

RESPONSE

Slavery, Atlantic trade and skills: a response to Mokyr's 'Holy Land of Industrialism'

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Abstract: We challenge the idea that Britain's short-lived industrial primacy in the late 18th and early 19th centuries is explained by 'comparative advantage' in high-level artisan skills possessed by an elite workforce. Skills were vital to the industrial revolution but the timing of change and its regional concentration suggest that Britain's rise to dominance in Atlantic trade was the major causal factor. Rapidly growing markets in Africa and the Americas, especially for textiles and metalwares, centred on Britain's leading role in the slave trade and the extension of her plantation frontier in the Caribbean. Structural and industrial change, concentrated in the economic hinterlands of Atlantic ports, facilitated product and process revolutions. Diverse Atlantic demands and new Atlantic raw material supplies stimulated skill development and key innovations in light and heavy industry.

Keywords: Britain, industrial revolution, skills, slave trade, Caribbean, Africa, Americas, markets, textiles, metalwares.

Notes on the authors: see end of article.

Mokyr's 'Holy Land of Industrialism' mirrors his earlier work on industrial enlightenment and the evolution of a knowledge economy. It attributes British precocity in industrialisation to an endogenous 'supply side' factor: her comparative advantage in 'Upper Tail Human Capital Formation'. This was not high-level scientific knowledge, but an intermediate knowledge of engineers, technicians, inventors, some manufacturers, and above all a dextrous workforce – mechanics, engineers, millwrights and metalworkers – whose abilities were largely tacit and intuitive. Comprising perhaps 2 per cent of the workforce, they benefited from rising incomes and nutritional levels, from a flexible apprenticeship system and from a relative absence of guild restrictions. It was these workers, Mokyr argues, who set Britain apart because of their ability to adapt and to modify abstract inventions until they were efficient and commercially advantageous.¹

By his own admission Mokyr is addressing the 'why Britain' question, leaving the crucial issue of timing 'in the background' (224–5). Yet Britain's apprenticeship system and relatively weak guild structures were not new to the 18th century.² Neither was the putative 'high wage economy'.³ Furthermore, Britain's industrial revolution was first and foremost a regional phenomenon, with growth and radical transformation occurring in clearly defined industrialising regions while other areas of the country declined or marked time. The industrialising regions were initially low-income areas where apprenticeship training was patchy, and experienced by few of the skilled workers (women and children as well as men) drawn into commercial manufacturing for distant markets during the 18th century.⁴

We argue that the timing, the regional dynamics, and the whole question of short-lived British industrial primacy can only be addressed by invoking an external, though far from independent, economic stimulus: British imperial and colonial endeavour, particularly that centred upon slavery and plantations in the 18th-century Caribbean. This is the force to which Mokyr's artisans and apprentices were responding; without this their skills and knowledge would have been more limited and less important to the economy.

Rapid growth of Atlantic markets provided the main stimulus for new, improved and innovative manufactured products that enlarged the scope of 'learning by doing' in the catchment areas of Britain's major Atlantic ports. Contrary to Mokyr's emphasis on knowledge institutions and hence industrialisation evolving 'unintended and unplanned' (243), the British slave-based Atlantic trading system was state-supported,

¹ Mokyr (2021: 223–47).

² Neither were they as unique to Britain as Mokyr suggests. Wallis (2008: 832–61; 2014: 1).

³ Britain's relatively high wage economy has been much debated and challenged. For the detailed original statement regarding causes and timing see Allen (2009).

⁴ Hudson (1989); Kelly *et al.* (2014: 363–89).

consciously pursued, and motivated by the possibility of material gains on a scale hard to achieve in the domestic economy of the 18th century. Exploring the forces unleashed by Britain's slave-based involvement in the Americas provides a better basis for understanding the multiplication of product and process innovations and of innovations in financial and commercial services that occurred in the long 18th century and particularly towards its close. It also provides a better foundation for understanding Britain's relative industrial decline in the later 19th century than explanations based on failure to sustain industrial and scientific training (Mokyr's argument). Britain's role in the slave-based Atlantic trading system up to and beyond the abolition of slavery in British territories in the 1830s, was formative in the emergence of long-term British 'comparative advantage' not in manufacturing but in financial services.⁵

The economic hinterlands of London, Bristol, Glasgow and Liverpool, including South Wales, the West Midlands and the North-East coalfield as well as south Lancashire, West Yorkshire, and west-central Scotland became nurseries of highly adaptable labour forces, able to utilise mechanical, textile, metal-using and chemical skills across different raw materials in the making of new products. These new products above all found their stimulus in Atlantic markets. Adaptive and flexible skills were honed to a wide range of African, Caribbean, North American and also Latin American market needs and tastes, creating manufacturing businesses at the forefront of product and process innovation and mass production. They also fuelled a domestic consumer revolution encouraged by the expansion of incomes, employment, population and 'industriousness' in the economic hinterlands of the Atlantic ports. Atlantic markets were clearly formative in bringing skills and knowledge into being, not in a general way as Mokyr suggests, but in highly specific regional, manufacturing and market contexts.

The Atlantic world and British industrialisation

Mokyr largely dismisses slave-based Atlantic trade as a causal factor in British industrialisation because all European nations participated (225). But this ignores the chronology and comparative importance of increasing British dominance in the

⁵Debates about the contribution of slavery to British economic growth and transformation generally side-line the connection between Caribbean trade and the emergence of Britain's world role in international investment, banking and financial services. Yet, from the perspective of the long term trajectory of the British economy, this was vital. The topic is addressed in Hudson (2021) and, in detail, in Berg & Hudson (2022).

Atlantic in the 18th century.⁶ By the early 18th century London was already the premier cosmopolitan entrepôt for European trade with the Americas and for the African trade. It was also the linchpin of credit and finance in trade and investment in the British Atlantic. The wealth and political influence of the West Indies interest at Westminster was central to policy formation in the fiscal military state.⁷ Over the entire period between 1556 and 1807 British slave traders were responsible for embarking well over a quarter of the 12.5 million enslaved Africans recorded on transatlantic shipments. By the 1770s British traders dominated the slave trade, accounting for more than half of total shipments from Africa during the quarter century before 1807.⁸ By the mid 18th century Liverpool was the leading slave trade port not only of Britain but of Europe, responsible for approximately twice as many shipments as Nantes, the leading French slave trade port.⁹ Island acquisitions in the West Indies at the Treaty of Paris in 1763 resulted in a great expansion of plantation cultivation and investment, mainly at the expense of the French and the Dutch. The Dutch also lost much of their financial place to Britain after the crises in Dutch international finance in the 1770s. The Napoleonic War period and the revolution in St. Domingue together confirmed British dominance of Caribbean trade and investment from the 1790s, at great cost to the French.¹⁰

Britain gained disproportionately from her role in the slave-based Caribbean because her North American colonies (extending into Canada and until 1775 including what became the USA) were an integral and vital part of the trading system, falling within the scope of the Navigation Acts that reserved British trade for British shipping over an extensive free-trade area. The sale of timber, fish, grains and other plantation supplies to the Caribbean significantly financed North American colonists' growing demands for imported British manufactures, and ensured the supply of essential goods to the plantation colonies, encouraging them to specialise in cash

⁶For the importance of slave-based Atlantic trade to British industrialisation and critiques of the problematic models and calculations that play it down, see: Wright (2020: 353–83); Findlay & O'Rourke (2007: 335–45); Acemoglu *et al.* (2005: 546–79); Inikori (2002); Blackburn (1997: 511, 516). For earlier key essays on the importance of slavery to the Atlantic trading system See Solow & Engerman (1988); Solow (1991). For a recent contrasting evaluation see Harley (2015: 161–83).

⁷Zahedieh (2010); Rawley (2003); Sheridan (1958: 249–63); Hoppit (2017: 123–9).

⁸<https://www.slavevoyages.org/assessment/estimates>; Morgan (2000).

⁹Drawing upon the 36,000 slave voyages where details have been digitised, between 1676 and 1825 two and a half times as many enslaved Africans were embarked on British than French ships and more than nine times as many as on Dutch vessels. Between 1680 and 1807 4686 slave trade voyages left from Liverpool, more than three times as many as from Nantes. London slave voyages were approximately twice the number from Nantes, and Bristol also exceeded Nantes' shipments by a large margin: <https://www.slavevoyages.org> search results 16 September 2021. Also see Rawley (2003: xii, 39); Daudin (2004: 144–71).

¹⁰Morgan (2000); Richardson (1987: 739–6); Checkland (1958: 461–9).

crops and sugar mono-culture.¹¹ In turn, protected home markets for Caribbean products, particularly sugar, guaranteed comparatively high returns for British plantation owners, traders, and investors.¹² Britain also gained disproportionately because her increasing 18th-century dominance in the slave trade further stimulated her stronghold in Asian trade: brightly printed Indian cottons and other goods from the east, were in high demand on the West African coast and in the Americas.¹³ Finally, the British economy gained more than European rivals from Caribbean and Atlantic trading because it led not only to innovation and skill development in manufacturing but also in the tertiary sector, especially in international financial, investment and brokerage services, insurance and shipping, all of which Britain came to dominate.¹⁴

Products and Atlantic markets

North American and West Indian consumer demand for a wide range of essential and luxury manufactures added to the array of exports, especially metalwares and textiles, exchanged for enslaved Africans on the West African coast. There was, in addition, a mass-market plantation demand for coarse plain woollens and linens for slave clothing, for a variety of hand tools geared to specific crops and soils, and for imported British-made producer goods for sugar cane processing as well as cultivation. The latter included a range of copper vessels, windmill gears, hydraulic equipment, and steam engines.¹⁵ Boulton and Watt alone sent 130 steam engines to sugar plantations in the West Indies and Brazil, 114 of these to Jamaica, British Guiana and Trinidad between 1803 and 1830.¹⁶

The implications of this for British manufacturing development are not hard to see. Ralph Davis in the early 1960s wrote that ‘the process of industrialization in England from the second quarter of the eighteenth century [was] to an important extent a response to colonial demands for nails, axes, firearms, buckets, coaches, clocks, saddles, handkerchiefs, buttons, cordage and a thousand other things.’¹⁷ North America and the West Indies took 11 per cent of English exports in 1700–1; 16 per cent 1750–1, 38 per cent in 1772–3, and 57 per cent in 1797–8.¹⁸ Between 1700 and

¹¹ Morgan (2000); Sheridan (2007; 1974); Findlay & O’Rourke (2007: 335–9); Wright (2002: 362).

¹² Sheridan (1957: 62–83); Rönnbäck (2014): 23–45.

¹³ Riello (2013: 135–59); Inikori (2002: 405–472); Kobayashi (2019); Richardson, (1979:303–330).

¹⁴ Inikori (2002: 265–361); Acemoglu *et al.* (2005: 546–579); Hudson (2014: 36–59); Hudson (2021).

¹⁵ Sheridan (2007: 112–18); Zahedieh (2021: 789–92).

¹⁶ Satchell (2010: 132–3).

¹⁷ Davis (1962: 290).

¹⁸ Zahedieh (2002: 64).

1773 official exports from England to British America (overwhelmingly manufactures) rose six-fold in value to £4.4 million, exceeding sales to Europe by a considerable margin between the mid 1770s and 1815.¹⁹ The West Indies alone took one half to two-thirds of English wares exported in transatlantic trade during the decades between 1784/6 and 1814/16, and 85 per cent of Irish exports during the later colonial period.²⁰ Nick Crafts calculated that net exports accounted for 45 per cent of the output of manufacturing, mining and building by 1801, about 55 per cent of which went to Africa and the Americas.²¹ During the previous century re-exports of colonial crops rose five-fold, underpinning imports from Europe, particularly vital supplies of raw materials: ‘iron, flax, hemp, masts, deals, pitch and tar – that kept thousands of sailors and tens of thousands of workers busy in Britain’.²²

The growth in textile markets was to a great degree an export story. As more and more English wool textile production came to be concentrated in West Yorkshire (20 per cent at the beginning of the century growing to about a third of national production in 1772 and to 60 per cent by 1800),²³ the proportion of West Yorkshire woollens and worsteds going abroad rose from 40 per cent in 1700 to 72 per cent 1771–2 (amounting to £3.5 million per annum).²⁴ According to one contemporary source, 90 per cent of Yorkshire broadcloths and kerseys, 80 per cent of worsteds and almost 70 per cent of blankets were exported. Much of the increase in exports, particularly of lighter, more colourful woollens and patterned worsteds, went to Atlantic markets by the late century.²⁵ The percentage going to African and American markets rose from 6.1 per cent *c.* 1700 to between 45 and 50 per cent in the 1790s and 1800s.²⁶

The USA and the West Indies took 73 per cent of British linen exports in 1784–6 and nearly 82 per cent ten years later.²⁷ By 1780 the Scottish linen industry may have occupied as many as 230,000 men, women and children. Ninety per cent of linen exports went to America and the West Indies, destinations as significant to Ireland as to Scotland.²⁸ Between 1700 and 1774 West Africa and the Americas together absorbed between 79 and 94 per cent of total British ‘cotton’ exports (predominantly made with linen warps). Total British cotton output rose from £600,000 in 1760 to £5.4 million in

¹⁹ Zahedieh (2014: 412–3); Inikori (2002: 405–72).

²⁰ Sheridan (1974: 448); Davis (1979: 80, Table 38); Nash (1985: 330); Also see Zahedieh (2021a: 789).

²¹ Crafts (1985: 127).

²² Price (1998: 86).

²³ Deane (1957: 215, 220); Wilson (1973: 228).

²⁴ Wilson (1973: 230). Hudson (1986: 155–74).

²⁵ Based on estimates of Thomas Wolrich, Leeds Merchant, 1772, quoted in Bischoff (1842; 1967: 187–9); Hudson (1986: 66, 156); Smail (1999).

²⁶ Inikori (2002: 414).

²⁷ Davis (1979: 94–7 Table 41).

²⁸ Devine (2017: 235–36); Nash (1985: 331); Griffiths *et al.* (2008: 630, 633, 635); Durie (1979: 148).

1784–86 (annual average) to £11.1 million in 1798–1800 and £30 million in 1815–17, by which time most of the exports were entirely made of cotton with piece goods in an increasing variety of styles, qualities, colours and prints. Between 1784 and 1806 more than half of total cotton exports was sent directly to Atlantic markets, including West Africa, while the same areas took even higher proportions of the more innovative exports of printed cottons and linens: between 70 and 85 per cent over the period 1765–1800. Spain and Portugal took additional substantial textile exports from Britain, much of which was destined for onward transatlantic trade.²⁹

The record left by the metals, engineering and ceramics industries is at least as strong. North America provided 60 per cent of the market for English hardwares and, by the 1790s, the largest export market for English ceramics. Metals made up the highest value, by a good deal, of London exports to Jamaica at £121,834 in 1772 and £154,958 in 1773. Atlantic markets took 63 per cent of wrought iron exports in 1750 and 73 per cent in 1770; the West Indies took *c.* 28 per cent and North America *c.* 34 per cent of British wrought iron and nails exported during each decade of the 18th century.³⁰ Between 54 per cent and 67 per cent of Britain's wrought copper exports were destined for the West Indies between 1740 and 1760, and the Caribbean continued thereafter to take close to or over 50 per cent up to 1774.³¹

British manufactures in Atlantic markets met not only the productive infrastructure needs of her New World colonies, but also their consumer culture.³² Like textiles, many goods were portable, fashionable, and crafted in new designs and materials honed to specific colonial demands and tastes: textile accessories (buckles, belts and buttons), light furnishings and metal ornaments, looking glasses, clocks and watches, cutlery, table, tea and glass ware.³³ The impact of Atlantic markets applied not only to textiles, the lighter metalwares, hardware, ceramics and engineering components, but also to capital-intensive heavy industries. Exports of copper and iron to Atlantic markets had large ramifications for investment in the South Wales coalfield, Cornish copper mines, copper refining in the Swansea Valley, iron refining in South Wales and the West Midlands, coal mining and iron processing in the North-East, and the heavy industrial development of the West of Scotland. Not only did such producer goods sectors feel the pulse of demand from the Atlantic but much of their lumpy initial investment lay in resources arising from plantation and wider Atlantic profits.³⁴

²⁹Inikori (2002: 427–51, Tables 9.6, 9.9, 436, 448); Riello (2013: 149–50).

³⁰Zahedieh (2021a: 787); Inikori (2002: 457, Table 9.11).

³¹Harley (2015: 166–7, Table 8.1); McCusker & Menard (1985) Price (1998: 88); Weatherill, (1983: 15–46); Zahedieh (1994: 242, 252–3); Zahedieh (2021a: 789–90).

³²Davis (1962: 108–9).

³³Price (1980: 18) Berg (2005: 279–325).

³⁴*Legacies of British Slave Ownership* database: <https://www.ucl.ac.uk/lbs/>; Evans (2010: 56–65); Williams (1944: 103–4); Devine (1976: 1–13).

The success of British consumer and capital goods in Atlantic markets rested on the same infrastructure of commercial and financial services that were pioneered to underpin the trade in slaves and plantation products. By the late 18th century Britain had come to dominate the financial framework of Atlantic trade.³⁵ Banks, insurance houses, investment intermediaries, mortgage brokers, commodity brokers, shipping and commercial intelligence intermediaries all enabled this trade and profited from it. New skills and institutions of the tertiary sector and their expansion in the 18th century call for as much attention from historians of the British economy as those formed in the secondary sector. The commercial and financial infrastructure of Atlantic trade, pivoted on London but incorporating the resources of the Atlantic ports, impacted significantly upon the wider British economy.³⁶

Atlantic ports and their economic hinterlands

Specialised regional industrial clusters, associated with ports serving Atlantic markets, particularly London, Bristol, Liverpool and Glasgow, were key to the expansion of Britain's industrial skills base. Imports of new raw materials from Iberia, Africa and the plantation-Caribbean also provided the basis for new processing industries, giving Atlantic port regions an advantage. These included the refining of new specialised sugars, rum, punch, and other sugar derivatives, tobacco, chocolate, and patterned textiles. Industrial regions linked to Atlantic port cities developed advantages of industrial agglomeration, central to the dynamics of the industrial revolution.³⁷ These advantages included face-to-face trading and manufacturing environments, as well as formal institutions, in which the latest industrial, technological and commercial knowledge circulated.

Atlantic markets shifted and spread the growth centres of the economy to the newly industrialising regions of the West Midlands, Lancashire, West Yorkshire and west-central Scotland, and to trade routes, both internal and external, that were less and less focused through London. This caused a *relative* decline in the position of London as the key British urban population centre, and rapid growth of population in both urban and rural areas of the industrialising regions.³⁸ In England and Wales

³⁵ Inikori (2002: 314–61); Hudson (2021).

³⁶ Hudson (2014); Hudson (2021); Rönnbäck (2014).

³⁷ Inikori (2002: 362–404); Hudson (1989). See Cookson (2018: 36–58) on engineering skills and the factory system.

³⁸ In 1700, with a population of 575,000, London was almost twice as large as all other towns combined. By 1801 its share of the urban total had reduced to 38 per cent even though it had grown in size to 959,000, and it remained vitally important as a centre of consumption, national and international

between 1750 and 1801 the national population grew by *c.* 46 per cent. In West Yorkshire it grew by 82 per cent and in Lancashire by 122 per cent, an increase primarily arising from labour migration that enriched the skills pool in the receiving areas.³⁹ Similarly Glasgow and its hinterland grew from 181,000 to 331,000 between 1755 and 1801, or from 14.2 per cent to 20 per cent of the total Scottish population.⁴⁰

Structural change reflecting occupational specialisation and the multiplication of an experienced industrial workforce was also overwhelmingly confined to the same Atlantic port catchments. Secondary sector occupations as a proportion of the workforce increased markedly in these regions in the century before 1750, just as the Atlantic trading system was taking off. In industrial Lancashire and Yorkshire, already by 1755 two-thirds of employed adult males worked in the secondary sector.⁴¹ Absolute numbers employed in industry and manufacturing continued to rise in these and other industrialising counties in the classic industrial revolution period. This was stimulated not only by Atlantic markets, but also by regional domestic markets that structural change, rising population, and increasing employment and incomes were creating. However, the *proportion* employed in the secondary sector had stabilised. The concentration of new export-oriented manufacturing in Atlantic port hinterlands was well established before 1750, creating the conditions for in-migration, skill expansion, innovation and rising labour productivity in the same regions in the later 18th and early 19th centuries. These were the hallmarks of industrialisation occurring largely in the economic catchment areas of the Atlantic ports.⁴²

More limited data for Scotland testify to the extremely rapid and acute nature of the industrialisation process north of the border in the classic industrial revolution

finance, specialised manufacturing and trade. The urban population is here defined as all towns with over 5000 population: Shaw Taylor & Wrigley (2014: 53–88).

³⁹ Between 1700 and 1750 population in the industrial counties in the hinterland of Liverpool (Lancashire, Cheshire, Staffordshire, the West Riding of Yorkshire and Warwickshire) grew by 36.5 per cent while in agricultural counties it grew by only 5.2 per cent. Between 1750 and 1801 the industrial group rose by 87.4 per cent compared with the agricultural group *c.* 29 per cent: Shaw Taylor & Wrigley (2014: 78–81).

⁴⁰ Slaven (1975: 136).

⁴¹ Shaw Taylor & Wrigley make a reasoned case that the inclusion of female workers would not materially alter these important and early sectoral shifts. Including women slightly enlarges the secondary sector share at the beginning of the 18th century and makes the tertiary sector significantly larger throughout but with a similar high trend rate of growth. Shaw Taylor & Wrigley (2014: 66–70).

⁴² At the same time, some counties including Hertfordshire, Northamptonshire and Bedfordshire saw a rise in the proportion of the population employed in agriculture because of the collapse of rural industries. For more detailed expositions and regional analysis see <https://www.campop.geog.cam.ac.uk/research/occupations/>. For an earlier argument about Atlantic trade and the regional concentration of industrialisation see: Inikori (2015).

period, especially in Glasgow and its industrial hinterland.⁴³ Geared to Atlantic trading more than any other port, Glasgow rapidly became a major industrial city where trade, manufacturing, finance, shipping and other branches of the tertiary sector operated alongside one another, often with overlapping partnerships and finance, in the same urban space.⁴⁴ Liverpool's industrial hinterland, connected by major investment in transportation links, extended from the West Midlands in the south, north-central Wales to the West, to mid Yorkshire in the east, and throughout Lancashire to the north. Here there developed a distinctive locational specialisation. Liverpool in the 1760s had 60 per cent of the employed population in the industrial sector. But, in a remarkable transformation, by 1810 its industrial share had declined to under 30 per cent, reflecting growing specialisation as a port rather than a manufacturing centre.⁴⁵ By 1801 commercial manufacturing for export via Liverpool took place almost entirely in Liverpool's huge economic hinterland, benefiting from the now-specialised port. Liverpool's success in Atlantic trade set the city up for its important role from the early 19th century in cotton importing and broking, in the mass exporting of cotton piece goods, and also in the further development of shipping and insurance. Although Bristol did not develop a comparable industrial hinterland, Atlantic trade and its accumulated wealth played a major part in transforming industrial South Wales, the Black Country and parts of the South-West of England, while the city became a great centre for the processing and supply of colonial consumer goods.

Mapping changes in the occupational structure of England and Wales (as accomplished in recent years by researchers at the Cambridge Group for the History of Population and Social Structure) provides clear visual evidence of the geographically concentrated nature of structural transformation and hence skill formation in the economy of England and Wales and its relationship to Atlantic port hinterlands.⁴⁶ The Cambridge Group maps demonstrate the regional concentration of secondary and tertiary sector employment growth with (export-oriented) textile and metalware occupations showing the highest, and increasing, levels of regional concentration between the early 18th century and 1851.⁴⁷

⁴³ By 1851 the proportion of male occupations in the secondary sector was higher in Scotland than in England (47.1 per cent compared with 42.6 per cent). Scotland also had a significantly higher proportion of employment in textiles than England in 1851 (15 per cent compared with 8.8 per cent) and a tertiary sector that was rapidly catching up with England's proportionally. See Shaw Taylor & Wrigley (2014: 70–72); <https://www.campop.geog.cam.ac.uk/research/occupations/>

⁴⁴ Morgan, (2000: 87); Devine (1977: 177–190); Devine & Jackson (1995: 14, 235).

⁴⁵ Langton & Laxton (1978: 78–82); Longmore (2006: 113–170).

⁴⁶ <https://www.economiespast.org/sec/1817/#7/53.035/-2.895>

⁴⁷ The UK distribution of slave ownership compensation payments after 1834, as well as that of mid to later 19th century millionaires and half millionaires overlap significantly with the major centres of Atlantic-oriented structural change and Atlantic-derived wealth: <https://www.ucl.ac.uk/lbs/maps/britain/>; Rubenstein (1981: 74–145; Tables 3.11–3.13 130–132).

Textiles

Fast growing African and New World demands for lighter brighter textiles created, as with metalwares, not just an extension of the market but a product revolution. The revolution was initially stimulated by the success of re-exported Indian cottons in Atlantic-world markets. West African tastes for stripes and checks, mass demand for basic textiles for slave use, and colonial settler demand for high quality, light and colourful printed cloths drove innovation, as did trade advantage in Atlantic supplies of Iberian wool, logwood, indigo, gum arabic (used in textile printing), and, above all, in Sea Island cotton.

Export-oriented linen industries in south Lancashire, Scotland and Ireland supplied sailcloth and fabric for slave clothing. The manufacture of major new woollen products including 'Welsh Plains', 'Penistones' and 'Kendal cloths', all geared specifically to slave clothing, covered significant proto-industrial areas of Wales, the Pennines and the Lake District. Welsh plains were particularly prized for their durability and cheapness and comprised a major component of what contemporaries termed 'negro cloth'. Their manufacture was gradually dominated by Liverpool middle men and merchants who extended credit and took the finished cloths for export.⁴⁸ Many patterns and designs of highly coloured innovative woollens and worsted goods at the higher end of the market were developed in West Yorkshire specifically for Atlantic, including African, consumers. The manufacturers of Halifax Parish had, by the 1750s, developed a trade with 'Guinea' in Sais of a strong blue shade. They '... were packed in pieces of 12 and a half yards in length, and wrapped in oilcloth painted with negroes and elephants to captivate the natives ...'.⁴⁹ Information flows between buyers in North America, the Caribbean and Africa and their suppliers dictated preferences for particular colours, designs and qualities as well as discussing prices.⁵⁰

Atlantic markets and raw materials above all drove the rapid transformation of the British cotton industry. 'Perhaps even more than in Europe, cottons came to be part of the everyday textiles used by consumers in the warm climates of the Caribbean, but also in areas as varied as New France, Pennsylvania, South Carolina and Louisiana', despite being more costly than linens.⁵¹ By the 1760s and 1770s consumers in the American colonies were not only buying velvets, satins, damasks and taffetas

⁴⁸ Evans (2010: 46–54).

⁴⁹ James (1857; 1968: 290) quoting Thomas Pennant, *Tour in Scotland* (1770).

⁵⁰ Smail, (1999: 32–75, 113–132). Contrast with Mokyr's caricature: 'French inventors worried about elegance and taste more than about price and cost, in sharp contrast to the sober and practical craftsmen working away in the grimy workshops of Leeds and Keighley' (229).

⁵¹ Riello (2013: 146–7).

but also printed and painted cottons for male as well as female dress, upholstery and curtains.⁵² Buoyant North American demand continued to increase long after 1783. By 1800 the United States imported nearly £60 million worth of English merchandise, three times the value of the entire trade between India and England.⁵³ New products responded to particular sophisticated sumptuary and fashion demand in West Africa and the Americas. Product innovation emphasising design, colour and composition dominated 18th-century textile patents. Only after 1790 do patents reflect growing inventiveness in textile manufacturing processes and engineering.⁵⁴

The close association between Sea Island raw cotton and the innovation of key textile spinning technologies is now recognised.⁵⁵ Fluffy, long-stapled New World cotton was ideally suited to the all-cotton wefts in fustians and its use expanded rapidly from the 1730s. By 1780 Sea Island cotton imports were over three times those arriving from the Levant and were said to comprise more than 80 per cent of the raw cotton used in Lancashire.⁵⁶ Dominica, Grenada and Jamaica accounted for over 65 per cent of such imports before the 1780s, and greater supplies into the early 1800s were provided by imports from captured French and Dutch slave-plantation colonies (particularly Demerara and Surinam) and from slave-based plantations in Brazil via a re-export trade from Lisbon. Imports of cotton from the Southern United States were negligible before 1800 and consistently provided more than 50 per cent of British supplies only after 1820.⁵⁷ The French cotton industry (principally in Normandy and especially Rouen) also began to use Caribbean cotton from the mid 1730s. But Levant cotton remained as important as New World supplies in Normandy, and there was a dramatic increase in its use in the 1780s as it was purchased in return for French wool textiles that increasingly dominated Ottoman markets.⁵⁸

British cotton spinning, well before 1750, had developed a distinctive production system, geared to Atlantic cotton supply, as well as to Atlantic demand for high quality printed fustians and cottons. This system differed markedly from the rest of Europe

⁵²Riello (2013: 147); Du Plessis (2016).

⁵³Riello (2013: 148).

⁵⁴O'Brien *et al.* (1996: 167); Griffiths *et al.* (1992: 896); Griffiths *et al.* (2008: 636, 646).

⁵⁵The key research here is Styles (2020: 195–236). The following paragraphs draw heavily on his work.

⁵⁶Wadsworth & De Lacey Mann (1931; 1968: 520–521); Styles (2020: 199, Figure 1, 200).

⁵⁷Olmstead & Rhode (2018: 1–17, Figure 2 p. 4); Riello (2013: 202–3); Pereira (2018: 925). For details on the distribution of cotton exports and imports from the individual islands see Pereira (2018: 943 Table 6, 944, Table 7; 947). Also see Ryden (2013: 539–570); Mokyr writes that 'by the time cotton became central to the Atlantic, the regions that grew it were no longer controlled by Britain (225 n. 2). We argue that New World cotton was central to Atlantic trade and to textile inventiveness *before* US supplies were dominant. Even after 1820, with US supplies dominating, this was still a supply entirely dependent upon the institution of slavery, irrespective of British control.

⁵⁸Riello (2013: 200); Styles (2020: 199).

and created a uniquely propitious environment for spinning innovation. New World cotton facilitated a drive to finer, higher quality, yarns in which the preparatory processes were all important. Careful preparatory processes stimulated the invention and introduction of the jenny which was designed to spin low-twist rovings into soft weft yarn suitable for plain cloths (Blackburn greys in particular) made to take evenly to colour-printing. Such intensive preparatory processes would not have been economic on lower-cost traditional Levant supplies of raw cotton.⁵⁹ Sea Island cotton was a new raw material, its impact on the need for adaptive skills similar to that caused by the use of coal in iron manufacture, metal refining, ceramics and glass manufacture.⁶⁰

Arkwright's water frame likewise benefited from ready supplies of Sea Island cotton, this time applied to the mechanisation of warp spinning where its longer staple was an advantage in achieving the required twist.⁶¹ Arkwright technology enabled mass production of all-cotton cloths which took to printing better than fustians. Aided by the 1774 repeal of the Calico Act of 1721 that prevented the use and sale of domestically produced all-cotton cloth in England, this allowed the cotton bleaching and printing industries of Lancashire and Scotland to take off. Cotton imports into Scotland from America and the West Indies rose 32 times between 1783 and 1800 facilitating the expansion of water frame spinning.⁶² The longer staple of New World cotton, as well as its quality, again proved advantageous with the invention and innovation of Crompton's spinning mule developed in 1779 to produce more even warp and weft yarns for calicos and muslins. By 1811 the mule had become the dominant spinning technology in Lancashire by some margin, but the other two technologies were also common, then and later, in Scotland and Yorkshire, as well as Lancashire, because all three produced yarns of different specificity to be used in combination to create distinctive products of cotton, cotton-linen, and cotton-wool and worsteds (from the 1820s), whose demands were dictated by diverse tropical as well as temperate markets.⁶³

Direct connections between cotton manufacturing for African and American markets, technological pioneers and slave trading are well known. Prominent manufacturers such as the Hibberts, Sir William Fazackerly and Samuel Touchet were slave traders, while other leading firms, like the Gregs, benefited from family wealth and trading connections made in Africa or the Caribbean.⁶⁴ Of 76 West India merchants making industrial investments in the Glasgow area before 1815, 21 were partners in cotton firms including two major investors in James Findlay & Co., Scotland's largest

⁵⁹ Styles (2020: 201–206, 219).

⁶⁰ Styles (2020: 227); Harris (1992: 3–16); Berg (2005: 120, 175).

⁶¹ Hahn (2020: 69–75); Styles (2020: 211–12).

⁶² Devine (2017: 238–9).

⁶³ Hahn (2020: 82–86).

⁶⁴ Riello, (2013: 152); Hahn (2020: 73); <https://www.ucl.ac.uk/lbs/>

cotton firm in the early 19th century.⁶⁵ Samuel Touchet, slave and sugar trader, was the main financial backer for the first (unsuccessful) powered spinning machine and the first mill both developed by Lewis Paul and John Wyatt during the 1740s and early 1750s. With his brothers, he ran one of the leading cotton check firms in Manchester and had shares in twenty West India ships.⁶⁶

Metals and mining

Mokyr devotes himself to metals and engineering skills, millwrights, engineers, and metal manufacturers, for example the proto-industrial Prescott watch part makers in the Liverpool hinterland. They not only produced parts for London's Clerkenwell watch and clockmakers who sold in quantity on Atlantic markets, but had the expertise to apply their skills to tools for textile machine making.⁶⁷ Local knowledge was more important than apprenticeship qualification, as the great Scots engineer William Fairbairn was to discover at the beginning of the 19th century. His millwrighting apprenticeship at a Northumberland colliery did not pass muster before the Millwright's Society that controlled access to John Rennie's London millwrighting business. Local knowledge gained after many difficult weeks introduced him to alternative independent millwright societies with more relaxed access rules, and thus he started his millwrighting and engineering career.⁶⁸

The metal hardwares and guns of the West Midlands are the stock and trade of connections between slavery and British industry. Great ironware capitalists such as Crowley in the North-East as well as others in the West Midlands and small-scale putting out ironmongers organised production of hand wrought nails, all manner of ironmongery, West Indies hoes and sugar cane knives, as well as 'chains of all kinds'.⁶⁹ As canals were extended in the later 18th century, increasing amounts of Midlands products were exported via Liverpool, but the West Midlands metalworkers had early ready access via the River Severn to Bristol and on to rapidly growing markets in the West Indies and the American colonies. As early as 1657 it was well known in Barbados that 'nails of all sorts with hooks, hinges and clamps of iron are to be had at Birmingham and in Staffordshire much cheaper than in London.'⁷⁰ Ships left Bristol

⁶⁵ Devine (1978: 40–67); Devine (2017: 236–7); Devine (1976: 1–13); Thompson & MacKenzie (2005:203).

⁶⁶ Wadsworth and Mann (1931; 1968: 149); Williams (1944: 70); Sheridan (1974; 1994: 479); Inikori (2002: 442); Thomas (1997: 249).

⁶⁷ Cookson (2018: 82).

⁶⁸ Pole (1877: 72, 90–92).

⁶⁹ Berg & Berg (2001: 262, 265–6, 295); Court (1953: 177–203).

⁷⁰ Rowlands (1975: 127).

every week for Virginia, Barbados or Jamaica with nails, hoes, bills, and scythes and other wrought iron work. High diversification and specialisation, often for new markets, generated Mokyr's high levels of artisan skill. A plethora of designs of the plantation hoe, made throughout the Black Country and in the North-East, honed the product to specific crops and soils.⁷¹ At Willenhall 138 locksmiths produced nineteen different types of lock;⁷² Sketchley's Directory in 1770 listed over 70 different metal trades in Wolverhampton, Walsall, Bilston, Willenhall and Dudley, including a 'Negro collar maker' in Wolverhampton.⁷³

The Birmingham gun sector is often dismissed as a technological backwater weighted down by the restrictions of craft traditions. In fact it drew on the significant knowledge spill-overs of the allied hardware trades in the town, improving gun barrels, applying brassworking expertise in gunlocks and fittings, developing its own unofficial proofing systems, and responding nimbly to large orders suddenly placed by slave traders, plantation managers and others. Farmer & Galton met orders for 15,900 guns for the African market in 1772; one order from Liverpool included 6,410 guns.⁷⁴

Few economic historians including Mokyr acknowledge the significant Atlantic stimulus to the heavy industrial sector. Substantial innovatory investment was made in coal mining, iron production and copper smelting by West India merchants and banks based in London and Bristol. They financed the South Wales coalfield, Cornish copper mines, iron refining in South Wales, Scotland and the West Midlands, and coal mining in the North-East for the London market.⁷⁵ The Swansea Valley's 'Copperopolis' thus became the earliest site of a fully industrialised region with a centralised workforce of wage-dependent workers engaged in coal-fired production before the mid 18th century. It was the first copper smelting region to use coal in a revolutionary new high-output 'Welsh process', employing some of the lowest paid workers in Britain. Between the 1770s and the 1840s the region routinely produced a third of the world's smelted copper, often more. Approximately 40 per cent was exported, mostly to the Americas.⁷⁶ This transformation, like that of the South Wales iron industry in its wake, was intimately linked with the needs of plantation-processing, the slave trade and shipping. These demands brought the copper industry out of stagnation from the mid-17th century onwards, accelerating with the rising demand for copper vessels for sugar processing and refining that occurred with the expansion of the sugar frontier

⁷¹ Evans (2012: 71–100).

⁷² Rowlands (1975: 130).

⁷³ Rowlands (1975: 127, 131–2, 180–1).

⁷⁴ Richards (1980: 53–55); Satia (2018: 188–190).

⁷⁵ Evans (2010 31–41, 59–71; 116–21); Williams (1944: 102–4); Devine (1976: 1–13).

⁷⁶ Evans & Miskell (2020: 78–118); Hughes (2000/2008: 131–64).

in the later 18th century.⁷⁷ This copper revolution was magnified by the copper bottoming of ships in tropical trades from the 1760s onwards.⁷⁸ Newcomen and Watt steam pumping engines were developed in Cornwall's deep copper mines. Entrepreneurs and mining engineers, Matthew Boulton and the Trevethicks moved between Cornwall and South Wales, seeking out and recruiting the technical skills they needed as their ventures grew.⁷⁹ Coal production in South Wales also expanded to fuel this great copper refining and iron making region. The output of the western coalfields grew from 70,000 tons in 1700 to 250,000 tons in 1775, and South Wales doubled its contribution to national coal output.⁸⁰

It was to Britain's particular mercantilist hold in the Caribbean and the American colonies before the American Revolution that J.R. Harris, the leading historian of the copper, iron and the hardware industries, attributed the export trade in iron.⁸¹ Abraham Darby, so well-known for developing the coke smelting of iron, spent his earlier career connected with the Bristol Brassworks, and in the copper smelting works at Crew's Hole near Bristol. He moved on to Coalbrookdale in 1703, setting up his famous iron works and developing coke smelting; he found ready markets for his cast goods and pipe work among the Cornish engine makers.⁸² Darby's major investor was the Bristol merchant, Thomas Goldney, who had made his fortune in shares in merchant and slaving vessels to the West Indies, and acquired a controlling interest in the works by 1718. Darby's works also produced manillas and brass objects sold in the slave trade.⁸³

The background of the entrepreneurs of the great Cyfartha ironworks in South Wales, the 'largest and most technically advanced iron works in world by 1800', was little different. Anthony Bacon drew his wealth from garrison contracts on the Senegal coast and slave contracts with the West Indies to invest lavish amounts in Cyfartha. There his partner, Richard Crawshay perfected and developed to large-scale production the famed iron technology, Cort's puddling process. His son ('the uncrowned iron king') went on to establish a major London merchant house, and his grandson to become a rich West India merchant.⁸⁴

⁷⁷ Zahedieh (2013: 81; 2021b: 6, 14); Evans (2014: 66); Evans (2010: 35–9).

⁷⁸ Solar & Rönneback (2015: 810–11); Harris, (1966: 550–68).

⁷⁹ Hamilton (1926: 167, 171, 195). Also see Zahedieh who cites 40 Cornish orders for Boulton and Watt engines as well as 30 'pirate' engines supplied, with 52 constructed by 1802: Zahedieh (2021: 13).

⁸⁰ Zahedieh (2021a: 797).

⁸¹ Harris (1988: 51–3); Evans (2005: 15–28).

⁸² Zahedieh (2021a: 798).

⁸³ Birch, (1967: 61); Morgan (2009).

⁸⁴ Birch (1967: 39, 80), Evans (2010: 64–5).

Conclusion

Joel Mokyr's 'Holy Land of Industrialism' builds a supply-side explanation for Britain's industrial revolution in her steady accretion of innate artisanal, manufacturing and inventive skills especially in metalworking and engineering. This supply-based case does not explain the deficiencies of other European countries that left Britain to take the lead in early industrialisation. Nor does it offer enough to explain the timing or the regional concentration of what became the 'tipping point' to make an industrial revolution. Focusing on two key industries, textiles and metals, we have argued that new demands arising from global trade, and especially plantation-based trade, provided the stimulus for inventive activity and skill development. A global sugar economy, based in slave plantations in the Caribbean, developed from the mid 17th century, with dramatic expansion of consumer demand in the 18th century. This drove the product and process revolutions of early industrialisation. Diverse Atlantic demands for new manufactured goods, together with new raw material supplies, and the regional concentration of innovative industries, honed the existing skills base and brought new skills into being.

The chronology of British industrialisation can be related to the timing of Britain's success vis-à-vis her European rivals in war, colonial extraction and finance starting with the rapid development of the sugar islands and the slave trade in the later 17th century. Structural shifts in favour of Atlantic port hinterlands were largely a story of the first half of the 18th century when the British economy reoriented itself firmly in the direction of trade with Africa and the Americas. The technological breakthroughs of the late 18th century occurred at the time of British dominance of trade and finance in the Caribbean and wider Atlantic. The rapid extension of the sugar frontier and plantation investment after 1763; the restoration and expansion of trade with the USA from the late 1780s; and the scramble for quick Caribbean profits in the heady circumstances of the early Napoleonic War period were all important. This chronology connects to a build-up of product and process innovations across manufacturing industries. It also connects the accessing and development of key raw materials, especially Sea Island cotton, to the celebrated inventions of the spinning jenny, the water frame, the spinning mule and cotton printing technologies. And it connects the processing and manufacture of sugar products in the Caribbean and in Britain, with revolutions in the copper, iron and engineering industries.

Attempting to pin down a precise correlation between periods of Atlantic trade expansion and technological change would be fruitless given the incomplete nature of trade data (for the Americas in particular) and the complexities created by lags in ascertaining cause and effect in such demand-side analysis. What we can say is that the build-up of skills, stimulated by production for westward export, shipping and

investment was a volatile process that lasted more than a century. During this process, growing British domination of the slave trade and of Caribbean investment and cultivation had a fundamental impact in redistributing incomes and profits in Britain, regionally, socially and across sectors. This created a fertile environment for industrial take off. Skilled artisans, technical experts, inventors, and the manufacturers and merchants who applied their knowledge, made vital contributions to the industrial revolution. On this we agree. But the timing of this revolution, its regional focus, and the stimulus behind knowledge and skill development lay elsewhere: in a market and raw material supply revolution centred on Atlantic trade and underpinned by plantation slavery.

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