

TECHNOLOGICAL UNEMPLOYMENT IN THE BRITISH INDUSTRIAL REVOLUTION: THE DESTRUCTION OF HAND-SPINNING[★]

The spectre of technological unemployment looms over all episodes of transformative innovation and stalks present-day debates about the future of work.¹ However, until recently there has been widespread doubt in economics and economic history about whether large-scale and sustained job loss caused by innovation has ever occurred or is even possible.² In debates over

[★] I am grateful to Joyce Burnette, Jane Humphries, Elise van Nederveen Meerkerk, Carmen Sarasúa, Leigh Shaw-Taylor and John Styles for helpful comments and advice. I thank Laurien Berkeley for exceptionally careful and patient copyediting. I also thank conference and seminar participants at the University of Oxford; Royal Holloway, University of London; the University of Westminster; the University of Sussex; the University of Derby; the XIX World Economic History Congress, Paris, July 2022; the Royal Netherlands Institute in Rome; and the University of Cambridge.

¹ Erik Brynjolfsson and Andrew McAfee, *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies* (New York, 2014); Carl Benedikt Frey, *The Technology Trap: Capital, Labor, and Power in the Age of Automation* (Princeton, 2019); Richard Baldwin, *The Globotics Upheaval: Globalisation, Robotics and the Future of Work* (London, 2019); Amy Sue Bix, *Inventing Ourselves out of Jobs? America's Debate over Technological Unemployment, 1929–1981* (Baltimore, 2002). The *Oxford Dictionary of Economics* defines technological unemployment as ‘Unemployment due to technical progress. This applies to particular types of worker whose skill is made redundant because of changes in methods of production, usually by substituting machines for their services’: Nigar Hashimzade, Gareth Myles and John Black, *Oxford Dictionary of Economics*, 5th edn (Oxford, 2017).

² Joel Mokyr, *The Gifts of Athena: Historical Origins of the Knowledge Economy* (Princeton, 2002), 254–6; Joel Mokyr, Chris Vickers and Nicolas L. Ziebarth, ‘The History of Technological Anxiety and the Future of Economic Growth: Is This Time Different?’, *Journal of Economic Perspectives*, xxix, 3 (2015); Gregory R. Woirol, *The Technological Unemployment and Structural Unemployment Debates* (Westport, CT, 1996).

Past & Present, no. 270 (Feb. 2026) © The Author(s) 2025. Published by Oxford University Press on behalf of The Past and Present Society, Oxford. All rights reserved. For commercial re-use, please contact reprints@oup.com for reprints and translation rights for reprints. All other permissions can be obtained through our RightsLink service via the Permissions link on the article page on our site—for further information please contact journals.permissions@oup.com.

<https://doi.org/10.1093/pastj/gtae049> Advance Access published on 9 April 2025

the impact of British industrialization on living standards, technological unemployment has been downplayed or ignored outright.³ While historians of the Industrial Revolution have noted various examples of work-replacing technology, these analyses have lacked the quantification required to prove that there was substantial job destruction and that workers did not shift quickly into other employments. Neglect of technological unemployment in academic circles has given rise to a common view in debates about the future of work that any negative impacts of innovation are short-lived.⁴ In recent years pioneering research has finally quantified a few examples of work-replacing technology with durable negative consequences for incumbents.⁵

This article adds a much larger example to the growing literature on technological unemployment, providing the first systematic analysis of the elimination of hand-spinning in the Industrial Revolution. This case has only received substantial discussion in histories of women's work, while in the rest of economic history it has been relegated to a passing line or a footnote, left in the background as research has focused on the handloom weavers and Luddite resistance to innovation.⁶ The

³ R. M. Hartwell, 'The Rising Standard of Living in England, 1800–1850', *Economic History Review*, xiii, 3 (1961), 400; Jeffrey G. Williamson, 'Urban Disamenities, Dark Satanic Mills, and the British Standard of Living Debate', *Journal of Economic History*, xli, 1 (1981).

⁴ See Benjamin Schneider and Hillary Vipond, *The Past and Future of Work: How History Can Inform the Age of Automation*, CESifo Working Papers, no. 10766 (2023).

⁵ James Feigenbaum and Daniel P. Gross, 'Answering the Call of Automation: How the Labor Market Adjusted to Mechanizing Telephone Operation', *Quarterly Journal of Economics*, cxxix, 3 (2024); Hillary Vipond, 'Technological Change and Labour Displacement in Historical Perspective', Paper presented to the Economic History Society Annual Conference, University of Cambridge, Apr. 2022.

⁶ Ivy Pinchbeck, *Women Workers and the Industrial Revolution, 1750–1850* (London, 1930); Deborah M. Valenze, *The First Industrial Woman* (Oxford, 1995). The extensive literature on the handloom weavers includes Duncan Bythell, *The Handloom Weavers: A Study in the English Cotton Industry during the Industrial Revolution* (London, 1969); Geoffrey Timmins, *The Last Shift: The Decline of Handloom Weaving in Nineteenth-Century Lancashire* (Manchester, 1993); Clark Nardinelli, 'Technology and Unemployment: The Case of the Handloom Weavers', *Southern Economic Journal*, liii, 1 (1986). See also discussions of the lack of attention paid to hand-spinners in Robert C. Allen, 'Lessons from History for the Future of Work', *Nature*, dl, 7676 (2017); Jane Humphries and Benjamin Schneider, 'Spinning the Industrial Revolution', *Economic History Review*, lxxii, 1 (2019); Jane Humphries and Benjamin Schneider, 'Gender Equality, Growth, and How a Technological Trap Destroyed Female Work', *Economic History of Developing Regions*, xxxvi, 3 (2021).

article also illustrates how historical studies can contribute to a deeper understanding of the impacts of technological change.⁷

While job loss in hand-spinning has been mentioned in past research, it has usually been presented as a minor episode, and the timing, scale and locations have not been analysed in detail. As shown here, within a little more than fifty years, innovations eliminated an occupation that had provided work for nearly one in six women and children, 8 per cent of the whole population. After the elimination of spinning, many women could only find seasonal and insecure employment in agriculture, and some had no work at all. The size of this labour market shock shows that technological unemployment must be part of any discussion about changing living standards during industrialization. While spinning had an unusually high employment share before this technological shift and the productivity gains of mechanization were dramatic, the scale and duration of unemployment question sanguine views about the consequences of technological change.

The plan of the article is as follows. Section I presents the existing discussions of the destruction of hand-spinning in Britain and suggests why the mainstream of economic history has neglected the evidence of extensive labour displacement posited by gender historians. Section II discusses the sources and methods used to estimate pre-industrial employment, and compares them with the approach used in 2012 by Craig Muldrew. The employment estimates provide context for the analysis of technological unemployment by demonstrating the importance of hand-spinning during the pre-industrial period. The estimates show that more than 15 per cent of women and children in Britain may have spun for at least part of the year by 1770. This is somewhat lower than Muldrew's estimate, and incorporates cotton and linen into the headline figure.⁸

Section III discusses the early qualitative evidence of unemployment and analyses labor displacement and unemployment

⁷ Schneider and Vipond, *Past and Future of Work*.

⁸ Craig Muldrew, "Th'Ancient Distaff" and "Whirling Spindle": Measuring the Contribution of Spinning to Household Earnings and the National Economy in England, 1550–1770', *Economic History Review*, lxxv, 2 (2012).

in cotton spinning, the first sector affected by the machines of the Industrial Revolution. Section IV widens the picture, providing the first comprehensive and systematic analysis of this instance of job destruction using four groups of qualitative sources, drawn from more than 200 texts and totalling 2,099 observations. It shows that as late as the 1830s there was insufficient replacement work or income for the women and children who had toiled at spinning wheels in the mid eighteenth century, or for their descendants. In current terminology, there was massive labour displacement of hand-spinners, but little reinstatement of those workers in factory employment.⁹

The effects of labour-replacing technology continued at least into the mid nineteenth century: almost half of the parishes that responded to the Poor Law Commissioners' Rural and Town Queries (1834) reported that there was little work, irregular employment, or no work at all for women. This was a dramatic increase in reports of unemployment and underemployment compared to the 1770s. Further, because spinning had provided winter income for families in agricultural districts, its disappearance meant that employment was limited by the seasons in a fifth of parishes.

The destruction of hand-spinning is the largest instance of technological unemployment documented to date. The loss of hand-spinning work affected 8 per cent of the population, while newly created jobs in textiles employed less than 1% of the population, and many of those jobs were occupied by men. The result was large-scale and long-term unemployment and underemployment for women.

Section V considers the distributional effects on different types of households and local labour markets. It shows that families without a male breadwinner experienced the largest reductions in household income from the demise of hand-spinning, and it models the potential impacts across stylized or 'ideal type' households in areas that saw the creation of new work or only

⁹ Daron Acemoglu and Pascual Restrepo, 'Automation and New Tasks: How Technology Displaces and Reinstates Labor', *Journal of Economic Perspectives*, xxxiii, 2 (2019). Acemoglu and Restrepo define 'displacement' as capital (in the form of new technology) taking the place of labour in production tasks. 'Reinstatement' occurs when new technology generates new tasks that are completed by labour. Reinstatement of former spinners has been mentioned briefly when looking at smaller-scale changes in Maxine Berg, 'What Difference Did Women's Work Make to the Industrial Revolution?', *History Workshop Journal*, no. 35 (1993), 40.

job destruction. This exercise highlights the unequal distributional effects of the technological shock in spinning. Section VI concludes by emphasizing the importance of this example for research about the impacts of innovation and for debates about trends in living standards during the Industrial Revolution.

I

Spinning has long been recognized by scholars as a common occupation in seventeenth- and eighteenth-century Britain.¹⁰ It appeared in economic commentaries as well as texts describing contemporary culture and society.¹¹ The process of combining plant or animal fibres into yarn existed in most organized human societies and saw relatively little technological change in the centuries before the Industrial Revolution. The traditional spindle and distaff method was slowly supplanted by the spinning wheel in England from the fourteenth century, but the former continued in use into the eighteenth century in some areas. While the wheel was not an unchanging piece of technology, the productivity gains enabled by the flyer wheel from the sixteenth century were limited compared to later developments. Moreover, the flyer was primarily used to spin flax and hemp, which were a modest share of the yarn market.¹²

Although historians have acknowledged the ubiquity of spinning in pre-industrial Britain, there has been less discussion of whether mechanization caused substantial dislocation, and the effects of this technological shock have disappeared from the most recent scholarship on the development of living standards.¹³ Some early narratives of the Industrial Revolution recognized job loss from new techniques: in 1828 William Radcliffe claimed that before mechanization there was ‘inexhaustible’ demand for labour to spin yarn, and it enabled workers to avoid relying on

¹⁰ Pinchbeck, *Women Workers and the Industrial Revolution*; Valenze, *First Industrial Woman*; Pamela Sharpe, *Adapting to Capitalism: Working Women in the English Economy, 1700–1850* (Basingstoke, 1996).

¹¹ For example, Daniel Defoe, *A Tour Through the Whole Island of Great Britain: Divided into Circuits or Journies*, 7th edn, 4 vols. (London, 1769). Also see the discussion of Arthur Young’s *Tours* in section IV.

¹² Harold Catling, *The Spinning Mule* (Newton Abbot, 1970), 16.

¹³ Daniel Gallardo-Albarrán and Herman de Jong, ‘Optimism or Pessimism? A Composite View on English Living Standards during the Industrial Revolution’, *European Review of Economic History*, xxv, 1 (2021).

the parish poor rates for subsistence. After about 1770, though, 'what was gained by some families who had the advantage of machinery, might, in a great measure, be said to be lost to the others' who were no longer employed in hand-spinning.¹⁴ Friedrich Engels alluded to employment and income loss for spinners who, 'if they had not means of purchasing a jenny, were forced to live upon the wages of the father alone'.¹⁵

The founders of economic history and the first combatants in the living standards debate took a similar position. Barbara and J. L. Hammond highlighted unemployment from mechanization and its regional focus: 'It was the south-eastern counties of Norfolk, Suffolk, and Essex that suffered most severely from the loss of domestic spinning'.¹⁶ They also noted that 'the loss to [a] particular occupation may be temporary only; but then, as it has been remarked, man's life is temporary also'.¹⁷ After the Hammonds, scholars began to take less interest in whether the mechanization of spinning involved job-destroying innovation. J. H. Clapham admitted that hand-spinning was eliminated in some parts of Britain by the early nineteenth century but downplayed the effects. It was only harmful to 'widows and others who had lived by spinning'.¹⁸ While T. S. Ashton noted technological unemployment and a mismatch between labour and

¹⁴ William Radcliffe, *Origin of the New System of Manufacture, Commonly Called 'Power-Loom Weaving', and the Purposes for Which This System Was Invented and Brought into Use, Fully Explained in a Narrative, Containing William Radcliffe's Struggles through Life to Remove the Cause Which Has Brought This Country to its Present Crisis* (Stockport, 1828), 60–64. Neither Richard Guest nor Edward Baines mentioned unemployment of spinners in their histories, which focused on the cotton section of the industry: Richard Guest, *A Compendious History of the Cotton-Manufacture: With a Disproval of the Claim of Sir Richard Arkwright to the Invention of its Ingenious Machinery* (Manchester, 1823); Edward Baines, *History of the Cotton Manufacture in Great Britain*, 2nd edn (London, 1966).

¹⁵ Friedrich Engels, *The Condition of the Working-Class in England* (London, 1892), 5.

¹⁶ J. L. Hammond and Barbara Hammond, *The Skilled Labourer, 1760–1832*, 2nd edn (London, 1920), 153. Their sole citation for this claim was W. Cunningham, *The Growth of English Industry and Commerce in Modern Times*, 2nd edn (Cambridge, 1890–92), ii. In turn, Cunningham largely relied on Arthur Young (ed.), *Annals of Agriculture, and Other Useful Arts*, 45 vols. (London, 1784–1808) (analysed in section IV).

¹⁷ Hammond and Hammond, *Skilled Labourer*, 53.

¹⁸ J. H. Clapham, *An Economic History of Modern Britain: The Early Railway Age, 1820–1850* (Cambridge, 1926), 46, 130.

job locations in the factory age, he did not discuss employment loss in spinning or its impacts on living standards.¹⁹ A decade later Eric Hobsbawm raised technological unemployment in his exchanges with Max Hartwell, and while both noted that it may have reduced living standards, neither considered spinning specifically or attempted to assess the scale of technologically induced unemployment.²⁰ Like Hartwell, Peter Lindert and Jeff Williamson only discussed male unemployment, and they dismissed the possibility of involuntary unemployment for women in a few lines, without considering the role of technology.²¹ More stridently, Joel Mokyr claimed that 'technological unemployment did not materialize' in the Industrial Revolution.²²

In none of these analyses, even those of the pessimists, did the loss of hand-spinning significantly reduce living standards. Only the literature on gendered impacts of industrialization and studies of specific industries and locations have included detailed discussions of hand-spinning.²³ Common assumptions and perspectives about women's paid work in the past may contribute to the lack of attention in economic history to the disappearance of this female-dominated occupation. The most detailed research reconstructing British gross domestic product in the

¹⁹ T. S. Ashton, *The Industrial Revolution, 1760–1830* (London, 1948), 46, 78, 106; T. S. Ashton, 'The Standard of Life of the Workers in England, 1790–1830', *Journal of Economic History*, ix, suppl. S1 (1949).

²⁰ E. J. Hobsbawm, 'The British Standard of Living, 1790–1850', *Economic History Review*, x, 1 (1957), 52–7; Hartwell, 'Rising Standard of Living in England', 400, 413; R. M. Hartwell, 'The Standard of Living', *Economic History Review*, xvi, 1 (1963), 138.

²¹ Peter H. Lindert and Jeffrey G. Williamson, 'English Workers' Living Standards during the Industrial Revolution: A New Look', *Economic History Review*, 2nd ser., xxxvi, 1 (1983), 12–19. The closest that Lindert and Williamson came to considering technological unemployment was a veiled reference to 'structural changes' during the first third of the nineteenth century.

²² Mokyr, *Gifts of Athena*, 255. The only support offered is in Mokyr's note 49, which asserts that there was a contradiction between workers' complaints about technological unemployment, long working hours and poor environmental conditions in growing industrial cities.

²³ Pinchbeck, *Women Workers and the Industrial Revolution*, 147–56; Adrian Randall, *Before the Luddites: Custom, Community and Machinery in the English Woollen Industry, 1776–1809* (Cambridge, 1991); A. F. J. Brown, *Essex at Work, 1700–1815* (Chelmsford, 1969). Robert Allen has also mentioned spinning as an early example of technological displacement: Allen, 'Lessons from History for the Future of Work'.

long run assumes that women formed 30 per cent of the labour force.²⁴ In their contributions to the living standards debate, Lindert and Williamson claimed that female labour force participation fell in the early nineteenth century because women voluntarily left market employment.²⁵ If women were a minority of the workforce, or if they had a preference for leisure or household work, then their disappearance from paid employment may not be a major concern.

The recent interest in composite measures of living standards has also neglected technological unemployment because it cannot be precisely quantified before centralized unemployment statistics and occupational censuses.²⁶ Women's and children's work was rarely recorded in many of the sources that have been used to reconstruct the occupational structure of pre-industrial Britain.²⁷ The absence of reliable statistics on employment and unemployment is another explanation for the neglect of women's job loss in the living standards debate. The lack of firm quantification combined with assumptions about women's economic activities is linked to the mismatch between rigid,

²⁴ Stephen Broadberry *et al.*, *British Economic Growth, 1270–1870* (Cambridge, 2015).

²⁵ Lindert and Williamson, 'English Workers' Living Standards during the Industrial Revolution', 19.

²⁶ Gallardo-Albarrán and de Jong, 'Optimism or Pessimism?'; N. F. R. Crafts, 'The Human Development Index and Changes in Standards of Living: Some Historical Comparisons', *European Review of Economic History*, i, 3 (1997).

²⁷ As a result, national studies for the pre-industrial period have generally not included women or have only done so with speculative estimates: for example, Leigh Shaw-Taylor and E. A. Wrigley, 'Occupational Structure and Population Change', in *The Cambridge Economic History of Modern Britain*, i, ed. Roderick Floud, Jane Humphries and Paul Johnson (Cambridge, 2014); Patrick Wallis, Justin Colson and David Chilosì, 'Structural Change and Economic Growth in the British Economy before the Industrial Revolution, 1500–1800', *Journal of Economic History*, lxxviii, 3 (2018). While not focusing on women's employment, Osamu Saito noted that female industrial work had dropped precipitously in the two locations he analysed between the late eighteenth century and the 1851 census: Osamu Saito, 'Who Worked When: Life-Time Profiles of Labour Force Participation in Cardington and Corfe Castle in the Late Eighteenth and Mid-Nineteenth Centuries', *Local Population Studies*, xxii (1979), 15, 25. However, there is an important literature on measuring women's work, particularly Sara Horrell and Jane Humphries, 'Women's Labour Force Participation and the Transition to the Male-Breadwinner Family, 1790–1865', *Economic History Review*, xlviii, 1 (1995); Amy Louise Erickson, 'Married Women's Occupations in Eighteenth-Century London', in *Partners in Business?*

frequently binary categories for measuring employment (in or out of the labour force) and its irregular reality, especially in historical settings.²⁸

Reliance on existing data to populate models, an inflexible approach to measuring labour force participation, and assumptions about women's employment have limited discussion of the transformative and destructive impacts of the spinning jenny, the water frame and the spinning mule.

II

The work of Muldrew advanced hand-spinning to a more prominent place in the early modern economy. He estimated that about half a million women in England were employed in spinning wool by 1700, increasing to nearly 750,000 in 1770. At the latter date, this was more than 10 per cent of the population. If he was correct, hand-spinning was far more economically

(n. 27 cont.)

Spousal Cooperation in Trades in Early Modern England and the Dutch Republic, special issue of *Continuity and Change*, xxiii, 2 (2008); Jane Whittle and Mark Hailwood, 'The Gender Division of Labour in Early Modern England', *Economic History Review*, lxxiii, 1 (2020); Amy Louise Erickson, 'Wealthy Businesswomen, Marriage and Succession in Eighteenth-Century London', *Business History*, lxvi, 1 (2022). In general, these studies have argued that women worked more than has been appreciated by the mainstream of economic history. There is more research on women's employment once occupations began to be recorded in the census in the mid-nineteenth century: for example, Osamu Saito, 'Occupational Structure, Wages, and Age Patterns of Female Labour Force Participation in England and Wales in the Nineteenth Century', *Keio Economic Studies*, xvi, 1–2 (1979); Leigh Shaw-Taylor, 'Diverse Experiences: The Geography of Adult Female Employment in England and the 1851 Census', in Nigel Goose (ed.), *Women's Work in Industrial England: Regional and Local Perspectives* (Hatfield, 2007); more recently, Xuesheng You, 'Working with Husband? "Occupation's Wife" and Married Women's Employment in the Censuses in England and Wales between 1851 and 1911', *Social Science History*, lxiv, 4 (2020). An earlier article that covers the divide between pre-industrial and census-era studies on women's work is Berg, 'What Difference Did Women's Work Make to the Industrial Revolution?' Scholarship on this topic in other parts of Europe includes Carmen Sarasúa, 'Women's Work and Structural Change: Occupational Structure in Eighteenth-Century Spain', *Economic History Review*, lxxii, 2 (2019). There is a broader discussion in Jane Humphries and Carmen Sarasúa, 'Off the Record: Reconstructing Women's Labor Force Participation in the European Past', *Feminist Economics*, xviii, 4 (2012).

²⁸ Joyce Burnette, 'Mismeasuring Women's Work', Paper presented to the Social Science History Association Annual Meeting, Washington, DC, Nov. 2023.

and socially significant than previously believed. Muldrew also briefly noted the implications of a large pre-industrial spinning sector for structural change beginning in the 1770s.²⁹ A different approach taken by Leigh Shaw-Taylor, Keith Sugden and Xuesheng You calculated female employment as a ratio of male occupations, for which there is individual-level data in the eighteenth century. They suggested that spinning may have employed more than 20 per cent of women in England and Wales.³⁰

This section builds upon Muldrew's contribution with different sources and a broader perspective. Muldrew used cloth exports plus an estimate of English demand based on Gregory King's household budgets to determine the weight of wool that needed to pass through spinners' fingers. For productivity, he used estimates from contemporary pamphlets extolling the value of the textile trades for earnings and employment.³¹ While King's estimates were admirable considering the paucity of information available to him, his claims had a limited empirical basis and have been challenged.³² The figures Muldrew used for productivity have also been questioned based on new evidence.³³ This section presents an alternative approach to estimate spinning employment before industrialization. This estimate fully incorporates linen and cotton spinning, and, while it suggests that there were fewer full-time workers than suggested by Muldrew, and by Shaw-Taylor, Sugden and You, it reinforces that spinning employed a large and growing share of the population before mechanization.³⁴

²⁹ Muldrew, "Th'Ancient Distaff" and "Whirling Spindle", 499, 523.

³⁰ Leigh Shaw-Taylor, Keith Sugden and Xuesheng You, *A Preliminary Estimate of the Female Occupational Structure of England and Wales, 1700–1911*, Cambridge Working Papers in Economic and Social History (2019).

³¹ Muldrew, "Th'Ancient Distaff" and "Whirling Spindle"; [Gregory King], 'The LCC Burns Journal', repr. in *The Earliest Classics*, ed. P. Laslett (Farnborough, 1973).

³² Scepticism of King includes G. S. Holmes, 'Gregory King and the Social Structure of Pre-Industrial England', *Transactions of the Royal Historical Society*, xxvii (1977).

³³ Humphries and Schneider, 'Spinning the Industrial Revolution'.

³⁴ Linen and hemp were discussed by Muldrew in an appendix. He calculated that almost 870,000 additional workers would have been required to spin these two fibres by about 1770. Muldrew, "Th'Ancient Distaff" and "Whirling Spindle", online supplement: 'Linen and Hemp Spinning Estimates', <https://onlinelibrary.wiley.com/action/downloadSupplement?doi=10.1111%2Fj.1468-0289.2010.00588.x&file=EHR_588_sm_online_supp.doc> (accessed 11 Oct. 2024).

There are four principal differences from the approach used by Muldrew. The first is productivity. The dominant view on the quantity of fibre that a spinner could turn into yarn per time has relied on the claims of contemporary social commentators. Most of these writers claimed that an adult woman (sometimes an 'industrious' one) could spin a pound of yarn per day.³⁵ These assertions have been repeated by various scholars in the following two centuries.³⁶ In our research on spinners' earnings, Jane Humphries and I collected original records of hand-spinners' output per time. This evidence suggested much lower levels of productivity: closer to 0.4 pounds per day, with some variation by fibre.³⁷ The estimates here use the productivity figures proposed in our previous research for wool and cotton. For flax, much coarse spinning probably occurred within households (not observed by us and not relevant for the wages we constructed from piece rates), so productivity is estimated at 0.5 pounds per day.

The second and third elements required to produce estimates of employment are figures for the throughput of fibre and the geographical unit. This study uses measures of the supply of wool, cotton and flax as the basis for throughput of fibre in Great Britain. For wool, domestic yields from Stephen Broadberry *et al.* are combined with net imports from Elizabeth Schumpeter. Muldrew did not estimate employment in cotton spinning, but supply inputs are available in net import data. The calculations for flax spinning are based on several secondary and primary sources for the period 1750–80, producing a trade-based supply

³⁵ For example, Frederic Morton Eden, *The State of the Poor: or, An History of the Labouring Classes in England, from the Conquest to the Present Period: In Which Are Particularly Considered, their Domestic Economy, with Respect to Diet, Dress, Fuel, and Habitation. And the Various Plans which, from Time to Time, have been Proposed, and Adopted, for the Relief of the Poor*, 3 vols. (London, 1797), iii, 796. David Davies claimed that a woman 'more than ordinarily notable and industrious' who 'sits closely to her wheel the whole day . . . can spin 2 lbs. of coarse flax': David Davies, *The Case of the Labourers in Husbandry Stated and Considered* (Bath, 1795), 84–5.

³⁶ H. Heaton, 'The Assessment of Wages in the West Riding of Yorkshire in the Seventeenth and Eighteenth Centuries', *Economic Journal*, xxiv, 94 (1914), 235; Randall, *Before the Luddites*, 59. There is a more modest estimate in J. de L. Mann, *The Cloth Industry in the West of England from 1640 to 1880* (Oxford, 1971), 322–3.

³⁷ Humphries and Schneider, 'Spinning the Industrial Revolution', 138, 140 (table 5).

estimate for the earlier eighteenth century.³⁸ Muldrew's study estimated employment in England, rather than Britain.

The raw amounts of fibre must be converted into weights of fibre received by spinners. Cotton required the least processing, though some weight could be lost in transportation or when bales were opened. The calculations use a conservative estimate that 10 per cent of the imported weight was lost before spinners received fibre. Wool (both short- and long-staple) had to be cleaned (carded or combed) to remove dirt, burrs and other detritus, and some weight could be lost in transit. This is estimated at 25 per cent. Flax required extensive processing from the stalk to spinnable fibre, with substantial loss of weight between cultivation or import and spinning; this is estimated at 60 per cent.³⁹

The fourth and final difference from Muldrew is the estimated working days of spinners. Muldrew assumed a six-day week and thirty-five weeks of work per year, or 210 days of work each year.⁴⁰ Even though he acknowledges that spinning stopped for parts of the year, this estimate appears high when compared with work in other trades during the eighteenth century.⁴¹ Further, descriptive evidence shows that work in spinning fit around the agricultural calendar. In August 1727, the Wiltshire clothier John Usher wrote in a letter that 'The harvest

³⁸ B. R. Mitchell, *British Historical Statistics* (Cambridge, 1988), 330–32, 337–8, 347–8; Broadberry *et al.*, *British Economic Growth*, pp. xxxv, 112. In addition, Stephen Broadberry generously shared the yearly data. For net trade, see Elizabeth Boody Schumpeter, *English Overseas Trade Statistics, 1697–1808* (Oxford, 1960), 52–9. The importation of cotton to Scotland was negligible up to 1760: Philipp Robinson Roessner, 'Scottish Foreign Trade towards the End of the Pre-Industrial Period, 1700–1760' (University of Edinburgh Ph.D. thesis, 2007), 248. To estimate total flax throughput before 1760, see n. 49. The estimated flax throughput is substantially lower than the figures provided by Mitchell, which suggest that domestic production accounted for a very high share of the fibre supply (nearly 80 per cent). Hemp is not included as there are no systematic supply data for the eighteenth century, and much was likely used in ropemaking, which required different technology.

³⁹ Compare N. B. Harte, 'The Rise of Protection and the English Linen Trade, 1690–1790', in N. B. Harte and K. G. Ponting (eds.), *Textile History and Economic History: Essays in Honour of Miss Julia de Lacy Mann* (Manchester, 1973), 104–5.

⁴⁰ Muldrew, "'Th' Ancient Distaff" and "Whirling Spindle"', 510.

⁴¹ Judy Z. Stephenson, 'Working Days in a London Construction Team in the Eighteenth Century: Evidence from St Paul's Cathedral', *Economic History Review*, lxxiii, 2 (2020).

coming on sooner than expected, [we] could not get the spinning to make it [the cloth] longer, it being still in the spinners' hands'. A Wiltshire cloth merchant, Henry Hindley, wrote to a contact in Hamburg in late October 1762: 'Our spinning is now begun, therefore [I] should be glad to have the flax shipped'.⁴² At Colehill, Warwickshire, the work of a spinning school was suspended during the late summer of 1802. A note in the spinning book explained the stoppage: 'During the weeks 18th-19th-20th & 21st — the spinning was suspended for the purpose of giving the children an opportunity of Gleaning'. In Kent, the accounts of St Mary, Rolvenden, also show that most spinning occurred during the winter, especially in December.⁴³ The importance of winter spinning to stabilize incomes was mentioned in surveys of Gloucestershire, Perthshire, Peebleshire, Sutherland and Berwickshire.⁴⁴ Spinning could provide income at times of the year when other types of employment were not available.

This evidence supports the view that spinning was a regular employment for part of the year.⁴⁵ If women spun consistently from mid October to mid March and for a few weeks in the spring and summer when there was less demand for agricultural work, they would have worked about 150 days. Therefore, Figures 1–4 present an estimate of the number of full-time equivalent workers (250 days per year) to capture spinning's place in British

⁴² *Documents Illustrating the Wiltshire Textile Trades in the Eighteenth Century*, ed. Julia de L. Mann (Devizes, 1964), 14, 54.

⁴³ Warwickshire County Record Office, Warwick, DR(B) 100/89; Kent History and Library Centre, Maidstone, P308/12/16.

⁴⁴ Thomas Rudge, *General View of the Agriculture of the County of Gloucester: Drawn up for the Consideration of the Board of Agriculture and Internal Improvement* (London, 1813), 347; James Robertson, *General View of the Agriculture of the County of Perth: With Observations on the Means of its Improvement. Drawn up for the Consideration of the Board of Agriculture and Internal Improvement* (Perth, 1799), 86; Charles Findlater, *General View of the Agriculture of the County of Peebles: With Various Suggestions as to the Means both of the Local and General Improvement of Agriculture* (Edinburgh, 1802), 216; John Henderson, *General View of the County of Sutherland: With Observations on the Means of its Improvement. To Which Is Annexed a Particular Account of the More Recent Improvements in that County* (London, 1812), 118; Robert Kerr, *General View of the Agriculture of the County of Berwick: With Observations on the Means of its Improvement. Drawn up for the Consideration of the Board of Agriculture and Internal Improvement, and Brought Down to the End of 1808* (London, 1813), 321.

⁴⁵ Jane Humphries and Benjamin Schneider, 'Losing the Thread: A Response to Robert Allen', *Economic History Review*, lxxiii, 4 (2020), 1139–40.

occupational structure (or labour force participation using traditional methods), and an estimate of more realistic part-time workers (150 days per year) to determine its actual prevalence. The figures display yearly employment estimates (one for a 250-day working year and one for a 150-day year), and eleven-year moving averages to present the general trends of each series.

Figure 1 presents estimates of employment in wool spinning using the wool output estimates of Broadberry *et al.* combined with retained imports, the productivity estimates from Humphries' and my article 'Spinning the Industrial Revolution', and the working years just described.⁴⁶ Muldrew's demand-based estimate suggests a more substantial increase in wool throughput because of growth in population and exports, and a commensurate rise in employment to 1750.⁴⁷ His calculations also incorporate falling productivity per worker in wool spinning as finer spinning increased in market share during the eighteenth century. Adding such a trend would increase the slope of the lines in Figure 1.

The estimates with the firmest empirical basis are for cotton spinning as the supply of fibre is available in the import statistics. Figure 2 presents estimates of employment in cotton spinning between 1697–8 and 1770. Cotton spinning employed fewer women than wool, and most of them were in the north-west of England, but employment increased almost fourfold over the seventy years before mechanization.⁴⁸

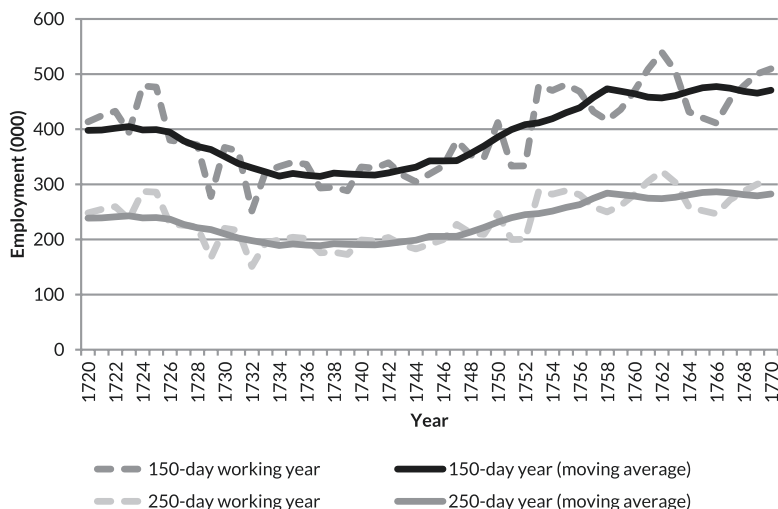
Sources for the supply of flax for spinning are less reliable and the estimates are therefore tentative. However, linen yarn was clearly more important than cotton before mechanization, and employment in spinning flax may have been substantial. The estimate in Figure 3 uses flax production estimates in primary

⁴⁶ Broadberry *et al.*, *British Economic Growth*, 107 (fig. 3.03), 109 (table 3.13). In the earlier part of the eighteenth century Broadberry *et al.*'s data show that British wool output fell because of a sharp drop in the number of sheep following the Great Frost of 1709.

⁴⁷ Muldrew, "Th'Ancient Distaff" and "Whirling Spindle", 518.

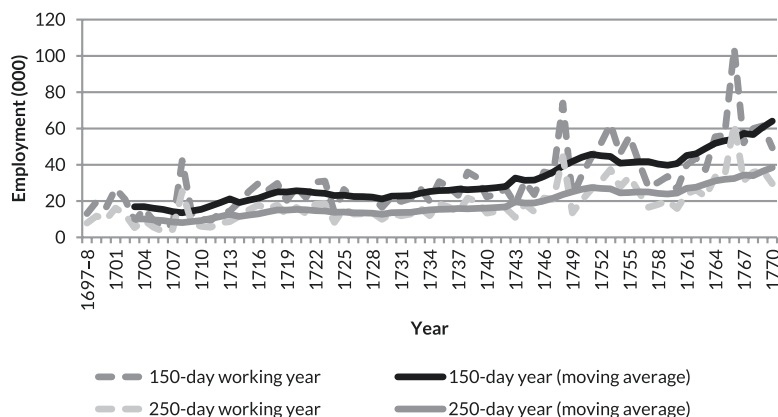
⁴⁸ On locations of cotton hand-spinning, see section IV below and John Styles, 'Fashion, Textiles and the Origins of the Industrial Revolution', *East Asian Journal of British History*, v (2016).

FIGURE 1
WOOL-SPINNING EMPLOYMENT ESTIMATE, 1720–1770*



* Sources: Stephen Broadberry *et al.*, *British Economic Growth, 1270–1870* (Cambridge, 2015); Jane Humphries and Benjamin Schneider, 'Losing the Thread: A Response to Robert Allen', *Economic History Review*, lxxiii, 4 (2020); Elizabeth Boody Schumpeter, *English Overseas Trade Statistics, 1697–1808* (Oxford, 1960).

FIGURE 2
COTTON-SPINNING EMPLOYMENT ESTIMATE, 1697/8–1770*



* Source: B. R. Mitchell, *British Historical Statistics* (Cambridge, 1988).

and secondary sources and trade statistics.⁴⁹ The employment estimate suggests that linen spinning was an important source of work, albeit much less so than wool. The estimated increase in employment accords with research on the growth of flax spinning in peripheral areas of Britain during the 1700s.⁵⁰

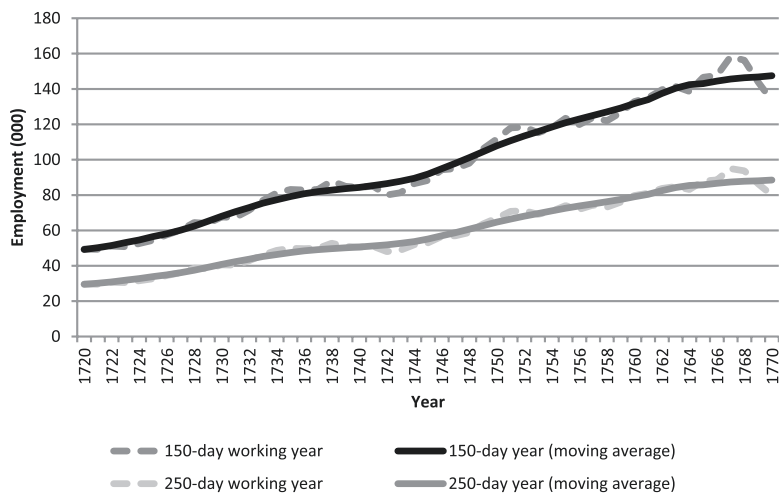
Combining the estimates for each fibre produces Figure 4. Based on the sources and parameters used here, spinning grew notably, though not steadily, through the period 1735–70. Table A2 compares the estimates produced here with those of Muldrew.

How large was this estimated employment relative to the British population during the eighteenth century? Figure 5 presents the share of the population employed in spinning in the mid eighteenth century using the estimates produced above. Contemporary sources suggest that almost all spinners were women and children, so the estimates of employment can also be presented as a share of this part of the population: women and girls 5 years old and older, and boys aged 5 to 14 (Figure A1). As there were likely few children under 8 years of

⁴⁹ I am grateful to John Styles for suggesting the sources and approach used here. The English trade statistics record imported flax from 1700: Schumpeter, *English Overseas Trade Statistics*, 52–9. Assuming that flax imported to England was a constant share of the total supply, then it is possible to construct a rough estimate of total supply about 1770 from other sources and to use the import statistics to estimate employment in producing linen yarn for the period 1700–70. The trade statistics show that about 13.6 million pounds of flax were imported in 1770. The contemporary writer Alexander Somerville claimed that £300,000 worth of flax was grown in England in 1773, or nearly 8.8 million pounds: W. G. Rimmer, *Marshalls of Leeds, Flax-Spinners, 1788–1886* (Cambridge, 1960), 5. Negley Harte contended that Somerville's figure was too high. Based on bounties paid for cultivation, a minimum of 1.83 million pounds of flax were produced per year in the early 1780s, but Harte also stated that the bountied quantity was 'substantially below total English output': Harte, 'Rise of Protection and the English Linen Trade', 104–6. Therefore, it is plausible to estimate that 16 million pounds of flax were spun in England in 1770 (13.6 million pounds of imported flax and 2.4 million pounds of domestic production). The Scottish trade statistics show that approximately 4.6 million pounds of flax were imported each year from 1755 to 1759: Roessner, 'Scottish Foreign Trade towards the End of the Pre-Industrial Period', 241. Alastair Durie asserts that contemporaries believed 'less than half' of flax spun in Scotland was home-grown: Alastair J. Durie, *The Scottish Linen Industry in the Eighteenth Century* (Edinburgh, 1979), 35. Therefore, 25 million pounds of flax may have been available for spinning in Great Britain in 1770. English imports would have been roughly 54 per cent of this total. Linking total supply to this proportion enables the back-projection to 1700 used for the employment estimates in Figure 3.

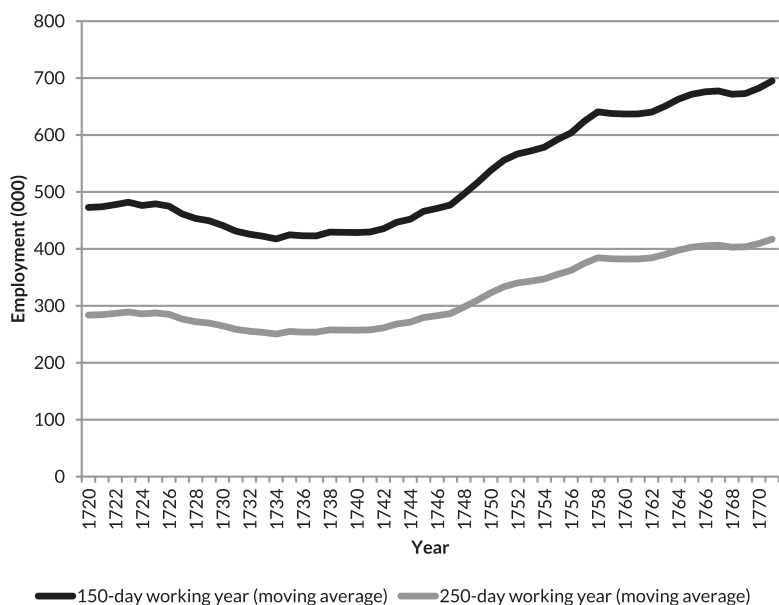
⁵⁰ Durie, *Scottish Linen Industry in the Eighteenth Century*.

FIGURE 3
FLAX-SPINNING EMPLOYMENT ESTIMATE, 1720–1770*



* Sources: See n. 49.

FIGURE 4
TOTAL SPINNING EMPLOYMENT ESTIMATE, 1720–1770*



* Sources: See Figures 1–3.

age who spun, this is a conservative estimate of the share of the available workforce employed in spinning.⁵¹

Spinning was a large and growing source of employment in 1770. The estimate for wool-spinning employment in [Figure 1](#) is lower than calculated by Muldrew, and the increase in employment may have been greater (perhaps from a lower initial level) as finer spinning increased in market share. Some production would also have been for household use, primarily of linen yarn.

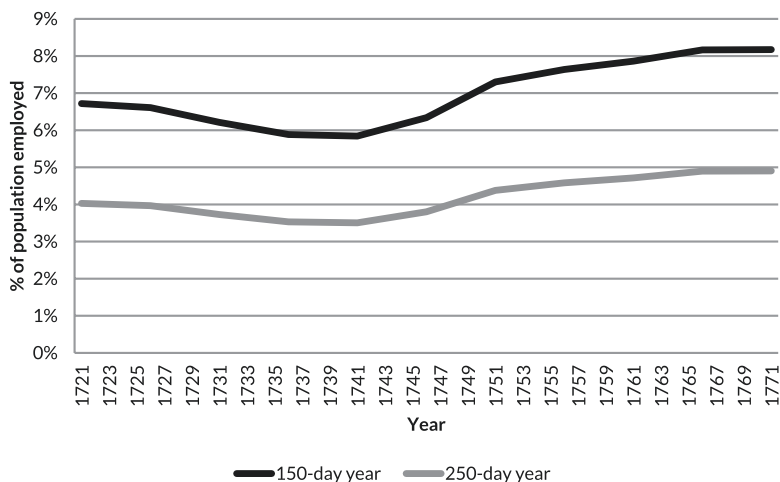
There are three dimensions on which these estimates might be modified while using the same supply figures. If the average working year in spinning was shorter than 150 days, then more women and children would have been employed, but spinning would have been a smaller share of their annual income. If the working year was longer, then the reverse would be true. If productivity per spinner was higher, in line with Robert Allen's claim that Humphries and I observed low-quality workers (strongly rejected in our reply), then employment would have been lower, but individual and household earnings higher.⁵² If, on the other hand, rising cloth quality demanded finer yarn, then the increase in spinning employment would have been more rapid than shown in [Figures 4](#) and [5](#), and likely to a higher peak level. [Table A3](#) shows how some alternative assumptions would change the estimates for employment in 1770. All scenarios demonstrate that spinning was an important occupation in pre-industrial Britain, providing employment for at least 3.5 per cent and perhaps as high as 12 per cent of the whole population by about 1770.

The estimates constructed here using varying parameters, as well as the even larger estimates produced using different approaches and with distinct sources by Muldrew and

⁵¹ E. A. Wrigley and R. S. Schofield, *The Population History of England, 1541–1871: A Reconstruction* (Cambridge, 1981), 529. The Welsh population share is estimated using the later relative size of the Welsh and English populations: *ibid.*, 566, 577. This method of roughly estimating the Welsh population produces a similar figure for the late eighteenth century (about 500,000) to that suggested in John Davies, *A History of Wales* (London, 1993), 319. The Scottish population share is estimated in the same way using Mitchell, *British Historical Statistics*, 8–9, 11.

⁵² Robert C. Allen, 'Spinning their Wheels: A Reply to Jane Humphries and Benjamin Schneider', *Economic History Review*, lxxiii, 4 (2020), 1129; Humphries and Schneider, 'Losing the Thread', 1141–5.

FIGURE 5
ESTIMATED SHARE OF POPULATION EMPLOYED IN SPINNING,
1721–1771*



* Sources: See Figures 1–3; E. A. Wrigley and R. S. Schofield, *The Population History of England, 1541–1871: A Reconstruction* (Cambridge, 1981); B. R. Mitchell, *British Historical Statistics* (Cambridge, 1988).

by Shaw-Taylor, Sugden and You, clearly demonstrate that hand-spinning was one of the largest sources of employment in Britain by about 1770.

III

The three machines of the Industrial Revolution — the spinning jenny, the water frame and the mule — enabled much higher productivity than the hand wheel.⁵³ This section and section IV assess the speed, scale and locations of job destruction. First, this section reviews the early qualitative evidence that mechanization was replacing workers. Then, limited contemporary estimates of machine spindles processing cotton yarn enable a rough quantification of unemployment in hand-spinning of cotton by the late 1780s. Section IV uses evidence from more than 200 qualitative sources from the 1770s to the 1830s to construct a systematic

⁵³ Peter Maw *et al.*, ‘After the Great Inventions: Technological Change in U.K. Cotton Spinning, 1780–1835’, *Economic History Review*, lxxv, 1 (2022).

view of the decline of hand-spinning, the (limited) replacement work available, and the deprivation caused by mechanization. Section V considers the possible impacts on household incomes.

Evidence of technological unemployment began to appear in the 1780s and 1790s.⁵⁴ A booklet from 1780 provided a description of concentrated unemployment among cotton spinners in Lancashire, Derbyshire and Cheshire. The authors stated that cotton spinning 'is the only employment whereby many thousands of families subsist', and that declining incomes were the cause of machine-breaking riots. They further proposed that parliament halt the use of spinning machines or impose a tax on them 'as thereby to give liberty to the poor laborious manufacturer . . . to compleat the Cotton upon the same or nearly the same terms as the Machines'.⁵⁵ This is perhaps the first example of a 'robot tax' or 'automation tax', which applies a tax to labour-replacing innovations to disincentivize their adoption.⁵⁶

In the same year (1780), hand-spinners of cotton in Lancashire sent a petition for relief to parliament. The document does not survive, but a committee convened to review it and published a response:

In the Course of the last Summer great Complaints were made by the Cotton Spinners in Lancashire, for Want of Employment; and that many of them were reduced to the utmost Distress, and in great want both of Food and Raiment, which the Witnesses attributed to the Introduction of Patent Machines and Carding Engines, used in the Cotton Manufacture, which have greatly increased within the last Three or Four Years.⁵⁷

⁵⁴ Fear of technological unemployment appeared in Lancashire during the 1760s and 1770s through instances of machine-breaking, including of James Hargreaves's jennies: C. Aspin and S. D. Chapman, *James Hargreaves and the Spinning Jenny* (Preston, 1964), 17–18, 47.

⁵⁵ W.C. and R.M., *An Impartial Representation of the Case of the Poor Cotton Spinners in Lancashire, &c: With a Mode Proposed to the Legislature for their Relief* (London, 1780), 1–4.

⁵⁶ Compare Xavier Oberson, 'How Taxing Robots Could Help Bridge Future Revenue Gaps', *OECD Yearbook 2017: Bridging Divides* (2017). Possibly the strongest movement for this type of taxation occurred during the 1930s in the United States, again as a result of concerns about technological unemployment: Gregory R. Woirol, 'The Machine Taxers', *History of Political Economy*, 1, 4 (2018).

⁵⁷ *Report from the Committee to Whom the Petition of the Cotton Spinners and Others, in and Adjoining to the County of Lancaster, and also the Petition of John Hilton, Agent for the Cotton Manufactures of the Town and Neighbourhood of Manchester, on*

However, the committee also stated that machinery had supported the growth of cotton manufacturing, and particularly that male weavers' wages were higher than ten years previously. One witness acknowledged that the poor rates had risen, 'but that it was not owing to the distress of the Manufacturers by the Introduction of the Machines, but to various other Causes', perhaps alluding to the ongoing war. The committee concluded that mechanization was beneficial for the cotton industry as a whole and that 'there is no Want of Employment for the industrious Poor'.⁵⁸

These sources suggest that there may have been labour displacement producing unemployment or underemployment for cotton spinners by about 1790, but the scale is uncertain. Any attempt to quantify unemployment will be imprecise as there is little data available on the prevalence of machinery, but a brief estimation can suggest the size of the technological shock at this stage. In 1787 Patrick Colquhoun compiled a list of operational factories and estimates of spindles in use on jennies, frames and mules. He counted 143 mills, mostly in Lancashire, Derbyshire and Nottinghamshire.⁵⁹

(n. 57 cont.)

behalf of the Said Manufacturers, Were Referred (27 June 1780), House of Commons Sessional Papers of the Eighteenth Century, 1780, (20), xxxi, 3–4. Another petition of impoverished spinners does survive: William Ludlam, *To the Nobility, Gentry, Magistrates, and Representatives in Parliament, of Every County and Town in Great Britain: More Especially those of the Town and County of Leicester: The Humble Petition of the Poor Spinners of the Town and County Aforesaid* (1787).

⁵⁸ *Report from the Committee to Whom the Petition of the Cotton Spinners . . . Were Referred*, 4–6. A contemporary pamphlet in favour of mechanization was Thomas Bentley, *Letters on the Utility and Policy of Employing Machines to Shorten Labour, Occasioned by the Late Disturbances in Lancashire: To Which Are Added Some Hints for the Further Extension and Improvement of our Woollen Trade and Manufactures* (London, 1780). Bentley took a mercantilist angle and extolled the benefits of silk-throwing machines and cotton-spinning machinery for employment in the British silk and cotton industries.

⁵⁹ Harvard Business School, Baker Library Special Collections, MSS 442 1771–1789 C722. There are criticisms of Colquhoun's estimates: in the early 1980s, Stanley Chapman collected evidence of mill sites and determined that there were at least 208 premises in use by the same date: S. D. Chapman, 'The Arkwright Mills: Colquhoun's Census of 1788 and Archaeological Evidence', *Industrial Archaeology Review*, vi, 1 (1981). While Chapman claims that Colquhoun's mill figure was an undercount, Styles argues that Colquhoun likely exaggerated the number of jennies: John

(cont. on p. 126)

In that year, Britain retained about 22 million pounds of cotton imports, and Colquhoun stated that there were 1,605,000 jenny spindles, 50,000 mule spindles and 286,000 water frame spindles in factories. If the average jenny had about eighty spindles and an operative could produce 3.25 pounds of cotton per day, the average mule had 120 spindles and could produce four pounds, and the average sixty-spindle frame could process about 4.5 pounds, then mechanized production would have consumed nearly all retained cotton imports, leaving enough cotton for only 1,500 hand-spinners working 150 days per year. Total employment in mechanized spinning using Colquhoun's spindleage estimates would have been about 25,000 (20,000 jenny spinners, 400 mule spinners and 5,000 factory workers).⁶⁰ The baseline estimate of cotton spinners in section II in 1770 is 64,000, which means that there was a net reduction in employment in spinning directly of about 37,000. However, some hand-spinners did not purchase jennies or move to work in factories, meaning the actual number of hand-spinners who lost work and were not re-employed in spinning was likely higher.⁶¹

Cotton was probably a unique case. The areas where hand-spinning of cotton had been concentrated before industrialization and where the largest numbers of jobs were eliminated by machinery were fairly close to new jobs in mills.⁶² Spinning before mechanization also frequently included other

(n. 59 cont.)

Styles, 'The Rise and Fall of the Spinning Jenny: Domestic Mechanisation in Eighteenth-Century Cotton Spinning', *Textile History*, li, 2 (2021), 224. Richard Arkwright claimed that there were only about 357,000 jenny spindles in 1784, less than a quarter of what Colquhoun stated three years later: *ibid.*, 225 (table 3). We use Colquhoun's figures here as they provide estimates of all three main types of machinery, although he may have underestimated the number of factory spindles and overestimated the number of jenny spindles.

⁶⁰ Harvard Business School, Baker Library Special Collections, MSS 442 1771–1789 C722; Chapman, 'Arkwright Mills'; Maw *et al.*, 'After the Great Inventions'. The productivity and spindles per machine estimates here are lower than those in Maw *et al.* to account for the continuing use of older, smaller, less productive machines.

⁶¹ For consistency, this calculation uses the 150-day working year. If spinners worked for 250 days per year, about 1,000 would have been employed in 1787, and the net employment loss would have been about fourteen thousand.

⁶² Trade disruptions from the American Revolution may also have contributed to a downturn in cotton spinning, but net imports of cotton changed little during this period: Mitchell, *British Historical Statistics*, 330–31.

tasks, including cleaning fibre, making rovings and reeling spun yarn. In workshops and factories these tasks were usually separated into distinct occupations, such as card-room workers, who are not captured in the estimate above. While we do not know how many former hand-spinners in Lancashire, Cheshire, Derbyshire and Nottinghamshire found work in factories, the opportunity did exist, and the costs of migration were lower than for many other hand-spinners. To use the terminology proposed by Daron Acemoglu and Pascual Restrepo, there was substantial labour displacement, but there were also opportunities for reinstatement.⁶³

Pamphlets from the 1790s provided more evidence of unemployment and suggested that hand-spinners outside cotton manufacturing were losing work, with much less job creation to offset displacement. Most of these women lived further from new mills, which made it more difficult for them to find new work. In 1791 Robert Sadler published a lengthy poem called *The Discarded Spinster* lamenting the decline of spinning. Sadler admitted that machines produced concentrated benefits in industrial districts, but said that these upsides came at the cost of rural unemployment and poverty.⁶⁴ A pamphlet published in 1794, *Observations on the Detriment . . . from the Loss of Woollen Spinning*, discussed the practice of discounting spinners' wages (making deductions from the normal piece rate during a downturn) and stated that yarn merchants increasingly turned away spinners and combers looking for work. The author pointed out that unemployed women and girls who previously spun had no alternative employment except for agricultural work, which only provided income in some seasons.⁶⁵ The pamphlet also suggested that spinning unemployment was leaving families dependent on a male breadwinner: 'the loss of those earnings, the wife and her children used to bring in, until these Machines threw the whole burthen of maintaining the family on the man'.⁶⁶

⁶³ Acemoglu and Restrepo, 'Automation and New Tasks'.

⁶⁴ Robert Sadler, *The Discarded Spinster: or, A Plea for the Poor, on the Impolicy of Spinning Jennies. A Poem* (London, 1791).

⁶⁵ A.B., *Observations on the Detriment that It Is Supposed Must Arise to the Family of Every Cottager throughout the Kingdom from the Loss of Woollen Spinning by the Introduction of Machines for that Work* (1794), 4–5. The author also noted that the implications of cotton mechanization were not so deleterious by comparison with wool.

⁶⁶ *Ibid.*, 10. Compare Humphries and Schneider, 'Gender Equality, Growth, and How a Technological Trap Destroyed Female Work'.

IV

As indicated in these later descriptive sources, the consequences of the spinning innovations were much greater outside cotton production. Cotton had been the smallest part of pre-industrial employment and saw comparatively substantial new work. Mechanization in woollen, worsted and flax spinning also enabled large productivity gains, and increasingly cheap, light and fashionable cotton textiles made from factory-spun yarn increased their share of the market.⁶⁷ Jennies were adopted in woollen spinning as early as the 1770s, while the mechanization of worsted primarily used water frames. The first worsted factory was built in Lancaster in 1784, and many more were constructed in the West Riding of Yorkshire in the early 1800s.⁶⁸ Flax-spinning machinery was introduced from 1787, and there were factories with thousands of flax spindles in operation by the late 1790s. Mechanization fully replaced hand-spinning of fine linen yarn, the most stubborn of the fibres, by the 1830s.⁶⁹

Productivity increases and cotton's increasing market share caused far more unemployment among wool and flax spinners than among hand-spinners of cotton. This unemployment also lasted much longer. To understand the national scale, timing and main locations of unemployment in hand-spinning, this section turns to the detailed observations of social commentators and the reports of parish officers and local magistrates.

The agriculturalist Arthur Young travelled around England and Wales in the late 1760s and 1770s to observe farming practices and the rural economy, and he reported his observations in three books published in 1770 and 1771. These sources provide evidence of the prevalence of spinning and the general availability of work before significant mechanization.⁷⁰ Young and

⁶⁷ Woollen, worsted and linen fabrics continued to be purchased for some uses: see, for example, Sara Horrell, Jane Humphries and Ken Sneath, 'Consumption Conundrums Unravelling', *Economic History Review*, lxxviii, 3 (2015), 853–5.

⁶⁸ David Seward, 'The Wool Textile Industry, 1750–1960', in J. Geraint Jenkins (ed.), *The Wool Textile Industry in Great Britain* (London, 1972), 41–4.

⁶⁹ Rimmer, *Marshalls of Leeds, Flax-Spinners*, 9, 24, 56–7.

⁷⁰ On the validity of Young as a source of quantitative evidence, see Liam Brunt, 'Rehabilitating Arthur Young', *Economic History Review*, lvi, 2 (2003). The approach taken here uses Young's wage data as an indicator of the availability of work.

TABLE 1
 AVAILABILITY OF EMPLOYMENT FOR WOMEN IN ARTHUR YOUNG'S
TOURS (1770–1771) AS A PERCENTAGE OF REPORTS*

Work available	Little or irregular work	Seasonal work	No work	No answer
80.27	6.80	0.68	0	19.73

* *Notes*: Number of reports = 147. These figures include agricultural work. For work availability coding criteria, see [Table A1](#); see also [Table A4](#).

* *Sources*: See n. 71.

the writings he reproduced from correspondents mentioned the occurrence and locations of hand-spinning, as well as other types of labour and wages. Three areas were not included in these texts: the south-west (Devon and Cornwall), the Welsh borders (Herefordshire and Shropshire) and part of East Anglia (Huntingdonshire and Cambridgeshire). Young and his correspondents noted the presence of spinning in every county mentioned in the *Tours* except Kent and Sussex, and spinning was by far the most common manufacturing occupation for women and children. Wool was the most common fibre spun, followed by flax. Cotton was only spun in Lancashire. Young did not document any places without employment for women, in part because spinning was so prevalent ([Table 1](#), [Table A4](#)).⁷¹

⁷¹ [Arthur Young], *A Six Months Tour through the North of England, Containing, an Account of the Present State of Agriculture, Manufactures and Population, in Several Counties of this Kingdom . . . Interspersed with Descriptions of the Seats of the Nobility and Gentry, and Other Remarkable Objects*, 2nd edn, corrected and enlarged, 4 vols. (London, 1771); [Arthur Young], *A Six Weeks Tour, through the Southern Counties of England and Wales . . . Interspersed with Accounts of the Seats of the Nobility and Gentry, and Other Objects Worthy of Notice: In Several Letters to a Friend*, 2nd edn, corrected and enlarged (Dublin, 1771); [Arthur Young], *The Farmer's Tour through the East of England: Being the Register of a Journey through Various Counties of this Kingdom, to Enquire into the State of Agriculture, &c. . . With Other Subjects that Tend to Explain the Present State of English Husbandry*, 4 vols. (London, 1771). These data differ from those collected by Styles as they include both Young's own observations and those of his correspondents, and [Tables 1](#) and [A1](#) include all types of work either mentioned directly or implicitly (for example, wages listed for women in agriculture or domestic service), not only manufacturing employment: compare Styles, 'Fashion, Textiles and the Origins of the Industrial Revolution', 166–8. The prevalence of service stands in surprising contrast to the scarcity of such employment available in the other sources examined here, and it is the main reason that 'Other work' in [Figure 7](#) is much higher in Young's *Tours*. The observations in this section are coded

(cont. on p. 130)

The first sources that provide a similar coverage to Young's *Tours* during the era of mechanization are the 136 county surveys produced by the Board of Agriculture between 1793 and 1815. The surveys covered most of the English, Welsh and Scottish counties, and focused on farming practices and technology, but also included comments on the economy, especially in rural areas. The surveys were written by many different authors and had only a loosely similar structure and approach, so they do not match the more consistent evidence collection by Young.

Hand-spinning was mentioned 123 times in the 136 surveys; these observations have been coded for the status of spinning (Table 2). A few points emerge from the surveys. First, about a third of the mentions of spinning discuss its decline or disappearance. On the other hand, there were still places where spinning for the market continued, especially in Scotland. In these transitional decades, spinning also persisted in English workhouses or houses of industry as a means of occupying the poor. In a few places there were attempts (usually short-lived) to establish spinning schools. Finally, there was a little spinning to produce yarn for household use. The surveys occasionally suggested that the American Revolution and the French revolutionary and Napoleonic wars had disrupted commerce and caused some unemployment. However, most comments about the decline of spinning either gave no specific cause or blamed 'spinning machinery'.

(n. 71 *cont.*)

for employment for women as this was more commonly reported than children's work. The International Labour Organization has three criteria to count an individual as 'unemployed': the person must not have worked during the reference period (the week or month of the survey), the person must be available to take up employment, and the person must have been actively seeking work: International Labour Organization, 'International Definitions and Prospects of Underemployment Statistics', 1 Nov. 1999, <<https://www.ilo.org/publications/international-definitions-and-prospects-underemployment-statistics>> (accessed 11 Oct. 2024). As discussed in section I, this definition is designed for settings in which workers are steadily employed (or not employed) in a single job, and when employment status can be observed at an individual level. Sources from this period rarely provide individual-level information, and spinning itself was a seasonal employment. Therefore, the sources are coded using two sets of criteria: the availability of work (Tables 1, 3 and 5) and the status of spinning (Tables 2, 4). The availability of work coding criteria (Table A1) capture whether paid employment opportunities were present in the location of observation at the time when the report was produced, and whether work was irregular and only available in some seasons. The tables show the share of non-responses, while the figures present the data excluding non-responses.

TABLE 2
 MENTIONS OF SPINNING IN THE GENERAL VIEW OF AGRICULTURE COUNTY SURVEYS (1793–1815) (%)*

Nation	No. of mentions	Market or unspecified spinning	Workhouse spinning	Spinning for household use	Spinning declining or disappeared
England	69	43.48	17.39	7.25	33.33
Scotland	46	54.35	2.17	8.70	30.43
Wales	8	25.00	0.00	12.50	50.00
TOTAL	123	46.34	10.57	8.13	33.33

Descriptive information in the surveys indicates the impacts of job loss. Most pertinently, the loss of spinning employment substantially reduced rural incomes and enhanced seasonal variation in earnings. In Gloucestershire, 'The families of labourers who were used to earn a good deal towards their maintenance by spinning, have now no employment in the winter, and only a partial supply of such agricultural business as is suited to their strength in summer'.⁷² Returning to an earlier theme, in some locations observers stated that the loss of earnings in spinning was the cause of rising poor rates.⁷³ A complete list of examples is presented in [Table A7](#).

A more comprehensive and consistent source that contains information about employment in spinning is Frederic Eden's *State of the Poor*. It was published in 1797 and the information was collected concurrently with some of the county surveys. This text had a more regular approach for presenting comments on the availability of work, which makes it more appropriate for longitudinal comparison than the surveys, but it was focused on the conditions of the poor and did not always describe general labour market conditions. As with Young's *Tours*, all of the parish-level comments have been coded for the presence of employment and the types of work that were available. The main limitation of this source is the large share of parishes for which no information was provided, even indirectly, about the availability of work for women (see the right-hand column in [Table 3](#)).

Concurrently with Eden and the county agricultural surveys, Arthur Young published his periodical *Annals of Agriculture*, usually semi-annually, from 1784 until 1808. The *Annals* combined Young's own observations with letters from his subscribers and correspondents around the country. [Table 4](#) summarizes these observations. Frequently in response to solicitations for information from Young, respondents stated that spinning was in a poor state or, less commonly, had disappeared altogether. One

⁷² Rudge, *General View of the Agriculture of the County of Gloucester*, 347.

⁷³ G. B. Worgan, *General View of the Agriculture of the County of Cornwall: Drawn up and Published by Order of the Board of Agriculture and Internal Improvement* (London, 1811), 33, 178–9; Thomas Davis, *General View of the Agriculture of the County of Wilts: With Observations on the Means of its Improvement. Drawn up for the Consideration of the Board of Agriculture and Internal Improvement* (London, 1794), 154.

TABLE 3

AVAILABILITY OF EMPLOYMENT FOR WOMEN IN FREDERIC MORTON EDEN'S *THE STATE OF THE POOR* (1797) AS A PERCENTAGE OF REPORTS*

Work available	Little or irregular work	Seasonal work	No work	No answer
70.59	2.94	1.18	0	28.82

* *Note:* Number of reports = 120.

* *Source:* Frederic Morton Eden, *The State of the Poor* (London, 1797).

other phenomenon, also apparent in the county surveys, featured in the *Annals*: as spinning declined in the 1790s and early 1800s, commentators continued to suggest putting the poor to work at spinning in workhouses and teaching children to spin in spinning schools. Rather than preparing a future workforce, these writers encouraged investment in rapidly depreciating skills.

The largest and most systematic body of evidence on employment loss from the mechanization of hand-spinning is contained in the *Report of the Poor Law Commissioners*, published in 1834. As part of the Poor Law Commissioners' investigation, they sent questionnaires to every parish in England and Wales. A total of 1,563 parishes responded to the Queries, and their replies were reproduced in Appendix B (rural parishes) and Appendix B.2 (town parishes). Question 11 of the Rural Queries and question 36 of the Town Queries asked, 'Have you any and what Employment for Women and Children?'⁷⁴ The

⁷⁴ *Royal Commission of Inquiry into Administration and Practical Operation of Poor Laws: Report, Index, Appendix*, Parliamentary Papers, 1834 (44), xxvii, 1. This part of the Queries has previously been used by Nicola Verdon, although she only briefly noted the disappearance of spinning and its implications: Nicola Verdon, 'The Rural Labour Market in the Early Nineteenth Century: Women's and Children's Employment, Family Income, and the 1834 Poor Law Report', *Economic History Review*, lv, 2 (2002), 307. Other research using the Queries includes Joyce Burnette, 'An Investigation of the Female-Male Wage Gap during the Industrial Revolution in Britain', *Economic History Review*, l, 2 (1997); George R. Boyer, *An Economic History of the English Poor Law, 1750-1850* (Cambridge, 1990). A total of 1,582 responses were printed (fourteen parishes sent multiple responses that were printed separately and fifty-five parishes sent multiple responses that were printed together). In total 1,563 parishes responded to the Queries. Question 34 in the Town Queries asked about employment for the poor, but the replies described employment for men.

detail in the answers varied widely, from no answer, to a simple 'None' or 'Agricultural', to paragraph-length descriptions of the types of work available or complaints about unemployment.⁷⁵ All responses have been transcribed and coded to produce [Table 5](#) and [Table A6](#) (coding criteria are provided in [Table A1](#)).⁷⁶ To capture the varying level of detail in the responses, they have been coded to capture the loss of spinning employment in several ways: little or irregular work, fluctuations in the availability of work based on the seasons, and whether the only work available was in agriculture, which generally varied in demand for labour across the year.⁷⁷

While there was at least some work available throughout the year in many rural parishes, the share of parishes with little work and irregular employment had increased dramatically since the 1770s. Almost half of parishes reported having either no work at all for women, or only little or irregular employment. Without winter spinning, work and incomes were seasonally inconsistent in many places. The shares of locations reporting little work, seasonal work and no work were all much higher than those observed by Arthur Young in the 1770s ([Table 1](#)). The changes are summarized in [Figure 6](#). Note that the first set of bars uses extremely generous criteria for work availability including *any* mention of, or allusion to, work available for women in a location ([Table A1](#)).

[Figure 6](#) shows that the share of locations where work was available had fallen, and that irregular work, seasonal work and

⁷⁵ This article is concerned with paid work and lost earnings, which avoids most difficulties of interpreting the answers discussed by Verdon. While the parishes that responded to the Queries may not have been a representative sample, this is the best national-level source that captures employment availability and type before the occupational census. Including responses to the Town Queries as well as the Rural Queries, unlike Verdon, helps to mitigate concerns about selection: Verdon, 'Rural Labour Market in the Early Nineteenth Century', 303–4. See also [Figure 8](#) and the related discussion, which matches reports from parishes in Young's *Tours* with responses to the Queries.

⁷⁶ Each parish's response was coded once for each variable (e.g. Work available, Seasonal work) as some parish reports noted both, for example, that little work was available and that work was limited by the seasons. Coding for a 2 per cent random sample of parishes is provided in [Table A10](#). In cases where there were multiple responses, the response from the individual likely to have the best information was preferred (compare [Figure A2](#)).

⁷⁷ Excluding non-responses, only agriculture offered work for women in 9.32 per cent of locations in Young's *Tours*. By contrast, in the Queries (again excluding non-responses), 31.96 per cent of parishes only reported employment for women in agriculture.

TABLE 4
SPINNING STATUS IN ARTHUR YOUNG'S *ANNALS OF AGRICULTURE* AS A PERCENTAGE OF REPORTS, 1784–1804*

Market or unspecified spinning	Workhouse or spinning school	Household spinning	Good trade	Poor or declining trade	No spinning
75.29	12.07	2.30	1.72	39.66	8.05

* *Note:* Number of reports = 131. There are no reports of spinning in the *Annals* after 1804.

* *Source:* Arthur Young (ed.), *Annals of Agriculture, and Other Useful Arts*, 45 vols. (London, 1784–1808).

locations with no work at all had all risen sharply over the preceding sixty years. As Eden did not note the availability of work in many locations in *The State of the Poor*, see [Figure A3](#) for the findings including these non-responses. [Figure 7](#) presents the major types of work documented across the sources, and shows that spinning had almost completely disappeared across the early decades of the nineteenth century. The findings are largely unchanged when London parish replies to the Queries are omitted ([Table A11](#)). Other textile employments that had been considered acceptable occupations for women and could smooth earnings across the year, such as lacemaking and knitting, did not grow enough to employ the increasing number of unemployed or underemployed women.⁷⁸ In many places the only work available was employment in agriculture, which meant seasonal unemployment or substantial income variation.

The Queries also elicited specific responses that highlighted the destruction of hand-spinning. These are presented in [Table A8](#).⁷⁹ [Table A9](#) summarizes work availability by county, as described in the Queries. Wales, East Anglia and Greater London parishes reported the lowest rates of work availability.⁸⁰ Reports of irregular work were highest in the south-east,

⁷⁸ Keith Sugden and Amy Erickson argue that handloom weaving of cotton employed many more women than previously thought (up to half of all weavers and about 60,000–110,000 individuals) in the late eighteenth and early nineteenth century: Keith Sugden and Amy Louise Erickson, *Estimating the Number of Cotton Handloom Weavers in England, c. 1780–1813: Women and Children Hiding in Plain Sight*, Cambridge Working Papers in Economic and Social History, no. 36 (2024). In the Queries, thirty-three parish replies included reports of women weaving and three further replies specifically mentioned silk weaving. This gender division of labour differs from conventional accounts, but is not ‘reinstatement’ (in the terminology of Acemoglu and Restrepo), as reinstatement is only work in newly created tasks: Acemoglu and Restrepo, ‘Automation and New Tasks’. The growth of women’s employment in weaving was likely the result of an expanded supply of relatively inexpensive yarn that had to be woven by hand. Even so, this new labour demand did not come close to offsetting the loss of spinning, and the new work, like outright reinstatement in factories, was concentrated in the north-west.

⁷⁹ Other parliamentary evidence in the 1830s showed similar findings. The House of Lords Committee on the Poor Law heard complaints about the decline of spinning and resulting poverty: *Select Committee of House of Lords on Poor Laws and Petitions Praying for Relief from Pauperism: Reports, Minutes of Evidence, Appendix, Index*, 1831 (227), vii, 321, 33, 38, 68–9, 128, 204, 283, 294–5.

⁸⁰ The replacement of hand-spinning was alluded to in, for example, M. F. Lloyd Prichard, ‘The Decline of Norwich’, *Economic History Review*, iii, 3 (1951).

TABLE 5
 AVAILABILITY OF EMPLOYMENT FOR WOMEN IN THE REPORT OF THE POOR LAW COMMISSIONERS (1834) AS A PER-
 CENTAGE OF PARISH RESPONSES*

Parish type	No. of parishes	Work available	Little or irregular work	Seasonal work	No work	No answer
Rural	1,207	79.70	38.11	24.44	5.05	15.24
Town	356	42.70	18.54	1.97	45.22	12.08
TOTAL	1,563	71.27	33.65	19.32	14.20	14.52

* Note: Table A1 provides the coding criteria.

* Source: *Royal Commission of Inquiry into Administration and Practical Operation of Poor Laws: Report, Index, Appendix, Parliamentary Papers, 1834* (44), xxxvii, 1.

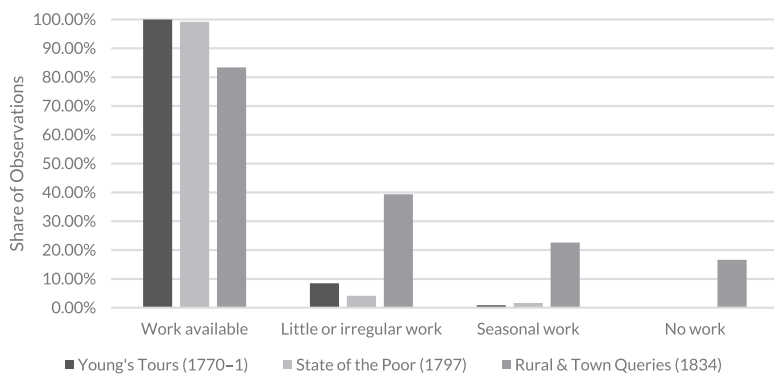
north-west, East Anglia and Wales. The north-east and the West Midlands produced the most positive reports, although even in these areas seasonal and/or irregular work were common.

It is also possible to compare responses from the parishes that replied to the Queries to reports about the same locations in Young's *Tours*. There are thirty-nine places (out of 147 reports in Young's *Tours*) that appear in both sources, and, of these, there is information about work for women in both sources for twenty-nine locations.⁸¹ This robustness check helps to mitigate concerns about selection bias of parishes that responded to the Queries. Figure 8 presents the work availability data from matched parishes and shows a set of outcomes similar to those depicted in Figures 6 and 7. Work availability dropped only slightly, but the number of locations with little or irregular work rose dramatically to 50 per cent of matched parishes, and reports of seasonal work and no work increased. Spinning was reported in over 40 per cent of these parishes in Young's *Tours*, but it was not reported in *any* of the same parishes that responded to the Queries. Young and his correspondents observed spinning in thirteen locations that appeared in both sources; eight of these reported little or irregular work in their replies to the Queries and one reported no work for women.

One final source for consideration is the first national tabulation of occupations in the 1851 census. In England and Wales, there were 84,926 workers employed in cotton, woollen and worsted spinning. A further 53,637 workers were employed in preparatory processes in cotton and woollen spinning, many of which had been carried out by hand-spinners before mechanization. The productivity gains of industrialization meant that far fewer workers were needed to process a much greater volume of fibre. Moreover, the gender composition of spinning had transformed: more than half of these workers (56 per cent, or

⁸¹ In three places that could be matched (Chesterfield, Derbyshire; Wisbech, Cambridgeshire; Evesham, Worcestershire) there were multiple replies from the same parish or the same town or village in the Queries. In these cases, the more optimistic reply was used for coding the matched parish data. In one case, a reply with information was used (Oxford) instead of a non-response from the same location (St Giles, Oxford). A reply from Old Alresford, Hampshire, in the Queries was matched to Young's report from Alresford as the parishes are just over half a mile apart and therefore were likely part of the same labour market.

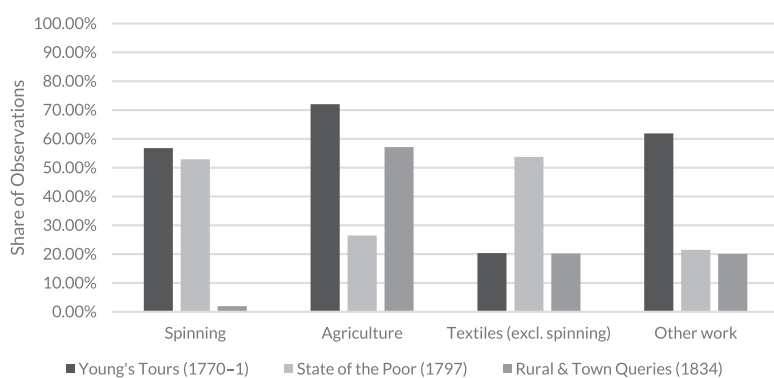
FIGURE 6
EMPLOYMENT FOR WOMEN IN ENGLAND AND WALES, 1770–1834*



* *Note:* This Figure excludes non-responses.

* *Sources:* Derived from [Tables 1, 3, 5](#) and [A12](#) and the sources there.

FIGURE 7
TYPES OF WORK FOR WOMEN IN ENGLAND AND WALES, 1770–1834*



* *Note:* Percentages exclude non-responses.

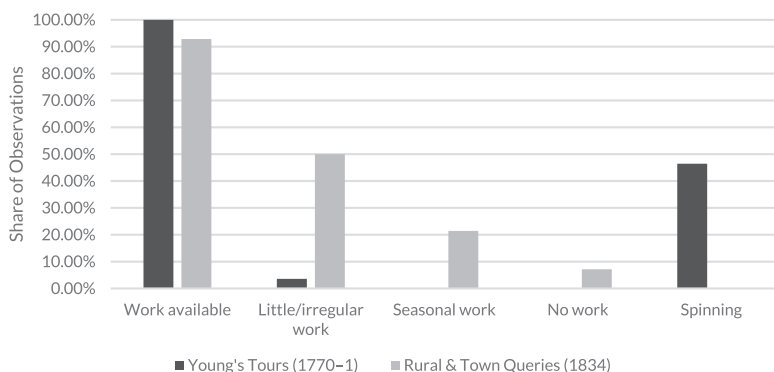
* *Sources:* Derived from [Tables A4–A6](#) and the sources there.

47,192) were men and boys.⁸² Not only were there far fewer jobs available, women were employed in a minority of these positions. While the gender shift of spinning labour is well known,

⁸² Flax spinners were not tabulated separately from other flax workers in the census, but this industry was smaller than the other textile branches. There was no category for preparatory workers in worsted spinning, and winders were tabulated

(*cont. on p. 140*)

FIGURE 8
EMPLOYMENT FOR WOMEN IN MATCHED PARISHES,
1770–1771 AND 1834*



* Sources: Young's *Tours* (see n. 71); *Royal Commission of Inquiry into Administration and Practical Operation of Poor Laws: Report, Index, Appendix*, Parliamentary Papers, 1834 (44), xxxvii.

the implications for women's living standards have rarely been discussed outside the gender histories of industrialization presented in section I. Changes in the distribution of employment and job quality in textiles were male-biased during the First Industrial Revolution.⁸³

The roughly 700,000 part-time (150 days per year) or 420,000 full-time hand-spinning jobs available in 1770, which employed 8 per cent of the population, had been eliminated by the 1830s. They were replaced by fewer than 150,000 full-time jobs in both spinning and preparatory work by 1851, which employed less

(n. 82 cont.)

with warpers and weavers. More than half of preparatory workers (63 per cent, or 33,680) were male. Occupations are not available for the Scottish census from the Integrated Census Microdata (ICeM) Nesstar Catalogue until 1861. In that year, there were 106,453 spinners across the three main branches enumerated in England and Wales, and only 6,823 in Scotland, along with 1,213 preparatory workers in cotton and woollen. Census of England and Wales 1851, 1861; Census of Scotland 1861, all available at <icem-nesstar.data-archive.ac.uk>.

⁸³ Benjamin Schneider, 'Job Quality in History', *European Review of Economic History*.

than 1 per cent of the population. Less than half of these factory jobs were occupied by women and girls. Therefore, over the eight decades from 1770 to 1851, at least 600,000 women and children, overwhelmingly those employed in wool and flax spinning outside Lancashire, Cheshire and the West Riding of Yorkshire, lost work and income from spinning. Across the industry, there was massive job destruction and comparatively few new jobs were created. The Queries only provide information about the availability or absence of work in locations, rather than under-employment or unemployment rates for individuals or places. Nonetheless, more than a third of parishes that replied to the Queries reported that there was little or irregular work, and a further 14.2 per cent reported that there was no work available for women at all. Beyond the initial job loss, later generations of women did not have the opportunity to take up spinning employment, which had been one of the most common sources of female work. As a result, the evidence from the Queries suggests that by the 1830s the disappearance of hand spinning led to substantially lower market labour force participation by women.

This example reinforces the results of other recent research on technological unemployment: when jobs are created by new technologies, it is generally in aggregate, and many displaced incumbents do not move into the new jobs.⁸⁴ Moreover, these new jobs may not be of the same quality as the occupations that were eliminated by a technological shock, which has further implications for quality of life and the well-being effects of innovation.⁸⁵ Together, these findings challenge the neutral language of labour 'displacement' and 'reinstatement'. Are workers merely 'displaced' when many may become long-term under-employed or unemployed? And if they do not return to their previous position, and incumbents rarely enter newly created jobs, is this 'reinstatement'?⁸⁶ While 'displacement' and 'reinstatement' may be suitable for discussing changes at the level

⁸⁴ Feigenbaum and Gross, *Automation and the Fate of Young Workers*. In the case of telephone operators, later generations of young women did not experience reduced labour force participation. This may be because far fewer workers were employed in that occupation than in hand spinning.

⁸⁵ Schneider, 'Job Quality in History'.

⁸⁶ Acemoglu and Restrepo, 'Automation and New Tasks'. This study and Feigenbaum and Gross, *Automation and the Fate of Young Workers*, show that technological shocks may push incumbent women out of employment entirely.

of tasks or macro shifts in labour demand, these terms do not capture the effects of labour-replacing technology on employment opportunities and well-being. Analysis of the labour market impacts of technological shocks requires more attention to these unequal effects and appropriate terminology.

V

There is one further dimension of the consequences of technological change to consider: the impact of the loss of spinning wages on household incomes. Muldrew discussed the relative wages of spinners and suggested that spinning was an important part of family earnings. Humphries and I argued that the wages he cited were overly optimistic, and in section II this article has proposed a lower level of industriousness for most spinners.⁸⁷

This section examines the potential impact of the loss of hand-spinning income through two sets of stylized households. The first set (Tables 6–8) considers the impact on households with variation in the family members engaged in market-facing labour. The second set of households (Tables 9–10) derives

TABLE 6
STYLIZED HOUSEHOLDS, SCENARIOS 1–4, C.1770

Scenario	Household composition and work
1	1 adult woman (150 days spinning, 100 days casual work), 1 adult man (250 days casual work), 3 children (not working)
2	1 adult woman (150 days spinning, 100 days casual work), 1 adult man (250 days casual work), 3 children (1 spinning 150 days, 1 in casual work 150 days, 1 not working)
3	1 adult woman (150 days spinning, 100 days casual work), 1 adult man (annual contract), 3 children (not working)
4	1 adult woman (150 days spinning, 100 days casual work), 1 adult man (not working), 3 children (all working 250 days; 2 spinning 150 days, casual work 100 days; third child 250 days casual work)

⁸⁷ Muldrew, “‘Th’Ancient Distaff” and “Whirling Spindle”, 521–3; Humphries and Schneider, ‘Spinning the Industrial Revolution’.

TABLE 7
STYLIZED HOUSEHOLD INCOMES, SCENARIOS 1–4, C.1770*

Scenario	Household income (d.)	Spinning earnings (d.)	Spinning (% of total)	Household welfare ratio (barebones basket)	Household welfare ratio (respectability basket)
1	4,141½	600	14.49	2.18	0.91
2	5,382	1,050	19.51	2.83	1.18
3	4,221	600	14.21	2.22	0.93
4	4525½	1,500	33.15	2.38	0.99

* *Note:* See Table 6. Annual household incomes can be compared with living costs using consumption baskets. Here, two baskets developed by Robert Allen are used: the very parsimonious ‘barebones’ basket, containing a set of necessary items (for example, food, clothing, fuel, shelter); and the more generous ‘respectability’ basket, containing larger quantities of food and higher-quality items. Income is divided by cost of the basket to produce a ‘welfare ratio’, where 1 is a household with sufficient income to purchase just these essential or respectable goods. Following Horrell, Humphries and Weisdorf, ‘Family Standards of Living over the Long Run, England’, the welfare ratio calculation assumes that these households required 3.5 baskets per day.

* *Sources:* For wage data, see n. 88. For the composition of consumption baskets, see R. C. Allen, ‘The High Wage Economy and the Industrial Revolution: A Restatement’, *Economic History Review*, lxviii, 1 (2015). For consumption basket costs, see Humphries and Weisdorf, ‘Unreal Wages?’, online supplement, table A2, ‘Other variables: CPI/day Respect, 1760–1770’.

TABLE 8
STYLIZED HOUSEHOLDS THAT LOST SPINNING INCOME, SCENARIOS 1–4, 1820–1830*

Scenario	Household income (d.)	Household welfare ratio (barebones basket)	Household welfare ratio (respectability basket)
1	5,826	2.19	0.87
2	8,184	3.08	1.23
3	7,711	2.90	1.16
4	5,119	1.93	0.77

* *Note:* See Table 6.

* *Sources:* See Table 7.

work availability from three situations suggested by the previous section’s analysis of the Rural and Town Queries.

Table 7 presents wages, the share of income from spinning, and welfare ratios for the first four stylized household units,

TABLE 9
STYLIZED HOUSEHOLD INCOMES, SCENARIOS 5–7, C.1770*

Sce- nario	Household income (d.)	Spinning earnings (d.)	Spinning (% of total)	Household welfare ratio (barebones basket)	Household welfare ratio (respectabil- ity basket)
5–7	4,641½	900	19.39	2.44	1.02

* *Note:* Household composition for Scenarios 5–7: 1 adult woman (150 days spinning, 50 days casual work), 1 adult man (250 days casual work), 3 children (1 spinning 100 days, 1 in casual work 100 days).

* *Sources:* See [Table 7](#).

TABLE 10
STYLIZED HOUSEHOLD INCOMES, SCENARIOS 5–7, C.1820–1830*

Scenario	Household income (d.)	Household welfare ratio (barebones basket)	Household welfare ratio (respectability basket)
5	10,421½	3.92	1.56
6	6,214	2.34	0.93
7	5,816	2.19	0.87

* *Note:* Household composition for Scenario 5: 1 adult woman (150 days casual labour), 1 adult man (250 days casual labour), 3 children (1 little piecer 250 days, 1 scavenger 250 days). For Scenario 6: 1 adult woman (50 days casual labour), 1 adult man (250 days casual labour), 3 children (1 working 100 days). For Scenario 7: 1 adult woman (unemployed), 1 adult man (250 days casual labour), 3 children (1 working 100 days).

* *Sources:* See [Table 7](#); George Henry Wood, *The History of Wages in the Cotton Trade during the Past Hundred Years* (London, 1910).

described in [Table 6](#).⁸⁸ The welfare ratios are calculated using Allen’s very frugal ‘barebones’ consumption basket and the more generous ‘respectability’ basket. The estimates of household income use a very optimistic estimate for non-spinning work available to women and children. If less work was available,

⁸⁸ Jane Humphries and Jacob Weisdorf, ‘The Wages of Women in England, 1260–1850’, *Journal of Economic History*, lxxv, 2 (2015); Jane Humphries and Jacob Weisdorf, ‘Unreal Wages? Real Income and Economic Growth in England, 1260–1850’, *Economic Journal*, cxxix, 623 (2019); Sara Horrell and Jane Humphries, ‘Children’s Work and Wages in Britain, 1280–1860’, *Explorations in Economic History*, lxxiii (2019); Jane Humphries and Benjamin Schneider, ‘Losing the Thread:

(cont. on p. 145)

then spinning would have been a larger share of family incomes. In the age of spinning, these households achieved or were close to a respectable living standard (a welfare ratio of 1 or higher).

Many households had no spinning income, while others, such as elderly couples with no income from working children, may have relied extensively on the wife's spinning when both partners were unable to undertake heavy labour outside the home. Poorer households, those with more children who could spin, households without able-bodied men, and households with fewer alternative employments would have suffered most from the loss of spinning earnings. Table 8 presents the same stylized households for about 1820–30 with no spinning income. As in Table 7, the stylized households are modelled with an optimistic estimate of the availability of non-spinning work outside the home. Rising male wages, especially for workers on annual contracts (Scenario 3), meant that some households (Scenarios 2 and 3) were better off despite the disappearance of spinning, but the family without a male breadwinner (Scenario 4) experienced substantially lower material living standards in the absence of spinning. The disappearance of spinning meant that families needed an able-bodied man who could find regular work to achieve and sustain a respectable living standard. These calculations do not consider changes in the intra-household allocation of resources, which may have been unfavourable to women who could no longer earn income from spinning.⁸⁹

The second group of scenarios (Scenarios 5–7, Tables 9–10) is based on the responses to the Rural and Town Queries, which suggest three possible stylized labour markets. Scenario 5 is modelled on a possible household in the north-west of England. In this scenario the adult woman was able to find casual work

(n. 71 cont.)

A Response to Robert Allen', *Economic History Review*, lxxiii, 4 (2020); Sara Horrell, Jane Humphries and Jacob Weisdorf, 'Family Standards of Living over the Long Run, England, 1280–1850', *Past and Present*, no. 250 (Feb. 2021); Sara Horrell, Jane Humphries and Jacob Weisdorf, 'Beyond the Male Breadwinner: Life-Cycle Living Standards of Intact and Disrupted English Working Families, 1260–1850', *Economic History Review*, lxxv, 2 (2022).

⁸⁹ Sara Horrell and Deborah Oxley, 'Bringing Home the Bacon? Regional Nutrition, Stature, and Gender in the Industrial Revolution', *Economic History Review*, lxxv, 4 (2012).

by the period 1820–30, and two children worked in a mule spinning factory (one as a scavenger and one as a little piecer). This corresponds to a parish where work was present and readily available in the Queries. Scenario 6 is a household in the south of England, where work was available in the Queries but only on a limited seasonal basis in agriculture (fifty days of casual work per year). The household in Scenario 7 lived in an area where there was no work available for women after the end of hand-spinning.

As in Scenarios 1–4, these three stylized households show the unequal distributional effects of the destruction of hand-spinning. Households in the new factory districts earned higher real incomes (albeit at the cost of substantial disamenities), while those in areas with little or no work for women, and without access to new work in factories, experienced lower material living standards.

In many parts of Britain the labour market conditions were like those presented in Scenarios 6 and 7, with few sources of replacement income for the hundreds of thousands of women whose main employment was eliminated by the machines of the Industrial Revolution. No occupation came close to taking the place of spinning as a source of income for the winter months. Many workers did not shift out of old jobs and into new industries. They were stranded in locations where there was little or no work available.

VI

The destruction of hand-spinning is the earliest documented example of mass technological unemployment and the largest case of job destruction yet studied.⁹⁰ Hand-spinning was a large and growing occupation in the mid eighteenth century, but was eliminated by the jenny, water frame and mule over the half-century from 1770. Rising complaints about unemployment

⁹⁰ In the United States in the early twentieth century, there were about 120,000 telephone operators and they were roughly 2 per cent of the adult female workforce: Feigenbaum and Gross, *Automation and the Fate of Young Workers*. There were about 150,000 bootmakers in Britain before mechanization in the mid nineteenth century: Vipond, 'Technological Change and Labour Displacement in Historical Perspective'.

and poverty from 1780 to the 1830s show that this was a major disruption to work and incomes, and unemployment continued into the mid nineteenth century. While unemployment for cotton spinners was probably brief as workers in the north-west of England may have shifted into factory spinning or weaving, wool and flax spinning employed far larger numbers of workers, and the unemployment of these women and children was persistent. The destruction of spinning without substantial replacement work was likely a major contributor to the fall in women's market labour force participation, which did not recover to pre-industrial levels until the 1980s.⁹¹

Many former hand-spinners did not easily shift into other occupations, usually because there was no work to take the place of spinning during the winter months. While there were some new jobs in factories, there were far fewer positions available and men claimed many of them, including all of the best occupations. The fact that there were many locations with few employment options for women as late as the 1830s suggests that moving to a location with new industrial jobs was not a simple option, or that there were not enough jobs available even if workers wanted to migrate.

The evidence presented here challenges earlier scholarship that largely dismissed the importance of job-destroying innovation as a drag on living standards during the Industrial Revolution.⁹² Technological unemployment must be incorporated into the debate on how industrialization affected well-being, and on the unequal gendered impacts of innovation.

The search for a conclusive single series or composite measure of welfare using existing data has led to neglect of the distributional consequences of industrialization, which was one of the most important features of its effect on living standards, and inattention to salient aspects of life for which there are no existing national-level data. The difficulties of measuring historical unemployment and female labour force participation are not sufficient cause to discount the disemployment effects of industrialization for women. Further, researchers using a

⁹¹ Shaw-Taylor, Sugden and You, 'A Preliminary Estimate of the Female Occupational Structure of England and Wales'.

⁹² Lindert and Williamson, 'English Workers' Living Standards during the Industrial Revolution'.

twentieth-century paradigm from rich countries in which workers are employed full-time in only one occupation may misunderstand the effects of labour-replacing technology in the many contexts where workers combine different employments.

The mechanization of spinning impacted employment and living standards in Britain first, but it also had effects across the world of textile production. British mechanization produced unemployment and poverty in Ireland, Switzerland and India.⁹³ An international study of technological unemployment among hand-spinners and its consequences for women's incomes globally could illuminate important dimensions of the effects of technology on work and provide historical context for twenty-first-century concerns about 'premature deindustrialization'.⁹⁴

The example of spinning presented in this article refutes sanguine views of the impacts of innovation that have claimed that the fear of labour-replacing technology is exaggerated and that its effects are only transitory.⁹⁵ It also shows how the terminology

⁹³ For Ireland, see *Select Committee on State of Poor in Ireland, and Means of Improving their Condition: Minutes of Evidence (I)*, 589, vii.173 (1830), 238, 240, 245; *Select Committee on State of Poor in Ireland, and Means of Improving their Condition: Minutes of Evidence (II)*, 644, vii.451 (1830), 356; Frank Geary, 'The Act of Union, British-Irish Trade, and Pre-Famine Deindustrialization', *Economic History Review*, xlviii, 1 (1995); Frank Geary, 'Regional Industrial Structure and Labour Force Decline in Ireland between 1841 and 1851', *Irish Historical Studies*, xxx, 118 (1996). Ireland also experienced regional concentration of textile employment, as observed in Britain. For Switzerland, see Sandra Ujpétery, 'Die "Verdienstlosigkeit" nach dem Ende der Handspinnerei: Arbeitslosigkeit und Hunger in Glarus, 1790–1820', *Arbeit im Wandel: Jahrbuch SGWSG*, xxxvii (forthcoming). For India, see Tirthankar Roy, *The Economic History of India, 1857–1947*, 3rd edn (Delhi, 2011). The mechanization of spinning also fits into a longer trajectory of textile mechanization, another stage of which is considered in Robert C. Allen, 'The Hand-Loom Weaver and the Power Loom: A Schumpeterian Perspective', *European Review of Economic History*, xxii, 4 (2018).

⁹⁴ Dani Rodrik, 'Premature Deindustrialization', *Journal of Economic Growth*, xxi, 1 (2016). Examples of textile industries in other locations suggest that adaptation to competition may have been possible: Katharine Frederick and Elise van Nederveen Meerkerk, 'Local Advantage in a Global Context: Competition, Adaptation and Resilience in Textile Manufacturing in the "Periphery", 1860–1960', *Journal of Global History*, xviii, 1 (2023). In the British colonies of North America, market-facing hand-spinning was a minor employment, so factory production in the early United States was largely import-substituting and there was little technological unemployment: Benjamin Schneider, 'Technological Change and Work' (University of Oxford D.Phil. thesis, 2022), ch. 5.

⁹⁵ Mokyr, Vickers and Ziebarth, 'History of Technological Anxiety and the Future of Economic Growth'; Mokyr, *Gifts of Athena*.

of labour ‘displacement’ and ‘reinstatement’ does not fully capture how technological shocks disrupt lives and labour markets. While the machines of the Industrial Revolution enabled huge leaps in productivity, providing cheaper and higher-quality clothing to a growing market and creating new jobs, the downsides extended beyond long hours, factory discipline and reduced occupational safety in mills. Long-term technological unemployment has occurred at scale, with substantial consequences for well-being and social structures.⁹⁶

SUPPLEMENTARY DATA

Supplementary data is available at *Past & Present Journal* online.

Benjamin Schneider 
Oslo Metropolitan University, Norway

⁹⁶ Humphries and Schneider, ‘Gender Equality, Growth, and How a Technological Trap Destroyed Female Work’. In addition to the direct effects of unemployment on household incomes, we argue that the loss of hand-spinning work for women may have led to their long-run exclusion from the paid labour force. In turn, this exclusion contributed to the development of the male-breadwinner family and structural poverty for families without an adult man earning a ‘family wage’.