estonia		Croatia	0.71	Italy	0.56	Italy	4.05
Italy	0.31	Austria		Estonia	0.70	Denmark		France	4.00
Portugal	0.30	Finland		Poland	0.69	Spain		**Gt Britain**	**3.78**
Austria		Poland		Latvia	0.65	Poland		Greece	3.56
Ireland		Portugal		Spain	0.55	Portugal		Slovenia	2.77
Finland		Latvia		Italy	0.50	Estonia		Poland	2.68
Estonia		Switzerland		Slovenia	0.47	Latvia		Estonia	2.08
Serbia		Serbia		Serbia	0.41	Serbia		Russia	2.03
Slovenia		Slovenia		Portugal	0.24	Slovenia		Serbia	1.86
Croatia		Croatia		Finland		Croatia		Latvia	1.62
Poland		Greece		Greece		Greece		Portugal	1.59
Spain		Russia		Russia		Russia		Croatia	

Note: The same set of countries is shown in each year. Blanks indicate missing values. Great Britain and the leading economies of western and northern Europe are shown throughout, but the representation of central and eastern Europe is erratic.

Source: Computed from Young (1875), Williamson (1995) and his sources, Williamson and Lindert (1980), Summers and Heston (1984), International Labor Office (1932, 1934), and International Labor Organization, ILOSTAT, mean monthly earnings of employees by sex and activity for 2011 in US dollars at 2011 purchasing power parity (https://ilostat.ilo.org/topics/wages/).

The important point made by Table 6 is that British workers were amongst the highest paid from 1870 to 1960. In 1870, they were number one. An unskilled labourer in Britain earned almost enough to enjoy the standard of living that a German skilled worker had achieved in 1905. Furthermore, the underlying city data show that this standard of living was achieved in all parts of Great Britain and Northern Ireland.[16] This favourable ranking was repeated in 1905. Britain's Industrial Revolution had paid off for the working class.

Scandinavian real wages rose dramatically between 1872 and 1933, and by the latter date, the Scandinavians and the Dutch had overtaken Britain for the top spots. But British wages were still above those on the rest of the continent often by very large margins. By 1960, British manufacturing wages were once again in the number one position in western Europe

Why did Britain do so well? Part of the answer is globalisation, which had its greatest positive impact before World War I. With the repeal of the Corn Laws in 1846 and the Navigation Acts three years later, Britain embarked on a policy of tariff-free trade that lasted until 1932. One consequence was that Britain obtained its food from the cheapest possible source. By the middle of the nineteenth century, exports of wheat and beef from North America, Australia, Russia and Argentina began to grow inexorably. The settlement of the American West and Canadian prairies led to a vast expansion in wheat production and exports to Europe. This was a challenge for all countries because production costs were lower on the Great Plains. Leading continental producers such as France, Germany and Italy reacted by imposing substantial tariffs on grain imports. These charges protected small-scale peasant producers as well as German Junkers at the cost of high food prices that disadvantaged urban workers. Britain, in contrast, remained faithful to free trade, with the result that grain prices in Britain were relatively low. Grain production contracted, and land was shifted to pasture. The gainers in Britain were the urban workers, who paid less for their food. As food was a big part of their spending, free trade and globalisation contributed to rising real wages in Britain (O'Rourke, 1997).

A second reason for high wages in the UK was technological high productivity in all of the UK's regions. Despite all of the worries about UK performance in this regard, GDP per worker was high by European standards, as we have seen. The situation remained favourable to the UK through the 1950s. By 1960, however, there were signs of relative slippage as north-west Europe boomed, but UK regions were still generally 15%–20% more productive than the European mean.

6. Phase 4: the shift to services, 1973–2020

Wages affected technology

If the popular media and blogosphere are to be believed, we are now living through a period of unprecedented technological change. Terms such as the 'fourth industrial revolution' encapsulate the view that IT and artificial intelligence are remaking the economy. In addition, the outsourcing of production to China and other developing countries highlights the (possibly growing) importance of globalisation. The significance of these developments can only be assessed by locating them within the overall evolution of the economy.

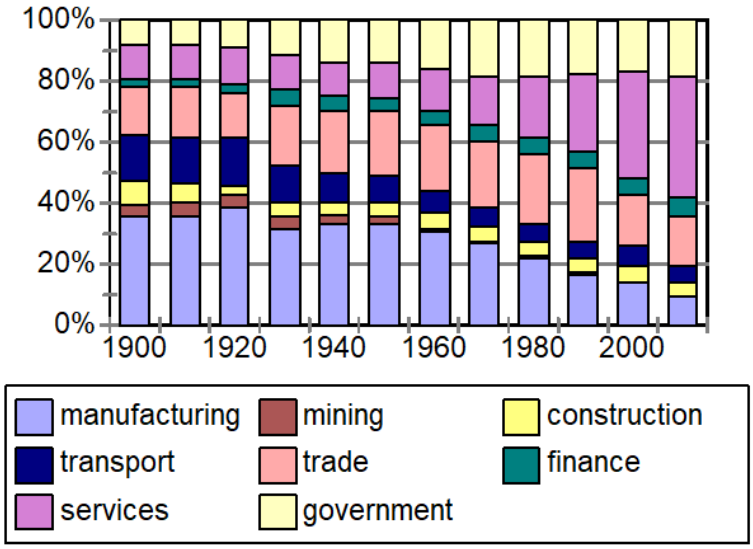
The US economy has been transformed since the 1960s in several important respects. A fundamental change is the collapse in manufacturing and the rise of the service sector. Figure 15 summarises some of the important trends in employment in the non-agricultural economy since

[16] For further confirmation of the uniformity across Britain in wages, see also British Labour Statistics: Historical Abstract, 1886–1968 (pp. 32–3).

1900. In the first decades of the twentieth century, manufacturing accounted for almost 40% of the jobs. Together with its near relatives – mining, construction and transportation (read railways) – modern industry accounted for over 60% of the non-farm economy. These sectors were closely linked and shared many of the same industrial relations practices and generated similar wages. The government also tended to match these wages. 'Modern industry' was a big enough share of the economy to sustain the American middle class, which is why it is important.

All this has changed. The share of employment in manufacturing and related sectors declined modestly between 1920 and the 1960s, but was still large enough to provide widespread prosperity. Since the 1960s, the decline has been precipitous. By 2010, manufacturing employed only 9% of the non-farm workforce – including mining, construction and transportation only brings the share up to 19%. Government employs only 17%. All of the rest was private services. These ranged from doctors, teachers and business consultants to waitresses, checkout clerks, hospital orderlies and parking lot attendants. The managerial and professional jobs generally require technical training or university degrees, while the sales and low-skill service jobs do not. As we will see, the former have had rapidly rising real incomes in the last 50 years, while the latter earn low incomes that have been static in many (but not all) cases. The shift to a service economy means that the standard living of the bulk of the US population is no longer determined by the wage level in manufacturing, transport or construction, but rather in services. And wage inequality is very great in that sector.

Figure 15.US non-farm employment trends



Source: US Census Bureau, Historical Statistics of the United States, online, Table Ba840-848, Employees on non-agricultural payrolls, by Industry: 1919–1999 [Bureau of Labor Statistics], extended to 2010.

What factors account for this enormous structural change? I begin with manufacturing. The Great Depression aside, we saw earlier that employment in manufacturing increased steadily after 1850. It peaked in 1979 at 20 million jobs and has since fallen by half for a loss of almost nine million. Declines have been uneven across industries. Apparel, footwear and textile mill products peaked earlier and have suffered declines of the order of 90% in employment. Primary metals have lost 70% of their peak number of jobs. However, chemicals, fabricated metals and transportation equipment have seen only small falls, and employment in food and beverage production is at an all-time high. Computers showed explosive growth for several decades but, in recent years, employment in that industry has been falling as well.

Why did this happen? Globalisation is an obvious suspect, for the spread of industrialisation to poor, low-wage countries has made them competitive in cloth, apparel and footwear, and imports of these products explain much of the decline in employment in these industries. Imports now account for almost 90% of the US market in footwear and apparel. Imports have also made inroads in cloth (41%), furniture (30%), computers (36%) and electrical machinery (58%). In other industries such as primary metals, non-electrical machinery, paper, printing and publishing, however, import penetration is generally less than 10% and often negligible, and yet employment has fallen 50%–75%. Clearly, something besides imports from low-wage countries is involved.

Aggregate statistics point to the same conclusion. Total imports of manufactures equalled 12% of shipments of manufactures in 2016. If US factories had expanded to replace those imports and employment increased proportionally, manufacturing jobs would have grown by 1.4 million workers. This figure is less than the two million workers suggested by the more complicated analyses of Autor, Dorn and Hanson (2013, p. 2140) and Acemoglu et al. (2016, s145). These take account of re-allocation, inter-industry linkages, and general equilibrium effects. None of these estimates is large enough to explain the decline in manufacturing employment.[17] In addition, declines in manufacturing employment started in 1970 or earlier – when imports of manufactures were either non-existent or inconsequentially small. Furthermore, as Feenstra et al. (2018) point out, the US is a major exporter of manufactures and increases in exports raised manufacturing employment by about as much as imports reduced it. If the issue is the impact of greater globalisation on US manufacturing employment, as it is, then the export side must be included, and that offsets the import side.

Perhaps technical change has been the culprit. Production processes have, indeed, been redesigned to be more capital intensive. Between 1950 and 2014, the wage of a US production worker relative to the Penn World Table cost of capital more than doubled, and the corresponding ratio in the UK increased almost fourfold. The capital–labour ratio increased almost sevenfold between 1965 and 2014 in the UK, while it tripled in the US. Between 1970 and 2016, output per worker in US manufacturing increased almost fivefold.[18] If all else other than productivity had stayed the same, then today employment in manufacturing would be almost five times its present level.

What about computers and robots? The period after World War II has been marked by the proliferation of computer and IT systems and their integration into business practice. These represent the substitution of capital for labour at an accelerated rate. The substitution has been driven by rapidly falling prices: computers and related equipment dropped in price (adjusted for quality) by about 20% per year between 1973 and 2010. Semiconductor and software prices also fell, although not as rapidly. Between 1947 and 1973, computers made little contribution to the growth in aggregate US total factor productivity growth or the decline in manufacturing employment. Since 1973, total factor productivity growth in the US economy has been driven mainly by productivity growth in the IT sector itself and in the industries that use IT extensively, which are mainly services. Labour productivity has risen in manufacturing outside of IT primarily because of increases in capital intensity (Jorgenson, Ho and Samuels, 2016).

Since around 1990, the installation of industrial robots has proceeded very rapidly in east Asia, North America and Germany. This trend was driven by a steep fall in the quality-adjusted price of

[17] Pierce and Shott (2016) argue that the US granting Permanent Normal Trade Relations to China in 2000 explains the 18% decline in US manufacturing employment between 2000 and 2007.

[18] In this calculation, real gross output is divided by employment. A smaller increase is obtained by dividing real value added by employment.

robots. Even with production workers realising no increase in their real (consumption) wage, the rate of return to installing robots has risen dramatically. Robots are promoted on the grounds that they are a cost-effective way of substituting capital for labour in manufacturing, so factor prices are integral to their diffusion and invention. Robots are an accelerated iteration of the technical change that has characterised the past two centuries.

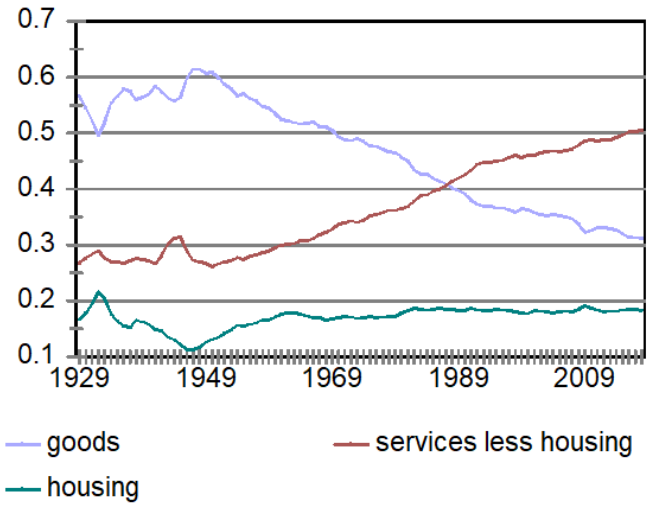
Another development in management practice has also made a small contribution to the reduction in measured employment in manufacturing, and that is domestic outsourcing. It is not unusual now for employers to replace directly employed workers with workers provided by service firms or on other irregular contracts, in which case the worker is tallied by the statistical agencies as being employed in the service sector rather than in manufacturing. This practice is most common in education, health, construction, and business and personal services. Katz and Krueger (2019) estimated about 11% of workers in manufacturing were employed on these contracts.[19] Some of these would have been tallied (misleadingly) as service sector workers. If they all were so tallied, they would have totalled about one million in 2016. This is only a small fraction of the decline of production employees, let alone all employees, that the US manufacturing sector has experienced.

There is a subtle issue in assessing the role of technical change in the decline in manufacturing employment. Technical change means that output per worker has increased. This occurred in the Age of Manufactures and was then manifested as an increase in employment accompanied by an even greater proportional increase in output. Today productivity is also rising but manufacturing employment is declining. Why the difference? The answer is that demand for manufactures is only slowly increasing. In aggregate, this has not been due to the replacement of domestic production by imports, but rather by a fundamental shift in the structure of demand in the economy. In the US, the structure of consumer demand has shifted from manufactures to services, and this has depressed the growth rate of manufacturing output. From 1929 until 1970, goods rather than services comprised at least half of what consumers bought. By the late 1980s, the share had dropped to 40% and today it is 31% (Figure 16). The price of services was rising with respect to the price of goods, which indicates that the shift to services reflected a demand increase in their favour. This is often attributed to Engel's law–the observation that as people become richer their consumption of food levels out while their consumption of manufactures increases until it, too, decelerates and the consumption of services rises.

It is not enough to assume that the demand for manufactures automatically weakened by treating Engel's law as a deus ex machina. The demand for manufactures was sustained by product innovation in the late nineteenth and much of the twentieth centuries – it was the invention of bicycles, cars, televisions and so forth that kept Americans buying manufactured goods. Product innovation has continued since World War II. Playstations and smart phones are in the same tradition but have not had the decisive importance of the earlier inventions.

[19] The surveys analysed by Dorn, Schmieder and Spletzer (2018) point to a similar conclusion.

Figure 16. The shift in consumer expenditures from goods to services



Source: US Bureau of Economic Analysis, Table 2.4.5, Personal Consumption Expenditures by Type of Product, 1929–2019 (https://apps.bea.gov/iTable/iTable.cfm?reqid=19&step=2#reqid=19&step=2&isuri=1&1921=survey).

Many new products have their roots in mission-oriented research (Nelson and Wright, 1992, pp. 1950–4). Many of the electronics innovations are spin-offs of technology developed for military purposes. All of the major features of the iPhone touch screens, for instance, and GPS are commercial applications of technology developed under US defence contracts (Mazzucato, 2013). The original purpose was the solution of a military problem and not cost reduction or commercial advantage.

Modern drugs and medical instruments are also the results of mission-oriented research in the health area. These discoveries have played a fundamental role in shifting consumer demand. While they are produced by manufacturing firms, most are dispensed through the service sector. The share of consumer spending on health care has risen from 2% in 1929 to 16% today, and this would not have happened without the advances in medical technology that prompted the expenditures. The growth of income in the health sector was also due to its organisation, which has led to very high prices and the promotion of high-cost interventions (Case and Deaton, 2020).

Other innovations that promoted the sectoral shift include the IT revolution that has created many new jobs managing or exploiting information technology (Acemoglu and Restrepo, 2018, 2019). Many of these jobs are in the service sector, and schools and universities – components of the service sector – have expanded to train people in the new technology wherever it is used. In addition, globalisation played a role as people's taste in cuisine was broadened to include eating dishes from around the world. A rising demand for travel was a counterpart.

These changes in spending shares mattered. Had the share spent on goods remained at 50%, the consumption of manufactures by consumers would have been two-thirds greater than it is now, and this would have translated into a commensurately greater manufacturing sector and a higher level of employment had import penetration remained as it is. Under these circumstances, there would not have been much of an employment decline in manufacturing employment.

Wages, globalisation and economic policy affect the evolution of the economy and technology in the UK

The late 1950s was also the high point of the Age of Manufactures in the UK. Since then, the UK economy has also been radically restructured into a service economy. In 1960, value added in industry (mining, manufacturing, construction and utilities) amounted to 47% of UK GDP. By 2015, the share had dropped to 19%. Most of the drop was in manufacturing whose share fell from 36% to 10%. Employment statistics tell the same story. These falls were counterbalanced by the explosion in services, which grew from 49% to 80% of GDP. Education, health, and financial and business services were the big gainers in the service sector and accounted for most of its expansion.

Has the service revolution been a satisfactory basis for economic development? Economists are inclined to say that anything that passes through the market is OK, so services are as good as manufacturing. Many other people disagree. Rather than debate this question abstractly, the aim here is to examine what has happened since 1960. International comparisons provide a context for assessing British performance. They point to bleak conclusions.

The UK's macroeconomic statistics were satisfactory towards the end of the Industrial Era. From 1945 to 1973, output and productivity rose more rapidly than they had since the middle of the nineteenth century. There was full employment and stable prices. Nevertheless the period was filled with gloom about the UK's economic performance (Feinstein, 1994, pp. 95–6). The reason for this was that many continental countries and Japan were growing even faster, so the UK's leads in income and manufacturing were slipping. This 'relative decline', of course, had begun before World War I. On the policy plain, Labour and some Conservative governments promoted interventionists policies to promote technological advance in industry. Many more conservatives, however, advocated for a reduced role of the state and the free play of market forces. In 1979, Mrs Thatcher became prime minister, and her government began putting these ideas into practice, transforming the political and economic landscape.

In cliometric circles, the response to the UK's performance was less alarmist. A popular appeal was to the convergence hypothesis. Baumol (1986) produced a regression that showed that growth rates were faster in countries that were poorer. This finding was taken by many economic historians – incorrectly, as it happens (Friedman, 1992) – as confirmation of their view that poor countries could catch up to rich countries by importing their technology. Millions of cross-country regressions followed as economists sought to work out the implications and limitations of this idea. Convergence was taken up by several authors (Feinstein, 1994; Milward, 1994; Supple, 1994) in the second edition of 'The Economic History of Britain since 1870'. It provided a comforting narrative for Britain's relative decline, for it suggested that all of the rich countries, at least, would end up with similar incomes. There was nothing that Britain could do about that, and nothing to worry about either. Not all cliometricians were this sanguine, however. In a series of papers, Crafts (1991, 1998, 2012, 2014) and Broadberry and Crafts (2003) have argued that the UK underperformed in productivity terms up to 1979, at which point productivity began to rise rapidly, stimulated by the increased competition and trade union reforms pushed by the Thatcher regime.

The convergence hypothesis looks ever more shaky as time goes by. The countries of western Europe have not all ended up at the same income level. Table 7 shows the income rankings, and the UK has slid steadily down it, as more and more countries have overtaken her. As late as 1960, the UK had the highest GDP per head of any large country in western Europe – exceptions being Switzerland, Sweden and Denmark. The UK ranked fourth out of the 16 countries in the table in

1960. By 2010, the UK had dropped to thirteenth place, beating only Italy, Spain and Portugal. This is not a reassuring trajectory.

The evolution of GDP per person is a reflection of the trends in output per worker. These are most revealing when examined at the regional level. Before World War II, productivity in all of the UK's regions led Europe (Table 5). There had been some slippage by 1960 when Sweden, Belgium and the Netherlands were pulling ahead of the UK, but its regions as a whole were still more productive than the rest of the continent. Between 1960 and 2010, however, there was a great divergence within the UK: London remained at the top of Europe's productivity league table (see the graphic in Table 8), but every other region (with the possible exception of the East/South-East) had slipped to the very bottom, where they mingled with the detritus of the former German Democratic Republic (GDR).

The gap between most UK regions and the leading countries of western Europe is very large. Outside London and the East/South-East, labour productivity in the UK in 2010 was 75% of the average productivity of western Europe. A more instructive comparison, however, is between the unproductive UK regions and the prosperous parts of western Europe. Taking an expansive view of prosperity, we could define the prosperous regions to be those whose output per worker was above 90% of the western European average. This puts 40 regions in the prosperous group and 26 in the poor group, with the break point lying between the East/South-East of England (prosperous) and the Canary Islands (poor). The poor regions include most of the UK, the former GDR, and parts of Italy and Spain as well as Portugal. The average productivity of the prosperous 40 was fully 48% higher than the average of the unproductive UK regions. Even the least prosperous was 23% more productive than the poorer UK regions. The UK's productivity performance has been a disaster.

However, there is a paradox here that needs to be born in mind. While most of the UK has performed poorly, it has not stood still, let alone declined. The thing is that productivity has risen in all regions in Europe – it is just that it rose less rapidly in the UK than almost anywhere else. So the UK was overtaken by northern Italy, Catalonia and most of France. Productivity is up everywhere because every region has ATMs, online shopping and Airbnb. But the rest of Europe has done things that the UK has not.

Table 7. Per capita GDP in European countries (2011 US$)

1960		2010	
Luxembourg	19,528	Luxembourg	85,796
Switzerland	19,151	Norway	58,523
Sweden	13,454	Switzerland	52,351
Denmark	12,523	Netherlands	45,163
UK	**11,937**	Ireland	44,622
Norway	11,535	Austria	42,633
Netherlands	11,496	Denmark	41,991
France	10,517	Sweden	41,738
Belgium	10,492	Belgium	40,848
Germany	10,215	Germany	40,207
Austria	9,369	Finland	39,121
Finland	9,245	France	37,824
Italy	7,275	**UK**	**36,485**
Ireland	6,478	Italy	34,992
Spain	5,798	Spain	33,036
Portugal	4,383	Portugal	28,726

Source: Penn World Table, version 9.0 (Feenstra et al., 2015).

The graphic shown in Table 8 defines the current problem: how did the UK go from being one of the richest states in Europe to one of poorest and one so divided between a productive, rich capital and unproductive provinces? A common view is that the UK was good at inventing but bad at commercialising new technology. What the country needed was a 'development state' – government departments that would fund research, guide innovation, rationalise industry and, thereby, boost productivity. The trouble is that UK governments from between World War II and the 1970s did just that. In the 1960s, 3% of GDP was spent on research and development. Huge sums of public money were spent on nuclear reactors and aircraft of all sorts. Yet none of this resulted in export sales. In the case of commercial aircraft, concern with communications within the Empire took precedence over cheap transatlantic performance. The VC10, the most successful British model, was designed to land and take off on short African runways and operate in the 'hot and high' conditions of South Asian routes. On the New York–London route, the Boeing 707 was the better choice, and this was where the market was. The failures became object lessons for the Conservatives, showing that the state could not successfully pick winners (Edgerton, 2018, pp. 281–338).

Table 8. Regional GDP per worker relative to the European mean, 1960–2010

	1960		1970		1980		1990		2000		2010
Luxembo	2.11	Luxembo	1.88	isle-de-fr	2.37	isle-de-fr	1.84	isle-de-fr	1.80	isle-de-fr	1.97
Switzerla	1.87	Hamburg	1.58	Mediterra	1.87	Luxembo	1.48	Luxembo	1.49	Luxembo	1.33
Hamburg	1.72	Switzerla	1.54	Neth-N	1.70	Mediterra	1.40	London C	1.38	Belg-grea	1.32
isle-de-fr	1.65	isle-de-fr	1.50	Nord	1.67	Centre-es	1.36	Swed-eas	1.29	London C	1.30
Neth-W	1.58	Neth-N	1.45	Bassin par	1.64	Belg-grea	1.31	Belg-grea	1.29	Norway	1.27
Belg-grea	1.54	Neth-W	1.37	Est	1.64	Hamburg	1.31	Mediterra	1.28	Mediterra	1.27
Swed-eas	1.50	Neth-E	1.36	Sud-ouest	1.61	Est	1.30	Hamburg	1.26	Ireland	1.24
Swed--no	1.44	Swed-eas	1.34	Centre-es	1.61	Nord	1.29	Centre-es	1.23	Centre-es	1.22
Bremen	1.38	Bremen	1.33	Ouest	1.53	Bassin par	1.29	Neth-W	1.20	Neth-W	1.21
Neth-S	1.37	Belg-grea	1.29	Belg-grea	1.49	Sud-ouest	1.28	Sud-ouest	1.15	Hamburg	1.20
London C	1.36	Swed-sou	1.26	Luxembo	1.42	Neth-N	1.26	Italy-NW	1.14	Madrid	1.19
Swed-sou	1.32	Neth-S	1.24	Belg-Flan	1.27	Hessen	1.21	Finland	1.13	Finland	1.19
Neth-N	1.29	Swed--no	1.23	Belg-Wall	1.21	Ouest	1.21	Est	1.13	Est	1.16
Neth-E	1.26	Denmark	1.18	Switzerla	1.20	Switzerla	1.18	Bassin par	1.13	Sud-ouest	1.14
Belg-Wall	1.26	Est	1.14	Hamburg	1.18	London C	1.16	Nord	1.12	Nord	1.13
Belg-Flan	1.25	Belg-Flan	1.14	Neth-W	1.13	Italy-NW	1.16	Ouest	1.12	Neth-N	1.13
Rest of Sc	1.22	Nord	1.13	Italy-NW	1.10	Belg-Flan	1.12	Swed-sou	1.11	Swed-eas	1.12
Wales	1.21	Belg-Wall	1.12	Neth-E	1.09	Swed-eas	1.12	Norway	1.10	Spain-NE	1.10
Nordrheir	1.17	Norway	1.12	Neth-S	1.09	Bremen	1.09	Belg-Flan	1.10	Neth-S	1.10
Centre-es	1.17	Nordrheir	1.12	Denmark	1.07	Swed-sou	1.07	Swed--no	1.09	Bassin par	1.10
Est	1.17	Bassin par	1.12	London C	1.07	Italy-cent	1.07	Neth-S	1.08	Belg-Flan	1.09
West Mid	1.17	Mediterra	1.10	Madrid	1.06	Belg-Wall	1.06	Aust-east	1.08	Ouest	1.09
Nord	1.16	London C	1.10	Italy-cent	1.02	Madrid	1.06	Neth-N	1.08	Italy-NW	1.08
SouthWes	1.15	Centre-es	1.10	Italy-NE	1.02	Italy-NE	1.05	Hessen	1.06	Aust-east	1.08
North	1.14	Italy-NW	1.08	Bremen	1.02	Neth-W	1.04	Italy-cent	1.06	Switzerla	1.06
Scotland	1.14	Madrid	1.04	Hessen	0.99	Baden-Wu	1.04	Italy-NE	1.05	Hessen	1.02
East Midl	1.13	Hessen	1.04	Swed-eas	0.97	Neth-S	1.04	Ireland	1.05	Aust-Wes	1.01
Yorks & H	1.11	Sud-ouest	1.03	Swed--no	0.95	Swed--no	1.02	Rest of Sc	1.04	Spain-E	1.01
Saarland	1.09	Saarland	1.03	Nordrheir	0.95	Bavaria	1.01	Aust-Wes	1.03	Italy-cent	0.99
Bassin par	1.07	Ouest	1.02	Norway	0.95	Finland	1.01	Madrid	1.00	Italy-NE	0.99
Mediterra	1.07	Aust-east	1.00	Swed-sou	0.95	Rest of Sc	1.01	Switzerla	1.00	Swed--no	0.97
Hessen	1.03	Finland	0.99	Spain-NE	0.94	Nordrheir	1.00	Bremen	0.98	Denmark	0.97
Baden-Wu	1.00	Italy-cent	0.98	Rest of Sc	0.93	Neth-E	0.99	Belg-Wall	0.97	Bremen	0.96
Finland	0.98	Baden-Wu	0.98	Spain-E	0.93	Aust-east	0.97	Spain-NE	0.95	Neth-E	0.95
Italy-NW	0.97	Rest of Sc	0.96	Baden-Wu	0.93	Niedersac	0.97	Neth-E	0.94	Bavaria	0.95
Aust-east	0.97	Rheinlanc	0.96	Scotland	0.89	Scotland	0.96	Baden-Wu	0.94	Baden-Wu	0.95
Niedersac	0.97	SouthWes	0.94	Italy-islan	0.89	Rheinlanc	0.95	Italy-islan	0.93	Belg-Wall	0.94
Berlin	0.94	Wales	0.94	North	0.88	Italy-islan	0.95	Bavaria	0.93	Nordrheir	0.94
Schleswig	0.94	West Mid	0.94	Rheinlanc	0.88	Spain-NE	0.95	Nordrheir	0.93	Swed-sou	0.93
Northern	0.93	Aust-Wes	0.93	Niedersac	0.88	Spain-E	0.95	Aust-sout	0.92	Rest of Sc	0.92
Sud-ouest	0.92	Italy-NE	0.93	SouthWes	0.87	Ireland	0.94	Scotland	0.92	Canaries	0.90
Madrid	0.91	Scotland	0.93	Schleswig	0.87	Saarland	0.94	SouthWes	0.91	Aust-sout	0.88
Bavaria	0.88	Yorks & H	0.93	Bavaria	0.87	Schleswig	0.93	West Mid	0.91	Italy-islan	0.87
Aust-Wes	0.86	Spain-NE	0.92	Saarland	0.86	North	0.92	North	0.91	Italy-S	0.87
Meckelnb	0.83	North	0.91	Finland	0.86	Northern	0.91	Denmark	0.90	Berlin	0.86
Italy-cent	0.81	Bavaria	0.90	Yorks & H	0.85	Wales	0.91	East Midl	0.90	Rheinlanc	0.86
Brandenb	0.81	Spain-E	0.90	East Midl	0.85	SouthWes	0.91	Italy-S	0.89	Saarland	0.86
Ouest	0.81	Niedersac	0.87	Aust-east	0.84	East Midl	0.91	Yorks & H	0.89	Niedersac	0.85
Sachsen-A	0.80	Schleswig	0.87	Wales	0.84	Canaries	0.90	Rheinlanc	0.88	Spain-S	0.85
Thuringer	0.80	East Midl	0.86	West Mid	0.82	West Mid	0.89	Northern	0.88	Spain-NW	0.84
Rheinlanc	0.80	Berlin	0.86	Canaries	0.82	Norway	0.89	Berlin	0.88	Spain-Cer	0.83
Aust-sout	0.79	Aust-sout	0.78	Northern	0.81	Aust-Wes	0.89	Niedersac	0.87	Scotland	0.83
Italy-NE	0.78	Italy-islan	0.78	Aust-Wes	0.81	Italy-S	0.87	Schleswig	0.86	Schleswig	0.83
Spain-E	0.78	Northern	0.78	Italy-S	0.77	Yorks & H	0.87	Saarland	0.85	SouthWes	0.78
Ireland	0.78	Canaries	0.74	Ireland	0.77	Denmark	0.84	Spain-E	0.82	East Midl	0.75
Spain-NE	0.78	Italy-S	0.73	Berlin	0.75	Spain-S	0.79	Wales	0.76	Portugal	0.75
Sachsen	0.77	Ireland	0.73	Spain-S	0.73	Spain-Cer	0.76	Canaries	0.74	North	0.75
Denmark	0.65	Spain-S	0.67	Aust-sout	0.68	Aust-sout	0.75	Spain-Cer	0.73	Brandenb	0.75
Italy-islan	0.59	Thuringer	0.66	Spain-Cer	0.68	Berlin	0.71	Spain-NW	0.73	West Mid	0.75
Norway	0.59	Sachsen	0.66	Spain-NW	0.64	Spain-NW	0.71	Spain-S	0.72	Sachsen-A	0.73
Italy-S	0.58	Sachsen-A	0.66	Sachsen	0.60	Portugal	0.56	Brandenb	0.70	Yorks & H	0.73
Canaries	0.56	Brandenb	0.65	Thuringer	0.60	Brandenb	0.39	Sachsen-A	0.69	Northern	0.73
Spain-S	0.53	Portugal	0.65	Sachsen-A	0.59	Meckelnb	0.35	Meckelnb	0.66	Sachsen	0.69
Portugal	0.53	Meckelnb	0.63	Brandenb	0.58	Sachsen	0.33	Portugal	0.65	Meckelnb	0.69
Spain-Cer	0.51	Spain-Cer	0.61	Meckelnb	0.54	Sachsen-A	0.32	Sachsen	0.64	Wales	0.67
Spain-NW	0.51	Spain-NW	0.59	Portugal	0.52	Thuringer	0.31	Thuringer	0.62	Thuringer	0.67

Source: Regional GDP divided by regional employment and normalized to the mean. GDP for countries (Table 4) apportioned to regions using shares from the database of Rosés and Wolf (2019), who kindly provided me with their estimates of employment by region, for which I am very grateful.

For an insight into the UK's poor productivity performance, a first step is to examine how the economic structures of London and the rest of the country changed over the past half century. Table 9 compares the employment structure of London in 1971 to its structure in 2011. Total employment was remarkably constant at around four million. In the period, manufacturing lost one million jobs and virtually disappeared. These jobs losses were balanced by an increase of 300,000 jobs in education and health and over 800,000 jobs in finance and business services. London had been a world financial centre since the Industrial Revolution. Now it was propelled forward by two things. One was the IT revolution, which allowed a vast increase in business. The second was the 'big bang' in 1986, when the regulatory regime was transformed, and the financial industry became highly competitive. Increasing returns to scale meant that the financial expansion was self-reinforcing: expansion of the sector made it more efficient, and the greater efficiency induce further expansion.

Table 9. Employment (in thousands) in the UK and its regions, 1971 and 2011

	London		South-East and East		Other regions		Great Britain	
	1971	2011	1971	2011	1971	2011	1971	2011
Agriculture, forestry, fishing	5	2	177	59	453	208	635	269
Mining	5	6	11	9	376	66	391	80
Manufacturing	1,093	129	1,384	554	5,659	1,889	8,136	2,572
Utilities	62	25	71	86	229	268	362	378
Construction	250	262	358	585	1,062	1,396	1,669	2,244
Transportation	303	200	193	374	628	864	1,124	1,438
Distribution	548	522	586	1,130	1,882	2,945	3,016	4,597
Financial & business services	498	1,331	235	1,651	659	3,095	1,392	6,077
Education & health	507	813	639	1,538	1,755	4,185	2,901	6,535
Other services	499	507	554	709	1,482	1,868	2,534	3,085
Public administration	316	202	364	416	892	1,150	1,572	1,767
Total	4,086	3,999	4,571	7,110	15,076	17,934	23,733	29,043
Manufacturing share	0.27	0.03	0.30	0.08	0.38	0.11	0.34	0.09
Industry share	0.35	0.11	0.40	0.17	0.49	0.20	0.44	0.18

Note: Industry includes mining, utilities and construction as well as manufacturing.

Source: Lee (1979).

Developments outside London had much in common with the story in the capital but differed in important ways – notably productivity. What they had in common was employment trends (Table 9). Manufacturing employment declined dramatically everywhere, although not quite to the same extent as in London. The hundreds of thousands of jobs in mining (mainly coal) that existed in 1971 were gone by 2011. Manufacturing had largely vanished in every part of the country. Nationally, the share of jobs in manufacturing in 1971 was 34%, and it had dropped to 9% in 2011. The share was only 3% in London, 8% in the South-East and East, and 11% in the rest of the country. Between 1911 and 1971, many jobs in the 'old industries' had been lost in the North, but they were replaced with 'new industry' jobs in vehicles (in the Midlands) and chemicals and electrical goods fabrication everywhere. Between 1971 and 2011, most of the old industry jobs in the North and the new industry jobs generally were eliminated. In all regions, they were replaced with new jobs in

education, health, finance and business services. Outside London, there were also many additional jobs in distribution and construction.

About 40% of employment in 2011 in all regions was in education, health, social services, public administration, and hotels and restaurants. The latter aside, these are largely state-funded and provide services either highly desirable in themselves or regarded as necessary to address social ills. While the employment percentages are similar across regions in 2011, they were not so in 1971: the proportion of service sector employment in the North was much smaller than in other regions. The expansion in this area has made a bigger contribution to employment creation in the North than elsewhere in the country. This expansion has been in the state-funded activities because employment in hotels and restaurants has fallen in all regions in this period.

Even though the employment structures of London and the North have become similar since 1970, their productivity levels have diverged. An important reason is that not all services are equal. Financial and business services, for instance, are highly heterogeneous activities. In London, the growth in employment has centred on international finance and investment banking. These are highly lucrative. Elsewhere in the country, finance is less lucrative – in the North, it is largely retail banking. This is reflected in employment statistics for 2001.[20] In London, 40% of the employees in finance were managers or professionals and 32% were clerks. In the North, managers and professionals were 26% and clerks 47%. The differences were similar in business services where 51% of employees in London were managers or professionals, versus 37% in the North. The difference was made up by greater employment in the North of clerks, semi-skilled workers and, especially, elementary workers (15% in the North versus 8% in London). The professionals were employed in supplying design, consulting and IT support to businesses and governments. Most of the elementary workers were cleaners, and their employment indicates that much business service activity in the North consisted of contracted-out cleaning services, much of it purchased by the public sector. Public funds were supporting a considerable part of the business services sector in the North

The loss of manufacturing jobs was also a major cause of regional divergence because the incomes generated in manufacturing were greater than the incomes in the service jobs that replaced them. The manufacturing jobs were not lost because foreign markets were lost to foreign producers or because imported manufactures displaced domestic production. The big export surpluses racked up by coal, iron and steel, textiles, and engineering before World War I were long gone by World War II. The only Victorian stalwart to die from import competition after 1970 was shipbuilding – and its fall was cataclysmic. From 1.2 million gross tons of shipping produced in the early 1970s, production fell to barely 100,000 tons by the early 1990s. In this case, it was Japanese competition using advanced industrial technology to mass produce identikit tankers – the main type of ship in demand – that defeated the UK industry with its craft workers making bespoke merchant ships (Lorenz, 1991). Otherwise, the output of the Victorian staples followed domestic consumption.

This was also the predominant pattern among the 'new industries'. Their trade was generally in balance. This was true of the manufacturing sector as a whole. After the UK joined the Common Market, exports of manufactures rose to 15%–30% of sales. Imports were about the same. With more integration and the Single Market, both exports and imports have increased to 70% of sales. This represents a huge volume of intra-industry trade with complex supply chains that will be disrupted by Brexit. Autos may be an extreme case but illustrate the situation. In 2018, 1.52

[20] Computed from the Integrated Public Use Microdata Series (IPUMS) (Minnesota Population Center, 2020).

million cars were produced in the UK of which 1.24 million were exported and only 0.28 million registered in the UK. However, 2.37 million new cars were registered, over two million of which were imported. In the same year, the UK manufactured 2.72 million engines, 1.2 million of which were exported.[21] There was trade both ways in other components. But it remains the case that UK trade is roughly in balance, so UK production is close to UK consumption of manufactured goods.

There was one way, however, in which the development of the international economy proved detrimental to UK manufacturing, and that was through the exchange rate. The Single Market might have been a great fillip to UK manufacturing. The chance to export freely to a market of hundreds of millions of consumers might have led UK firms to build highly efficient factories that required that large scale of production. Indeed, there were some investments to that end. The UK firms that dominated the auto industry for most of the twentieth century were replaced by foreign firms such as Honda and Nissan, which built large modern factories to supply the European market.

However, the potential has not been realised as fully as it might have been, had the Single Market not been accompanied by the success of the UK's finance industry. The latter achieved very large exports of financial services. In addition, the expertise it provided and the attractiveness of the UK as a 'safe haven' for foreign investors led to a large flow of capital to purchase real estate and equities. Both the export of services and the import of foreign savings required foreigners to purchase sterling, and the result was a rise in the value of the British pound in foreign exchange markets. Finance displaced oil in a British mutation of the Dutch disease. The rising value of sterling made the production and export of manufactured goods in the UK less profitable than it would otherwise have been (Krugman, 2016). It was the loss of potential export markets that limited UK sales to domestic demand.

The immediate problem for UK workers was that the consumption of manufactured goods was growing slowly because demand was shifting to services. In this case, technical progress that raised labour productivity in manufacturing reduced employment. Between 1971 and 2001, employment in manufacturing fell from 8.1 million to 2.6 million (Table 9), while manufacturing output increased by a factor of 1.21. Output per worker increased by a factor of 3.78 = 1.21/(2.6/8.1). In this case, the fall in employment was much greater than the increase in output. Slowly growing output combined with rapid technical change was the immediate cause of the decline in manufacturing employment. Thatcherite reforms to the labour market and the creation of the European Union's Single Market were intended to increase competition among UK firms to spur them to greater efficiency. This may have been what happened, but the ironic effect is that its significance is constantly diminishing as the share of employment in manufacturing declines. UK manufacturing has become much more efficient, but the impact on wages is small because the sector is too small to affect overall labour supply and demand. It is the service sector that determines wage levels.

Manufacturing employment has been declining in all of the rich countries for the reason just outlined, but was it inevitable that UK employment should fall so much? Was it possible that manufacturing might have been more vital and made some contribution to raising productivity in the North? Questions along these lines have been debated since before World War I, as we have noted. While cliometricians have usually avoided damning the Victorian entrepreneurs, their

[21] SMMT Motor Industry Facts, 2019, https://www.smmt.co.uk/wp-content/uploads/sites/2/SMMT-Motor-Industry-Facts-May-2019-V2.pdf.

redemption is far from certain. Avoiding mistakes in the choice of technique is only one aspect of effective business leadership. Another is the speed with which businesses respond to new business opportunities: if entrepreneurs in one country respond more rapidly than those in another, the first country will gain market share even if businesses in both countries ultimately make the same decisions about plant design and business organisation (Allen, 1981). Crafts (2012) has sharpened the analysis and extended it to the present by arguing that non-competitive structures slow the rate of response, and the interventionist government policies from the 1930s to the 1970s had that effect. Sluggishness was reinforced by negotiations with trade unions that shared rents with employees in the form of static work arrangements. This argument goes some way to explaining the behaviour of UK firms, but it does not dispose of the wider issue of the innovativeness of the economic system more broadly. The invention and application of new knowledge typically depends on other actors as well – scientific institutions, universities, the state. British science has been impressive in making important discoveries that underpin modern technology – the jet engine, the first programmable computer, DNA, the internet – but the successful commercialisation of these has taken place elsewhere. It is important to sort out whether this result reflects failures in social organisation or mundane economic issues such as market size. More successful outcomes in the UK might have made a useful contribution to redressing the imbalances in regional productivity.

Technology and globalisation affect the labour market in the US

The period since 1973 has much in common with the Industrial Revolution. In the US, for instance, where the trends are most intense, the average real income of the labour force has risen slowly and fallen much behind the growth in output per worker (Figure 17). As a result, labour's share of the national income has dropped from 56% to 46% between 1970 and 2016 (Figure 18). This is one labour market manifestation of the rise in overall income inequality that has defined the period. In addition, wage inequality has increased dramatically. Since 1973, the real wages of production and non-supervisory workers have fallen slightly, while the incomes of managerial and profession workers have skyrocketed (Figure 19). These trends are similar to those in Britain during the Industrial Revolution.

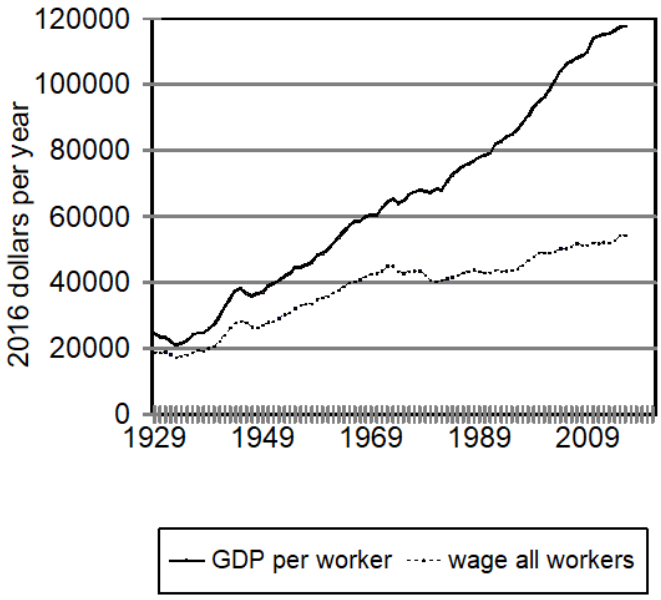
There are also parallel causal explanations of these trends, although there are also important differences. What the two periods have in common is the emergence of a new production structure and the eclipsing of the old. During the Industrial Revolution, it was the rise of the factory that drove handicraft cottage producers out of business. Post-1973, it is the rise of the service sector and the decline of manufacturing.[22] There is an important difference here, however; the factories of the Industrial Revolution produced the same or similar products to those of the handicraft sector, and the factories won by producing these goods at lower cost. This was creative destruction with a vengeance. Today, however, the service sector produces a different kind of output from manufacturing (cataract operations, for instance, versus paper towel dispensers), and the shift to services represents a shift of demand in that direction – creative destruction by subterfuge.

The problem with the decline in manufacturing and the rise of the service sector is that it depresses wage growth for less-skilled workers. Table 10 summarises annual earnings data for 1972, near the peak of the real wage series of production and non-supervisory workers, with 2017, the most recent year available. The focus is on semi-skilled operators in manufacturing in view of their significance as a corner stone of the American middle class and low-skilled service employees such as retail clerks, cashiers, waitresses, bartenders, cleaners, nursing aides and

[22] Temin (2017) offers another two-sector model with a different division but many of the same themes.

hairdressers. Semi-skilled manufacturing workers who lost their jobs often moved into these service jobs, as did young people entering their labour force who might in an earlier generation have aspired to semi-skilled factory work. Comparisons are clearest for full-time, full-year (FTFY) employees, but figures for part-time workers and all workers are included as part-time work is prevalent, especially in the service sector, and many workers who would prefer full-time work end up with part-time jobs. In both years, the manufacturing jobs paid more than the service jobs. This is not due to differences in human capital such as education attainment, which was, in fact, slightly higher among the service workers and which does not explain the wage differentials when entered in standard wage regressions. Nor did other variables such as race, ethnicity or nativity play important roles. Probably unions played a role in raising manufacturing wages in 1972. Their importance was substantially lower in 2017, and yet their decline did not result in a real wage collapse in that sector. Why semi-skilled manufacturing wages still command a premium is a puzzle.

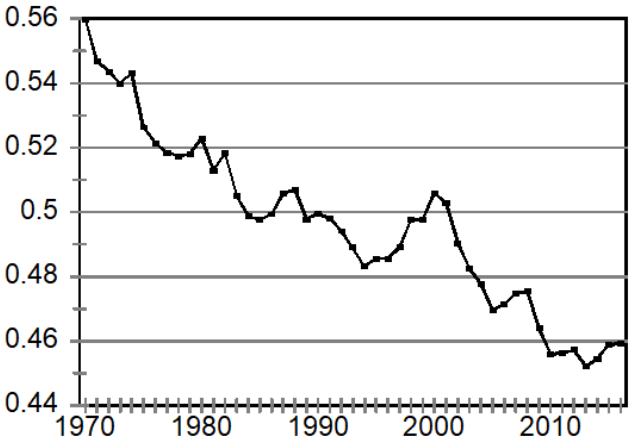
Figure 17. Real output per worker and average labour income per employed person in the US



Note: 'Wage all workers' includes the self-employed. In this graph, their income is set equal to the average wage and salary of all employed workers. Various alternatives were explored and gave similar results.

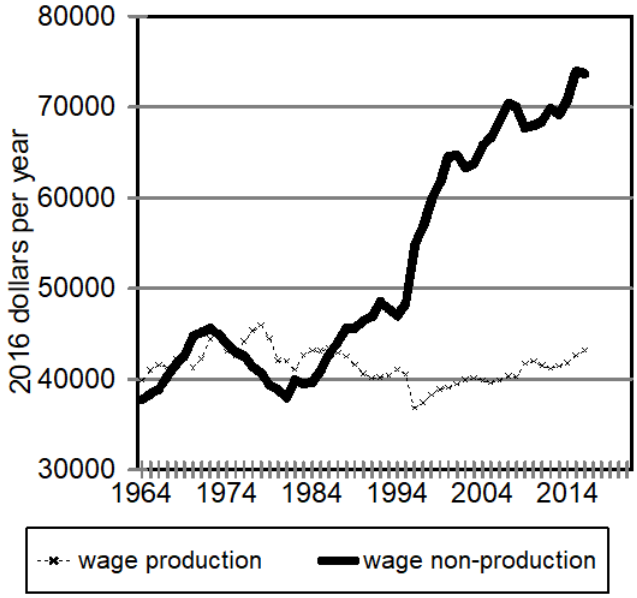
Source: GDP in billions of chained 2009 dollars from https://www.bea.gov.national/index.htm#gdp. Total workers: 1929–90, total employed civilian labour force, US Census Bureau, Historical Statistics of the United States, online, Table Ba471; 1991–2016, Current Population Survey, Labor Force Statistics, series LNS 12000000. Total wage and salary income of all employed workers from US Bureau of Economic Analysis, Table 2.1, Personal Income and Its Disposition, 1929–2019 (https://apps.bea.gov/iTable/iTable.cfm?reqid=19&step=2#reqid=19&step=2&isuri=1&1921=survey). For 'production and non-supervisory workers', total earnings, total number and earnings per worker were computed as follows. 1909–65, US Census Bureau, Historical Statistics of the United States, online, Tables Ba4361 and Ba4362, 'Hourly and weekly earnings of production workers in manufacturing, 1909–1965' and 'Hours worked per week calculated as the ratio'. 1964–2016, Federal Reserve Bank of St Louis, FRED economic data, average hourly earnings of production and non-supervisory employees, total private from https://fred.stlouisfed.org/series/CEU0500000008 and total number from Federal Reserve Bank of St Louis, FRED economic data, production and non-supervisory employees, total private https://fred.stlouisfed.org/series/CES0500000006. Total earnings computed as hourly earnings multiplied by 40 hours per week multiplied by number of workers. 40 hours per week is consistent with corresponding data for 1909–65. For 'non-production and supervisory workers', total earnings, number of workers and earnings per worker were computed as the totals of all employed workers minus the totals for 'production and non-supervisory workers'.

Figure 18. Labour's share of US GDP



Source: Same as Figure 17.

Figure 19. Wages of production and non-supervisory workers stagnate in the US while the salaries of professional and managerial workers rise



Source: See Figures 10 and 17.

Whatever the solution of that puzzle, Table 10 highlights key changes that have characterised the low-wage half of the labour market in the past 50 years. If we compare wages in 2017 to those in 1972 within occupations, we observe relatively favourable patterns. Men certainly did worse. Those working full-time in manufacturing saw their real earnings rise by about $2,000, while their counterparts in low-skill services saw their earnings drop by about the same amount. These were small changes in percentage terms, so the main conclusion is 'no change' in the real earnings of men over the period. This is not a good result.

Table 10. Earnings of low-skill workers in US manufacturing and services

	Men		Women	
	Semi-skilled manufacturing	Low-skilled services	Semi-skilled manufacturing	Low-skilled services
1972				
FYFT	$49,302	$41,470	$28,904	$24,342
Part-time	$10,622	$7,141	$7,904	$7,215
All	$41,261	22,624	$19,942	$11,662
2017				
FYFT	$51,075	$39,364	$40,359	$29,745
Part-time	$20,340	$10,215	$23,458	$10,945
All	$45,983	$27,914	$34,927	$20,311

Note: FYFT = full-year, full-time. Full-time, part-year workers are included in 'all' but not separately tabulated.

Source: Current Population Survey, Annual Social and Economic Supplements for 1972 and 2017 (Flood et al., 2020).

The results for women were more satisfactory. Women fully employed in semi-skilled manufacturing jobs achieved an increase of $11,000 (40%).[23] Women in services did not do quite as well, realising a rise of $5,000 (22%). This performance was much better than that of men and may reflect the effect of affirmative action and equal pay policies.

The problem is that most workers did not have it this good. The reason is the big shifts in employment structure. Very few women worked in manufacturing and achieved the wage gain shown because most of the semi-skilled jobs for women in manufacturing had disappeared by 2017, so the women (or, to be more exact in view of the time interval, their daughters) worked in services. The earnings of fully employed women in services in 2017 compared with manufacturing in 1972 shows a gain of less than $1,000.

For men, the situation was far worse. Comparing manufacturing in 1972 to services in 2017 shows a real annual earnings decline of almost $10,000, or 20%. The shift to the service economy has been a serious setback for men in the bottom half of the wage and salary distribution.

Technology and globalisation affect the labour market in the UK

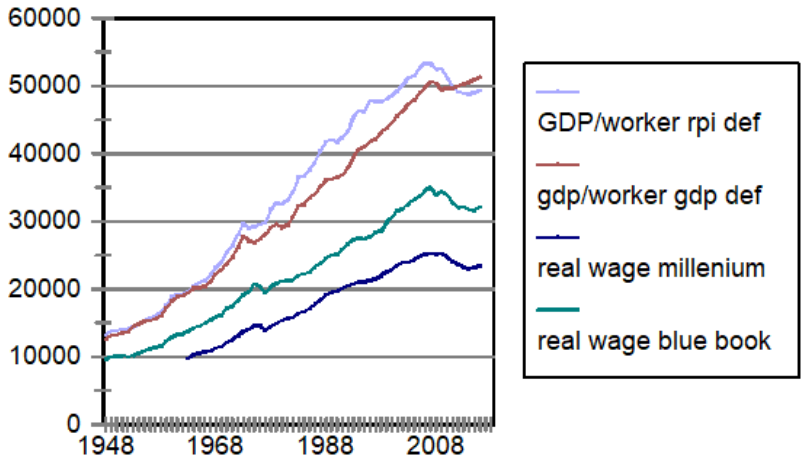
How well has the UK been served by the economic development that took place between 1970 and the present? Not very well. One shortcoming relates to wages and the labour market, the other to productivity. These are, of course, linked as the demand for labour depends on its productivity.

[23] The substantial real-wage increase for full-time full-year women in manufacturing is of little moment as there are very few such jobs left anymore.

I begin with the first. Comparison with the US frames the issues. As noted previously, the US labour market since 1970 has been unsatisfactory in two respects: the average wage has fallen behind output per worker, so labour's share of the national income has declined, and wage inequality has increased dramatically because production and non-supervisory workers have realised essentially no rise in real earnings since 1973, while more highly educated managerial and professional employees have achieved substantial increases in their real earnings.

At first glance, UK labour market outcomes look much more successful. Figure 20 shows two measures of real output per worker and two measures of the average real wage. The top two curves show output per worker deflated by a GDP deflator and by the retail price index. The important point is that they behave similarly, indicating that any differences between real wages deflated by the RPI and real GDP as conventionally measured are not due to the deflator.[24] Below these curves are two measures of real labour income. The higher is total employee compensation from the official national income figures (known as the Blue Books) divided by the number of employees.[25] The lower is the average weekly earnings series (multiplied by 52) shown in the Bank of England's 'A millennium of macroeconomic data'. Both of these real wage series appear to rise in step with output per worker until the financial crisis in 2008. Then all of them decline. The period up to the financial crisis looks like more Solow-in-action, and the weakness in the labour market since then looks like poor macroeconomic recovery in the wake of the great financial shock to the world economy. The main lesson is that these data indicate no long-term weakness in the behaviour of the UK economy or its labour market.

Figure 20. UK GDP per worker and two real wage series



Source: Bank of England, 'A millennium of macroeconomic data for the UK', Version 3.1, A47 Wages and Prices, Column B (https://www.bankofengland.co.uk/statistics/research-datasets).

This favourable assessment is too Panglossian, however, from four perspectives: the division of the national income between labour and capital, growing inequality within the working class, increasing regional disparities, and international comparisons.

[24] There is an alternative wage deflator – the consumer price index. This inflates a bit less rapidly over the period, implying a higher rate of real wage growth. I will continue to deflate wages with the RPI.

[25] Dividing the sum of employee compensation and income of the self-employed (so called 'mixed income' in the national accounts) by the number of employees plus the number of self-employed produces a real-wage series that is virtually indistinguishable from the narrower one plotted.

Consider the distribution of the national income between labour and property. Figure 21 plots labour's share of GDP at factor cost from 1920 to the present. The longest running series shows the share of national income going to employees. Until the early 1970s, this was steady at about 65% of GDP. Then the share dropped precipitously to 51% in 1988. There was some fluctuation in the low 50%s until the nadir was reached in 1996 at half of national income. The share has since recovered but only to about 55% of GDP – that is, 10 percentage points less than the pre-1970 norm. Broadening the definition of labour to include the self-employed does not weaken the conclusion.

Figure 21. Labour's share of GDP, 1920–2016

Note: The curve labelled 'wages & salaries' shows labour's share as the ratio of total employee compensation divided by GDP at factor cost, while the curve labelled 'wages, salaries & self-employed' equals the sum of employee compensation plus the income of the self-employed divided by GDP at factor cost.

Source: Data since 1948 from www.ons.gov.uk series CGCB, HAEA, and QWLT. Earlier data from Bank of England, 'A Millennium of Macro Economic Data for the UK,' A14:CT and A9:B.

The growth in wage inequality is the second issue. It has figured prominently in US debates and is highlighted by the difference between the average real earnings of 'production and non-supervisory employees', which have been static since 1973, and those of 'non-production and supervisory employees' (managerial and professional workers), which have risen dramatically. Have the same trends occurred in the UK? It is hard to know because the corresponding UK series have not been consistently reported by the statistical authorities. Beginning in 1968, the New Earnings Survey (NES) used a 1% sample of tax records to track earnings by occupation. Estimates of the earnings of full-time manual and non-manual workers were calculated. The NES was discontinued in 2000. It was superseded by the Annual Survey of Hours and Earnings (ASHE), which was also based on a 1% sample of tax records, and which has appeared regularly since 1997. The ASHE has not continued to report the average earnings of manual and non-manual workers.

Using the occupational breakdowns in the NES and ASHE, we can continue the manual/non-manual series to the present and also construct an approximation to the US distinction between

production and non-supervisory employees and its complement.[26] In the UK parlance, non-manual workers included managers and supervisors above the level of foremen, professionals, technicians, teachers and academics, most medical, clerical and sales personnel, and security personnel including police officers but not private guards. The remainder were non-manual employees and included most workers in manufacturing, mining, construction, transportation and agriculture, as well as catering, domestic services, and all other service activities. In 1971, 58% of employees were manual, but in 2011 the fraction had fallen to 34%.

To approximate the US distinction, I combined the clerical and sales personnel with the manual workers as a proxy for production and non-supervisory employees. This is not a perfect replica of the US category, which also includes some professionals such as teachers and lawyers, but, in any event, it is impossible to replicate the US series exactly as the data are based on surveys of employers in which the personnel officers who completed the questionnaire made the decision on how to classify their employees, with little more guidance than the one paragraph description on the Bureau of Labor Statistics website.[27] Consistent classification cannot be expected. My proxy implies that the share of production and non-supervisory employees in the UK dropped from 80% in 1971 to 56% in 2011.

Figure 22 plots the series, and these highlight the growing inequality of the wage distribution in the UK, although the British story is not identical to the American story. In the UK, the average worker realised an 80% increase in real earnings between 1971 and 2011. This was unequally divided as the average production worker earned 14% more in 2011 than in 1971, while the average non-production and supervisory worker reaped a 93% gain. In terms of the manual/non-manual breakdown, the manual worker's real wage rose 21% while the non-manual worker's income increased by a factor of 2.09. While the incomes of the non-manual and supervisory workers look to have increased steadily over the period, the earnings of the production and manual workers rose until about 1990 and then began to decline. A poor labour market for the bottom half of UK workers began long before the financial crisis.

To learn more about winners and losers, we need to divide the workforce further. What was the impact of the decline in manufacturing on the earnings distribution? How did the expansion of female employment affect outcomes? Did UK women do better than men as their counterparts did across the pond?

Table 11 tracks these changes. Between 1971 and 2011, the number of manual jobs in manufacturing fell by 4.3 million from 6.1 million to 1.8 million. (These figures are smaller in both years than manufacturing employment shown in Table 9, because the latter includes white-collar workers as well as manual workers.) In the case of women as manual workers in manufacturing, employment fell by over 90%. With men, the decline was 'only' 62%, leaving 1.6 million manufacturing jobs in 2011.

[26] To do this, it was necessary to estimate the number and earnings for part-time workers for 1971–2000 as this information was only patchily recorded in the in the NES. Somewhat different procedures were used in different years because the reported information changed. One check on my procedures is to compare average weekly earnings in 2000 as I estimated it from the NES with the ASHE finding for the same year. My overall average from the NES was £342.96 per week versus the ASHE measurement of £354.50, which is a 3% difference.

[27] https://www.bls.gov/ces/report-forms/home.htm.

Figure 22. Real wages of supervisory workers versus production and non-supervisory workers

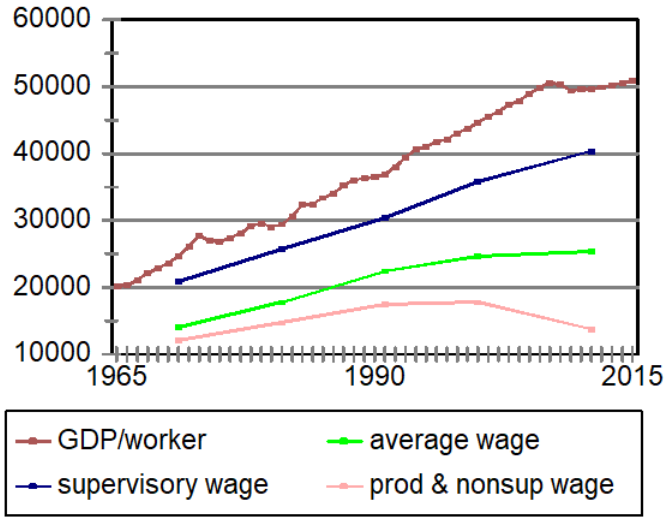


Table 11. Employment by occupation 1971–2011

	1971			2011		
	Full-time	Part-time	Total	Full-time	Part-time	Total
Men						
Managerial, professional, technical	1,467	34	1,501	5,456	480	5,936
Clerical, sales, personal service	3,274	459	3,733	2,310	1,008	3,318
Manual workers, manufacturing	3,903	445	4,348	1,582	57	1,639
Manual workers, transport and construction	3,590	408	3,998	1,308	172	1,480
Total	12,234	1,346	13,580	10,656	1,717	12,373
Women						
Managerial, professional, technical	169	9	178	3,408	1,264	4,672
Clerical, sales, personal service	3,744	2,441	6,185	3,117	3,891	7,008
Manual workers, manufacturing	1,208	498	1,706	140	9	149
Manual workers, transport and construction	209	113	322	103	76	179
Total	5,330	3,061	8,391	6,768	5,240	12,008

Note: This table includes paid employees and excludes the self-employed. It includes Great Britain only (excluding Northern Ireland). Manual workers, manufacturing also includes mining. Manual workers, transport and construction also includes agriculture.

Source: NES, 1971, pp. 226-33, and ASHE, 2011, Table 15.1a.

The declines in the employment of manual workers in manufacturing were offset by increases elsewhere. The shifts were most pronounced in the case of women. The greatest increases were in the category 'managerial, professional, technical'. In 1971, women were scarcely employed at this level, which was overwhelmingly male. By 2011, women's employment had expanded from less than 0.2 million in 1971 to 4.8 million. Employment of women in 'clerical, sales, personal service' increased slightly from 6.2 to 7.0 million and declined in all types of manual work to low levels.

In the case of men, employment gains were confined to 'managerial, professional, technical' jobs where employment grew from 1.5 to 5.9 million. Employment for all other occupational groups fell, especially among manual workers.

It should also be noted that between 1971 and 2011, there was a shift to part-time work with one exception: manual workers in manufacturing. In this sector, part-time work had always been minor, and it declined further. The most notable increase was among men in 'clerical, sales, personal service', where part-time employment rose from 39% to 56%.

On balance, between 1971 and 2011, manual workers who lost their jobs in manufacturing were redeployed to new managerial, professional and technical jobs. However, because the dates of the comparison are 40 years apart, many of the redeployments were, in fact, inter-generational (although the fall in total employment of men raises the suspicion that some men dropped out of the workforce altogether). In most cases, the question is: where did the children of 1971's factory workers end up in 2011?

One could answer this question by tracing people, but the necessary data are lacking. Fortunately, the possible trajectories are clear in comparisons of the 1971 and 2011 cross-sections. Table 12 summarises wages (all in 2011 British pounds) for all categories of workers. Between 1971 and 2011, real GDP per employed person rose by a factor of 2.1, while average weekly earnings across all workers increased by 80%. Table 12 implies a less optimistic account of labour incomes and labour's share than Figure 20.[28]

Table 13 summarises the data in Table 12 in terms of increases between 1971 and 2011. It is clear that women gained the most. Real average earnings in each of the occupational categories increased by factors ranging from 1.67 to 2.72.[29] Except for women in 'clerical, sales, personal care', which had the smallest increase, all beat the average increase of 1.80. In contrast, the increases in men were all less than the average increase and ranged from 0.97 – an actual drop – for men in 'clerical, sales, personal care' to 1.61 for manual workers in manufacturing.

[28] The increase in the real average weekly earnings by a factor of 1.80 is less than the rise of 1.93 over the same period shown in Figure 20. The difference is not due to the deflator, which is the RPI in both cases. Rather, it is down to the nominal earnings series. Figure 20 uses the series on sheet A47, column B, in the Bank of England's Excel compendium 'A Millennium of Macro Economic Data for the UK', which has become the go-to source for macro series. The data series is referenced to the ONS average weekly wage series KAB9. In recent years, this is the ASHE. The Bank of England does not tell us whether they have chosen the mean or the median, but the number they report for 2011 is closest to the mean earnings of all workers (£487.20), so I presume they are using means. The problem arises for the 1971 figure (BofE: £20.64) as this must have come from the NES, the predecessor to the ASHE, but the NES does not report an overall mean or median. It reports medians and means for full-time men and women separately and provides only sketchy data on part-time workers. Using all data in the NES, 1971, I have computed overall mean weekly earnings of £24.16. This includes part-time workers, and so is comparable to the ASHE figure. My 1971 estimates for full-time men and women are close to those reported by NES, 1971, p. 29.

[29] These and subsequent factors are based on all workers to reflect the likelihood of part-time work.

Table 12. Earnings of low-skill workers in manufacturing and services

	Men		Women	
	Semi-skilled manufacturing	Low-skilled services	Semi-skilled manufacturing	Low-skilled services
1972				
FYFT	$49,302	$41,470	$28,904	$24,342
Part-time	$10,622	$7,141	$7,904	$7,215
All	$41,261	$22,624	$19,942	$11,662
2017				
FYFT	$51,075	$39,364	$40,359	$29,745
Part-time	$20,340	$10,215	$23,458	$10,945
All	$45,983	$27,914	$34,927	$20,311

Note: FYFT = full-year, full-time. Full-time, part-year workers are included in 'all' but not separately tabulated.

Source: Current Population Survey, Annual Social and Economic Supplements for 1972 and 2017 (Flood et al., 2020).

Table 13 also shows income gains from the transitions of manual workers in manufacturing to other jobs. In the case of women, the only relevant shifts were to 'managerial, professional, technical' and 'clerical, sales, personal service' jobs. Managerial and professional women in 2011 whose mothers had been manual workers in 1971 would have earned incomes 3.83 times greater than their mothers, on average – truly an exceptional gain. Women whose mothers were factory operatives and who shifted to 'clerical, sales, personal services' jobs would have earned an income 1.67 times that of their mothers.

Men did worse. Consider the sons in 2011 of men who were manual workers in 1971. On average, the son who worked in 'clerical, sales, personal services' did worst, and earned 3% less than his father had. Sons who worked in 'other manual jobs' (mainly in construction and transport) did better, realising a 36% increase in earnings over their fathers. Sons who went into 'management, professional, technical' work earned 53% more than their fathers, while sons who remained in manual factory work did best of all, making 61% more than their fathers in real terms. All of these gains fell below the 80% increase in the average real wage.

While the improved earnings of women should be celebrated, their success is not unblemished. A comparison of the 2011 earnings of women to the 1971 earnings of men shows that the level women reached in 2011 was the level that men had already reached in 1971. Only in 'management professional, technical' jobs did women earn more in 2011 than in 1971, and then by only 23%. These gains reflected the expansion of higher-paying employment opportunities for women at that level, which in 1971 were confined mainly to jobs as nurses, teachers and retail shop managers. Otherwise, the upward surge in women's earnings only brought them to level pegging with their fathers.

Table 13. Relative gains in real income by occupation, 1971–2011

	Women	Men
Panel A		
MPT	2.72	1.53
CSPS	1.67	0.97
M mfg	2.29	1.61
M cta	1.84	1.36
Panel B		
M mfg => MPT	3.84	2.54
M mfg => CSPS	1.67	1.04
M mfg => M mfg	–	1.61
M mfg => M cta	–	1.35

Note: Panel A shows relative income changes (2011 income divided by 1971 income) within occupations. Panel B shows relative income changes (2011 income divided by 1971 income) from manual workers in manufacturing to other occupations. MPT = managerial, professional, technical; CSPS = clerical, sales, personal service; M mfg = manual workers in manufacturing; M cta = other manual jobs (mainly in construction and transport).

Source: Computed from Table 3 and underlying data.

Technology and globalisation affect the labour market, regional and aggregate productivity in the UK

UK labour market performance has been less than satisfactory not only in terms of the declining share of GDP going to labour and the increase in wage and salary inequality among employees, but also in terms of regional disparities and international comparisons. They are best considered together. These comparisons also throw light on the causes of the national trends previously discussed.

The growth process we have already described sets the stage for these issues. The last 50 years have seen large scale de-industrialisation across the UK. One million industrial jobs disappeared in London, and about five million elsewhere in the country. In both cases, the losses amounted to more than one-quarter of the jobs. Counterbalancing these declines was the growth in service employment. In London, this was driven by the vast expansion of the highly lucrative jobs in finance and business services. In the rest of the country, the new service jobs were less productive.

The labour market links between the two service revolutions were surprising. What did not happen was a large-scale movement of workers from the depressed North to London. While redundant manual workers were never going to transmute into finance analysts, their children who went to university might have done so, but, in the event, did not, at least on a large scale. Instead, London's new workforce was drawn from a third area – abroad. Immigrants came both from the European Union and from outside it, many from Africa. In 1971, immigrants accounted for about one-fifth of the jobs in London; by 2011, the share had increased to 40%. Because the numbers of employed Londoners in both years were about the same (four million), the increase in the immigrant work force exceeded the losses in employment among the native-born. Temporally, London lost population in the 1970s as manufacturing jobs were disappearing. The population rebounded once finance took off in the mid-1980s with most of the new jobs being filled by foreigners.

The reason this happened is because for all but the mostly highly paid managerial and professional jobs, wages and salaries in London were not high enough to make the move to London worthwhile for people in the North. Overall averages, with which we begin, would seem to belie this, but it becomes clear upon disaggregation. Table 14 details average weekly earnings for all full-time workers in three occupations in 2011. The earnings have been adjusted in two ways to bring out important features. First, because the cost of living is higher in London than elsewhere, the earnings have been divided by a regional price index to place them on an equal footing in terms of purchasing power. Second, the earnings were then normalised by dividing them by the average real earnings in regions other than London and the East/South-East. This normalisation was done separately for men and for women.

The table highlights some important patterns. First, in high-status occupations, real earnings in London are much higher than elsewhere. It is highest among corporate managers and directors followed by lower-level managers, culture, media and sports professionals, business and public service professionals, and some other white-collar and technical positions. The pattern is similar for women (although their salaries are lower). Not all professional workers realised a London premium – employees in the education and health sectors were no better off in consumption terms than their counterparts elsewhere in the country. Except for construction workers and fitness trainers, the London premium was lower for less-skilled workers than it was for white-collar workers, and for men in the least-skilled jobs it was non-existent.

Second, north of London there was scarcely any difference in real earnings (except possibly a small premium for Scotland, perhaps due to its national status). The uniformity of wages in all occupations outside London indicates that labour markets were highly integrated for those regions, at least. What about London? Why are its wages and salaries higher? There are three possibilities. The first is that internal migration has not been substantial enough to equalise wages across London and the outer regions. The lack of wage differences at the lower ends of the occupational range belies this – surely if drivers can allocate themselves across space to equalise wages, so can management consultants. The second possible explanation of the wage difference is that the high cost of housing in London is not fully captured by the interregional price indices. In that case, real wages might be equalised but the figures in Table 14 include some land value as well as labour value. The third possibility is that categories such as 'corporate manager' or 'director' are too crude to classify the workforce; that is, corporate managers in London, for instance, were more talented or enterprising than their counterparts elsewhere and, hence, were paid more. In that case, the high earnings indicate a return to this human capital. The truth is probably a combination of the second and third explanations.

Table 14. Relative real wages in UK regions, 2011

	Men			Women		
	Managers and senior officials	Admin and clerical	Elementary	Managers and senior officials	Admin and clerical	Elementary
London	1.57	1.29	1.00	1.48	1.27	1.11
South-East	1.13	1.05	1.00	1.07	1.05	1.00
East	1.05	1.07	1.03	1.04	1.02	0.98
West Midlands	1.00	1.01	0.97	0.99	0.98	0.95
Yorkshire & Humber	0.99	1.00	1.00	0.98	1.01	1.01
East Midlands	1.02	0.97	1.01	0.97	0.96	1.02
South-West	0.96	1.04	0.97	0.94	0.98	0.99
North-East	1.03	0.91	1.01	1.06	0.99	1.00
North-West	1.00	0.96	0.97	0.97	1.00	0.99
Wales	0.90	1.04	1.01	0.95	1.03	1.07
Scotland	1.06	0.99	1.02	1.09	1.02	1.00

Note: Based on average weekly earnings deflated by index of regional price levels including housing.

Source: Average weekly earnings from ONS, 'REVISED–Work Region Occupation SOC10(2) Table 3.1a Weekly Pay-Gross 2011'. Inter-regional price differences measured by ONS index in Wingfield, Fenwick and Smith (2005, p. 39, national weights).

While wages, when properly measured, have probably been equalised across the UK, the same is not true of land values, as has been noted. The reason is that land, unlike labour, cannot move from a place of low returns to a place of high returns. The result is dramatic differences in the price of real estate. In 2011, the average price of a terraced house ranged from £293,000 in London to £78,000 in Northern Ireland. The rental value of this real estate accounts for much of the cost of living difference between regions used to adjust the real wages for comparable purchasing power.

Unless a Brit was a high flyer who could get one of the high-paying jobs, a move to London would not have made him or her much better off. This was emphatically not the case for a doctor coming from Nigeria or an office cleaner from Slovenia. Comparisons across Europe in real wages in 1960 showed that UK wages were higher than most places on the continent (Table 6), and the situation still persists in so far as eastern and southern Europe are concerned. Incomes in developing countries from which the UK draws immigrants are also well below UK incomes.

There are several sources of data that permit international real wage comparisons, and they all tell the same stories. The International Labor Organisation (ILO) website[30] summarises national labour force surveys and converts the reported salaries into US dollars at 2011 PPPs. Average incomes are reported for the same job categories we have just examined in Table 14 and some others in the same classification scheme.

The data in Tables 15 and 16 support two important conclusions. First, real wages in the UK were higher than real wages in eastern and southern Europe. The UK wages in the ILO data set are average wages across the UK from the ASHE, so London wages were higher for high-wage jobs. A Russian computer programmer, a Greek dentist, a Romanian carpenter and a Latvian cleaner could all dramatically increase their income by moving to London (or anywhere in the UK), and they did so in large numbers. The same was not true of their counterparts in Newcastle or Manchester.

The second important conclusion follows from a comparison of the 2011 wages and salaries to the 1960 wages we considered previously (Table 6). In 1960, UK wages were still above those of most of Europe. By 2011, the UK's standing had collapsed. In every job category, the UK was surpassed by every western and northern European country with the exception of Portugal. In four out of the six important job classes shown for men in the ILO data, the UK ranked fourteenth, just above Spain. Women did a bit worse. In half of the job categories, UK salaries ranked eighteenth, and the UK was below Spain. UK women managers, clerical workers, technicians (which includes nurses) and elementary workers were even being nosed out by their counterparts in the highest-paying countries of eastern Europe and earned very much below the western European countries to which the UK historically compared itself.[31]

Similar rankings emerge from the wage and salary data reported in the International Comparison Project[32] (ICP) from 2011. The aim of the ICP was to collect prices to compute PPP exchange rates – the same exchange rates that the ILO used to put wages and salaries into US dollars – and wages and salaries are reported for occupations to deflate service sector aggregates. The ICP annual earnings data have the advantage that the job categories are more tightly defined than in the ILO data set. The ICP data present a somewhat more nuanced account of the UK's position in the Euro-salary sweepstakes (Table 17). For middle and lower status jobs, the UK labour market performed very badly. Office cleaners and secretaries (non-medical) earned much less than secretaries virtually anywhere in western Europe. It was the same story for drivers, building caretakers, prison guards, computer operators and data base administrators. In these jobs, it was only eastern European countries where real earnings were below the UK's, and many workers have left these countries to work in the UK. In some higher-status jobs, such as government statisticians and doctors UK salaries were in the middle of the

[30] https://www.ilo.org/global/lang--en/index.htm.

[31] Very similar conclusions are obtained if the comparisons are performed using hourly earnings rather than average monthly earnings.

[32] https://www.worldbank.org/en/programs/icp#1.

west European range. The employees who did best in the ICP survey were the favourites of conservative politicians – police and firefighters.

It is difficult not to see the wage and migration patterns as linked. Cheaper international travel and the European Union have made it feasible for eastern European, Asian and African workers to find work in London, and the wage differentials have made that more desirable. Immigration has been more than enough to satisfy the labour demand created by London's finance boom. Indeed, one study of the period 1980–2000 found that immigration into London was pushing out native workers into adjoining regions (Hatton and Tani, 2005). Recruiting 40% of its labour force from low-wage parts of the globe must surely have placed downward pressure on London wages, while the movement of displaced workers out of London into the rest of the UK must have transmitted that pressure to the provinces.

Table 15. Average weekly earnings, ISOC occupations, men (2011 US$ at PPP)

Managers		Professionals		Technicians		Craft		Semi-skilled		Elementary	
Luxembourg	9,075	Switzerland	6,941	Switzerland	5,776	Switzerland	4,426	Switzerland	4,417	Switzerland	4,137
Switzerland	8,593	Germany	5,865	Denmark	4,858	Iceland	3,804	Denmark	3,695	Denmark	3,032
Germany	7,926	Luxembourg	5,489	Germany	4,826	Denmark	3,706	Norway	3,435	Norway	2,934
Italy	7,856	Austria	5,478	Norway	4,673	Ireland	3,441	Sweden	3,297	Iceland	2,752
Denmark	7,281	Norway	5,276	Iceland	4,630	Sweden	3,439	Iceland	3,198	Sweden	2,744
Belgium	7,224	Denmark	5,189	Luxembourg	4,552	Norway	3,435	Netherlands	3,160	Ireland	2,656
Austria	7,196	Ireland	5,153	Ireland	4,151	Netherlands	3,112	Ireland	3,133	Belgium	2,588
Iceland	7,029	Belgium	4,990	Sweden	4,098	Germany	3,006	Belgium	3,037	Luxembourg	2,373
Sweden	6,403	Iceland	4,784	Netherlands	4,051	Belgium	2,936	Germany	2,994	Finland	2,335
Norway	6,360	Italy	4,754	Austria	4,047	Finland	2,902	Finland	2,976	Austria	2,215
Finland	6,071	Netherlands	4,731	Belgium	3,983	**UK**	**2,838**	Luxembourg	2,975	Germany	2,184
Netherlands	5,868	Sweden	4,613	Finland	3,549	Luxembourg	2,780	Austria	2,896	Italy	2,086
Ireland	5,832	France	4,518	Italy	3,451	Austria	2,645	Italy	2,567	Netherlands	1,974
UK	**5,408**	**UK**	**4,353**	**UK**	**3,330**	Italy	2,362	**UK**	**2,446**	France	1,860
Spain	5,334	Finland	4,337	France	3,084	France	2,181	France	2,301	**UK**	**1,753**
Croatia	4,632	Spain	3,844	Spain	3,063	Spain	2,157	Spain	2,235	Spain	1,628
France	4,518	Slovenia	3,522	Slovenia	2,513	Slovenia	1,773	Slovenia	1,670	Slovenia	1,351
Poland	4,309	Croatia	3,185	Croatia	2,484	Croatia	1,577	Poland	1,606	Croatia	1,315
Slovenia	4,230	Hungary	2,885	Czechia	2,169	Czechia	1,517	Croatia	1,561	Poland	1,223
Czechia	4,218	Czechia	2,865	Poland	2,131	Poland	1,511	Czechia	1,507	Czechia	1,146
Hungary	4,168	Turkey	2,638	Slovakia	1,926	Slovakia	1,377	Greece	1,425	Greece	1,062

Table continues on next page

Table 15 continued

Managers		Professionals		Technicians		Craft		Semi-skilled		Elementary	
Slovakia	3,677	Poland	2,587	Hungary	1,923	Estonia	1,373	Hungary	1,381	Estonia	1,029
Turkey	3,276	Estonia	2,304	Estonia	1,859	Hungary	1,338	Estonia	1,326	Turkey	940
Estonia	3,115	Slovakia	2,257	Turkey	1,717	Greece	1,246	Slovakia	1,324	Slovakia	937
Romania	2,969	Portugal	2,199	Greece	1,655	Russia	1,212	Russia	1,282	Hungary	936
Portugal	2,669	Romania	2,068	Portugal	1,548	Turkey	1,184	Portugal	1,055	N Macedonia	836
N Macedonia	2,506	Latvia	1,810	Latvia	1,471	Romania	1,048	Romania	1,042	Portugal	827
Russia	2,484	N Macedonia	1,794	Russia	1,462	Portugal	991	Turkey	1,040	Latvia	781
Latvia	2,123	Greece	1,776	N Macedonia	1,445	Latvia	985	Latvia	1,019	Bosnia & Her	700
Greece	2,060	Russia	1,548	Romania	1,405	N Macedonia	908	N Macedonia	973	Romania	682
Albania	1,701	Albania	1,343	Albania	986	Bosnia & Her	772	Bosnia & Her	768	Russia	580
Bosnia & Her	1,477	Bosnia & Her	1,221	Bosnia & Her	913	Serbia	671	Albania	756	Serbia	516
Serbia	1,255	Serbia	1,150	Serbia	908	Albania	633	Serbia	681	Albania	487

Note: Harmonised series in US$ at 2011 PPP.

Source: https://www.ilo.org/shinyapps/bulkexplorer3/.

Table 16. Average weekly earnings, ISOC occupations, women (2011 US$ at PPP)

Managers		Professionals		Technicians		Clerical		Sales and service		Elementary	
Luxembourg	6,825	Switzerland	5,962	Switzerland	4,905	Switzerland	4,226	Switzerland	3,643	Switzerland	3,395
Switzerland	6,445	Luxembourg	5,012	Luxembourg	4,542	Luxembourg	3,462	Norway	2,853	Norway	2,791
Belgium	6,223	Ireland	4,518	Denmark	3,843	Denmark	3,367	Sweden	2,800	Denmark	2,511
Italy	5,717	Norway	4,417	Norway	3,752	Norway	3,272	Denmark	2,658	Sweden	2,509
Denmark	5,640	Belgium	4,378	Ireland	3,495	Sweden	3,021	Netherlands	2,483	Iceland	2,318
Germany	5,583	Germany	4,237	Sweden	3,472	Belgium	2,845	Luxembourg	2,416	Ireland	2,235
Iceland	5,410	Denmark	4,067	Germany	3,389	Ireland	2,839	Ireland	2,318	Luxembourg	2,049
Sweden	5,362	Netherlands	3,872	Belgium	3,348	Iceland	2,838	Germany	2,317	Netherlands	1,913
Norway	5,061	Sweden	3,739	Iceland	3,331	Germany	2,731	Iceland	2,285	Germany	1,887
Finland	4,899	Iceland	3,598	Netherlands	3,105	Netherlands	2,688	France	2,004	Finland	1,809
Austria	4,691	Finland	3,597	Italy	2,887	Italy	2,510	Finland	2,003	Italy	1,772
Spain	4,603	Austria	3,455	Finland	2,819	Finland	2,410	Italy	1,988	France	1,767
France	4,538	France	3,418	France	2,712	Austria	2,306	Belgium	1,804	Belgium	1,661
Croatia	4,458	Italy	3,338	Austria	2,704	France	2,169	Slovenia	1,479	Slovenia	1,272
Netherlands	4,188	Spain	3,305	Spain	2,426	Spain	2,060	Austria	1,446	Austria	1,199
Ireland	4,182	**UK**	**3,240**	Slovenia	2,354	Slovenia	2,002	Spain	1,411	Spain	1,136
Slovenia	4,017	Slovenia	3,229	**UK**	**2,232**	Croatia	1,851	Croatia	1,342	Croatia	1,086
UK	**3,676**	Croatia	2,502	Croatia	2,127	**UK**	**1,668**	**UK**	**1,288**	Poland	960
Turkey	3,489	Turkey	2,127	Czechia	1,731	Poland	1,515	Czechia	1,046	Czechia	906
Poland	3,111	Czechia	2,063	Poland	1,669	Czechia	1,435	Poland	1,027	**UK**	**876**
Czechia	2,976	Poland	2,041	Turkey	1,579	Turkey	1,373	Greece	1,001	Greece	835

Table continues on next page

Table 16 continued

Managers		Professionals		Technicians		Clerical		Sales and service		Elementary	
Hungary	2,969	Hungary	1,996	Hungary	1,548	Hungary	1,343	Hungary	924	Hungary	814
Romania	2,816	Portugal	1,884	Greece	1,423	Greece	1,330	Turkey	923	Turkey	800
Slovakia	2,509	Romania	1,680	Slovakia	1,408	N Macedonia	1,231	Slovakia	860	N Macedonia	764
N Macedonia	2,358	Slovakia	1,678	Estonia	1,372	Slovakia	1,154	N Macedonia	840	Slovakia	721
Estonia	2,304	N Macedonia	1,647	Portugal	1,274	Estonia	1,087	Estonia	816	Estonia	687
Albania	2,000	Estonia	1,619	N Macedonia	1,259	Portugal	1,078	Portugal	790	Romania	672
Greece	1,851	Greece	1,564	Romania	1,196	Romania	1,006	Romania	706	Portugal	638
Portugal	1,823	Latvia	1,293	Latvia	1,189	Latvia	927	Latvia	683	Latvia	613
Latvia	1,734	Albania	1,218	Albania	913	Albania	905	Russia	668	Bosnia & Her	519
Russia	1,700	Russia	1,145	Bosnia & Her	840	Bosnia & Her	832	Bosnia & Her	571	Russia	501
Bosnia & Her	1,190	Bosnia & Her	1,093	Russia	829	Russia	748	Albania	563	Albania	468
Serbia	1,118	Serbia	967	Serbia	765	Serbia	712	Serbia	494	Serbia	442

Note: Harmonised series in US$ at 2011 PPP.

Source: https://www.ilo.org/shinyapps/bulkexplorer3/.

Table 17. Annual earnings in 2011 in US dollars at PPP

Office cleaner		Non-medical secretary		Government statistician		Policeman	
Belgium	62,912	Luxembourg	66,934	Luxembourg	125,355	Luxembourg	73,964
Norway	50,794	Belgium	66,142	Austria	111,468	Austria	72,113
Italy	48,828	Switzerland	50,329	France	101,673	Norway	69,627
Luxembourg	48,075	Austria	49,084	Belgium	100,906	**UK**	**69,477**
France	46,095	Norway	47,785	Ireland	82,481	France	67,442
Netherlands	43,972	Netherlands	46,378	Germany	82,066	Ireland	65,909
Germany	43,794	Germany	45,177	Switzerland	79,103	Italy	63,584
Switzerland	43,321	Denmark	42,854	**UK**	**76,883**	Switzerland	63,380
Denmark	42,912	Finland	40,915	Netherlands	74,463	Netherlands	58,231
Austria	42,167	Sweden	40,413	Denmark	71,632	Denmark	53,445
Ireland	39,969	Italy	40,347	Italy	67,159	Finland	53,220
Finland	39,657	France	40,254	Finland	66,282	Belgium	50,708
Sweden	35,535	Spain	36,514	Spain	62,207	Germany	48,957
Spain	33,991	Ireland	34,661	Sweden	58,686	Spain	44,326
Cyprus	32,470	**UK**	**33,076**	Portugal	56,101	Slovenia	38,733
UK	**28,794**	Portugal	29,477	Cyprus	56,002	Cyprus	35,950
Greece	26,211	Cyprus	28,999	Slovenia	40,300	Greece	33,102
Slovenia	22,539	Slovenia	26,463	Hungary	35,000	Portugal	31,437
Turkey	21,711	Greece	26,160	Greece	32,716	Czech Rep	29,644

Table continues on next page

Table 17 continued

Office cleaner		Non-medical secretary		Government statistician		Policeman	
Bosnia & Her	21,474	Czech Rep	22,570	Malta	29,624	Hungary	27,329
Croatia	20,737	Bosnia & Her	21,481	Bosnia & Her	28,929	Turkey	26,018
Hungary	17,017	Poland	21,430	Croatia	28,481	Croatia	24,563
Portugal	16,830	Croatia	21,079	Czech Rep	26,721	Estonia	22,349
Poland	16,177	Malta	19,557	Poland	25,688	Lithuania	21,822
Slovakia	16,057	Hungary	19,130	Turkey	25,081	Slovakia	21,654
Malta	15,184	Turkey	18,596	Latvia	23,713	Bosnia & Her	21,548
Estonia	13,777	Russian Fed	16,414	Slovakia	23,473	Russian Fed	21,151
Czech Rep	12,603	Slovakia	16,379	Estonia	22,456	Malta	21,029
Latvia	11,697	Estonia	14,673	Montenegro	19,823	Bulgaria	16,565
Serbia	10,474	Lithuania	14,410	Serbia	18,827	Latvia	16,214
Romania	10,284	Latvia	12,731	Lithuania	18,562	Serbia	14,919
Lithuania	9,569	Montenegro	11,933	Macedonia	18,164	Albania	13,718
Montenegro	8,185	Macedonia	11,026	Bulgaria	16,043	Macedonia	12,904
Russian Fed	7,468	Serbia	10,335	Albania	15,348	Montenegro	12,269
Bulgaria	7,456	Romania	9,152	Russian Fed	14,275	Romania	9,122
Macedonia	6,670	Albania	7,066	Romania	11,992		
Albania	5,184	Bulgaria	6,747				

Source: World Bank, ICP2011 Data for Researchers, 22 June 2015. These data are available to researchers upon application to the Director of the Data Development Group at the World Bank. I am grateful to the World Bank and Dr Nada Hamadeh for access and support.

7. Conclusion

The last four centuries have seen alterations in the relationship between growth in output per worker and the real wage. In the run up to the Industrial Revolution (1620–1770), both increased, and wages tended to converge upwards. High wages relative to capital prices precipitated the invention of capital-intensive factory production. Competition between the new factories and the remaining handicraft producers during the Industrial Revolution (1770–1867) led to rising inequality in wages, flat average real wages overall, and rising inequality. Once the handicraft sector was competed out of existence by the factories, a long period of fairly steady growth in output per worker ensued from 1867 to 1973.

The Industrial Age (1867–1973) in both the US and the UK depended on several background factors. Settling the West and the British Empire gave both countries huge potential markets for continually increasing output. Demand growth was also maintained by the ceaseless invention of new manufactured products, which were essential in maintaining buoyant demand for so long. In both countries, real wages rose in pace with overall labour productivity. By the end of the nineteenth century, the real wages of skilled workers in the US, in particular, were leaping ahead, and the chance to eliminate their expensive jobs led to the invention of mass production and the routinisation of work – a process that continued through the 1960s. By the 1930s, the spread of collective bargaining throughout manufacturing created an industrial relations system through which the manufacturing work force could secure wage increases that matched productivity growth.

As the US pulled ahead of the UK technologically, new issues appeared for the UK: why was the UK no longer at the forefront of progress? Should it be adopting US technology more completely? The UK was still a dynamic, industrial economy, however. While the US pulled ahead of the UK in per capita income and real wages, the UK remained a leading industrial power in Europe. UK productivity and incomes were higher than those of the leading states in Europe.

In both the US and the UK, the positive situation lasted until about 1973, when the growth in manufacturing output slacked markedly as consumers and government shifted spending towards services, and imports from developing countries began to satisfy domestic demand. Slowly growing manufacturing output in conjunction with the continual substitution of capital for labour via new production technology meant that the number of manufacturing workers went into long-term contraction. More and more of the new work force was absorbed in the new ascendant sector (that is, services). While it provided many high-paying technical and professional jobs, it also recruited large numbers of workers (who would have become factory workers in previous generations) into low-paid jobs, many of which were part-time. Weakness in the labour market contributed to a rise in profits, which now originate mainly in services.

In both countries, the new economic structure has led to regional adjustment problems. They are especially severe in the UK. The only part of the country with a successful economy is London. The rest is largely de-industrialised, and the service sector that has emerged outside London is of low productivity. In 1960, the UK was at or near the top of the western European league tables in productivity and wages. Today, it has been relegated to the central and eastern European league, where it sits on or near the top.

Both countries must address the problems of high inequality and a large section of the work force in low-paying, precarious work. In the case of the UK, this segues into a regional problem that involves at least two-thirds of the country. There are menus of policies to address these issues, and it is the task of the moment to decide how to do that.

References

Acemoglu, D. (2002), 'Directed Technical Change', Review of Economic Studies, 69, 781–810.

Acemoglu, D., Autor, D., Dorn, D., Hanson, G. H., and Price, B. (2016), 'Import Competition and the Great US Employment Sag of the 2000s', *Journal of Labor Economics*, 34 (S1, Part 2), S141–98.

Acemoglu, D., and Restrepo, P. (2018), 'The Race Between Man and Machine: Implications of Technology for Growth, Factor Shares and Employment', *American Economic Review*, 108 (6), 1488–542.

Acemoglu, D., and Restrepo, P. (2019), 'Automation and New Tasks: How Technology Displaces and Reinstates Labor', *Journal of Economic Perspectives*, 33 (2), 3–30.

Acemoglu, D., and Robinson, J. A. (2015), 'The Rise and Decline of General Laws of Capitalism', *Journal of Economic Perspectives,* 29 (1), 3–28.

Aghion, P. and Howitt, P. (1992), 'A Model of Growth through Creative Destruction', Econometrica, 60, 323–51.

Aldrich, N. W. (1893), *Wholesale Prices, Wages, and Transportation*, United States Senate Committee on Finance, 52nd Congress, Washington, DC: Government Printing Office.

Allen, R. C. (1977), 'The Peculiar Productivity History of American Blast Furnaces, 1840–1913', *Journal of Economic History*, 37, 605–33.

Allen, R. C. (1981), 'Entrepreneurship and Technical Progress in the Northeast Coast Pig Iron Industry, 1850–1913', *Research in Economic History*, 6, 35–71.

Allen, R. C. (1983), 'Collective Invention', *Journal of Economic Behavior and Organization*, 4, 1–24.

Allen, R. C. (2001), 'The Great Divergence in European Wages and Prices from the Middle Ages to the First World War', *Explorations in Economic History*, 38, 411–47.

Allen, R. C. (2009a), *The British Industrial Revolution in Global Perspective*, Cambridge: Cambridge University Press.

Allen, R. C. (2009b), '"Engels" Pause: Technical Change, Capital Accumulation, and Inequality in the British Industrial Revolution', *Explorations in Economic History*, 46, 418–35.

Allen, R. C. (2012), 'Technology and the Great Divergence: Global Economic Inequality since 1820', *European Review of Economic History*, 40, 1–16.

Allen, R. C. (2014), 'American Exceptionalism as a Problem in Global History', *Journal of Economic History*, 74, 309–50.

Allen, R. C. (2017), *The Industrial Revolution: A Very Short Introduction*, Oxford: Oxford University Press.

Allen, R. C., Bassino, J.-P., Ma, D., Moll-Murata, C., and van Zanden, J. L. (2011), 'Wages, Prices, and Living Standards in China,1739–1925: in Comparison with Europe, Japan, and India', *Economic History Review*, 64, 8–38.

Allen, R. C., Murphy, T., and Schneider, E. (2012), 'The Colonial Origins of Divergence in the

Americas: A Labour Market Approach', *Journal of Economic History*, 72, 863–94.

Austrian, G. (1982), *Herman Hollerith, Forgotten Giant of Information Processing*, New York: Columbia University Press.

Autor, D., Dorn, D., and Hanson, G. H. (2013), 'The China Syndrome: Local Labor Market Effects of Import Competition in the United States', *American Economic Review*, 103 (6), 2121–68.

Baines, J. A. (1900), 'On Census-Taking and Its Limitations', *Journal of the Royal Statistical Society*, 63, 41–71.

Baumol, W. J. (1986), 'Productivity Growth, Convergence and Welfare: What the Long Run Data Show', *American Economic Review*, 76 (5), 1072–159.

Bowles, S., and Gintis, H. (1976), *Schooling in Capitalist America: Educational Reform and the Contradictions of Economic Life*, New York: Basic Books.

Bowley, A. L. (1937), *Wages and Income in the United Kingdom since 1860*, Cambridge: Cambridge University Press.

Braverman, H. (1974), *Labor and Monopoly Capital*, New York: Monthly Review Press.

Bright, J. R. (1958a), 'Does Automation Raise Skill Requirements?', *Harvard Business Review*, 36 (4), 85–98.

Bright, J. R. (1958b), *Automation and Management*, Boston, MA: Harvard University.

Broadberry, S. N. (1997), *The Productivity Race: British Manufacturing in International Perspective, 1850–1990*, Cambridge: Cambridge University Press.

Broadberry, S., Campbell, B. M. S., Klein, A., Overton, M., and van Leeuwen, B. (2015), *British Economic Growth: 1270–1870*, Cambridge: Cambridge University Press.

Broadberry, S., and Crafts, N. (2003), 'UK Productivity Performance from 1950 to 1979: A Restatement of the Broadberry–Crafts View', Economic History Review, 56, 718–35.

Budd, E. C. (1960), 'Factor Shares, 1850–1910', in *Trends in the American Economy in 1960*, National Bureau of Economic Research, Studies in Income and Wealth, Vol. 24, Princeton, NJ: Princeton University Press, 365–406.

Cahan, D. (1989), *An Institute for an Empire: The Physikalisch-Technische Reichsanstalt, 1871–1918*, Cambridge: Cambridge University Press.

Case, A., and Deaton, A. (2020), *Deaths of Despair and the Future of Capitalism*, Princeton, NJ: Princeton University Press.

Chandler, A. D. (1977), *The Visible Hand: The Managerial Revolution in American Business*, Cambridge, MA: Belknap Press of Harvard University Press.

Chinoy, E. (1955), *Automobile Workers and the American Dream*, Boston, MA: Beacon Press.

Clark, G. (2005), 'The Condition of the Working Class in England, 1209–2004', *Journal of Political Economy*, 113, 1307–40.

Clark, G. (2007), *A Farewell to Alms: A Brief Economic History of the World*, Princeton, NJ:

Princeton University Press.

Collins, W. J. (1997), 'When the Tide Turned: Immigration and the Delay of the Great Black Migration', *Journal of Economic History*, 57, 607–32.

Crafts, N. F. R. (1991), 'Productivity Growth Reconsidered', *Economic Policy*, 15, 388–414.

Crafts, N. F. R. (1998), 'Forging Ahead and Falling Behind: The Rise and Relative Decline of the First Industrial Nation', *Journal of Economic Perspectives*, 12 (2), 193–210.

Crafts, N. F. R. (2012), 'British Relative Economic Decline Revisited: The Role of Competition', *Explorations in Economic History*, 49, 17–29.

Crafts, N. F. R. (2014), 'Economic Growth during the Long Twentieth Century', in R. Floud, J. Humphries, and P. Johnson *(eds), The Cambridge Economic History of Modern Britain*, *Vol. II: 1870 to the Present,* 2nd edition, Cambridge: Cambridge University Press, 26–59.

Denison, E. F. (1962), '*The Sources of Economic Growth in the United States and the Alternatives Before Us'*, Committee for Economic Development, New York, Supplementary Paper No. 13.

Dorn, D., Schmieder, J. F., and Spletzer, J. R. (2018), 'Domestic Outsourcing in the United States', https://www.dol.gov/sites/dolgov/files/OASP/legacy/files/Domestic-Outsourcing-in-the-United-States.pdf.

Editor of The 'Statist' (1918), 'Wholesale Prices of Commodities in 1917', *Journal of the Royal Statistical Society*, 81, 334–49.

Editor of The 'Statist' (1938), 'Wholesale Prices in 1937', *Journal of the Royal Statistical Society*, 101, 376–93.

Edgerton, D. (2018), *The Rise and Fall of the British Nation: A Twentieth-Century History*, London: Penguin Random House.

Elbaum, B. (1989), 'Why Apprenticeship Persisted in Britain But Not in the United States', *Journal of Economic History*, 49, 337–49.

Engels, F. (1845), *The Condition of the Working Class in England*, translation (1958) by W. O. Henderson and W. H. Chaloner (eds), Oxford: Basil Blackwell.

Feenstra, R., Ma, H., Sasahara, A., and Xu, Y. (2018), 'Reconsidering the "China shock" in trade', VoxEU, 18 January, https://voxeu.org/article/reconsidering-china-shock-trade.

Feenstra, R. C., Inklaar, R., and Timmer, M. P. (2015), 'The Next Generation of the Penn World Table', *American Economic Review*, 105 (10), 3150–82.

Feinstein, C. H. (1972), *National Income, Expenditure and Output of the United Kingdom, 1855–1965*, Cambridge: Cambridge University Press.

Feinstein, C. H. (1998a), 'Pessimism Perpetuated: Real Wages and the Standard of Living in Britain during and after the Industrial Revolution', *Journal of Economic History*, 58, 625–58.

Feinstein, C. H. (1998b), 'Wage-Earnings in Great Britain during the Industrial Revolution', in I. Begg and S. G. B. Henry *(eds), Applied Economics and Public Policy*, Cambridge: Cambridge University Press, 181–208.

Feinstein, C. H. (1994), 'Success and Failure: British Economic Growth since 1948', in R. Floud and D. McCloskey *(eds), The Economic History of Britain since 1700*, *Vol. 3: 1939–1992,* 2nd edition,

Cambridge: Cambridge University Press, 95–122.

Flood, S., King, M., Rodgers, R., Ruggles, S., and Warren, J. R. (2020), Integrated Public Use Microdata Series, Current Population Survey: Version 7.0 [ASEC for 1972 and 2017]. Minneapolis, MN: IPUMS, https://doi.org/10.18128/D030.V7.0.

Ford, H. (1922), *My Life and Work*, London: William Heineman.

Friedman, M. (1992), 'Do Old Fallacies Ever Die?', Journal of Economic Literature , 30, 2129–32.

Gilboy, E. W. (1934), *Wages in Eighteenth Century England*, Cambridge, MA: Harvard University Press.

Goldin, C. (1994), 'The Political Economy of Immigration Restriction in the United States, 1890 to 1921', in C. Goldin and G. D. Libecap *(eds), The Regulated Economy: A Historical Approach to Political Economy*, Chicago, IL: University of Chicago Press, 223–58.

Goldin, C., and Katz, L. (1998), 'The Origins of Technology–Skill Complementarity', *Quarterly Journal of Economics*, 113, 693–732.

Goldin, C., and Katz, L. (2008), *The Race between Education and Technology*, Cambridge, MA: Belknap Press.

Goldin, C., and Margo, R. A. (1992), 'The Great Compression: The Wage Structure of the United States at Mid-Century', *Quarterly Journal of Economics*, 107, 1–34.

Gordon, R. J. (2016), *The Rise and Fall of American Growth*, Princeton, NJ: Princeton University Press.

Grossman, G. M. and Helpman, E. (1991), Innovation and Growth in the Global Economy, Cambridge, MA: MIT Press.

Hammond, J. L., and Hammond, B. (1919), *The Town Labourer: 1760–1832*, London: Longmans, Green.

Hartwell, R. M. (1961), 'The Rising Standard of Living in England, 1800–1850', *Economic History Review*, 13, 397–416.

Hatton, T. J., and Tani, M. (2005), 'Immigration and Inter-regional Mobility in the UK, 1980–2000', *Economic Journal*, 115, F342–58.

Hobsbawm, E. J. (1957), The British Standard of Living, 1790–1850', *Economic History Review*, 10, 46–68.

Homer, S., and Sylla, R. (1996), *A History of Interest Rates*, 3rd edition, rev., New Brunswick, NJ: Rutgers University Press.

Humphries, J., and Weisdorf, J. (2015), 'The Wages of Women in England, 1260–1850', *Journal of Economic History,* 75, 405–47.

Humphries, J., and Weisdorf, J. (2019), 'Unreal Wages? Real Income and Economic Growth in England, 1260–1850', *Economic Journal*, 129, 2867–87.

International Labor Office (1934), 'Retail Prices and Rents in Certain Towns and Countries in October 1933', International Labor Review, XXIX, 859–65.

International Labor Office (1932), 'Wages, Hours of Labor and Retail Prices in Certain Towns',

International Labor Review, XXIX, 105–16.

Jorgenson, D., and Griliches, Z. (1967), 'The Explanation of Productivity Change', *Review of Economic Studies,* 34, 249–80.

Jorgenson, D., Ho, M. S., and Samuels, J. D. (2016), 'The Impact of Information Technology on Postwar US Economic Growth', Telecommunications Policy, 40, 398–411.

Kaldor, N. (1957), 'A Model of Economic Growth', *Economic Journal*, 67, 591–624.

Katz, L. F., and Krueger, A. B. (2019), 'The Rise and Nature of Alternative Work Arrangements in the United States', *ILR Review,* 72, 382–416.

Katz, L. F., and Margo, R. A. (2014), 'Technical Change and the Relative Demand for Skilled Labor: The United States in Historical Perspective', in L. P. Boustan, C. Frydman and R. A. Margo *(eds), Human Capital in History: The American Record*, Chicago, IL: University of Chicago Press, 15–57.

Khan, B. Z., and Sokoloff, K. L. (1993), '"Schemes of Practical Utility": Entrepreneurship and Innovation among "Great Inventors" in the United States, 1790–1846', *Journal of Economic History*, 53, 289–307.

Krugman, P. (2016), 'Notes on Brexit and the Pound', *The New York Times*, October 11, https://krugman.blogs.nytimes.com/2016/10/11/notes-on-brexit-and-the-pound/.

Lee, C. H. (1979), *British Regional Employment Statistics, 1841–1971*, Cambridge: Cambridge University Press.

Lindert, P. H., and Williamson, J. G. (2016), *Unequal Gains: American Growth and Inequality since 1700*, Princeton, NJ: Princeton University Press.

Lorenz, E. H. (1991), *Economic Decline in Britain: The Shipbuilding Industry, 1890–1970*, Oxford: Oxford University Press.

Lucas, R. E. (1988), 'On the Mechanics of Economic Development', Journal of Monetary Economics, 22, 3–42.

Maddison, A. (2006), *The World Economy*, Paris: OECD Publishing.

Margo, R. A. (2000), 'New Estimates for Nominal and Real Wages in the Antebellum Period', in R. A. Margo *(ed.), Wages and Labor Markets in the United States 1820–1860*, Chicago, IL: University of Chicago Press, 36–75.

Marx, K. (1867), *Capital: A Critique of Political Economy*, Moscow: Progress Publishers, First English edition of 1887, Marx/Engels Internet Archive (marxists.org), 1995, 1999, Volume I.

Mazzucato, M. (2013),The Entrepreneurial State: Debunking the Public vs Private Myths in Risk and Innovation, London: Anthem Press.

Meyer, S. (1981), *The Five Dollar Day: Labor Management and Social Control in the Ford Motor Company, 1908–1921*, Albany, NY: State University of New York Press.

Milward, R. (1994), 'Industrial and Commercial Performance since 1950', in R. Floud and D. McCloskey *(eds), The Economic History of Britain since 1700*, *Vol. 3: 1939–1992*, 2nd edition, Cambridge: Cambridge University Press, 123–67.

Minnesota Population Center (2020), *Integrated Public Use Microdata Series, International:*

Version 7.3 [United Kingdom 2000]]. Minneapolis, MN: IPUMS, https://doi.org/10.18128/D020.V7.2.

Mitchell, B. R., and Deane, P. (1971), *Abstract of British Historical Statistics*, Cambridge: Cambridge University Press.

Mokyr, J. (1990), *The Lever of Riches: Technological Creativity and Economic Progress*, New York: Oxford University Press.

Mokyr, J. (2002), *The Gifts of Athena: Historical Origins of the Knowledge Economy*, Princeton, NJ: Princeton University Press.

Mokyr, J. (2009), *The Enlightened Economy: The Economic History of Britain, 1700–1850*, London: Penguin Press.

Mokyr, J. (2017), *The Culture of Growth*, Princeton, NJ: Princeton University Press.

Nelson, R. R, and Wright, G. (1992), 'The Rise and Fall of American Technological Leadership: The Postwar Era in Historical Perspective', *Journal of Economic Perspectives*, 30 (4), 1931–1964.

North, D. C., and Thomas, R. P. (1973), *The Rise of the Western World*, Cambridge: Cambridge University Press.

Nuvolari, A. (2004), 'Collective Invention during the British Industrial Revolution: The Cast of the Cornish Pumping Engine', *Cambridge Journal of Economics*, 28, 347–63.

Officer, L. H., and Williamson, S. H. (2020), 'The Annual Consumer Price Index for the United States, 1774–Present', MeasuringWorth, http://www.measuringworth.com/uscpi/.

O'Rourke, K. H. (1997), 'The European Grain Invasion, 1870–1913', *Journal of Economic History*, 57, 775–801.

O'Rourke, K. H. (2019), 'Economic History and Contemporary Challenges to Globalization', *Journal of Economic History*, 79, 356–82.

Potter, N., and Christy, F. T., Jr (1962), *Trends in Natural Resource Commodities: Statistics of Prices, Output, Consumption, Foreign Trade, and Employment in the United States, 1870–1957*, Resources for the Future, Baltimore, MD: Johns Hopkins Press.

Pierce, J. R., and Shott, P. K. (2016), 'The Surprisingly Swift Decline of US Manufacturing Employment', *American Economic Review*, 106 (7), 1632–62.

Piketty, T. (2014), *Capital in the Twenty-First Century*, Cambridge, MA: Harvard University Press.

Ray, D. (2015), 'Nit-Piketty: A Comment on Thomas Piketty's Capital in the Twenty First Century', CESifo Forum, ifo Institute – Leibniz Institute for Economic Research at the University of Munich, 16, 19–25.

Romer, P. M. (1986), 'Increasing Returns and Long-Run Growth', Journal of Political Economy, 94, 1002–37.

Romer, P.M. (1990), 'Endogenous Technological Change', Journal of Political Economy, 98, S71–S102.

Rosés, J. R., and Wolf, N. (2019), *The Economic Development of Europe's Regions: A Quantitative History since 1900*, Abingdon: Routledge.

Sauerbeck, A. (1886), 'Prices of Commodities and the Precious Metals', *Journal of the Statistical Society of London*, 49, 581–648.

Sauerbeck, A. (1907), 'Prices of Commodities in 1906', *Journal of the Royal Statistical Society*, 70, 107–21.

Schumpeter, J. A. (1994), *Capitalism, Socialism, and Democracy*, London: Routledge, ebook.

Schwartz, L. D. (1985), 'The Standard of Living in the Long Run: London: 1700–1860', Economic History Review, 38, 24–41.

Solow, R. M. (1956), 'A Contribution to the Theory of Economic Growth', *Quarterly Journal of Economics*, 70, 65–94.

Summers, R., and Heston, A. (1984), 'Improved International Comparisons of Real Product and its Composition: 1950–1980', *Review of Income and Wealth*, 30, 207–62.

Supple, B. (1994), 'British Economic Decline since 1945', in R. Floud and D. McCloskey *(eds), The Economic History of Britain since 1700*, *Vol. 3: 1939–1992, 2nd edition,* Cambridge: Cambridge University Press, 318–46.

Temin, P. (1964), *Iron and Steel in Nineteenth-century America: An Economic Enquiry*, Cambridge, MA: MIT Press.

Temin, P. (2017), *The Vanishing Middle Class: Prejudice and Power in a Dual Economy*, Cambridge, MA: MIT Press.

Truesdell, L. E. (1965), *The Development of Punch Card Tabulation in the Bureau of the Census, 1890–1940*, Washington, DC: Bureau of the Census.

UK Board of Trade (1911), 'Report of an Enquiry [...] into Working Class Rents, Housing and Retail Prices [...] in [...] the United States of America', Parliamentary Papers, cd 5609, Vol. LXXXVIII.

UK Department of Employment and Productivity (1971), *British Labour Statistics: Historical Abstract, 1886–1968*, London, Her Majesty's Stationery Office.

Williamson, J. G. (1995), 'The Evolution of Global Labor Markets since 1830: Background Evidence and Hypotheses', *Explorations in Economic History*, 32, 141–96.

Williamson, J. G., and Lindert, P. H. (1980), *American Inequality: A Macroeconomic History*, New York: Academic Press.

Wingfield, D., Fenwick, D., and Smith, K. (2005), 'Relative Regional Consumer Price Levels in 2004', *Economic Trends, 615*, 36-45, https://www.ons.gov.uk/economy/inflationandpriceindices/articles/relativeregionalconsumerpricelevelsuk/2016.

Young, E. (1875), *Labor in Europe and America*, Washington, DC: Government Printing Office.