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# The Past and Future of Work: How history can inform the age of automation

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# The Past and Future of Work: How History Can Inform the Age of Automation

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**Abstract**

Debates about the future of work frequently reference past instances of transformative innovation to explain how automation and artificial intelligence could reshape society and the economy. However, historians have rarely engaged with these discussions, and most economists and technologists have limited knowledge of past experiences of technological change. In this paper we show that a deeper understanding of history can expand our understanding of possibilities and pitfalls for employment in the future. We open by demonstrating that evidence from historical events has been used to inform responses to present-day challenges. We argue that history provides the only way to analyze the long-term impacts of technological change, and that the scale of the First Industrial Revolution may make it the only precedent for emerging transformations. Next, we present an overview of the current debates around the potential effects of impending labour-replacing innovation. We then summarize existing historical research on the causes and consequences of technological change and identify areas in which salient historical findings are overlooked. We close by proposing further research into past technological shocks that can enhance our vision of an automated future.

## Introduction

Technological change is frequently discussed as one of the major challenges of the 21st century. A wave of books in the 2010s depicted idyllic and catastrophic visions of an automated future (Brynjolfsson and McAfee 2014, Ford 2015,

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Baldwin 2019), and the spectre of driverless vehicles causing large-scale job destruction has attracted particular attention. However, the impacts of past innovations on work and labour markets have received only superficial analysis in contemporary discussions. In this paper we argue that history can make important contributions to debates on the future of work.

The plan of the paper is as follows. Section 1 articulates a general case for how history can provide useful knowledge. We give examples of historical research informing understanding of present-day concerns: during two major crises, the 2007–09 Global Financial Crisis and the COVID-19 pandemic, the public and policymakers have looked to history to understand events and inform responses. We argue that debates on the future of work would similarly benefit from a historical perspective.

In Section 2 we review the current debates on the future of work. The discussion is led by economists, technologists, and policymakers, and centres around analysis of which jobs are most at risk of labour displacement, the potential for employment polarization, and whether new technologies will entrench inequalities on multiple dimensions. Engagement with past experiences of technological unemployment in these debates rarely extends beyond simplistic histories of the British Industrial Revolution. This produces an overly optimistic view of the outcomes of previous technological shocks and justifies sanguine projections for the future.

In Section 3 we review existing economic, social, and technological history scholarship on the impacts of innovation on work and labour markets, focusing on examples from Europe and the United States. We highlight research in the following areas: incentives for innovation; resistance to technology; quantifying technological unemployment in historical contexts; the distributional consequences of new technology; and changes to work organization, job content, and job quality. Past examples of technological change illustrate the extent to

which the impacts of technology can be shaped or mediated by individual and institutional choices.

In Section 4 we describe key areas in which the gap between historical knowledge and current debates has led to a narrow perspective of possible trajectories for the future of work. We show that the uncertain future of innovation, the risk of technological unemployment, and the difficulty of predicting skill demands are readily visible in existing scholarship of the history of technological change. We go on to highlight areas in which further historical research could contribute additional insights to the future of work debates. Section 5 concludes.

**1: History as Useful Knowledge**

History is the basis of all empirical decision-making. When we use evidence to analyze choices or make predictions we are informed by the past, whether recent or distant. The more recent past is often assumed to be a better source of evidence for policymaking. It has the benefit of proximity, which gives researchers an expectation that many unobserved variables remain constant between the case study and the present problem. However, there are situations in which the more distant past can provide a more applicable analogue. The features of some current problems may only have parallels that occurred far earlier in history: for example, earlier events may be more appropriate comparators because of their scale. Large changes happen rarely, and comparisons with recent but smaller social, economic, or political shifts or events may be inaccurate.

History provides a far wider range of events and evidence for study than is available in the recent past. If studies of technological change are limited to the last few decades, researchers will have comparatively few examples to investigate and limited variation in the important contextual variables that shape the eventual impacts of an innovation, as we discuss in Section 3. There

are many examples of disruptive technologies in the past, and they have occurred in a variety of settings. Awareness of social, political, and cultural influences on the course and effects of innovation, and differences between technological waves and their implications, is more acute in history than contemporary research on economics and technology (Freeman and Louçã 2001, Allen 2017).

The methodological diversity of historical research enables a broader perspective on the impacts of technological change than analysis which relies exclusively on approaches from economics. Many aspects of the development, adoption, and consequences of innovation are not easily quantified or modelled mathematically. While economics provides powerful approaches to identify causal relationships, it has had less success in capturing social or political resistance to inventions, and non-economic factors that influence the direction of technological change and the adoption of new techniques. Economics has also, until very recently, neglected analysis of qualitative elements of work that may change dramatically with innovation, such as effort demands and control over the work process. The mixture of descriptive and quantitative approaches used in history enables a uniquely wide-ranging and systematic view of the course and effects of technological transformations.

While historical research has provided deep understanding of qualitative aspects of life, it is now also able to provide a quantitative account for selected periods. Recent increases in computing power, together with the new availability of large datasets from the 19th century and after, are enabling scholars to generate a more comprehensive view of long-run economic and social dynamics than had been possible before. Two examples are illustrative: Thomas Piketty's *Capital in the 21st Century* (2014) used long-run administrative data to overturn long-held views on the relationship between development and inequality. In *Streets of Gold* (2022) Ran Abramitzky and Leah Boustan use millions of data points to revisit traditional narratives on immigration and social mobility in the United States. These initiatives reflect a sea change in the study of history. They herald a

future in which the past can yield increasingly powerful insights into social science processes, and in which the historical record is routinely consulted.

Two major catastrophes of the last two decades, the Global Financial Crisis (GFC) of 2007–09 and the coronavirus (COVID-19) pandemic, illustrate how historical research can also inform policymaking. In each case, the public, policymakers, and researchers looked to history and historical knowledge to understand the unfolding crisis. During and after the GFC, economists and economic historians used historical evidence, especially from the Great Depression, to understand what policy responses to financial crises and contractions may be more, or less, effective, the constraints of currency blocs, and the transmission mechanisms of financial distress to the real economy. Research on the duration of the Great Depression and the constraints of fixed exchange rates under the gold standard was important during public and policy discussions of the slow recovery from the GFC and the ensuing Eurocrisis (Eichengreen 2015). The GFC also stimulated research on booms and financial crises, using comparative perspectives (Schularick and Taylor 2012, Calomiris and Haber 2014, Dimsdale and Hotson 2014, Turner 2014, Bordo, Redish et al. 2015, Quinn and Turner 2020) and detailed analysis of individual events (Accominotti 2019). Research on the causes of financial crises, their effects, and policy responses with historical perspectives has continued into the 2020s (Albers 2020, Bent 2020, Lennard 2020, Kenny, Lennard et al. 2021, Rockoff 2021).

Insights from economic history directly shaped policymaking: then-US President Barack Obama stated that the Great Depression expertise of Christina Romer and Ben Bernanke was an important reason for appointing the former to be Chair of the Council of Economic Advisors and re-nominating the latter as Chair of the Federal Reserve. Bernanke himself has recently argued that history is essential to understand monetary policymaking (Bernanke 2022), and his work on the Depression (Bernanke 1983) was cited by the Nobel committee when it awarded him the 2022 economics prize (Kungliga Vetenskapsakademien 2022).

Similarly, the COVID-19 pandemic produced a sharp increase in public and scholarly interest in the 1918 influenza pandemic and other historical pandemics, including the Black Death. Faced with supposedly "unprecedented" events, there was a scramble *for* precedents: Google search trends show an explosion in searches for "Spanish flu" and "Black Death" in the first half of 2020.[3] Reflecting this growing popular and scholarly interest, pre-existing research was given much greater prominence, and the COVID-19 crisis stimulated new studies. Scholars have sought to understand the effects of past pandemics on employment, inequality, education, innovation, and other social and economic indicators, and have used these findings to inform public debates and policy (Guimbeau, Menon et al. 2020, Arthi and Parman 2021, Basco, Domènech et al. 2021, Mamelund and Dimka 2021, Alfani 2022, Beach, Clay et al. 2022, Franke 2022, Jedwab, Johnson et al. 2022). The crisis led to the creation of new research centres on pandemics, some of which incorporate historical studies, and more funding for academic research on past disease outbreaks.

In sharp contrast to the two crises discussed above, the emerging debate on the future of work has enjoyed minimal input from the historical record. This is not from a lack of general interest: most of the popular books on automation and the future of work include a brief section on economic history to provide context for recent developments. However, these chapters are almost invariably superficial. The absence of detailed historical analysis from the future of work debates is a missed opportunity, as past instances of technological change can illuminate the future of work in unique ways. While there are differences between 21st century automation and past innovations, four salient characteristics make historical experiences relevant. The first is scale: the First Industrial Revolution (c. 1750–1850) may have been characterized by widespread labour displacement that has been unmatched since. If this was the case, then it could be the best parallel to

[3] Similarly, searches for terms related to the 1929 financial crisis and the Great Depression spiked in late 2008.

what technologists claim will be a wave of labour-displacing innovation in the coming decades.

Second, and relatedly, there is a fundamental similarity between the First Industrial Revolution and the potential outcomes of automation. The major technologies of 1750–1850, in broad terms, replaced human and animal muscle and dexterity with inanimate power and implements. Textile machines supplanted the arms and legs of weavers and the hands of spinners. Sewing and riveting machines replaced the hand-sewing work of bootmakers. Steam engines took the place of human strength and draught animals to drive machinery and move goods over water and rails. Technologies of the Second Industrial Revolution (c. 1850–1940) improved on these inanimate methods in physical production, and the Third Industrial Revolution or ICT Revolution (c. 1970–present) introduced early digital technologies that primarily augmented and did not replace labour. The potential impacts of the automation revolution or "Fourth" Industrial Revolution are most similar to the First Industrial Revolution: technologists are aiming to replace human cognition in the workplace, superseding the human brain's capacity for pattern recognition and routine decision-making.[4]

Matching the scale of past and present innovations is essential to make reasonable predictions for the future of work. An inaccurate comparison, no matter how good the underlying data, will produce a poor projection. By way of analogy, even if an economist in 1750 had access to excellent data from the then-recent past and econometric tools equivalent to those available in the 2020s, he would not have been able to predict the dramatic transformations of the following century. Contemporary research constrained to data from the last half-century of innovation, which has seen steadily diminishing breakthroughs, may draw misleading lessons for the future of work. In Schumpeterian language,

[4] Some researchers have questioned whether automation technologies will achieve this goal (e.g. Cetrulo & Nuvolari 2019, and, more forcefully, Munn 2022).

while the gales of creative destruction have been perennial over the last two centuries, some storms are of greater consequence.

Third, labour-replacing technology is a key—if not *the* key—feature of global economic development over the last 250 years. Cycles of innovation, adoption, and labour replacement have been recurring since the late 18th century, and although much has changed in the processes of production, labour displacement and reinstatement has remained a core feature.

Finally, the full effects of technological change on labour can only be captured over the long run, which requires historical analysis. History includes entire cycles of labour replacing technology for study, whereas the effects of recent innovations are incomplete and complicated by interactions with global trade and offshoring. Analyzing the life cycles of both workers and technological shocks requires a long-term perspective. This is necessarily true of the intergenerational impacts of the shocks. Analysis and comparison of historical changes in technology over the long run can enable more informed decision-making by firms, workers, and governments about how to approach the risks of technological unemployment, the potential for job-changing innovation, and how to secure the opportunities of inventions that replace human labour.

## 2: The Current Debates on the Future of Work

At present, debates on the future of work are dominated by economists, technological futurists, and political scientists. Most discussions start with estimates of how many jobs are at risk of automation. Estimates are high. The much-circulated paper by Frey and Osborne (2017) found that up to 47% of jobs in the United States were potentially automatable, and other research has produced similarly dramatic and concerning results (Chang and Huynh 2016). These emerging views stand in sharp contrast to the sanguine outlook economists once held about the impact of technological change on labour markets.

Once the scale of the challenge is established, the discussion moves to consider two separate concerns. The first of these is whether this cycle of rapid technological progress is substantially different from earlier cycles, in that, with the emergence of artificial intelligence (AI), we are potentially facing permanent technological unemployment. The second addresses the distributional effects of labour displacement and reinstatement.

2.1: Permanent Technological Unemployment and Distributional Effects

A central question of the future of work debate is whether new technologies will permanently replace human labour. Anxiety about permanent technological unemployment is perennial: Aristotle wrote about it, as did Karl Marx, Jean-Baptiste Say, David Ricardo, and John Maynard Keynes (Bix 2000).

Prior to the era of modern economic growth, the concern that new technologies would displace labour often created political barriers to their adoption (Frey 2019). However, over the last two hundred years, in aggregate, more new jobs have been created than lost. This did not mean that transitions were seamless: workers often faced periods of unemployment, a decline in the value of their human capital, and technological shocks may have entrenched geographic or intergenerational disadvantages.

The emergence of AI has revived real concern that new technology may cause permanent technological unemployment, which participants in the debate claim has not been considered a threat since the 19th century.[5] The central contention is that AI will outcompete human labour on every front, and that the new work created by new technology will also be performed by machines (Pratt 2015, Susskind 2020). It is worth noting how very recent this revival of the old concern has been. It is only in the last decade that it has received serious consideration by scholars, and despite the new interest in this area, most economists continue to avoid the well-established Keynesian terminology. Instead of discussing

[5] In fact, fears about permanent technological unemployment occurred at various times in the 20th century, most notably in the 1930s (Bix 2000).

technological unemployment, they refer to "labour displacement" (Acemoglu and Restrepo 2019), or the "equilibrium impacts of technological progress" (Goos 2018). Despite the neutral language, economists are concerned: in a recent poll of leading economists, 35–40% agreed that artificial intelligence will increase long-term unemployment (Autor 2022).

The second concern is that the adoption of new technologies may entrench inequality. This consideration is linked to the short-term labour displacing impacts of technology. Economists have addressed how the adoption of new technology impacts labour market outcomes through the lens of three different paradigms over the last three decades (Autor 2022), and each paradigm implies a different set of distributional effects driven by the adoption of new technology.

The first model, Skills Biased Technological Change (SBTC), is the canonical "race between technology and education". It casts the distributional impacts of the adoption of new technologies as the result of supply and demand. When the supply of highly-educated workers increases, their wage premiums will not decrease if the demand for their skills keeps pace or exceeds the additional supply (Tinbergen 1974, Goldin and Katz 2008). The model allows that highly skilled workers may be securing a skill premium. However, it does not imply that the real wages of low skilled workers will decline. Therefore, while the adoption of new technologies may be driving an increase in inequality, this is the result of increasing skill premiums. The model focuses on the impact that new technologies have in terms of skill premiums and does not explore job creation or job loss resulting from changes in the demand for skills.

In the SBTC paradigm, innovation increases the wage premium for highly skilled labour. Early SBTC models are based on the countervailing forces of supply and demand: new technologies have a skills bias and increase demand for highly skilled workers. This increased demand, if it is not offset by increasing supply, then drives a wage premium for skill (Tinbergen 1974, Goldin and Katz 2008). In *The Race Between Education and Technology*, Goldin and Katz show

that despite a large increase in the number and proportion of highly skilled workers in the United States over the last century, wage premiums persist. Sustained demand for highly skilled workers is driven by the ongoing technological innovations powering modern economic growth (Goldin and Katz 2008). SBTC is often referred to as the canonical model.

Routine Biased Technological Change (RBTC) or the "Task Polarization Model" was developed out of the canonical model but differs in that it identifies the impact of innovation at the task level. Introduced in the early 2000s and built on the scaffolding of the SBTC model, RBTC takes as its starting point that the adoption of new technologies impacts tasks within occupations (Autor, Levy et al. 2003). This model allows for differential impacts of technological change within an industry or an occupation: some workers are more exposed to labour-replacing innovation, and more routine tasks are more likely to be replaced. Empirical papers find a hollowing out of the occupational structure and polarization of incomes resulting from the adoption of new technologies (Goos and Manning 2007).

The third and most recent model is one of labour replacement and reinstatement (Acemoglu and Restrepo 2019). In this model, the impacts of shifting demand for labour are considered both in terms of skills premiums or penalties and job loss and job creation. Autor et al (2022) show that new jobs created in recent decades are frequently poorly paid, have bad working conditions, and lack a safety net. Moreover, 50–70% of the increases in wage inequalities between 1980–2016 can be attributed to the polarizing impacts of new technologies (Acemoglu and Restrepo 2022).

The academic discussions about unemployment and wage polarization resulting from technological change are often translated into policy recommendations. At present, these revolve around developing retraining opportunities. In the words of the MIT report on the Future of Work: "Our policy focus is on education and training for adults, particularly those whose work is more vulnerable to

automation". This approach may in part be the legacy of the decades of work done within the SBTC paradigm, but the MIT researchers admit that it has seen relatively little success and policy makers are exploring new ideas. The same report acknowledges that more research is needed to understand how to serve workers displaced by new technologies (Autor, Mindell et al. 2020). History can help to understand the dimensions and duration of labour-replacing innovations' impacts on workers, families, and communities. Such research can then inform the scale and targeting of policy responses.

2.2: History in the Contemporary Debate

Historical experiences of labour replacement often appear in the current debate. Many recent books addressing the automation revolution include a historical chapter (Brynjolfsson and McAfee 2014, Ford 2015, Baldwin 2019, Bootle 2019, Susskind 2020, Aghion, Antonin et al. 2021), but this is often merely a framing device. Usually placed immediately after the introduction, these chapters present a brief, simplified summary of global economic history over the last 2000 years. The consistent message is that poverty was the norm and there was little growth for thousands of years. Then, in the late 1700s, a series of inventions dramatically changed the British economy and society, and eventually spread to the rest of the world. Prices for goods dropped, and consumers everywhere benefited. Some workers lost their jobs, but creative destruction also generated new employment opportunities, and by the mid-19th century most people had benefited substantially from industrialization. The discussion generally ends on this optimistic note, without considering the lasting impacts of these shocks on workers or their families. It bases expectations of the future on a misunderstanding of the past: there may be some disruption, but innovation will proceed and improve wellbeing across the globe. A few of the recent books on the future of work do acknowledge short-term "frictions" introduced by job destruction (e.g. Baldwin 2019), but evidence of deleterious long-run impacts from past technological changes is usually ignored.

On the other hand, Frey (2019), whose work benefits from extensive historical grounding, discusses social resistance to innovation and the negative impacts of technology for some workers in detail. This difference in approach and interpretation illustrates the extent to which a genuinely historical view of the impacts of innovation offers a broader understanding of potential future outcomes.

In policy documents the history of labour displacement is mentioned only in passing. The OECD's position on the future of work is devoted to understanding the characteristics of AI and classifying potential AI innovations as augmenting or replacing labour. They do not take a long run view. However, they do compare present day changes to events of the past to suggest that artificial intelligence may herald a new age in labour displacement by creating permanent technological unemployment (OECD 2019). The Institute for the Future of Work notes that there are winners and losers with each wave of new technology, and that neither the beneficial nor the adverse consequences of automation are evenly distributed. Their evidence suggests that polarization between pay and conditions in work will continue (Institute for the Future of Work 2022). The 2018 MIT Work of the Future Report opens with a brief overview of the history of labour displacement, which argues that the last 125 years of creative destruction have yielded a net creation in jobs rather than a net job loss. The increase is both in proportion, with a net increase in the share of adults in full time employment, and in absolute numbers. This long-run perspective also highlights the extent to which new work has been rapidly created: more than 60% of the employment in 2018 was in work that had not been "invented" in 1940.

However, this report, and most other reports and popular books on the future of work do not investigate the long-run deleterious impacts of past technological shocks on families or regions, or how non-economic factors have shaped technological adoption.

## 3: Technology and Work in History

While historians have rarely addressed future of work debates directly, existing research can contribute to a better understanding of how technological shifts impact work and labour markets. In this section we synthesize findings in five areas that are relevant for future of work debates.

### 3.1: Innovation

Economic historians have made significant progress, especially in recent years, towards understanding the genesis of innovation. Researchers have provided evidence for the importance of scientific knowledge, networks of information, human capital formation and education, factor prices, and market size. Historical studies have also illustrated the difficulty of predicting which technologies will dominate and explained the long persistence of older techniques.

Perhaps the most influential arguments discuss the relative prices of capital, land, and labour. The work of Hicks (1932), Habakkuk (1962) and most recently Allen (2009) has argued that inventors seek to economize on the most expensive factor of production. In the United States in the 19th century, this produced skilled-labour-saving innovation that used natural resources extensively by comparison with British practices (Habakkuk 1962, Temin 1966, Ames and Rosenberg 1968, James and Skinner 1985, Broadberry 1997). The production of knowledge on induced innovation has led directly to significant public discussions and attempts to base policy on economic history research (e.g. the British government's claim in 2021 that it would create a "high-wage" economy, BBC 2021).

Researchers have shown that networks of producing and sharing knowledge are a contributor to innovation (Mokyr 2002), as are the skills or human capital of both potential inventors (Squicciarini and Voigtländer 2015) and technology adopters (Hornung 2014, Kelly, Mokyr et al. 2014, de la Croix, Doepke et al. 20178)

The institutional shift in economic history has contributed to our understanding of the best conditions for innovation. Beginning with North & Weingast (1989), economic historians and economists have argued that formal and informal institutions enable (or inhibit) and shape the directions of innovative activity (e.g. Acemoglu et al. 2005, Cantoni & Yuchtman 2014, Cox 2017).

Following on from interest in institutions, scholars have begun to investigate the role of culture. While this area remains more debated than that of institutions, a number of papers have argued that culture is important for growth, either directly (Becker and Woessmann 2009) or through institutions (Temin 1997, Belloc, Drago et al. 2016).

In addition to research on the drivers of innovation, historical studies show that innovations that later appear demonstrably superior are not always rapidly or uniformly adopted. Two examples are the variety of power sources and designs available to early automobiles (Wells 2007), and the competition between railroads and canals in the 1820s and 1830s (Goodrich 1961). There were multiple technological paths available at many points in history, as there are now. Similarly, historical examples of innovation show that technological diffusion is an extended process, and not purely for reasons of lock-in. Sailing ships continued in use long into the age of steam (Harley 1972, Harley 1973), and water power was a major source of energy for American manufacturing up to the end of the 19th century (Hunter 1979, Hunter 1985, Hunter and Bryant 1991). Seemingly "obsolete" technologies can continue in use for many decades, with implications for available jobs, work organization, and job locations.

These strands of research are both conflicting and reinforcing: the causes of growth through innovation are multifarious (Koyama and Rubin 2022). While the structures for generating and sharing new ideas have changed with the rise of corporate R&D and government research funding (Reich 1985, Usselman 2002), economic, social, political, and cultural forces continue to shape the rate and direction of technological development and diffusion. History has provided a

firmer basis for understanding the conditions that are conducive to innovative activity, the incentives that encourage inventors to develop technology in different directions, and the uncertain path of technological development.

### 3.2: Social and Political Responses to Technology

Historical cycles of technological change demonstrate that the adoption of new technology is not simply a matter of inventors developing ideas and entrepreneurs deciding whether and how to use new machinery. Instead, the process is frequently mediated by politics. The most famous example is machine breaking during the First Industrial Revolution, and Luddites make a cameo appearance in most popular books about the future of work. However, they were neither the only nor the first instance of direct action against job-replacing innovation.

One famous anecdote illustrates the power of technological resistance. William Lee developed the first stocking frame for knitting in 1589 and applied to the British crown for a patent. Queen Elizabeth I is reputed to have said "Thou aimest high, Master Lee. Consider thou what the invention could do to my poor subjects. It would assuredly bring to them ruin by depriving them of employment, thus making them beggars". It is possible that the Queen was responding to political pressure from the hosiers' guilds, as they were concerned that the invention would undermine their skills.

In this vein, some researchers have argued that guilds systematically opposed the introduction of new labour-replacing or deskilling technologies (Mokyr 1992, Frey 2019). Others have taken a more nuanced view, arguing that the guilds supported new technologies which reinforced their existing position in the market, and resisted those which undermined it (Epstein 1998).

As well as the Luddites in the 19th century, workers destroyed spinning jennies during the 1770s (Aspin 1964), and the "Captain Swing" riots saw the destruction of threshing machines, mostly in Southern England, around 1830

(Hobsbawm and Rudé 1969). This resistance to innovation was ultimately unsuccessful, but localized machine-breaking may have delayed or limited technological adoption in some areas, which contributed to later decline and deindustrialization (Mann 1971). Indeed, the stocking frame example is not the only instance in which resistance to technological change was so strong that innovations were prohibited outright (Frey 2019). Differing state responses to machine-breaking also played a role in allowing or limiting the potential for innovations to be adopted (Horn 2005).

Nuvolari (2002) has persuasively argued that machine-breaking in the First Industrial Revolution was primarily intended to *direct* technological adoption away from deskilling technologies that demanded factory discipline, and not simply to prevent innovation outright. Other studies have examined how machine-breaking may have been related to the adoption of labour-replacing technology (Caprettini and Voth 2020).

Incorporating this history demonstrates that resistance to technological change can be a rational response for workers whose earnings are threatened by innovation, and aim to shape, rather than simply block, technological transitions. Machine-breaking, mediated by politics and state coercive capacity, may have affected differing rates of technological adoption but as we will discuss in Section 4, this question merits further study. The history of resistance to technology also underlines that the impacts of innovation are not a fixed outcome determined purely by the features of an innovation but can be altered by human activity.

### 3.3: Technological Unemployment in History

There has been a long-standing debate about whether labour displacement took place during the Industrial Revolution. Some scholars refer to technological unemployment that devastated workers (Frey 2019), while others doubt whether substantial and sustained job destruction took place at all (Mokyr, Vickers et al. 2015). In addition to the scarcity of comprehensive occupational information for

now-rich countries before the mid-19th century, researchers continue to face the difficulty of disentangling technological unemployment from other sources of changes in labour demand (Bix 2000). New research is quantifying the extent of labour displacement.

The canonical episode of technological transformation, as discussed above and mentioned in contemporary debates, is the First Industrial Revolution. Unemployment received sporadic attention in the various rounds of 20th century debates about how British living standards changed during this period. One of the earliest prominent "optimists", J. H. Clapham, described the "loss of domestic spinning" in certain regions, but did not dwell on any long-term consequences as he claimed, unevidenced, that it was replaced by other rural by-employments and the effects were only severe for some "widows and others who had lived by spinning" (Clapham 1926). This assertion is part of a tradition of minimizing the elimination of female-dominated occupations (Humphries and Schneider 2021), from which gender historians have been the main dissidents (Pinchbeck 1930, Valenze 1995). In their series on British laborers, the pessimists Barabara and J. L. Hammond pointed to unemployment in various places and highlighted that what appears as "temporary" job loss in hindsight could nonetheless have been injurious to workers. They also emphasized the importance of regionally concentrated unemployment (Hammond and Hammond 1920). T. S. Ashton noted technological unemployment *en passant* in his general history of the Industrial Revolution (Ashton 1948), though it did not even merit a mention in his 1949 article on the standard of living.

By the mid-20th century Max Hartwell, from the optimist camp, conceded that there were "pockets of underemployment" and "technological underemployment" after Eric Hobsbawm emphasized this point in their exchanges (Hobsbawm 1957, Hartwell 1961, Hobsbawm 1963). Nonetheless, Hartwell downplayed the importance of job loss. In a later round of the debate, Jeff Williamson and Peter Lindert dismissed unemployment as a significant drag on living standards in their key contributions (Williamson 1980, Lindert and Williamson 1983), while

focusing—as many late 20th century writers in this area have—on male unemployment.

Although job loss appeared at various times in these debates across many decades, the difficulty of measuring unemployment during the 18th and 19th century limited its salience. Following the limited quantitative evidence on the scale of job destruction during the First Industrial Revolution, recent popular books on the future of work suggest that technological change has always generated enough new jobs to replace those destroyed by innovation in the medium term (Brynjolfsson and McAfee 2014).

As mentioned in Section 1, the recent digitization of census records and administrative data has allowed researchers to quantify some instances of technological unemployment and capture its effects on workers. Feigenbaum & Gross (2020) have shown that the automation of telephone switching in the US during the early 20th century, which replaced manual operators, pushed incumbents out of the labour market or into lower-paying jobs. Two other recent papers explore the outcomes of mechanization on employment in the United Kingdom. A study of the impact of mechanization on the British bootmaking industry finds that approximately 150,000 jobs were lost as the industry mechanized and 142,000 jobs were created, but that incumbents did not move from the old jobs into the new (Vipond 2023). Industrial innovations also eliminated hand spinning, which had employed up to 20% of women and children in Britain in the late 18th century. There was scant labour reinstatement and the resulting job loss persisted at least into the 1830s (Schneider 2023).

Two other papers take a less direct approach. The first draws on the Hand and Machine Labor Study (1894), which compared the relative productivity of manual and mechanized labour across a range of US industries. The paper finds that mechanization led to both job loss and job creation (Atack, Margo et al. 2019). A second paper matches US patent data with extensive administrative data, and finds that industries exposed to technological innovation experienced

declining wages and a decrease in the number of jobs (Kogan, Papanikolaou et al. 2021).

While several papers find that new jobs were generated to replace those lost to new labour-saving technologies, access to these new employment opportunities was stratified by gender, age, education, and geographical location. Incumbents whose skills were rendered obsolete by new technologies may have had a limited ability to take up the new employment opportunities.

### 3.4: Distributional Effects

The three paradigms discussed in Section 2.1 have all been applied to economic history. An early paper using the SBTC model, by Claudia Goldin and Lawrence Katz (1998), argues that while the innovations of the First Industrial Revolution may have been de-skilling, this was not the case from 1909 to 1929 in the US. Instead, the adoption of new technologies over this period was correlated with higher pay. More recent papers arguing that the adoption of new technology is associated primarily with an increase in pay for highly skilled workers include Bessen (2011), which used micro-data to assess the skill levels of weavers in the 19th century US and concluded that the automation of tasks was linked with higher levels of skill. Van Lottum and Van Zanden (2014) found skill complementarity in the 18th century shipping industry, and Ridolfi, Salvo, and Weisdorf (2022) use French industrial census data from the 19th century and conclude that areas with more steam engines had more and better-paid jobs.

Other historical papers have found RBTC-type impacts. Chin et al. (2006), using an extensive individual-level dataset of wages for seamen, found that the transition between sail and steam created both a deskilling effect, as able-bodied seamen were replaced with unskilled workers, and a skills-biased effect, through the new demand for engineers. The average wage for workers on steam ships was 40% higher than workers on sailing ships. In addition to higher income inequality, the authors also found labour displacing impacts as employment of able-bodied seamen and sailmakers fell. Another paper leveraged historical

employer–employee panel data and found that the introduction of steam technology had both deskilling and skill-demanding impacts (Hynninen, Ojala et al. 2013). The distributional impacts of the RBTC paradigm are less benign than those in SBTC-type models, by construction: the new technologies increase inequality not only through rising skill premia, but also as the result of low-skilled workers receiving lower pay or being displaced entirely from the production process.

The most recent paradigm, labour displacement and reinstatement, has also been applied to historical instances of innovation. Papers have found that the adoption of new technologies has been correlated with both declining wages and fewer employment opportunities for impacted incumbents (Atack, Margo et al. 2019, Feigenbaum and Gross 2020, Kogan, Papanikolaou et al. 2021, Vipond 2023). It is notable that many economic history papers that aim to quantify technological unemployment also explore the distributional impacts. Also, Humphries & Schneider (2021) argue that because the destruction of hand spinning during the British Industrial Revolution drove hundreds of thousands of women from paid work, it led to the development of the male breadwinner family model.

While economic historians have begun to investigate the diverse impacts of technology on employment over the medium term, the individual consequences of job loss and the intergenerational impacts require further investigation.

### 3.5: The Organization, Content, and Quality of Work

The task-based breakthrough in modelling the impacts of innovation (Autor, Levy et al. 2003) and potential future effects (Frey and Osborne 2017) should draw attention to the effects of technology on the content and organization of work. The most important and studied example of changes in the organization of work in historical contexts is the establishment of factory production during industrialization. Another important area of research has been in the changing task composition of labour, which emerged as a subsidiary element of debates

about the direction of technological change in the 19th century United States (noted in Topic 3.1 above). These two strands have implications for the quality of jobs, which has seen growing interest in contemporary studies, including by researchers interested in the future of work. One limitation of existing historical research on the organization and quality of work is that economic historians have been less interested in examining working conditions and the content of jobs than labour historians, while the latter have rarely taken a comparative or systematic approach or applied their findings to the future of work.

The rise of factory production led to a fundamental shift in the organization of work: the development of centralized work premises. While some large construction projects in the pre-industrial age had fixed, concentrated work locations, the permanence and division of labour in factories set them apart from these earlier projects (Pollard 1965). Centralization was essential to exploit inanimate power sources, but it also enabled work discipline and it was accompanied by shifts in job quality.

The classic downside when work in factories replaced home-based labour was a sacrifice of employee control. This was usually accompanied by other changes—longer working hours, lower occupational safety, and more exhausting labour, in exchange for higher and more stable wages—but employer control was the foundation of the disamenities of factory work (Marglin 1974, Schneider 2022). The trade-offs of factory labour have been discussed by researchers for decades (e.g. McKendrick 1961, Pollard 1965, Thompson 1967) albeit without a systematic approach. The recent development of 21st century job quality measurement (Clark 2005, Cazes, Hijzen et al. 2015, Warhurst 2017) and its application in history (Schneider 2022) enables a clearer analysis of how technology has changed work tasks, practices, organization, and job quality. Differences in work systems between firms and locations again suggest that human decisions as well as technology shape work organization and quality (e.g. Cohen 1990, Lazonick 1990). In this spirit, longue durée social history can make

important contributions to understanding the forces that have changed the organization of work (Lucassen 2021).

A second strand of related literature considers changes in the task content of work. A classic formulation comes from the American gun-making industry in the 19th century: induced innovation, responding to expensive skilled labour, led to the invention of deskilling technology, which paired semiskilled workers with advanced machinery to replace skilled employees (Ames and Rosenberg 1968, Hounshell 1984, James and Skinner 1985). This deskilling made work more repetitive. Its descendant is the division of labour in an assembly line factory, which followed the Smithian principle whereby workers focusing on fewer tasks would be more productive (Hounshell 1984). The assembly line system also added dimensions such as the ready supply of parts and tools to reduce walking time on the factory floor. To increase productivity, workers were forced to be more like machines, similar to present-day work practices in Amazon fulfilment centres (Yeginsu 2018).

There is significant space for further studies in this area, especially using systematic and comparative approaches, but the existing studies show that First and Second Industrial Revolution technologies used centralization to impose labour discipline, at least partly compensated by higher and more stable wages, and skill-replacing technology made some of this low-control work more repetitive. Parallels with aspects of recent technological change (as in the fulfilment centre example) suggests that there is value in more detailed analysis of this process in the past.

## 4: Including History in the Debate

Having discussed the current debates on the future of work in Section 2 and reviewed the literature on past instances of technological change in Section 3, we now summarize areas in which historical research could contribute to a richer and more comprehensive understanding of the possibilities and pitfalls of technological change. At present, most economic research on this subject does not integrate history. The public-facing narrative in the books discussed in 2.2 presents a thin version of the past that shapes improbable expectations of the future. By sidelining historical analysis of the causes and consequences of innovation, the research frontier and policy discussions contain important omissions and errors. Below we discuss four areas in which debates on the future of work would be improved by existing research on the history of technological change (4.1), and then (4.2) survey how new research on past instances of innovation could further enhance our understanding of possible futures of work.

### 4.1: A Broader View

Firstly, as discussed in Section 3.2, history emphasizes that there has been considerable social resistance to labour-replacing technologies. In addition to the examples above, the containerization of shipping threatened jobs for longshoremen by the 1970s, but strong unions in some countries were able to resist layoffs for decades (Turnbull and Wass 1994, Levinson 2016). This issue extends beyond the challenge of automation: a rapid net zero transition implies job loss in some industries (Scheer, Schwarz et al. 2022). A recent ILO report on the employment impacts of climate change adaptation argues that transition and mitigation measures will, on net, generate employment opportunities that offset lost jobs (Maitre, Behrendt et al. 2018). However, a survey in twenty countries that together account for 72% of global CO2 emissions finds that support for climate change policies hinges in part on their perceived impact on the respondents' household (Dechezleprêtre, Fabre et al. 2022). Writers on the future of work and the green energy transition have not sufficiently allowed for the possibility of widespread, effective, resistance to technological change. The Institute for the Future of Work's flagship policy paper recognizes the political

nature in choices made to adopt new technologies, declaring "innovators rarely consider impacts on work, which reduces the likelihood that its benefits spread to working people" (Institute for the Future of Work 2022). The same questions haunt the recent emergence of large language model AIs such as ChatGPT (Acemoglu and Johnson 2023). Despite this, few economists have looked towards the many past examples of transformative innovation and their reception.[6] To project possibilities for the future of automation and the global response to climate change, researchers and policymakers need to incorporate the politics of resistance to job-replacing and job-changing innovation.

Secondly, and *contra* Mokyr et al. (2015), there is evidence that previous industrial revolutions caused job loss with scarring effects on workers and their families. As shown by the papers cited in Section 3.3 and 3.4 above, examples such as hand spinners and bootmakers in the 18th and 19th centuries indicate that technological unemployment can be a long-term negative shock to individuals and communities. There is also a growing body of literature that shows how recent trade shocks and deindustrialization, for example, have entrenched the spatial dimension of disadvantage (Acemoglu, Autor et al. 2016, Blanchflower 2019). While some economists are beginning to express concern about technological unemployment (Autor 2022, Brynjolfsson 2023), they have rarely incorporated historical examples of job destruction and the long-run impacts on individuals and regions. Beyond the immediate costs to workers and their families, new technologies may have disproportionate impacts on the earnings of women, people from different religious and ethnic backgrounds, and locations. The restructuring of social structures, norms, and opportunities in response to technological shocks can only be assessed over the long run, and these broader questions have not yet been addressed by the present-day debates on automation.

[6] Baldwin (2019) takes the threat of substantial political resistance to innovation far more seriously than most books in this area.

Thirdly, historical scholarship cautions against a deterministic view of the adoption and diffusion of new technologies (see 3.1). Which innovations dominate may take decades to determine, and seemingly obsolete technologies can persist for a similar timeframe. Both of these points have important implications for the future of work. Some automation technologies that appear successfully initially may attract investment in complementary human capital that is later rendered of lesser value by successor or competitor innovations. At the same time, pre-AI technologies in services or production techniques that use little physical automation may continue in use for much of this century, with implications for labour demand. While some authors are appealing for attention to these points (Brynjolfsson 2023) and integrating them into the construction of incentive structures which will drive outcomes, they remain largely overlooked.

Finally, although the dominant paradigm for considering the impact of the adoption of new technologies on labour market outcomes has shifted away from the SBTC model, many policy recommendations continue to focus on training and "upskilling". This is not a solution if the newer RBTC and labour displacement models are correct. In these paradigms the adoption of new technologies creates demand for *new* skills or categories of skills, while destroying demand for other skills. As shown in Sections 2 and 3 above, there are historical examples of rapid human capital depreciation, and predicting skill demands in advance of major technological shocks is extremely difficult. If we expect skills obsolescence to be a routine outcome of technological change, then the impacts, and potential approaches to mitigation, can be studied across many previous instances.

### 4.2: Historical Research Frontiers

The strengths of historical analysis of technology explained in Section 1, namely the ability to conduct long run studies, a diversity of examples for comparison, and methodological pluralism, enable six directions of research to inform the future of work. Quantifying technological unemployment would enable analysis of the causes and consequences of job-replacing innovation, including

intergenerational impacts and path-dependent spatial inequality. Qualitative analysis can provide a broader perspective on the quality of life impacts of work-changing innovation.

Firstly, a long-run view can offer insight into the evolution of inequality driven by ongoing waves of technological change and consider intergenerational impacts. The current debates have only recently, with the acceptance of RBTC models, accepted the distributional impacts of technological change. However, the generational implications have not been explored, and can only be investigated with a long-run historical approach. Access to new opportunities may be driven by class, race, age, or geographical location, meaning that cycles of technological change entrench inequalities across generations. There is, as yet, no research which focuses on this aspect of change.

Secondly, while new studies in economic geography have established the path dependency of the creation of new work and its implications for regional development, the sources of this path dependency have yet to be fully explored. The origins of spatial inequality could be observed over the long-term, which may yield insights that the more short-term view could miss. Historical analysis also incorporates the social and cultural underpinnings of long-run deprivation, which may intersect with technological change (Humphries and Thomas 2023).

As noted in Topic 3.3 above, we lack consistent quantification of technological unemployment. At present, there are only a handful of case studies that investigate this point. The definition of "technological unemployment" varies: some papers suggest it only occurs when there is an aggregate change in the unemployment rate (Ridolfi, Salvo et al. 2022), while others use it when there is job loss that may be offset by new jobs for other workers (Vipond 2023). Most importantly, we do not know what examples of technological unemployment need to be analyzed, and when they impacted different economies. Much additional work is required to consistently measure labour displacement and technological unemployment in the past.

Fourthly, history can provide more insight into the political economy of creative destruction, and case studies of how resistance to innovation has impacted technological adoption and growth. While there is substantial evidence of resistance, as shown in 3.2, its effects on the rate, and particularly the direction, of innovation and adoption have received less attention. Frey (2019) and Voth & Caprettini (2020) have begun to examine this question, but there is ample room to explore further. As we have emphasized, the political economy of technology has been neglected in the modern debate: most futurists and economists assume that innovation will continue to create as many jobs as it destroys, avoiding the problem of permanent technological unemployment. When the implications are discussed, it is by futurists, who are often debating the merits of Universal Basic Income or Universal Basic Services in a world without work (Coote and Percy 2020, Susskind 2020). Ignoring potential distributional consequences and resulting resistance enables futurists to avoid addressing the tradeoffs of technology, how to compensate losers from innovation, and the possibility that citizens may resist new inventions at work, at the ballot box, or in the streets.

At a more granular level, there is little systematic research that analyzes the shopfloor or cubicle-level impact of technology across examples of innovation. Some papers mentioned above in 3.5 examine single instances of technological change, but task-level analysis and job quality measurement enable detailed comparative investigation of working conditions and work content. One possible avenue exploiting this approach is analysis of deskilling technologies in history, which may show that RBTC is a phenomenon much older than suggested in the economics literature, and with more diverse consequences.

Finally, the rise of global history in recent decades provides the opportunity for researchers to consider the international dimensions of technological dynamism, which are less commonly incorporated into contemporary studies. Innovations are likely to have differing effects in different contexts and dynamic impacts across countries. As yet, most research on the future of work only analyzes impacts in single countries, which compounds the limitations of a short-term

view. Such studies could pursue the implications of premature deindustrialization in a more detailed way (Rodrik 2016).

## Conclusion

The public and policymakers look to history to understand major contemporary challenges. Historical research has made important contributions to our understanding of two recent crises, the Global Financial Crisis and the COVID-19 pandemic. Faced with tremendous—but not, as has commonly been stated, unprecedented—catastrophes, the public, policymakers, and scholars have drawn on the past to comprehend the implications of current events and possible routes out of the crisis.

Debates on the future of work focus on two issues: whether automation will cause permanent technological unemployment, and how the labour market impacts of the widespread adoption of AI will be distributed. Popular books on the topic often open with a brief, stylized, history of technological change which paints an overly optimistic picture of the impacts of technology. This sanguine narrative shapes understandings of the past and expectations of the future. Academic and policy research incorporates still less engagement with past examples of innovation.

Existing research on technological shocks in historical contexts is well placed to make contributions to the debate on the future of work in the areas discussed in Sections 3 and 4. Scholars have investigated key factors that shape the rate and direction of innovative activity, resistance to technological change, the risk of technological unemployment, the distributional impacts of innovation, and how technology can alter the organization, content, and quality of work.

The neglect of past experiences of technological change in future of work circles has sustained longstanding beliefs, including that technologies will be broadly accepted, technological unemployment is an imagined risk, technological paths

are clear *ex ante*, new techniques rapidly displace old, and the prescription of skill-based policies to adapt the workforce for the future. These positions are now being reconsidered by some economists, which highlights how omitting historical experience may have impoverished debates up to recent years. New historical evidence can enable a more accurate and broader examination of the consequences of technological change.

There are many ways in which history is well-placed to inform debates about the future of work. They all rely upon a sufficiently detailed knowledge of the past to select appropriate comparators and comprehend key differences in context between past and present. Evidence from history can enable a broader and richer understanding of the potentials of the Fourth Industrial Revolution. It can allow for an intergenerational analysis of the impact of labour market outcomes, consider the potential for long-term scarring, and assess the effects of social and political resistance to new technologies. Historical studies can also measure the extent of technological unemployment, investigate how technology has changed the organization, content, and quality of jobs, and explore the global effects of technological shocks. Such studies may be particularly valuable because the purported cognition-replacing technologies of the Fourth Industrial Revolution will, if futurists are to be believed, have implications more similar to the macroinventions that replaced human muscle and dexterity during the First Industrial Revolution than recent microinventions that are the focus of most economics research.

We have shown here why researchers, policymakers, and citizens concerned about the future of work can benefit from looking to past instances of innovation. We hope that colleagues across the many sectors and academic fields interested in the future of work will join in collaborations that use history to understand the possibilities for our automated future.

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