

# Technological change and work

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This doctoral thesis examines the impact of technological change on jobs using three sector case studies from Great Britain and the United States between 1750 and 1910. It analyzes changes in work-related well-being by constructing and applying the first metric for good jobs in the past, the Historical Occupational Quality Index (HOQI). The job quality analysis is based on more than 14,000 observations of wages and working time from manuscript sources. The thesis makes extensive use of qualitative evidence in workers' letters, diaries, and memoirs, doctors' reports, corporate records of discipline and accidents, factory inspectors' reports, and technical handbooks. These sources are used to describe tasks, tools, work locations, and components of job-related well-being such as intensity, safety, and control.

The impact of the Industrial Revolution on living standards is among the most studied topics in economic history. Scholars have analyzed income (Williamson 1985, Margo & Villaflor 1987, Feinstein 1998), consumption (Mokyr 1988, Logan 2006), anthropometrics (Floud *et al* 1990, Komlos 1993, Komlos & A'Hearn 2019), and the outputs of multidimensional indicators such as the Human Development Index (Crafts 1997, Prados de la Escosura 2021). However, work has not been examined systematically or independently. Analysis of historical job-related well-being also has contemporary motivations, including the declining number of good, middle-income jobs in rich countries, or “job polarization” (Autor *et al* 2006). The International Labor Organization has promoted the study of job quality and United Nations members have committed to achieving universal access to “decent work” in the Sustainable Development Goals. Future technological changes may lead to extensive labor displacement and changes in work organization (Frey & Osborne 2017, Baldwin 2019).

The thesis uses a tripartite approach to assess changes in work-related well-being and access to good work. It constructs the first index of historical job quality using evidence of past workers' preferences about what constituted “good jobs”. The index has eight components: wages, working time, stability of earnings, accident risk, industrial disease risk, control, intensity, and repetitiveness. The thesis considers changing access to good jobs using evidence and estimates of sectoral employment, and also analyzes workforce demographics.

The first case study analyzes the spinning section of the British textile industry. Yarn production on spinning wheels was a widespread, low-paid, high-control, safe occupation for women in the eighteenth century. From the 1760s, the spinning jenny, water frame, and spinning mule radically changed work-related well-being, altered the organization of work, and caused significant unemployment. Factory operatives earned higher wages at the cost of long hours, increased occupational risks, higher work intensity, and reduced control. Mechanization expanded the range of tasks, and firms increased the number of distinct occupations. Men claimed the best factory jobs as mule operatives and overseers, while high machine productivity caused technological unemployment for hundreds of thousands of hand spinners.

Managers hoped that the invention of the “self-acting” mule in the 1820s would allow them to replace highly paid and militant operatives. However, this automation was partial

because early self-actors could only spin coarse yarn and continued to require substantial adjustment by a trained worker. Mule spinners were unionized from the first third of the nineteenth century, which enabled them to retain high wages and job control. After the 1833 Factory Act, regulations primarily reduced working hours, and safety and ventilation were hardly regulated despite frequent injuries and mounting evidence of respiratory disease. In the late nineteenth century, firms' efforts to lower costs by economizing on raw materials and raising machine speeds increased work intensity, especially for non-unionized child workers.

The second case study considers the development of factory spinning in the Northeastern United States. There was an inchoate market for yarn in the American colonies and many families produced clothing for themselves or purchased imported fabrics, so mechanization caused little job loss. Import-substituting industrialization in the United States featured three factory models: a corporate, paternalistic system in Massachusetts, a competitive model with small partnerships around Philadelphia, and a family labor system in Rhode Island. Workers across US mills experienced higher occupational risks, low control, longer hours, and greater intensity than in hand spinning, but the Massachusetts system provided slightly higher job quality than the other models. As in Britain, men claimed the best jobs when new technology expanded the task range and firms increased the division of labor.

The adoption of more productive ring frames in the 1830s was followed by the "speedup" and "stretch-out" in the 1840s, which required operatives to monitor more machines running at higher speeds. Productivity rose with increasing effort levels and higher capital-per-worker, but wages stagnated until the 1860s. States began to enforce factory regulation from the 1880s with limits on hours and child labor, but as in Britain, there was little safety regulation. Rising wages, especially after 1900, and statutory limits on hours were the main sources of job quality improvements.

The third case study is interurban transport in the Northeastern United States. Most research on US transport innovation has focused on macroeconomic impacts (Taylor 1951, Fogel 1964). There have been fewer studies of work (Smith 1963, Licht 1983, Aldrich 2006) and no comparisons of labor between technologies. Innovations in this sector, particularly the development of steam railroads, vastly increased the range of tasks required for operation. Firms responded by creating many new jobs, such as firemen to fuel locomotives, machinists to repair rolling stock, signalmen and flagmen to control trains, and administrators to monitor expenditure, set timetables, and handle capital acquisitions. Modern management (Chandler 1977) developed in part to handle the expanded range and repetition of tasks. The new division of labor encompassed a wide spectrum of job quality: track laborers toiled in exhausting conditions for modest wages and brakemen risked their lives clambering between cars on every journey while managers enjoyed very high pay and safe conditions.

Microinventions continued to affect railroad work up to the First World War. Many developments, such as replacing iron with steel in rails and locomotive boilers, could have improved safety. However, firms' drive to increase productivity incentivized intensive use, which mitigated the innovations' accident-reducing potential. Federal regulation eventually mandated railroads adopt some additional safety-improving technology, but the effects were limited, and work-related well-being remained unequal.

The case studies show that macroinventions expanded the task range of work, which led firms to increase the division of labor. This more specialized workforce experienced greater differences in job quality or "job stratification". The productivity gains of macroinventions sometimes outstripped increases in demand for cheaper products and services, which caused substantial technological unemployment. When macroinventions produced substitutes for imports or enabled a sector to grow together with the broader economy, there was little

or no labor displacement. After firms adopted macroinventions, their continuing search for productivity gains led managers to increase work intensity while adopting microinventions. These smaller innovations could have reduced effort or improved safety, but increased throughput limited or negated the effort-saving or safety-increasing potential of microinventions. The race between productivity and working conditions meant rising wages and regulations that reduced working hours were the primary drivers of improved job quality in the late nineteenth and early twentieth century. Finally, higher status workers claimed or retained the best jobs following disruptive innovation. In spinning, men invariably filled the best factory occupations, and white men dominated US railroad jobs. These findings contribute to research on historical living standards and debates about the relationship between technology, employment, and labor conditions.

### Acknowledgement

I am grateful to my supervisors, Jane Humphries and Stephen Broadberry, for their support in researching and writing this dissertation and my examiners, Brian A'Hearn and Sara Horrell, for their constructive feedback. This research was supported by the Clarendon Fund, Merton College, Oxford, the Rothermere American Institute, and the Oxford Global History of Capitalism Project. The archival research was funded by the Economic History Society, Harvard Business School, the Dacre Trust, the Brettschneider Fund, the Hagley Museum & Library, the New York State Archives, the Colin Matthew Fund, the Rajiv Kapur Trust, Merton College, Oxford, and the Oxford History Faculty's Arnold, Bryce, and Read Funds.

### Data availability

There are no new data directly associated with this dissertation summary.

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