

Arkwright revisited: wages and innovation in Industrial Revolution Britain, 1786-1811

What factors drove innovation during the Industrial Revolution? Of all the great inventions, much work has been devoted to the three most famous spinning machines: the spinning jenny (1764), the water frame (1769), and the spinning mule (1780).¹ This paper examines the case of Richard Arkwright's (1732-1792) water frame, and revisits debates surrounding its invention by analysing never-before digitised wage books from the inventor's own Lumford Mill at Bakewell, Derbyshire between 1786 and 1811. A rich dataset of 143 thousand observations offers considerably more detailed evidence of wages at the advent of industrialisation, and challenges existing debates on the impetus behind technological innovation during the Industrial Revolution, which have often centered on pre-industrial wages being a driving factor. Analysis of the data reveals that wages remained relatively stable during the crucial transition from hand spinning to the mechanised water frame mills. This challenges the assumption that wages were the primary impetus for innovation.

Before industrialisation, spinning was the most important source of female employment, carried out entirely by hand and primarily by women and children at home.² Arkwright's water frame radically altered this status quo by bringing hand spinners into water-powered factories. Workers in the new factories were no longer paid intermittently based on the pounds of yarn they spun but consistently based on their hours worked. In addition, for Britain to produce its own

¹ For theories of mechanisation, see Allen, *British industrial revolution*, pp. 25-26, 182-216; Mokyr, *The enlightened economy*. For development, see Catling, *Spinning mule*; Chapman, *Cotton industry*; Tunzelmann, *Steam power*; Berg, *Age of manufactures*. For diffusion, see Sugden, 'An Occupational Study'; Maw et al., 'After the great inventions'.

² Muldrew, "Ancient distaff".

pure cotton cloths that could rival Indian imports the technical problem of spinning the warp yarns economically needed to be solved.³ Doing so was only made possible by the water frame.⁴ Not only did this innovation usher in the revolutionary factory system, but it also allowed the economically feasible production of pure cotton cloths in Britain. Given the water frame's central importance to the Industrial Revolution, it is surprising that relatively little is known about the actual wages of workers in the early water frame mills. This paper analyses the most detailed set of wages yet compiled from an early water frame mill and asks what they reveal about the factors that contributed to industrial innovation.

This question has important implications for the debate on why the Industrial Revolution was British. Allen has argued that Britain had high hand spinning wages relative to capital costs on the eve of the Industrial Revolution, which made inventing labour-saving technologies like the water frame not only attractive, but uniquely profitable.⁵ Humphries and Schneider contest this, arguing that hand spinning was a universally low-wage, low-productivity employment, suggesting instead that the invention of machines like the frame were introduced to take advantage of abundant low-wage labour.⁶ In comparing water frame wage distributions from Lumford with hand spinning wages, this paper highlights how neither claims about universally 'low' and 'high' wages are comprehensive. Hand spinners in England prior to mechanisation earned a spectrum of wages, depending on their productivity and the type and fineness of fibre they spun (whether wool, cotton, or other). In Derbyshire, the plausible range for cotton hand spinning does not differ dramatically from the range of wages in water frame spinning at

³ See Raman, 'Indian Cotton Textiles'.

⁴ Styles, 'Fashion, Textiles', p.185.

⁵ Allen, *British industrial revolution*.

⁶ Humphries and Schneider, 'Spinning the Industrial Revolution', p. 28; Also Humphries and Schneider, 'Losing the Thread'.

Lumford Mill. This revelation calls for a reassessment of Allen's thesis that high wages spurred the mechanisation of spinning, and Humphries/Schneider's suggestion that the low wages of underemployed labour were an incentive for Arkwright to invent the water frame. The water frame's novel technical achievement allowed British manufacturers to produce cotton cloths that could previously only be imported from India. Its invention was driven mainly by the profit incentive associated with the need for a new production technology. This paper steers the debate on industrial innovation beyond wages to consider the importance of new, industry-specific production techniques.

This paper is organised as follows: section I presents the source data, section II discusses pre-industrial hand spinning wages, and section III presents the Lumford data and concludes.

I

Lumford Mill in Bakewell was probably operational as early as 1783.⁷ The archival data gathered for this paper are highly valuable, as they allow for a study of employment and wage patterns taken directly from the factory floor at the time of transition between hand and machine spinning, unlike well-known sources like the parliamentary papers.

These books contain weekly wages in the spinning department for the periods 1786-88, 1793-96, 1804-08 and 1808-11.⁸ The wage books group employees by their occupation,

⁷ Bray, *Sketch of a Tour*, p.74.

⁸ Derbyshire Record Office, D6907/1-4.

including: the ‘spinners’, ‘workmen’, and ‘pickers’. Only the ‘spinning’ wages were digitised, of which all the entries have been analysed.

Within ‘spinning’, workers performed different tasks. First, there were workers with ‘operative roles’, which consisted of tending the frames and joining together any broken threads.⁹ Second, there were the overseers whose role was to supervise the ‘operative’ workers. There is no distinction made in the wage books between the roles. Nevertheless, the contemporary evidence on factory wages, suggests that the wage distributions at Lumford discussed in the next section can be plausibly sorted by worker role.

The only previous mentions of the Lumford books are in a 1959 paper by Mackenzie and a 1965 book by Collier.¹⁰ At that time neither author was able to digitally process the vast amounts of data and compile wage distributions. This paper’s methodology is novel in that it analyses *all* the extant wage data from Lumford. No other data from Arkwright mills survive.

II

To understand whether high or low wages played a significant role in ushering in technical innovation, it is necessary to determine what hand spinning wages were before mechanisation. There is evidence of cotton being hand-spun near Bakewell prior to mechanisation, as well as in neighbouring Lancashire.¹¹ Evidence on cotton wages is scarce for this region, but there are four relevant contemporary estimates. In Mellor, Derbyshire, William Radcliffe recalled cotton hand

⁹ Aspin, *The Water-Spinners*, p.48.

¹⁰ Mackenzie, 'Bakewell Cotton Mill'; Collier, *The Family Economy*, pp.70-72.

¹¹ Pilkington, *State of Derbyshire*, p. 51; Chapman, 'James Longsdon', p.271.

spinning wages before 1770 for women and children of 1–3s. per week.¹² Thomas Bentley recorded that the typical weekly wages of adult women in Lancashire were 2s.6d.–3s. per week prior to mechanisation.¹³ Arthur Young noted that near Manchester in 1770, adult women spinning cotton could earn between 2–5s. per week, and girls 1s.–1s.6d.¹⁴ A cotton spinners' petition from Lancashire reported that in 1764, adult women could earn 5s.–7s.6d. per week.¹⁵ This petition is clearly biased, as it was written by spinners decrying the negative impact competition from new machinery had had on their wages. Wages this high were probably a rarity. For this paper, it is assumed that Young's and other commentators' wages *represent as much as local market conditions would allow* women and children to earn per week on the presumption of hard work and proficient ability. In summary, in 1770, adult women hand spinners probably could earn 2–3s. per week, while children earned 1–2s. per week. Higher wages of 5s. or more may also have been possible, especially in high-demand centres like Manchester.

III

How do wages at Lumford compare with these ranges? The frequency distribution of wages for 1788 is shown in Figure 1. The 1788 distribution was chosen because it is the point in time nearest the transition between hand and machine spinning. In 1788, 86% of the spinning workers were earning rates in the range of 1–5s. per week. These wages are consistent with what

¹² Radcliffe, *New System of Manufacture*, p.60.

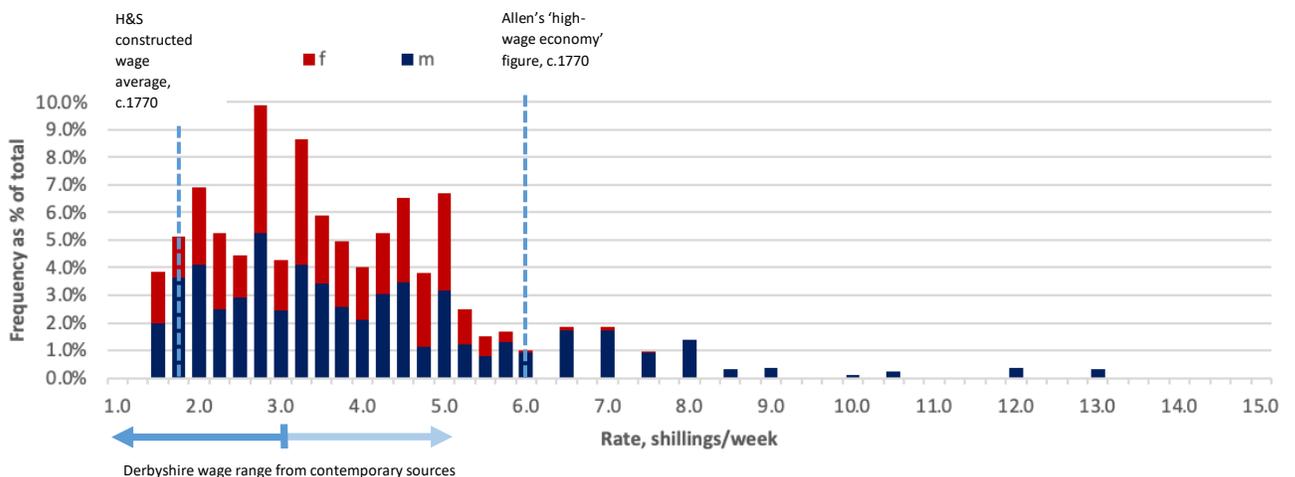
¹³ Bentley, *Letters*, p.31.

¹⁴ Young, *Six Months Tour*, vol. 3, p.192.

¹⁵ *H. of C. Papers*, XXXI (1780), 27 June.

contemporaries noted in spinning at other water frame mills at this time. At Wirksworth (near Bakewell), Frederick Eden reported in 1795 that children aged 8-14 earned 1–5s. per week, women 3–5s., while overseers received 12s.¹⁶ In Nottinghamshire, Eden noted that women and children earned 1–5s. per week, while in Yorkshire, children aged 8-14 received 1–6s. per week.¹⁷ This suggests that the 86% of spinning workers who earned 1–5s. per week in 1788 at Lumford were also mainly children, and were the operative workers. The 50% of workers who earned 3–5s. per week probably also included some adult women. The males earning over 12s. at Lumford were likely the overseers. Given that in the Derbyshire region prior to the mill, children could earn 1–2s. and adults 2–3s. per week (and perhaps more), the wage ranges did not change considerably. Even as late as 1810, 42% of Lumford’s workers were still earning 1–5s. per week. The distributions from Lumford thus suggest that the possibility of earning higher wages became available in water frame mills– though perhaps not dramatically higher. What was new and potentially attractive was the offer of *consistent* wages.

Fig. 1: Wage distribution, 1788



Note: 1786, n=5331.

¹⁶ Eden, *State of the Poor*, vol. II, p.130.

¹⁷ *Ibid.*, vol. II, p.565; vol. III, p.866.

Given these considerations, Figure 1 shows the huge disparity between Humphries/Schneider's and Allen's estimates of hand spinning wages. Humphries/Schneider's wage constructions from productivity and piece-rates suggest that around 1770, hand spinning wages in England were very low, averaging 1s.9d. per week, which includes data from child and adult spinners across fibre types.¹⁸ Their only constructed wage for cotton is 0.9s. per week.¹⁹ Contrasting these low numbers with Figure 1, their account implies that factory wages were much higher than hand spinning wages. The 1788 data show that 86% earned between 1–5s. per week, and most of these workers were likely children. This optimistic story appears at odds with their suggestion that the water frame was invented to take advantage '...of [the] low wages for underemployed female and child workers'.²⁰ If this exploitative narrative behind industrialisation is to be believed, then one might expect factory wages to be lower given the very low hand spinning wages the authors suggest were typical. If hand spinning wages were so poor and labour so abundant, why would Arkwright offer children steady wages of up to 500 per cent higher than they were accustomed to earning? Even Bakewell, an established town (population 1,412 in 1801), did not apparently have sufficient local labour to staff Arkwright's new Lumford Mill.²¹ While women and children spun yarn domestically in the region, any local pool of underemployed, poorly paid spinners was insufficiently large for Arkwright to exploit and dictate wages to. Indeed, the opposite seems to have been true, and Arkwright had to import workers (often families) to his mills and persuade them with adequate wages, and often lodging

¹⁸ Humphries and Schneider, 'Spinning the Industrial Revolution', p.18.

¹⁹ Ibid., Online appendix S2.

²⁰ Ibid., p.28.

²¹ 1801 Census.

<http://www.histpop.org/ohpr/servlet/AssociatedPageBrowser?path=Browse&active=yes&mno=2&tocstate=expandn&ew&display=sections&display=tables&display=pagetitles&pageseq=68&associtle=Census%20of%20England%20and%20Wales.%201801>

and other benefits. At another of Arkwright's mills, Cromford, he built homes, a pub, and even held festivals for his workers.²² At Bakewell, Arkwright took steps to provide 'substantial cottages' to attract labour.²³ Writing contemporaneously, White Watson recalled '...hands came from Manchester [to Bakewell], introducing good-natured girls here, to whom the town was a stranger.'²⁴ While female and child labour were certainly cheaper than male labour, their suggestion that this was a primary motivation behind mechanisation remains speculative. The fact that nearly half of Lumford's workforce was male also challenges this view. Wages at Lumford were probably set at the lowest possible rate that would still attract a sufficient supply of labour.

In contrast, Allen's 'high wage economy' thesis, rests on his assertion that 6s. per week was a typical adult cotton hand spinning wage in 1770.²⁵ While Figure 1 would appear on the surface consistent with Allen's thesis that high hand spinning wages led to labour-saving mechanisation, Allen's 1770 figure is ultimately drawn from the same biased 1780 petition discussed above (the rough midpoint of 5s.–7s.6d per week), and is too high to be representative.²⁶ As argued above, hand spinning wages prior to mechanisation were mainly in the range of 1–3s. per week for women and children. This suggests that saving labour costs was probably not Arkwright's primary motivation behind invention. The general impact of a labour-saving technology like the water frame on wages is not clear, and more data on yarn production, worker productivity, and product demand would be needed to determine this precisely.

²² See <https://www.cromfordmills.org.uk/wp-content/uploads/2021/11/KS-3-4-Information-Sheets.pdf>

²³ Fitton, *The Arkwrights*, pp.56-7.

²⁴ Watson, 'Observations on Bakewell', p.160.

²⁵ Allen's data: <https://www.nuffield.ox.ac.uk/people/sites/allen-research-pages/>.

²⁶ 6s. from Feinstein, *Wage-Earnings*, p.190, Table 8.2; Feinstein's from Hammond and Hammond, *The Skilled Labourer*, p.56, who cite the 1780 petition, fn 15.

To conclude, the new body of evidence from Lumford Mill suggests that the impetus behind key inventions like the water frame must be sought beyond just wages. The Lumford data reveal the different roles workers played and the consistent wages they could receive. They do not, however, support an argument that hand spinning wages were a motivation for mechanisation. They do support a theory of industrial innovation which places the need for new production technologies and their practical achievements at the centre of the debate, in line with recent work by Styles and Raman. For the water frame, the achievement was making cotton cloth production possible in Britain.

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